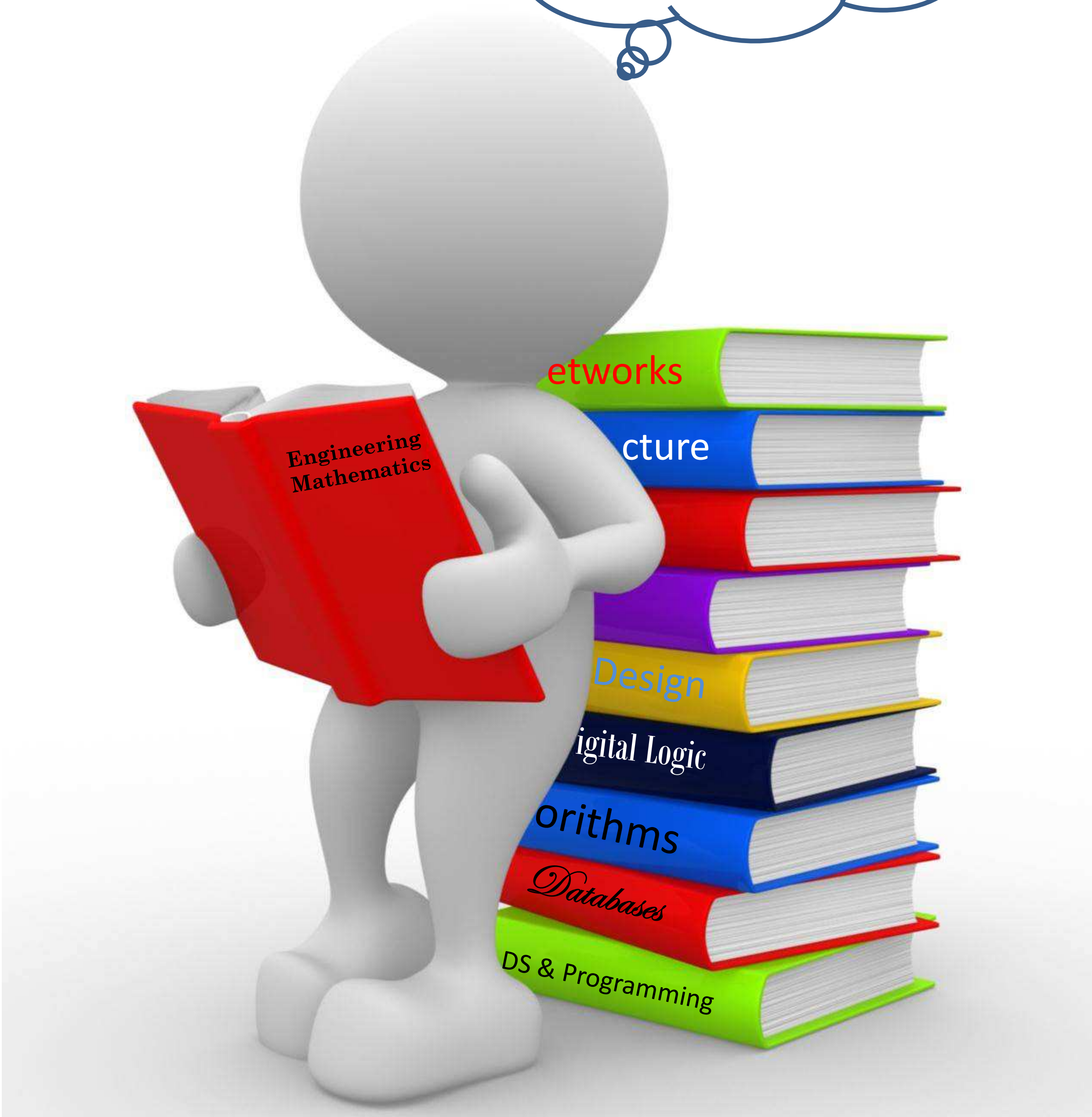
GATE Overflow

2017 Vol. 2



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This book was created programmatically by GATE Overflow on Sep 21, 2017. If you feel any doubt regarding the answer, click on the question link and give a comment on the site. Studying all these questions might get you 60 marks in GATE but that might not be enough for an IIT. So, read standard books, solve exercise questions and use these questions for cementing the concepts and aim 85+. At least if you are not getting the solution to a given problem first refer standard book. If any error is found on any question it shall be updated at **http://gateoverflow.in/corrections**.
PDFs for the remaining subjects will be made available at **http://classroom.gateoverflow.in** and you can enroll in **this course** to get notification for the same. Enrollment is free and account details are of GATE Overflow with a new password which have been sent to all registered emails on GATE Overflow. New users will receive this email within a few minutes of confirming their email address.

You can now join our **Facebook group** for GATE CSE discussions.

You can visit **http://playlists.gatecse.in** for high quality videos for GATE CSE and how to use GO site/ebook.

This book consists of only previous year GATE, TIFR, ISI and CMI questions (CS from 1987 and all 5 years of IT) all of which are relevant for GATE. Out of syllabus subjects as of GATE 2017 are removed from this book except in rare cases.

Since **GATE Overflow** started in August 2014, a lot of people have dedicated their time and effort in bringing this book now. Initiated by **Omesh Pandita** and **Arjun Suresh** as a Q/A platform for CSE students, **Kathleen Bankson** was instrumental in getting all previous year GATE questions here. Then experts like **Praven Saini**, **Happy Mittal**, **Sankaranarayanan P.N.**, **Suraj Kumar** etc. have contributed a lot to the answers here. **Pragy Agarwal** even after topping GATE has continuously contributed here with his knowledge as well as in making the contents beautiful with fine latex skills. We also have to thank the work by **Jothee**, **Misbah**, **Ishrat** and **Nataliyah** who are continuously adding and keeping the contents here neat and clean. There are also many toppers of GATE 2015, 2016, 2017 and probably 2018 who are contributing a lot here. The list of all the contributors can be found **here** but even that does not include the contributions of some like Arif Ali Anapparakkal in helping design this book, **Arvind Devaraj** and others who have provided guidance and help etc. Last but not the least, we thank all the users of GATE Overflow.

We thank the contributions of **Silpa V.S.**, **Rahul Kumar Yadav** and others for getting the **GATECSE Lastrank** page maintained. **Bikram Ballav** is behind most of the exams on GO (**http://mockgate.com**) and **Arindam Sarkar** made the interface for it. **Pragy Agarwal** is also behind the rank and score predictor tool, (**http://mymarks.gatecse.in**) used by GO which has 99-100% accuracy over the last 2 years.

Special thanks to **Sachin Mittal** for making the **How to Use GO vidoes**, **Silpa V.S.** for classifying the questions topicwise for the book, **Pooja Palod** for making the **GATE 2018 schedule** and **Debashish Deka** for GO classroom contributions.

Also thanks to all toppers who took time to write a review for GO.

Table of Contents

1 Algorithms (306) top

1.1 Algorithm Design(5) top

1.1.1 Algorithm Design: CMI2012-B-03b top http://gateoverflow.in/47088

Let A be array of n integers, sorted so that $A[1] \leq A[2] \leq \ldots A[n]$. Suppose you are given a number x and you wish to find out if there exist indices k, l such that $A[k] + A[l] = x$.

a. Design an $O(n)$ algorithm for this problem.

descriptive cmi2012 algorithms algorithm-design

Answer

1.1.2 Algorithm Design: GATE1992-8 top http://gateoverflow.in/587

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

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

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

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

gate1992 algorithms descriptive algorithm-design

Answer

1.1.3 Algorithm Design: GATE2006-17 top http://gateoverflow.in/978

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

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

gate2006 algorithms normal algorithm-design

Answer

1.1.4 Algorithm Design: GATE2006-54 top http://gateoverflow.in/1832

Given two arrays of numbers $a_1, \ldots, a_n$ and $b_1, \ldots, b_n$ where each number is 0 or 1, the fastest algorithm to find the largest span (i, j) such that $a_i + a_{i+1} + \cdots + a_j = b_i + b_{i+1} + \cdots + b_j$ or report that there is not such span,

A. Takes $0(3^n)$ and $\Omega(2^n)$ time if hashing is permitted
B. Takes $0(n^3)$ and $\Omega(n^{2.5})$ time in the key comparison mode
C. Takes $\Theta(n)$ time and space
D. Takes $O(\sqrt{n})$ time only if the sum of the $2n$ elements is an even number

gate2006 algorithms normal algorithm-design time-complexity

Answer

1.1.5 Algorithm Design: TIFR2011-B-29 top http://gateoverflow.in/20576

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

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

How many moves are required?

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

tifr2011 algorithms algorithm-design

Answer

Answers: Algorithm Design

1.1.1 Algorithm Design: CMI2012-B-03b top http://gateoverflow.in/47088

Selected Answer

Here is the algorithm, Which return **True** if there is a number **x** present such that **(A[k] + A[l] == x)** else return **false**.

```
// Consider this algorithm is called as
// AlgorithmCheck(A,1,size,x);
// Where A is the sorted array

Bool AlgorithmCheck(A, L, K, x){
    while(L<K){
        if(A[L]+A[K] == x)
            return true;
        else if(A[L]+A[K] < x)
            L++;
        else
            K--;
    }
    return false;
}
```

This will take only **O(n) time** to do its work.

9 votes -- Muktinath Vishwakarma (34.1k points)

1.1.2 Algorithm Design: GATE1992-8 top http://gateoverflow.in/587

Union-Find Algorithm can be used to find the cycle.

Ref: http://www.geeksforgeeks.org/union-find/

4 votes -- Rajarshi Sarkar (35k points)

1.1.3 Algorithm Design: GATE2006-17 top http://gateoverflow.in/978

Selected Answer

Ans B should be correct.

We can move from right keeping a note of the maximum element(suppose current_max). At the start the right most element will always be a leader. If an element is greater than our current_max, it will a leader. Add this element to leaders. Set current_max to this element and carry on leftward. Time Complexity would be O(n)

19 votes -- Madhur Rawat (2.6k points)

1.1.4 Algorithm Design: GATE2006-54 top http://gateoverflow.in/1832

Selected Answer

Answer is (C). Following algorithm would do.

Since array is binary, the max sum will go until n and so the sum difference of the two arrays can vary between $-n$ and n. We use array start to keep the starting index of each possible sum (hence of size $2n+1$) and array end to keep the ending index (these two arrays work like hash tables and since we have only $2n+1$ possible keys, we can do a perfect hashing). So, our required solution will be max(end[i]-start[i]) provided both are assigned values.

The algorithm works as follows:

1. Initialize diff array to contain the difference of sum of elements of array a and b. i.e., $diff[i] = \sum_{i=0}^{n} a[i] - b[i]$.
2. Now diff[i] can have values from $-n$ to n which gives $2n+1$ possible values and the first occurrence of a diff value marks the beginning of a span and the last occurrence marks the end. We use start and end array for storing these two positions for the $2n+1$ possible values.
3. Now, the largest value of end[i] - start[i] for any i, will be the largest span and the start of it will be start[i] + 1, and end will be end[i]. If the span is starting from first position itself (arrays a and b have same first elements), then it will start from start[i] itself.

```
#include <stdio.h>

#define size 100 //assume n is less than 100
int main()
{
    int n, a[size], b[size];
    int start[2*size+1], end[2*size+1];
    int sum1 = 0, sum2 = 0, i;
    int diff[size];
    printf("Enter n: ");
    scanf("%d", &n);
    for(i = 0; i < n; i++)
    {
        printf("Enter a[%d]: ", i);
        scanf("%d", &a[i]);
    }
    for(i = 0; i < n; i++)
    {
        printf("Enter b[%d]: ", i);
        scanf("%d", &b[i]);
    }

    for(i = 0; i < n; i++)
    {
        if(a[i]) sum1++;
        if(b[i]) sum2++;
        diff[i] = sum1 - sum2;
    }
    for(i = 0; i < 2*n; i++)
        start[i] = -1,end[i] = -1;
    start[n] = end[n] = 0;
    //initially sum is 0 at the beginning of array and
    //the first n-1 elements of start and end are used
    //if sum of A till ith element is less than sum of B till ith element
    for(i=0; i < n; i++)
    {
        if(start[diff[i] + n] == -1)//interested only in the first occurrence of diff[i]
            start[diff[i] + n] = i;
        end[diff[i] + n] = i;//interested in the last occurrence of diff[i]
    }
    int max = -1;
    int savei = -1; //savei is for storing the sum having the largest span

    for(i = 0; i < 2*n; i++)
    {
        if(start[i] > -1 && (end[i] - start[i] > max))
        {
            max = end[i] - start[i];
            savei = i;
        }

    }
    if(savei >= 0)
    {
        printf("The largest span is from %d to %d\n", start[savei]+(savei != n), end[savei]);
    //when sum zero is having the largest span, span starts from first element itself.
    //Else, the span starts from the next element from which the span does not change
    }
    else
    {
        printf("No span\n");
    }
}
```

8 votes -- Arjun Suresh (294k points)

1.1.5 Algorithm Design: TIFR2011-B-29 top

http://gateoverflow.in/20576

Selected Answer

I think its Tower of Hanoi problem.
Therefore Total number of function call 2^n-1 = 1023 option B

7 votes -- Umang Raman (15.2k points)

1.2 Algorithm Design Techniques(4) top

1.2.1 Algorithm Design Techniques: GATE1997-1.5 top

http://gateoverflow.in/2221

The correct matching for the following pairs is

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

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

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

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

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

gate1997 algorithms normal algorithm-design-techniques

Answer

1.2.2 Algorithm Design Techniques: GATE2015-1-6 top

http://gateoverflow.in/8088

Match the following:

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

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

gate2015-1 algorithms normal algorithm-design-techniques

Answer

1.2.3 Algorithm Design Techniques: GATE2015-2-36 top

http://gateoverflow.in/8161

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

1. Dijkstra's Shortest Path	i. Divide and Conquer

2. Floyd-Warshall algorithm to compute all pairs shortest path	ii. Dynamic Programming
3. Binary search on a sorted array	iii. Greedy design
4. Backtracking search on a graph	iv. Depth-first search
	v. Breadth-first search

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

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

gate2015-2 algorithms easy algorithm-design-techniques

Answer

1.2.4 Algorithm Design Techniques: GATE2017-1-05 top http://gateoverflow.in/118707

Consider the following table:

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

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

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

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

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

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

gate2017-1 algorithms algorithm-design-techniques

Answer

Answers: Algorithm Design Techniques

1.2.1 Algorithm Design Techniques: GATE1997-1.5 top http://gateoverflow.in/2221

Selected Answer

answer B

10 votes -- ankitrokdeonsns (9.1k points)

1.2.2 Algorithm Design Techniques: GATE2015-1-6 top http://gateoverflow.in/8088

Selected Answer

option c is correct ..

12 votes -- Anoop Sonkar (4.9k points)

1.2.3 Algorithm Design Techniques: GATE2015-2-36 top http://gateoverflow.in/8161

Selected Answer

Answer: C

14 votes -- Rajarshi Sarkar (35k points)

1.2.4 Algorithm Design Techniques: GATE2017-1-05 top http://gateoverflow.in/118707

Selected Answer

in KRUSKAL in every iteration, an edge of the MOST MINIMUM WEIGHT (GREEDIEST) possible is selected and added to MST construction. Hence, GREEDY.

in QUICKSORT we partition the problem in to subproblems, solve them and the combine. Hence it is DIVIDE and CONQUER

Floyd-Warshal uses Dynamic programming.

Hence correct answer is

OPTION (C)

9 votes -- sriv_shubham (2.7k points)

1.3 Asymptotic Notations(21) top

1.3.1 Asymptotic Notations: GATE1994-1.23 top http://gateoverflow.in/2466

Consider the following two functions:

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

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

Which of the following is true?

A. $g_1(n)$ is $O(g_2(n))$

B. $g_1(n)$ is $O(n^3)$

C. $g_2(n)$ is $O(g_1(n))$

D. $g_2(n)$ is $O(n)$

gate1994 algorithms asymptotic-notations normal

Answer

1.3.2 Asymptotic Notations: GATE1996-1.11 top http://gateoverflow.in/2715

Which of the following is false?

A. $100n \log n = (\frac{n \log n}{100})$

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

1.3.3 Asymptotic Notations: GATE1999-2.21 top

http://gateoverflow.in/1498

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

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

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

gate1999 algorithms recurrence asymptotic-notations normal

Answer

1.3.4 Asymptotic Notations: GATE2000-2.17 top

http://gateoverflow.in/664

Consider the following functions

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

Which of the following is true?

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

gate2000 algorithms asymptotic-notations normal

Answer

1.3.5 Asymptotic Notations: GATE2001-1.16 top

http://gateoverflow.in/709

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

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

gate2001 algorithms asymptotic-notations time-complexity normal

Answer

1.3.6 Asymptotic Notations: GATE2003-20 top

http://gateoverflow.in/910

Consider the following three claims

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

Which of the following claims are correct

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

gate2003 algorithms asymptotic-notations normal

Answer

1.3.7 Asymptotic Notations: GATE2004-29 top http://gateoverflow.in/1026

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

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

gate2004 algorithms sorting asymptotic-notations easy

Answer

1.3.8 Asymptotic Notations: GATE2004-IT-55 top http://gateoverflow.in/3698

Let f(n), g(n) and h(n) be functions defined for positive inter such that
f(n) = O(g(n)), g(n) ≠ 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) ≠ O(f(n))
D. f(n)h(n) ≠ O(g(n)h(n))

gate2004-it algorithms asymptotic-notations normal

Answer

1.3.9 Asymptotic Notations: GATE2005-37 top http://gateoverflow.in/1373

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

Which one of the following is FALSE?

A. $T(n) = O(n^2)$

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

C. $T(n) = \Omega(n^2)$

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

gate2005 algorithms asymptotic-notations recurrence normal

Answer

1.3.10 Asymptotic Notations: GATE2008-39 top http://gateoverflow.in/450

Consider the following functions:

$f(n) = 2^n$

$g(n) = n!$

$h(n) = n^{\log n}$

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

A. $f\left(n\right)=O\left(g\left(n\right)\right); g\left(n\right)=O\left(h\left(n\right)\right)$

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

C. $g(n) = O(f(n)); h(n) = O(f(n))$

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

gate2008 algorithms asymptotic-notations normal

Answer

1.3.11 Asymptotic Notations: GATE2008-IT-10 top http://gateoverflow.in/3270

Arrange the following functions in increasing asymptotic order:

a. $n^{1/3}$
b. e^n
c. $n^{7/4}$
d. $n \log^9 n$
e. 1.0000001^n

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

gate2008-it algorithms asymptotic-notations normal

Answer

1.3.12 Asymptotic Notations: GATE2011-37 top http://gateoverflow.in/2139

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

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

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

gate2011 algorithms asymptotic-notations normal

Answer

1.3.13 Asymptotic Notations: GATE2012-18 top http://gateoverflow.in/50

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

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

gate2012 algorithms easy asymptotic-notations

Answer

1.3.14 Asymptotic Notations: GATE2015-3-4 top http://gateoverflow.in/8398

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

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

The equality above remains correct if X is replaced by

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

gate2015-3 algorithms asymptotic-notations normal

Answer

1.3.15 Asymptotic Notations: GATE2015-3-42 top http://gateoverflow.in/8501

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

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

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

gate2015-3 algorithms asymptotic-notations normal

Answer

1.3.16 Asymptotic Notations: GATE2017-1-04 top http://gateoverflow.in/118703

Consider the following functions from positive integers to real numbers:

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

The CORRECT arrangement of the above functions in increasing order of asymptotic complexity is:

(A) $\log_2 n, \frac{100}{n}, 10, \sqrt{n}, n$

(B) $\frac{100}{n}, 10, \log_2 n, \sqrt{n}, n$

(C) $10, \frac{100}{n}, \sqrt{n}, \log_2 n, n$

(D) $\frac{100}{n}, \log_2 n, 10, \sqrt{n}, n$

gate2017-1 algorithms asymptotic-notations normal

Answer

1.3.17 Asymptotic Notations: TIFR2011-B-27 top http://gateoverflow.in/20573

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

A. $n^{1/\sqrt{\log_2 n}} < \sqrt{\log_2 n} < n^{1/100}$

B. $n^{1/100} < n^{1/\sqrt{\log_2 n}} < \sqrt{\log_2 n}$

C. $n^{1/\sqrt{\log_2 n}} < n^{1/100} < \sqrt{\log_2 n}$

D. $\sqrt{\log_2 n} < n^{1/\sqrt{\log_2 n}} < n^{1/100}$

E. $\sqrt{\log_2 n} < n^{1/100} < n^{1/\sqrt{\log_2 n}}$

tifr2011 asymptotic-notations

Answer

1.3.18 Asymptotic Notations: TIFR2012-B-6 top http://gateoverflow.in/25106

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

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

tifr2012 algorithms asymptotic-notations

Answer

1.3.19 Asymptotic Notations: TIFR2014-B-8 top http://gateoverflow.in/27192

Which of these functions grows fastest with n?

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

tifr2014 algorithms asymptotic-notations

Answer

1.3.20 Asymptotic Notations: TIFR2016-B-7 top http://gateoverflow.in/30720

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

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

tifr2016 asymptotic-notations

Answer

1.3.21 Asymptotic Notations: TIFR2017-A-4 top http://gateoverflow.in/94943

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

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

tifr2017 algorithms asymptotic-notations

Answer

Answers: Asymptotic Notations

1.3.1 Asymptotic Notations: GATE1994-1.23 top

http://gateoverflow.in/2466

Selected Answer

For asymptotic complexity, we assume sufficiently large n. So, $g_1(n) = n^2$ and $g_2(n) = n^3$. Growth rate of g_1 is less than that of g_2. i.e., $g_1(n) = O(g_2(n))$.

Options A and B are true here.

17 votes -- Arjun Suresh (294k points)

1.3.2 Asymptotic Notations: GATE1996-1.11 top

http://gateoverflow.in/2715

Selected Answer

- $100n \log n = (\frac{n \log n}{100})$ **:** cant do comment about it not given properly in paper.
- $\sqrt{\log n} = O(\log \log n)$ **:** false take any long value like 256 LHS results 16 But RHS resuts 4 only . gerenraly we take log left side but that is wrong.
- $0 < x < y \text{ then } n^x = O(n^y)$ **:** true since y is always greater than x so RHS is always greater than LHS.
- $2^n \neq O(nk)$ **:** true since k is constant .so for large value of n LHS is very higher than RHS (exponential function always greater than linear)

Only B is false

12 votes -- Prashant Singh (49.2k points)

1.3.3 Asymptotic Notations: GATE1999-2.21 top

http://gateoverflow.in/1498

Selected Answer

(M) $T(n)$ = Sum of first n natural numbers = $\frac{n(n+1)}{2} = O(n^2)$

(N) $T(n) = \Theta(n) = O(n)$, third case of Master theorem

($f(n) = n = \Omega\left(n^{\log_b a + \epsilon}\right) = \Omega\left(n^{\log_2 1 + \epsilon}\right) = \Omega\left(n^{0+\epsilon}\right)$, satisfied for any positive $\epsilon \leq 1$. Also, $af\left(\frac{n}{b}\right) < cf(n) \implies f\left(\frac{n}{2}\right) < cf(n) \implies \frac{n}{2} < cn$, satisfied for any c between 0 and 0.5)

(O) $T(n) = \Theta(n \log n) = O(n \log n)$, third case of Master theorem

($f(n) = n \log n = \Omega\left(n^{\log_b a + \epsilon}\right) = \Omega\left(n^{\log_2 1 + \epsilon}\right) = \Omega\left(n^{0.5+\epsilon}\right)$, satisfied for positive $\epsilon = 0.5$. Also, $af\left(\frac{n}{b}\right) < cf(n) \implies f\left(\frac{n}{2}\right) < cf(n) \implies \frac{n}{2} \log \frac{n}{2} < cn \log n$, satisfied for $c = 0.5$)

(P) Like in (M), here we are adding the log of the first n natural numbers. So,

$T_n = \log 1 + \log 2 + \log 3 + \dots + \log n$

$= \log(1 \times 2 \times \dots \times n)$

$= \log(n!)$

$= \Theta(n \log n)$ (Stirling's Approximation)

14 votes -- Arjun Suresh (294k points)

1.3.4 Asymptotic Notations: GATE2000-2.17 top

http://gateoverflow.in/664

Selected Answer

	$n = 256$	$n = 65536$
$f(n) = 3n^{\sqrt{n}}$	3×256^{16} $= 3 \times 2^{128}$	3×65536^{256} $= 3 \times 2^{16 \times 256}$ $= 3 \times 2^{4096}$
$g(n) = 2^{\sqrt{n}\log_2 n}$	$2^{16 \times 8}$ $= 2^{128}$	$2^{256 \times 16}$ $= 2^{4096}$
$h(n) = n!$	$256!$ $= O\left(\left(2^8\right)^{256}\right)$ $= O\left(2^{2048}\right)$	$65536!$ $= O\left(\left(2^{16}\right)^{65536}\right)$ $= O\left(2^{1M}\right)$

Case of h(n) is given only by an upper bound but factorial has higher growth rate than exponential.

http://math.stackexchange.com/questions/351815/do-factorials-really-grow-faster-than-exponential-functions

f(n) and g(n) are having same order of growth as f(n) is simply 3 g(n) (we can prove this by taking log also). So, (d) is correct and all other choices are false.

24 votes -- Arjun Suresh (294k points)

1.3.5 Asymptotic Notations: GATE2001-1.16 top http://gateoverflow.in/709

Selected Answer

	f(n)	g(n)
n = 2^{10}	$10 * 2^{10} * 2^{10}$	$2^{10} * 10^{10}$
n = 2^{256}	$256 * 2^{256} * 2^{256}$	$2^{256} * 256^{10}$

So, as n is going larger, f(n) is overtaking g(n) and the growth rate of f is faster than that of g. So, g(n) = O(f(n)) and f(n) ≠ O(g(n)).

B choice.

24 votes -- Arjun Suresh (294k points)

1.3.6 Asymptotic Notations: GATE2003-20 top http://gateoverflow.in/910

Selected Answer

1) Clearly rate of growth of $(n+k)^m = n^m$ as k and m are constants

so TRUE

2) $2^{n+1} = 2 * (2^n) = \Theta\left(2^n\right)$ as 2 is a constant here

As 2^{n+1} is both upper and lower bounded by 2^n we can say $2^{n+1} = O\left(2^n\right)$

so TRUE

3) 2^{2n+1} has same rate of growth as 2^{2n}

$2^{2n} = 2^{n2}$

2^n is upper bounded by $(2^n)^2$, not the other way round so FALSE

17 votes -- Danish (3.6k points)

1.3.7 Asymptotic Notations: GATE2004-29 top http://gateoverflow.in/1026

Selected Answer

For comparison-based sorting the asymptotically tight bound for worst case is given by $\Theta(n \log n)$, which means it is the tightest upper bound (big O) as well as the tightest lower bound (big omega). So, answer is $n \log n$.

Tightest lower bound of sorting (say S(n)) is $n \log n$ means there is no function f which has an order of growth larger than $n \log n$ and $f(n) = \Omega(S(n))$ holds.

A usual mistake is to think worst case changes with lower and upper bounds, but that is not the case. Worst case is defined for the algorithm and it is always the input which causes the algorithm the maximum complexity.

20 votes -- Arjun Suresh (294k points)

1.3.8 Asymptotic Notations: GATE2004-IT-55 top http://gateoverflow.in/3698

Answer is (D)

We can verify as : f<=g BUT g!<=f . Therefore **f<g**

Also **g=h** as g=O(h) and h=O(g)

8 votes -- Sandeep_Uniyal (7.3k points)

1.3.9 Asymptotic Notations: GATE2005-37 top http://gateoverflow.in/1373

Selected Answer

Applying Masters theorem T(n) = ⊖(n log n) So, it can't be $\Omega(n^2)$

Hence answer is C.

14 votes -- shreya ghosh (3.4k points)

1.3.10 Asymptotic Notations: GATE2008-39 top http://gateoverflow.in/450

Selected Answer

$g(n) = n!$ on expanding factorial we get $g(n) = \mathcal{O}(n^n)$:

$$n^n > n^{\log n}$$
$$n^n > 2^n$$

this condition is violated by option A, B and C by first statements of each Hence, they cannot be said true.

second statement of option D says that $g(n)$ is asymptotically biggest of all.

answer = **option D**

7 votes -- Amar Vashishth (28.7k points)

1.3.11 Asymptotic Notations: GATE2008-IT-10 top http://gateoverflow.in/3270

Selected Answer

A < C and A < D

E < B

and

C, D < E as E is exponential function.

Now, we just need to see if C or D is larger.

In C we have a term $n^{3/4}$ and correspondingly in D we have $\log^9 n$ (after taking n out).

$n^{3/4}$ is asymptotically larger than $\log^9 n$ as when $n = 10^{100}, \log^9 n$ gives 100^9, while $n^{3/4}$ gives $10^{75} > 100^{37}$ a much higher value and this is true for all higher values of n. So, D < C.

Thus A is correct.

19 votes -- Arjun Suresh (294k points)

1.3.12 Asymptotic Notations: GATE2011-37 top

http://gateoverflow.in/2139

Selected Answer

[EDIT]

answer A

$n\log_2 n < n^{3/2}$ is quite straightforward

also $n^{3/2} < n^{\log_2 n}$ and $n^{3/2} < 2^n$

now only $n^{\log_2 n}$ and 2^n need to be compared

taking log of both $(\log_2 n)^2$ and n

$n > (\log_2 n)^2$

hence $2^n > n^{\log_2 n}$

16 votes -- ankitrokdeonsns (9.1k points)

1.3.13 Asymptotic Notations: GATE2012-18 top

http://gateoverflow.in/50

Selected Answer

Worst case complexity can never be lower than the average case complexity, but it can be higher. So, (C) is the answer.

$$A(n) = O(W(n))$$

16 votes -- Arjun Suresh (294k points)

1.3.14 Asymptotic Notations: GATE2015-3-4 top

http://gateoverflow.in/8398

Selected Answer

Sum of the cubes of the first n natural numbers is given by $(n(n+1)/2)^2$ which is □(n^4). So, I, III and IV are correct. II is wrong. C choice.

24 votes -- Arjun Suresh (294k points)

1.3.15 Asymptotic Notations: GATE2015-3-42 top

http://gateoverflow.in/8501

Selected Answer

The answer is option D.

Since the value of sin(n) will always range from -1 to +1, hence g(n) can take values 1, n, n^2.

Hence, if g(n) = 1, Statement I is incorrect.

And, if g(n) = n^2, then Statement II is incorrect.

24 votes -- saurabhrk (1.5k points)

1.3.16 Asymptotic Notations: GATE2017-1-04 top

http://gateoverflow.in/118703

Selected Answer

10 - constant. Growth rate is 0.

$\sqrt{n}$ - grows slower than linear but faster than $\log$. (Consider $\frac{\sqrt{n^2}}{\sqrt{n}} = \sqrt{n}$, where as $\frac{\log(n^2)}{\log n} = 2$.

n - growth rate is linear.

$\log_2 n$ - growth rate is logarithmic, for asymptotic growth the base does not matter,

$\frac{100}{n}$ - growth rate decreases with n.

So, correct answer is B.

PS: Please never substitute large values of n in such questions. If ever you do, at least do for 2 such values and take ratio to get the growth rate or plot a graph. Remember $1.01^n \neq O\left(n^{100}\right)$

3 votes -- Arjun Suresh (294k points)

1.3.17 Asymptotic Notations: TIFR2011-B-27 top

http://gateoverflow.in/20573

Selected Answer

Let $n = 2^x$. Then, $\log_2 n = x$

$$\begin{array}{rclcl} f(n) & = & n^{1/\sqrt{\log_2 n}} & = & \left(2^x\right)^{1/\sqrt{x}} = 2^{x/\sqrt{x}} & = & 2^{\sqrt{x}} \\ g(n) & = & \sqrt{\log_2 n} & = & \sqrt{\log_2\left(2^x\right)} & = & \sqrt{x} \\ h(n) & = & n^{1/100} & = & \left(2^x\right)^{1/100} & = & 2^{x/100} \end{array}$$

Since exponentials grow faster than polynomials, $h(n) > g(n)$ for large n.

Since linear functions grow faster than square roots, $\frac{x}{100} > \sqrt{x}$ for large x. Thus, $h(n) > f(n)$ for large n.

Since exponentials grow faster than polynomials, $2^{\sqrt{x}} > \sqrt{x}$ for large $\sqrt{x}$. Thus, $f(n) > g(n)$ for large n.

Hence, the relation is,

$g(n) < f(n) < h(n)$

Thus, option D is correct.

11 votes -- Pragy Agarwal (19.5k points)

1.3.18 Asymptotic Notations: TIFR2012-B-6 top

http://gateoverflow.in/25106

Selected Answer

Ans will be C

Take $n = 2^{1024}$

Now, $2^{\sqrt{(2\log n)}} \approx 2^{45}$

$n^{\frac{1}{3}} \approx 2^{341}$

$n/\log n = 2^{1024}/1024 \approx 2^{1014}$

Just one value is not enough to confirm growth rate. So, take $n = 1024$.

Now, $2^{\sqrt{(2\log n)}} \approx 2^{4}$

$n^{\frac{1}{3}} \approx 2^{3}$

$n/\log n = 2^{10}/10 \approx 2^{7}$

So, as n increases the gap between second and third function increases and also the second function overtakes the first. So, $f1 < f2 < f3$.

8 votes -- srestha (58.4k points)

1.3.19 Asymptotic Notations: TIFR2014-B-8 top

http://gateoverflow.in/27192

Selected Answer

Assuming that the base of the $\log$ in the question is e.

Let us try to rewrite each of these functions in the form $e^{\text{something}}$, to make the comparison easier.

$$\begin{array}{l|llll}
a. & e^n \;/\; n & = \dfrac{e^n}{e^{(\ln n)}} & & = e^{(n - \ln n)} \\
b. & e^{n - 0.9\ln n} & & & = e^{(n - 0.9\ln n)} \\
c. & 2^n & = \left(e^{\ln 2}\right)^n & & = e^{(n\ln 2)} \\
d. & (\ln n)^{n-1} & = \left(e^{\ln\ln n}\right)^{n-1} & & = e^{(n\ln\ln n - \ln\ln n)}
\end{array}$$

Now, if we just compare the exponents of all, we can clearly see that $(n\ln\ln n - \ln\ln n)$ grows faster than the rest. Note that in option c. the multiplicative $\ln 2$ is a constant, and hence grows slower than the multiplicative $\ln\ln n$ from option d.

This implies that $e^{(n\ln\ln n - \ln\ln n)}$ grows the fastest, and hence, $(\ln n)^{n-1}$ grows the fastest.

Thus, option d. is the correct answer.

12 votes -- Pragy Agarwal (19.5k points)

1.3.20 Asymptotic Notations: TIFR2016-B-7 top

http://gateoverflow.in/30720

m	n=m!	log n/log log n

m	n = m!	log n/log log n
4	24	4/2 = 2
6	720	9/3 = 3
8	720*56	15/3 = 5
10	720*56*90	21/4 = 5

If we see, m is growing at same rate as log n/log log n.

3 votes -- Arjun Suresh (294k points)

1.3.21 Asymptotic Notations: TIFR2017-A-4 top http://gateoverflow.in/94943

Selected Answer

Let $N = 2^{256}$

- $(\log \log N)! = 8!$
- $(\log \log N)^{\log N} = (8)^{256} = 2^{768}$
- $(\log \log N)^{\log \log \log N} = 8^3 = 512$
- $(\log N)^{\log \log N} = (256)^8 = 2^{64}$
- $2^{\sqrt{\log \log N}} = 2^{2\sqrt{2}}$

Let $N = 2^{16}$

- $(\log \log N)! = 4!$
- $(\log \log N)^{\log N} = (4)^{16} = 2^{32}$
- $(\log \log N)^{\log \log \log N} = 4^2 = 16$
- $(\log N)^{\log \log N} = (16)^4 = 2^{16}$
- $2^{\sqrt{\log \log N}} = 2^2 = 4$

Taking ratio for both N values,

- $(\log \log N)! \to 8!/4!$
- $(\log \log N)^{\log N} \to 2^{736}$
- $(\log \log N)^{\log \log \log N} \to 32$
- $(\log N)^{\log \log N} \to 2^{48}$
- $2^{\sqrt{\log \log N}} \to \approx 2$

Option B = $(\log \log N)^{\log N}$ asymptotically grows the fastest as N goes to infinity as for the same change in N, the value increased the most (growth) for option B.

11 votes -- Kapil Phulwani (47.9k points)

1.4 Bst(1) top

1.4.1 Bst: GATE2011_29 top http://gateoverflow.in/2131

We are given a set of n distinct elements and an unlabeled binary tree with n nodes. In how many ways can we populate the tree with the given set so that it becomes a binary search tree?

A. 0
B. 1
C. $n!$
D. $\frac{1}{n+1}.^{2n} C_n$

gate2011 bst normal

Answer

Answers: Bst

1.4.1 Bst: GATE2011_29 top

http://gateoverflow.in/2131

Selected Answer

Given binary tree is unlabeled . So as it is given we are not allowed to change the formation of tree. Then To make it BST we can use atmost 1 way . As for particular structure we can not use n! arrangement of nodes (Becasue they are labeled and it is BST not BT)

20 votes -- Palash Nandi (1.5k points)

With n nodes there are 2nCn/(n+1) distinct tree structures possible.

Corresponding to each structure only 1 binary search tree can be formed because inorder is fixed.

Here we are already given one such structure therefore only 1 tree possible.

If Binary trees would be asked n! possible corresponding to each distinct tree structure.

13 votes -- Anurag Semwal (8k points)

1.5 Dynamic Programming(11) top

1.5.1 Dynamic Programming: GATE 2016-2-14 top

http://gateoverflow.in/39570

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

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

gate2016-2 algorithms dynamic-programming easy

Answer

1.5.2 Dynamic Programming: GATE 2016-2-38 top

http://gateoverflow.in/39587

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

gate2016-2 dynamic-programming normal numerical-answers

Answer

1.5.3 Dynamic Programming: GATE2008-80 top

http://gateoverflow.in/498

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

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

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

gate2008 algorithms normal dynamic-programming

Answer

1.5.4 Dynamic Programming: GATE2008-81 top

http://gateoverflow.in/43484

The subset-sum problem is defined as follows. Given a set of n positive integers, $S = \{a_1, a_2, a_3, \dots, a_n\}$, 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 $\{a_1, a_2, \dots, a_i\}$ whose elements sum to j.

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

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

gate2008 algorithms normal dynamic-programming

Answer

1.5.5 Dynamic Programming: GATE2009-53 top

http://gateoverflow.in/1338

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

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

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

Which one of the following options is correct?

A. $\text{expr1} = l(i - 1, j) + 1$

B. $\text{expr1} = l(i, j - 1)$

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

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

gate2009 algorithms normal dynamic-programming recursion

Answer

1.5.6 Dynamic Programming: GATE2009-54 top

http://gateoverflow.in/43476

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

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

$l(i, j) = 0$, if either i = 0 or j = 0
= expr1, if i,j > 0 and X[i-1] = Y[j-1]
= expr2, if i,j > 0 and X[i-1] ≠ Y[j-1]
The value of $l(i, j)$ could be obtained by dynamic programming based on the correct recursive definition of $l(i, j)$ of the form given above, using an array $L[M, N]$, where $M = m + 1$ and $N = n + 1$, such that $L[i, j] = l(i, j)$.

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

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

gate2009 normal algorithms dynamic-programming recursion

Answer

1.5.7 Dynamic Programming: GATE2010-34 top http://gateoverflow.in/2208

The weight of a sequence $a_0, a_1, \dots, a_{n-1}$ of real numbers is defined as $a_0 + a_1/2 + \dots + a_{n-1}/2^{n-1}$. 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 $a_o, a_1, \dots, a_{n-1}$ and Y the maximum possible weight of a subsequence of $a_1, a_2, \dots, a_{n-1}$. Then X is equal to

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

gate2010 algorithms dynamic-programming normal

Answer

1.5.8 Dynamic Programming: GATE2011-25 top http://gateoverflow.in/2127

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

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

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

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

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

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

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

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

gate2011 algorithms easy dynamic-programming

Answer

1.5.9 Dynamic Programming: GATE2011_38 top http://gateoverflow.in/2140

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

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

(A) 248000

(B) 44000

(C) 19000

(D) 25000

gate2011 algorithms dynamic-programming normal

Answer

1.5.10 Dynamic Programming: GATE2014-2-37 top http://gateoverflow.in/1996

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

gate2014-2 algorithms normal numerical-answers dynamic-programming

Answer

1.5.11 Dynamic Programming: GATE2014-3-37 top http://gateoverflow.in/2071

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

gate2014-3 algorithms normal numerical-answers dynamic-programming

Answer

Answers: Dynamic Programming

1.5.1 Dynamic Programming: GATE 2016-2-14 top http://gateoverflow.in/39570

Selected Answer

In floyd warshalls we calcuate all possibilities and select best one so its neither dac nor greedy but based on Dynamic Programming Paradigm.

16 votes -- Anurag Semwal (8k points)

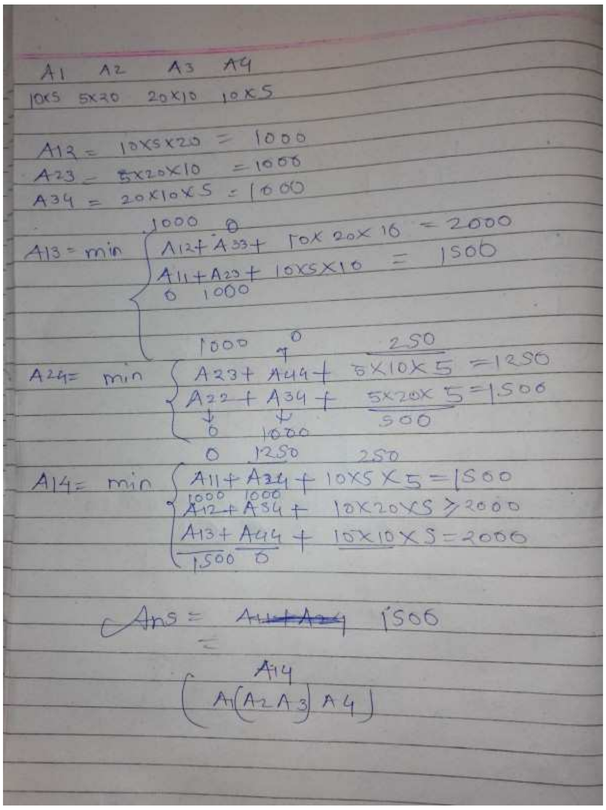
1.5.2 Dynamic Programming: GATE 2016-2-38 top http://gateoverflow.in/39587

Selected Answer

Answer is 1500 !

Matrix Paranthesizing => A1 ((A2 A3) A4)

Check my solution below, using dynamic programming (There was little mistake while writing in parantheses in this image, ignore it Check paranthesis above) =>



👍 16 votes -- Akash (43.8k points)

1.5.3 Dynamic Programming: GATE2008-80 top

http://gateoverflow.in/498

I think answers are

80. (B)

$X[i][j] = X[i-1][j] \cup X[i-1][j-a_i]$

We calculate the value of $X[i][j]$ as if we include the value

a_i in the subset $X[i-1][j-a_i]$ or we do not include the value in the subset$X[i-1][j]$.

81. (C)

```
// Returns true if there is a subset of set[] with sun equal to given sum
bool isSubsetSum(int set[], int n, int sum)
{
    // The value of subset[i][j] will be true if there is a subset of set[0..j-1]
    //  with sum equal to i
    bool subset[sum+1][n+1];

    // If sum is 0, then answer is true
    for (int i = 0; i <= n; i++)
      subset[0][i] = true;

    // If sum is not 0 and set is empty, then answer is false
    for (int i = 1; i <= sum; i++)
      subset[i][0] = false;

     // Fill the subset table in botton up manner
     for (int i = 1; i <= sum; i++)
     {
       for (int j = 1; j <= n; j++)
       {
         subset[i][j] = subset[i][j-1];
         if (i >= set[j-1])
           subset[i][j] = subset[i][j] || subset[i - set[j-1]][j-1];
       }
     }

    /* // uncomment this code to print table
```

```
    for (int i = 0; i <= sum; i++)
    {
      for (int j = 0; j <= n; j++)
         printf ("%4d", subset[i][j]);
      printf("\n");
    } */

    return subset[sum][n];
}
```

5 votes -- Sona Praneeth Akula (4k points)

1.5.4 Dynamic Programming: GATE2008-81 top

http://gateoverflow.in/43484

Selected Answer

ANS) C ,If LAST ROW and LAST COLUMN entry is 1, then there exists subset whose elements sum to W

5 votes -- Shivam Bhardwaj (241 points)

1.5.5 Dynamic Programming: GATE2009-53 top

http://gateoverflow.in/1338

Selected Answer

Answer is **C.** When the currently compared elements doesn't match, we have two possibilities for the LCS, one including X[i] but not Y[j] and other including Y[j] but not X[i].

16 votes -- Akash (43.8k points)

Answer is **C.** When the currently compared elements doesn't match, we have two possibilities for the LCS, one including X[i] but not Y[j] and other including Y[j] but not X[i].

```
/* Returns length of LCS for X[0..m-1], Y[0..n-1] */
int lcs( char *X, char *Y, int m, int n )
{
   if (m == 0 || n == 0)
     return 0;
   if (X[m-1] == Y[n-1])
     return 1 + lcs(X, Y, m-1, n-1);
   else
     return max(lcs(X, Y, m, n-1), lcs(X, Y, m-1, n));
}
```

13 votes -- Sona Praneeth Akula (4k points)

1.5.6 Dynamic Programming: GATE2009-54 top

http://gateoverflow.in/43476

Selected Answer

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

When the currently compared elements doesn't match, we have two possibilities for the LCS, one including X[i] but not Y[j] and other including Y[j] but not X[i].

```
/* Returns length of LCS for X[0..m-1], Y[0..n-1] */
int lcs( char *X, char *Y, int m, int n )
{
   if (m == 0 || n == 0)
     return 0;
   if (X[m-1] == Y[n-1])
     return 1 + lcs(X, Y, m-1, n-1);
   else
     return max(lcs(X, Y, m, n-1), lcs(X, Y, m-1, n));
}
```

54. Answer is **B.** Dynamic programming is used to save the previously found LCS. So, for any index [p,q] all smaller ones

should have been computed earlier. Option D is not correct as the condition given requires even L[3,2] to be computed before L[2,4] which is not a necessity if we follow row-major order.

```
int lcs( char *X, char *Y, int m, int n )
{
   int L[m+1][n+1];
   int i, j;

   /* Following steps build L[m+1][n+1] in bottom up fashion. Note
      that L[i][j] contains length of LCS of X[0..i-1] and Y[0..j-1] */
   for (i=0; i<=m; i++)
   {
     for (j=0; j<=n; j++)
     {
       if (i == 0 || j == 0)
         L[i][j] = 0;

       else if (X[i-1] == Y[j-1])
         L[i][j] = L[i-1][j-1] + 1;

       else
         L[i][j] = max(L[i-1][j], L[i][j-1]);
     }
   }

   /* L[m][n] contains length of LCS for X[0..n-1] and Y[0..m-1] */
   return L[m][n];
}
```

15 votes -- Arjun Suresh (294k points)

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

When the currently compared elements doesn't match, we have two possibilities for the LCS, one including X[i] but not Y[j] and other including Y[j] but not X[i].

Answer is **B.** We can either use Row Major or column major order.

Issue of option D -> Read option D carefully.

L[p,q] needs to be computed before L[r,s] if either p < q or r < s

Assuming that we want to compute L(3,3). We need not compute L(4,2) if we are using Row Major Order ! Here L(4,2) = L[p,q] & L(3,3) = L[r,s]. Then q<s still we need not compute it ! so **D IS FALSE**

12 votes -- Akash (43.8k points)

1.5.7 Dynamic Programming: GATE2010-34 top

http://gateoverflow.in/2208

Selected Answer

$$\begin{aligned} S &= \langle a_0, S_1 \rangle \\ S_1 &= \langle a_1, a_2, a_3 \ldots a_{n-1} \rangle \end{aligned}$$

Two possible cases arise:

1. a_0 **is included in the max weight subsequence of** S**:**

   In this case, $X = \text{weight}\Big(\big(\langle a_0, S_1 \rangle\big)\Big) = a_0 + \dfrac{Y}{2}$

2. a_0 **is not included in the max weight subsequence of** S**:**

   In this case, $X = \text{weight}(S_1) = Y$

Since the value of a_0 can be anything (negative or $< \frac{Y}{2}$ in general) $\{\because a_i \in \mathbb{R}\}$, it is possible that $Y > a_0 + \frac{Y}{2}$.

The maximum possible weight of a subsequence of S is given by:

$$X = \max\left(Y, a_0 + \frac{Y}{2}\right)$$

Thus, option B is correct.

34 votes -- Pragy Agarwal (19.5k points)

1.5.8 Dynamic Programming: GATE2011-25 top

http://gateoverflow.in/2127

Selected Answer

(A) is the answer.

The algorithm is storing the optimal solutions to subproblems at each point (for each i), and then using it to derive the optimal solution of a bigger problem. And that is dynamic programming approach. And the program has linear time complexity.

http://stackoverflow.com/questions/1065433/what-is-dynamic-programming

Now, branch and bound comes when we explore all possible solutions (branch) and backtracks as soon as we find we won't get a solution (in classical backtracking we will retreat only when we won't find the solution). So, backtracking gives all possible solutions while branch and bound will give only the optimal one. http://www.cs.cornell.edu/~wdtseng/icpc/notes/bt2.pdf

The given algorithm here is neither backtracking nor branch and bound. Because we are not branching anywhere in the solution space.

And the algorithm is not divide and conquer as we are not dividing the problem and then merging the solution as in the case of merge sort (where merge is the conquer step).

https://en.wikipedia.org/wiki/Divide_and_conquer_algorithms

27 votes -- Arjun Suresh (294k points)

1.5.9 Dynamic Programming: GATE2011_38 top

http://gateoverflow.in/2140

Selected Answer

Answer is **C.**

$$\begin{array}{l}\text{Ordering: First Multiply } M_2 \times M_3. \text{ This requires 100*20*5 multiplications.}\\ \text{Then Multiply } M_1 \times (M_2 \times M_3). \text{ This requires 10*100*5 multiplications.}\\ \text{Then Multiply } (M_1 \times (M_2 \times M_3)) \times M_4. \text{ This requires 10*5*8 multiplications.} \quad \text{Total 19000 Multiplications.}\end{array}$$

Brute Force approach - anyone can do.

No. of possible ordering for 4 matrices is C_3 where C_3 is the 3^{rd} Catalan number and given by $n = 3$ in $\frac{1}{n+1}{}^{2n}C_n = 5$.

So, here we have

1. $(M_1 \times M_2) \times (M_3 \times M_4)$
2. $(M_1 \times (M_2 \times M_3)) \times M_4$
3. $((M_1 \times M_2) \times M_3) \times M_4$
4. $M_1 \times (M_2 \times (M_3 \times M_4))$
5. $M_1 \times ((M_2 \times M_3) \times M_4))$

Each of these would give no. of multiplications required as

1. $pqr + rst + prt$
2. $qrs + pqs + pst$
3. $pqr + prs + pst$
4. $rst + qrt + pqt$
5. $qrs + qst + pst$

The last 2 are having qt terms which are the highest terms by far and hence we can avoid them from consideration $qt = 8000$ multiplied by one other term would be larger than any value in choice. So, just find the value of first 3 terms.

1. $pqr + rst + prt = 20000 + 8000 + 16000 = 44000$
2. $qrs + pqs + pst = 10000 + 5000 + 4000 = 19000$ - smallest value in choice, we can stop here.
3. $pqr + prs + pst$

Dynamic Programming Solution (should know Matrix Chain Ordering algorithm)

Here we have a chain of length 4.

Dynamic programming solution of Matrix chain ordering has the solution

$$m[i,j] = \begin{cases} 0 & \text{if } i = j \\ \min_{i \leq k < j} m[i]k] + m[k+1][j] + p_{i-1} p_j p_k & \text{if } i < j \end{cases}$$

So, we can fill the following table starting with the diagonals and moving upward diagonally. Here $k < j$ but $\geq i$.

	j=1	j=2	j=3	j=4
i=1	0	$p_0 p_1 p_2 = 20000$	$\min(10000 + p_0 p_1 p_3, 20000 + p_0 + p_2 p_3) = 15000$	$\min(18000 + p_0 p_1 p_4, 20000 + 8000 + p_0 + p_2 + p_4, 15000 + p_0 p_3 p_4) = 19000$
i=2		0	$p_1 p_2 p_3 = 10000$	$\min(10000 + p_2 p_3 p_4), p_1 p_3 p_4) = 18000$
i=3			0	$p_2 p_3 p_4 = 8000$
i=4				0

Our required answer is given by $m[1,4] = 19000$.

14 votes -- Sona Praneeth Akula (4k points)

1.5.10 Dynamic Programming: GATE2014-2-37 top

http://gateoverflow.in/1996

Selected Answer

34

qprr

Pqrr

qpqr

In first string

If we want to get 4 as max len den lcs should end with either rr or qr

Only 4combinations possible for lcs with len 4

qpqr

qqrr

pqrr

qprr

Now check for matching sequences in second string, except for qqrr all possible

9 votes -- Anurag Semwal (8k points)

1.5.11 Dynamic Programming: GATE2014-3-37 top http://gateoverflow.in/2071

Selected Answer

T(9) = Distance from 9 to 100
T(9)=1+ min(T(y),T(z))=1+min(Distance from y to 100 , Distance from z to 100)

There are only two such values where we can reach from 9 , one is simple step to right on number line , i.e 10 and another is 15 (given shortcut)

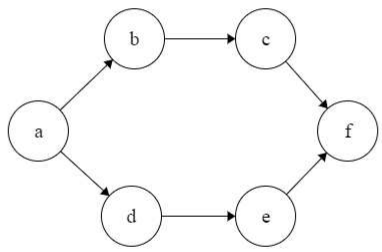
Hence , y=10 , z=15
yz=10x15 = 150

19 votes -- Srinath Jayachandran (3.7k points)

1.6 Graph Algorithms(48) top

1.6.1 Graph Algorithms: GATE 2016-1-11 top http://gateoverflow.in/39669

Consider the following directed graph:



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

gate2016-1 algorithms graph-algorithms normal numerical-answers

Answer

1.6.2 Graph Algorithms: GATE 2016-2-11 top http://gateoverflow.in/39563

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

gate2016-2 algorithms graph-algorithms normal numerical-answers

Answer

1.6.3 Graph Algorithms: GATE1994-1.22 top http://gateoverflow.in/2465

Which of the following statements is false?

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

gate1994 algorithms normal graph-algorithms

Answer

1.6.4 Graph Algorithms: GATE1994_24 top

http://gateoverflow.in/2520

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

```
V: Set of all vertices in the tree;
I := ϕ
while V ≠ ϕ do
begin
    select a vertex u ∈ V such that
    _______;
    V := V - {u};
    if u is such that
    ________then I := I ∪ {u}
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

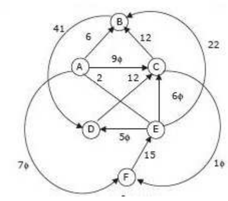
gate1994 algorithms graph-algorithms normal

Answer

1.6.5 Graph Algorithms: GATE1996_17 top

http://gateoverflow.in/2769

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



We are interested in the shortest paths from A.

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

gate1996 algorithms graph-algorithms normal

Answer

1.6.6 Graph Algorithms: GATE1998-1.21, ISRO2008-16 top

http://gateoverflow.in/1658

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

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

gate1998 algorithms graph-algorithms easy isro2008

Answer

1.6.7 Graph Algorithms: GATE2000-1.13 top

http://gateoverflow.in/636

The most appropriate matching for the following pairs

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

is:

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

gate2000 algorithms easy graph-algorithms

Answer

1.6.8 Graph Algorithms: GATE2001-2.14 top http://gateoverflow.in/732

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

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

gate2001 algorithms graph-algorithms normal

Answer

1.6.9 Graph Algorithms: GATE2002-12 top http://gateoverflow.in/865

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

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

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

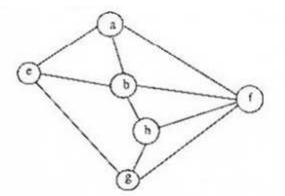
a. Copy the complete line containing the blanks in the Initialization step and fill in the blanks.
b. Copy the complete line containing the blanks in the Algorithm step and fill in the blanks.
c. Fill in the blank: The running time of the Algorithm is O(___).

gate2002 algorithms graph-algorithms time-complexity normal descriptive

Answer

1.6.10 Graph Algorithms: GATE2003-21 top http://gateoverflow.in/911

Consider the following graph



Among the following sequences

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

which are depth first traversals of the above graph?

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

gate2003 algorithms graph-algorithms normal

Answer

1.6.11 Graph Algorithms: GATE2003-67 top

http://gateoverflow.in/954

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

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

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

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

gate2003 algorithms graph-algorithms normal

Answer

1.6.12 Graph Algorithms: GATE2003-70 top

http://gateoverflow.in/957

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

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

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

Consider the following algorithm.

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

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

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

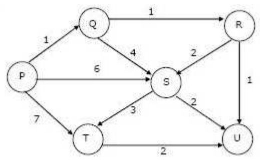
gate2003 algorithms graph-algorithms normal

Answer

1.6.13 Graph Algorithms: GATE2004-44 top

http://gateoverflow.in/1041

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



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

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

gate2004 algorithms graph-algorithms normal

Answer

1.6.14 Graph Algorithms: GATE2004-81 top

http://gateoverflow.in/1075

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

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

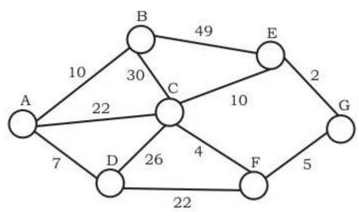
gate2004 algorithms graph-algorithms normal

Answer

1.6.15 Graph Algorithms: GATE2004-IT-56 top

http://gateoverflow.in/3699

Consider the undirected graph below:



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

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

gate2004-it algorithms graph-algorithms normal

Answer

1.6.16 Graph Algorithms: GATE2005-38 top

http://gateoverflow.in/1374

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

A. $O\left(|V|^2\right)$

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

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

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

gate2005 algorithms graph-algorithms normal

Answer

1.6.17 Graph Algorithms: GATE2005-82a top http://gateoverflow.in/1404

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

The edge e must definitely belong to:

A. the minimum weighted spanning tree of G

B. the weighted shortest path from s to t

C. each path from s to t

D. the weighted longest path from s to t

gate2005 algorithms graph-algorithms normal

Answer

1.6.18 Graph Algorithms: GATE2005-82b top http://gateoverflow.in/82129

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

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

A. a path from s to t in the minimum weighted spanning tree

B. a weighted shortest path from s to t

C. an Euler walk from s to t

D. a Hamiltonian path from s to t

gate2005 algorithms graph-algorithms normal

Answer

1.6.19 Graph Algorithms: GATE2005-IT-14 top http://gateoverflow.in/3759

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

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

gate2005-it algorithms graph-algorithms normal

Answer

1.6.20 Graph Algorithms: GATE2005-IT-15 top http://gateoverflow.in/3760

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

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

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

gate2005-it algorithms graph-algorithms normal

Answer

1.6.21 Graph Algorithms: GATE2005-IT-84a top

http://gateoverflow.in/3856

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

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

Choose the correct expressions for E_1 and E_2

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

gate2005-it algorithms graph-algorithms normal

Answer

1.6.22 Graph Algorithms: GATE2005-IT-84b top

http://gateoverflow.in/3857

A sink in a directed graph is a vertex i such that there is an edge from every vertex j ≠ 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 E3

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

gate2005-it algorithms graph-algorithms normal

Answer

1.6.23 Graph Algorithms: GATE2006-12 top http://gateoverflow.in/891

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

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

gate2006 algorithms graph-algorithms easy

Answer

1.6.24 Graph Algorithms: GATE2006-48 top http://gateoverflow.in/1824

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

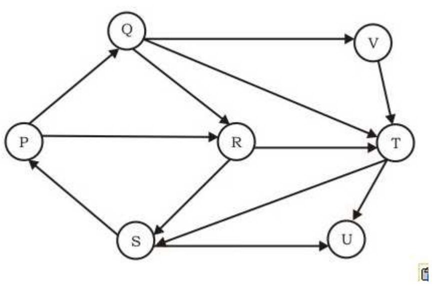
A. There must exist a vertex w adjacent to both u and v in G
B. There must exist a vertex w whose removal disconnects u and v in G
C. There must exist a cycle in G containing u and v
D. There must exist a cycle in G containing u and all its neighbours in G

gate2006 algorithms graph-algorithms normal

Answer

1.6.25 Graph Algorithms: GATE2006-IT-46 top http://gateoverflow.in/3589

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



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

gate2006-it algorithms graph-algorithms normal

Answer

1.6.26 Graph Algorithms: GATE2006-IT-47 top http://gateoverflow.in/3590

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

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

Which one of the following statements is TRUE about the graph

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

gate2006-it algorithms graph-algorithms normal

Answer

1.6.27 Graph Algorithms: GATE2007-41 top http://gateoverflow.in/1239

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

A. Dijkstra's algorithm starting from S.

B. Warshall's algorithm.

C. Performing a DFS starting from S.

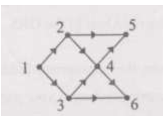
D. Performing a BFS starting from S.

gate2007 algorithms graph-algorithms easy

Answer

1.6.28 Graph Algorithms: GATE2007-5 top http://gateoverflow.in/31821

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



Which of the following is not a topological ordering?

A. 1 2 3 4 5 6
B. 1 3 2 4 5 6
C. 1 3 2 4 6 5
D. 3 2 4 1 6 5

gate2007 algorithms graph-algorithms

Answer

1.6.29 Graph Algorithms: GATE2007-IT-24 top http://gateoverflow.in/3457

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

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

gate2007-it algorithms graph-algorithms normal

Answer

1.6.30 Graph Algorithms: GATE2007-IT-3, UGCNET-June2012-III-34 top http://gateoverflow.in/3434

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

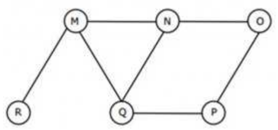
A. Weight $(u, v) \leq 12$
B. Weight $(u, v) = 12$
C. Weight $(u, v) \geq 12$
D. Weight $(u, v) > 12$

gate2007-it algorithms graph-algorithms normal ugcnetjune2012iii

Answer

1.6.31 Graph Algorithms: GATE2008-19 top http://gateoverflow.in/417

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

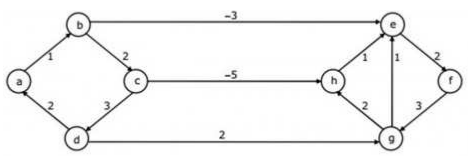


A. MNOPQR
B. NQMPOR
C. QMNPRO
D. QMNPOR

gate2008 normal algorithms graph-algorithms

Answer

1.6.32 Graph Algorithms: GATE2008-45 top http://gateoverflow.in/457



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

A. only vertex a

B. only vertices a, e, f, g, h

C. only vertices a, b, c, d

D. all the vertices

gate2008 algorithms graph-algorithms normal

Answer

1.6.33 Graph Algorithms: GATE2008-7 top http://gateoverflow.in/405

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

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

gate2008 algorithms graph-algorithms time-complexity normal

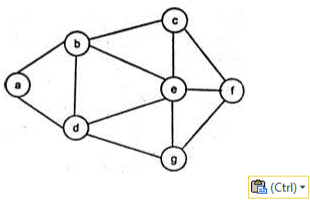
Answer

1.6.34 Graph Algorithms: GATE2008-IT-47 top http://gateoverflow.in/3357

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

1. a b e f d g c
2. a b e f c g d
3. a d g e b c f
4. a d b c g e f

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



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

gate2008-it algorithms graph-algorithms normal

Answer

1.6.35 Graph Algorithms: GATE2009-13 top http://gateoverflow.in/1305

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

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

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

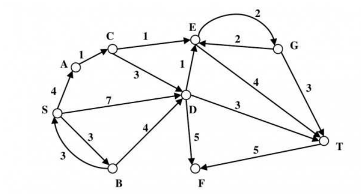
A. P only
B. Q only
C. Both P and Q
D. Neither P nor Q

gate2009 algorithms graph-algorithms normal

Answer

1.6.36 Graph Algorithms: GATE2012_40 top http://gateoverflow.in/1765

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



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

gate2012 algorithms graph-algorithms normal

Answer

1.6.37 Graph Algorithms: GATE2013_19 top http://gateoverflow.in/1441

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

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

gate2013 algorithms graph-algorithms normal

Answer

1.6.38 Graph Algorithms: GATE2014-1-11 top http://gateoverflow.in/1771

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

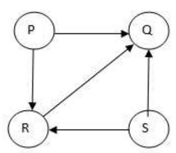
A. $\Theta(n)$
B. $\Theta(n+m)$
C. $\Theta(n^2)$
D. $\Theta(m^2)$

gate2014-1 algorithms graph-algorithms normal

Answer

1.6.39 Graph Algorithms: GATE2014-1-13 top http://gateoverflow.in/1779

Consider the directed graph below given.



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

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

gate2014-1 graph-algorithms easy

Answer

1.6.40 Graph Algorithms: GATE2014-2-14 top http://gateoverflow.in/1969

Consider the tree arcs of a BFS traversal from a source node W in an unweighted, connected, undirected graph. The tree T

formed by the tree arcs is a data structure for computing

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

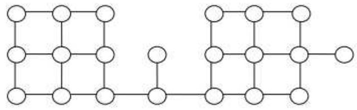
gate2014-2 algorithms graph-algorithms normal

Answer

1.6.41 Graph Algorithms: GATE2014-3-13 top

http://gateoverflow.in/2047

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



gate2014-3 algorithms graph-algorithms numerical-answers normal

Answer

1.6.42 Graph Algorithms: GATE2015-1_45 top

http://gateoverflow.in/8321

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

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

gate2015-1 algorithms graph-algorithms normal

Answer

1.6.43 Graph Algorithms: GATE2016-2-41 top

http://gateoverflow.in/39620

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

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

gate2016-2 algorithms graph-algorithms normal

Answer

1.6.44 Graph Algorithms: GATE2017-1-26 top

http://gateoverflow.in/118306

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

(I) Minimum Spanning Tree of G is always unique.

(II) Shortest path between any two vertices of G is always unique.

Which of the above statements is/are necessarily true?

(A) (I) only

(B) (II) only

(C) both (I) and (II)

(D) neither (I) nor (II)

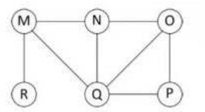
gate2017-1 algorithms graph-algorithms normal

Answer

1.6.45 Graph Algorithms: GATE2017-2-15 top

http://gateoverflow.in/118196

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



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

gate2017-2 algorithms graph-algorithms

Answer

1.6.46 Graph Algorithms: Gate2000-2.19 top

http://gateoverflow.in/4208

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

A. {u, v} must be an edge in G, and u is a descendant of v in T
B. {u, v} must be an edge in G, and v is a descendant of u in T
C. If {u, v} is not an edge in G then u is a leaf in T
D. If {u, v} is not an edge in G then u and v must have the same parent in T

gate2000 algorithms graph-algorithms normal

Answer

1.6.47 Graph Algorithms: TIFR2013-B-5 top

http://gateoverflow.in/25666

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

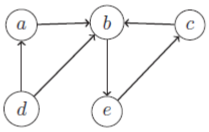
A. $O(n)$
B. $O(n.\log(n))$ but not $O(n)$
C. $O(n^{1.5})$ but not $O(n\log n)$
D. $O(n^3)$ but not $O(n^{1.5})$
E. $O(2^n)$ but not $O(n^3)$

tifr2013 algorithms graph-algorithms

Answer

1.6.48 Graph Algorithms: TIFR2014-B-3 top http://gateoverflow.in/27137

Consider the following directed graph.



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

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

tifr2014 algorithms graph-algorithms

Answer

Answers: Graph Algorithms

1.6.1 Graph Algorithms: GATE 2016-1-11 top http://gateoverflow.in/39669

Selected Answer

Here Start with a and End with f.

a _ _ _ _ f

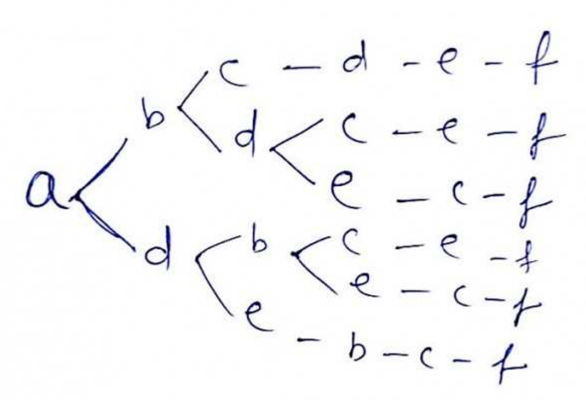
Blanks spaces are to be filled with b, c, d, e such that b comes before c, and d comes before e..
Number of ways to arrange b,c,d,e such that b comes before c and d comes before e. will be = 4!/(2!*2!) = 6

35 votes -- Abhilash Panicker (8.8k points)

In topological sorting all nodes are like tasks and edges show the dependency among the tasks.

Node i to j an edge is there means task i must complete before task j.(in the mean time some other task may get complete after task i and before task j..but task i and j sequence need to be maintained)

Here in following 6 ways all the 6 tasks can get completed.



Best link to understand topological sorting:-https://m.youtube.com/watch?v=0iyjVWLIFr0

11 votes -- Rajesh Pradhan (18.6k points)

1.6.2 Graph Algorithms: GATE 2016-2-11 top http://gateoverflow.in/39563

Selected Answer

No of nodes at level 0(root) of tree =>1

No of nodes at level 1 of tree =>2

No of nodes at level 2 of tree =>4

No of nodes at level 3 of tree =>8

No of nodes at level 4 of tree =>16

Last node in level 4th is the node we are looking for => 1+2+4+8+16 => 31

13 votes -- Akash (43.8k points)

1.6.3 Graph Algorithms: GATE1994-1.22 top http://gateoverflow.in/2465

Answer: B

(a) True.
(b) False.
(c) True.
(d) True.

7 votes -- Rajarshi Sarkar (35k points)

1.6.4 Graph Algorithms: GATE1994_24 top http://gateoverflow.in/2520

(a) While adding vertex u to I it should not have an edge with any node in I.

(b) The algorithm runs till V is empty (in O(n) time) and is checking u with each vertex v in set I (in O(n) time). So, overall complexity $O(n^2)$.

6 votes -- Rajarshi Sarkar (35k points)

1.6.5 Graph Algorithms: GATE1996_17 top http://gateoverflow.in/2769

Part a: A B D C F E

Part b: A B D C F E

Part c : 84

6 votes -- Himanshu Agarwal (16.2k points)

1.6.6 Graph Algorithms: GATE1998-1.21, ISRO2008-16 top http://gateoverflow.in/1658

Selected Answer

Answer is A because floyd warshall algorithm used to find all shortest path which is a dynamic programming approach.

10 votes -- shashi shekhar (515 points)

1.6.7 Graph Algorithms: GATE2000-1.13 top http://gateoverflow.in/636

Selected Answer

X - 3 DFS uses stack implicitly
Y-2 BFS uses queue explicitly in Algo
Z-1 Heap-Heapsort

Answer C

9 votes -- Akash (43.8k points)

1.6.8 Graph Algorithms: GATE2001-2.14 top

http://gateoverflow.in/732

Selected Answer

Ans :->

C.

BFS is used to count shortest path from source (If all path costs are 1 !)

now if u is visited before v it means 2 things.

1. Either u is closer to v.

2. if u & v are same distance from r, then our BFS algo chose to visit u before v.

11 votes -- Akash (43.8k points)

1.6.9 Graph Algorithms: GATE2002-12 top

http://gateoverflow.in/865

Selected Answer

```
INITIALIZATION: For i = 1 ... n
    {For j = 1 ... n
        { if a[i,j] = 0 then P[i,j] =infinite  // i.e. if there is no direct path then put infinite
          else P[i,j] =a[i,j];
         }
    }
ALGORITHM:
For i = 1 ... n
    {For j = 1 ... n
        {For k = 1 ... n
            {
               P[i, j] = min( p[i,j] , p[i,k] + p[k,j])
            };
        }
    }
```

time complexity 0(n^3)

this algorithm is 4 weighted graph but it will work 4 unweighted graph 2 because if p[i,j]=1, p[i,k]=1 and p[k,j]=1 then according to the algo p[i,j] = min(p[i,j] ,p[i,k] + p[k,j]) =min(1,2) =1

And all the other case is also satisfied.(like as if p[i,j] was 0 in last iteration nd there exist a path via k)

6 votes -- Saurav Kumar Gupta (2.1k points)

1.6.10 Graph Algorithms: GATE2003-21 top

http://gateoverflow.in/911

Selected Answer

For GATE purpose, without actually Applying DFS, you could answer by just seeing options.

In DFS, we go in depth first i.e., one node to another in depth first order.

Here, abfehg is not possible as we can not go from f to e directly.

Thus, option D is correct.

In all the other options we could reach directly from the node to the next node.

So, just visualize and do.

6 votes -- Monanshi Jain (8.5k points)

1.6.11 Graph Algorithms: GATE2003-67 top

http://gateoverflow.in/954

Selected Answer

After applying the shortest path algorithm, check cost of vertex from source to every vertex in G_1. If G_1 is connected all these costs must be 0 as edge weights of subgraph G_1 is 0 and that should be the shortest path. If cost is not 0, to at least one vertex in G_1 (not necessarily G), then G_1 is disconnected.

Ans is b

21 votes -- Anurag Semwal (8k points)

1.6.12 Graph Algorithms: GATE2003-70 top

http://gateoverflow.in/957

Selected Answer

D is correct.

Consider a graph with 2 nodes and one edge from to V_1 and V_2,

Running the above algorithm will result in A being

A	**1**	**2**
1	1	2
2	1	2

Clearly options B and C are wrong. Since

1. A[1][1] and A[2][2] > n-1 and there exists no Hamiltonian cycle. Hence invalid
2. The longest path between V_1 and V_2 is 1, but A[1][2] is 2, which is invalid. And no path between V_2 and V_1 yet A[2][1] = 1 // **it should be max cost path between j and k not path length.**

Hence A or D could be valid.

Now consider a graph with 2 nodes and two edges, one from V_1 and V_2 and other form V_2 and V_1. Running the above algorithm will result in A being

A	**1**	**2**
1	2	3
2	3	4

Hence option A is invalid, as A[i][j] can be >n

D is correct

15 votes -- ryan sequeira (3k points)

1.6.13 Graph Algorithms: GATE2004-44 top

http://gateoverflow.in/1041

Selected Answer

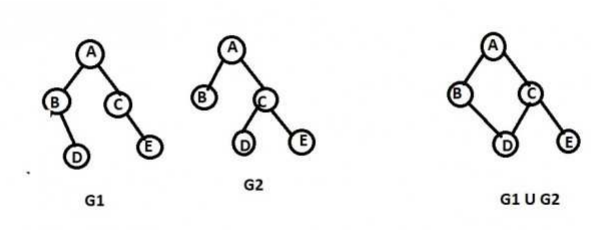
Ans is (B). In Dijkstra's algorithm at each point we choose the smallest weight edge which starts from any one of the vertices in the shortest path found so far and add it to the shortest path.

👍 11 votes -- gate_asp (755 points)

1.6.14 Graph Algorithms: GATE2004-81 top http://gateoverflow.in/1075

Selected Answer

Take a tree for example



(A) False. Every vertex of tree(other than leaves) is a cut vertex

(B)True

(C)False. Without E in G1 and G2, G1 U G2 has no bridge.

(D)False. G1 U G2, G1, G2 three graphs have same chromatic number of 2.

👍 16 votes -- srestha (58.4k points)

1.6.15 Graph Algorithms: GATE2004-IT-56 top http://gateoverflow.in/3699

Selected Answer

Answer is (D)

(A) and (B) produce disconnected components with the GIVEN order in options which is NEVER allowed by prims's algorithm.

(C) produces connected component every instant a new edge is added BUT when first vertex is chosen(first vertex is chosen randomly) first edge must be the minimum weight edge that is chosen . Therefore (A,D) MUST be chosen BEFORE (A,B). Therefore (C) is FALSE

👍 10 votes -- Sandeep_Uniyal (7.3k points)

1.6.16 Graph Algorithms: GATE2005-38 top http://gateoverflow.in/1374

Selected Answer

D.- Binary heap. |E| decrease key operations and each taking O(log |V|) time plus |V| extract-min operations each taking O(log |V|).

B- Fibonacci heap. |E| decrease key operations and each taking O(1) time plus |V| extract-min operations each taking O(log |V|).

A- Array. Finding min-vertex in each iteration takes O(V) and this needs to be done |V| times.

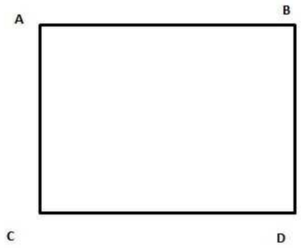
Binomial Heap- same as Binary heap here as the critical operations are decrease key and extract-min.

👍 20 votes -- Gate Keeda (19.1k points)

1.6.17 Graph Algorithms: GATE2005-82a top http://gateoverflow.in/1404

Selected Answer

For 82a The answer should be Option A because edge 'e' is the lightest safe edge connecting X and Y so the minimum spanning tree of G must contain 'e' (Greedy and optimal choice).
While B might seem correct but it is not always true. One such case is when G is not connected therefore there might not be any path between 's' and 't'.
Since the question is about definitely true B is incorrect and A is the only correct optio



Lets say AC =1 CD = 2 BD = 3 and AB=4

Then if s= A and t= B then AC is the lightest edge crossing X and Y where X = { A } and Y = { C, B, D}
But clearly AC is not on the shortest path from A to B. The shortest path is AB = 4.

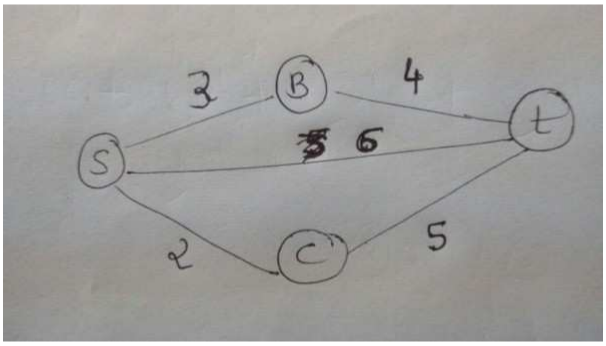
7 votes -- chandan1223 (207 points)

1.6.18 Graph Algorithms: GATE2005-82b top

http://gateoverflow.in/82129

Selected Answer

Here ans should be A.



Here shortest path will give 6 .

Spanning tree contains edges of weights 2,3,4 so congestion in this case is max(2,3,4) thai is 4. for path s to t overall congestion is max(3,4) =4 but total weight is 7.

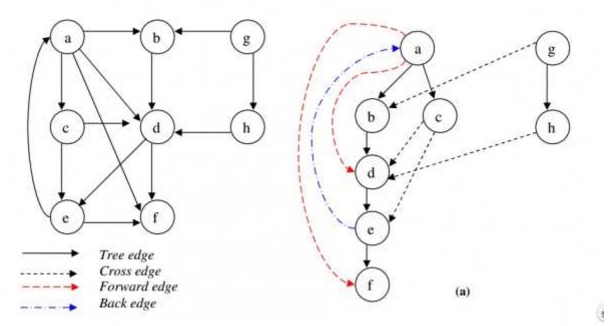
option C and D are i think not related to this quetion.

6 votes -- papesh (24.1k points)

1.6.19 Graph Algorithms: GATE2005-IT-14 top

http://gateoverflow.in/3759

Selected Answer



Tree edges are those edges which appear in the final DFS forest. For example in case of connected graph (i.e. resulting dfs forest containg only one tree), if we run DFS over it, edges belonging to the resulting DFS tree are called tree edges.

Let us assume the graph has x number of connected (or strongly connected in case of a directed graph) components. And assume 1st component has K_1 tree edges, 2nd component has K_2 tree edges and xth component has K_x tree edges.

Such that $K_1 + K_2 + K_3 + \ldots\ldots + K_x = K$ (= total)

Or in other way we can imagine like, the final DFS forest has x trees and those trees are having K_1 , K_2 , K_3 , ... K_x edges respectively.

Now we know that a tree having K_x edges contains $K_x + 1$ nodes. Similarly a tree having K_1 edges contains $K_1 + 1$ nodes, etc. and so on.

So, Summation of nodes in each tree = n

$$(K_1+1)+(K_2+1)+(K_3+1)+\ldots\ldots\ldots\ldots\ldots+(K_x+1)=n \quad => (K_1+K_2+K_3+\ldots\ldots+K_x)+x=n \quad =>$$

18 votes -- Debashish Deka (51.4k points)

Answer D => n-k

Why ?

If Graph is connected , while doing DFS we will visit some spanning Tree of Graph. So no of edges will be n-1 &

No of components => n - (n-1) => 1

If Graph is not connected in that case when we do the DFS on those disconnected graph,

For every disconnected component with say x vertices, we will get x-1 Tree edge. When we sum up all vertices we will get total no of vertices. When we sum up all edges in spanning tree of each component, we will get => Total no of vertices - Total No of connected component (Due to for each connected component we are getting tree of no of vertices in that connnected component - 1)

So Total connected component => D) n-k

14 votes -- Akash (43.8k points)

1.6.20 Graph Algorithms: GATE2005-IT-15 top

http://gateoverflow.in/3760

Selected Answer

1. Bellman-Ford algorithm =>: O (nm) Assuming n as edges , m as vertices, for every vertex we relax all edges. m*n , O(mn)
2. Kruskal's algorithm => Remaining Option ,A : O (m log n)
3. Floyd-Warshall algorithm => Dynamic Programming Algo, O(N^3)
4. Topological sorting => Boils Down to DFS, O(V+E) D

Answer A)

10 votes -- Akash (43.8k points)

1.6.21 Graph Algorithms: GATE2005-IT-84a top http://gateoverflow.in/3856

Selected Answer

If there is a sink in the graph, the adjacency matrix will contain all 1's(except diagonal) in one column and all 0's (except diagonal) in the corresponding row of that vertex. The given algorithm is a smart way of doing this as it finds the sink in $O(n)$ time complexity.

The first part of the code, is finding if there is any vertex which doesn't have any outgoing edge to any vertex coming after it in adjacency matrix. The smart part of the code is E2, which makes rows skip when there is no edge from i to it, making it impossible them to form a sink. This is done through

E1: !A[i][j]
and
E2: i = j;

E1 makes sure that there is no edge from i to j and i is a potential sink till A[i][j] becomes 1. If A[i][j] becomes 1, i can no longer be a sink, similarly all previous j can also not be a sink (as there was no edge from i to them and a sink requires an edge from all other vertices). Now, the next potential candidate for sink is j. So, in E2, we must make i = j.

So, answer is (C)

For E3,
http://gateoverflow.in/3857/gate2005-it_84b

15 votes -- Arjun Suresh (294k points)

1.6.22 Graph Algorithms: GATE2005-IT-84b top http://gateoverflow.in/3857

Selected Answer

If there is a sink in the graph, the adjacency matrix will contain all 1s (except diagonal) in one column and all 0s (except diagonal) in the corresponding row of that vertex. The given algorithm is a smart way of doing this as it finds the sink in $O(n)$ time complexity.

The first part of the code, is finding if there is any vertex which does not have any outgoing edge to any vertex coming after it in adjacency matrix. The smart part of the code is E2, which makes rows skip when there is no edge from i to it, making it impossible them to form a sink. This is done through

E1: !A[i][j]
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E1 makes sure that there is no edge from i to j and i is a potential sink till A[i][j] becomes 1. If A[i][j] becomes 1, i can no longer be a sink, similarly all previous j can also not be a sink (as there was no edge from i to them and a sink requires an edge from all other vertices). Now, the next potential candidate for sink is j. So, in E2, we must make i = j.

Now, the loop breaks when we found a potential sink- that is a vertex which does not have any outgoing edge to any coming after it in adjacency matrix. So, if the column in which this vertex comes is all 1s and the row is all 0s (except diagonal), this is the sink. Otherwise there is no sink in the graph. So, E3 is checking this condition.

But in the code flag is used for storing the state that sink is present or not. And as per the usage of flag in code, by default sink is considered present. So, the condition in E3 must make flag = 0, if the found i is not a sink. So, the condition should be:

A[i][j] || !A[j][i]

So, (D) is the answer.

19 votes -- Arjun Suresh (294k points)

1.6.23 Graph Algorithms: GATE2006-12 top http://gateoverflow.in/891

Selected Answer

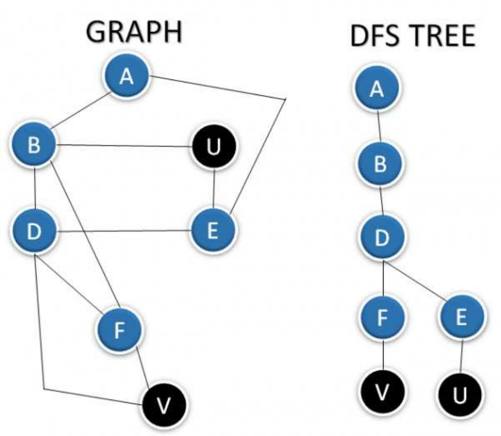
Answer is A) Queue

we can find single source shortest path in unweighted graph by using Breadth first search (BFS) algorithm which using "Queue" data structure , which time O(m+n) (i.e. linear with respect to the number of vertices and edges.)

26 votes -- Mithlesh Upadhyay (5.4k points)

1.6.24 Graph Algorithms: GATE2006-48 top http://gateoverflow.in/1824

Selected Answer



One diagram, which is eliminating option A, B, C.
Hence D is the answer.

4 votes -- Ahwan Mishra (5.3k points)

1.6.25 Graph Algorithms: GATE2006-IT-46 top http://gateoverflow.in/3589

Selected Answer

Here the answer is B.

A graph is said to be **strongly connected** if every vertex is reachable from every other vertex.

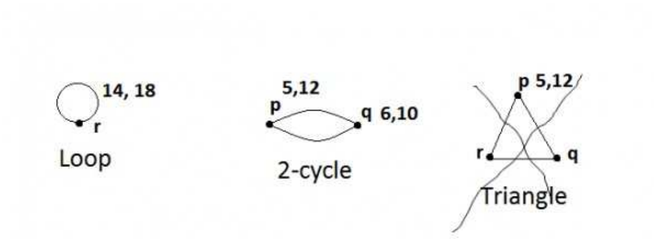
The strongly connected component is always maximal that is if x is strongly connected component there should not exist another strongly connected component which contains x.

If we take R as a strongly connected component but which is part of PQRS and PQRS is part of PQRSVT.

10 votes -- papesh (24.1k points)

1.6.26 Graph Algorithms: GATE2006-IT-47 top http://gateoverflow.in/3590

Selected Answer



As seen in quetion after 10 we have to go for p again and since p is finish and then r is start so r must be disconnected because if their is edges from q to r then r must be visited before of q and p ending.

D is answer

8 votes -- Prashant Singh (49.2k points)

1.6.27 Graph Algorithms: GATE2007-41 top http://gateoverflow.in/1239

Selected Answer

Dijkastra and warshall 's algo only used for weighted graph.

Both DFS and BFS can be used for finding path between 2 vertices in undirected and unweighted graph but BFS can only give the shortest path as concern in given question so BFS is Ans.

Note :- finding only path(DFS) and finding shortest path(BFS) ..Matters a lot

Must Read:-

https://www.quora.com/What-are-the-advantages-of-using-BFS-over-DFS-or-using-DFS-over-BFS-What-are-the-applications-and-downsides-of-each

2 votes -- Rajesh Pradhan (18.6k points)

1.6.28 Graph Algorithms: GATE2007-5 top http://gateoverflow.in/31821

Selected Answer

Go with Vertex with indegree 0 remove that vertex with all edges foing from it . Follow that procedure.

We See 3 cannot come at first B/c indegree is not 0. **so D is answer here .**

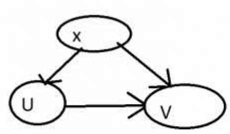
ALL other options are Topologocal order.

Only 1 and 4 order matter for this quetion.

5 votes -- Prashant Singh (49.2k points)

1.6.29 Graph Algorithms: GATE2007-IT-24 top http://gateoverflow.in/3457

Selected Answer



I'm gonna disprove all wrong options here.

A) d[u] < d[v] , Counter Example => Well if we directly start DFS on V first. Then I call DFS on X which visits U.

B) d[u] < f[v] Counter example => Same as A)

C) f[u] < f[v] Counter example => Same as A) again

So answer is D)

12 votes -- Akash (43.8k points)

1.6.30 Graph Algorithms: GATE2007-IT-3, UGCNET-June2012-III-34 top http://gateoverflow.in/3434

Selected Answer

C. weight(u,v) ≥ 12

If weight (u, v) < 12, then the min. weight of (s, v) = weight of (s, u) + weight of (u, v) = 53 + (<12) will be less than 65.

19 votes -- Arjun Suresh (294k points)

1.6.31 Graph Algorithms: GATE2008-19 top http://gateoverflow.in/417

Selected Answer

A) MNOPQR -> If you try to run BFS, after M, you must traverse NQR (In some order) Here P is traversed before Q, which is wrong.

B) NQMPOR -> This is also not BFS. P is traversed before O !

C) QMNPRO -> Correct

D) QMNPOR -> Incorrect. Because R need to be traversed before O.(Because M is ahead of N in queue.

Answer :- > C

5 votes -- Akash (43.8k points)

1.6.32 Graph Algorithms: GATE2008-45 top http://gateoverflow.in/457

Selected Answer

(d) all the vertices. Just simulate the Dijkstra's algorithm on it. Dijkstra's algorithm is not meant for graphs with negative-edge-weight-cycle, but here it does give the correct shortest path.

17 votes -- Arjun Suresh (294k points)

1.6.33 Graph Algorithms: GATE2008-7 top http://gateoverflow.in/405

Selected Answer

Run DFS to find connected components. Its time complexity is $\Theta(m+n)$, hence **(C)** is the answer.

12 votes -- Happy Mittal (10.9k points)

1.6.34 Graph Algorithms: GATE2008-IT-47 top http://gateoverflow.in/3357

Selected Answer

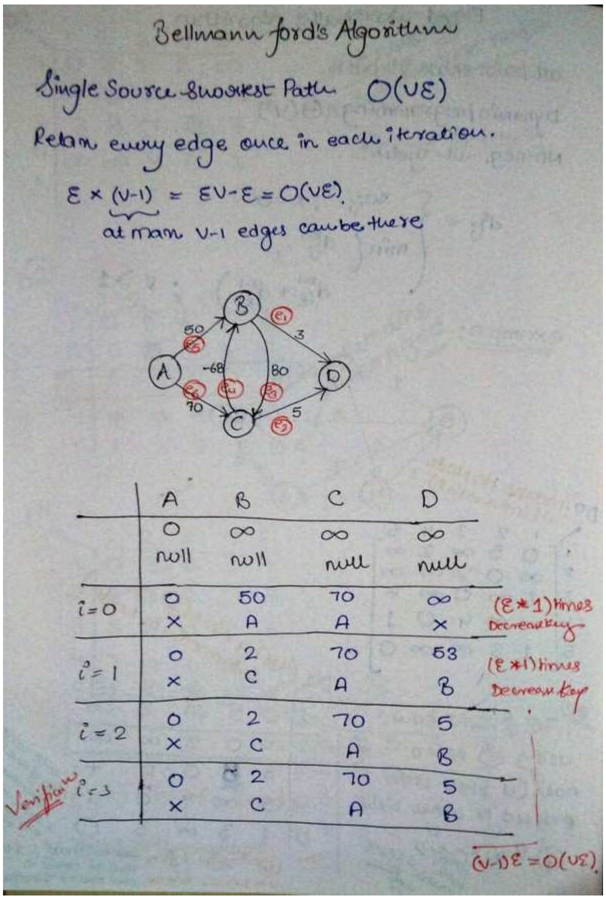
Answer: B

1. After f is visited, c or g should be visited next. So, the traversal is incorrect.
4. After c is visited, e or f should be visited next. So, the traversal is incorrect.
2 and 3 are correct.

7 votes -- Rajarshi Sarkar (35k points)

1.6.35 Graph Algorithms: GATE2009-13 top http://gateoverflow.in/1305

Selected Answer



as we can see that last step is the verification step. In that step values remained unchanged. If there was a negative edge weight cycle reachable from source then at verification step also those values will be different from the values above.

In case the cycle is not reachable from source then we can see that they will be at ∞ distance(or cost) from the source from the beginning till the last step. As take anything away from the ∞ it will still be infinite.

But it can also be the case that there are some points which are not forming a cycle and are still unreachable from source those also will be at ∞ distance from the source from the beginning till end.

Hence, we won't be able to make a distinction among the cycle and such vertices. Thus, we say that this algorithm can detect negative edge weight cycles only if they are reachable from the source.

answer = **option B**

13 votes -- Amar Vashishth (28.7k points)

1.6.36 Graph Algorithms: GATE2012_40 top http://gateoverflow.in/1765

Selected Answer

Relaxation at every vertex is as follows

Note the next vertex is taken out here is in RED colour

	A	B	C	D	E	F	G	T
S	4	3(by s)	∞	7	∞	∞	∞	∞
B	4(by s)		∞	7 ∵(4+3 also=7)(S->d	∞	∞	∞	∞
A			5(S->B->A)	7	∞	∞	∞	∞
C				7	6(S->B->C)	∞	∞	∞
E				7(S->D)		∞	8(S->A->C->E)	10(S->A->C->E)
D						12(S->B->D)	8	10(same so no change)
E						12		**10**
T						12		

Now We see for S to T its (S->A->C->E->.T)

which is Option
D

16 votes -- Kalpish Singhal (2.1k points)

1.6.37 Graph Algorithms: GATE2013_19 top http://gateoverflow.in/1441

Selected Answer

Time complexity of Bellman-Ford algorithm is $\Theta(|V||E|)$ where $|V|$ is number of vertices and $|E|$ is number of edges. If the graph is complete, the value of $|E|$ becomes $\Theta\left(|V|^2\right)$. So overall time complexity becomes $\Theta\left(|V|^3\right)$. And given here is n vertices. So answers ends up to $\Theta\left(n^3\right)$.

23 votes -- Gate Keeda (19.1k points)

1.6.38 Graph Algorithms: GATE2014-1-11 top http://gateoverflow.in/1771

Selected Answer

Ans (C)

http://web.eecs.utk.edu/~huangj/CS302S04/notes/graph-searching.html

12 votes -- Keith Kr (6.3k points)

1.6.39 Graph Algorithms: GATE2014-1-13 top http://gateoverflow.in/1779

Selected Answer

The C option has been copied wrongly
C) Both PSRQ and SPRQ are topological orderings
i)Apply DFS by choosing P or S as starting vertices
ii)As the vertex gets a finishing time assign it to the head of a linked list
iii)The linked list is your required topological ordering

13 votes -- Akshay Jindal (501 points)

choose vertex in the graph which has 0 indegree . now see graph has such two vertices ie P,S so we can start totpological sort either from vertex P or from Q .

lets first start from vertex P now remove this vertex from graph ,we left with three vertices named asQ,S,R from these vertices see which vertex has INDEGREE 0,S vertex HAS indegree 0 therefore sequence IS P,S,R,Q

repeat the above step from wuth vertex S we get sequence as S,P,R,Q

14 votes -- kunal (20.8k points)

1.6.40 Graph Algorithms: GATE2014-2-14 top

http://gateoverflow.in/1969

Selected Answer

BFS always having starting node. It does not calculate shortest path between every pair but it computes shorted path between W and any other vertex ..

14 votes -- Digvijay (47k points)

1.6.41 Graph Algorithms: GATE2014-3-13 top

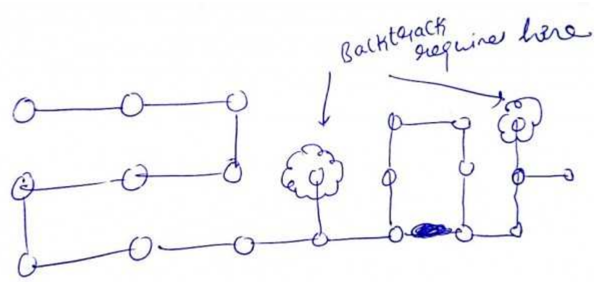
http://gateoverflow.in/2047

Selected Answer

Total 21 nodes are there out of 2 nodes require back track here in this question.

So max recursion depth is 21-2= 19

(Do dfs from extreme ends such that max recursion depth will occur i.e. take Left - top node as initial node for DFS as shown in below img.)



Note:- Backtrack means it reduces recursion depth in stack.

10 votes -- Rajesh Pradhan (18.6k points)

19. apply DFS.

11 votes -- Gate Keeda (19.1k points)

1.6.42 Graph Algorithms: GATE2015-1_45 top

http://gateoverflow.in/8321

Selected Answer

2 is the answer.

$d(u) - d(v) = 0$ is possible when both u and v have an edge from t and t is in the shortest path from s to u or v.

$d(u) - d(v) = 1$ is possible when v and t are in the shortest path from s to u and both t and v are siblings- same distance from s to both t and v causing $t - u$ edge to be in BFS tree and not $v - u$.

$d(u) - d(v) = -1$ is possible as explained above by interchanging u and v.

$d(u) - d(v) = 2$ is not possible. This is because on BFS traversal we either visit u first or v. Let's take u first. Now, we put all neighbors of u on queue. Since v is a neighbour and v is not visited before as assumed, $d(v)$ will become $d(u) + 1$. Similarly, for v being visited first.

18 votes -- Arjun Suresh (294k points)

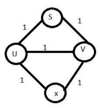
(B)Take distance from S

d(U) =1 from S

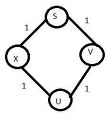
d(V)=1 from S

So, d(U) - d(V) =0 , d(X) is one shortest distance of the graph

and BFS traversal will not take edge UV



(C) Now for assuming d(U) and d(V) has a distance 1, we similarly calculate the distance from S(in next figure)



(A)In previous figure change the position of U and V, so get

d(U)-d(V) = -1

(D) but 2 not possible as there is a direct edge from U to V always, So, no graph possible with min distance 2. The max distance could be 1

So, ans is (D)

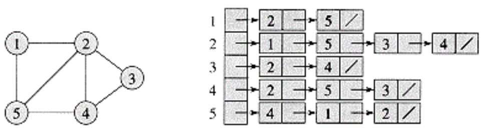
12 votes -- srestha (58.4k points)

1.6.43 Graph Algorithms: GATE2016-2-41 top

http://gateoverflow.in/39620

Selected Answer

Applying BFS on Undirected graph give you twin pointer .Visit every vertex level-wise for every vertex fill adjacent vertex in the adjacency list. BFS take 0(m+n) time.



(a) (b)

take extra field for storing no. of linked list for perticular vertex. take extra m+n time(m vertex and n edges).

So B is answer

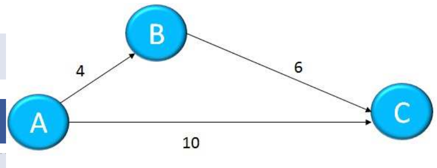
18 votes -- Prashant Singh (49.2k points)

1.6.44 Graph Algorithms: GATE2017-1-26 top

http://gateoverflow.in/118306

Selected Answer

Ans: **A**
> MST is not unique only when edges are not distinct. Here the edges are distinct. Be careful for the keyword DISTINCT.
> Shortest Path can be different even if the edges are distinct. Example is shown below. Shortest path from A to C is not unique here.



6 votes -- Ahwan Mishra (5.3k points)

1.6.45 Graph Algorithms: GATE2017-2-15 top http://gateoverflow.in/118196

Selected Answer

In BFS starting from a node, we traverse all node adjacent to it at first then repeat same for next nodes

Here you can see only D is following BFS sequence properly

As per BFS if we start from M then RQN has to come after it in any order but in A here O comes so it is not

As per BFS if we start from Nthen QMO has to come after it in any order but in A here P comes so it is not

As per BFS if we start from M then MNOP has to come after it in any order but in A here R comes so it is not

but D following the sequences

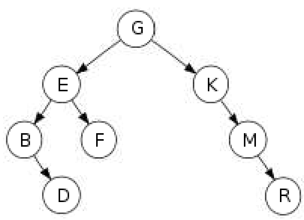
so **D** is correct answer

more editing coming soon

7 votes -- Aboveallplayer (18.5k points)

1.6.46 Graph Algorithms: Gate2000-2.19 top http://gateoverflow.in/4208

Selected Answer



let this be the dfs order of tree then

u= D and v = F

so what we conclude

1. its not necessary their is edge b/w them .

2. if thier is no edge then u must be leaf i.e. D is leaf here.

3. it not always possible u and v have same parent . but they have same ancestor .

17 votes -- Prashant Singh (49.2k points)

1.6.47 Graph Algorithms: TIFR2013-B-5 top http://gateoverflow.in/25666

I think arbitrary large weights means having positive weight cycle...so bellmanford algo can be used..O(VE)....changing sign of weights of edges....

3 votes -- papesh pathare (495 points)

1.6.48 Graph Algorithms: TIFR2014-B-3 top http://gateoverflow.in/27137

Selected Answer

Since they said that whenever their is a choice we will have to select the node which is alphabetically earlier , therefore we choose the starting node as A .

The tree then becomes A-B-E-C . Therefore no of tree edges is 3 that is (T=3) .

Now there is one cycle B-E-C so we will get a back edge from C to B while performing DFS. Hence B=1 .

Now D becomes disconnected node and it can only contribute in forming cross edge . There are 2 cross edges D-A , D-B . Therefore C=2 .

Answer is Option D .

Correct me if am going wrong.

13 votes -- Riya Roy(Arayana) (7.1k points)

1.7 Greedy Algorithm(8) top

1.7.1 Greedy Algorithm: CMI2015-B-04 top http://gateoverflow.in/47063

You are given n positive integers, $d_1, d_2 \dots d_n$, each greater than 0. Design a greedy algorithm to test whether these integers correspond to the degrees of some n-vertex simple undirected graph $G = (V, E)$. [A simple graph has no self-loops and at most one edge between any pair of vertices].

cmi2015 descriptive algorithms greedy-algorithm

Answer

1.7.2 Greedy Algorithm: GATE1999-2.20 top http://gateoverflow.in/466

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

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

gate1999 algorithms normal greedy-algorithm

Answer

1.7.3 Greedy Algorithm: GATE2003-69 top http://gateoverflow.in/956

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

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

gate2003 algorithms normal greedy-algorithm

Answer

1.7.4 Greedy Algorithm: GATE2005-84a top

http://gateoverflow.in/1406

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

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

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

A. All tasks are completed

B. T_1 and T_6 are left out

C. T_1 and T_8 are left out

D. T_4 and T_6 are left out

gate2005 algorithms greedy-algorithm process-schedule normal

Answer

1.7.5 Greedy Algorithm: GATE2005-84b top

http://gateoverflow.in/82514

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

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

What is the maximum profit earned?

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

gate2005 algorithms greedy-algorithm process-schedule normal

Answer

1.7.6 Greedy Algorithm: GATE2006-IT-48 top

http://gateoverflow.in/3591

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

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

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

110111100111010

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

gate2006-it algorithms greedy-algorithm normal

Answer

1.7.7 Greedy Algorithm: GATE2007-76 top

http://gateoverflow.in/1271

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

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

A. 0, 10, 110, 1110, 11110, 11111

B. 11, 10, 011, 010, 001, 000

C. 11, 10, 01, 001, 0001, 0000

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

gate2007 algorithms greedy-algorithm normal

Answer

1.7.8 Greedy Algorithm: GATE2007-77 top

http://gateoverflow.in/43513

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

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

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

gate2007 algorithms greedy-algorithm normal

Answer

Answers: Greedy Algorithm

1.7.1 Greedy Algorithm: CMI2015-B-04 top

http://gateoverflow.in/47063

1. Sort the degrees in non-increasing order.
2. Pick up the highest degree (let us say it a), remove it from the list of degrees and subtract 1 from next a degrees in list.
3. Repeat Step 2 until :

- **If we get all 0 entries in list $\Rightarrow$ Simple Graph exits**
- **If we get a negative entry or not enough entries to subtract 1 in step 2 $\Rightarrow$ Simple Graph does not exist**

Read More : http://goo.gl/4u3nfh

Let's take a example : $3, 2, 1, 2$

Step 1 : Sort the degree sequence : $3, 2, 2, 1$

Step 2: Pick 3, Remove 3 from list and from next 3 elements subtract 1, $Result : (1, 1, 0)$

Again repeat step 2 : select 1, Remove 1 and from next 1 subtract 1, $Result : (0, 0, 0)$

Thus, a simple graph exists for the following degree-sequence.

5 votes -- Manish Joshi (25.2k points)

1.7.2 Greedy Algorithm: GATE1999-2.20 top

http://gateoverflow.in/466

Selected Answer

Arrange files in increasing order of records

D A C B E

5 10 15 20 25

75

30 45

15 15(C) 20 (B) 25(E)

5(D) 10(A)

No of movements=15+30+45+75=165

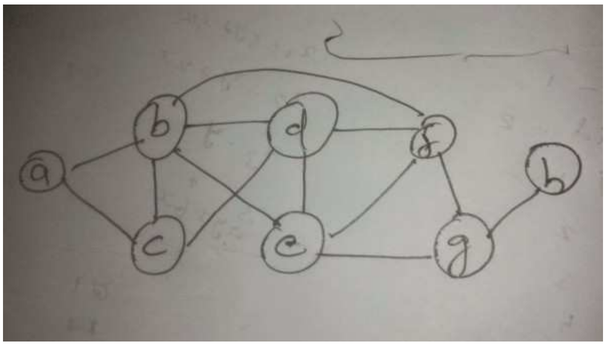
15 votes -- Pooja Palod (32.4k points)

1.7.3 Greedy Algorithm: GATE2003-69 top http://gateoverflow.in/956

Selected Answer

Solution: B

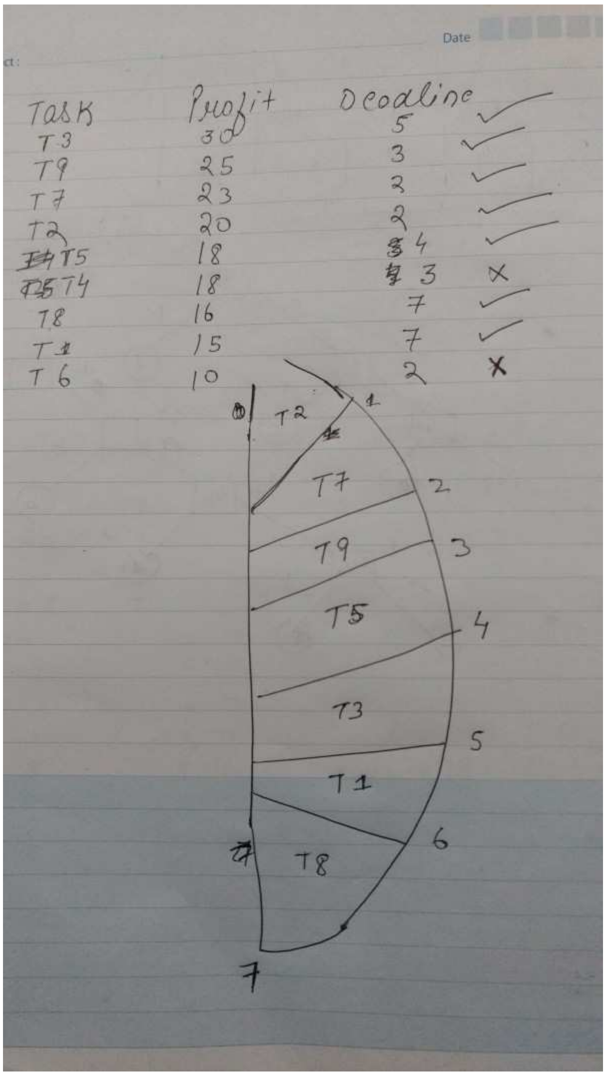
The problem can be modeled as a graph coloring problem. Construct a graph with one node corresponding to each activity $$A,B,C,D,E,F,G and H. Connect the activities that occur between the start and end time of an activity now the chromatic number of the graph is the number of rooms required.



16 votes -- Gowthaman Arumugam (1.4k points)

1.7.4 Greedy Algorithm: GATE2005-84a top http://gateoverflow.in/1406

Selected Answer



Step -1 Sort the tasks in decreasing order of profit and if any conflict arises between two or more tasks,resolve them by sorting them on basis of having greater deadline first(Because we have more time to complete the task with greater deadline and same profit).

Step 2- Since Maximum deadline given is 7, so we consider we have 7 time slots ranging from 0-7 where a task T having deadline say 2 can be filled in slots either 0-1 or 1-2 and not beyond 2 because this task has deadline of 2 time units, so this task has to be completed by atmost time T=2.

Now according to question, since Each task completes in Unit time, so a single tasks takes only one slot as shown.

Now Take the first task in the list i.e. T3 which has a deadline of 5, so it can be completed in maximum 5 time units, so place it in slot 4-5 which is the maximum deadline by which this task can be completed.

Task T9 with deadline 3 is similarly placed in slot 2-3.

Task T7 with deadline 2 is placed in slot 1-.2.

Now for task T2 having deadline 2 can be placed in either 0-1 or 1-2(Occupied by T7). So T2 will occupy slot 0-1.

Task T5 with deadline 4 is placed in slot 3-4.

Now comes task T4 which has deadline 3 can be put in slots 0-1 or 1-2 or 2-3 and not beyond that.Unfortunately, all such slots are occupied so **T4 will be left out.**

Task T8 with deadline 7 goes in slot 6-7.

Task T1 with deadline 7 can be placed in slot 5-6.

Now all time slots are **full.**

So, Task **T6 will be left out.**

So, option (d) is the answer.

6 votes -- Ayush Upadhyaya (1.9k points)

The most important statement in question is

each task requires one unit of time

This shows that we can greedily choose the better task and that should give us the optimal solution. The best task would be the one with maximum profit. Thus we can sort the tasks based on deadline and then profit as follows:

Task	**T7**	**T2**	**T9**	**T4**	**T5**	**T3**	**T6**	**T8**	**T1**
Deadline	2	2	3	3	4	5	5	7	7

0 ----T7 ----- 1----T2-----2-----T9-----3-----T5-----4-----T3-----5-----T8-----6-----T1------7

T4 and T6 left out

D is answer.

11 votes -- Pooja Palod (32.4k points)

1.7.5 Greedy Algorithm: GATE2005-84b top

http://gateoverflow.in/82514

Selected Answer

The most important statement in question is

each task requires one unit of time

This shows that we can greedily choose the better task and that should give us the optimal solution. The best task would be the one with maximum profit. Thus we can sort the tasks based on deadline and then profit as follows:

Task	**T7**	**T2**	**T9**	**T4**	**T5**	**T3**	**T6**	**T8**	**T1**
Deadline	2	2	3	3	4	5	5	7	7

0 --T7 -- 1 -- T2 -- 2 -- T9 -- 3 -- T5 -- 4 -- T3 -- 5 -- T8 -- 6 -- T1 -- 7

so we know that T4 and T6 are left

so profit will not include T4 and T6 = 15 + 20 +30 +18 + 16 + 23 + 25 = 147

A is answer

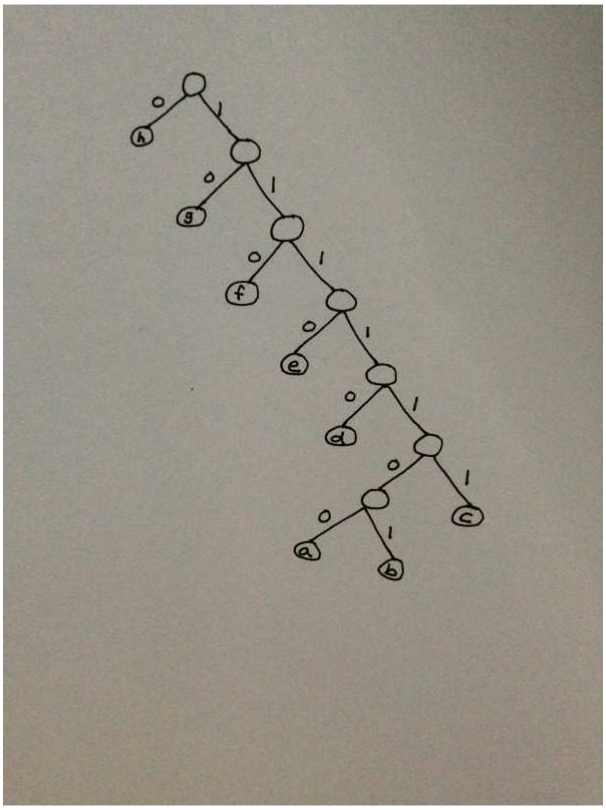
8 votes -- Prashant Singh (49.2k points)

1.7.6 Greedy Algorithm: GATE2006-IT-48 top

http://gateoverflow.in/3591

Selected Answer

Answer is A. Huffman's tree is as follows. The two least frequent characters are taken as the children of a newly made node and the frequency of the newly made node is made equal to the sum of those two child nodes. Then the same procedure is repeated till all nodes are finished.



110111100111010 = 110 11110 0 1110 10 = fdheg

13 votes -- Arjun Suresh (294k points)

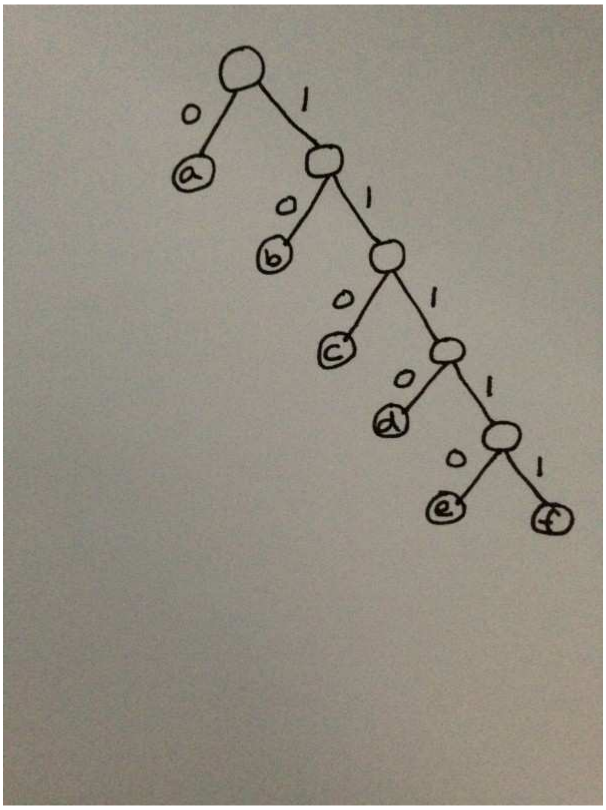
1.7.7 Greedy Algorithm: GATE2007-76 top http://gateoverflow.in/1271

Selected Answer

Based on the probabilities, we can say the probable frequency of the letters will be

16, 8, 4, 2, 1, 1

Now, the Huffman tree can be constructed as follows:



So, A is the answer for 76.

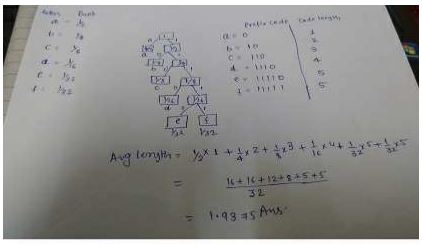
https://www.siggraph.org/education/materials/HyperGraph/video/mpeg/mpegfaq/huffman_tutorial.html

10 votes -- Arjun Suresh (294k points)

1.7.8 Greedy Algorithm: GATE2007-77 top http://gateoverflow.in/43513

Selected Answer

Ans should be D)



9 votes -- sonam vyas (13.2k points)

1.8 Identify Function(35) top

1.8.1 Identify Function: CMI2013-A-09 top http://gateoverflow.in/46599

The below question is based on the following program.

```
procedure mystery (A : array [1..100] of int)
    int i,j,position,tmp;
    begin
```

```
        for j := 1 to 100 do
            position := j;
            for i := j to 100 do
                if (A[i] > A[position]) then
                    position := i;
                endfor
            tmp := A[j];
            A[j] := A[position];
            A[position] := tmp;
        endfor
end
```

When the procedure terminates, the array A has been:

A. Reversed
B. Sorted in descending order
C. Left unaltered
D. Sorted in ascending order

cmi2013 algorithms identify-function

Answer

1.8.2 Identify Function: GATE1991-03-viii top http://gateoverflow.in/523

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

Consider the following Pascal function:

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

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

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

gate1991 algorithms easy identify-function

Answer

1.8.3 Identify Function: GATE1993_7.4 top http://gateoverflow.in/2292

What does the following code do?

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

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

gate1993 algorithms identify-function easy

Answer

1.8.4 Identify Function: GATE1994_6 top

http://gateoverflow.in/2502

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

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

gate1994 algorithms identify-function normal

Answer

1.8.5 Identify Function: GATE1995_1.4 top

http://gateoverflow.in/2591

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

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

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

gate1995 algorithms identify-function easy

Answer

1.8.6 Identify Function: GATE1995_2.3 top

http://gateoverflow.in/2615

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

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

A. Computes the LCM of two numbers

B. Divides the larger number by the smaller number

C. Computes the GCD of two numbers

D. None of the above

gate1995 algorithms identify-function normal

Answer

1.8.7 Identify Function: GATE1995_4 top

http://gateoverflow.in/2640

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

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

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

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

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

gate1995 algorithms identify-function normal

Answer

1.8.8 Identify Function: GATE1998_2.12 top http://gateoverflow.in/1684

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

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

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

gate1998 algorithms recursion identify-function normal

Answer

1.8.9 Identify Function: GATE1999_2.24 top http://gateoverflow.in/1501

Consider the following C function definition

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

The functional Trial:

A. Finds the maximum of a, b, and c

B. Finds the minimum of a, b, and c

C. Finds the middle number of a, b, c

D. None of the above

gate1999 algorithms identify-function normal

Answer

1.8.10 Identify Function: GATE2000-2.15 top http://gateoverflow.in/662

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

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

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

gate2000 algorithms normal identify-function

Answer

1.8.11 Identify Function: GATE2003-1 top http://gateoverflow.in/892

Consider the following C function.

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

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

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

gate2003 algorithms identify-function normal

Answer

1.8.12 Identify Function: GATE2003-88 top http://gateoverflow.in/971

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

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

The set of numbers printed by this program fragment is

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

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

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

D. { }

gate2003 algorithms identify-function normal

Answer

1.8.13 Identify Function: GATE2004-41 top http://gateoverflow.in/1038

Consider the following C program

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

The program computes

A. $x + y$ using repeated subtraction

B. $x \mod y$ using repeated subtraction

C. the greatest common divisor of x and y

D. the least common multiple of x and y

gate2004 algorithms normal identify-function

Answer

1.8.14 Identify Function: GATE2004-42 top http://gateoverflow.in/1039

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

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

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

gate2004 algorithms identify-function normal

Answer

1.8.15 Identify Function: GATE2005-31 top http://gateoverflow.in/1367

Consider the following C-program:

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

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

```
}
```

What does the above program print?

A. 8, 4, 0, 2, 14

B. 8, 4, 0, 2, 0

C. 2, 0, 4, 8, 14

D. 2, 0, 4, 8, 0

gate2005 algorithms identify-function recursion normal

Answer

1.8.16 Identify Function: GATE2005-IT-57 top

http://gateoverflow.in/3818

What is the output printed by the following program?

```
#include <stdio.h>

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

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

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

gate2005-it algorithms identify-function normal

Answer

1.8.17 Identify Function: GATE2006-50 top

http://gateoverflow.in/1828

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

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

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

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

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

The set Z computed by the algorithm is:

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

gate2006 algorithms identify-function normal

Answer

1.8.18 Identify Function: GATE2006-53 top

http://gateoverflow.in/1831

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

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

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

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

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

gate2006 algorithms identify-function normal

Answer

1.8.19 Identify Function: GATE2006-IT-52 top

http://gateoverflow.in/3595

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

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

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

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

gate2006-it algorithms identify-function normal

Answer

1.8.20 Identify Function: GATE2008-IT-82 top

http://gateoverflow.in/3406

Consider the code fragment written in C below :

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

What does f(173) print?

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

gate2008-it algorithms recursion identify-function normal

Answer

1.8.21 Identify Function: GATE2008-IT-83 top

http://gateoverflow.in/3407

Consider the code fragment written in C below :

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

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

<table>
<tr><th>P1</th><th>P2</th></tr>
<tr><td>

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

</td><td>

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

</td></tr>
</table>

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

gate2008-it algorithms recursion identify-function normal

Answer

1.8.22 Identify Function: GATE2009-18 top

http://gateoverflow.in/1310

Consider the program below:

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

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

The value printed is

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

gate2009 algorithms recursion identify-function normal

Answer

1.8.23 Identify Function: GATE2010-35 top

http://gateoverflow.in/2336

What is the value printed by the following C program?

```
#include<stdio.h>

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

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

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

gate2010 algorithms recursion identify-function normal

Answer

1.8.24 Identify Function: GATE2011-48 top http://gateoverflow.in/2154

Consider the following recursive C function that takes two arguments.

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

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

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

gate2011 algorithms recursion identify-function normal

Answer

1.8.25 Identify Function: GATE2011-49 top http://gateoverflow.in/43324

Consider the following recursive C function that takes two arguments.

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

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

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

gate2011 algorithms recursion identify-function normal numerical-answers

Answer

1.8.26 Identify Function: GATE2013_31 top http://gateoverflow.in/1542

Consider the following function:

```
int unknown(int n){
```

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

}
```

The return value of the function is

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

gate2013 algorithms identify-function normal

Answer

1.8.27 Identify Function: GATE2014-1-41 top http://gateoverflow.in/1919

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

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

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

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

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

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

gate2014-1 algorithms identify-function normal

Answer

1.8.28 Identify Function: GATE2014-2-10 top http://gateoverflow.in/1964

Consider the function func shown below:

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

The value returned by func(435) is ________

gate2014-2 algorithms identify-function numerical-answers easy

Answer

1.8.29 Identify Function: GATE2014-3-10 top http://gateoverflow.in/2044

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

```
C=100;
for i=1 to n do
```

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

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

gate2014-3 algorithms identify-function easy

Answer

1.8.30 Identify Function: GATE2015-1-31 top http://gateoverflow.in/8263

Consider the following C function.

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

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

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

gate2015-1 algorithms normal identify-function

Answer

1.8.31 Identify Function: GATE2015-2_11 top http://gateoverflow.in/8060

Consider the following C function.

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

The return value of fun(5) is ______.

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

Answer

1.8.32 Identify Function: GATE2015-3_49 top http://gateoverflow.in/8558

Suppose $c = \langle c[0], \dots, c[k-1] \rangle$ 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

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

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

gate2015-3 algorithms identify-function normal numerical-answers

Answer

1.8.33 Identify Function: TIFR2010-B-24 top http://gateoverflow.in/18742

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

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

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

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

tifr2010 algorithms identify-function

Answer

1.8.34 Identify Function: TIFR2014-B-2 top http://gateoverflow.in/27136

Consider the following code.

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

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

  return count
```

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

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

tifr2014 algorithms identify-function

Answer

1.8.35 Identify Function: TIFR2017-A-12 top http://gateoverflow.in/95299

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

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

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

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

tifr2017 algorithms identify-function

Answer

Answers: Identify Function

1.8.1 Identify Function: CMI2013-A-09 top http://gateoverflow.in/46599

Selected Answer

Ans- B .Sorted in descending order (selection sorting algorithm is used)

4 votes -- Dhananjay Kumar Sharma (25.2k points)

1.8.2 Identify Function: GATE1991-03-viii top http://gateoverflow.in/523

Selected Answer

For N=9, it returns 3.

For N=10 it returns 4.

For N=16 it returns 4.

For N=17 it returns 5.

So answer should be C.

6 votes -- Taymiyyah Bhat (3.8k points)

1.8.3 Identify Function: GATE1993_7.4 top http://gateoverflow.in/2292

Selected Answer

Answer is simply A i.e. it swaps the values of the two.. Take any two values for A and B. and perform the given operations over them.

9 votes -- Gate Keeda (19.1k points)

1.8.4 Identify Function: GATE1994_6 top http://gateoverflow.in/2502

Selected Answer

answer - x^n

5 votes -- ankitrokdeonsns (9.1k points)

1.8.5 Identify Function: GATE1995_1.4 top

http://gateoverflow.in/2591

Selected Answer

Ans of X remains unchanged. As the if condition becomes false.

```
X := -10
```

ans is C . This is classic example of if-else issue. Always else matches for nesting to closest if in C Programming & Pascal .

https://en.wikipedia.org/wiki/Dangling_else

```
if (x>y)
{
   if (x<0)
       x=abs(x)
    else
       x=2*x
}
```

10 votes -- Akash (43.8k points)

1.8.6 Identify Function: GATE1995_2.3 top

http://gateoverflow.in/2615

Selected Answer

Answer: C

Let X = 3 and Y = 7.
1st pass: X=3, Y=4
2nd pass: X=3, Y=1
3rd pass: X=2, Y=1
4th pass: X=1, Y=1
write (X), which writes 1.

Ref: http://www.naturalnumbers.org/EuclidSubtract.html

8 votes -- Rajarshi Sarkar (35k points)

1.8.7 Identify Function: GATE1995_4 top

http://gateoverflow.in/2640

Selected Answer

A. = 3

For B.

begin

for I:=2 to N do

for J:=1 to (I-1) do

begin

TMP:= A[I, J];

A[I, J]:= A[J, I];

A[J, I]:= TMP

end

Should be the condition...

3 votes -- papesh (24.1k points)

1.8.8 Identify Function: GATE1998_2.12 top http://gateoverflow.in/1684

Selected Answer

$fun(95) = fun(fun(106)) = fun(96) = fun(fun(107)) = fun(97) = fun(fun(108)) = fun(98) = fun(fun(109)) =$

13 votes -- Digvijay (47k points)

1.8.9 Identify Function: GATE1999_2.24 top http://gateoverflow.in/1501

Selected Answer

a	b	c	Return
1	1	1	The final return statement is c < b, so this never returns. Answer D.

20 votes -- Arjun Suresh (294k points)

1.8.10 Identify Function: GATE2000-2.15 top http://gateoverflow.in/662

Selected Answer

Answer is (a)

Effect of the above 3 reversal for any K is equivalent to left rotation of the array of size n by k.

Let , S[1......7]

1	2	3	4	5	6	7

so, n=7 ,k = 2

reverse(S,1,2) we get [2,1,3,4,5,6,7]

reverse(S,3,7) we get [2,1,7,6,5,4,3]

reverse(S,1,7) we get [3,4,5,6,7,1,2]

hence option (a) Rotates s left by k position is correct

19 votes -- Kalpna Bhargav (3.2k points)

1.8.11 Identify Function: GATE2003-1 top http://gateoverflow.in/892

Selected Answer

$$i = 1 \quad \text{then} \quad p = x \quad \& \quad s = 1 + x$$

$$i = 2 \quad \text{then} \quad p = \frac{x^2}{2} \quad \& \quad s = 1 + x + \frac{x^2}{2}$$

As y tends to infinity, s tends to e^x.

Hence, the correct answer is option B.

17 votes -- Pooja Palod (32.4k points)

1.8.12 Identify Function: GATE2003-88 top

http://gateoverflow.in/971

Selected Answer

The nested loop is taking all integers from 2 to 2 * $\log_2$ n take all their non-multiples before n, and make the corresponding entry in A as 1. For example, for 2, and n = 10, A[3], A[5], A[7], and A[9] are made 1. Similarly for 3, 4, ... till 2 * log n. So, if any entry A[p] is 1 means it must be a multiple of 2, 3, ... 2$\log_2$ n, which is (2 log n)! and is greater than n. So, for no index p, A[p] will be 0. So, answer is D.

Suppose the line

```
A[j] = A[j] || (j%k);
```

is replaced with

```
A[j] = A[j] || !(j%k);
```

Now, the nested loop is taking all integers from 2 to $\log_2$ n, take all their multiples before n, and make the corresponding entry in A as 1. For example, for 2, and n = 10, A[4], A[6], A[8] and A[10] are made 1. Similarly for 3, 4, ... till 2 * log n. So, for all non-prime indices of A, we will have a 1, and for prime indices we have a 0. And we print i if A[j] is 0 meaning j is prime.

9 votes -- Arjun Suresh (294k points)

1.8.13 Identify Function: GATE2004-41 top

http://gateoverflow.in/1038

Selected Answer

It is a simple algorithm of gcd

here while loop executes until m==n

take any two number as m,n and compute it , get the answer

Ans will be (C)

3 votes -- srestha (58.4k points)

1.8.14 Identify Function: GATE2004-42 top

http://gateoverflow.in/1039

Selected Answer

by putting y = m/x into x = (x + y)/2

x= (x + m/x) /2

=> 2x^2 = x^2 + m

=> x = m^1/2

or we can check by putting 2-3 different values also.

17 votes -- gate_asp (755 points)

1.8.15 Identify Function: GATE2005-31 top

http://gateoverflow.in/1367

Selected Answer

Option d.

foo is printing the lowest digit. But the printf inside it is after the recursive call. This forces the output to be in reverse order

2, 0, 4, 8

The final value "sum" printed will be 0 as C uses pass by value and hence the modified value inside foo won't be visible inside main.

10 votes

-- anshu (3.2k points)

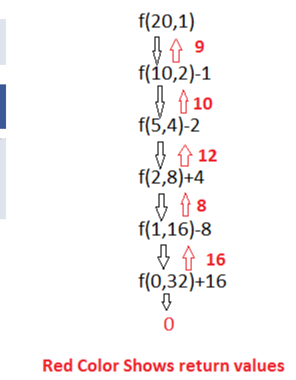
1.8.16 Identify Function: GATE2005-IT-57 top

http://gateoverflow.in/3818

Selected Answer

See the following calling sequnce

Hence Ans is Option C



10 votes

-- Rajesh Pradhan (18.6k points)

1.8.17 Identify Function: GATE2006-50 top

http://gateoverflow.in/1828

Selected Answer

Option (d)

In the given algorithm the for loop contains a logical expression

```
z[i] = (x[i] ∧ ~y[i]) ∨ (~x[i] ∧ y[i]);
```

The equivalent set representation of a given logical expression if we assume z[i] = z, X[i] = X, Y[i] = Y then

z = (X ^ Y') V (X ' ^ Y)

z = (X - Y) V (Y - X) [A ^ B' = A - B]

6 votes

-- Prasanna Ranganathan (4.3k points)

1.8.18 Identify Function: GATE2006-53 top

http://gateoverflow.in/1831

Selected Answer

The while loop add elements from a and b (whichever is smaller) to c and terminates when either of them exhausts. So, when loop terminates either i = n or j = m.

Suppose i = n. This would mean all elements from array a are added to c => k must be incremented by n. c would also contain j elements from array b. So, number of elements in c would be n+j and hence k = n + j.

Similarly, when j = m, k = m + i.

Hence, option (D) is correct. (Had k started from -1 and not 0 and we used ++k inside loop, answer would have been option (C))

24 votes -- Arjun Suresh (294k points)

1.8.19 Identify Function: GATE2006-IT-52 top http://gateoverflow.in/3595

Selected Answer

Answer: C

Because $\binom{m}{0}$ = 1 and $\binom{n}{n}$ = 1.

16 votes -- Rajarshi Sarkar (35k points)

1.8.20 Identify Function: GATE2008-IT-82 top http://gateoverflow.in/3406

Selected Answer

Answer: D

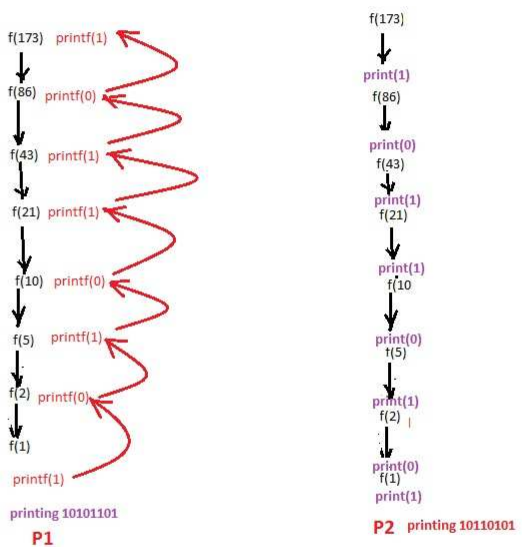
The function prints the binary equivalent of the number n.

Binary equivalent of 173 is 10101101.

9 votes -- Rajarshi Sarkar (35k points)

1.8.21 Identify Function: GATE2008-IT-83 top http://gateoverflow.in/3407

Selected Answer



here P1 and P2 will print opposite in direction as shown in diagram

and given code fragment will print like P1 and not like P2

Hence ans will be (C)

12 votes -- srestha (58.4k points)

1.8.22 Identify Function: GATE2009-18 top http://gateoverflow.in/1310

Selected Answer

The answer is B.

Let the address of x be 1000.

1.f(5,1000) = 8

2.f(4,1000) = 5

3.f(3,1000) = 3

4.f(2,1000) = 2

5.f(1,1000) = 1.

The evaluation is done from 5 to 1. Since recursion is used.

6 votes -- Gate Keeda (19.1k points)

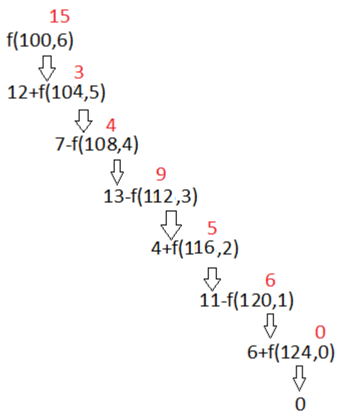
1.8.23 Identify Function: GATE2010-35 top http://gateoverflow.in/2336

Selected Answer

Suppose int array takes 4 byte for each element and strored at base address 100.

Follow below img and Red color shows the return value.

So 15 is Ans.



6 votes -- Rajesh Pradhan (18.6k points)

It will print
12 + (7 - (13 - (4 + (11 - (6 + 0)))))
= 12 + (7 - (13 - (4 + (11 -6)))))
= 12 + 7 - 13 + 9
= 15

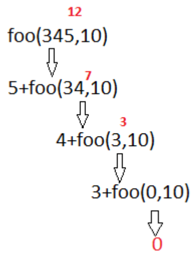
16 votes -- gatecse (13.4k points)

1.8.24 Identify Function: GATE2011-48 top http://gateoverflow.in/2154

Selected Answer

Red color represent return values

Ans is 12



10 votes -- Rajesh Pradhan (18.6k points)

1.8.25 Identify Function: GATE2011-49 top

http://gateoverflow.in/43324

Selected Answer

The function returns the sum of digits in a binary representation of the given number

so 1+0+0+0+0+0+0+0+0+1 = 2

6 votes -- Sandeep_Uniyal (7.3k points)

1.8.26 Identify Function: GATE2013_31 top

http://gateoverflow.in/1542

Selected Answer

The outer loop is running for n/2 times and inner loop is running for $\log_2 n$ times (each iteration doubles j and j stops at n means $\log_2 n$ times j loop will iterate).

Now in each iteration k is incremented by n/2. So, overall k will be added n/2 * log n * n/2 with an initial value of 0. So, final value of k will be $\Theta(n^2 \log n)$

27 votes -- Arjun Suresh (294k points)

1.8.27 Identify Function: GATE2014-1-41 top

http://gateoverflow.in/1919

Selected Answer

answer is (A) maximum possible sum of elements in any sub-array of array **E**.

```
int MyX ( int * E, unsinged int size )
{
    int Y= 0;
    int z;
    int i, j,k;
    // calculate sum of the elements of the array E and stores it in Y
    for i 0;i<size;i++)
      Y = Y+E[i];
    //calculate the sum of all possible subaarays (starting from postion 0..n-1)
    for (i=0;i<size;i++)
        for(j=i;j<size ;j++)
        {
            z = 0;
            for(k=i; k<=j;k++)
                z=z+E[k];
             // checks whether sum of elements of each subarray is greater than the current max, if so, then assign it to currentmax
            if(z>Y)
                Y = z;
        }
    // ultimately returns the maximum possible sum of elements in any sub array of given array E
    return Y;
}
```

17 votes -- Kalpna Bhargav (3.2k points)

1.8.28 Identify Function: GATE2014-2-10 top http://gateoverflow.in/1964

Selected Answer

Ans - 9

435-(110110011)

num >>= 1; implies a num is shifted one bit right in every while loop execution.While loop is executed 9 times successfully and 10th time num is zero.

So count is incremented 9 times.

Note:

Shifting a number `"1"` bit position to the right will have the effect of dividing by 2:

```
8 >> 1 = 4    // In binary: (00001000) >> 1 = (00000100)
```

11 votes -- Prasanna Ranganathan (4.3k points)

1.8.29 Identify Function: GATE2014-3-10 top http://gateoverflow.in/2044

Selected Answer

A.

In the computation of given pseudo code for each row and column of Matrix A, each upper triangular element will be interchanged by its mirror image in the lower triangular and after that the same lower triangular element will be again re-interchanged by its mirror image in the upper triangular, resulting the final computed Matrix A same as input Matrix A.

15 votes -- Gate Keeda (19.1k points)

1.8.30 Identify Function: GATE2015-1-31 top http://gateoverflow.in/8263

Selected Answer

i loop is executing n times. j loop is executing log n times for each i, and so value of p is log n. k loop is executing log p times, which is log log n times for each iteration of i. In each of these q is incremented. So, over all iterations of i, q will be incremented n log log n times. So, D choice.

28 votes -- Arjun Suresh (294k points)

1.8.31 Identify Function: GATE2015-2_11 top http://gateoverflow.in/8060

Selected Answer

fun(1) = 1;

fun(2) = 1 + fun(1) * fun(1) = 1 + 1 = 2;

fun(3) = 1 + fun(1) * fun(2) + fun(2) * fun(1) = 5;

fun(4) = 1 + fun(1) * fun(3) + fun(2) * fun(2) + fun(3) * fun(1) = 1 + 5 + 4 + 5 = 15;

fun(5) = 1 + fun(1) * fun(4) + fun(2) * fun(3) + fun(3) * fun(2) + fun(4) * fun(1) = 1 + 15 + 10 + 10 + 15 = 51;

More formal way:

The recurrence relation is

$$f(n) = \begin{cases} 1, n = 1 \\ 1 + \sum_{i=1}^{n-1} f(i) \times f(n-i), n > 1 \end{cases}$$

$$f(1) = 1$$

$$f(2) = 1 + f(1).f(1) = 1 + 1.1 = 2$$

$$f(3) = 1 + f(1).f(2) + f(2).f(1) = 1 + 1.2 + 2.1 = 5$$

$$f(4) = 1 + f(1).f(3) + f(2).f(2) + f(3).f(2) = 1 + 1.5 + 2.2 + 5.1 = 15$$

$$f(5) = 1 + f(1).f(4) + f(2).f(3) + f(3).f(2) + f(4).f(1) = 1 + 1.15 + 2.5 + 5.2 + 15.1 = 51$$

31 votes -- Arjun Suresh (294k points)

```
fun(1) =1

fun(2) : x=1+fun(1)*fun(1)
           x=1+1*1
           x=2
         fun(2) = 2

fun(3) : x = x+fun(1)*fun(2)
          x= 1+1*2
          x= 3

          x= 3+fun(2)*fun(1)
          x= 3+2*1
          x= 5
          fun(3) = 5

fun(4) : x = x+fun(1)*fun(3)
          x= 1+1*5
          x= 6

         x = x+fun(2)*fun(2)
         x= 6+2*2
         x= 10

         x = x+fun(3)*fun(1)
         x= 10+5*1
         x= 15

fun(5): x = x+fun(1)*fun(4)
         x= 1+1*15
         x= 16

         x = x+fun(2)*fun(3)
         x= 16+2*5
         x= 26

         x = x+fun(3)*fun(2)
         x= 26+5*2
         x= 36

        x = x+fun(4)*fun(1)
        x= 36+15*1
        x= 51
```

10 votes -- Prasanna Ranganathan (4.3k points)

1.8.32 Identify Function: GATE2015-3_49 top

http://gateoverflow.in/8558

Selected Answer

Initially **k = 4, c = [1, 0, 1, 1], a = 2, n = 8**

now let's iterate through the function step by step :

z = 1 (at the start of do-something)

i = 0 (start of external for loop)

in the do loop

z = 1*1 % 8 = 1 (non zero value so considered as true and continue)

c[0] = 1 so in the if clause z = 1*2 % 8 = 2

in the do loop

z = 2*2 % 8 = 4 (since now z = 2) (non zero value so considered as true and continue)

c[0] = 1 so in the if clause z = 4*2 % 8 = 0

now no need to check further :

reason all the operations that update Z are multiplicative operations and hence the value of Z will never change from 0.

17 votes -- Tamojit Chatterjee (2.2k points)

1.8.33 Identify Function: TIFR2010-B-24 top http://gateoverflow.in/18742

It prints with gcd(x,y) and lcm(x,y)

consider x,y,u,v=17,3,3,17

X=14, v=20

X=11,v=23

X=8, v=26

X=5,v=29

X=2,v=32

Y=1,u=35

X=1,v=67

This is the value obtained

lastly print (x+y)/2 and (v+u)/2 gives 1 and 51

4 votes -- zambus (273 points)

1.8.34 Identify Function: TIFR2014-B-2 top http://gateoverflow.in/27136

Selected Answer

option c. It return no of 1's in binary representation of n.
here n&(n-1) reset rightmost bit of n in each iteration.

e.g

Suppose n=15=00001111(binary)

n-1=14(00001110)

```
  00001111
^  00001110
---------------------
   00001110
```

5 votes -- Avdhesh Singh Rana (2.3k points)

1.8.35 Identify Function: TIFR2017-A-12 top http://gateoverflow.in/95299

Selected Answer

```
1.for i=1 to n:
2.    for j=1 to n:
3.        temp=A[i][j]+10
4.        A[i][j]=A[j][i]
5.        A[j][i]=temp-10
6.    end for
7.end for
```

The 3,4,5 lines swap A [j] [i] and A [i] [j].

The same variables are swapped twice. For eg when: i =5, j = 10. A [10] [5] and A [5] [10] will be swapped. They will be swapped again when i = 10, j =5.

Two times swap of same elements will lead to A remaining unchanged.

Hence, E is correct.

3 votes -- tarun_svbk (1k points)

1.9 Minimum Maximum(4) top

1.9.1 Minimum Maximum: GATE2014-1-39 top http://gateoverflow.in/1917

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

gate2014-1 algorithms numerical-answers normal minimum-maximum

Answer

1.9.2 Minimum Maximum: TIFR2014-B-10 top http://gateoverflow.in/27198

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

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

tifr2014 algorithms minimum-maximum

Answer

1.9.3 Minimum Maximum: TIFR2014-B-6 top http://gateoverflow.in/27183

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

5 9 4 2 6 8 0 3 1 7

What is the expected number of times MIN is updated?

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

E. n

tifr2014 algorithms minimum-maximum

Answer

1.9.4 Minimum Maximum: TIFR2014-B-9 top

http://gateoverflow.in/27194

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

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

tifr2014 algorithms minimum-maximum

Answer

Answers: Minimum Maximum

1.9.1 Minimum Maximum: GATE2014-1-39 top

http://gateoverflow.in/1917

Selected Answer

Ans: minimum number of comparison require to find minimum and maximum is: Approach is divide and conquer ....

```
T(n) = T(floor(n/2)) + T(ceil(n/2)) + 2
T(2) = 1 // if two element then compare both and return max and min
T(1) = 0 // if one element then return both max and min same
```

If n is a power of 2, then we can write T(n) as:

```
T(n) = 2T(n/2) + 2
```

After solving above recursion, we get

```
T(n)  = 3/2n -2
```

Thus, the approach does 3/2n -2 comparisons if n is a power of 2. And it **does more than 3/2n -2 comparisons if n is not a power of 2**.

So, here in this case put n=100 and we will get (3/2)(100) - 2 = 148 comparison .....

28 votes -- Jay (1.2k points)

Another easier way to find it is by using **Tournament Method Technique** -

1. To find the smallest element in the array will take **n-1 comparisions = 99.**

2. To find the largest element -

a.After the first round of Tournament , there will be exactly **n/2 numbers = 50** that will loose the round.

b.So the biggest looser (the largest number) should be among these 50 loosers.To find the largest number will take **n/2 - 1 comparisons = 49.**

Total **99+49 = 148.**

11 votes -- Harsh181996 (2.7k points)

1.9.2 Minimum Maximum: TIFR2014-B-10 top

http://gateoverflow.in/27198

Selected Answer

I think ans will be C)

to be accurate it will be need 3n/2 -2 comparisons .

5 votes -- Pranay Datta (9.7k points)

1.9.3 Minimum Maximum: TIFR2014-B-6 top

http://gateoverflow.in/27183

Selected Answer

Let us consider 3 numbers {1,2,3}

We will consider the permutation along with min no of times MIN is updated .

Permutation :	No of times MIN updated (Minimum)
1,2,3	1
1,3,2	1
2,1,3	2
2,3,1	2
3,1,2	2
3,2,1	3

Total number of times MIN updated is : 11 .

Average no of times MIN updated is : (11/6)

Now going by the options i am getting B .

$H_3 = 1 + 1/2 + 1/3 = 11/6$.

H_3 is the answer and that is option B .

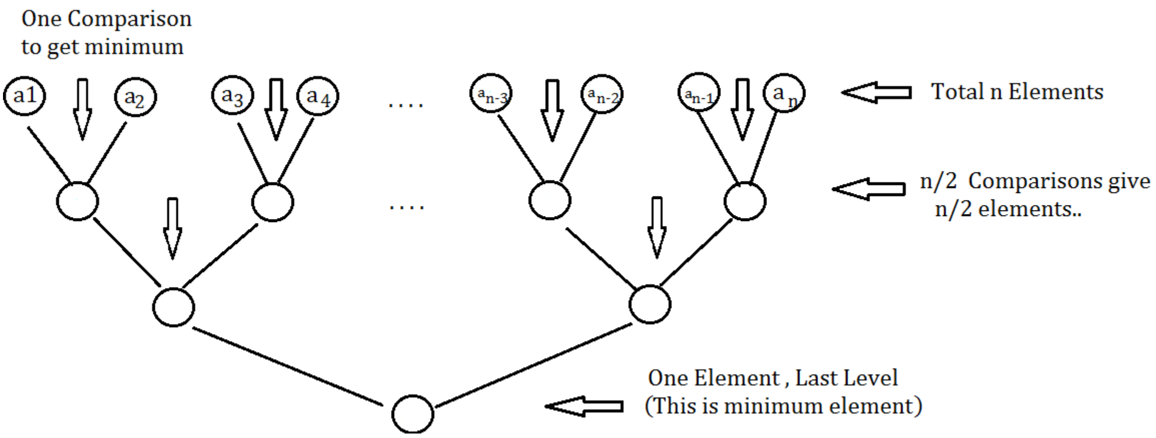
10 votes -- Riya Roy(Arayana) (7.1k points)

1.9.4 Minimum Maximum: TIFR2014-B-9 top

http://gateoverflow.in/27194

Selected Answer

Option (C) is correct .. Reason is as follows :



Here , At first level we are Given n elements , out of which we have to find smallest 3 numbers.

we compare 2 -2 elements as shown in figure & get n/2 elements at Second level.

Note: Minimum element is in these n/2 elements.

So, comparisons for this is n/2..

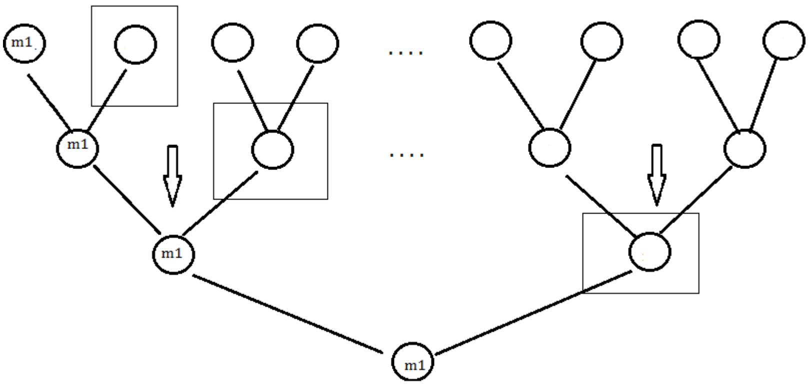
Similarly for next level we have n/4 Comparisons & n/2 elements..and so on..

Total Comparisons till now is n/2 + n/4 + n/8 + ... + 4 + 2 +1 = ($2^{\log n}$ -1) = n-1 {Use G.P. sum}

Now we have to get smallest 3..

We have 1st smallest at last level already => 0 Comparison for this..

=> 2^{nd} & 3^{rd} smallest can be found in O(log n) time as shown below:



Minimum Element must have descended down from some path from top to Bottom..

=> SQUARES represent Candidates for 2nd minimum..

every element that is just below m1(first minimum) is a candidate for second minimum..

So, O(log n) Comparisons for finding second smallest..

=> similarly for 3rd minimum we get O(log n) time.. As, every element that is just below 1st & 2nd minimum is a candidate for 3rd minimum ..

11 votes -- Himanshu Agarwal (16.2k points)

All element are distinct

1.Using heap
Make a min heap tree = O(n)
Delete Three element from top = 3logn
+
n + 3logn = n+ O(logn) comparison
2.Using Selection sort
3 pass to get three minimum element
Comparison = n-1+ n-2 +n-3 = 3n-5
Swap =1+1+1 = 3
+
3n+2
3. for(i=0;i<=n;i++) // Min1 Min2 Min3 are first 3 element of array

{
if x < Min1 then, Min3 = Min2; Min2 = Min1; Min1 = x;
else if Min1 < x < Min2 then, Min3 = Min2; Min2 = x;
else if Min2 < x < Min3 then, Min3 = x;

else if Min3 < x skip
}
Worst case 3n comparision

4.using Divide and Conquer
minimum element = n-1 compare
second minimum = $\log_2 n$ - 1 compare
third minimum = $\log\log_2 n$ - 1 compare
total = n+$\log_2 n$ + $\log\log_2 n$- 3 = n + O($\log_2 n$)

So i think three element can be retrieved in O(n){n + O(logn)} time but comparison cant be n + 0(1) since all 3 element can be at n*(n-1)*(n-2) location and we have to scan the list at least once and compare the to 3 elements.

Option C.

10 votes -- Umang Raman (15.2k points)

1.10 Minimum Spanning Trees(1) top

1.10.1 Minimum Spanning Trees: CMI2012-B-05b top http://gateoverflow.in/47090

Given an undirected weighted graph $G = (V, E)$ with non-negative edge weights, we can compute a minimum cost spanning tree $T = (V, E')$. We can also compute, for a given source vertex $s \epsilon V$, the shortest paths from s to every other vertex in V. We now increase the weight of every edge in the graph by 1. Are the following true or false, regardless of the structure of G? Give a mathematically sound argument if you claim the statement is true or a counterexample if the statement is false.

i. All the shortest paths from s to the other vertices are unchanged.

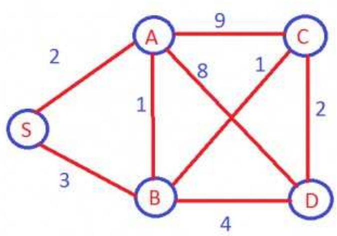
cmi2012 descriptive algorithms graph-algorithms minimum-spanning-trees

Answer

Answers: Minimum Spanning Trees

1.10.1 Minimum Spanning Trees: CMI2012-B-05b top http://gateoverflow.in/47090

Selected Answer



The given statement "All the shortest paths from s to the other vertices are unchanged." is false . From the above graph it is clear that the shortest path from S to D is S->A->B->C->D and the cost is 6.

Now we increment the edge cost of all the edges by 1 .

After incrementation , the shortest path from S to D gets changed.Now the shortest path becomes S->B->D and shortest path cost is 9 . The above graph is the proof

3 votes -- balaeinstein (917 points)

1.11 Np Completeness(13) top

1.11.1 Np Completeness: CMI2015-A-06 top http://gateoverflow.in/47041

Suppose we have constructed a polynomial time reduction from problem A to problem B. Which of the following can we infer from this fact?

A. If the best algorithm for B takes exponential time, there is no polynomial time algorithm for A.
B. If the best algorithm for A takes exponential time, there is no polynomial time algorithm for B.
C. If we have a polynomial time algorithm for A, we must also have a polynomial time algorithm for B.
D. If we don't know whether there is a polynomial time algorithm for B, there cannot be a polynomial time algorithm for A.

cmi2015 algorithms np-completeness

Answer

1.11.2 Np Completeness: GATE1992_02,vi top http://gateoverflow.in/561

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

(vi) Which of the following problems is not NP-hard?

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

gate1992 np-completeness algorithms

Answer

1.11.3 Np Completeness: GATE2003-12 top http://gateoverflow.in/903

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

A. Π is NP-hard but not NP-complete

B. Π is in NP, but is not NP-complete

C. Π is NP-complete

D. Π is neither NP-hard, nor in NP

gate2003 algorithms np-completeness normal

Answer

1.11.4 Np Completeness: GATE2004-30, ISRO2017-10 top http://gateoverflow.in/1027

The problem 3-SAT and 2-SAT are

A. both in P

B. both NP complete

C. NP-complete and in P respectively

D. undecidable and NP complete respectively gate2004 algorithms np-completeness easy isro2017

Answer

1.11.5 Np Completeness: GATE2005-58 top http://gateoverflow.in/1381

Consider the following two problems on undirected graphs:

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

Which one of the following is TRUE?

A. α is in P and β is NP-complete

B. α is NP-complete and β is in P

C. Both α and β are NP-complete

D. Both α and β are in P

gate2005 algorithms np-completeness normal

Answer

1.11.6 Np Completeness: GATE2006-16 top http://gateoverflow.in/977

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

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

gate2006 algorithms np-completeness normal

Answer

1.11.7 Np Completeness: GATE2006-31 top http://gateoverflow.in/994

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

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

gate2006 algorithms np-completeness normal

Answer

1.11.8 Np Completeness: GATE2008-44 top http://gateoverflow.in/456

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

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

gate2008 algorithms np-completeness normal

Answer

1.11.9 Np Completeness: GATE2009-14 top http://gateoverflow.in/1306

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

A. There is no polynomial time algorithm for π_A.

B. If π_A can be solved deterministically in polynomial time, then P = NP.

C. If π_A is NP-hard, then it is NP-complete.

D. π_A may be undecidable.

gate2009 algorithms np-completeness

Answer

1.11.10 Np Completeness: TIFR2010-B-39 top

http://gateoverflow.in/18754

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

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

tifr2010 algorithms np-completeness

Answer

1.11.11 Np Completeness: TIFR2011-B-37 top

http://gateoverflow.in/20922

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

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

tifr2011 algorithms np-completeness

Answer

1.11.12 Np Completeness: TIFR2013-B-7 top

http://gateoverflow.in/25668

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

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

tifr2013 algorithms np-completeness

Answer

1.11.13 Np Completeness: TIFR2017-B-2 top

http://gateoverflow.in/95673

Consider the following statements:

Checking if a given $undirected$ graph has a cycle is in P

Checking if a given $undirected$ graph has a cycle is in NP

Checking if a given $directed$ graph has a cycle is in P

Checking if a given $directed$ graph has a cycle is in NP

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

Only i and ii

Only ii and iv

Only ii, iii, and iv

Only i, ii and iv

All of them

tifr2017 algorithms np-completeness

Answer

Answers: Np Completeness

1.11.1 Np Completeness: CMI2015-A-06 top http://gateoverflow.in/47041

Selected Answer

Problem A reduces to Problem B,

Option **B) If the best algorithm for A takes exponential time, there is no polynomial time algorithm for B**. will be correct.

5 votes -- Muktinath Vishwakarma (34.1k points)

1.11.2 Np Completeness: GATE1992_02,vi top http://gateoverflow.in/561

Selected Answer

a. Is NPC and hence NP hard.

b. Is again NP hard (optimization version is NP hard and decision version is NPC). Ref: http://stackoverflow.com/questions/3907545/how-to-understand-the-knapsack-problem-is-np-complete

c.Is in P. See the algorithm here based on DFS: http://en.wikipedia.org/wiki/Biconnected_component

d. NPC and hence NP hard.

8 votes -- Arjun Suresh (294k points)

1.11.3 Np Completeness: GATE2003-12 top http://gateoverflow.in/903

Selected Answer

C

Ram's reduction shows $\prod$ is NP hard.
Shyam's reduction shows $\prod$ is in NP.

So NPC.

8 votes -- Anurag Semwal (8k points)

1.11.4 Np Completeness: GATE2004-30, ISRO2017-10 top

http://gateoverflow.in/1027

Selected Answer

Option c.

http://cstheory.stackexchange.com/questions/6864/why-is-2sat-in-p

5 votes -- anshu (3.2k points)

1.11.5 Np Completeness: GATE2005-58 top

http://gateoverflow.in/1381

Selected Answer

Independent Set- a set of vertices in a graph no two of which are adjacent.

Maximal Independent set problem - Given a graph G, find the size of the maximal independent set in it. This problem in NP-hard.

Independent set decision problem - Given a graph G and a number k, does G have an independent set of size k. This problem is NP-complete (NP-hard but in NP).

Now, in the given problem β corresponds to the Independent set decision problem. But there is a difference there. We have 5 instead of k. And this drastically changes the problem statement. We can now give a polynomial time **deterministic** algorithm for β.

- Find all vertex sets of size 5. We get ${}^{|V|}C_5$ such vertex sets
- For each of them check if there is any adjacent vertices. This check can be done in constant time if we use an Adjacency matrix representation

Thus the whole time complexity reduces to ${}^{|V|}C_5$ which is $O\left(|V|^5\right)$ and hence polynomial. (${}^{|V|}C_k$ is not polynomial but ${}^{|V|}C_5$ is).

Problem α is asking for an independent set of size $|V|-4$. This is equivalent to asking if G has a vertex cover* of size 4. Following a similar approach as done for β this problem also can be done in polynomial time.

So, both α and β are in P.

D choice.

Vertex cover of a graph G is the set of vertices such that each edge of the graph is incident on atleast one of those vertices.

Independent Set and Vertex cover Reduction: https://www.cs.cmu.edu/~ckingsf/bioinfo-lectures/npcomplete.pdf

8 votes -- Arjun Suresh (294k points)

1.11.6 Np Completeness: GATE2006-16 top

http://gateoverflow.in/977

Selected Answer

Answer B.

As S is NPC i.e NPHard and NP.

> We know that If NPHard problem is reducable to another problem in Polynomial Time, then that problem is also NPHard which means every NP problem can be reduced to this problem in Polynomial Time

Therefore R is NPHard.

Now Q is reduced To S in polynomial time.

> If Q is reducable to S in polynomial time, Q could be NP because all NP problems can be reduced to S. Since Q could be Np therefore Q could be P also as P is subset of NP. Also Q could be NPC because every NPC problem can

be reduced to another NPC problem in polynomial time.

So nothing can be concluded about Q.

1 votes -- Mehak Sharma (1.5k points)

Q cannot be NP hard as no np hard problems(unless they are np) can be polynomial time reducible to np complete. Answer is B, as npc problem can be reducible to np hard problem. But there is confusion if Q is not NP hard then what complexity class it is in!!

11 votes -- Shaun Patel (6.9k points)

1.11.7 Np Completeness: GATE2006-31 top http://gateoverflow.in/994

Selected Answer

The only difference between SHAM and DHAM, in SHAM |V| is divisible by 3.. which can be check in constant amount of time.. So the hardness of the two problem will the same... Next, finding hamiltonian cycle comes under NPC problem and NPC problem is a subset of NPH, so both are NPH..

So, option (A)

8 votes -- Vicky Bajoria (4.9k points)

1.11.8 Np Completeness: GATE2008-44 top http://gateoverflow.in/456

Selected Answer

Subset problem is NP-Complete - there is reduction proof but I don't remember (Can see the below link). So, (C) and (D) are true as an NPC problem is in NP as well as NPH.

https://en.wikipedia.org/wiki/Subset_sum_problem

Now, complexity of Q is O(nW), where W is an integer.
(a) Input is encoded in unary. So, length of input is equal to the value of the input. So, complexity = O(nW) where both n and W are linear multiples of the length of the inputs. So, the complexity is polynomial in terms of the input length. So, (a) is true.

(b) Input is encoded in binary. So, length of W will be lgW. (for W=1024, input length will be just 10). So, now W is exponential in terms of the input length of W and O(nW) also becomes exponential in terms of the input lengths. So, Q is not a polynomial time algorithm. So, (B) is false.

11 votes -- Arjun Suresh (294k points)

1.11.9 Np Completeness: GATE2009-14 top http://gateoverflow.in/1306

Selected Answer

A problem which is in P , is also in NP- so A is false. If problem can be solved deterministically in Polynomial time, then also we can't comment anything about P=NP, we just put this problem in P. So, B also false. C is TRUE because that is the definition of NP-complete.

D is false because all NP problems are not only decidable but decidable in polynomial time using a non-deterministic Turing machine.

8 votes -- shreya ghosh (3.4k points)

1.11.10 Np Completeness: TIFR2010-B-39 top http://gateoverflow.in/18754

Selected Answer

Option E leads to a contradiction, hence is false.

We know that L is $\mathbf{NPC}$, hence $\in \mathbf{NP}$. If $\mathbf{P} \neq \mathbf{NP}$, then L can't be in $\mathbf{P}$

5 votes -- Pragy Agarwal (19.5k points)

1.11.11 Np Completeness: TIFR2011-B-37 top

http://gateoverflow.in/20922

Selected Answer

The reverse problem can be solved in polynomial time as a^b requires at most $\log b$ recursive calls using the approach given below:

```
pow(int a, int b)
{
    if(b%2)
        return a* pow(a*a, b/2);
    else
        return pow(a*a, b/2);
}
```

Now, the forward problem is also solvable in polynomial time. We need to check for all the roots of n (from $\sqrt{n}$ till $n^{\frac{1}{\log n}}$) whether it is an integer . But each of these check can be done in $\log n$ time using a binary search on the set of integers from 2..n and so, the overall complexity will be $(\log n)^2$ which is polynomial in $\log n$ ($\log n$ is the size of input). So, (a) must be the answer.

5 votes -- gatecse (13.4k points)

1.11.12 Np Completeness: TIFR2013-B-7 top

http://gateoverflow.in/25668

Selected Answer

I believe Umang is right, Option B is the correct answer.

Intractability : We are looking for EFFICIENT algorithms.

Intractable Problems are problems that are decidable, although the algorithm to decide that problem might be efficient (P) or inefficient (NP), but at least an algorithm exists to solve these problems.

Here we talk about efficient vs inefficient computations.

Thus the language of problems in P and NP classes is the language of Decidable Problems i.e. Recursive Language.

Undecidability: We are looking for algorithms.

Undecidable Problems are problems for which there is no algorithm to solve these problems.

Here we talk about what can or can not be computed.

The language of Undecidable Problems are "Recursively Enumerable but not recursive languages" & "Not Recursively Enumerable Languages".

Clearly we can talk about the intractability of any problem if we know at least one algorithm to solve the problem, if there is no algorithm to solve a problem how can we talk about efficiency?

Halting Problem is undecidable.

I guess, all other problems mentioned here are decidable.

I don't know the most efficient algorithms to solve these problems but at least I can say that Brute force approach will work on all the other options except the Halting Problem.

What P = NP implies?

"Any problem that is solved by a non deterministic Turing machine in polynomial time also be solved by some deterministic Turing machine in polynomial time, even if the degree of the polynomial is higher."

and

There is neither a Non Deterministic Turing Machine nor Deterministic Turing Machine that can solve the Halting Problem.

So **any inference about P & NP is not going to affect the solvability of Halting Problem, since it is undecidable.**

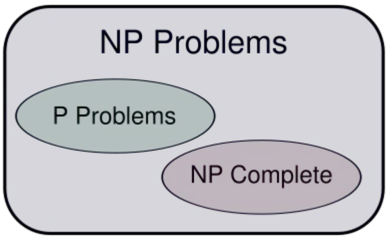
7 votes -- Anurag Pandey (13.1k points)

1.11.13 Np Completeness: TIFR2017-B-2 top http://gateoverflow.in/95673

Selected Answer

E) all of them
because all of them can be solved by Depth first traversal.

Every P problem is a subset of NP.



7 votes -- Motamarri Anusha (11.6k points)

1.12 Numerical Computation(2) top

1.12.1 Numerical Computation: GATE2014-1-37 top http://gateoverflow.in/1915

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

gate2014-1 algorithms numerical-answers normal numerical-computation

Answer

1.12.2 Numerical Computation: TIFR2014-B-20 top http://gateoverflow.in/27354

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

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

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

tifr2014 algorithms numerical-computation

Answer

Answers: Numerical Computation

1.12.1 Numerical Computation: GATE2014-1-37 top http://gateoverflow.in/1915

Selected Answer

Suppose x is no of coins of 11gm and Y is no of 10 gm coins

so according to question 11X+10Y= 323 ...(1)

X+Y=31.....(2) solving (1),(2) we get X=13 and Y=18 so here coins of 11gm are 13 ,and one and only possible combination for 13= 1 coin from bag1+4 coins from bag3 +8 coins from bag4...

so product of label of bags will be =1*3*4=12..

18 votes -- sonam vyas (13.2k points)

There are 5 bags , I assumed initially all bags are having 10 gm coins, and picked them as per the given condition

1,2,4,8,16 of all bags have 10 gm coins then total weight will come to

10 + 20 + 40 + 80+ 160 = 310 but total weight should be 323, but 13 is less, i divided 13 into 1 + 4 + 8
11 + 20 + 44+ 88 + 160, means 1st, 3rd and 4th bags have 11 gm coins. so product of labels will be 1*3*4 = 12

15 votes -- Manu Thakur (6k points)

1.12.2 Numerical Computation: TIFR2014-B-20 top http://gateoverflow.in/27354

Selected Answer

OPTION d is correct

Here the list is (48, 99, 120, 165 ,273.)

Gcd(48,99)=3 ,means if we subtract(99-48=51) that no is also % 3,

so the no's like (3,6,9----99) are added , total no's=99/3=33

//y Gcd(48,120)=24,so the no's %24 are added like (24,48,---120) ,total no's=120/24=5

//y Gcd(48,165)=3,so the nos(3,6,9,--24--48--99--120---165) are added ,totally 165/3=55

at end Gcd(48,273)=3,so the no's(3,6,9--24---48--99---120--165---273) are added(which covers all the above no's)

so total no"s added to this list=273/3=91

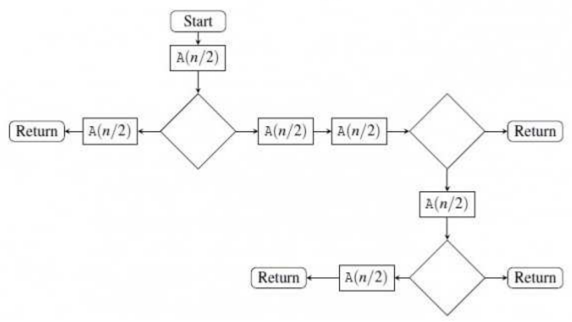
9 votes -- venky.victory35 (673 points)

1.13 Recurrence(29) top

1.13.1 Recurrence: GATE 2016-2-39 top http://gateoverflow.in/39581

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

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



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

Answer

1.13.2 Recurrence: GATE1987-10a top http://gateoverflow.in/82450

Solve the recurrence equations

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

gate1987 algorithms recurrence

Answer

1.13.3 Recurrence: GATE1990-17a top http://gateoverflow.in/86878

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

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

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

gate1990 descriptive algorithms recurrence

Answer

1.13.4 Recurrence: GATE1992-07a top http://gateoverflow.in/586

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

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

[n is a positive integer greater than zero]

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

gate1992 algorithms recurrence descriptive

Answer

1.13.5 Recurrence: GATE1992-07b top http://gateoverflow.in/43600

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

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

[n is a positive integer greater than zero]

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

gate1992 algorithms recurrence descriptive

Answer

1.13.6 Recurrence: GATE1993_15 top http://gateoverflow.in/2312

Consider the recursive algorithm given below:

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

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

gate1993 algorithms recurrence normal

Answer

1.13.7 Recurrence: GATE1994-1.7, ISRO2017-14 top http://gateoverflow.in/2444

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

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

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 easy isro2017

Answer

1.13.8 Recurrence: GATE1996_2.12 top http://gateoverflow.in/2741

The recurrence relation

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

has the solution $T(n)$ equal to

A. $O(n)$

B. $O(\log n)$

C. $O\left(n^{\frac{3}{4}}\right)$

D. None of the above

gate1996 algorithms recurrence normal

Answer

1.13.9 Recurrence: GATE1997_4.6 top http://gateoverflow.in/2247

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

Which of the following statements is true?

A. $T(n) = O\sqrt{n}$

B. $T(n) = O(n)$

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

D. None of the above

gate1997 algorithms recurrence normal

Answer

1.13.10 Recurrence: GATE1998-6a top http://gateoverflow.in/44584

Solve the following recurrence relation

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

$x_1 = 2$

gate1998 algorithms recurrence descriptive

Answer

1.13.11 Recurrence: GATE2002-1.3 top http://gateoverflow.in/807

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

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

gate2002 algorithms recurrence normal

Answer

1.13.12 Recurrence: GATE2002-2.11 top http://gateoverflow.in/841

The running time of the following algorithm

Procedure A(n)

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

is best described by

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

gate2002 algorithms recurrence normal

Answer

1.13.13 Recurrence: GATE2003-35 top http://gateoverflow.in/925

Consider the following recurrence relation

$T(1) = 1$

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

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

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

gate2003 algorithms time-complexity recurrence

Answer

1.13.14 Recurrence: GATE2004-83, ISRO2015-40 top http://gateoverflow.in/1077

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

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

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

gate2004 algorithms recurrence time-complexity normal isro2015

Answer

1.13.15 Recurrence: GATE2004-84 top http://gateoverflow.in/1078

The recurrence equation
$T(1) = 1$
$T(n) = 2T(n-1) + n, n \geq 2$
evaluates to

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

gate2004 algorithms recurrence normal

Answer

1.13.16 Recurrence: GATE2004-IT-57 top http://gateoverflow.in/3700

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

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

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

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

gate2004-it algorithms recurrence normal

Answer

1.13.17 Recurrence: GATE2005-IT-51 top http://gateoverflow.in/3812

Let $T(n)$ be a function defined by the recurrence

$T(n) = 2T(n/2) + \sqrt{n}$ for $n \geq 2$ and
$T(1) = 1$

Which of the following statements is TRUE?

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

gate2005-it algorithms recurrence easy

Answer

1.13.18 Recurrence: GATE2006-51, ISRO2016-34 top http://gateoverflow.in/1829

Consider the following recurrence:

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

Which one of the following is true?

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

algorithms recurrence isro2016 gate2006

Answer

1.13.19 Recurrence: GATE2008-78 top http://gateoverflow.in/497

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

Which of the following recurrences does x_n satisfy?

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

gate2008 algorithms recurrence normal

Answer

1.13.20 Recurrence: GATE2008-79 top

http://gateoverflow.in/43485

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

The value of x_5 is

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

gate2008 algorithms recurrence normal

Answer

1.13.21 Recurrence: GATE2008-IT-44 top

http://gateoverflow.in/3354

When n = 2^{2k} for some k ≥ 0, the recurrence relation

T(n) = √(2) T(n/2) + √n, T(1) = 1

evaluates to :

A. √(n) (log n + 1)
B. √(n) log n
C. √(n) log √(n)
D. n log √n

gate2008-it algorithms recurrence normal

Answer

1.13.22 Recurrence: GATE2009-35 top

http://gateoverflow.in/1321

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

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

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

A. $\Theta(n)$

B. $\Theta(n \log n)$

C. $\Theta(n^2)$

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

gate2009 algorithms recurrence time-complexity normal

Answer

1.13.23 Recurrence: GATE2012-16 top

http://gateoverflow.in/48

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

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

gate2012 algorithms easy recurrence

Answer

1.13.24 Recurrence: GATE2014-2-13 top http://gateoverflow.in/1968

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

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

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

gate2014-2 algorithms recurrence normal

Answer

1.13.25 Recurrence: GATE2015-1_49 top http://gateoverflow.in/8355

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

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

gate2015-1 algorithms recurrence normal

Answer

1.13.26 Recurrence: GATE2015-3_39 top http://gateoverflow.in/8498

Consider the following recursive C function.

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

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

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

gate2015-3 algorithms recurrence normal

Answer

1.13.27 Recurrence: GATE2017-2-30 top http://gateoverflow.in/118623

Consider the recurrence function

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

Then $T(n)$ in terms of θ notation is

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

gate2017-2 algorithms recurrence

Answer

1.13.28 Recurrence: TIFR2014-B-11 top http://gateoverflow.in/27308

Consider the following recurrence relation:

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

Which of the following statements is FALSE?

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

tifr2014 algorithms recurrence

Answer

1.13.29 Recurrence: TIFR2015-B-1 top http://gateoverflow.in/29657

Consider the following recurrence relation:

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

Which of the following statements is TRUE?

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

tifr2015 algorithms recurrence time-complexity

Answer

Answers: Recurrence

1.13.1 Recurrence: GATE 2016-2-39 top http://gateoverflow.in/39581

Selected Answer

If they are asking for worst case complexity hence,
By calling A(n) we get A(n/2) 5 times,

$$A(n) = 5A(n/2) + O(1)$$

Hence by applying masters theorem,
Case 1 : $a > b^k$

$n^{\log_2 5}$

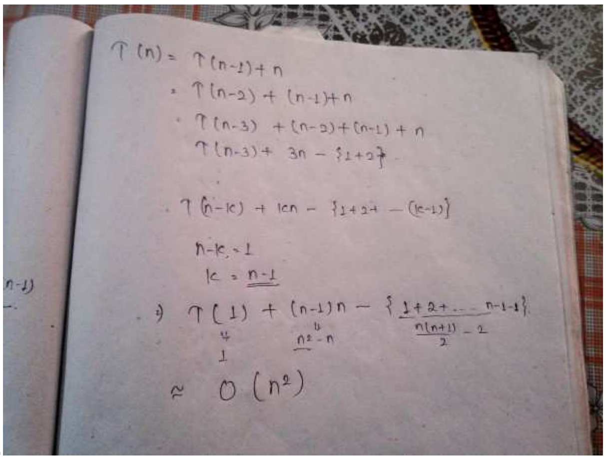
Thus value of alpha will be 2.32

29 votes -- Shashank Chavan (3.4k points)

1.13.2 Recurrence: GATE1987-10a top

http://gateoverflow.in/82450

Selected Answer



......

4 votes -- kirti singh (3.4k points)

1.13.3 Recurrence: GATE1990-17a top

http://gateoverflow.in/86878

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

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

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

substituting value of T(n-1) from eqn (2) in eqn (1)

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

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

now substituting value of T(n-2) in above eqn

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

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

.

.

.

.

so on

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

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

now let n-k=1 so k = n-1, substitute value of k in above eqn

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

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

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

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

T(n) = (n+1)*H_n - n

Now H_n≈logn+γ

where γ is the Euler-Mascheroni constant.

T(n) = O(nlogn)

2 votes -- Digvijaysingh Gautam (7.9k points)

1.13.4 Recurrence: GATE1992-07a top http://gateoverflow.in/586

Selected Answer

1 - The function $F(n)$ is NOT a recursive function. You can't have a recurrence relation for it in the first place!

2 - $F(n)$ calculates $(n-1)^n$.

The equivalent C++ code is as follows: (You can try it out here: http://ideone.com/w0u4lk)

```
long F(long n) {
 long F1 = 1;

 if(n==1) { return 3; }
 else {
  for(long i = 1; i <= n; i++) {
   long C = 0;
   // Note: the before For loop only has one line
   for(long j = 1; j <= n-1; j++) { C = C+1; }
   // At the end of this for loop, C will be = (n-1)
   F1 = F1 * C;
  }
 }
 return F1;
}
```

It is clear that the inner for loop can be replaced by a single statement as follows:

```
long F(long n) {
 long F1 = 1;

 if(n==1) { return 3; }
 else {
  for(long i = 1; i <= n; i++)
   F1 = F1 * (n-1);
 }
 return F1;
}
```

And this calculates
$(n-1)^n$

9 votes -- Pragy Agarwal (19.5k points)

1.13.5 Recurrence: GATE1992-07b top

http://gateoverflow.in/43600

```
Function F(n)
begin
F1 ← 1
if(n=1) then F ← 3  //if (n==1) then return 3
 else
   For i = 1 to n do
        begin
            C ← 0
           For j = 1 to n - 1 do //inner loop runs n-1 times outer loop runs for n times
           begin C ← C + 1 end   //means C=n-1
           F1 = F1 * C  //means n-1 is getting multiplied n times so ans is (n-1)^n for n>=2
       end
    F = F1
end
```

5 votes -- Rajesh Pradhan (18.6k points)

1.13.6 Recurrence: GATE1993_15 top

http://gateoverflow.in/2312

Selected Answer

$a_n = a_{n-1}$ + n-1 (n-1 comparisons for n numbers)

$a_n = a_{n-2}$ + (n-2) + (n-1)

$a_n = a_{n-3}$ + (n-3) + (n-2) + (n-1)

.

.

$a_n = a_{n-n}$ + (n-n) + (n-(n-1)) + ... + (n-3) + (n-2) + (n-1)

a_n = 0 + 1 + 2 + ...+ (n-3) + (n-2) + (n-1)

which given $a_n = \frac{(n-1)\times(n)}{2}$

9 votes -- Rajarshi Sarkar (35k points)

1.13.7 Recurrence: GATE1994-1.7, ISRO2017-14 top

http://gateoverflow.in/2444

Selected Answer

It is B. searching for only one half of the list. leading to T(n/2) + constant time in comparing and finding mid element.

11 votes -- Gate Keeda (19.1k points)

1.13.8 Recurrence: GATE1996_2.12 top

http://gateoverflow.in/2741

Selected Answer

Answer: A

According to Master theorem,
$T(n) = aT(\frac{n}{b}) + f(n)$ can be expressed as:
$T(n) = [n^{\log_b a}][T(1) + u(n)]$
where $u(n) = \Theta(h(n))$ where $h(n) = \frac{f(n)}{n^{\log_b a}} = \frac{n}{n^{\log_4 3}} = n^{1-\log_4 3}$ as $h(n) = n^r$ where $r > 0$.
So, $T(n) = [n^{\log_b a}][T(1) + u(n)] = T(n) = [n^{\log_4 3}][T(1) + \Theta(n^{1-\log_4 3})] = \Theta(n^1)$.

👍 7 votes -- Rajarshi Sarkar (35k points)

1.13.9 Recurrence: GATE1997_4.6 top

http://gateoverflow.in/2247

Selected Answer

answer B

using master method (case 1)

where a = 2, b = 2

O($n^{1/2}$) < O($n^{\log_b a}$)

O($n^{1/2}$) < O($n^{\log_2 2}$)

👍 7 votes -- ankitrokdeonsns (9.1k points)

1.13.10 Recurrence: GATE1998-6a top

http://gateoverflow.in/44584

Selected Answer

$$T(n) = 2T(n-1) - 1 = 2(2T(n-2) - 1) - 1 = 2^2T(n-2) - 2 - 1 = 2^2(2T(n-3) - 1) - 2 - 1 = 2^3T(n-3) - 2^2$$

👍 7 votes -- srestha (58.4k points)

1.13.11 Recurrence: GATE2002-1.3 top

http://gateoverflow.in/807

Selected Answer

Let $x = 2^k$

$T(x) = 3T\left(\frac{x}{2}\right) + 1$

We can apply Master's theorem case 1 with $a = 3$ and $b = 2$ as $f(x) = 1 = O\left(x^{\log_2 3 - \epsilon}\right), \epsilon > 0$

So, $T(x) = \Theta\left(x^{\log_2 3}\right) = \Theta\left(2^{k \log_2 3}\right) = \Theta\left(2^{\log_2 3^k}\right) = \Theta\left(3^k\right)$

So, only option possible is B.

We can also directly solve as follows:

$$T(x) = 3T\left(\frac{x}{2}\right) + 1 = 9T\left(\frac{x}{4}\right) + 1 + 3 \ldots = 3^{\log_2 2^k} + \left(1 + 3 + 9 + \cdots + 3^{\log_2 2^k - 1}\right) (\text{recursion depth is } \log_2 x \text{ and } x = 2$$

OR

$$T\left(2^k\right) = 3T\left(2^{k-1}\right) + 1 = 3^2T\left(2^{k-2}\right) + 1 + 3 \ldots = 3^kT\left(2^{k-k}\right) + \left(1 + 3 + 9 + \cdots + 3^{k-1}\right) (\text{recursion depth is } k) = 3^k +$$

👍 19 votes -- Arjun Suresh (294k points)

1.13.12 Recurrence: GATE2002-2.11 top

http://gateoverflow.in/841

Selected Answer

The complexity will be the number of times the recursion happens which is equal to the number of times we can take square root of n recursively, till n becomes 2.

$T(n) = T\left(\lceil \sqrt{n} \rceil\right) + 1$

$T(2) = 1$
$T\left(2^2\right) = T(2) + 1 = 2$
$T\left(2^{2^2}\right) = T(4) + 1 = 3$
$T\left(2^{2^3}\right) = T(16) + 1 = 4$

So, $T(n) = \lg \lg n + 1 = O\left(\log \log n\right)$

23 votes -- Arjun Suresh (294k points)

1.13.13 Recurrence: GATE2003-35 top

http://gateoverflow.in/925

Selected Answer

$T(m^2) = T(m^2 - 1) + \left\lfloor \sqrt{(m^2)} \right\rfloor$

$= T(m^2 - 2) + \left\lfloor \sqrt{(m^2 - 1)} \right\rfloor + \left\lfloor \sqrt{(m^2)} \right\rfloor$

$= T(m^2 - 3) + \left\lfloor \sqrt{(m^2 - 2)} \right\rfloor + \left\lfloor \sqrt{(m^2 - 1)} \right\rfloor + \left\lfloor \sqrt{(m^2)} \right\rfloor$

$= \dots$

$= T(1) + \left\lfloor \sqrt{(2)} \right\rfloor + \left\lfloor \sqrt{(3)} \right\rfloor + \dots + \left\lfloor \sqrt{(m^2)} \right\rfloor$

$= 3 \times 1 + 5 \times 2 + \dots + (2m - 1) \times (m - 1) + m$ (We are taking floor of square root of numbers, and between successive square roots number of numbers are in the series $3, 5, 7 \dots$ like 3 numbers from $1..4$, 5 numbers from $5 - 9$ and so on).

We can try out options here or solve as shown at end:

Put $m = 5, T(25) = 3 \times 1 + 5 \times 2 + 7 \times 3 + 9 \times 4 + 5 = 75$

Option A: 59
Option B: 75
Option C: non-integer
Option D: 297.5

So, answer must be B.

$T(m^2) = 3 \times 1 + 5 \times 2 + \dots + (2m - 1) \times (m - 1) + m = m + \sum_i = 1^{m-1} (2i + 1).(i) = m + \sum_i = 1^{m-1} 2i^2 + i = m$

[Sum of the first
n natural numbers
$= \frac{n.(n+1)}{2}.$

Sum of the squares of first
n natural numbers
$= \frac{n.(n+1).(2n+1)}{6}.$]

11 votes -- Arjun Suresh (294k points)

1.13.14 Recurrence: GATE2004-83, ISRO2015-40 top

http://gateoverflow.in/1077

Selected Answer

option D

```
int recursive (int n) {
    if(n == 1)                      // takes constant time say 'A' time
        return (1);                 // takes constant time say 'A' time
    else
        return (recursive (n-1) + recursive (n-1)); // takes T(n-1) + T(n-1)  time
}
```

$T(n) = 2T(n-1) + a$ is the recurrence equation found from the pseudo code .

Solving the Recurrence Equation By Back Substitution Method

$T(n) = 2T(n-1) + a$ ---------(equation 1)

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

$T(n-2) = 2T(n-3) + a$

We can re write Equation 1 as

$$\begin{aligned} T(n) &= 2[2T(n-2) + a] + a = 4T(n-2) + 3a \\ &= 2[2T(n-3) + a] + 3a = 8T(n-3) + 7a \\ &\dots \\ &= 2^k T(n-k) + 2^{k-1} a \end{aligned}$$ ------ (Equation 2)

On Substituting Limiting Condition

$T(1) = 1$ implies $n - k = 1 \implies k = n - 1$

Therefore Equation 2 becomes

$$2^{n-1} + 2^{n-2} a = O(2^n)$$

15 votes -- pC (21.4k points)

1.13.15 Recurrence: GATE2004-84 top

http://gateoverflow.in/1078

Selected Answer

$T(n) = 2T(n-1) + n, n >= 2, T(1) = 1$

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

$= n(1 + 2 + \dots + 2^{n-1}) - (1.2 + 2.2^2 + 3.2^3 + \dots + (n-1).2^{n-1})$

$= n(2^n - 1) - (n.2^n - 2^{n+1} + 2)$

$= 2^{n+1} - n - 2$

26 votes -- suraj (5.1k points)

T(1) = 1

T(2) = 4

T(3) = 11

T(4) = 26

T(5) = 57

T(6) = 120

T(7) = 247

So,

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

30 votes -- Arjun Suresh (294k points)

1.13.16 Recurrence: GATE2004-IT-57 top http://gateoverflow.in/3700

Selected Answer

answer B

5 votes -- Sankaranarayanan P.N (11.2k points)

1.13.17 Recurrence: GATE2005-IT-51 top http://gateoverflow.in/3812

Selected Answer

Option C it can be done by Master theorem.

$n^{\log_b a} = n^{\log_2 2} = n$.

$f(n) = \sqrt{n} = n^{\frac{1}{2}}$.

So, $f(n) = O\left(n^{\log_b a - \epsilon}\right)$ is true for any real ϵ, $0 < \epsilon < \frac{1}{2}$. Hence Master theorem Case 1 satisfied,

$$T(n) = \Theta\left(n^{\log_b a}\right) = \Theta(n).$$

13 votes -- Bhagirathi Nayak (13.3k points)

1.13.18 Recurrence: GATE2006-51, ISRO2016-34 top http://gateoverflow.in/1829

Selected Answer

$T(n) = 2T\left(n^{\frac{1}{2}}\right) + 1 = 2\left(2T\left(n^{\frac{1}{2^2}}\right) + 1\right) + 1 = 4 \times T\left(n^{\frac{1}{2^2}}\right) + 5 = 8 \times T\left(n^{\frac{1}{2^3}}\right) + 13 \dots = 2^{(\lg \lg n)} + 2 \times \lg \lg n + 1$

$n^{\frac{1}{2^k}} = 2(\text{Putting 2 so that we can take log.One more step of recurrence can't change the complexity.}) \implies \frac{1}{2^k} \lg n = 1($

So, answer is B, $T(n) = \Theta(\log n)$

19 votes -- Arjun Suresh (294k points)

1.13.19 Recurrence: GATE2008-78 top http://gateoverflow.in/497

Selected Answer

0 1 -2
01 10 11 -3
010 011 101 110 111 -5
0101 0110 0111 1010 1011 1101 1110 1111 -8

So, $x_n = x_{n-1} + x_{n-2}$ (For all the strings ending in 1, we get two new strings and for all strings ending in 0, we get a new string. So, the new set of strings for n+1, will have exactly n strings ending in 1)

x_5 = 8+5 = 13

12 votes -- Arjun Suresh (294k points)

1.13.20 Recurrence: GATE2008-79 top http://gateoverflow.in/43485

Selected Answer

Number of binary strings of length n that contain no consecutive 0s, following will be the required recurrence relation:

T(n) = T(n-1) + T(n-2)   n>2
base condition T(1) = 2   and T(2) = 3

T(1) =2   There will be 2 strings of length 1, i.e 0 & 1
T(2) =3   There will be 3 strings of length 2, i.e. 01,10,11
T(3) = T(1) + T(2) = 2+3 = 5
T(4) = T(3) + T(2) = 5 + 3 = 8
T(5) = T(4) +T(3) = 8 + 5 = 13

Hence, answer is 13, but no option matches!

4 votes -- Vijay Thakur (15.4k points)

1.13.21 Recurrence: GATE2008-IT-44 top http://gateoverflow.in/3354

Selected Answer

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

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

$\dots$

$= \sqrt{2}^{\lg n} T(1) + \lg n \sqrt{n}$

$= \sqrt{n} + \lg n \sqrt{n}$

$= \sqrt{n}\,(\lg n + 1)$

If we use Master theorem we get option B. But one must know that Matser theorem is used to find the asymptotic bound and not an EXACT value. And in the question here it explicitly says **"evaluates to"**.

26 votes -- Arjun Suresh (294k points)

1.13.22 Recurrence: GATE2009-35 top http://gateoverflow.in/1321

Selected Answer

$a = 1, b = 3, \log_b a = 0$

So $n^{\log_b a} = n^0 = 1$

$f(n) = n$

So, $f(n) = \Omega(1)$

To, check Master theorem case 3, we need $c > 0$,

$f(n/3) \leq cf(n)$

$c = 1$

So using case three of master theorem

$T(n) = \Theta(f(n)) = \Theta(n)$

answer is a

11 votes -- Pooja Palod (32.4k points)

1.13.23 Recurrence: GATE2012-16 top

http://gateoverflow.in/48

Selected Answer

Recurrence relation for ***Towers of Hanoi*** is

T(1) = 1

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

So Answer should be **(D)**

13 votes -- Narayan Kunal (419 points)

1.13.24 Recurrence: GATE2014-2-13 top

http://gateoverflow.in/1968

Selected Answer

$f(n) = \log n$

$a = 2, b = 2 \implies n^{\log_b a} = n$

So, $f(n) = \log n = O\left(n^{1-\epsilon}\right)$, we can take any ϵ from 0-1 for example 0.5 which gives $\log n = O(\sqrt{(n)})$, whose proof is given here: http://math.stackexchange.com/questions/145739/prove-that-logn-o-sqrtn

So, Master theorem Case 1, and answer will be $O\left(n^{\log_2 2}\right) = O(n)$

Alternate way:

$T(1) = 1T(2) = 2T(1) + \log 2 = 3 = 3n - 2T(4) = 2T(2) + \log 4 = 8 = 3n - 4T(8) = 2T(4) + \log 8 = 19 = 3n - 5T($

The second term being subtracted is growing at a lower rate than the first term. So, we can say $T(n) = O(n)$.

20 votes -- Arjun Suresh (294k points)

1.13.25 Recurrence: GATE2015-1_49 top

http://gateoverflow.in/8355

Selected Answer

Counting the number of bit strings NOT containing two consecutive 1's. (It is easy to derive a recurrence relation for the NOT case as shown below.)

0 1
00 01 10 - 3 (append both 0 and 1 to any string ending in 0, and append 0 to any string ending in 1)
000 001 010 100 101 - 5 (all strings ending in 0 give two strings and those ending in 1 give 1 string)
0000 0001 0010 0100 0101 1000 1001 1010 - 8
....

$a_n' = a_{n-1}' + a_{n-2}'$ (where a_n denote the number of bit strings of length n containing two consecutive 1s)

$2^n - a_n = (2^{n-1} - a_{n-1}) + (2^{n-2} - a_{n-2})$

$a_n = 2^{n-2}(4 - 2 - 1) + a_{n-1} + a_{n-2}$

$a_n = a_{n-1} + a_{n-2} + 2^{n-2}$

A choice.

22 votes -- Arjun Suresh (294k points)

Strings of Length	Number of valid Strings
1	0
2	1
3	3
4	8

apply value putting and try to satisfy options using these values.
only option A holds good.

answer = **option A**

10 votes -- Amar Vashishth (28.7k points)

1.13.26 Recurrence: GATE2015-3_39 top

http://gateoverflow.in/8498

Selected Answer

T(n) = T(n-1) + T(n-3) + 2, here T(n) denotes the number of times a recursive call is made for input n. 2 denotes the two direct recursive calls.

T(n<=0) = 0
T(1) = 2
T(2) = 4
T(3) = 6
T(4) = 10
T(5) = 16
T(6) = 24

So, answer is 24 + 1 call from main = 25.

27 votes -- Arjun Suresh (294k points)

1.13.27 Recurrence: GATE2017-2-30 top

http://gateoverflow.in/118623

Selected Answer

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

Put, $n = 2^m$

$T(2^m) = 2T(2^{m/2}) + 1$

put,$T(2^m) = s(m)$

$s(m) = 2s(m/2) + 1$

Using case 1 of master method ,

$= \Theta(m) = \Theta(\log n)$

http://gateoverflow.in/1829/gate2006-51-isro2016-34?show=37791#c37791

6 votes -- jatin saini (2.1k points)

1.13.28 Recurrence: TIFR2014-B-11 top

http://gateoverflow.in/27308

OPTION b is false

c) apply Akra-Bazzi method .

for ex k=4, then eq is T(n)=T(n/4)+T(3n/4)+n

let g(n)=n and a1=1,b1=1/4,a2=1,b2=3/4

then ∑ ai (bi)p=1 :: 1 (1/4)p + 1 (3/4)p =1 --> p=1

then T(n)=O(np(1+1∫n (g(u) / u1+p).du)

=n(1+1∫n u/u2 du

=n(1+logn)

=O(nlogn) ::option c is correct

d) apply back substitution

if k=5 T(n)=T(n/5) + T(3n/4)+n ---eq1

T(n/5)=T(n/52) + T((1/5)(3/4)n)+n/5

T(3n/4)=T((3/4)((1/5)n)+T((3/4)2n)+3n/4 substitute in eq1

we got T(n)=T(n/52) + 2 T((1/5)(3/4)n)+T((3/4)2n)+n(1/5+3/4) +n

in the next we get T(n)=T(n/53)+--+n(1/5+3/4)2+n(1/5+3/4) +n

T(n)=T(n/53)+--+n(19/20)2+n(19/20) +n

T(n)=T(n/5k) + --+n(1+(19/20)+(19/20)2)+--(19/20)k-1)

T(n)=T(n/5k)+--+n(-(19/20)k +1)/(1/20))

n/5k=1 --> k=logn

::T(n)=1+ 20 n- 20 n(19/20)logn)

:: T(n)=O(n) which inturn O(n logn) both d,e are correct

a)by observing option a &b T(n)=(n √n) T(n)=O(n logn) and logn=O(√n)

so if option b is correct then option a is also correct ----> so option b is false (we can eliminate)

4 votes -- venky.victory35 (673 points)

1.13.29 Recurrence: TIFR2015-B-1 top

http://gateoverflow.in/29657

Selected Answer

Let $n = 2^k$

$T\left(2^k\right) = 2T\left(2^{k/2}\right) + k$

Let $T\left(2^k\right) = S(k) \implies T\left(2^{k/2}\right) = S(k/2)$

$S(k) = 2S(k/2) + k$

This gives $S(k) = \Theta(k \log k)$ (Master theorem case 2)

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

So ans is b

8 votes -- Pooja Palod (32.4k points)

1.14 Searching(8) top

1.14.1 Searching: GATE1996-18 top http://gateoverflow.in/2770

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

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

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

gate1996 algorithms searching normal

Answer

1.14.2 Searching: GATE1996-2.13, ISRO2016-28 top http://gateoverflow.in/2742

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

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

gate1996 algorithms easy isro2016 searching

Answer

1.14.3 Searching: GATE2002-2.10 top http://gateoverflow.in/840

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

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

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

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

gate2002 searching normal

Answer

1.14.4 Searching: GATE2008-84 top http://gateoverflow.in/394

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

```
    f (int Y[10] , int x) {
```

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

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

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

gate2008 algorithms searching normal

Answer

1.14.5 Searching: GATE2008-85 top

http://gateoverflow.in/43508

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

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

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

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

gate2008 algorithms searching normal

Answer

1.14.6 Searching: GATE2017-1-48 top

http://gateoverflow.in/118331

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

gate2017-1 algorithms normal numerical-answers searching

Answer

1.14.7 Searching: TIFR2010-B-29 top

http://gateoverflow.in/18752

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

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

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

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

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

tifr2010 searching

Answer

1.14.8 Searching: TIFR2012-B-11 top

http://gateoverflow.in/25140

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

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

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

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

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

tifr2012 algorithms searching

Answer

Answers: Searching

1.14.1 Searching: GATE1996-18 top

http://gateoverflow.in/2770

Selected Answer

the code is wrong here ....k=(i+j) / 2;

if(a[k] < x) then i = k ;
else j = k ;

the (correct) code should be ..

k=(i+j) / 2;

if(a[k] < x) then i = k +1 ;
else j = k -1 ;

try an example ....with given code in question
let an array a[1,2,3,4,5,6,7,8,9,10]
index number 1,2,3,4,5,6,7,8,9,10
and x=10 ; now run the code ;

initially i = 1 ,j=10;
first time k =(i+j) /2 = 11/2 =5.5 = 5 (because of integer type) =i
second time = k =(i+j) /2 =15/2 =7.5 =7 =i
third time = k =(i+j) /2 = 17/2 = 8.5 = 8 =i

fourth time = k =(i+j) /2 = 18/2 = 9 = i fifth time = k =(i+j) /2 = 19/2 = 9.5 =9 = i

sixth time = k =(i+j) /2 = 19/2 = 9.5 =9 = i

seventh time = k =(i+j) /2 = 19/2 = 9.5 =9 = i
....
going to infinite loop (run time error) .... ;

for terminating loop , it should be , i = k + 1 instead of i =k ;and j = k - 1 instead of j = k ;
correct me ....???

12 votes -- Mithlesh Upadhyay (5.4k points)

1.14.2 Searching: GATE1996-2.13, ISRO2016-28 top http://gateoverflow.in/2742

Selected Answer

Expected number of comparisons
= 1 × Probability of first element be x + 2 × Probability of second element be x + ... +n × Probability of last element be x.

$= \frac{1}{n} + \frac{2}{n} + \frac{3}{n} + \ldots + \frac{n}{n}$

$= \frac{\left(\frac{n \times (n+1)}{2}\right)}{n}$

$= \frac{n+1}{2}$

32 votes -- Arjun Suresh (294k points)

First consider smaller example...
say list given = {3,1,2} and say you want to search element '2' in sequential way.So first you will visit first element and compare it with '2' .If it is '2' then your search will end at first element with only 1 comparison. But if it is not equal to '2',then you compare it with second element. so second element is '1' so again search was unsuccessful and comparison required was total '2' i.e. b/w '2' & '3' and b/w '2' & '1' and so on.
So if required element is found at first position , no of comparison = 1;
if required element is found at second position , no of comparison = 2 ...and so on.

Now since our list is not sorted so it can be anything e.g. list can be {1,2,3} or {3,2,1} or {2,3,1}etc.So the element we are looking for may be present at any of these three positions with equal chances of 1/3.

Now consider our list containing 'n' elements. So element to be searched can be present at any of these 'n' positions in the list with equal chance(probability) of 1/n.

Total comparison required = No.of comparison if element present in 1st position + No.of comparison if element present in 2nd position + ...+ No.of comparison if element present in nth position
= 1 + 2 + 3+ ......+n = n(n+1)/2
Since there are 'n' elements in the list.
So avg. no. of comparison = Total comparison/total no of elements = [n(n+1)/2] / n = (n+1)/2.

14 votes -- Shashank Kumar (3.5k points)

1.14.3 Searching: GATE2002-2.10 top http://gateoverflow.in/840

Selected Answer

Expected number of comparisons (E) = 1 * Probability of find on first comparison + 2 * Probability of find on second comparison + ... + i* Probability of find on i^{th} comparison + ...

$= 1 \times \frac{1}{n} + 2 \times \frac{n-1}{n^2} + 3 \times \frac{(n-1)^2}{n^3} + \ldots$

$= \frac{1/n}{1 - \frac{n-1}{n}} + \frac{(n-1)/n^2}{\left(1 - \frac{n-1}{n}\right)^2} \left(\text{Sum to infinity of aritmetico-geometric series with } a = \frac{1}{n}, r = \frac{n-1}{n} \text{ and } d = \frac{1}{n}\right) = 1 + n - 1 = n$

Ref: https://en.wikipedia.org/wiki/Arithmetico-geometric_sequence

Or we can also do,

$$E = 1 \times \frac{1}{n} + 2 \times \frac{n-1}{n^2} + 3 \times \frac{(n-1)^2}{n^3} + \dots$$

$$E\frac{n-1}{n} = \frac{n-1}{n^2} + 2 \times \frac{(n-1)^2}{n^3} + 3 \times \frac{(n-1)^3}{n^4} + \dots$$

$$E - E\frac{n-1}{n} = \frac{1}{n} + \frac{n-1}{n^2} + \frac{(n-1)^2}{n^3} + \dots$$

$$E.\frac{1}{n} = \frac{(1/n)}{1-\frac{n-1}{n}} = 1 \left(\text{Sum to infinity of GP with } a = \frac{1}{n} \text{ and } r = \frac{n-1}{n}\right) \implies E = n$$

26 votes -- Arjun Suresh (294k points)

Why is the third term $2 \times \frac{n-1}{n} \times \frac{1}{n-1}$, and not $2 \times \frac{n-1}{n} \times \frac{1}{n}$

The way I see it, the probability of getting it in 2nd try is: Probability of failing at first trial times probability of succeeding in 2nd trial.

It's not like we are removing one element from the list after the first trial.

Here is my calculation and proof:

```
>>> def expec(n, trials):
        x = rand(1,n)
        count = 0
        for _ in range(trials):
                while rand(1,n)!=x:
                        count+=1
                count+=1
        return count/trials

>>> expec(5, 100000)
4.96281
>>> expec(5, 100000)
4.99996
>>> expec(5, 1000000)
5.008354
>>> expec(5, 1000000)
5.014607
>>> expec(5, 10000000)
5.0016018
>>> expec(10, 1000000)
9.999555
>>> expec(100, 100000)
100.1595
>>> |
```

10 votes -- Pragy Agarwal (19.5k points)

1.14.4 Searching: GATE2008-84 top

http://gateoverflow.in/394

Selected Answer

for Q.84

when it is **option C** the control will continue to iterate as $i = 8$ and $j = 9$;
again and again i will be assigned k which itself equals 8 as $\frac{8+9}{2}$ being stored in an integer type variable, will evaluate to 8.

For option A, with $x = 9$, k will take the following values:

- 4
- 6
- 7
- 8 - y[8] = 9, x found

For option D, with $x = 10$, k will take the following values:

- 4, y[4] = 10, x found

15 votes -- Amar Vashishth (28.7k points)

1.14.5 Searching: GATE2008-85 top http://gateoverflow.in/43508

Selected Answer

Ans should be A

```
if( Y[k] < x) then i = k + 1;
```

if given element that we are searching is greater then searching will be continued upper half of array

otherwise **j = k - 1;**

lower half.

Take few case in consideration i.e.

1. all elements are same

2. increasing order with no repeatation

3. increasing order with repeatation.

8 votes -- Manoj Kumar (37.5k points)

1.14.6 Searching: GATE2017-1-48 top http://gateoverflow.in/118331

Selected Answer

Here since 0 s are followed by 1s so we have a sorted sequence and we can apply binary search..

at each stage we compare with (low + high)/2 th element index and if its 1 we check left and if its 0 we check right...

total worst case probes is ceil(Log31(base2))=5

so answer is 5

13 votes -- sriv_shubham (2.7k points)

1.14.7 Searching: TIFR2010-B-29 top http://gateoverflow.in/18752

Selected Answer

Option D is the correct answer.

We can simply use clever indexing to binary search the element in the odd positions, and in the even positions separately.

This will take $O(\log n)$ time and $O(1)$ space in the worst case.

A: Sorting using Quicksort will take $O(n^2)$ time.
B: Merging will take $O(n)$ time and $O(n)$ space.
C: Binary search only works on a sorted array.
E: Sequential search will take $O(n)$ time.

11 votes -- Pragy Agarwal (19.5k points)

1.14.8 Searching: TIFR2012-B-11 top http://gateoverflow.in/25140

Selected Answer

first program wont work if array has elements same..it may go into infinite loop .To make it work it properly we have to do following changes j=k-1 and i=k+1

For second program a[k]==x condition is missing so it is wrong

Third program is also wrong as j!=k-1 and condition a[k]==x is missing

So ans is e

7 votes -- Pooja Palod (32.4k points)

1.15 Sorting(53) top

1.15.1 Sorting: CMI2011-B-06a top http://gateoverflow.in/46212

Consider a plate stacked with several disks, each of a different diameter (they could all be, for instance, $dosas$ or $chapatis$ of different sizes). We want to sort these disks in decreasing order according to their diameter so that the widest disk is at the bottom of the pile. The only operation available for manipulating the disks is to pick up a stack of them from the top of the pile and invert that stack. (This corresponds to lifting up a stack $dosas$ or $chapatis$ between two big spoons and flipping the stack.)

i. Give an algorithm for sorting the disks using this operation.

cmi2011 descriptive algorithms sorting

Answer

1.15.2 Sorting: CMI2013-A-05 top http://gateoverflow.in/46595

You have n lists, each consisting of m integers sorted in ascending order. Merging these lists into a single sorted list will take time:

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

cmi2013 algorithms sorting

Answer

1.15.3 Sorting: GATE 2016-1-13 top http://gateoverflow.in/39660

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

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

gate2016-1 algorithms sorting easy

Answer

1.15.4 Sorting: GATE 2016-2-13 top http://gateoverflow.in/39561

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

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

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

gate2016-2 algorithms sorting time-complexity normal ambiguous

Answer

1.15.5 Sorting: GATE1987-1-xviii top

http://gateoverflow.in/80366

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

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

gate1987 algorithms sorting

Answer

1.15.6 Sorting: GATE1988-1iii top

http://gateoverflow.in/91338

Quicksort is ________ efficient than heapsort in the worst case.

gate1988 algorithms sorting

Answer

1.15.7 Sorting: GATE1991_01,vii top

http://gateoverflow.in/505

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

gate1991 normal algorithms sorting

Answer

1.15.8 Sorting: GATE1991_13 top

http://gateoverflow.in/540

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

gate1991 sorting time-complexity algorithms difficult

Answer

1.15.9 Sorting: GATE1992_02,ix top

http://gateoverflow.in/559

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

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

(a). Heap sort

(b). Quick sort

(c). Merge sort

(d). Radix sort

gate1992 easy algorithms sorting

Answer

1.15.10 Sorting: GATE1992_03,iv top http://gateoverflow.in/581

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

gate1992 algorithms sorting easy

Answer

1.15.11 Sorting: GATE1994-1.19, ISRO2016-31 top http://gateoverflow.in/2462

Algorithm design technique used in quicksort algorithm is?

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

gate1994 algorithms sorting easy isro2016

Answer

1.15.12 Sorting: GATE1995_1.16 top http://gateoverflow.in/2603

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

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

gate1995 algorithms sorting normal

Answer

1.15.13 Sorting: GATE1995_1.5 top http://gateoverflow.in/2592

Merge sort uses

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

gate1995 algorithms sorting easy

Answer

1.15.14 Sorting: GATE1995_12 top http://gateoverflow.in/2648

Consider the following sequence of numbers

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

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

gate1995 algorithms sorting easy

Answer

1.15.15 Sorting: GATE1996-14 top

http://gateoverflow.in/2766

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

Fill in the blanks:

a. The smallest item in the array is at $A[i][j]$ where $\boxed{i=\_\_}$ and $\boxed{j=\_\_.}$
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

Answer

1.15.16 Sorting: GATE1996_2.15 top

http://gateoverflow.in/2744

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

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

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

1.15.17 Sorting: GATE1998-1.22 top

http://gateoverflow.in/1659

Give the correct matching for the following pairs:

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

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

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

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

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

gate1998 algorithms sorting easy

Answer

1.15.18 Sorting: GATE1999-1.14, ISRO2015-42 top

http://gateoverflow.in/1467

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

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

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

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

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

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

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

gate1999 algorithms sorting normal isro2015

Answer

1.15.19 Sorting: GATE1999-8 top

http://gateoverflow.in/1507

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

gate1999 algorithms sorting normal descriptive

Answer

1.15.20 Sorting: GATE1999_1.12 top

http://gateoverflow.in/1465

A sorting technique is called stable if

A. it takes $O(n \log n)$ time

B. it maintains the relative order of occurrence of non-distinct elements

C. it uses divide and conquer paradigm

D. it takes $O(n)$ space

gate1999 algorithms sorting easy

Answer

1.15.21 Sorting: GATE2000-17 top

http://gateoverflow.in/688

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

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

gate2000 algorithms sorting normal descriptive

Answer

1.15.22 Sorting: GATE2001-1.14 top http://gateoverflow.in/707

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

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

gate2001 algorithms sorting time-complexity easy

Answer

1.15.23 Sorting: GATE2003-22 top http://gateoverflow.in/912

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

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

gate2003 algorithms sorting time-complexity normal

Answer

1.15.24 Sorting: GATE2003-61 top http://gateoverflow.in/949

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

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

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

gate2003 algorithms sorting normal

Answer

1.15.25 Sorting: GATE2003-62 top http://gateoverflow.in/43576

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

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

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

gate2003 algorithms sorting normal

Answer

1.15.26 Sorting: GATE2005-39 top http://gateoverflow.in/784

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

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

gate2005 algorithms sorting normal

Answer

1.15.27 Sorting: GATE2005-IT-59 top

http://gateoverflow.in/3820

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

I. a[i] ≥ b [i] => c[2i] ≥ a [i]
II. a[i] ≥ b [i] => c[2i] ≥ b [i]
III. a[i] ≥ b [i] => c[2i] ≤ a [i]
IV. a[i] ≥ b [i] => c[2i] ≤ b [i]

Which of the following is TRUE?

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

gate2005-it algorithms sorting normal

Answer

1.15.28 Sorting: GATE2006-14, ISRO2011-14 top

http://gateoverflow.in/975

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

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

gate2006 algorithms sorting easy isro2011

Answer

1.15.29 Sorting: GATE2006-52 top

http://gateoverflow.in/1830

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

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

gate2006 algorithms sorting easy

Answer

1.15.30 Sorting: GATE2007-14 top

http://gateoverflow.in/1212

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

A. Merge sort

B. Bubble sort

C. Quick sort

D. Selection sort

gate2007 algorithms sorting time-complexity easy

Answer

1.15.31 Sorting: GATE2008-43 top

http://gateoverflow.in/455

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

A. $T(n) \leq 2T(n/5) + n$

B. $T(n) \leq T(n/5) + T(4n/5) + n$

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

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

gate2008 algorithms sorting easy

Answer

1.15.32 Sorting: GATE2008-IT-43 top

http://gateoverflow.in/3353

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

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

gate2008-it algorithms sorting normal

Answer

1.15.33 Sorting: GATE2009-11 top

http://gateoverflow.in/1303

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

A. $\Theta(n)$

B. $\Theta(n \log n)$

C. $\Theta(n^2)$

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

gate2009 algorithms sorting easy

Answer

1.15.34 Sorting: GATE2009-39 top

http://gateoverflow.in/1325

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

A. $\Theta(n)$

B. $\Theta(n \log n)$

C. $\Theta(n^2)$

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

gate2009 algorithms sorting normal

Answer

1.15.35 Sorting: GATE2012_39 top http://gateoverflow.in/1762

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

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

gate2012 algorithms sorting normal

Answer

1.15.36 Sorting: GATE2013_30 top http://gateoverflow.in/1541

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

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

gate2013 algorithms sorting normal

Answer

1.15.37 Sorting: GATE2013_6 top http://gateoverflow.in/1415

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

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

gate2013 algorithms sorting easy

Answer

1.15.38 Sorting: GATE2014-1-14 top http://gateoverflow.in/1780

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

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

gate2014-1 algorithms sorting easy

Answer

1.15.39 Sorting: GATE2014-2-38 top http://gateoverflow.in/1997

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

gate2014-2 algorithms sorting normal numerical-answers

Answer

1.15.40 Sorting: GATE2014-3-14 top

http://gateoverflow.in/2048

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

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

gate2014-3 algorithms sorting easy

Answer

1.15.41 Sorting: GATE2015-1_2 top

http://gateoverflow.in/8017

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

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

gate2015-1 algorithms recurrence sorting easy

Answer

1.15.42 Sorting: GATE2015-2-45 top

http://gateoverflow.in/8243

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

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

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

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

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

The missing arguments lists are respectively

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

gate2015-2 algorithms normal sorting

Answer

1.15.43 Sorting: GATE2015-3_27 top http://gateoverflow.in/8480

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

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

gate2015-3 algorithms sorting

Answer

1.15.44 Sorting: ISI2011-A-2a top http://gateoverflow.in/48028

Give a strategy to sort four given distinct integers a, b, c, d in increasing order that minimizes the number of pairwise comparisons needed to sort any permutation of a, b, c, d.

descriptive isi2011 algorithms sorting

Answer

1.15.45 Sorting: TIFR2010-B-23 top http://gateoverflow.in/18623

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

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

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

tifr2010 algorithms time-complexity sorting

Answer

1.15.46 Sorting: TIFR2010-B-27 top http://gateoverflow.in/19036

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

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

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

a. There is no input on which insertion Sort makes n (n - 1) / 2 comparisons.
b. Insertion Sort makes n (n - 1) / 2 comparisons when the input is already sorted in ascending order.
c. Insertion Sort makes n (n - 1) / 2 comparisons only when the input is sorted in descending order.
d. There are more than one input orderings where insertion sort makes n (n - 1) / 2 comparisons.
e. Insertion Sort makes n (n - 1) / 2 comparisons whenever all the elements of L are not distinct.

tifr2010 algorithms sorting

Answer

1.15.47 Sorting: TIFR2011-B-21 top http://gateoverflow.in/20324

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

a. This problem can be solved in $O(\log n)$ time.
b. This problem can be solved in $O(n)$ time but not in $O(\log n)$ time.
c. This problem can be solved in $O(n \log n)$ time but not in $O(n)$ time.
d. This problem can be solved in $O\left(n^2\right)$ time but not in $O(n \log n)$ time.
e. None of the above.

tifr2011 algorithms sorting

Answer

1.15.48 Sorting: TIFR2011-B-31 top http://gateoverflow.in/20617

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

a. Both these elements can be determined using $2k$ comparisons.
b. Both these elements can be determined using $n - 2$ comparisons.
c. Both these elements can be determined using $n + k - 2$ comparisons.
d. $2n - 3$ comparisons are necessary to determine these two elements.
e. nk comparisons are necessary to determine these two elements.

tifr2011 algorithms sorting

Answer

1.15.49 Sorting: TIFR2011-B-39 top http://gateoverflow.in/20935

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

a. At least n comparisons are necessary in the worst case.
b. At least $\log m$ comparisons are necessary in the worst case.
c. $O(\log(m - n))$ comparisons suffice.
d. $O(\log n)$ comparisons suffice.
e. $O(\log(m/n))$ comparisons suffice.

tifr2011 algorithms sorting

Answer

1.15.50 Sorting: TIFR2012-B-13 top http://gateoverflow.in/25207

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

a. A can be sorted with constant $. kn$ comparison but not with fewer comparisons.
b. A cannot be sorted with less than constant $. n \log n$ comparisons.
c. A can be sorted with constant $. n$ comparisons.
d. A can be sorted with constant $. n \log k$ comparisons but not with fewer comparisons.
e. A can be sorted with constant $. k^2 n$ comparisons but not fewer.

tifr2012 algorithms sorting

Answer

1.15.51 Sorting: TIFR2012-B-14 top http://gateoverflow.in/25209

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

a. The running time of the algorithm is $\Theta(n)$.

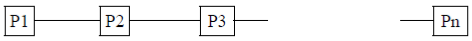
b. The running time of the algorithm is $\Theta(n \log n)$.
c. The running time of the algorithm is $\Theta(n^{1.5})$.
d. The running time of the algorithm is $\Theta(n^2)$.
e. None of the above.

tifr2012 algorithms sorting

Answer

1.15.52 Sorting: TIFR2013-B-20 top http://gateoverflow.in/25878

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



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

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

tifr2013 algorithms sorting

Answer

1.15.53 Sorting: TIFR2017-B-7 top http://gateoverflow.in/95699

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

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

tifr2017 algorithms sorting

Answer

Answers: Sorting

1.15.1 Sorting: CMI2011-B-06a top http://gateoverflow.in/46212

Selected Answer

Let's say we have disk of radius 0,5,1,4,3,2

We have many disks, one above other, our task is to arrange them from largest disk to smaller disk.
The only operations available is, take a couple of disks from the top, hold it in your hand, rotate it & put it back.
Just imagine in a real scenario.
How we will do it.

0,5,1,4,3,2

What I will do is, I will take all plates from 5 to 2 (5,1,4,3,2) I hold them in my hand, rotated my hand 360 degree & put

it back.
0,2,3,4,1,5
Now I will rotate all.
5,1,4,3,2,0
Now 5 is at its right place. We will not consider it.

Now find the second largest plate..... 4... rotate from 4 to 0....
5 | ,1,0,2,3,4
rotate from 1 to 4.

5,4 |,3,2,0,1
Now 4 is at its right place.

next maximum is 3, it is at its right place, so we may add one more line in the code to reduce steps...
Otherwise, the same algo will also keep 3 at it's right place....
The same algo will sort them at last.

Hence our algo is ....

Step 1:
Find the current largest element.
Step 2:
Rotate the elements from largest element to end of the array. (Hold the disks from disk of max size to disk at top & rotate)
Step 3:
Now rotate the array from current start+1 to top.

Continue this process till it is sorted.
Note that initially current_start = -1 it will be incremented by one every time we get our largest disk placed at its correct place.

1 votes -- Ahwan Mishra (5.3k points)

1.15.2 Sorting: CMI2013-A-05 top http://gateoverflow.in/46595

Selected Answer

Since n lists of each size m.

Since each list is sorted in ascending order use directly merge procedure of merge sort algo.

take two list and merge..so one pair will take **2m time.**

so total pairs in first level will be n/2. So total cost for one levl is **(n/2)*2m=nm.**

In next level cost for one pair is 4m and no of pairs will be n/4.. so next level cost will be nm.

so like this each level will have cost nm.

No of levels will be when we have one complete list..

$n/2^k$ =1..

k=$\log_2 n$.

So total cost will be **log n *(nm)**

7 votes -- sonu (2.4k points)

1.15.3 Sorting: GATE 2016-1-13 top http://gateoverflow.in/39660

Selected Answer

Answer is D..

Insertion sort = $\Theta(n^2)$

Merge sort = $\Theta(n\log n)$

Quick sort = $\Theta(n^2)$

Note : here Θ is not average case since question asked worst case so Θ represent worst case only

17 votes -- Abhilash Panicker (8.8k points)

1.15.4 Sorting: GATE 2016-2-13 top

http://gateoverflow.in/39561

Selected Answer

Q = Q can be used instead of Theta

I) Quicksort takes Q(N^2) in case of already sorted input. This is true

II) This is false. If no swap happens then bubble sort can stop in single loop. Q(N) is best case. This is false !

iii) Mergesort never takes more than Q(NlogN) This is false

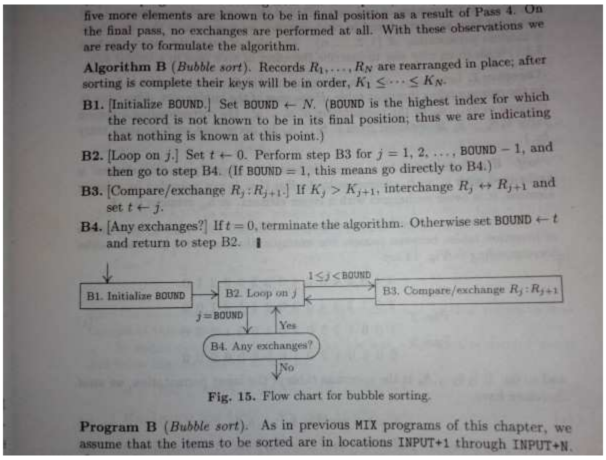
IV) This is true. Insertion sort will finish in Q(N) time in case of sorted input.

Answer D) I and IV

Proof Bubble sort has best case O(N) =>

Ref -> https://en.wikipedia.org/wiki/Bubble_sort, Aduni lecture

Following Photo from Art of Computer Programming , Sorting and Searching (Volume 3)



five more elements are known to be in final position as a result of Pass 4. On the final pass, no exchanges are performed at all. With these observations we are ready to formulate the algorithm.

Algorithm B (*Bubble sort*). Records $R_1, \ldots, R_N$ are rearranged in place; after sorting is complete their keys will be in order, $K_1 \le \cdots \le K_N$.

B1. [Initialize BOUND.] Set BOUND ← N. (BOUND is the highest index for which the record is not known to be in its final position; thus we are indicating that nothing is known at this point.)

B2. [Loop on j.] Set $t \leftarrow 0$. Perform step B3 for $j = 1, 2, \ldots,$ BOUND − 1, and then go to step B4. (If BOUND = 1, this means go directly to B4.)

B3. [Compare/exchange $R_j : R_{j+1}$.] If $K_j > K_{j+1}$, interchange $R_j \leftrightarrow R_{j+1}$ and set $t \leftarrow j$.

B4. [Any exchanges?] If $t = 0$, terminate the algorithm. Otherwise set BOUND ← t and return to step B2. ▮

Fig. 15. Flow chart for bubble sorting.

Program B (*Bubble sort*). As in previous MIX programs of this chapter, we assume that the items to be sorted are in locations INPUT+1 through INPUT+N.

Now quicksort taking O(N) can happen in some cases but not all cases, so that is why I) should be considered true. WHereas Bubble sort time complexity in best case is always O(N) . So D is any time stronger answer than C

21 votes -- Akash (43.8k points)

1.15.5 Sorting: GATE1987-1-xviii top

http://gateoverflow.in/80366

Selected Answer

ACTUALLY IN BOTH THE CASES IT WILL TAKE O(n^2) TIME(O(n) TIME FOR PARTITION ALGORITHM AND T(n-1) TIME FOR SUB PROBLEM.AS n IS THE NUMBER OF INPUTS AND IN THE 2ND CASE INPUTS ARE 5(GREATER THAN 1ST ONE THAT IS 4) I THINK t1<t2

8 votes -- Rohan Ghosh (1.9k points)

1.15.6 Sorting: GATE1988-1iii top

http://gateoverflow.in/91338

Selected Answer

Answer is LESS

as worst case time for Quicksort is O(n^2) and worst case for heap sort is O(nlogn)

6 votes -- Pavan Kumar Munnam (10k points)

1.15.7 Sorting: GATE1991_01,vii top

http://gateoverflow.in/505

Selected Answer

Answer: 7

Minimum number of comparisons = $\lceil \log(n!) \rceil$ = $\lceil \log(5!) \rceil$ = $\lceil \log(120) \rceil$ = 7.

Ref: http://en.wikipedia.org/wiki/Comparison_sort#Number_of_comparisons_required_to_sort_a_list

12 votes -- Rajarshi Sarkar (35k points)

1.15.8 Sorting: GATE1991_13 top

http://gateoverflow.in/540

Selected Answer

ans should be counting sort which will take O(n+k) time

see here

http://www.geeksforgeeks.org/counting-sort/

6 votes -- One (9.6k points)

1.15.9 Sorting: GATE1992_02,ix top

http://gateoverflow.in/559

Selected Answer

Answer is (D) Part.

Although people have provided correct answers but it seems some more explanation is required.
Let there be **d digits** in max input integer, **b is the base** for representing input numbers and **n is total numbers** then **Radix Sort takes O(d*(n+b)) time**. Sorting is performed from least significant digit to most significant digit.

For example, for decimal system, b is 10. What is the value of d? If k is the maximum possible value, then d would be O($\log_b(k)$). So overall time complexity is O((n+b) $*\log_b(k)$). Which looks more than the time complexity of comparison based sorting algorithms for a large k. Let us first limit k. Let k <= n^c where c is a constant. In that case, the complexity becomes O(n$\log_b(n)$). But it still does not beat comparison based sorting algorithms.
What if we make value of b larger?. What should be the value of b to make the time complexity linear? If we **set b as n then** we will get the time complexity as O(n).

In other words, we can sort an array of integers with range from 1 ton^c, If the numbers are represented in base n (or every digit takes $\log_2(n)$ bits).

Reference --> http://www.geeksforgeeks.org/radix-sort/

1 votes -- Chhotu (2.2k points)

1.15.10 Sorting: GATE1992_03,iv top http://gateoverflow.in/581

Selected Answer

The algorithm will take maximum time when:
1) The array is already sorted in same order.
2) The array is already sorted in reverse order.
3) All elements are same in the array.

18 votes -- Rajarshi Sarkar (35k points)

1.15.11 Sorting: GATE1994-1.19, ISRO2016-31 top http://gateoverflow.in/2462

Selected Answer

C. it is one of the efficient algorithms in Divide and Conquer strategy.

15 votes -- Gate Keeda (19.1k points)

1.15.12 Sorting: GATE1995_1.16 top http://gateoverflow.in/2603

Selected Answer

It is C.

The number of moves are however always m+n so that we can term it as theta(m+n). But the number of comparisons vary as per the input. In the best case the comparisons are Min(m,n) and in worst case they are m+n-1.

17 votes -- Gate Keeda (19.1k points)

1.15.13 Sorting: GATE1995_1.5 top http://gateoverflow.in/2592

Selected Answer

It is A.

One of the best examples of Divide and conquer strategy.

13 votes -- Gate Keeda (19.1k points)

1.15.14 Sorting: GATE1995_12 top http://gateoverflow.in/2648

Selected Answer

1^{st} Pass: 37 52 12 11 25 92

2^{nd} Pass: 37 12 11 25 52 92

3^{rd} Pass: 12 11 25 37 52 92

4^{th} Pass: 11 12 25 37 52 92

5^{th} Pass: 11 12 25 37 52 92

13 votes -- Gate Keeda (19.1k points)

1.15.15 Sorting: GATE1996-14 top http://gateoverflow.in/2766

Selected Answer

a) smallest element is at index 1,1.

b) So we have to give an array which is partially sorted. Definition of partially sorted is given in the question.
We will give the value of x which is less than last row & column value.
At last, 1,1 should be deleted & x should be at its correct place.

```
 i=1;j=1; a[i][j]=x;
 while ((x>a[i+1][j]) || (x>a[i][j+1]))
 {
     if((a[i+1][j] < x) && (a[i+1][j] <a[i][j+1]))
     {
       a[i][j]=a[i+1][j];
       i=i+1;
     }
   else
     {
       a[i][j]=a[i][j+1];
       j=j+1;
     }
 }
 a[i][j]=x;
```

Enter the dimension of nxn array. Give the value of n
3
Enter the array elements in partially sorted order
2 3 9
5 6 10
8 11 15

Enter the value of x
7

The final output.
3 6 9
5 7 10
8 11 15

5 votes -- Ahwan Mishra (5.3k points)

1.15.16 Sorting: GATE1996_2.15 top http://gateoverflow.in/2744

Selected Answer

C.

both are the worst cases of quick sort. (assuming pivot is either first or last element)

i) is sorted in ascending order.

ii) is sorted in descending order.

14 votes -- Gate Keeda (19.1k points)

1.15.17 Sorting: GATE1998-1.22 top http://gateoverflow.in/1659

Selected Answer

selection sort O(n^2)

merge sort O(nlogn)

binary search (log n)

insertion sort O(n) note if you use O(n^2) here you will not be left with any choice to fill selection sort

9 votes -- Bhagirathi Nayak (13.3k points)

1.15.18 Sorting: GATE1999-1.14, ISRO2015-42 top

http://gateoverflow.in/1467

Selected Answer

```
20   47   15   8   9    4   40   30   12   17
 \   /      \   /    \   /      \   /      \   /
 20 47     8  15    4 9      30 40    12  17   after 1st pass
   \         /           \         /          \  /
    \       /             \       /            \/
8,15,20,47          4,9, 30,40        12,17    after 2nd pass
```

Ans. **B**

34 votes -- Vikrant Singh (13.4k points)

1.15.19 Sorting: GATE1999-8 top

http://gateoverflow.in/1507

Selected Answer

This is a two dimensional array of size 4x4.
2____5____8____9
4____11___19___21
6____13___24___27
8____15___25___29

You can see the elements in each row and each column are arranged in ascending order.
Smallest element : A[0][0] = 2
2nd Smallest element : min(A[0][1],A[1][0])= min(5,4)=4
3rd smallest element: Just exclude the element you got as 2nd smallest(4).... here we can compare A[2][0],A[0][1] no need to compare with A[0][2]..... So it depends upon from where you got 2nd element. You can draw a decision tree...If you got 2nd best from A[0][1] then what to do & if you get from A[1][0] then what to do.

Any way, time complexity is simply **O(1)**...
The elements are in ascending order. Not in non decreasing order. Clearly they are all distinct in a particular row or column.

6 votes -- Ahwan Mishra (5.3k points)

1.15.20 Sorting: GATE1999_1.12 top

http://gateoverflow.in/1465

Selected Answer

(b) If it maintains the relative order of occurrence of non-distinct elements.

(from definition of stable sorting)

11 votes -- Arjun Suresh (294k points)

1.15.21 Sorting: GATE2000-17 top

http://gateoverflow.in/688

Selected Answer

Since swaps are needed to be of adjacent elements only, the algorithm is actually Bubble sort.

In bubble sort, all smaller elements to right of an element are required to be swapped. So if have ordering

$[2,2,2,1,1,1,1,1,0,0,0,0]$, then we need total 47 swaps, and this will be the worst case.

so it answers actually both parts.

15 votes -- Happy Mittal (10.9k points)

1.15.22 Sorting: GATE2001-1.14 top

http://gateoverflow.in/707

Selected Answer

Answer will be (C)
There are following two cases, when Randomized Quick Sort will result into worstcase of time complexity $O(n^2)$

1. When all elements are same in the input array, Partition algo will divide input array in two sub-array, one with n-1 elements and second with 0 element. There is an assumption here that, we are using the same partition algorithm without any modification.

2. If the randomised pivot selector happens to select e.g. the smallest element N times in a row, we will get the worst possible performance. Though the probability of this particular case is about $\frac{1}{n!}$ "

PS: If the partitioning is **unbalanced**, Quick Sort algorithm runs asymptotically as slow as **Insertion Sort** i.e $O(n^2)$

3 votes -- manu00x (11.1k points)

In worst case, we may pick pivot elements in the increasing order (input also given in sorted order) which will result in running time of O(n^2)

Both the deterministic and randomized quicksort algorithms have the same best-case running times of O(nlgn) and the same worst-case running times of O(n2).The difference is that with the deterministic algorithm, a particular input can elicit that worst-case behavior. With the randomized algorithm, however, no input can always elicit the worst-case behavior. The reason it matters is that, depending on how partitioning is implemented, an input that is already sorted--or almost sorted--can elicit the worst-case behavior in deterministic quicksort.

source:Thomas Ccoremen

Ans. C

25 votes -- Vikrant Singh (13.4k points)

1.15.23 Sorting: GATE2003-22 top

http://gateoverflow.in/912

Selected Answer

In insertion sort, with linear search, it takes

(worst case) n comparisons for searching the right position, and n swaps to make room to place the element.

Hence for n elements, a total of $n \times (n+n)$; n for search and n for swaps.

$$= \Theta(2n^2) = \Theta(n^2)$$

If we replace it with binary search, it takes

(worst case)
$\log n$ comparisons for searching the right position, and
n swaps to make room to place the element.

Hence for n elements, a total of
$n \times (\log n + n)$;
n for search and
n for swaps.

$$= \Theta(n \times \log n + n^2) = \Theta(n^2)$$

Hence **answer is A**

24 votes -- ryan sequeira (3k points)

A. Complexity remains same.$\theta(n^2)$

To place the element x in the correct position first we are finding its correct position in the sorted array using binary search but we have to make the space for it by shifting all elements to the right, which in worst case may be equal to the size of the sorted array.

15 votes -- Vikrant Singh (13.4k points)

1.15.24 Sorting: GATE2003-61 top http://gateoverflow.in/949

Selected Answer

They are asking the average number of inversion. basically what i learned about averages from dbms indexing is.

average apart from the standard definition can be calculated as (best case + worst case)/2

and inversion is like 9,5.

so best case will be sorted array - 1,2,3,4,5 no inversion . = zero

worst case = 9,5,4,3,2,1 . here total number of inversion will be n(n-1)/2 as . 9 can be paired with any 5 elements (5,4,3,2,1) will form a inversion pair. similarly 5 with 4.elements .

so we can say if we have n elements then. it will be (n-1)+(n-2)+(n-3)...+2+1 which is the sum of first n-1 natural numbers. so it is n(n-1)/2

so expected average number of inversion = (n(n-1)/2 + zero (best case)) /2= n(n-1)/4

so option b.

second question.

we all know that insertion sort has complexity due to swapping and movements, if we have n n inversion pair then the movements and comparision will be restricted to n only . like if inversion is 1 , then array must be sorted and only the inversion should exist at the end, like 1,2,3,5,4. otherwise more than one inversion pair will form. so to sort this. for two it will be 1,2,3,7,5,4. so to sort this type of array using insertion sort atmost N swaps wiill be required, so d

20 votes -- No Need (14.1k points)

1.15.25 Sorting: GATE2003-62 top http://gateoverflow.in/43576

Selected Answer

ANSWER: D. $\Theta(n)$

REASON:

Count of number of times the inner loop of insertion sort executes is actually equal to number of inversions in input permutation $a_1, a_2, \dots a_n$. Since for each value of $i = 1..n$, j take the value $1..i-1$, which means for every $j < i$ it checks if $a[j] > a[i]$.

In any given permutation, maximum number of inversions possible is $n(n-1)/2$ which is $O(n^2)$. It is the case where the array is sorted in reverse order. Therefore, to resolve all inversions i.e., worst case time complexity of insertion sort is $\Theta(n^2)$.

However, as per the question the number of inversion in input array is restricted to n. The worst case time complexity of insertion sort reduces to $\Theta(n)$.

INSERTION SORT ALGORITHM (for reference)

18 votes -- Prateek Dwivedi (3.2k points)

1.15.26 Sorting: GATE2005-39 top

http://gateoverflow.in/784

Selected Answer

Since we have $\log n$ lists we can make a min-heap of $\log n$ elements by taking the first element from each of the $\log n$ sorted lists. Now, we start deleting the min-element from the heap and put the next element from the sorted list from which that element was added to the heap. (This identity can be done by making a structure of two values, one for the number and one for identifying the origin sorted list of that number and storing this structure in the heap). In this way each delete and the corresponding insert will take $O(\log\log n)$ time as delete in heap of size n is $O(\log n)$ and inserting an element on a heap of size n is also $O(\log n)$. (here, heap size is $\log n$). Now, we have a total of $\log n \times \frac{n}{\log n} = n$ elements. So, total time will be $O(n \log\log n)$.

31 votes -- gatecse (13.4k points)

1.15.27 Sorting: GATE2005-IT-59 top

http://gateoverflow.in/3820

Selected Answer

a[i] ≥ b[i]

Since both a and b are sorted in the beginning, there are i elements smaller than or equal to a[i] (i starts from 0), and similarly i elements smaller than or equal to b[i]. So, a[i] ≥ b[i] means there are 2i elements smaller than or equal to a[i], and hence in the merged array a[i] will come after these 2i elements (its index will be > 2i). So, c[2i] ≤ a[i] (equality takes care of the "equal to" case which comes when array contains repeated elements).

Similarly, a[i] ≥ b[i] says for b that, there are not more than 2i elements smaller than b[i] in the sorted array (i elements from b, and maximum another i elements from a). So, b[i] ≤ c[2i]

So, II and III are correct -> option (C)

14 votes -- Arjun Suresh (294k points)

1.15.28 Sorting: GATE2006-14, ISRO2011-14 top

http://gateoverflow.in/975

Selected Answer

Selection sort

because in selection the maximum swaps which can take place are O(n)

because we pick up an element an find the minimum(in case of forward sorting) from the next index till the end of array and than perform the swap

hence O(n) whereas in all other algos the swaps are greater (considering Worst-Case scenario)

13 votes -- ANKUR MAHIWAL (405 points)

1.15.29 Sorting: GATE2006-52 top

http://gateoverflow.in/1830

Selected Answer

as we choose the pivot a median element ...so every time we are going to have good splits guranteed so the best case O(nlogn)

15 votes -- Bhagirathi Nayak (13.3k points)

1.15.30 Sorting: GATE2007-14 top

http://gateoverflow.in/1212

Selected Answer

A.

Irrespective of the input, Merge sort always have a time complexity of $\Theta(n \log n)$.

13 votes -- Gate Keeda (19.1k points)

1.15.31 Sorting: GATE2008-43 top

http://gateoverflow.in/455

Selected Answer

$T(n) \leq T(n/5) + T(4n/5) + n$

One part contains $n/5$ elements
and the other part contains $4n/5$ elements
$+n$ is common to all options, so we need not to worry about it.

Hence, answer = **option B**

12 votes -- Amar Vashishth (28.7k points)

1.15.32 Sorting: GATE2008-IT-43 top

http://gateoverflow.in/3353

Selected Answer

Answer: C

The complexity of Radix Sort is $O(wn)$, for n keys which are integers of word size w.

Here, $w = \log_2(n^k) = k \times \log_2(n)$

So, the complexity is $O(wn) = O(k \times \log_2(n) \times n)$, which leads to option C.

23 votes -- Rajarshi Sarkar (35k points)

1.15.33 Sorting: GATE2009-11 top

http://gateoverflow.in/1303

Selected Answer

The answer is A.

we have 1 swap in each loop and hence n swaps at max for 1 to n. Therefore the worst case number of swaps is $\Theta(n)$

14 votes -- Gate Keeda (19.1k points)

1.15.34 Sorting: GATE2009-39 top

http://gateoverflow.in/1325

Selected Answer

B.

T(n)= O(n) pivot selection time + T(n/4 - 1) + T(3n/4)

which'll give $\Theta(n \log n)$.

Pivot selection complexity is given in questions. Pivot being the (n/4)th smallest element, once it is found, we have two sub arrays- one of size (n/4 - 1) and other of size (3n/4) and for both of these we solve recursively.

21 votes -- Gate Keeda (19.1k points)

1.15.35 Sorting: GATE2012_39 top http://gateoverflow.in/1762

Selected Answer

i thought like this:

you are given the first character of each n strings to sort it will take O(nlogn) time..in the worst case we may have to do the above process 2 times,3 times,........,n times so n*O(nlogn)=O(n^2 logn) please correct me if my approach is wrong...

21 votes -- Bhagirathi Nayak (13.3k points)

1.15.36 Sorting: GATE2013_30 top http://gateoverflow.in/1541

Selected Answer

To sort k elements in a heap, complexity is $\Theta(k \log k)$. Lets assume there are $\frac{\log n}{\log \log n}$ elements in the heap.

Complexity = $\Theta\left(\frac{\log n}{\log \log n} \log\left(\frac{\log n}{\log \log n}\right)\right)$

$= \Theta\left(\frac{\log n}{\log \log n}\left(\log \log n - \log \log \log n\right)\right)$

$= \Theta\left(\log n - \frac{\log n \log \log \log n}{\log \log n}\right)$

$= \Theta(\log n)$ (as shown below)

So, (c) is the answer.

$\log \log n > \log \log \log n$

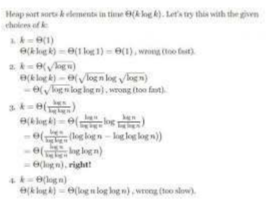
$\implies \frac{\log \log \log n}{\log \log n} < 1$

$\implies \frac{\log n \log \log \log n}{\log \log n} < \log n$

$\implies \Theta\left(\log n - \frac{\log n \log \log \log n}{\log \log n}\right) = \Theta(\log n)$

57 votes -- Arjun Suresh (294k points)

answer = **option C**


Heap sort sorts k elements in time $\Theta(k \log k)$. Let's try this with the given choices of k:

1. $k = \Theta(1)$
   $\Theta(k \log k) = \Theta(1 \log 1) = \Theta(1)$, wrong (too fast).
2. $k = \Theta(\sqrt{\log n})$
   $\Theta(k \log k) = \Theta(\sqrt{\log n} \log \sqrt{\log n})$
   $= \Theta(\sqrt{\log n} \log \log n)$, wrong (too fast).
3. $k = \Theta(\frac{\log n}{\log \log n})$
   $\Theta(k \log k) = \Theta(\frac{\log n}{\log \log n} \log \frac{\log n}{\log \log n})$
   $= \Theta(\frac{\log n}{\log \log n}(\log \log n - \log \log \log n))$
   $= \Theta(\frac{\log n}{\log \log n} \log \log n)$
   $= \Theta(\log n)$, **right!**
4. $k = \Theta(\log n)$
   $\Theta(k \log k) = \Theta(\log n \log \log n)$, wrong (too slow).

14 votes -- Amar Vashishth (28.7k points)

1.15.37 Sorting: GATE2013_6 top

http://gateoverflow.in/1415

Selected Answer

In selection max you can do is n swaps..selecting the smallest element from all the elements and replacing it correct position so O(n)

12 votes -- Bhagirathi Nayak (13.3k points)

1.15.38 Sorting: GATE2014-1-14 top

http://gateoverflow.in/1780

Selected Answer

it would be t1>t2, because the first case is the worst case of quicksort i.e. minimum number is chosen as pivot. Hence in the worst case the comparisons are high.

The splitting occurs as
[1] [2345]
[2] [345]
[3] [45]
[4] [5]

and

[123] [45]
[1] [23] [4][5]
[2] [3]

Number of recursive calls remain the same, but in second case the number of elements passed for the recursive call is less and hence the number of comparisons also less.

14 votes -- Parul Agarwal (793 points)

1.15.39 Sorting: GATE2014-2-38 top

http://gateoverflow.in/1997

Selected Answer

The optimal algorithm always chooses the smallest sequences for merging.

20 24 -44, 43 comparisons
30 35 -65, 64 comparisons
44 50 -94, 93 comparisons
65 94 -159, 158 comparisons

so, totally 43 + 64 + 93 + 158 = 358 comparisons.

45 votes -- Arjun Suresh (294k points)

1.15.40 Sorting: GATE2014-3-14 top

http://gateoverflow.in/2048

Selected Answer

(A) $O(n^2)$ is the answer. When we choose the first element as the pivot, the worst case of quick sort comes if the input is sorted- either in ascending or descending order. Now, when we choose the middle element as pivot, sorted input no longer gives worst case behaviour. But, there will be some permutation of the input numbers which will be giving the same worst case behaviour. For example,

1 2 3 4 5 6 7
This array gives worst case behaviour for quick sort when the first element is pivot.

6 4 2 1 3 5 7
This array gives the worst case behaviour of $O(n^2)$ if we take middle element as the pivot- each split will be 1 element on one side and n-1 elements on other side. Similarly, for any input, we can have a permutation where the behaviour is like this. So, whichever element we take as pivot it gives worst case complexity of $O(n^2)$ as long as pivot is from a fixed position (not random position as in randomized quick sort).

28 votes -- Arjun Suresh (294k points)

1.15.41 Sorting: GATE2015-1_2 top

http://gateoverflow.in/8017

Selected Answer

B.

Worst case for quick sort happens when 1 element is on one list and n-1 elements on another list.

18 votes -- Arjun Suresh (294k points)

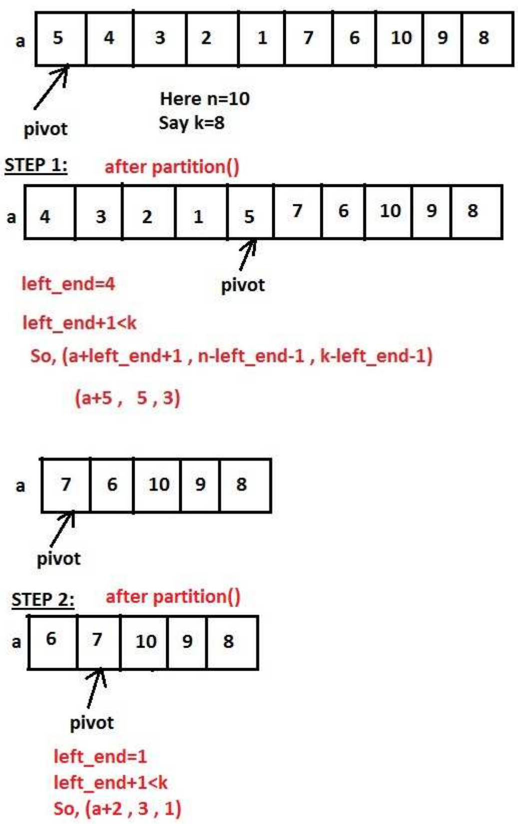
1.15.42 Sorting: GATE2015-2-45 top

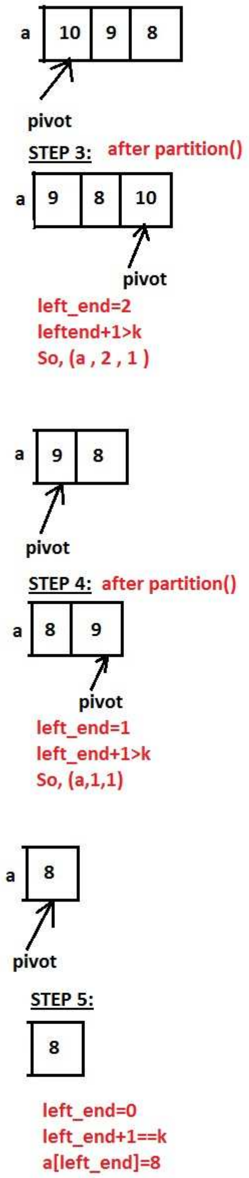
http://gateoverflow.in/8243

First of all here The return value is the number of elements less than the pivot

Pivot is just to minimize searching

So, now we are assuming our array has 10 elements , N=10 , k=8





So,in STEP 1 and STEP 2 'else' condition satisfying, and STEP3 and STEP 4 'if ' condition satisfying

Here partition is calling and returning left_end value

Ans will be (A)

8 votes -- srestha (58.4k points)

1.15.43 Sorting: GATE2015-3_27 top http://gateoverflow.in/8480

Selected Answer

The worst case time complexity of Mergesort is $k \times n \log n$ for an input of size n.

For an input of size 64, the algorithm takes $30s$. Therefore,

$$\begin{aligned} k \times 64 \log_2 64 &= 30s \\ k \times 384 &= 30s \\ \implies k &= 0.078125s \end{aligned}$$

Let the size of the problem that can be solved in 6 minutes be x. Then,

$$k \times x \log_2 x = 360s$$

From this, we get:

$$\begin{aligned} x \log_2 x &= \frac{360s}{0.078125s} \\ \implies x &= 512 \end{aligned}$$

28 votes -- Pragy Agarwal (19.5k points)

1.15.44 Sorting: ISI2011-A-2a top

http://gateoverflow.in/48028

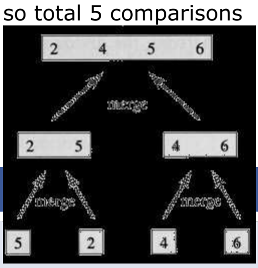
it will be merge sort

a,b,c,d

1+1 comparisons for lowest step

+3 comparisons for upper one

so total 5 comparisons



4 votes -- Tanushree (405 points)

1.15.45 Sorting: TIFR2010-B-23 top

http://gateoverflow.in/18623

Selected Answer

The given procedure resembles something like Bubble sort or Selection Sort.
Every time, for every input it will take O(n square) so **B** is the answer.

If you are thinking about heap sort, where in the procedure, it is talked about building a heap? You can do extract_max only on a heap. Right ? The procedure is nearly same as bubble sort or selection sort.

Read qsn again: *"First find the maximum. Remove this element from the list and find the maximum of the remaining elements, remove this element, and so on, until all elements are exhausted."*

Just follow the steps. Find max, take it to right side of array. Shift.
So n-1 comparisions & n-1 shifts in the worst case.
Total n-1+n-2+n-3+....+1 + n-1+n-2+n-3+..+1 which is O(n square)
Only number of comparisions is asked... which is also **O(n square)**

4 votes -- Ahwan Mishra (5.3k points)

1.15.46 Sorting: TIFR2010-B-27 top

http://gateoverflow.in/19036

Selected Answer

In worst case Insertion sort will have N(N-1)/2 comparisons i.e. when input is sorted in descending order.

50 40 30 20 10

pass 1 50 40 30 20 10.............n 0 compare

pass 2 40 50 30 20 10.............n 1 compare

.

.

.

pass n n ....10 20 30 40 50 n-1 compare

1+2+3...................+n-1 = N(N-1)/2 comparisons

5 votes -- Umang Raman (15.2k points)

1.15.47 Sorting: TIFR2011-B-21 top

http://gateoverflow.in/20324

Selected Answer

store the elements in an array and then call build_heap(A). the build_heap takes O(n) time.

so, option 'b' is correct.

---

but, if we try building heap by inserting each element one by one, the total complexity will be then O(n log n). cause insertion takes O(log n) and inserting 'n' elements will take O(n log n).

14 votes -- Sujit Kumar Muduli (209 points)

1.15.48 Sorting: TIFR2011-B-31 top

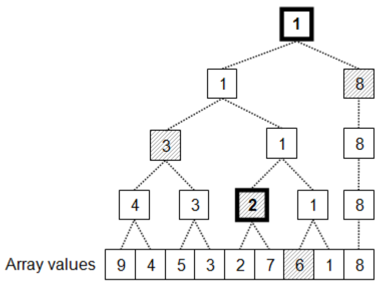
http://gateoverflow.in/20617

Selected Answer

Option c) $n + k - 2$

Here is a nice explanation of the algorithm: http://www.codinghelmet.com/?path=exercises/two-smallest

> it is solution to the problem known for ages, and it has to do with tennis tournaments. The question was, knowing the outcome of the tennis tournament, how can we tell which player was the second best? The defeated finalist is a good candidate, but there are other players that were defeated directly by the tournament winner and any of them could also be a good candidate for the second best. So the solution to the problem is quite simple: Once the tournament finishes, pick up the logN competitors that were beaten by the tournament winner and hold a mini-tournament to find which one is the best among them. If we imagine that better players correspond with smaller numbers, the algorithm now goes like this. Hold the tournament to find the smallest number (requires N-1 comparisons). During this step, for each number construct the list of numbers it was smaller than. Finally, pick the list of numbers associated with the smallest number and find their minimum in logN-1 steps. This algorithm requires N+logN-2 comparisons to complete, but unfortunately it requires additional space proportional to N (each element except the winner will ultimately be added to someone's list); it also requires more time per step because of the relatively complex enlisting logic involved in each comparison. When this optimized algorithm is applied to example array, we get the following figure.



Tournament held among numbers promotes value 1 as the smallest number. That operation, performed on an array with nine numbers, requires exactly eight comparisons. While promoting the smallest number, this operation has also flagged four numbers that were removed from competition by direct comparison with the future winner: 6, 2, 3 and 8 in that order. Another sequence of three comparisons is required to promote number 2 as the second-smallest number in the array. This totals 11 comparisons, while naive algorithm requires 17 comparisons to come up with the same result.

All in all, this algorithm that minimizes number of comparisons looks to be good only for real tournaments, while number cracking algorithms should keep with the simple logic explained above. Implementation of simple algorithm may look like this:

```
a - array containing n elements
min1 = a[0] - candidate for the smallest value
min2 = a[1] - candidate for the second smallest value
if min2 < min1
    min1 = a[1]
    min2 = a[0]
for i = 2 to n - 1
    if a[i] < min1
        min2 = min1
        min1 = a[i]
    else if a[i] < min2
        min2 = a[i]
```

by Zoran Horvat @zoranh75

18 votes -- Pragy Agarwal (19.5k points)

1.15.49 Sorting: TIFR2011-B-39 top http://gateoverflow.in/20935

Selected Answer

d)
$O(\log n)$ **comparisons suffice.**

Since it is possible that $m \ggg n$, we need to restrict ourselves to the first $O(n)$ elements to perform the binary search.

We start with the first element (index $i = 1$), and check if it is equal to 0. If not, we double the value of i, and check again. We repeat this process until we hit a 0.

```
i = 1;
while(arr[i] != 0)
    i *= 2;
```

Once we hit a 0, the largest possible value (worst case) of i can be $2n-2$. This will happen if $n = 2^k + 1$ for some k. Then, our 2nd last value of i will be 2^k, and then we get 2^{k+1}, which is equal to $2n-2$.

Now that we've hit a 0, and the array contains positive numbers in decreasing order, if x is present in L, it must be in the first i elements.

We can binary search the first i elements in $O(\log i)$ comparisons.

Since the largest possible value of $i = 2n-2$, our algorithm takes $O\Big(\log(2n-2)\Big) = O(\log n)$ comparisons.

10 votes -- Pragy Agarwal (19.5k points)

1.15.50 Sorting: TIFR2012-B-13 top http://gateoverflow.in/25207

Selected Answer

Let Array element be {4,3,2,1,7,5,6,9,10,8} and K be 3 here no element is more than 3 distance away from its final position
So if we take
arr(1 to 6) and sort then surely first three element will be sorted in its final position {12345769108} O(6log6)
then sort arr(3 to 9) then 3 to 6 will be sorted {12345679108} O(6log6)
then at last arr(6 to 9) less than O(6log6) {12345678910}

in general
Sort arr(0 to 2k)
Now we know that arr[0 to k) are in their final sorted positions
and arr(k to 2k) may be not sorted.

Sort arr(k to 3k)
Now we know that arr[k to 2k) are in their final sorted positions
and arr(2k to 3k) may be not sorted.
.
.
.
.

sort till arr(ik..N)
in final sorting there will be less than 2k element.

in each step it will take O(2klog2k)
and there will $\frac{n}{k}$ steps so O(nlogk)
option D.

7 votes -- Umang Raman (15.2k points)

1.15.51 Sorting: TIFR2012-B-14 top

http://gateoverflow.in/25209

Selected Answer

Algorithm is choosing $\text{median} = n/2$ smallest element as pivot.

Hence, the array is divided as:

$\left(\frac{n}{2}-1\right)$ elements	Median at $\frac{n}{2}$th location	$\left(n-\frac{n}{2}\right)$ elements

Therefore quick sort recurrence relation is given by:

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

Hence, Option B is the correct answer.

13 votes -- Umang Raman (15.2k points)

1.15.52 Sorting: TIFR2013-B-20 top

http://gateoverflow.in/25878

Exact N step take take worst case decresing oder . 1st elemnt come to its coreect place at n th step at the same time all elemnt goes to its coreect place.

6 votes -- Prashant Singh (49.2k points)

1.15.53 Sorting: TIFR2017-B-7 top

http://gateoverflow.in/95699

A pairwise swap will make the sorted array unsorted. Hence, the option (b) is correct.

For eg - if an array is 1 2 3 4 5 6 7 8

The array will become after a pair wise swap to 2 1 4 3 6 5 8 7. For all i between 2 and n-1, a[i] is either lower, or either greater than their adjacent elements.

Since, each element is being swapped exactly once. The operation has O(n) time complexity.

5 votes -- tarun_svbk (1k points)

1.16 Spanning Tree(31) top

1.16.1 Spanning Tree: GATE 2016-1-14 top http://gateoverflow.in/39673

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

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

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

gate2016-1 algorithms spanning-tree normal

Answer

1.16.2 Spanning Tree: GATE 2016-1-39 top http://gateoverflow.in/39725

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

gate2016-1 algorithms spanning-tree normal numerical-answers

Answer

1.16.3 Spanning Tree: GATE 2016-1-40 top http://gateoverflow.in/39727

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

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

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

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

gate2016-1 algorithms spanning-tree normal

Answer

1.16.4 Spanning Tree: GATE1991_03,vi top http://gateoverflow.in/521

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

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

(a). $O(n^2)$

(b). $O(mn)$

(c). $O(m+n)$

(d). $O(m \log n)$

(e). $O(m^2)$

gate1991 algorithms spanning-tree

Answer

1.16.5 Spanning Tree: GATE1992_01,ix top http://gateoverflow.in/549

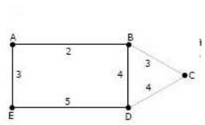
Complexity of Kruskal's algorithm for finding the minimum spanning tree of an undirected graph containing n vertices and m edges if the edges are sorted is ________

gate1992 spanning-tree algorithms time-complexity easy

Answer

1.16.6 Spanning Tree: GATE1995_22 top http://gateoverflow.in/2660

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



gate1995 algorithms graph-algorithms spanning-tree easy

Answer

1.16.7 Spanning Tree: GATE1996_16 top http://gateoverflow.in/2768

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

a. the weight of the edge (u, v) is $|u - v|$
b. the weight of the edge (u, v) is $u + v$

gate1996 algorithms graph-algorithms spanning-tree normal

Answer

1.16.8 Spanning Tree: GATE1997_9 top http://gateoverflow.in/2269

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

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

gate1997 algorithms spanning-tree normal

Answer

1.16.9 Spanning Tree: GATE2000-2.18 top http://gateoverflow.in/665

Let G be an undirected connected graph with distinct edge weights. Let e_{max} be the edge with maximum weight and e_{min} the edge with minimum weight. Which of the following statements is false?

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

gate2000 algorithms spanning-tree normal

Answer

1.16.10 Spanning Tree: GATE2001-15 top http://gateoverflow.in/756

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

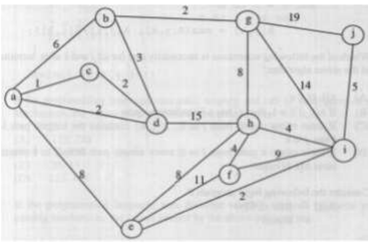
a. List the edges of a minimum spanning tree of the graph.
b. How many distinct minimum spanning trees does this graph have?
c. Is the minimum among the edge weights of a minimum spanning tree unique over all possible minimum spanning trees of a graph?
d. Is the maximum among the edge weights of a minimum spanning tree unique over all possible minimum spanning tree of a graph?

gate2001 algorithms spanning-tree normal descriptive

Answer

1.16.11 Spanning Tree: GATE2003-68 top http://gateoverflow.in/955

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



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

gate2003 algorithms spanning-tree normal

Answer

1.16.12 Spanning Tree: GATE2005-6 top http://gateoverflow.in/1348

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

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

gate2005 algorithms spanning-tree normal

Answer

1.16.13 Spanning Tree: GATE2005-IT-52 top http://gateoverflow.in/3813

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

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

D. All edges in G have the same weight.

gate2005-it algorithms spanning-tree normal

Answer

1.16.14 Spanning Tree: GATE2006-11 top http://gateoverflow.in/890

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

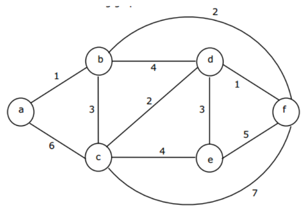
A. n-1
B. 2n-3
C. $\binom{n}{2}$
D. n^2

gate2006 algorithms spanning-tree normal

Answer

1.16.15 Spanning Tree: GATE2006-47 top http://gateoverflow.in/1823

Consider the following graph:



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

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

gate2006 algorithms graph-algorithms spanning-tree normal

Answer

1.16.16 Spanning Tree: GATE2007-49 top http://gateoverflow.in/1247

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

A. There is a minimum spanning tree containing e

B. If e is not in a minimum spanning tree T, then in the cycle formed by adding e to T, all edges have the same weight.

C. Every minimum spanning tree has an edge of weight w

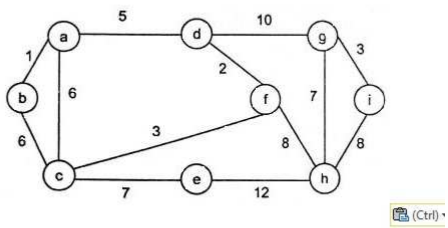
D. e is present in every minimum spanning tree

gate2007 algorithms spanning-tree normal

Answer

1.16.17 Spanning Tree: GATE2008-IT-45 top http://gateoverflow.in/3355

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



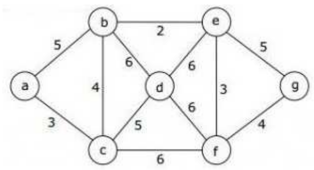
A. (a, b), (d, f), (f, c), (g, i), (d, a), (g, h), (c, e), (f, h)
B. (c, e), (c, f), (f, d), (d, a), (a, b), (g, h), (h, f), (g, i)
C. (d, f), (f, c), (d, a), (a, b), (c, e), (f, h), (g, h), (g, i)
D. (h, g), (g, i), (h, f), (f, c), (f, d), (d, a), (a, b), (c, e)

gate2008-it algorithms graph-algorithms spanning-tree normal

Answer

1.16.18 Spanning Tree: GATE2009-38 top http://gateoverflow.in/1324

Consider the following graph:



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

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

B. (b, e) (e, f) (a, c) (f, g) (b, c) (c, d)

C. (b, e) (a, c) (e, f) (b, c) (f, g) (c, d)

D. (b, e) (e, f) (b, c) (a, c) (f, g) (c, d)

gate2009 algorithms spanning-tree normal

Answer

1.16.19 Spanning Tree: GATE2010-50 top http://gateoverflow.in/2355

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

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

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

T?

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

gate2010 algorithms spanning-tree normal

Answer

1.16.20 Spanning Tree: GATE2010-51 top

http://gateoverflow.in/43328

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

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

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

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

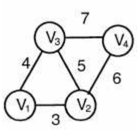
gate2010 normal algorithms spanning-tree

Answer

1.16.21 Spanning Tree: GATE2011-54 top

http://gateoverflow.in/2162

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



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

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

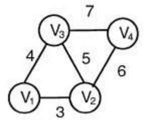
gate2011 algorithms graph-algorithms spanning-tree normal

Answer

1.16.22 Spanning Tree: GATE2011-55 top

http://gateoverflow.in/43325

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



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

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

gate2011 algorithms graph-algorithms spanning-tree normal

Answer

1.16.23 Spanning Tree: GATE2012_29 top http://gateoverflow.in/786

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

(A) $T' = T$ with total weight $t' = t^2$

(B) $T' = T$ with total weight $t' < t^2$

(C) $T' \neq T$ but total weight $t' = t^2$

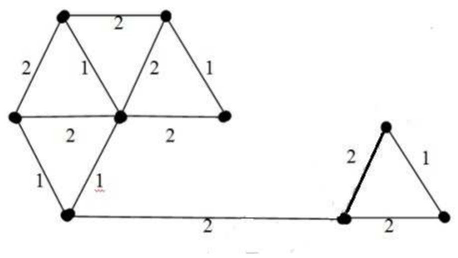
(D) None of the above

gate2012 algorithms spanning-tree normal marks-to-all

Answer

1.16.24 Spanning Tree: GATE2014-2-52 top http://gateoverflow.in/2019

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

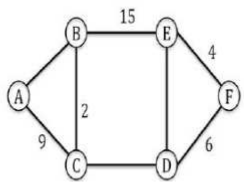


gate2014-2 algorithms spanning-tree numerical-answers normal

Answer

1.16.25 Spanning Tree: GATE2015-1_43 top http://gateoverflow.in/8313

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



gate2015-1 algorithms spanning-tree normal numerical-answers

Answer

1.16.26 Spanning Tree: GATE2015-3_40 top http://gateoverflow.in/8499

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

gate2015-3 algorithms spanning-tree easy numerical-answers

Answer

1.16.27 Spanning Tree: TIFR2011-B-35 top http://gateoverflow.in/20842

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

a. The edge e_1 has to be present in every maximum weight spanning tree.
b. Both e_1 and e_2 have to be present in every maximum weight spanning tree.
c. The edge e_m has to be present in every minimum weight spanning tree.
d. The edge e_m is never present in any maximum weight spanning tree.
e. G has a unique maximum weight spanning tree.

tifr2011 algorithms graph-algorithms spanning-tree

Answer

1.16.28 Spanning Tree: TIFR2013-B-17 top http://gateoverflow.in/25860

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

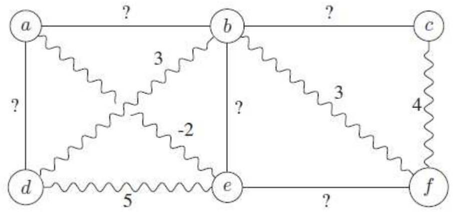
a. 1
b. n
c. equal to number of edges in the graph.
d. equal to maximum weight of an edge of the graph.
e. n^{n-2}

tifr2013 spanning-tree

Answer

1.16.29 Spanning Tree: TIFR2014-B-4 top http://gateoverflow.in/27174

Consider the following undirected graph with some edge costs missing.



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

a. cost$(a, b) \geq 6$.
b. cost$(b, e) \geq 5$.

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

tifr2014 algorithms graph-algorithms spanning-tree

Answer

1.16.30 Spanning Tree: TIFR2014-B-5 top http://gateoverflow.in/27180

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

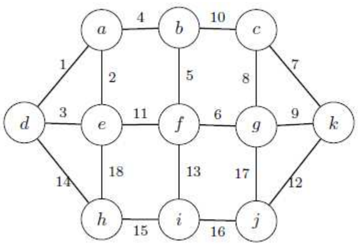
a. The tree T has to contain the edge e_1.
b. The tree T has to contain the edge e_2.
c. The minimum weight edge incident on each vertex has to be present in T.
d. T is the unique minimum spanning tree in G.
e. If we replace each edge weight $w_i = w(e_i)$ by its square w_i^2, then T must still be a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

tifr2014 algorithms spanning-tree

Answer

1.16.31 Spanning Tree: TIFR2015-B-2 top http://gateoverflow.in/29844

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



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

a. There is more than one minimum spanning tree and similarly, there is more than one maximum spanning tree here.
b. There is a unique minimum spanning tree, however there is more than one maximum spanning tree here.
c. There is more than one minimum spanning tree, however there is a unique maximum spanning tree here.
d. There is more than one minimum spanning tree and similarly, there is more than one second-best minimum spanning tree here.
e. There is unique minimum spanning tree, however there is more than one second-best minimum spanning tree here.

tifr2015 spanning-tree

Answer

Answers: Spanning Tree

1.16.1 Spanning Tree: GATE 2016-1-14 top http://gateoverflow.in/39673

Selected Answer

Statement P is true.

For statement Q consider a simple graph with 3 nodes.

	A	B	C

A	0	1	100
B	1	0	2
C	100	2	0

Shortest path from A to C is A-B-C = 1 + 2 = 3

Now if the value of each edge is increased by 100,

	A	**B**	**C**
A	0	101	200
B	101	0	102
C	200	102	0

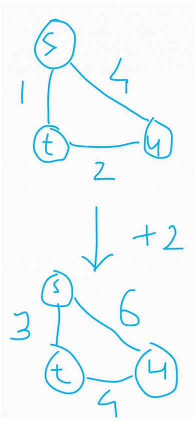
The shortest path from A to C is A-C = 200, (A-B-C = 101 + 102 = 203)

Hence option **A is correct.**

36 votes -- ryan sequeira (3k points)

P is True:-> Bcz distinct edge weights and all the edge cost are increasing with same value so edges which forms MST will remain intact.

Q is false . See counter example



See here shortest path from S to U was initially S-T-U but after increasing there value by 2 it becomes S-U.

Note here Min Spanning tree edges remains same ST and TU.

So P true and Q false So Option A is Ans.

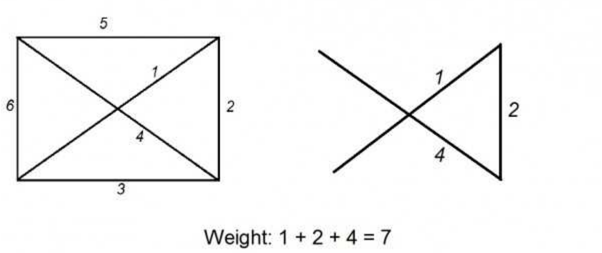
18 votes -- Rajesh Pradhan (18.6k points)

1.16.2 Spanning Tree: GATE 2016-1-39 top

http://gateoverflow.in/39725

Selected Answer

Graph G can be like this:



29 votes -- shaiklam09 (265 points)

ans is 7.

it is said maximum weight pssbl.

draw a triangle. 3 sides weight 1 2 3. and 4th point is in center. join it with tringle vertices.. got more 3 sides. new side weight 4 5 6. now draw mst. take 1 take 2. cant take 3, so take 4. 1+2+4=7

15 votes -- Debasmita Bhoumik (2.8k points)

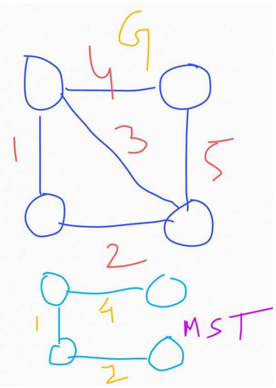
1.16.3 Spanning Tree: GATE 2016-1-40 top

http://gateoverflow.in/39727

Selected Answer

Statement 1:- False by [Cut Property of MST]

See counter example :- Here in below Graph G in (cycle 3,4,5) 3 is the lightest edge and still it is not included in MST.



Statement 2:->True by[Cycle property of MST] :->(in above Grahp G 1-2-3 is a cycle and 3 is the heaviest edge) If heaviest edge is in cycle then we will always exclude that bcz Cycle is their means we can have other choice of low cost edges.

So Option B is Ans.

Must visit Links

http://www.cs.princeton.edu/courses/archive/spr07/cos226/lectures/mst.pdf

http://www.cs.toronto.edu/~vassos/teaching/c73/handouts/cut-property.pdf

23 votes -- Rajesh Pradhan (18.6k points)

I think answer is option B

Statement 2 is correct absolutely. if e is the heaviest edge in cycle every mst excludes it.

Regarding statement 1, It is not fully right i think. When we think of a complete graph with 4 vertices and edge weights 1,2,5,6 in non diagonal and diagonal edges 3 and 4. 4,5,6 will create a cycle and we can exclude the lighest edge e (4) from it, in a MST

So i think answer could be B

27 votes -- Sreyas S (1.7k points)

1.16.4 Spanning Tree: GATE1991_03,vi top

http://gateoverflow.in/521

Selected Answer

Answer: D, B, E

When Union-Find algorithm is used to detect cycle while constructing the MST time complexity is $O(m \log n)$ where m is the number of edges, and n is the number of vertices. Since $n = O\left(m^2\right)$ in a graph, options B and E are also correct as big-O specifies asymptotic upper bound only.

Ref: http://www.geeksforgeeks.org/greedy-algorithms-set-2-kruskals-minimum-spanning-tree-mst/

8 votes -- Rajarshi Sarkar (35k points)

1.16.5 Spanning Tree: GATE1992_01,ix top http://gateoverflow.in/549

Selected Answer

if all edges are already sorted then this problem will reduced to union-find problem on a graph with E edges and V vertices.

```
for each edge (u,v) in E

    if(FIND-SET(u) != FIND-SET(v))
        UNION(u,v)
```

FIND-SET(v) and UNION(u,v) runs in α(|V|)

where α(n) is inverse ackermann function i.e log*(n)

So overall complexity becomes O(|E|.α(|V|))

16 votes -- Vikrant Singh (13.4k points)

1.16.6 Spanning Tree: GATE1995_22 top http://gateoverflow.in/2660

Selected Answer

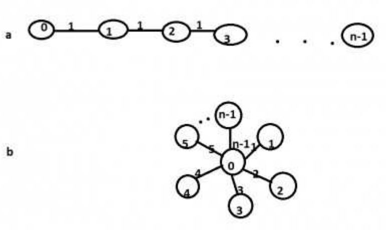
2 only.

{AB,BC,AE,BD} and {AB,BC,AE,CD}.

15 votes -- Gate Keeda (19.1k points)

1.16.7 Spanning Tree: GATE1996_16 top http://gateoverflow.in/2768

Selected Answer

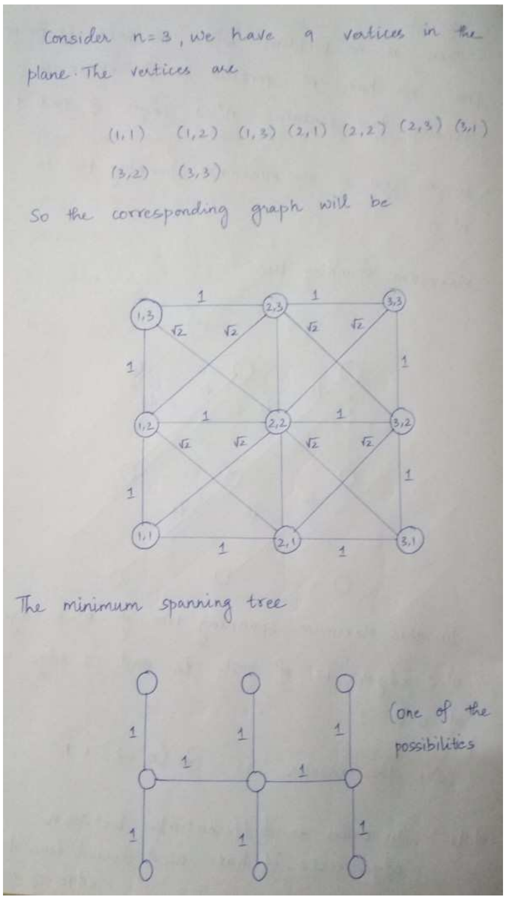


minimum spanning tree

10 votes -- Anu (10.6k points)

1.16.8 Spanning Tree: GATE1997_9 top http://gateoverflow.in/2269

Selected Answer



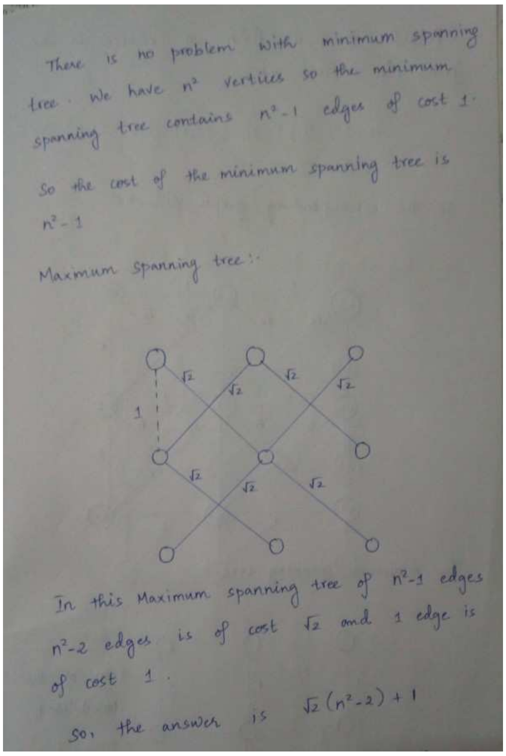
Consider $n = 3$, we have 9 vertices in the plane. The vertices are

(1,1) (1,2) (1,3) (2,1) (2,2) (2,3) (3,1) (3,2) (3,3)

So the corresponding graph will be

The minimum spanning tree

(one of the possibilities)



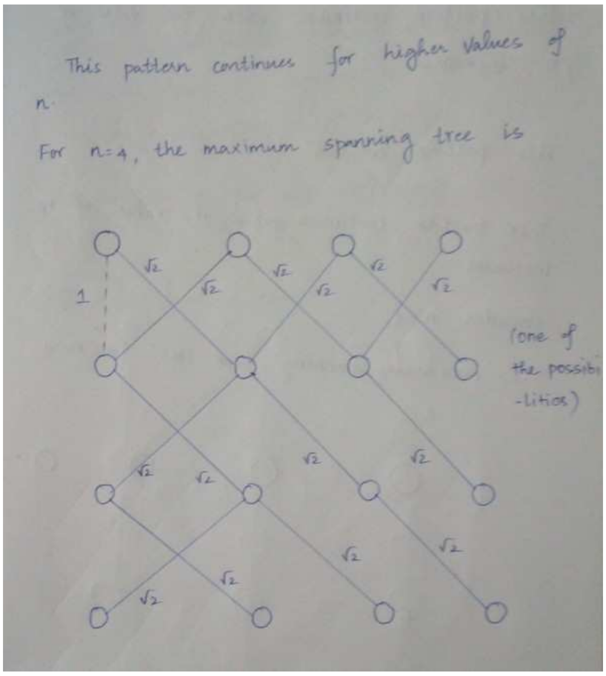
There is no problem with minimum spanning tree. We have n^2 vertices so the minimum spanning tree contains n^2-1 edges of cost 1.

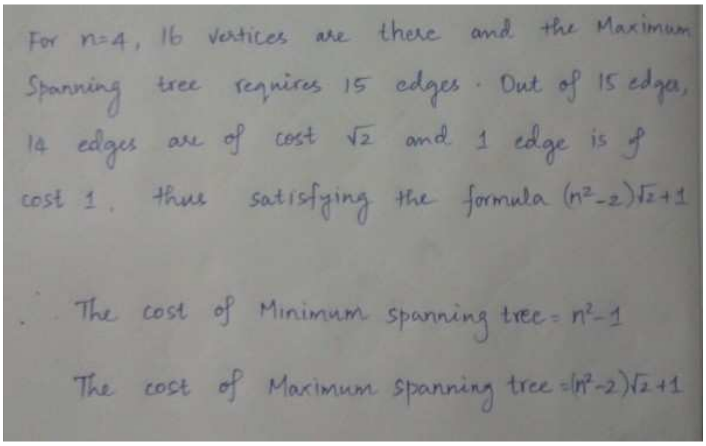
So the cost of the minimum spanning tree is n^2-1

Maximum spanning tree:

In this Maximum spanning tree of n^2-1 edges n^2-2 edges is of cost $\sqrt{2}$ and 1 edge is of cost 1.

So, the answer is $\sqrt{2}(n^2-2)+1$




For n=4, 16 vertices are there and the Maximum Spanning tree requires 15 edges. Out of 15 edges, 14 edges are of cost √2 and 1 edge is of cost 1, thus satisfying the formula $(n^2-2)\sqrt{2}+1$

∴ The cost of Minimum spanning tree = n^2-1

The cost of Maximum spanning tree = $(n^2-2)\sqrt{2}+1$

In the first image , the cost of the edge between the vertices (2,3) and (2,2)=1 and the cost of the edge between the vertices (2,2) and (2,1)=1.

👍 4 votes -- balaeinstein (917 points)

1.16.9 Spanning Tree: GATE2000-2.18 top http://gateoverflow.in/665

Selected Answer

C. the case should be written as "may or may not", to be true.

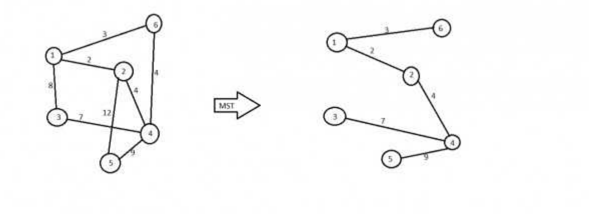
D will always be true as per the question saying that the graph has distinct weights.

👍 13 votes -- Gate Keeda (19.1k points)

1.16.10 Spanning Tree: GATE2001-15 top http://gateoverflow.in/756

Selected Answer

Minimum spanning tree:



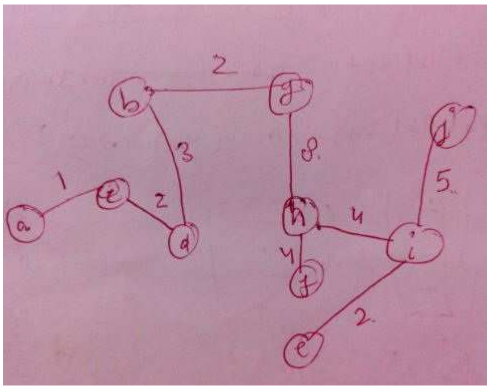
5 votes -- jayendra (8.1k points)

1.16.11 Spanning Tree: GATE2003-68 top

http://gateoverflow.in/955

Selected Answer

Apply Prim's algorithm, start from A as shown in figure below.



add all the weights in the given figure which would be equal to 31.

3 votes -- Monanshi Jain (8.5k points)

1.16.12 Spanning Tree: GATE2005-6 top

http://gateoverflow.in/1348

Selected Answer

Graph G has multiple distinct MSTs, each of cost $n-1$

From the given data given graph is a complete graph with all edge weights 1. A MST will contain $n-1$ edges . Hence weight of MST is $n-1$.

The graph will have multiple MST. In fact all spanning trees of the given graph wll be MSTs also since all edge weights are equal.

11 votes -- Sankaranarayanan P.N (11.2k points)

1.16.13 Spanning Tree: GATE2005-IT-52 top

http://gateoverflow.in/3813

Selected Answer

Option A is correct.

Questions says the MST of graph G contain an edge e which is a maximum weight edge in G. Nees to choose the answer which is always true to follow the above constraint.

Case-1

Option B says tht if edge e ia in MST then for sure there is a cycle having all edges of maximum weight. But it**is not true always because when there is only n-1 edges(but no cycle) in graph then also maximum edge has to be taken for MST**.

Case 2-

Option C says otherwise. That if e is in MST then it cannot be in any cycle that is wrong as if there is a cycee with all maximum edges then also e wip be in MST

Option D says all edges should be of same weight same explanation if there are n-1 distinct edges(but no cycle) in G then have to take all edges including maximum weight edge.

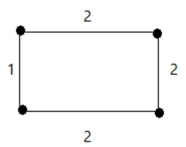
And at last option aA**says if e is in MST then for sure there is a cutset (minimum edge set whose removal disconnects the graph) in G having all edges of maximum weight. And it is true.**

Because then only we maximum weight edges has to be taken in MST.

For eg. If there are n-1 edges (but no cycle) then if edge e is not taken in the MST then MST will not be connected.

1 votes -- khush tak (6.8k points)

Option A is correct.



Here, in this example we can easily see that B, C, D are false. So, B,C,D are not always true.

that's why A is always true.. **A (Ans)**

13 votes -- Himanshu Agarwal (16.2k points)

1.16.14 Spanning Tree: GATE2006-11 top

http://gateoverflow.in/890

Selected Answer

2(n-1) the spanning tree will traverse adjacent edges since they contain the least weight.

13 votes -- anshu (3.2k points)

1.16.15 Spanning Tree: GATE2006-47 top

http://gateoverflow.in/1823

Selected Answer

in kruskal's algo the edges are added in non decreasing order of their weight. But in Option D edge d-e with weight 3 is added before edge d-c with weight 2. Hence Option D is wrong option

8 votes -- Sankaranarayanan P.N (11.2k points)

1.16.16 Spanning Tree: GATE2007-49 top

http://gateoverflow.in/1247

Selected Answer

D is the false statement.

A minimum spanning tree must have the edge with the smallest weight (In Kruskal's algorithm we start from the smallest weight edge). So, C is TRUE.

If e is not part of a minimum spanning tree, then all edges which are part of a cycle with e, must have weight ≤ e, as otherwise we can interchange that edge with e and get another minimum spanning tree of lower weight. So, B and A are also TRUE.

10 votes -- Arjun Suresh (294k points)

1.16.17 Spanning Tree: GATE2008-IT-45 top http://gateoverflow.in/3355

Selected Answer

Prim's algorithm starts with from any vertex and expands the MST by adding one vertex in each step which is close to the Intermediate MST(made till previous step).

Therefore correct answer would be (C).

(A): (d,f) is chosen but neither d nor f vertices are part of the previous MST(MST made till previous step).

(B): (g,h) is chosen but neither g or h vertices are part of the previous MST(MST made till previous step).

(D): (f,c) is chosen but at that point (f,d) is close to the intermediate MST.

12 votes -- suraj (5.1k points)

1.16.18 Spanning Tree: GATE2009-38 top http://gateoverflow.in/1324

Selected Answer

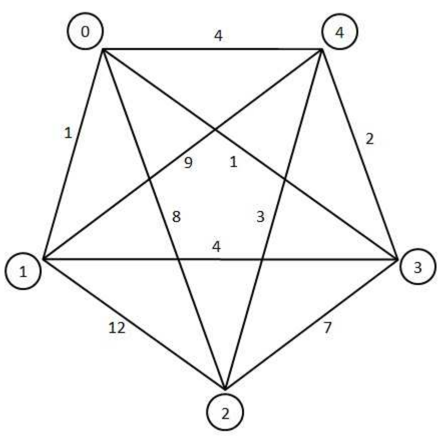
in option d b-c with weight 4 is added before a-c with weight 3 is added. In kruskal's algorithm edges should be added in non decreasing order of weight

So option D may be correct

9 votes -- Sankaranarayanan P.N (11.2k points)

1.16.19 Spanning Tree: GATE2010-50 top http://gateoverflow.in/2355

Selected Answer



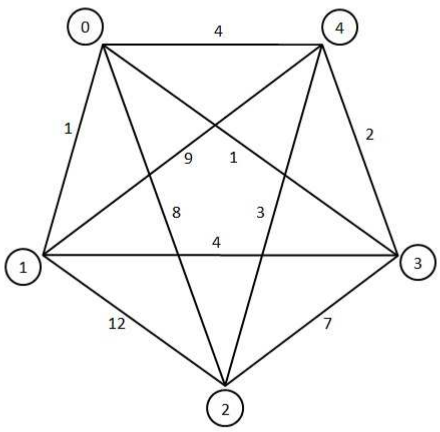
Answer is (D) 10. The edges of the spanning tree are: 0 - 1, 1 - 3, 3 - 4, 4 - 2. Total Weight = 10

14 votes -- Ashis Kumar Sahoo (823 points)

1.16.20 Spanning Tree: GATE2010-51 top

http://gateoverflow.in/43328

Selected Answer



Answer is (B) 8. The possible path is: 1 - 0, 0 - 4, 4 - 2.

9 votes

-- Ashis Kumar Sahoo (823 points)

1.16.21 Spanning Tree: GATE2011-54 top

http://gateoverflow.in/2162

Selected Answer

Q 54. Answer is **B**

We observe a pattern in the weight of MST being formed

For n=3 $(1+2+3)+(1)$
For n=4 $(1+2+3+4)+(1+2)$
For n=5 $(1+2+3+4+5)+(1+2+3)$
These can be obtained by drawing graphs for these graphs.
$\therefore$ Total weight of MST is $\sum_{i=1}^{n} i + \sum_{i=1}^{n-2} i = n^2 - n + 1$

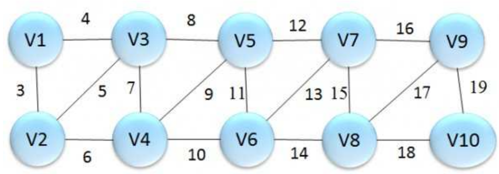
12 votes

-- Sona Praneeth Akula (4k points)

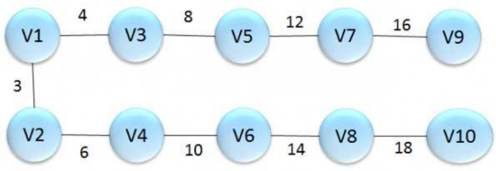
1.16.22 Spanning Tree: GATE2011-55 top

http://gateoverflow.in/43325

Selected Answer



Above is the graph....
Below is the MST.



Length of the path from v5 to v6= 8+4+3+6+10= **31** (Ans)

6 votes -- Ahwan Mishra (5.3k points)

1.16.23 Spanning Tree: GATE2012_29 top

http://gateoverflow.in/786

Selected Answer

When the edge weights are squared the minimum spanning tree won't change.

$t' < t^2$, because sum of squares is always less than the square of the sums except for a single element case.

Hence, B is the general answer and A is also true for a single edge graph. Hence, in GATE 2012, marks were given to all.

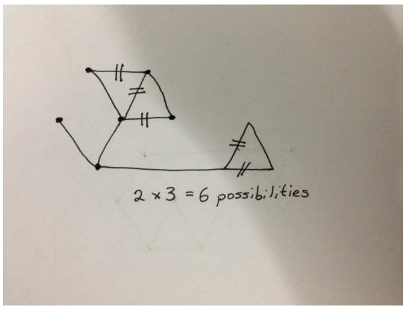
25 votes -- gatecse (13.4k points)

1.16.24 Spanning Tree: GATE2014-2-52 top

http://gateoverflow.in/2019

Selected Answer

6 is the answer.



19 votes -- Arjun Suresh (294k points)

1.16.25 Spanning Tree: GATE2015-1_43 top

http://gateoverflow.in/8313

Selected Answer

Consider the cycle ABC. AC and AB are part of minimum spanning tree. So, AB should be greater than max(AC, BC) (greater and not equal as edge weights are given to be distinct), as otherwise we could add AB to the minimum spanning tree and removed the greater of AC, BC and we could have got another minimum spanning tree. So, AB > 9.

Similarly, for the cycle DEF, ED > 6.

And for the cycle BCDE, CD > 15.

So, minimum possible sum of these will be 10 + 7 + 16 = 33. Adding the weight of spanning tree, we get the total sum of edge weights

= 33 + 36 = 69

28 votes -- Arjun Suresh (294k points)

1.16.26 Spanning Tree: GATE2015-3_40 top http://gateoverflow.in/8499

Selected Answer

first find no of edges in mst...
mst has n-1 edges where n is no of vertices. 100-1 =99 edges
each 99 edges in mst increases by 5 so weight in mst increased 99*5=495
now total weight of mst =500+495=995

22 votes -- Anoop Sonkar (4.9k points)

1.16.27 Spanning Tree: TIFR2011-B-35 top http://gateoverflow.in/20842

Selected Answer

a) & c) are trivially true. Edge with max value e1 must be present in Maximum spanning tree & same with minimum.

e) This is true, because all egde weights are distinct. maximum spanning tree is unique.

b) e1 & e2 must be present in Maximum spanning tree. I'll prove it using Kruskal Algorithm.

We will first insert weight with biggest value, e1. Then we insert e2 (second highest) . 2 edges do not create**cycle**. Then we can go on from there inserting edges according to edge weights.As they have just asked for top 2 edges, using Kruskal Algo we can say that top 2 edges must be in Maximum spanning tree.

d)

This is false. There are chances that this e_m weight edge is **cut edge(Bridge)** Then it must be inserted to from any spanning tree.

D is answer !

We can not say the same for Top 3 as they can create cycle & They we can not take a3 to make spanning tree.

Kruskal Algo Reference -> http://stackoverflow.com/questions/4992664/how-to-find-maximum-spanning-tree

5 votes -- Akash (43.8k points)

1.16.28 Spanning Tree: TIFR2013-B-17 top http://gateoverflow.in/25860

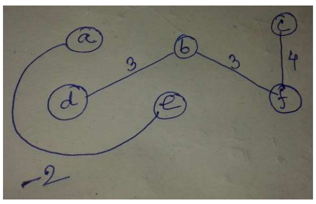
Selected Answer

There will be unique min weight spanning tree since all weights are distinct.
option A.

8 votes -- Umang Raman (15.2k points)

1.16.29 Spanning Tree: TIFR2014-B-4 top http://gateoverflow.in/27174

Selected Answer



Now check this diagram, this is forest obtained from above given graph using Kruskal's algorithm for MST.

So according to the question edge $d-e$ has weight 5 and it is included in the formation of MST. Now if edges $b-e$ and $e-f$ has weight greater than 5 than it is not a problem for our MST because still we will get the given tree as Kruskal's algorithm takes the smallest weighted edge without forming a cycle.

Cost of edge $b - c \geq 4$ may also lead us to the same tree as above though Kruskal's algorithm will have choice between $c - f$ and $b - c$.

Now if the edge weight of $a - d$ becomes 4, it is guaranteed that Kruskal's algorithm will not select edge $d - e$ because its edge cost is 5, and hence the tree structure will change. But there can be the case where edge weight is greater than 4 and we still get the same tree (happens when $a - d \geq 5$). Because in the question they asked to point out an unnecessary condition this case is not the answer as we need $a - d \geq 5$ which implies $a - d \geq 4$.

Now notice option A. Put $a - b = 5$. The given MST would not change. So, this condition is not always necessary and hence is the answer..

Therefore option A is the answer .

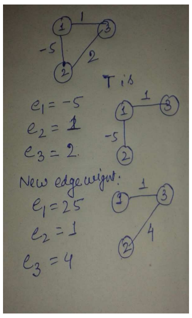
9 votes -- Riya Roy(Arayana) (7.1k points)

1.16.30 Spanning Tree: TIFR2014-B-5 top

http://gateoverflow.in/27180

Selected Answer

Answer is E . The catch here is Edges weights belongs to real number . Therefore edge weight can be negative . In that case the minimum spanning tree may be different .



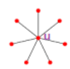
EDIT-

(Here every edge weight is distinct, therefore MST is unique. You do it using any algo.)

Option A is True. If we apply kruskal's algorithm then it will choose e_1

Option B is True. If we apply kruskal's algorithm then it will also choose e_2, and 2 edges can not forms a cycle. (e_3 is not guaranteed in MST, as it may form cycle.)

Option C is also true. If we apply prims also on any vertex (say u) then it chooses minimum



weight edge incident on vertex u.

Option D is true. Because every edge weight is distinct.

11 votes -- Riya Roy(Arayana) (7.1k points)

1.16.31 Spanning Tree: TIFR2015-B-2 top

http://gateoverflow.in/29844

Selected Answer

In the graph we have all edge weights are distinct so we will get unique minimum and maximum spanning tree.

Each Cycle must exclude maximum weight edge in minimum spanning tree.

Here we have two cycle of 3 edges , ade and cgk .

for second best minimum spanning tree = exclude ae edge and include de edge

other way : second best minimum spanning tree= exclude cg edge and include gk edge.

so e should be the ans.

7 votes -- papesh (24.1k points)

1.17 Time Complexity(32)

1.17.1 Time Complexity: CMI2013-A-10 top

http://gateoverflow.in/46602

The below question is based on following program:

```
procedure mystery (A : array [1..100] of int)
    int i,j,position,tmp;
    begin
        for j := 1 to 100 do
            position := j;
            for i := j to 100 do
                if (A[i] > A[position]) then
                    position := i;
                endfor
            tmp := A[j];
            A[j] := A[position];
            A[position] := tmp;
        endfor
end
```

The number of times the test $A[i] > A[position]$ is executed is:

A. 100
B. 5050
C. 10000
D. Depends on contents of A

cmi2013 algorithms time-complexity

Answer

1.17.2 Time Complexity: CMI2015-A-08 top

http://gateoverflow.in/47045

How many times is the comparison $i >= n$ performed in the following program?

```
int i=85, n=5;
main() {
    while (i >= n) {
        i=i-1;
        n=n+1;
    }
}
```

A. 40
B. 41
C. 42
D. 43

cmi2015 algorithms time-complexity

Answer

1.17.3 Time Complexity: GATE1989-2-iii top

http://gateoverflow.in/87080

Match the pairs in the following questions:

(A) $O(\log n)$	(p) Heapsort
(B) $O(n)$	(q) Depth-first search

(C) $O(n \log n)$ (r) Binary search

(D) $O(n^2)$ (s) Selection of the k^{th} smallest element in a set of n elements.

gate1989 match-the-following algorithms time-complexity

Answer

1.17.4 Time Complexity: GATE1993_8.7 top

http://gateoverflow.in/2305

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

a. $O(n)$
b. $O(n^2)$
c. $O(n^3)$
d. $O(3n^2)$
e. $O(1.5n^2)$

gate1993 algorithms time-complexity easy

Answer

1.17.5 Time Complexity: GATE1999-1.13 top

http://gateoverflow.in/1466

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

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

gate1999 algorithms time-complexity normal

Answer

1.17.6 Time Complexity: GATE1999-1.16 top

http://gateoverflow.in/1469

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

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

gate1999 algorithms time-complexity normal

Answer

1.17.7 Time Complexity: GATE1999_11a top

http://gateoverflow.in/1510

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

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

```
        end
end.
```

gate1999 algorithms time-complexity normal

Answer

1.17.8 Time Complexity: GATE2000-1.15 top

http://gateoverflow.in/638

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

A. $T(n)$ is $0(1)$
B. $n \leq T(n) \leq n \log_2 n$
C. $n \log_2 n \leq T(n) < \frac{n}{2}$
D. $T(n) = \left(\frac{n}{2}\right)$

gate2000 easy algorithms time-complexity

Answer

1.17.9 Time Complexity: GATE2003-66 top

http://gateoverflow.in/258

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

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

gate2003 algorithms time-complexity normal

Answer

1.17.10 Time Complexity: GATE2004-39 top

http://gateoverflow.in/1036

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

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

gate2004 algorithms time-complexity easy

Answer

1.17.11 Time Complexity: GATE2004-82 top

http://gateoverflow.in/1076

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

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

The complexity of this program fragment is

A. $\Omega(n^2)$

B. $\Omega(n \log n)$ and $O(n^2)$

C. $\Theta(n)$

D. $o(n)$

gate2004 algorithms time-complexity normal

Answer

1.17.12 Time Complexity: GATE2006-15 top http://gateoverflow.in/976

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

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

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

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

gate2006 algorithms normal time-complexity

Answer

1.17.13 Time Complexity: GATE2007-15,ISRO2016-26 top http://gateoverflow.in/56129

Consider the following segment of C-code:

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

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

A. $\lceil \log_2 n \rceil + 1$

B. n

C. $\lceil \log_2 n \rceil$

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

gate2007 algorithms time-complexity normal isro2016

Answer

1.17.14 Time Complexity: GATE2007-44 top http://gateoverflow.in/1242

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

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

How many recursive calls are made by this function?

A. $\Theta(\log_2 n)$

B. $\Omega(n)$

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

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

gate2007 algorithms time-complexity normal

Answer

1.17.15 Time Complexity: GATE2007-45 top http://gateoverflow.in/1243

What is the time complexity of the following recursive function?

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

A. $\Theta(n^2)$

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

C. $\Theta(\log_2 n)$

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

gate2007 algorithms time-complexity normal

Answer

1.17.16 Time Complexity: GATE2007-50 top http://gateoverflow.in/1248

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

A. At least $2n - c$ comparisons, for some constant c are needed.

B. At most $1.5n - 2$ comparisons are needed.

C. At least $n \log_2 n$ comparisons are needed

D. None of the above

gate2007 algorithms time-complexity easy

Answer

1.17.17 Time Complexity: GATE2007-51 top http://gateoverflow.in/1249

Consider the following C program segment:

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

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

A. $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(\sqrt{n})$

B. $T(n) = O(\sqrt{n})$ and $T(n) = \Omega(1)$

C. $T(n) = O(n)$ and $T(n) = \Omega(\sqrt{n})$

D. None of the above

gate2007 algorithms time-complexity normal

Answer

1.17.18 Time Complexity: GATE2007-IT-17 top http://gateoverflow.in/3450

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

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

gate2007-it algorithms time-complexity normal

Answer

1.17.19 Time Complexity: GATE2007-IT-81 top http://gateoverflow.in/3533

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

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

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

gate2007-it algorithms time-complexity normal

Answer

1.17.20 Time Complexity: GATE2008-40 top http://gateoverflow.in/452

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

A. $\Theta(n)$

B. $\Theta(\log n)$

C. $\Theta(\log^* n)$

D. $\Theta(1)$

gate2008 normal algorithms time-complexity

Answer

1.17.21 Time Complexity: GATE2008-47 top http://gateoverflow.in/459

We have a binary heap on n elements and wish to insert n more elements (not necessarily one after another) into this heap. The total time required for this is

A. $\Theta(\log n)$

B. $\Theta(n)$

C. $\Theta(n \log n)$

D. $\Theta(n^2)$

gate2008 algorithms time-complexity normal

Answer

1.17.22 Time Complexity: GATE2008-74 top http://gateoverflow.in/495

Consider the following C functions:

```
int f1 (int n)
{
    if(n == 0 || n == 1)
        return n;
    else
        return (2 * f1(n-1) + 3 * f1(n-2));
}
int f2(int n)
{
    int i;
    int X[N], Y[N], Z[N];
    X[0] = Y[0] = Z[0] = 0;
    X[1] = 1; Y[1] = 2; Z[1] = 3;
    for(i = 2; i <= n; i++){
        X[i] = Y[i-1] + Z[i-2];
        Y[i] = 2 * X[i];
        Z[i] = 3 * X[i];
    }
    return X[n];
}
```

The running time of f1(n) and f2(n) are

A. θ(n) and θ(n)
B. θ(2^n) and θ(n)
C. θ(n) and θ(2^n)
D. θ(2^n) and θ(2^n)

gate2008 algorithms time-complexity normal

Answer

1.17.23 Time Complexity: GATE2008-75 top http://gateoverflow.in/43489

Consider the following C functions:

```
int f1 (int n)
{
    if(n == 0 || n == 1)
        return n;
    else
        return (2 * f1(n-1) + 3 * f1(n-2));
}
int f2(int n)
{
    int i;
    int X[N], Y[N], Z[N];
    X[0] = Y[0] = Z[0] = 0;
    X[1] = 1; Y[1] = 2; Z[1] = 3;
    for(i = 2; i <= n; i++){
        X[i] = Y[i-1] + Z[i-2];
        Y[i] = 2 * X[i];
        Z[i] = 3 * X[i];
    }
    return X[n];
}
```

f1(8) and f2(8) return the values

A. 1661 and 1640
B. 59 and 59
C. 1640 and 1640
D. 1640 and 1661

gate2008 normal algorithms time-complexity

Answer

1.17.24 Time Complexity: GATE2010-12 top http://gateoverflow.in/2185

Two alternative packages A and B are available for processing a database having 10^k records. Package A requires $0.0001n^2$ time units and package B requires $10n\log_{10} n$ time units to process n records. What is the smallest value of k for which package B will be preferred over A?

A. 12
B. 10
C. 6
D. 5

gate2010 algorithms time-complexity easy

Answer

1.17.25 Time Complexity: GATE2014-1-42 top http://gateoverflow.in/1920

Consider the following pseudo code. What is the total number of multiplications to be performed?

```
D = 2
for i = 1 to n do
    for j = i to n do
        for k = j + 1 to n do
            D = D * 3
```

A. Half of the product of the 3 consecutive integers.
B. One-third of the product of the 3 consecutive integers.
C. One-sixth of the product of the 3 consecutive integers.
D. None of the above.

gate2014-1 algorithms time-complexity normal

Answer

1.17.26 Time Complexity: GATE2015-1_40 top http://gateoverflow.in/8299

An algorithm performs $(\log N)^{1/2}$ find operations , N insert operations, $(\log N)^{1/2}$ delete operations, and $(\log N)^{1/2}$ decrease-key operations on a set of data items with keys drawn from a linearly ordered set . For a delete operation, a pointer is provided to the record that must be deleted . For the decrease-key operation, a pointer is provided to the record that has its key decreased. Which one of the following data structures is the most suited for the algorithm to use, if the goal is to achieve the best total asymptotic complexity considering all the operations?

A. Unsorted array
B. Min - heap
C. Sorted array
D. Sorted doubly linked list

gate2015-1 algorithms data-structure normal time-complexity

Answer

1.17.27 Time Complexity: GATE2015-2_22 top http://gateoverflow.in/8113

An unordered list contains n distinct elements. The number of comparisons to find an element in this list that is neither maximum nor minimum is

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

gate2015-2 algorithms time-complexity easy

Answer

1.17.28 Time Complexity: GATE2017-2-03 top http://gateoverflow.in/118156

Match the algorithms with their time complexities:

Algorithms	**Time Complexity**
P. TOwers of honoi with n disks	i. Θ (n^2)
Q. Binary Search given n	ii. Θ(n log

numbers n sorted numbers	n)
R. Heap sort given n numbers at the worst case	iii. Θ(2^n)
S. Addition of two nxn matrices	iv. Θ(log n)

A. P→ (iii) Q → (iv) r →(i) S →(ii)
B. P→ (iv) Q →(iii) r →(i) S→(ii)
C. P→ (iii) Q →(iv) r →(ii) S→(i)
D. P→ (iv) Q →(iii) r →(ii) S→(i)

gate2017-2 algorithms time-complexity

Answer

1.17.29 Time Complexity: GATE2017-2-38 top

http://gateoverflow.in/118283

Consider the following C function

```
int fun(int n) {
    int I, j;
    for(i=1; i<=n; i++) {
        for (j=1; j<n; j+=i) {
            printf("%d %d", I, j);
        }
    }
}
```

Time complexity of fun in terms of θ notation is

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

gate2017-2 algorithms time-complexity

Answer

1.17.30 Time Complexity: TIFR2013-B-12 top

http://gateoverflow.in/25774

It takes $O(n)$ time to find the median in a list of n elements, which are not necessarily in sorted order while it takes only $O(1)$ time to find the median in a list of n sorted elements. How much time does it take to find the median of $2n$ elements which are given as two lists of n sorted elements each?

a. $O(1)$
b. $O(\log n)$ but not $O(1)$
c. $O(\sqrt{n})$ but not $O(\log n)$
d. $O(n)$ but not $O(\sqrt{n})$
e. $O(n \log n)$ but not $O(n)$

tifr2013 algorithms time-complexity

Answer

1.17.31 Time Complexity: TIFR2014-B-7 top

http://gateoverflow.in/27189

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

a. $(\log n)^{\log \log n} < 2^{\sqrt{\log n}} < n^{1/4}$

b. $2^{\sqrt{\log n}} < n^{1/4} < (\log n)^{\log \log n}$

c. $n^{1/4} < (\log n)^{\log \log n} < 2^{\sqrt{\log n}}$

d. $(\log n)^{\log \log n} < n^{1/4} < 2^{\sqrt{\log n}}$

e. $2^{\sqrt{\log n}} < (\log n)^{\log \log n} < n^{1/4}$

tifr2014 algorithms time-complexity

Answer

1.17.32 Time Complexity: TIFR2015-B-3 top http://gateoverflow.in/29846

Consider the following code fragment in the C programming language when run on a non-negative integer n.

```
int f (int n)
{
     if (n==0 || n==1)
         return 1;
     else
         return f (n - 1) + f(n - 2);
}
```

Assuming a typical implementation of the language, what is the running time of this algorithm and how does it compare to the optimal running time for this problem?

a. This algorithm runs in polynomial time in n but the optimal running time is exponential in n.
b. This algorithm runs in exponential time in n and the optimal running time is exponential in n.
c. This algorithm runs in exponential time in n but the optimal running time is polynomial in n.
d. This algorithm runs in polynomial time in n and the optimal running time is polynomial in n.
e. The algorithm does not terminate.

tifr2015 time-complexity

Answer

Answers: Time Complexity

1.17.1 Time Complexity: CMI2013-A-10 top http://gateoverflow.in/46602

Selected Answer

Ans- 5050 (100 +99 + 98 + ... +1 = (100 *101)/2)

3 votes -- Dhananjay Kumar Sharma (25.2k points)

1.17.2 Time Complexity: CMI2015-A-08 top http://gateoverflow.in/47045

Selected Answer

Correct answer is **C) 42**

It will start comparison from (85, 5), (84, 6), (83, 7) .... (45, 45), (44, 46)

Hence total number of comparison will be **(85-44) + 1 = 41 + 1 = 42**

9 votes -- Muktinath Vishwakarma (34.1k points)

1.17.3 Time Complexity: GATE1989-2-iii top http://gateoverflow.in/87080

Selected Answer

(A) O(logn)	R.Binary Search
(B) O(n)	S.Selection of the kth smallest element in a set of a elements. (Worst case)
(C) O(nlogn)	P.Heapsort
(D) O(n^2)	Q.Depth-first search(worst case If we consider Adjacency matrix)

PS: Kth smallest element can be found in O(n) time using partioning algorithm.

T(N)=T(N/2)+N (FOR FINDING KTH SMALLEST ELEMENT)

BY MASTERS THEOREM IT WILL BE O(N).

5 votes -- Prajwal Bhat (11.9k points)

1.17.4 Time Complexity: GATE1993_8.7 top http://gateoverflow.in/2305

Selected Answer

This is N added itself N times. So it is N^2 . Even if you consider as sum of O(1) + O(2) + .. O(n-1) + O(N). it will add up to N^2

So answer is

A) O(N) this is false.

B,C,D,E) All of this are true. We have N^2 here, so all options apart from A are correct.

In fact B = D = E this three options are same. and N^3 is always upper bound of N2. So $O(N^3)$ is also true.

PS: ∑ (K=1 to n) O(K) is never equal to n functions. It is always equal to one single function.

It can be written as C.1+c.2+c.3 and so on which results in O(N^2) (source Cormen)

11 votes -- Akash (43.8k points)

1.17.5 Time Complexity: GATE1999-1.13 top http://gateoverflow.in/1466

Selected Answer

Answer is (d) None of these

We just require n/2 swaps in the worst case. The algorithm is as given below:

Find positive number from left side and negative number from right side and do exchange. Since, at least one of them must be less than or equal to n/2, there cannot be more than n/2 exchanges. An implementation is given below:

http://gatecse.in/wiki/Moving_Negative_Numbers_to_the_Beginning_of_Array

21 votes -- Arjun Suresh (294k points)

1.17.6 Time Complexity: GATE1999-1.16 top http://gateoverflow.in/1469

Selected Answer

a. $\log n$

$a^n = (a^2)^{\frac{n}{2}}$.

One multiplication and recurrence on $\frac{n}{2}$. So, we get the recurrence relation for the number of multiplications as

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

This gives $T(n) = \log_2 n$

For n = 8, we can do

$b = a \times a$

$b = b \times b$

$b = b \times b$ and we get $b = a^8$

15 votes -- Arjun Suresh (294k points)

1.17.7 Time Complexity: GATE1999_11a top http://gateoverflow.in/1510

Selected Answer

The recurrence relation for time complexity is

$T(n) = T(n-1) + \frac{1}{n} + c$ (O(1/n) replaced with 1/n and so our answer will also be in O only and not Θ).

$T(n) = T(n-2) + \frac{1}{n-1} + \frac{1}{n} + 2c = T(1) + \frac{1}{2} + \frac{1}{3} + \dots + \frac{1}{n} + (n-1)c = A(1) + \frac{1}{2} + \frac{1}{3} \dots + \frac{1}{n} + nc = 1 + \frac{1}{2} + \frac{1}{3} \dots$

(Sum of the first n terms in harmonic series is $\Theta(\log n)$)

So, our time complexity will be $O(n)$.

14 votes -- Arjun Suresh (294k points)

1.17.8 Time Complexity: GATE2000-1.15 top http://gateoverflow.in/638

Selected Answer

Because array is always sorted just check the 1st two elements. option a.

17 votes -- anshu (3.2k points)

1.17.9 Time Complexity: GATE2003-66 top http://gateoverflow.in/258

Selected Answer

We can simply do a binary search in the array of natural numbers from $1..n$ and check if the cube of the number matches n (i.e., check if $a[i] * a[i] * a[i] == n$). This check takes $O(\log n)$ time and in the worst case we need to do the search $O(\log n)$ times. So, in this way we can find the cube root in $O(\log^2 n)$. So, options (A) and (B) are wrong.

Now, a number is represented in binary using $\log n$ bit. Since each bit is important in finding the cube root, any cube root finding algorithm must examine each bit at least once. This ensures that complexity of cube root finding algorithm cannot be lower than $\log n$. (It must be $\Omega(\log n)$). So, (D) is also false and (C) is the correct answer.

34 votes -- gatecse (13.4k points)

1.17.10 Time Complexity: GATE2004-39 top http://gateoverflow.in/1036

Selected Answer

D is correct

Here time complexity is asked, for each access of array element it will be constant,

So the time complexity will not depend upon storage. If at all program execution time is asked a is true

23 votes -- Anurag Semwal (8k points)

1.17.11 Time Complexity: GATE2004-82 top http://gateoverflow.in/1076

Selected Answer

The key part in the code is "counter = 0" in the else part as we can see below.

Lets take the best case. This happens when $a[i] = 1$ for all i, and then the loop executes with time complexity $\Theta(1)$ for each iteration and hence overall time complexity of $\Theta(n)$ and we can say time complexity of the code fragment is $\Omega(n)$ and hence options a and b are false.

Now, consider the worst case. This happens when $a[i] = 0$ or when else part is executed. Here, the time complexity of each iteration will be $\Theta(counter)$ and after each else, counter is reset to 0. Let k iterations go to the else part during the worst case. Then the worst case time complexity will be $\Theta(x_1) + \Theta(x_2) + \cdots + \Theta(x_k) + \Theta(n-k)$, where x_i is the value of the counter when, $A[i] = 0$ and $f(counter)$ is called. But due to $counter = 0$ after each call to $f()$, we have, $x_1 + x_2 + \cdots + x_k = n$. So, $\Theta(x_1) + \Theta(x_2) + \cdots + \Theta(x_k) + \Theta(n-k) = \Theta(n) + \Theta(n-k) = \Theta(n)$.

Since the time complexity is $\Omega(n)$ and $\Theta(n)$ we can say it is $\Theta(n)$ - Option (C). (Option D is false because the small o needs the growth rate to be **STRICTLY lower** and not equal to or lower as the case for big 0)

If $counter = 0$ was not there in else part, then time complexity would be $\Omega(n)$ and $O(n^2)$ as in worst case we can have equal number of 0's and 1's in array a giving time complexity $\Theta(1) + \Theta(2) + \cdots + \Theta(n/2) + \Theta(n/2)$ would give $O(n^2)$.

18 votes -- Arjun Suresh (294k points)

1.17.12 Time Complexity: GATE2006-15 top http://gateoverflow.in/976

Selected Answer

Answer will be $\Theta(n)$

$j = n/2 + n/4 + n/2 + \ldots + 1$

number of iteration will be $2^k = n$ or $k = \log n$

this is in GP find sum till $\log n$,= $\Theta(n)$

18 votes -- rahulkr (665 points)

1.17.13 Time Complexity: GATE2007-15,ISRO2016-26 top http://gateoverflow.in/56129

n	no. of comparision	Ceil($\log_2$n) + 1
1	2 (j = 1,2)	1
2	3 (j = 1,2,4)	2
3	3 (j = 1,2,4)	2
4	4 (j = 1,2,4,8)	3
5	4 (j = 1,2,4,8)	4

may be we have to count those comparisons which results in the execution of loop.

Answer should be Ceil($\log_2$n) + 1

EDIT: but answer could be: floor($\log_2$n) + 2

19 votes -- Vikrant Singh (13.4k points)

1.17.14 Time Complexity: GATE2007-44 top

http://gateoverflow.in/1242

Selected Answer

Worst case will arise when both n and m are consecutive Fibonacci numbers.

$$\gcd(F_n, F_{n-1}) = \gcd(F_{n-1}, F_{n-2}) = \cdots = \gcd(F_1, F_0) = 1$$

and n^{th} Fibonacci number is 1.618^n, where 1.618 is the Golden ratio.

So, to find $\gcd(n, m)$, number of recursive calls will be $\Theta(\log n)$.

18 votes -- Vikrant Singh (13.4k points)

1.17.15 Time Complexity: GATE2007-45 top

http://gateoverflow.in/1243

Selected Answer

We are asked the time complexity which will be the number of recursive calls in the function as in each call we perform a constant no. of operations and a recursive call. The recurrence relation for this is (considering constant time "c" as 1)

$$T(n) = T(\sqrt{n}) + 1 = T\left(n^{1/4}\right) + 2 = T\left(n^{1/8}\right) + 3$$

Going like this we will eventually reach T(3) or T(2). For asymptotic case this doesn't matter and we can assume we reach T(2) and in next step reach T(1). So, all we want to know is how many steps it takes to reach T(1) which will be 1+ no. of steps to reach T(2).

From the recurrence relation we know that T(2) happens when $n^{\left(\frac{1}{2^k}\right)} = 2$.

Taking $\log$ and equating,

$$\frac{1}{2^k}\log n = 12^k = \log nk = \log\log n$$.

So, T(1) happens in $\log\log n + 1$ calls, but for asymptotic complexity we can write as $\Theta\left(\log\log n\right)$

Alternatively,

Substituting values

$$T(1) = 1$$
$$T(2) = 1$$
$$T(3) = T(1) + 1 = 2$$
$$\ldots$$
$$T(8) = T(2) + 1 = 2$$
$$T(9) = T(3) + 1 = 3$$
$$\ldots$$

$$T\left(\left(\left(2^2\right)^2\right)^2\right) = T\left(\left(2^2\right)^2\right) + 1 = T(2^2) + 2 = T(2) + 3 = 1 + 3 = 4, \log\log n = 3 \text{ as } n = 256$$.

$$T\left(\left(\left(\left(\left(2^2\right)^2\right)^2\right)^2\right)^2\right) = 6, \log\log n = 5 \text{ as } n = 65536 \times 65536 = 2^{32}$$

$$T\left(2^{\left(2^{10}\right)}\right) = T\left(2^{512}\right) + 1 = T(2^{256}) + 2 = T(2^{128}) + 3 = T(2^{64}) + 4 = T(2^{32}) + 5 = T(2^{16}) + 6 = T(2^8) + 7 = T(2^4) +$$

So, answer is **D**

http://stackoverflow.com/questions/16472012/what-would-cause-an-algorithm-to-have-olog-log-n-complexity

👍 23 votes -- Arjun Suresh (294k points)

1.17.16 Time Complexity: GATE2007-50 top

http://gateoverflow.in/1248

Selected Answer

[need @arjun sir to verify it]

We are requested to find the MAX and MIN of the array of n elements . This can be done as follws

Non Divide And Conquer

```
Max_Min(A,n,max,min)
  max=min=a[i]
  for i-> 2 to n
  {
      if A[i] > max   // First Comparision
         max=A[i]
      else if A[i] < min  // Seond Comparision
         min = A[i]
  }
```

Analysis

Best Case

When input is in increasing order

- First Comparision : $n-1$ time
- Second Comparision: 1 time

Worst Case

When input is in Decreasing order

- First Comparision : $n-1$ time
- Second Comparision: $n-1$ time

Average Case

When First Comparision fails for half of the input

- First Comparision : $n-1$ time
- Second Comparision: $\frac{n}{2}$ time

Divide And Conquer

Given a function to compute on n inputs the divide-and-conquer strategy suggest splitting the inputs into k distinct subsets, $1 < K \leq n$, yielding k sub problems. These Sub problems must be solved, and then a method must be found to combine sub solutions into a solution of the whole.

Defining the Termination condition 'SMALL' of the problem , When $n \leq 2$. In this case, the maximum and minimum are $a[i]$ if $n = 1$. If $n = 2$, the problem can be solved by making one comparison.

How can we Combine The Subproblem ? If $\text{MAX}(\text{A})$ and $\text{MIN}(\text{P})$ are the maximum and minimum of the elements of A, then $\text{MAX}(\text{A})$ is the larger of $\text{MAX}(\text{A1})$ and $\text{MAX}(\text{A2})$ Similarly for $\text{MIN}(\text{A})$

```
 MaxMin(i, j, max, min)
// a[1:n] is a global array. Parameters i and j are integers,
// 1≤i≤j≤n. The effect is to set max and min to the largest and
// smallest values in a[i:j].
{
     if (i=j) then max := min := a[i]; //Small(P)
     else if (i=j-1) then // Another case of Small(P)
          {
                if (a[i] < a[j]) then max := a[j]; min := a[i];
                else max := a[i]; min := a[j];
          }
     else
     {
           // if P is not small, divide P into sub-problems.
           // Find where to split the set.
           mid := ( i + j )/2;
           // Solve the sub-problems.
           MaxMin( i, mid, max, min );
           MaxMin( mid+1, j, max1, min1 );
           // Combine the solutions.
           if (max < max1) then max := max1;
```

```
        if (min > min1) then min := min1;
    }
}
```

Analysis

Time Complexity

$$T(n) = \begin{cases} 0 & n = 1 \\ 1 & n = 2 \\ 2T(\frac{n}{2}) + 2 & n > 2 \end{cases}$$

Using Master Theorem Case 1 follows . Hence $T(n)$ is $\Theta(n)$

Solution

$$\begin{aligned} T(n) &= 2T(\frac{n}{2}) + 2 \\ &= 4T(\frac{n}{4}) + 2^2 + 2 \\ &\dots \\ &= 2^k T(\frac{n}{2^k}) + \sum_{i=1}^{k} 2^i \qquad (\text{where} \sum_{i=1}^{k} 2^i = 2^{k+1} - 2) \\ &= 2^k T(\frac{n}{2^k}) + 2^{k+1} - 2 \qquad (\text{where}, k = (\log n) - 1) \\ &= 2^{(\log n) - 1} T(1) + 2^{\log n} - 2 \\ &= \frac{n}{2} + n - 2 \\ &= \frac{3n}{2} - 2 \end{aligned}$$

For Input Class : Numbers in Increasing Order Non-Divide And Conquer Strategy Perform Better than Divide And Conquer

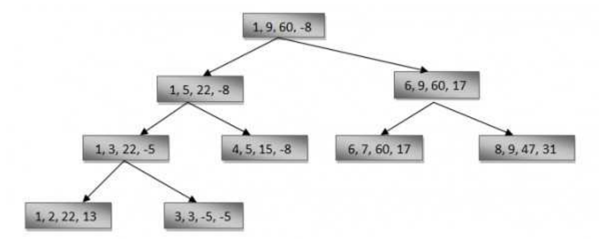
Space Complexity

$S(n) = n + \log n + c$ Where n is the input size and $\log n$ is the size of the stack . Hence the space complexity is $O(\log n)$

Example

Consider the array

$$A[] = \begin{Bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ 22 & 13 & -5 & -8 & 15 & 60 & 17 & 31 & 47 \end{Bmatrix}$$



Video Example : https://www.youtube.com/watch?v=EHRL2LbS5LU

References

1. https://www.youtube.com/watch?v=lEvzwEcjQ54&feature=youtu.be&t=1823
2. Cormen
3. http://somnathkayal.blogspot.in/2012/08/finding-maximum-and-minimum-using.html

8 votes -- pC (21.4k points)

1.17.17 Time Complexity: GATE2007-51 top

http://gateoverflow.in/1249

Selected Answer

Answer = **option B**

Worst Case : $T(n) = \mathcal{O}(\sqrt{n})$

Best Case : When n is an even number body of for loop is executed only 1 time (due to "return 0" inside if) which is irrespective of n. $\therefore T(n) = \Omega(1)$

17 votes -- Gate Keeda (19.1k points)

1.17.18 Time Complexity: GATE2007-IT-17 top

http://gateoverflow.in/3450

Selected Answer

Answer is (A)

We need to divide
n **recursively and compute like following:**

$C_1 = b^{\frac{n}{2}} \times b^{\frac{n}{2}}$. In this, we need to calculate $b^{\frac{n}{2}}$ only once.

$C_2 = b^{\frac{n}{4}} \times b^{\frac{n}{4}}$

$\vdots$

$C_k = b^2 \times b^2 \qquad \Big\{ k = \log n$

Recurrence relation: $T(n) = T\left(\frac{n}{2}\right) + O(1)$

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

21 votes -- Sandeep_Uniyal (7.3k points)

1.17.19 Time Complexity: GATE2007-IT-81 top

http://gateoverflow.in/3533

Selected Answer

Answer: B

Gradient = y_2-y_1/x_2-x_1

For gradient to be maximum x_2-x_1 should be minimum. So, sort the points (in θ(nlogn) time) according to x coordinate and find the minimum difference between them (in θ(n) time).

Best complexity: θ(nlogn + n) which leads to B.

https://www.careercup.com/question?id=4787065684230144

9 votes -- Rajarshi Sarkar (35k points)

1.17.20 Time Complexity: GATE2008-40 top

http://gateoverflow.in/452

Selected Answer

answer = **option B**

whenever there exists an element which is present in the array : more than $\frac{n}{2}$ times, then definitely it will be present at

the middle index position; in addition to that it will also be present at anyone of the neighbourhood indices namely $i-1$ and $i+1$
No matter how we push that stream of **More than** $\frac{n}{2}$ times of elements of same value around the Sorted Array, it is bound to be present at the middle index + atleast anyone of its neighbourhood

once we got the element which should have occurred more that $n/2$ times we count its total occurrences in $\mathcal{O}(\log n)$ time.

24 votes -- Amar Vashishth (28.7k points)

To check whether a given number is repeated n/2 times in the array can be done in O(log n) time.

Algo

1. find the **first** occurrence (index i) of x(given number) in the array which can be done in O(log n) time (a variant of binary search).

2. check if A[i] == A[n/2+i]

   return true

3. else return false

17 votes -- Vikrant Singh (13.4k points)

1.17.21 Time Complexity: GATE2008-47 top

http://gateoverflow.in/459

Selected Answer

an insert operation on a binary heap takes $\mathcal{O}(\log n)$ time, but an alternative approach we can use. which requires us to insert n elements in heap without any computation i.e. in constant time. after which we can apply Heapify operation(this operation creates heap in linear time) on the array of those element and Hence obtain a Heap in $\mathcal{O}(n)$ time.

Here "not necessairly one after another" should mean that we can insert n elements at once and not necesaairly have to wait for first insert to be completed before doing second.

22 votes -- Amar Vashishth (28.7k points)

1.17.22 Time Complexity: GATE2008-74 top

http://gateoverflow.in/495

Selected Answer

Q.74 = option B
Q.75 = option C

Time complexity of f1 is given by
T(n) = T(n-1) + T(n-2), (multiplication by 2 and 3 won't affect complexity as it is a constant time operation)
T(0) = T(1) = 1

The solution to this (fibonacci series) is given by Golden ratio. https://en.wikipedia.org/wiki/Golden_ratio which is O(2^n). (Using theta in question must be a mistake)

Time complexity of f2 is □(n) as here all recursive calls are avoided by saving the results in an array (dynamic programming).

So, answer to 74 is (B).

75. Both f1 and f2 are calculating the same function. So,

f1(2) = 2f1(1) + 3f1(0) = 2

```
f1(3) = 2f1(2) + 3f1(1) = 7
f1(4) = 20
f1(5) = 61
f1(6) = 182
f1(7) = 547
f1(8) = 1640 = f2(8)
```

👍 20 votes -- Arjun Suresh (294k points)

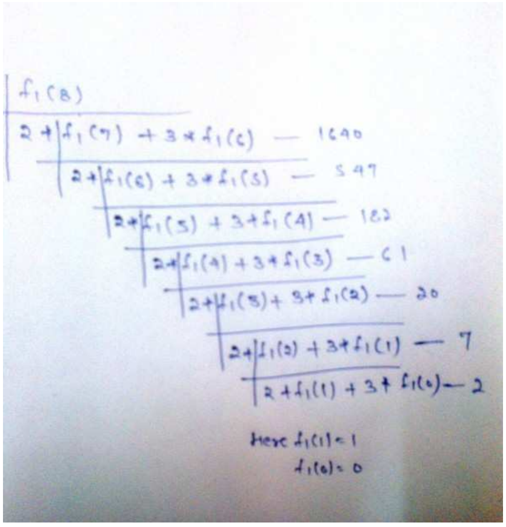
1.17.23 Time Complexity: GATE2008-75 top

http://gateoverflow.in/43489

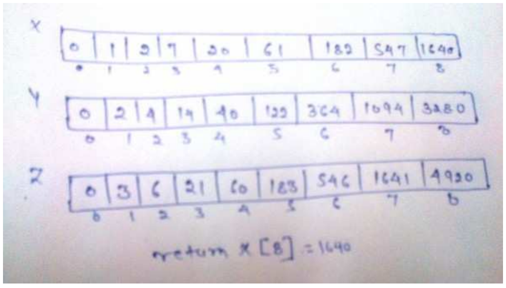
Selected Answer

Here Ans C. 1640 and 1640

f1(8)



f2(8) will return



👍 9 votes -- Manoj Kumar (37.5k points)

1.17.24 Time Complexity: GATE2010-12 top

http://gateoverflow.in/2185

Selected Answer

$10n \log_{10} n \leq 0.0001n^2$

$\implies 10 \times 10^k \log_{10} 10^k \leq 0.0001(10^k)^2$

$\implies 10^{k+1} k \leq 0.0001 \times 10^{2k}$

$\implies k \leq 10^{2k-k-1-4}$

$$\implies k \leq 10^{k-5}$$

Trying the values, 5 doesn't satisfy this but 6 satisfies.

22 votes -- Arjun Suresh (294k points)

1.17.25 Time Complexity: GATE2014-1-42 top

http://gateoverflow.in/1920

Selected Answer

Total number of multiplications

$$= \sum_{i=1}^{n} \sum_{j=i}^{n} \sum_{k=j+1}^{n} 1 = \sum_{i=1}^{n} \sum_{j=i}^{n} (n-j) = \sum_{i=1}^{n} (n-i) + (n-(i+1)) + \ldots + (n-n) = \frac{1}{2} \sum_{i=1}^{n} (n-i)(n-i+1)$$

Therefore, correct answer would be (C).

32 votes -- suraj (5.1k points)

1.17.26 Time Complexity: GATE2015-1_40 top

http://gateoverflow.in/8299

Selected Answer

	$(\log N)^{1/2}$ find	**N insert**	**$(\log N)^{1/2}$ delete**	**$(\log N)^{1/2}$ decrease-key**
Unsorted Array	$O(N (\log N)^{1/2})$	O(N)	$O(\log N)^{1/2})$	$O(\log N)^{1/2})$
Min-heap	$O(N (\log N)^{1/2})$	O(N log N)	$O((\log N)^{3/2})$	$O((\log N)^{3/2})$
Sorted Array	$O((\log N)^{3/2})$	$O(N^2)$	$O(N (\log N)^{1/2})$	$O(N (\log N)^{1/2})$
Sorted doubly linked-list	$O(N (\log N)^{1/2})$	$O(N^2)$	$O((\log N)^{1/2})$	$O(N(\log N)^{1/2})$

So, Unsorted array is the answer.

The operations given can be performed in any order. So, for Min-heap we cannot do the usual BuildHeap method.

Delete in unsorted array is O(1) as we can just swap the deleted element with the last element in the array and delete the last element.

For sorted-doubly linked-list we cannot do binary search as this would require another array to maintain the pointers to the nodes.

34 votes -- Arjun Suresh (294k points)

1.17.27 Time Complexity: GATE2015-2_22 top

http://gateoverflow.in/8113

Selected Answer

Ans O(1), because all elements are distinct, select any three numbers and output 2nd largest from them.

40 votes -- Vikrant Singh (13.4k points)

1.17.28 Time Complexity: GATE2017-2-03 top

http://gateoverflow.in/118156

Selected Answer

According to the recurrrence relation

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

Tower of hanoi we get it is $\Theta(2^n)$

now heap sort worst case $\Theta(n \log n)$

Binary Search given n numbers n sorted numbers $\Theta(\log n)$

Addition of two nxn matrices $\Theta(n^2)$

so C is correct answer here

12 votes -- Aboveallplayer (18.5k points)

1.17.29 Time Complexity: GATE2017-2-38 top

http://gateoverflow.in/118283

Selected Answer

inner for loop is dependent on i, so for each i we have to check no of times inner loop operating..

it ll be something like

$\frac{n-1}{1} + \frac{n-1}{2} + \frac{n-1}{3} + \ldots\ldots\ldots\ldots + \frac{n-1}{n-1} + 1$

$\frac{n}{1} + \frac{n}{2} + \frac{n}{3} + \ldots\ldots + \frac{n}{n-1} - log(n-1)$

n{$\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \ldots\ldots + \frac{1}{n-1}$ }-$log(n-1)$

$nlog(n-1) - log(n-1)$

$nlog(n-1)$

nlogn

12 votes -- 2018 (5.2k points)

1.17.30 Time Complexity: TIFR2013-B-12 top

http://gateoverflow.in/25774

Selected Answer

```
1) Calculate the medians m1 and m2 of the input arrays ar1[]
   and ar2[] respectively.
2) If m1 and m2 both are equal.
     return m1 (or m2)
3) If m1 is greater than m2, then median is present in one
   of the below two subarrays.
    a)  From first element of ar1 to m1 (ar1[0 to n/2])
    b)  From m2 to last element of ar2  (ar2[n/2 to n-1])
4) If m2 is greater than m1, then median is present in one
   of the below two subarrays.
   a)  From m1 to last element of ar1  (ar1[n/2 to n-1])
   b)  From first element of ar2 to m2 (ar2[0 to n/2])
5) Repeat the above process until size of both the subarrays
   becomes 2.
6) If size of the two arrays is 2 then
  the median.
    Median = (max(ar1[0], ar2[0]) + min(ar1[1], ar2[1]))/2
Time complexity O(logn)
```

http://www.geeksforgeeks.org/median-of-two-sorted-arrays/

11 votes -- Umang Raman (15.2k points)

1.17.31 Time Complexity: TIFR2014-B-7 top http://gateoverflow.in/27189

Selected Answer

Let us take $\log$ for each function.

1. $\log{(\log n)^{\log\log n}} = (\log\log n)^2$
2. $\log 2^{\sqrt{\log n}} = \sqrt{\log n} = (\log n)^{0.5}$
3. $\log n^{1/4} = 1/4 \log n$

Here, If we consider $\log n$ as a term (which is common in all 3), first 1 is a log function, second one is sqrt function and third one is linear function of $\log n$. Order of growth of these functions are well known and $\log$ is the slowest growing followed by sqrt and then linear. So, option A is the correct answer here.

PS: After taking $\log$ is we arrive at functions distinguished by some constant terms only, then we can not conclude the order of grpwth of the original functions using the $\log$ function. Examples are $f(n) = 2^n, g(n) = 3^n$.

7 votes -- srestha (58.4k points)

1.17.32 Time Complexity: TIFR2015-B-3 top http://gateoverflow.in/29846

Selected Answer

Ans : C

it is fibanacci series generation. it takes exponential time if we won't use dynamic programming.

if we use dynamic programming then it takes O(n)

8 votes -- pramod (3.3k points)

2 Compiler Design (159) top

2.0.1 GATE1989-4-v top http://gateoverflow.in/87885

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

if expression then statement 1

else statement 2

Template:

Code for expression

(*result in E, E > O indicates true *)

Branch on E > O to L1

Code for statement 1

L1: Code for statement 2

descriptive gate1989 compiler-design

Answer

2.0.2 GATE1994_17 top http://gateoverflow.in/2513

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

a. Coroutine is just another name for a subroutine.
b. A two pass assembler uses its machine opcode table in the first pass of assembly.

gate1994 compiler-design normal

Answer

Answers:

2.0.1 GATE1989-4-v top http://gateoverflow.in/87885

Selected Answer

I think the given template is wrong. The following should be correct:

Code for Expression

Branch on E>0 to L

Code for segment 2

Branch to L1

L: Code for statement 1

L1:

Please correct me if I am wrong.

2 votes -- Pinaki Dash (1k points)

2.0.2 GATE1994_17 top http://gateoverflow.in/2513

1) True

Subroutine are special cases of coroutine. Coroutine are generalized form of subroutine which is nonpreemptive multitasking

https://en.wikipedia.org/wiki/Coroutine

2) True. Basically machine opcode table is the symbol table which requires in 1st pass of two pass assembler

http://users.cis.fiu.edu/~downeyt/cop3402/two-pass.htm

2 votes -- srestha (58.4k points)

2.1 Abstract Syntax Tree(1) top

2.1.1 Abstract Syntax Tree: GATE2015-2-14 top http://gateoverflow.in/8084

In the context of abstract-syntax-tree (AST) and control-flow-graph (CFG), which one of the following is TRUE?

A. In both AST and CFG, let node N_2 be the successor of node N_1. In the input program, the code corresponding to N_2 is present after the code cprresponding to N_1
B. For any input program, neither AST nor CFG will contain a cycle
C. The maximum number of successors of a node in an AST and a CFG depends on the input program
D. Each node in AST and CFG corresponds to at most one statement in the input program

gate2015-2 compiler-design easy abstract-syntax-tree

Answer

Answers: Abstract Syntax Tree

2.1.1 Abstract Syntax Tree: GATE2015-2-14 top http://gateoverflow.in/8084

Selected Answer

Option (C) is Correct

(A) is false , In CFG , code of N_2 may be present before N_1 when there is a loop or Goto.

(B) is false , CFG contains cycle when input program has loop.

(C) is true ,successors in AST and CFG depend on Input program.

(D) is false, In CFG a single node may belong to a block of statements.

14 votes -- Himanshu Agarwal (16.2k points)

2.2 Assembler(5) top

2.2.1 Assembler: GATE1992-01,viii top http://gateoverflow.in/553

The purpose of instruction location counter in an assembler is ________

gate1992 compiler-design assembler normal

Answer

2.2.2 Assembler: GATE1992_03,ii top http://gateoverflow.in/579

Mention the pass number for each of the following activities that occur in a two pass assembler:

a. object code generation

b. literals added to literal table
c. listing printed
d. address resolution of local symbols

gate1992 compiler-design assembler easy

Answer

2.2.3 Assembler: GATE1993-7.6 top http://gateoverflow.in/2294

A simple two-pass assembler does the following in the first pass:

A. It allocates space for the literals.

B. It computes the total length of the program.

C. It builds the symbol table for the symbols and their values.

D. It generates code for all the load and store register instructions.

E. None of the above.

gate1993 compiler-design assembler easy

Answer

2.2.4 Assembler: GATE1994_18 top http://gateoverflow.in/2514

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

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

b. A symbol declared as 'external' in an assembly language program is assigned an address outside the program by the assembler itself.

gate1994 compiler-design normal assembler true-false

Answer

2.2.5 Assembler: GATE1996_1.17 top http://gateoverflow.in/2721

The pass numbers for each of the following activities

i. object code generation

ii. literals added to literal table

iii. listing printed

iv. address resolution of local symbols that occur in a two pass assembler

respectively are

A. 1, 2, 1, 2

B. 2, 1, 2, 1

C. 2, 1, 1, 2

D. 1, 2, 2, 2

gate1996 compiler-design normal assembler

Answer

Answers: Assembler

2.2.1 Assembler: GATE1992-01,viii top http://gateoverflow.in/553

Each section of an assembler language program has a location counter used to assign storage addresses to your program's statements. As the instructions of a source module are being assembled, the location counter keeps track of the current location in storage.

2 votes -- Rohan Ghosh (1.9k points)

2.2.2 Assembler: GATE1992_03,ii top http://gateoverflow.in/579

Selected Answer

a) 2

b) 1

c) 2

d) 1

P.S. : In first pass, symbol table is created and In second pass, machine code is generated. Listing of final machine code is done after 2nd pass only.

7 votes -- Aditya Gaurav (2.8k points)

2.2.3 Assembler: GATE1993-7.6 top http://gateoverflow.in/2294

Selected Answer

a, b, c are TRUE.

http://gateoverflow.in/?qa=blob&qa_blobid=2337905098612945492

15 votes -- Arjun Suresh (294k points)

2.2.4 Assembler: GATE1994_18 top http://gateoverflow.in/2514

A) This is true. We can not replace macro entirely using subroutine. Ex -> Macro constant used for renaming.

B) This is false. This is job of Linker.

4 votes -- Akash (43.8k points)

2.2.5 Assembler: GATE1996_1.17 top http://gateoverflow.in/2721

Selected Answer

Ans should be (B)

the functions performed in pass 1 and pass 2 in 2 pass assembler are

Pass 1

1. Assign addresses to all statements in the program.

2. Save the values assigned to all labels for use in pass 2

3. Perform some processing of assembler directives.

Pass 2

1. Assemble instructions.

2. Generate data values defined by BYTE, WORD etc.

3. Perform processing of assembler directives not done during pass 1.

4. Write the program and the assembling listing

10 votes -- sonam vyas (13.2k points)

2.3 Code Optimization(4) top

2.3.1 Code Optimization: GATE2008-12 top http://gateoverflow.in/410

Some code optimizations are carried out on the intermediate code because

A. They enhance the portability of the compiler to the target processor

B. Program analysis is more accurate on intermediate code than on machine code

C. The information from dataflow analysis cannot otherwise be used for optimization

D. The information from the front end cannot otherwise be used for optimization

gate2008 normal code-optimization compiler-design

Answer

2.3.2 Code Optimization: GATE2014-1-17 top http://gateoverflow.in/1784

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

A. A basic block is a sequence of instructions where control enters the sequence at the beginning and exits at the end.
B. Available expression analysis can be used for common subexpression elimination.
C. Live variable analysis can be used for dead code elimination.
D. $x = 4 * 5 \Rightarrow x = 20$ is an example of common subexpression elimination.

gate2014-1 compiler-design code-optimization normal

Answer

2.3.3 Code Optimization: GATE2014-3-11 top http://gateoverflow.in/2045

The minimum number of arithmetic operations required to evaluate the polynomial $P(X) = X^5 + 4X^3 + 6X + 5$ for a given value of X, using only one temporary variable is _______.

gate2014-3 compiler-design numerical-answers normal code-optimization

Answer

2.3.4 Code Optimization: GATE2014-3-34 top http://gateoverflow.in/2068

Consider the basic block given below.

```
a = b + c
c = a + d
d = b + c
e = d - b
a = e + b
```

The minimum number of nodes and edges present in the DAG representation of the above basic block respectively are

A. 6 and 6
B. 8 and 10
C. 9 and 12
D. 4 and 4

gate2014-3 compiler-design code-optimization normal

Answer

Answers: Code Optimization

2.3.1 Code Optimization: GATE2008-12 top

http://gateoverflow.in/410

Selected Answer

Ans is (A)

Intermediate codes are machine independent codes. So, intermediate code can be used for code optimization since a given source code can be converted to target machine code.

14 votes

-- Keith Kr (6.3k points)

2.3.2 Code Optimization: GATE2014-1-17 top

http://gateoverflow.in/1784

Selected Answer

A) A basic block is a sequence of instructions where control enters the sequence at the beginning and exits at the end is TRUE.

(B) Available expression analysis can be used for common subexpression elimination is TRUE. Available expressions is an analysis algorithm that determines for each point in the program the set of expressions that need not be recomputed. Available expression analysis is used to do global common subexpression elimination (CSE). If an expression is available at a point, there is no need to re-evaluate it.

(C)Live variable analysis can be used for dead code elimination is TRUE.

(D) x = 4 ∗ 5 => x = 20 is an example of common subexpression elimination is FALSE. Common subexpression elimination (CSE) refers to compiler optimization replaces identical expressions (i.e., they all evaluate to the same value) with a single variable holding the computed value when it is worthwhile to do so Source: Geeksforgeeks

5 votes

-- Pyuri sahu (2.2k points)

2.3.3 Code Optimization: GATE2014-3-11 top

http://gateoverflow.in/2045

Selected Answer

$P(X) = x^5 + 4x^3 + 6x + 5$

$= x(x^4 + 4x^2 + 6) + 5$

$= x(x(x^3 + 4x) + 6) + 5$

$= x(x(x(x^2 + 4)) + 6) + 5$

$= x(x(x(x(x) + 4)) + 6) + 5$

mul = pair of brackets 4
add = num of signs 3
total 7

30 votes

-- jayendra (8.1k points)

$P(x) = x^5 + 4x^3 + 6x + 5$ can be re written as follows

$P(x) = x^3(x^2 + 4) + 6x + 5$

Now using only one temporary variable t and any number of data transfer as well as memory related operation the polynomial can be evaluated as follows

1. $t = x * x$ [Evaluate x^2 and store in memory]
2. $t = t + 4$ [Evaluate $(x^2 + 4)$ and store in memory]
3. $t = x^2$ [Retinue x^2 from memory]
4. $t = t * X$ [Evaluate x^3 and store in memory]
5. $t = t * (x^2 + 4)$ [Evaluate $x^3(x^2 + 4)$ and store in memory]
6. $t = 6 * x$ [Evaluate 6x and store in memory]
7. $t = t + 5$ [Evaluate $(6x + 5)$ and store in memory]
8. $t = t + x^3(x^2 + 4)$ [Retrieve $x^2(x^2 + 4)$ from memory and evaluate $\{x^3(x^2 + 4) + 6x + 5\}$

In the above 8 steps of evaluation, the total number of arithmetic operations required are 7 [4 Multiplications, 3 Additions]
So answer is 7 arithmetic operations.

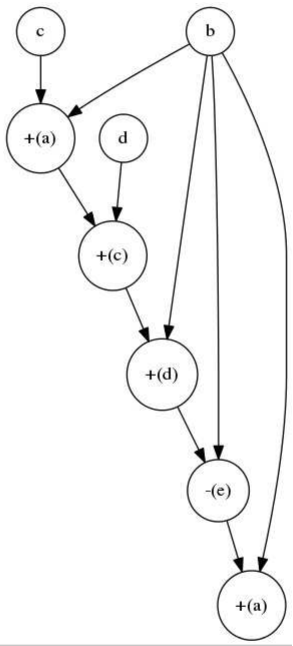
14 votes -- Gate Keeda (19.1k points)

2.3.4 Code Optimization: GATE2014-3-34 top

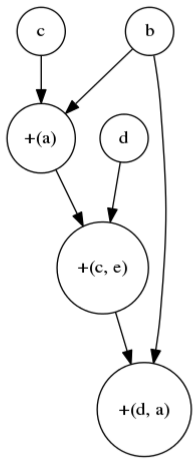
http://gateoverflow.in/2068

Selected Answer

A normal DAG construction will give 8 nodes and 10 edges as shown below.



Since, this question asks for minimum possible, we can assume algebraic simplification is allowed. So, d = b + c, e = d - b; can be simplified to d = b + c; e = c; Similarly, e = d - b; a = e + b; can be simplified to a = d. This gives the following DAG with 6 nodes and 6 edges.



https://cs.nyu.edu/~gottlieb/courses/2000s/2006-07-fall/compilers/lectures/lecture-14.html [working link]

22 votes -- Arjun Suresh (294k points)

2.4 Compilation Phases(7) top

2.4.1 Compilation Phases: CMI2012-A-09 top http://gateoverflow.in/46538

Consider the following programming errors:

I. Type mismatch in an expression.
II. Array index out of bounds.
III. Use of an uninitialized variable in an expression.

Which of these errors will typically be caught at compile-time by a modern compiler.

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

cmi2012 compiler-design compilation-phases

Answer

2.4.2 Compilation Phases: GATE 2016-2-19 top http://gateoverflow.in/39548

Match the following:

(P) Lexical analysis (i) Leftmost derivation

(Q) Top down parsing (ii) Type checking

(R) Semantic analysis (iii) Regular expressions

(S) Runtime environment (iv) Activation records

A. $P \leftrightarrow i, Q \leftrightarrow ii, R \leftrightarrow iv, S \leftrightarrow iii$
B. $P \leftrightarrow iii, Q \leftrightarrow i, R \leftrightarrow ii, S \leftrightarrow iv$
C. $P \leftrightarrow ii, Q \leftrightarrow iii, R \leftrightarrow i, S \leftrightarrow iv$
D. $P \leftrightarrow iv, Q \leftrightarrow i, R \leftrightarrow ii, S \leftrightarrow iii$

gate2016-2 compiler-design easy compilation-phases

Answer

2.4.3 Compilation Phases: GATE1987-1-xi top http://gateoverflow.in/80282

In a compiler the module the checks every character of the source text is called:

A. The code generator.
B. The code optimiser.
C. The lexical analyser.
D. The syntax analyser.

gate1987 compiler-design compilation-phases

Answer

2.4.4 Compilation Phases: GATE1990-2-ix top http://gateoverflow.in/84033

Match the pairs in the following questions:

(a) Lexical analysis	(p) DAG's
(b) Code optimization	(q) Syntax trees
(c) Code generation	(r) Push down automaton
(d) Abelian groups	(s) Finite automaton

gate1990 match-the-following compiler-design compilation-phases

Answer

2.4.5 Compilation Phases: GATE2009-17 top http://gateoverflow.in/1309

Match all items in Group 1 with the correct options from those given in Group 2.

Group 1		Group 2	
P.	Regular Expression	1.	Syntax analysis
Q.	Pushdown automata	2.	Code generation
R.	Dataflow analysis	3.	Lexical analysis
S.	Register allocation	4.	Code optimization

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

gate2009 compiler-design easy compilation-phases

Answer

2.4.6 Compilation Phases: GATE2015-2-19 top http://gateoverflow.in/8098

Match the following:

P. Lexical analysis	1. Graph coloring
Q. Parsing	2. DFA minimization
R. Register allocation	3. Post-order traversal
S. Expression evaluation	4. Production tree

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

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

gate2015-2 compiler-design normal compilation-phases

Answer

2.4.7 Compilation Phases: GATE2017-2-05 top http://gateoverflow.in/118592

Match the following according to input (from the left column) to the compiler phase (in the right column) that processes it:

P. Syntax tree	i. Code generator
Q. CHaracter stream	ii. Syntax analyser
R. Intermediate representation	iii. Semantic analyser
S. Token stream	iv. Lexical analyser

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

gate2017-2 compiler-design compilation-phases

Answer

Answers: Compilation Phases

2.4.1 Compilation Phases: CMI2012-A-09 top http://gateoverflow.in/46538

Selected Answer

Type mismatch gives compile time error for statically typed languages (type of variables are determined at compile time) like C.

Use of uninitialized variable can be detected by compiler? Not always- but possible in most cases. There can be cases where there are two branches and a variable is initialized in one but not in other. But, at compile time we can assume that we are only interested in those variables which are uninitialized in all the branches,

Array index out of bounds- can be detected by compiler in some cases. Consider

```
int a[100];
a[200] = 4;
```

A decent C compiler should catch this. But if the index is a variable it becomes more difficult to catch at compile time.

So, answer should be C.

3 votes -- Arjun Suresh (294k points)

2.4.2 Compilation Phases: GATE 2016-2-19 top http://gateoverflow.in/39548

Selected Answer

Option B.

Lexical Analysis phase uses regular expressions.

LMD is involved in top down parsing.

Type checking is done in semantic analysis phase.

Activation records are related to Run Time Environments

13 votes -- Sharathkumar Anbu (717 points)

2.4.3 Compilation Phases: GATE1987-1-xi top http://gateoverflow.in/80282

Selected Answer

lexical analyser phase checks every character of text to identify tokens..

3 votes -- kirti singh (3.4k points)

2.4.4 Compilation Phases: GATE1990-2-ix top http://gateoverflow.in/84033

Selected Answer

(a) Lexical analysis	(s) Finite automaton (Dfa creation for finding token)
(b) Code optimization	(p) DAG's (common subtree minimization.)
(c) Code generation	(q) Syntax trees (one can construct a derivation and from it a parse tree that can be used for code generation)
(d) Abelian groups	(r) Push down automaton (left one)

5 votes -- Prashant Singh (49.2k points)

2.4.5 Compilation Phases: GATE2009-17 top http://gateoverflow.in/1309

Selected Answer

Regular expressions are used in lexical analysis.

Pushdown automata is related to context free grammar which is related to syntax analysis.

Dataflow analysis is done in code optimization.

Register allocation is done in code generation.

Ans B

16 votes -- Keith Kr (6.3k points)

2.4.6 Compilation Phases: GATE2015-2-19 top http://gateoverflow.in/8098

Selected Answer

Answer: C

14 votes -- Rajarshi Sarkar (35k points)

1. Regular expression uses FA & Regular Sets.
2. Expression can be evaluated with postfix Traversals .
3. Register allocation can be modeled by graph coloring.
4. The parser constructs a production tree.

11 votes -- shekhar chauhan (42.9k points)

2.4.7 Compilation Phases: GATE2017-2-05 top http://gateoverflow.in/118592

Selected Answer

Q - IV because Character stream is given as input to lexical analyser.

P - iii Syntax tree is given as input to semantic analyser

R - i Intermediate code given as input to code generator

S -ii Token stream given as input to syntax analyser.

Ans: C

9 votes -- Arnabi (6.4k points)

2.5 Expression Evaluation(1) top

2.5.1 Expression Evaluation: GATE2002-2.19 top http://gateoverflow.in/849

To evaluate an expression without any embedded function calls

A. One stack is enough
B. Two stacks are needed
C. As many stacks as the height of the expression tree are needed
D. A Turing machine is needed in the general case

gate2002 compiler-design expression-evaluation easy

Answer

Answers: Expression Evaluation

2.5.1 Expression Evaluation: GATE2002-2.19 top http://gateoverflow.in/849

Selected Answer

Expression without any calls in it => 1+2*3-4

Expression with embedded calls => 1 + fun1(a,b,c) *fun2(3.4,58) - fun3(x,yz);

First we can convert Infix to Postfix using single stack (Using it as operator stack)

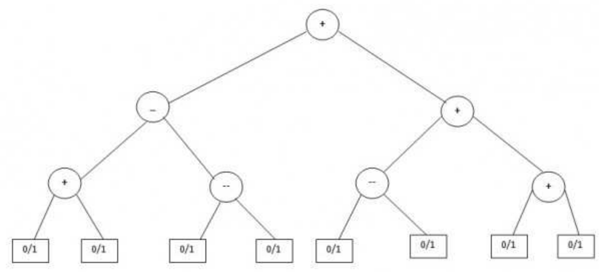
Then we can evaluate that expression using Single stack.

7 votes -- Akash (43.8k points)

2.6 Expression Tree(1) top

2.6.1 Expression Tree: GATE2014-2-39 top http://gateoverflow.in/1999

Consider the expression tree shown. Each leaf represents a numerical value, which can either be 0 or 1. Over all possible choices of the values at the leaves, the maximum possible value of the expression represented by the tree is ___.



gate2014-2 compiler-design normal expression-tree numerical-answers

Answer

Answers: Expression Tree

2.6.1 Expression Tree: GATE2014-2-39 top

http://gateoverflow.in/1999

Selected Answer

ans is 6

at left leafs

+ -----> (1,1)=2 intermediate + -------> 2-(-1)=3

- -------->(0,1)=-1

at right leafs

- minus ------->(1,0)=1 intermediate + ------> 1+2=3

+ ------------->(1,1)=2

at root + -------> 3+3=6

16 votes

-- GANNA (189 points)

2.7 Grammar(38) top

2.7.1 Grammar: GATE 2016-2-45 top

http://gateoverflow.in/39594

Which one of the following grammars is free from left recursion?

(A) $S \to AB$

$A \to Aa|b$

$B \to c$

(B) $S \to Ab|Bb|c$

$A \to Bd|\epsilon$

$B \to e$

(C) $S \to Aa|B$

$A \to Bb|Sc|\epsilon$

$B \to d$

(D) $S \to Aa|Bb|c$

$A \to Bd|\epsilon$

$B \to Ae|\epsilon$

gate2016-2 compiler-design grammar easy

Answer

2.7.2 Grammar: GATE 2016-2-46 top

http://gateoverflow.in/39598

A student wrote two context-free grammars G1 and G2 for generating a single C-like array declaration. The dimension of the array is at least one. For example,

```
int a[10] [3];
```

The grammars use D as the start symbol, and use six terminal symbols **int ; id [ ] num.**

Grammar **G1**	Grammar **G2**
D $\rightarrow$ **int L**;	D$\rightarrow$ int L;
L $\rightarrow$ **id [E**	L$\rightarrow$ **id E**
E $\rightarrow$ **num]**	E$\rightarrow$ **E [num]**
E $\rightarrow$ **num] [E**	E$\rightarrow$ **[num]**

Which of the grammars correctly generate the declaration mentioned above?

A. Both **G1** and **G2**
B. Only **G1**
C. Only **G2**
D. Neither **G1** nor **G2**

gate2016-2 compiler-design grammar normal

Answer

2.7.3 Grammar: GATE1990-16a top http://gateoverflow.in/86869

Show that grammar $G1$ is ambiguous using parse trees:

$G_1 : S \rightarrow$ if S then S else S

$S \rightarrow$ if S then S

gate1990 descriptive compiler-design grammar

Answer

2.7.4 Grammar: GATE1991-10a top http://gateoverflow.in/537

Consider the following grammar for arithmetic expressions using binary operators $-$ and $/$ which are not associative

$$E \rightarrow E - T \mid T$$

$$T \rightarrow T/F \mid F$$

$$F \rightarrow (E) \mid id$$

(E is the start symbol)

Is the grammar unambiguous? Is so, what is the relative precedence between $-$ and $/$? If not, give an unambiguous grammar that gives $/$ precedence over $-$.

gate1991 grammar compiler-design normal descriptive

Answer

2.7.5 Grammar: GATE1991-10b top http://gateoverflow.in/43604

Consider the following grammar for arithmetic expressions using binary operators $-$ and $/$ which are not associative

$$E \rightarrow E - T \mid T$$

$$T \rightarrow T/F \mid F$$

$$F \rightarrow (E) \mid id$$

(E is the start symbol)

Does the grammar allow expressions with redundant parentheses as in (id/id) or in $id - (id/id)$? If so, convert the grammar into one which does not generate expressions with redundant parentheses. Do this with minimum number of changes to the given production rules and adding at most one more production rule.

gate1991 grammar compiler-design normal descriptive

Answer

2.7.6 Grammar: GATE1991-10c top

http://gateoverflow.in/43605

Consider the following grammar for arithmetic expressions using binary operators $-$ and $/$ which are not associative

$$E \rightarrow E - T \mid T$$

$$T \rightarrow T/F \mid F$$

$$F \rightarrow (E) \mid id$$

(E is the start symbol)

Does the grammar allow expressions with redundant parentheses as in (id/id) or in $id - (id/id)$? If so, convert the grammar into one which does not generate expressions with redundant parentheses. Do this with minimum number of changes to the given production rules and adding at most one more production rule.

Convert the grammar obtained above into one that is not left recursive.

gate1991 grammar compiler-design normal descriptive

Answer

2.7.7 Grammar: GATE1994_1.18 top

http://gateoverflow.in/2461

Which of the following features cannot be captured by context-free grammars?

A. Syntax of if-then-else statements
B. Syntax of recursive procedures
C. Whether a variable has been declared before its use
D. Variable names of arbitrary length

gate1994 compiler-design grammar normal

Answer

2.7.8 Grammar: GATE1994_20 top

http://gateoverflow.in/2516

A grammar G is in Chomsky-Normal Form (CNF) if all its productions are of the form $A \rightarrow BC$ or $A \rightarrow a$, where A, B and C, are non-terminals and a is a terminal. Suppose G is a CFG in CNF and w is a string in $L(G)$ of length n, then how long is a derivation of w in G?

gate1994 compiler-design grammar normal

Answer

2.7.9 Grammar: GATE1994_3.5 top

http://gateoverflow.in/2482

Match the following items

(i) Backus-Naur form	(a) Regular expressions
(ii) Lexical analysis	(b) LALR(1) grammar
(iii) YACC	(c) LL(1) grammars
(iv) Recursive descent parsing	(d) General context-free grammars

gate1994 compiler-design grammar normal

Answer

2.7.10 Grammar: GATE1995_1.10 top

http://gateoverflow.in/2597

Consider a grammar with the following productions

$S \to a\alpha b \mid b\alpha c \mid aB$

$S \to \alpha S \mid b$

$S \to \alpha bb \mid ab$

$S\alpha \to bdb \mid b$

The above grammar is:

A. Context free
B. Regular
C. Context sensitive
D. LR(k)

gate1995 compiler-design grammar normal

Answer

2.7.11 Grammar: GATE1995_9 top

http://gateoverflow.in/2644

a. Translate the arithmetic expression $a^* - (b+c)$ into syntax tree.
b. A grammar is said to have cycles if it is the case that

   $A \Rightarrow^+ A$

   Show that no grammar that has cycles can be LL(1).

gate1995 compiler-design grammar normal

Answer

2.7.12 Grammar: GATE1996_11 top

http://gateoverflow.in/2763

Let G be a context-free grammar where $G = (\{S, A, B, C\}, \{a, b, d\}, P, S)$ with the productions in P given below.

$S \to ABAC$

$A \to aA \mid \varepsilon$

$B \to bB \mid \varepsilon$

$C \to d$

(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 $x \to y$, and x and y are non terminals).

gate1996 compiler-design grammar normal

Answer

2.7.13 Grammar: GATE1996_2.10 top

http://gateoverflow.in/2739

The grammar whose productions are

-> if id then <stmt>

-> if id then <stmt> else <stmt>

-> id := 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

2.7.14 Grammar: GATE1997_1.6 top

http://gateoverflow.in/2222

In the following grammar

$$\begin{aligned} X &::= X \oplus Y \mid Y \\ Y &::= Z * Y \mid Z \\ Z &::= id \end{aligned}$$

Which of the following is true?

a. '$\oplus$' is left associative while '$*$' is right associative
b. Both '$\oplus$' and '$*$' are left associative
c. '$\oplus$' is right associative while '$*$' is left associative
d. None of the above

gate1997 compiler-design grammar normal

Answer

2.7.15 Grammar: GATE1997_11 top

http://gateoverflow.in/2271

Consider the grammar

$S \rightarrow bSe$
$S \rightarrow PQR$
$P \rightarrow bPc$
$P \rightarrow \varepsilon$
$Q \rightarrow cQd$
$Q \rightarrow \varepsilon$
$R \rightarrow dRe$
$R \rightarrow \varepsilon$

where S, P, Q, R are non-terminal symbols with S being the start symbol; b, c, d, e are terminal symbols and 'ε' is the empty string. This grammar generates strings of the form b^i, c^j, d^k, e^m for some $i, j, k, m \geq 0$.

a. What is the condition on the values of i, j, k, m ?

b. Find the smallest string that has two parse trees.

gate1997 compiler-design grammar normal theory-of-computation

Answer

2.7.16 Grammar: GATE1998_6b top http://gateoverflow.in/1697

Consider the grammar

- S $\rightarrow Aa \mid b$
- A $\rightarrow Ac \mid Sd \mid \epsilon$

Construct an equivalent grammar with no left recursion and with minimum number of production rules.

gate1998 compiler-design grammar descriptive

Answer

2.7.17 Grammar: GATE1999_2.15 top http://gateoverflow.in/1493

A grammar that is both left and right recursive for a non-terminal, is

A. Ambiguous

B. Unambiguous

C. Information is not sufficient to decide whether it is ambiguous or unambiguous

D. None of the above

gate1999 compiler-design grammar normal

Answer

2.7.18 Grammar: GATE2000-2.21, ISRO2015-24 top http://gateoverflow.in/668

Given the following expression grammar:

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

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

Which of the following is true?

A. $*$ has higher precedence than $+$
B. $-$ has higher precedence than $*$
C. $+$ and $-$ have same precedence
D. $+$ has higher precedence than $*$

gate2000 grammar normal compiler-design isro2015

Answer

2.7.19 Grammar: GATE2001-1.18 top http://gateoverflow.in/711

Which of the following statements is false?

A. An unambiguous grammar has same leftmost and rightmost derivation
B. An LL(1) parser is a top-down parser
C. LALR is more powerful than SLR
D. An ambiguous grammar can never be LR(k) for any k

gate2001 compiler-design grammar normal

Answer

2.7.20 Grammar: GATE2001-18 top http://gateoverflow.in/759

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

$$S \to aSbS \mid bSaS \mid \epsilon$$

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

gate2001 compiler-design grammar descriptive

Answer

2.7.21 Grammar: GATE2003-56 top http://gateoverflow.in/944

Consider the grammar shown below

S $\to$ i E t S S' | a

S' $\to$ e S | ε

E $\to$ b

In the predictive parse table, M, of this grammar, the entries M[S' , e] and M[S' , $] respectively are

A. {S' $\to$ e S} and {S' $\to \varepsilon$}
B. {S' $\to$ e S} and { }
C. {S' $\to \varepsilon$} and {S' $\to \varepsilon$}
D. {S' $\to$ e S, S' $\to \varepsilon$} and {S' $\to \varepsilon$}

gate2003 compiler-design grammar normal

Answer

2.7.22 Grammar: GATE2003-58 top http://gateoverflow.in/946

Consider the translation scheme shown below.

S $\to$ T R

R $\to$ + T {*print*('+');} R$|\varepsilon$

T $\to$ **num** {*print*(**num**.val);}

Here **num** is a token that represents an integer and **num**.val represents the corresponding integer value. For an input string '9 + 5 + 2', this translation scheme will print

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

gate2003 compiler-design grammar normal

Answer

2.7.23 Grammar: GATE2004-45 top http://gateoverflow.in/1042

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

$$\begin{array}{ll} E \to E_1 \# T & \{E.value = E_1.value * T.value\} \\ \quad |T & \{E.value = T.value\} \end{array}$$

$$T \to T_1 \& F \quad \{T.value = T_1.value + F.value\}$$
$$|F \quad \{T.value = F.value\}$$
$$F \to \text{num} \quad \{F.value = num.value\}$$

Compute E.value for the root of the parse tree for the expression:2 # 3 & 5 # 6 & 4

A. 200
B. 180
C. 160
D. 40

gate2004 compiler-design grammar normal

Answer

2.7.24 Grammar: GATE2004-8 top

http://gateoverflow.in/1005

Which of the following grammar rules violate the requirements of an operator grammar? P, Q, R are nonterminals, and r, s, t are terminals.

I. P $\rightarrow$ Q R

II. P $\rightarrow$ Q s R

III. P $\rightarrow$ ε

IV. P $\rightarrow$ Q t R r

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

gate2004 compiler-design grammar normal

Answer

2.7.25 Grammar: GATE2004-88 top

http://gateoverflow.in/1082

Consider the following grammar G:

$S \to bS \mid aA \mid b$

$A \to bA \mid aB$

$B \to bB \mid aS \mid a$

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

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

gate2004 compiler-design grammar normal

Answer

2.7.26 Grammar: GATE2005-59 top

http://gateoverflow.in/1382

Consider the grammar:

$$E \to E + n \mid E \times n \mid n$$

For a sentence $n + n \times n$, the handles in the right-sentential form of the reduction are:

A. $n, E + n$ and $E + n \times n$

B. $n, E + n$ and $E + E \times n$

C. $n, n + n$ and $n + n \times n$

D. $n, E + n$ and $E \times n$

gate2005 compiler-design grammar normal

Answer

2.7.27 Grammar: GATE2006-32, ISRO2016-35 top

http://gateoverflow.in/995

Consider the following statements about the context free grammar

$$G = \{S \to SS, S \to ab, S \to ba, S \to \epsilon\}$$

I. G is ambiguous
II. G produces all strings with equal number of a's and b's
III. G can be accepted by a deterministic PDA.

Which combination below expresses all the true statements about G?

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

gate2006 compiler-design grammar normal isro2016

Answer

2.7.28 Grammar: GATE2006-59 top

http://gateoverflow.in/1837

Consider the following translation scheme.

$S \to ER$

$R \to^{*} E\{print('*');\}R \mid \varepsilon$

$E \to F + E\{print('+');\} \mid F$

$F \to S \mid id\{print(id.value);\}$

Here *id* is a token that represents an integer and *id.value* represents the corresponding integer value. For an input '2 * 3 + 4', this translation scheme prints

A. 2 * 3 + 4
B. 2 * +3 4
C. 2 3 * 4 +
D. 2 3 4+*

gate2006 compiler-design grammar normal

Answer

2.7.29 Grammar: GATE2006-84 top

http://gateoverflow.in/1856

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. $S \to aS \mid Sb \mid a \mid b$

C. $S \to AC \mid CB$

$C \to aCb \mid \varepsilon$

$A \to aA \mid \varepsilon$

$B \to Bb \mid \varepsilon$

D. $S \to AC \mid CB$

$C \to aCb \mid \varepsilon$

$A \to aA \mid a$

$B \to Bb \mid b$

gate2006 compiler-design grammar normal theory-of-computation

Answer

2.7.30 Grammar: GATE2006-85 top

http://gateoverflow.in/79801

The grammar

$S \to AC \mid CB$

$C \to aCb \mid \varepsilon$

$A \to aA \mid a$

$B \to Bb \mid b$

generates the language $L = \{a^i b^j \mid i \neq j\}$. In that grammar what is the length of the derivation (number of steps starting from S) to generate the string $a^l b^m$ with $l \neq m$

A. $max(l, m) + 2$
B. $l + m + 2$
C. $l + m + 3$
D. $max(l, m) + 3$

gate2006 compiler-design grammar normal

Answer

2.7.31 Grammar: GATE2007-52 top

http://gateoverflow.in/1250

Consider the grammar with non-terminals $N = \{S, C, S_1\}$, terminals $T = \{a, b, i, t, e\}$, with S as the start symbol, and the following set of rules:

$S \to iCtSS_1 \mid a$

$S_1 \to eS \mid \epsilon$

$C \to b$

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

gate2007 compiler-design grammar normal

Answer

2.7.32 Grammar: GATE2007-53 top http://gateoverflow.in/1251

Consider the following two statements:

- P: Every regular grammar is LL(1)
- Q: Every regular set has a LR(1) grammar

Which of the following is **TRUE**?

A. Both P and Q are true

B. P is true and Q is false

C. P is false and Q is true

D. Both P and Q are false

gate2007 compiler-design grammar normal

Answer

2.7.33 Grammar: GATE2007-78 top http://gateoverflow.in/1272

Consider the CFG with
$\{S, A, B\}$ as the non-terminal alphabet,
$\{a, b\}$ as the terminal alphabet, S as the start symbol and the following set of production rules:

S $\rightarrow$aB S$\rightarrow$bA

B $\rightarrow$ b A $\rightarrow$ a

B $\rightarrow$ bS A $\rightarrow$ aS

B $\rightarrow$ aBB S $\rightarrow$ bAA

Which of the following strings is generated by the grammar?

A. aaaabb
B. aabbbb
C. aabbab
D. abbbba

gate2007 compiler-design grammar normal

Answer

2.7.34 Grammar: GATE2007-79 top http://gateoverflow.in/43512

Consider the CFG with $\{S, A, B\}$ as the non-terminal alphabet, $\{a, b\}$ as the terminal alphabet, S as the start symbol and the following set of production rules:

S $\rightarrow$aB S$\rightarrow$bA

B $\rightarrow$ b A$\rightarrow$ a

B $\rightarrow$ bS A$\rightarrow$ aS

B $\rightarrow$ aBB S$\rightarrow$ bAA

For the string $aabbab$, how many derivation trees are there?

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

gate2007 compiler-design grammar normal

Answer

2.7.35 Grammar: GATE2007-IT-9 top http://gateoverflow.in/3442

Consider an ambiguous grammar G and its disambiguated version D. Let the language recognized by the two grammars be denoted by L(G) and L(D) respectively. Which one of the following is true?

A. L (D) ⊂ L (G)
B. L (D) ⊃ L (G)
C. L (D) = L (G)
D. L (D) is empty

gate2007-it compiler-design grammar normal

Answer

2.7.36 Grammar: GATE2008-50 top

http://gateoverflow.in/395

Which of the following statements are true?

I. Every left-recursive grammar can be converted to a right-recursive grammar and vice-versa
II. All ϵ-productions can be removed from any context-free grammar by suitable transformations
III. The language generated by a context-free grammar all of whose productions are of the form $X \rightarrow w$ or $X \rightarrow wY$ (where, w is a string of terminals and Y is a non-terminal), is always regular
IV. The derivation trees of strings generated by a context-free grammar in Chomsky Normal Form are always binary trees

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

gate2008 normal compiler-design grammar

Answer

2.7.37 Grammar: GATE2010-38 top

http://gateoverflow.in/2339

The grammar $S \rightarrow aSa \mid bS \mid c$ is

A. LL(1) but not LR(1)
B. LR(1) but not LL(1)
C. Both LL(1) and LR(1)
D. Neither LL(1) nor LR(1)

gate2010 compiler-design grammar normal

Answer

2.7.38 Grammar: GATE2014-2-17 top

http://gateoverflow.in/1973

Consider the grammar defined by the following production rules, with two operators $*$ and $+$

- $S \rightarrow T * P$
- $T \rightarrow U \mid T * U$
- $P \rightarrow Q + P \mid Q$
- $Q \rightarrow Id$
- $U \rightarrow Id$

Which one of the following is TRUE?

A. $+$ is left associative, while $*$ is right associative
B. $+$ is right associative, while $*$ is left associative
C. Both $+$ and $*$ are right associative
D. Both $+$ and $*$ are left associative

gate2014-2 compiler-design grammar normal

Answer

Answers: Grammar

2.7.1 Grammar: GATE 2016-2-45 top

http://gateoverflow.in/39594

Selected Answer

Option (a) has immediate left recursion."$A \rightarrow Aa$"

Option (c) has indirect left recursion "$S \rightarrow Aa \overset{A \rightarrow Sc}{\Longrightarrow} Sca$"

Option (d) has indirect left recursion "$A \rightarrow Bd \overset{B \rightarrow Ae}{\Longrightarrow} Aed$"

Option (b) is free from left recursion. No direct left recursion. No indirect left recursion.

option B is correct

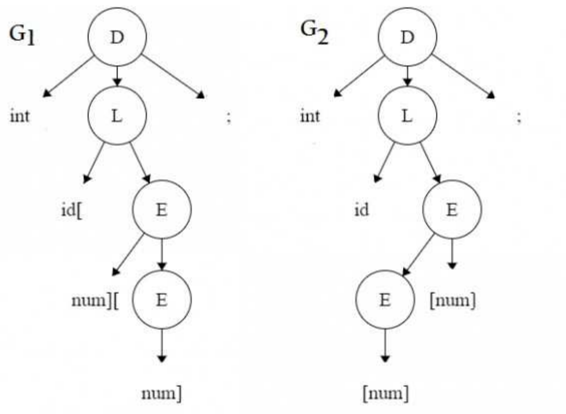
18 votes -- Ashish Deshmukh (1.5k points)

2.7.2 Grammar: GATE 2016-2-46 top

http://gateoverflow.in/39598

Selected Answer

Option A Both G1 and G2



22 votes -- Shashank Chavan (3.4k points)

2.7.3 Grammar: GATE1990-16a top

http://gateoverflow.in/86869

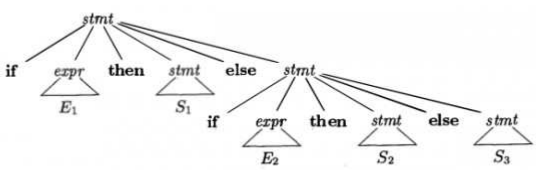
Selected Answer

The given grammer is well known as " [Dangling Else]() " problem . The given grammer is ambiguous and ambiguity can be resolved .

$$\begin{aligned} \textbf{stmt} \rightarrow\ & \textbf{if}\text{expr}\textbf{then}\ \text{stmt} \\ & |\ \textbf{if}\ \text{expr}\ \textbf{then}\ \text{stmt}\textbf{else}\ \text{stmt} \\ & |\textbf{other} \end{aligned}$$

Consider the compound coditional statement for the above grammer

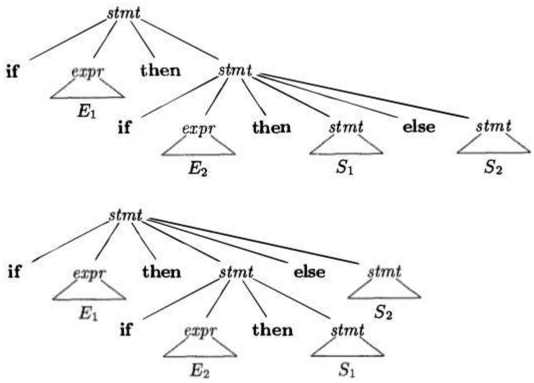
if $E1$ **then** $S1$ **else** if $E2$ **then** $S2$ **else** $S3$ has the following parse tree



Well this is ambiguous due to the statement

if $E1$ **then if** $E2$ **then** $S1$ **else** $S2$

The two parse trees are



Ambiguity can be resolved by parsers as follows

In all programming languages with conditional statements of this form, the first parse tree is preferred.
The general rule is, "Match each else with the closest unmatched then"

In practice it is rarely built into the productions .

stmt $\rightarrow$ **matched_stmt**
| **open_stmt**
matched_stmt $\rightarrow$ **if**expr**then** matched_stmt **else** matched_stmt
| **other**
open_stmt $\rightarrow$ **if**expr**then** stmt
| **if** expr **then** matched_stmt**else** open_stmt

However this grammer is also ambiguous .

! Exercise 4.3.3: The following grammar is proposed to remove the "dangling-else ambiguity" discussed in Section 4.3.2:

$$
\begin{array}{lcl}
stmt & \rightarrow & \textbf{if } expr \textbf{ then } stmt \\
 & | & matchedStmt \\
matchedStmt & \rightarrow & \textbf{if } expr \textbf{ then } matchedStmt \textbf{ else } stmt \\
 & | & \textbf{other}
\end{array}
$$

Show that this grammar is still ambiguous.

Solution is Given Here . Moreover there is no grammer exists that will **eliminate** ambiguity in Dangling Else Grammer . Hence we can say that Languge produced by dangling else grammer is " **inherently ambiguous** " .

Try running this code in any compilers . No doubt that all compilers will successfully parse and produce output

```
#include <stdio.h>

int main(void) {
 if(1<3)
 if(1<2)
 printf("1 is the smallest");
 else
 printf("2 is the smallest");
 return 0;
}
```

Thus we can say that ambiguity in Dangling Else Problem can be resolved but Cannot be Eliminated from the grammer .

Source

- Compilers: Principles, Techniques, & Tools -Aho & Ullman

Good Read

- http://cs.stackexchange.com/questions/32475/resolving-ambiguity-in-dangling-else
- http://gateoverflow.in/54718/inherently-ambiguous-languages-deterministic-context-grammars
- http://gateoverflow.in/84451/dangling-else-problem-and-ambiguity-elimination

6 votes -- pC (21.4k points)

2.7.4 Grammar: GATE1991-10a top

http://gateoverflow.in/537

Selected Answer

Yes. It is unambiguous grammar since for any string no more than 1 parse tree is possible.

For precedency draw the parse tree and find the depth of operator **-** and **/** .

Here "/" having more depth than " - " operator so precedency of" /" is higher than "-".

5 votes -- papesh (24.1k points)

2.7.5 Grammar: GATE1991-10b top

http://gateoverflow.in/43604

If the expression with redundant parentheses is (id/id) or id-(id/id) then it can be generated by the given grammar.

To generate expression (id/id) we can go through following steps-

1. E-> T
2. E-> F (T-> F)
3. E-> (E) (F-> (E))
4. E-> (T) (E->T)
5. E-> (T/F) (T- > T/F)
6. E-> (F/F) (T->F)
7. E-> (id/id) (F->id)

Now to generate expression id- (id/id) we can go through following steps-

1. E-> E - T
2. E-> E - F (T-> F)
3. E-> E - (E) (F-> (E))
4. E-> E - (T) (E->T)
5. E-> E - (T/F) (T- > T/F)
6. E-> E - (F/F) (T->F)
7. E-> T - (F/F) (E-> T)
8. E-> F - (F/F) (T->F)
9. E-> id - (id/id) (F->id)

4 votes -- Dhananjay Kumar Sharma (25.2k points)

2.7.6 Grammar: GATE1991-10c top

http://gateoverflow.in/43605

Selected Answer

Here we have to convert the grammar into one which does not generate expressions with redundant parentheses.So the grammar which does not generate expressions with redundant parentheses

$$E \to E - T \mid T$$

$$E' \to E - T$$

$$T \to id \mid T'/F$$

$$T' \to F \mid T'/F$$

$$F \to id \mid (E')$$

Now equivalent grammar after removing left recursion

$E \rightarrow TX'$

$X' \rightarrow -TX' \mid \epsilon$

$E' \rightarrow E - T$

$T \rightarrow id \mid T'/F$

$T' \rightarrow FY'$

$Y' \rightarrow /FY' \mid \epsilon$

$F \rightarrow id \mid (E')$

7 votes -- Manoj Kumar (37.5k points)

2.7.7 Grammar: GATE1994_1.18 top

http://gateoverflow.in/2461

Selected Answer

It will be C.

Since CFG's are used to show syntactic rules while designing compiler, and syntactic rules don't check for meaningful things such as if a variable has been declared before its use or not. Such things are meant to be handled by Semantic Analysis phase (requires power of a context sensitive grammar).

For D, a regular expression does not restrict the string length. Languages have restriction for variable name length for storing purpose like in symbol table.

For A, if then else is inherently ambiguous. But CFG can represent inherently ambiguous languages just that there are more than one parse trees possible for some strings.

19 votes -- Gate Keeda (19.1k points)

2.7.8 Grammar: GATE1994_20 top

http://gateoverflow.in/2516

Selected Answer

its answer is 2n-1 for n length string, because in CNF at every step only 1 terminal can replace a variable, for example
S-AB
A-a
B-c

for generating string 'ac' 3 production will be used.

15 votes -- Manu Thakur (6k points)

2.7.9 Grammar: GATE1994_3.5 top

http://gateoverflow.in/2482

Selected Answer

answer -

i - d

ii - a

iii - b

iv - c

5 votes -- ankitrokdeonsns (9.1k points)

2.7.10 Grammar: GATE1995_1.10 top

http://gateoverflow.in/2597

Selected Answer

S∝ ->

This violates the conditions of context-free and hence the grammar becomes context-sensitive.

16 votes -- Arjun Suresh (294k points)

2.7.11 Grammar: GATE1995_9 top

http://gateoverflow.in/2644

A grammer having left recursion generates a cycle.

And no left recursive grammer is LL(1) grammer.

6 votes -- simran (97 points)

2.7.12 Grammar: GATE1996_11 top

http://gateoverflow.in/2763

Selected Answer

final grammar is

S-----> ABAC / ABC / BAC / BC / AC / AAC / d

A------> aA / a

B-------> bB / b

C-------> d

correct me ....

15 votes -- Mithlesh Upadhyay (5.4k points)

2.7.13 Grammar: GATE1996_2.10 top

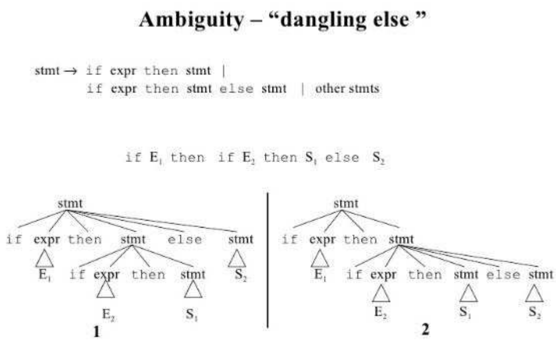
http://gateoverflow.in/2739

Selected Answer

(d) the sentence

- if a then if b then c: = d else c:= f has two parse trees as follows:

1. if a then (if b then c:= d) else c:= f
2. and if a then (if b then c:=d else c:= f)



15 votes -- Arjun Suresh (294k points)

2.7.14 Grammar: GATE1997_1.6 top

http://gateoverflow.in/2222

Selected Answer

It will be A. For multiple '$\oplus$', the derivation is possible only via 'X' which is on left side of '$\oplus$' in the production. Hence it is left associative.

For multiple '$*$', the derivation is possible only via 'Y' which is on the right side of '$*$' in the production. Hence it is right associative.

If both left and right derivations were possible, the grammar would have been ambiguous and we couldn't have given associativity.

17 votes -- Gate Keeda (19.1k points)

2.7.15 Grammar: GATE1997_11 top

http://gateoverflow.in/2271

Selected Answer

A) i+k=j+m
where i,j,k,m>=0
B) bcde

6 votes -- Danish (3.6k points)

2.7.16 Grammar: GATE1998_6b top

http://gateoverflow.in/1697

(b) As it is the case of indirect recursion so let first make it as direct recursion then apply rules of removal of left recursion.

to make it as direct recursion first production remain unchanged while in second production substitute the right hand side of first production wherever it comes.In the question S comes in middle of A so substitute the right hand side of production S.Now after substituting it looks like..

A->Ac|Aad|bd|ϵ

Now remove direct recursion from it

For removal of direct recursion rule--

$A \to A\alpha_1 \mid \ldots \mid A\alpha_n \mid \beta_1 \mid \ldots \mid \beta_m$

Replace these with two sets of productions, one set for A:

$A \to \beta_1 A' \mid \ldots \mid \beta_m A'$

and another set for the fresh nonterminal A'

$A' \to \alpha_1 A' \mid \ldots \mid \alpha_n A' \mid \epsilon$

After applying these rule we'll get..

A->bdA'|A'

A'->cA'|adA'|ϵ

Now complete production without left recursion is...

S->Aa|b

A->bdA'|A'

A'->cA'|adA'|ϵ

4 votes -- shashi shekhar (515 points)

2.7.17 Grammar: GATE1999_2.15 top http://gateoverflow.in/1493

Selected Answer

Let grammar is like this :
$S \rightarrow a$
$A \rightarrow AbA$
This grammar is left as well as right recursive but still unambiguous.. **A** is useless production but still part of grammar..
A grammar having both left as well as right recursion may or may not be ambiguous ..

Let's take a grammar say

$S \rightarrow SS$

Now, according to the link https://en.wikipedia.org/wiki/Formal_grammar

> For a grammar G, if we have L(G) then all the strings/sentences in this language can be produced after some finite number of steps .

But, for the grammar

$$S \rightarrow SS$$

Can we produce any string after a finite number of steps ? NO, and hence language of this grammar is empty set {} .

Hence, If a grammar is having both left and right recursion, then grammar may or may not be ambiguous .

16 votes -- Digvijay (47k points)

2.7.18 Grammar: GATE2000-2.21, ISRO2015-24 top http://gateoverflow.in/668

Selected Answer

I guess its B.

Operator which is at lower level in the grammar is termed to have higher precedence.

19 votes -- Gate Keeda (19.1k points)

2.7.19 Grammar: GATE2001-1.18 top http://gateoverflow.in/711

Selected Answer

(A) is the answer.

(A) We can not have different Left Most Derivation and Right Most Derivation parse trees BUT we can certainly have different LMD and RMD for a given string.(LMD and RMD here refers to the order of various productions used for derivation which could be different.)

(D) is wrong w.r.t. question because IT IS TRUE that any LR(k) IS NEVER AMBIGUOUS and so an ambiguous can never be an LR(K) for any k, no matter how large k becomes.

(B) and (C) can not be the answer because LL(1) is TOP-DOWN parser and LALR is powerful than SLR. So both are TRUE.

15 votes -- Sandeep_Uniyal (7.3k points)

2.7.20 Grammar: GATE2001-18 top http://gateoverflow.in/759

Selected Answer

a) S->aS'/bS'

S'->aS'/bS'/e

b)S->aSbS->abS->abaSbS>ababS->abab

S->aSbS->abSaSbS->abaSbS->ababS->abab

Two derivation so it is ambiguous

12 votes -- Pooja Palod (32.4k points)

2.7.21 Grammar: GATE2003-56 top

http://gateoverflow.in/944

Selected Answer

First (S)={i,a}

First(S')={e, episolon)

First(E)={b}

Follow(S')={e,$}

Only when first contains episolon we need to consider follow

M[S',e]={S'->eS(first),S'->episolon(considering follow)}

M[S',$}={S->episolon}

	a	i	b	e	t	$
S	S->a	S->ietSS'				
S'				S'->eS S'->episolon		S'->episolon
E			E->b			

answer is d

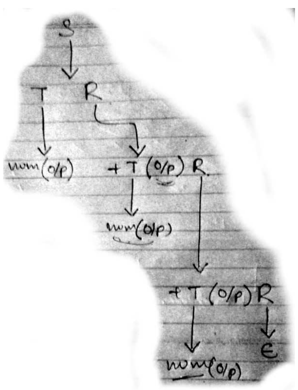
20 votes -- Pooja Palod (32.4k points)

2.7.22 Grammar: GATE2003-58 top

http://gateoverflow.in/946

Selected Answer

answer = option B
$9\,5+2+$



19 votes -- Amar Vashishth (28.7k points)

2.7.23 Grammar: GATE2004-45 top

http://gateoverflow.in/1042

Selected Answer

we can do in simple manner ...

here # is multiplication and & is addition by semantics rules given in the question ...

and by observation of productions ..

1. here &(+) is higher precedence than #(*). bcoz & is far from starting symbol ...

2. and both &,# are left associative so we can solve the express in this way ...

((2*(3+5))*(6+4)) =160 so ans should be (C).

18 votes -- sonam vyas (13.2k points)

2.7.24 Grammar: GATE2004-8 top

http://gateoverflow.in/1005

Selected Answer

answer is B .because operator grammer does not contain 1) nullable variable 2) 2 adjacent non-terminal on rhs of production

13 votes -- koushiksngh264 (233 points)

2.7.25 Grammar: GATE2004-88 top

http://gateoverflow.in/1082

Selected Answer

above CFG generate string b, aaa..
b will eliminate options A and D
aaa eliminate options B.
C is answer i.e. number of a = 3k, k =0,1,2....

13 votes -- Digvijay (47k points)

2.7.26 Grammar: GATE2005-59 top

http://gateoverflow.in/1382

Selected Answer

n+n*n

E+n*n

E*n

E

string in red indicates handle here

so ans is d

13 votes -- Pooja Palod (32.4k points)

2.7.27 Grammar: GATE2006-32, ISRO2016-35 top

http://gateoverflow.in/995

Selected Answer

I. True. G is ambiguous. E.g. the string ab has multiple derivation trees like $S \to SS \to abS \to ab$, and $S \to ab$.

II. False. G does not produce all strings with equal no. of a`s and $b$`s. ($aabb$ cannot be generated).

III. True. The given grammar G generates the language $(ab + ba)^*$, which is Regular and therefore also DCFL. So, a D-PDA can be designed for G.

Hence, the answer is option B.

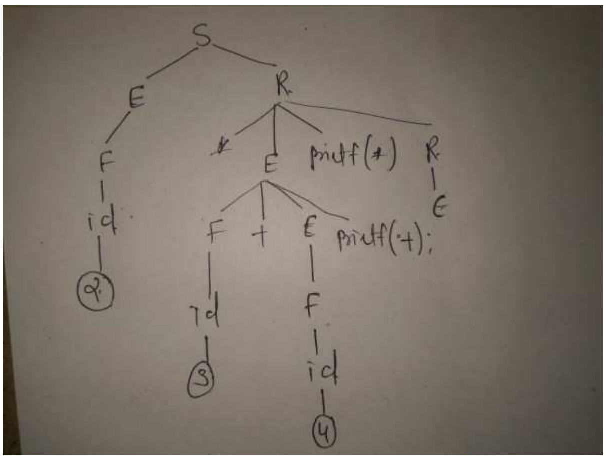
39 votes -- Pooja Palod (32.4k points)

2.7.28 Grammar: GATE2006-59 top

http://gateoverflow.in/1837

Selected Answer

It will be D. make a tree and perform post order evaluation.



14 votes -- Gate Keeda (19.1k points)

2.7.29 Grammar: GATE2006-84 top

http://gateoverflow.in/1856

Selected Answer

84, answer = option D 85 answer = option A

Q 84 .

option A

C⇒ a

or, C ⇒b

or, C ⇒aCb⇒aaCbb⇒ aaaCbbb .. soon

at last you have to put either C⟶ a or C⟶ b

so production C is used to derive $a^{n+1}b^n$ or a^nb^{n+1} n>=0

S⟶ AC [Aa^nb^{n+1}] can make $a^{n+1}b^{n+1}$ as single a can be derived from A [A⇒aA ⇒a as A⟶ ∊] , similarly S⟶ CB simple way, ab can be derived from grammar as S⇒ AC ⇒aAC ⇒aC⇒ ab

option A is wrong

option B , language is used to drive a^+b^* or a^*b^+ , ab will be derived as S⇒aS ⇒ab

option B is wrong

Option C

C ⇒ ∈

or C ⇒ aCb ⇒ aaCbb ⇒ aaaCbbb .. soon at last need to put C → ∈

Production C will generate a^nb^n n>=0

S→ AC can generate a^nb^n as A can be ∈ , similarly S →CB

option C is wrong

Option D .

production C is used for generate a^nb^n as in option C

S→ AC will increase no of a's before a^nb^n

as A will generate a or aa or aaa... i,e a^+ , so S→ AC will generate $a^+a^nb^n$, i.e a^ib^j i>j

S → CB will generate $a^nb^nb^+$ i.e a^ib^j i<j

option D is right .

Q 85

L =a^lb^m l ≠m means either l > m or l < m

Case I[l > m]

if l >m ,a^lb^m can be written as $\mathbf{a^{l-m}a^mb^m}$ [l-m cannot be 0 as l should be > m]

S→ AC , one step

a^{l-m} use l-m steps using productions of A

[as l-m = 1 , one step A → a

l-m =2 , two steps A →aA →aa

l-m = 3 , three steps , A→aA→aaA→aaa.. so on]

a^mb^m will be generate in m + 1 steps using production C

[as m = 0 one step C → ∈

m= 1 , two steps C → aCb → ab

m= 2, three steps C → aCb →aaCbb→ aabb.. so on]

so if l>m total steps = 1+l-m +m+1 = l +2

Case II [l<m]

simillar if l< m , a^lb^m can be written as $\mathbf{a^lb^lb^{m-l}}$ [m-l cannot be 0 as m should be > l]

S→ CB one step

a^lb^l will be derives using l+1 steps

b^{m-l} will be derived using m- l steps

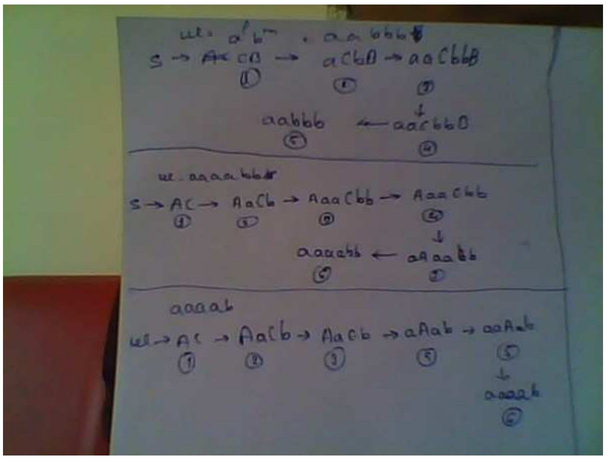
total = 1 +l+1+m-l = m +2

so L =a^lb^m l ≠m will take max(l,m)+2 steps

👍 17 votes -- Praveen Saini (53.6k points)

2.7.30 Grammar: GATE2006-85 top http://gateoverflow.in/79801

I think option A seems correct, please see the image for explanation



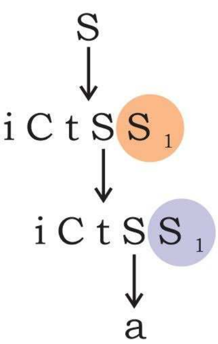
in case 2 and 3 reducing number of b's has no affect on number of productions required

👍 5 votes -- rameshbabu (3.3k points)

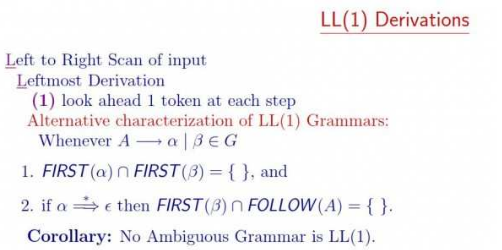
2.7.31 Grammar: GATE2007-52 top http://gateoverflow.in/1250

Selected Answer

here, we can expand any one of S_1 to $\in$ and other to ea, but which one will it be need not matter, coz in the end we will still get the same string.



this means that the Grammar is Ambiguous. LL(1) cannot be ambiguous. Here's a Proof for that.


LL(1) Derivations

Left to Right Scan of input
Leftmost Derivation
(1) look ahead 1 token at each step
Alternative characterization of LL(1) Grammars:
Whenever $A \longrightarrow \alpha \mid \beta \in G$

1. $FIRST(\alpha) \cap FIRST(\beta) = \{ \}$, and

2. if $\alpha \stackrel{*}{\Longrightarrow} \epsilon$ then $FIRST(\beta) \cap FOLLOW(A) = \{ \}$.

Corollary: No Ambiguous Grammar is LL(1).

answer = **option C**

👍 18 votes -- Amar Vashishth (28.7k points)

2.7.32 Grammar: GATE2007-53 top http://gateoverflow.in/1251

Selected Answer

P:- This is false.

Every regular language is LL(1) meaning we have a LL(1) grammar for it. But we can not say same about every Regular Grammar. For example, every regular language can be represented by Left & Right Linear Grammar, where Left Linear Grammar is not LL(1), Right linear is.

Example aa* we can represent this as S->Sa|a which is not LL(1) ,but S->a|aS is LL(1).

Q:- This is true because of every LL(1) is LR(1).

All regular sets have Right recursive grammar, which is LL(1) & Every LL(1) is LR(1).

We can also say that LR(1) accepts DCFL & Regular languages are subset of DCFL.

So Answer is C.

29 votes -- Aakash Kanse (361 points)

answer = **option C**

LL Grammar
Grammars which can be parsed by an LL parser.

LL parser
Parses the input from **L**eft to right, and constructs a **L**eftmost derivation of the sentence(i.e. it is always the leftmost non-terminal which is rewritten). LL parser is a top-down parser for a subset of context-free languages.
An LL parser is called an LL(k) parser if it uses k tokens of lookahead when parsing a sentence and can do it without backtracking.

Consider a Grammar
G:
$S \rightarrow a|aa$

this grammar is **Regular** but cannot be parsed by a LL(1) parser w/o backtracking, coz here, lookahead is of 1 symbol only and in the grammar for both productions, parser while looking at just one(first) symbol, which is a, fails to select the correct rule for parsing.

Hence, not every Regular grammar is LL(1); Statement P is False.

LR Grammar
Grammars which can be parsed by LR parsers.

LR Parsers
thery are a type of bottom-up parsers that efficiently handle deterministic context-free languages(DCFL) in guaranteed linear time.

all Regular Languages are also DCFL hence, They all can be parsed by a LR(1) grammar.

Hence, Statement Q is True.

10 votes -- Amar Vashishth (28.7k points)

2.7.33 Grammar: GATE2007-78 top

http://gateoverflow.in/1272

Selected Answer

S -> aB
-> aaBB
-> aabB
-> aabbS
-> aabbaB
-> aabbab

👍 12 votes -- Arjun Suresh (294k points)

2.7.34 Grammar: GATE2007-79 top

http://gateoverflow.in/43512

Selected Answer

S -> aB
-> aaBB
-> aabB
-> aabbS
-> aabbaB
-> aabbab

S -> aB
-> aaBB (till now, only 1 choice possible)
-> aabSB (last time we took B - > b, now taking B->bS)
-> aabbAB
-> aabbaB
-> aabbab

So, totally 2 possible derivation trees.

👍 9 votes -- Arjun Suresh (294k points)

2.7.35 Grammar: GATE2007-IT-9 top

http://gateoverflow.in/3442

Selected Answer

c)L (D) = L (G) , **Both must represent same language** .Also if we are converting a grammar from Ambiguous to UnAmbiguous form , we must ensure that our new new grammar represents the same language as previous grammar.

For ex G1: S->Sa/aS/a; {Ambiguous (2 parse trees for string 'aa')}

G1':S->aS/a;{Unambiguous}

Both represents language represented by regular expression: a^+

👍 11 votes -- Anurag Semwal (8k points)

c) grammar may change but language remain the same.

👍 24 votes -- Arpit Dhuriya (3k points)

2.7.36 Grammar: GATE2008-50 top

http://gateoverflow.in/395

Selected Answer

Answer is C:

Statement 1 is **true**: Using GNF we can convert Left recursive grammar to right recursive and by using reversal of CFG and GNF we can convert right recursive to left recursive.

Statement 2 is **false**: because if ∊ is in the language then we can't remove ∊ production from Start symbol. (For example L = a*)

Statement 3 is **true** because right linear grammar generates regular set

Statement 4 is **true**, only two non-terminals are there in each production in CNF. So it always form a binary tree.

👍 23 votes -- Vikrant Singh (13.4k points)

2.7.37 Grammar: GATE2010-38 top

http://gateoverflow.in/2339

Selected Answer

It will be C.

For LL(1) take First(S). and do intersection between the result. if intersection is Phi then LL(1) else not.

Making a parsing table and checking if there are two or more entries under any terminal. If yes then neither LL(1) nor LR(1).

19 votes -- Gate Keeda (19.1k points)

2.7.38 Grammar: GATE2014-2-17 top

http://gateoverflow.in/1973

Selected Answer

P->Q+P here P is to right of +

so + is right associative

Similarly for T->T *U * is left associative as T is to left of *

so ans is b

12 votes -- Pooja Palod (32.4k points)

2.8 Infix Postfix(2) top

2.8.1 Infix Postfix: GATE1997_1.7 top

http://gateoverflow.in/2223

Which of the following is essential for converting an infix expression to the postfix form efficiently?

a. An operator stack
b. An operand stack
c. An operand stack and an operator stack
d. A parse tree

gate1997 compiler-design normal infix-postfix

Answer

2.8.2 Infix Postfix: GATE1998_19b top

http://gateoverflow.in/15708

Compute the post fix equivalent of the following expression $3^* \log(x+1) - \frac{a}{2}$

gate1998 compiler-design infix-postfix

Answer

Answers: Infix Postfix

2.8.1 Infix Postfix: GATE1997_1.7 top

http://gateoverflow.in/2223

Selected Answer

A. **An operator stack** // **Infix to (Postfix or Prefix)**
B. An operand stack //Postfix or Prefix Evaluation
C. An operand stack and an operator stack //we never use two stacks
But for Prefix to (Infix or postfix) OR Postfix to (Infix or prefix) We can use a stack where both operator and operand can present simultaneously

D. A parse tree // Not relevant to this question

Hence, **Option A** is Ans

http://condor.depaul.edu/ichu/csc415/notes/notes9/Infix.htm is a good read.

4 votes -- Rajesh Pradhan (18.6k points)

A.

we use operator stack (only operators are pushed as +, *, (,), /) for converting infix to postfix. And we use operand stack(operands such as 5,4,17 etc) for postfix evaluation.

15 votes -- Gate Keeda (19.1k points)

2.8.2 Infix Postfix: GATE1998_19b top

http://gateoverflow.in/15708

Selected Answer

According to **http://faculty.washington.edu/jstraub/dsa/aexp/**

The priority of the operators follows the usual conventions:

- The highest priority is assigned to unary operators (note that, in this context, a function such as *sin* is considered a unary operator). All unary operators have the same priority.
- Exponentiation has the second highest priority.
- The third highest priority is assigned to the multiplication and division operators.
- The lowest priority is given to the addition and subtraction operators.

Example:->>
Infix expression: 3 * log(10)
Postfix expression:
=3 * (10 log) //(Priority of unary operator *log* forces log(10) to evaluate first.)
=3 10 log *

Now For our case

3*log(x + 1) - a / 2

first content inside parenthesis will evaluate

so x+1 will become x1+

now **among (*,/,log,+,-)operators ..log has highest priority due to unary opeartor**

So, log(x1+) will become **x1+log**

now **suppose z= x1+log**

so convert this 3* z - a / 2 to postfix

3z* a2/ -

now substitue z= x1+log

3x1+log* a2/ - ....is Ans.

19 votes -- Rajesh Pradhan (18.6k points)

$3x1 + \log *a2/-$

12 votes -- Happy Mittal (10.9k points)

2.9 Intermediate Code(7) top

2.9.1 Intermediate Code: GATE1992-11a top http://gateoverflow.in/590

Write syntax directed definitions (semantic rules) for the following grammar to add the type of each identifier to its entry in the symbol table during semantic analysis. Rewriting the grammar is not permitted and semantic rules are to be added to the ends of productions only.

$D \to TL;$

$T \to \text{int}$

$T \to \text{real}$

$L \to L, id$

$L \to id$

gate1992 compiler-design syntax-directed-translation intermediate-code normal

Answer

2.9.2 Intermediate Code: GATE1992-11b top http://gateoverflow.in/43583

Write 3 address intermediate code (quadruples) for the following boolean expression in the sequence as it would be generated by a compiler. Partial evaluation of boolean expressions is not permitted. Assume the usual rules of precedence of the operators.

$$(a+b) > (c+d) \text{ or } a > c \text{ and } b < d$$

gate1992 compiler-design syntax-directed-translation intermediate-code descriptive

Answer

2.9.3 Intermediate Code: GATE1994_1.12 top http://gateoverflow.in/2453

Generation of intermediate code based on an abstract machine model is useful in compilers because

A. it makes implementation of lexical analysis and syntax analysis easier
B. syntax-directed translations can be written for intermediate code generation
C. it enhances the portability of the front end of the compiler
D. it is not possible to generate code for real machines directly from high level language programs

gate1994 compiler-design intermediate-code easy

Answer

2.9.4 Intermediate Code: GATE2014-2-34 top http://gateoverflow.in/1993

For a C program accessing **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. **X** is declared as **"int X[32] [32] [8]"**.
B. **X** is declared as **"int X[4] [1024] [32]"**.
C. **X** is declared as **"char X[4] [32] [8]"**.
D. **X** is declared as **"char X[32] [16] [2]"**.

gate2014-2 compiler-design intermediate-code programming-in-c normal

Answer

2.9.5 Intermediate Code: GATE2014-3-17 top http://gateoverflow.in/2051

One of the purposes of using intermediate code in compilers is to

A. make parsing and semantic analysis simpler.
B. improve error recovery and error reporting.
C. increase the chances of reusing the machine-independent code optimizer in other compilers.
D. improve the register allocation.

gate2014-3 compiler-design intermediate-code easy

Answer

2.9.6 Intermediate Code: GATE2015-1_55 top http://gateoverflow.in/8365

The least number of temporary variables required to create a three-address code in static single assignment form for the expression q + r / 3 + s - t * 5 + u * v/w is__________________.

gate2015-1 compiler-design intermediate-code normal numerical-answers

Answer

2.9.7 Intermediate Code: GATE2015-1_8 top http://gateoverflow.in/8096

For computer based on three-address instruction formats, each address field can be used to specify which of the following:

(S1) A memory operand

(S2) A processor register

(S3) An implied accumulator register

A. Either S1 or S2
B. Either S2 or S3
C. Only S2 and S3
D. All of S1, S2 and S3

gate2015-1 compiler-design intermediate-code normal

Answer

Answers: Intermediate Code

2.9.1 Intermediate Code: GATE1992-11a top http://gateoverflow.in/590

PRODUCTION RULE	SEMANTIC ACTIONS
D->TL	L.in:=T.type
T->int	T.type:=integer
T->real	T.type:=real
L->L,id	L1.in=L.in
	Enter_type(id.entry, L.in)
L->id	Enter_type(id.entry, L.in)

3 votes -- Anupoju Satish Kumar (301 points)

2.9.2 Intermediate Code: GATE1992-11b top http://gateoverflow.in/43583

Selected Answer

Each instruction in quadruples presentation is divided into four fields: operator, arg1, arg2, and result. The above example is represented below in quadruples format:

(a+b)>(c+d)OR a>c AND b<d

(t1>t2)OR a>c AND b<d

t3 OR t4 AND t5

t3 OR t6

----

t1= a+b

t2= c+d

t3= t1>t2

t4= a>c

t5= b<d

t6= t4 AND t5

t7 =t3 OR t6

Op	arg1	arg2	Result
+	a	b	t1
+	c	d	t2
>	t1	t2	t3
.>	a	c	t4
<	b	d	t5
AND	t4	t5	t6
OR	t3	t6	t7

16 votes -- shekhar chauhan (42.9k points)

2.9.3 Intermediate Code: GATE1994_1.12 top http://gateoverflow.in/2453

Selected Answer

C. stating the actual use of the Intermediate Code.

Also optimizations can be done on intermediate code enhancing the portability of the optimizer.

16 votes -- Gate Keeda (19.1k points)

2.9.4 Intermediate Code: GATE2014-2-34 top http://gateoverflow.in/1993

Selected Answer

k is multiplied by 4, means sizeof(dataype) is int.
j is multiplied by 32, means the inner most dimension of array is 32/4 = 8 (we have to divide by the size of the inner dimension- which here is a simple integer)
i is multiplied by 1024, means the second dimension of array is 1024/32 = 32 (32 = 8*4 is the size of the inner dimension here)

So, (A) is correct. The first dimension is not needed for code generation and that is why in C language while passing an array to a function, we can omit the value of the first dimension but not any others.

We can also do as follows:

X[i][j][k] = *(*(*(X + i) + j) + k)

In Integer arithmetic, this equals

((*(X + i * sizeof(*X)) + j * sizeof(**X) + k * sizeof(***X))

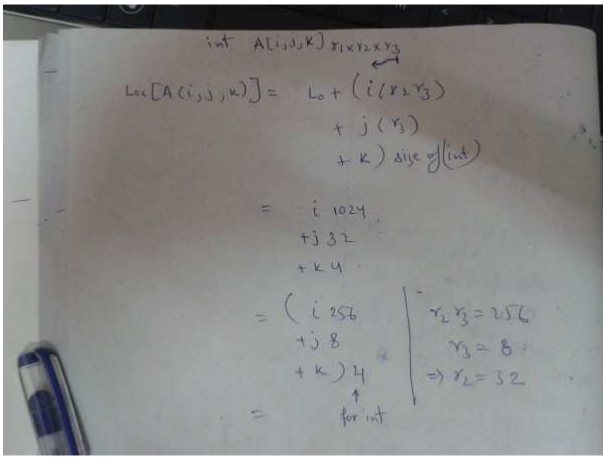
as for every add to a pointer we have to multiply the size of the pointed value (to get a valid address)

So, from the given code we get

sizeof(***X) = 4, - int
sizeof(**X) = 32 - int array of size 8
sizeof(*X) = 1024 - 2 D int array of size [32] havinf size of inner 1D array 32.

So, the inner dimensions must be 32 and 8 and type must be integer. So, only option A matches.

26 votes -- Arjun Suresh (294k points)



X is of type integer and dimensions of X are r_1 X r_2 X r_3.

value of r_2 = 32

r_3 = 8

16 votes -- Vikrant Singh (13.4k points)

2.9.5 Intermediate Code: GATE2014-3-17 top http://gateoverflow.in/2051

Selected Answer

C.

that is the actual use of intermediate code generator in a compiler.

16 votes -- Gate Keeda (19.1k points)

2.9.6 Intermediate Code: GATE2015-1_55 top http://gateoverflow.in/8365

Selected Answer

Answer is 8.

In compiler design, **static single assignment form** (often abbreviated as **SSA form** or simply **SSA**) is a property of an intermediate representation (IR), which requires that each variable is assigned exactly once, and every variable is defined before it is used. Existing variables in the original IR are split into *versions*, new variables.

We will need a temporary variable for storing the result of each binary operation as SSA (Static Single Assignment) implies the variable cannot be repeated on LHS of assignment.

```
q  + r / 3 + s - t * 5 + u * v/w

t1 = r/3;
t2 = t*5;
t3 = u*v;
t4 = t3/w;
t5 = q + t1;
t6 = t5 + s;
t7 = t6 - t2;
t8 = t7 + t4
```

http://web.stanford.edu/class/archive/cs/cs143/cs143.1128/handouts/240%20TAC%20Examples.pdf

38 votes -- Arjun Suresh (294k points)

2.9.7 Intermediate Code: GATE2015-1_8 top

http://gateoverflow.in/8096

Selected Answer

Three address Instruction

Computer with three addresses instruction format can use each address field to specify either processor register or memory operand.

Ex. X = (A + B) * (C + A)

Equivalent **Three address Instructions**

ADD R1, A, B   R1 ® M [A] + M [B]
ADD R2, C, D   R2 ® M [C] + M [D]
MUL X, R1, R2   M [X] ® R1 * R2

The advantage of the three address formats is that it results in short program when evaluating arithmetic expression. The disadvantage is that the binary-coded instructions require too many bits to specify three addresses.

http://www.laureateiit.com/projects/bacii2014/projects/coa_anil/instruction_formate.html#sthash.7y6Hcwvd.dpuf

17 votes -- Prasanna Ranganathan (4.3k points)

option A either A memory operand or A processor register.

15 votes -- Anoop Sonkar (4.9k points)

2.10 Left Recursion(1) top

2.10.1 Left Recursion: GATE2017-2-32 top

http://gateoverflow.in/118374

Consider the following expression grammar G:

- $E->E-T \mid T$
- $T->T+F \mid F$
- $F->(E) \mid id$

Which of the following grammars is not left recursive, but is equivalent to G?

A. $E->E-T \mid T$

$T->T+F \mid F$

$F->(E) \mid id$

B. $E->TE'$

$E'->-TE' \mid \epsilon$

$T->T+F \mid F$

$F->(E) \mid id$

C. $E->TX \mid (TX)$

$X->-TX \mid +TX \mid \epsilon$

$T->id$

$F->(E) \mid id$

D. $E->TX$

$X->-TX \mid \epsilon$

$T->+FY \mid \epsilon$

$F->(E) \mid id$

gate2017-2 grammar left-recursion

Answer

Answers: Left Recursion

2.10.1 Left Recursion: GATE2017-2-32 top

http://gateoverflow.in/118374

Selected Answer

Since the grammar given in the question is left recursive , we need to remove left recursion ,

If Grammar is of form

A--->Aα | β

then after removal of left recursion it should be written as

A --->βA'

A'--->αA' | ϵ

Since the grammar is :

E---> E - T | T (Here α is '-T' and β is T)

T---> T + F | F (Here α is '+F' and β is F)

F---> (E) | id (It is not having left recursion)

Rewriting after removing left recursion :

E ---> TE'

E'---> -TE' | ϵ

T ---> FT'

T'---> +FT' | ϵ

F ---> (E) | id

Now replace E' with X and T' with Y to match with Option C.

E ---> TX

X---> -TX | ϵ

T ---> FY

Y---> +FY | ϵ

F ---> (E) | id

Hence C is correct.

8 votes -- Indranil Maji (201 points)

2.11 Lexical Analysis(4) top

2.11.1 Lexical Analysis: GATE2000-1.18, ISRO2015-25 top http://gateoverflow.in/641

The number of tokens in the following C statement is

```
printf("i=%d, &i=%x", i, &i);
```

A. 3
B. 26
C. 10
D. 21

gate2000 compiler-design lexical-analysis easy isro2015

Answer

2.11.2 Lexical Analysis: GATE2010-13 top http://gateoverflow.in/2186

Which data structure in a compiler is used for managing information about variables and their attributes?

A. Abstract syntax tree
B. Symbol table
C. Semantic stack
D. Parse table

gate2010 compiler-design lexical-analysis easy

Answer

2.11.3 Lexical Analysis: GATE2011_1 top http://gateoverflow.in/2103

In a compiler, keywords of a language are recognized during

(A) parsing of the program

(B) the code generation

(C) the lexical analysis of the program

(D) dataflow analysis

gate2011 compiler-design lexical-analysis easy

Answer

2.11.4 Lexical Analysis: GATE2011_19 top http://gateoverflow.in/2121

The lexical analysis for a modern computer language such as Java needs the power of which one of the following machine models in a necessary and sufficient sense?

(A) Finite state automata

(B) Deterministic pushdown automata

(C) Non-deterministic pushdown automata

(D) Turing machine

gate2011 compiler-design lexical-analysis easy

Answer

Answers: Lexical Analysis

2.11.1 Lexical Analysis: GATE2000-1.18, ISRO2015-25 top http://gateoverflow.in/641

Selected Answer

answer - C

Tokens are:

1. printf
2. (
3. "i=%d, &i=%x"
4. ,
5. i
6. ,
7. &
8. i
9.)
10. ;

20 votes -- ankitrokdeonsns (9.1k points)

2.11.2 Lexical Analysis: GATE2010-13 top http://gateoverflow.in/2186

Selected Answer

Symbol table is answer . It can be implemented by using array , hash table , tree and eve some time with the help of lInked list !

16 votes -- Dexter (9.7k points)

B. It uses array to implement.

13 votes -- Gate Keeda (19.1k points)

2.11.3 Lexical Analysis: GATE2011_1 top http://gateoverflow.in/2103

Selected Answer

Typically, the lexical analysis phase of compilation breaks the input text up into sequences of lexemes that each belongs to some particular token type that's useful in later analysis. Consequently, keywords are usually first recognized during lexical analysis in order to make parsing easier. Since parsers tend to be implemented by writing context-free grammars of tokens rather than of lexemes (that is, the *category* of the lexeme rather than the *contents* of the lexeme), it is significantly easier to build a parser when keywords are marked during lexing. Any identifier is also a token so it is recognized in lexical Analysis .
Hence option C is True.
ref@ http://stackoverflow.com/questions/5202709/phases-of-a-compiler

19 votes -- Mithlesh Upadhyay (5.4k points)

2.11.4 Lexical Analysis: GATE2011_19 top http://gateoverflow.in/2121

Selected Answer

Answer - A

In compiler lexical analyzer categorizes character sequence into lexemes and produces tokens as output for parser. And tokens are expressed in regular expressions so a simple Finite Automata is sufficient for it.

18 votes -- ankitrokdeonsns (9.1k points)

2.12 Linking(3) top

2.12.1 Linking: GATE1991_03,ix top http://gateoverflow.in/519

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

A "link editor" is a program that:

A. matches the parameters of the macro-definition with locations of the parameters of the macro call
B. matches external names of one program with their location in other programs
C. matches the parameters of subroutine definition with the location of parameters of subroutine call.
D. acts as a link between text editor and the user
E. acts as a link between compiler and the user program

gate1991 compiler-design normal linking

Answer

2.12.2 Linking: GATE2003-76 top http://gateoverflow.in/962

Which of the following is NOT an advantage of using shared, dynamically linked libraries as opposed to using statistically linked libraries?

A. Smaller sizes of executable files

B. Lesser overall page fault rate in the system

C. Faster program startup

D. Existing programs need not be re-linked to take advantage of newer versions of libraries

gate2003 compiler-design runtime-environments linking easy

Answer

2.12.3 Linking: GATE2004-9 top http://gateoverflow.in/1006

Consider a program P that consists of two source modules M_1 and M_2 contained in two different files. If M_1 contains a reference to a function defined in M_2 the reference will be resolved at

A. Edit time
B. Compile time
C. Link time
D. Load time

gate2004 compiler-design easy linking

Answer

Answers: Linking

2.12.1 Linking: GATE1991_03,ix top http://gateoverflow.in/519

Selected Answer

Link editor or (linker) performs

1. external symbol resolution

2. relocation.

ANS: B

Matches external names of one program with their location in other programs

7 votes -- pramod (3.3k points)

2.12.2 Linking: GATE2003-76 top

http://gateoverflow.in/962

Selected Answer

option c: DLL takes more time in program setup (in loading and linking phase to set up the global offset table and load and link the required libraries)

- Since DLLs are separated from executable, the size of executable becomes smaller. Since DLLs are shared among multiple executables, the total memory usage of the system goes down and hence overall page fault rate decreases.
- Dynamic linking takes place during program runtime. So, if a DLL is replaced to a new version, it will automatically get linked during runtime. There is no explicit relinking required as in the case of static linking. (This works by linking the DLL calls to Global Offset Table and the contents of this table is filled during program run. A simple jump in static linking becomes an indirect jump in dynamic linking).

Reffer :From galvin

8.1.5 Dynamic Linking and Shared Libraries

Figure 8.3 also shows **dynamically linked libraries.** Some operating systems support only **static linking,** in which system language libraries are treated like any other object module and are combined by the loader into the binary program image. The concept of dynamic linking is similar to that of dynamic loading. Here, though, linking, rather than loading, is postponed until execution time. This feature is usually used with system libraries, such as language subroutine libraries. Without this facility, each program on a system must include a copy of its language library (or at least the routines referenced by the program) in the executable image. This requirement wastes both disk space and main memory.

With dynamic linking, a *stub* is included in the image for each library-routine reference. The stub is a small piece of code that indicates how to locate the appropriate memory-resident library routine or how to load the library if the routine is not already present. When the stub is executed, it checks to see whether the needed routine is already in memory. If not, the program loads the routine into memory. Either way, the stub replaces itself with the address of the routine and executes the routine. Thus, the next time that particular code segment is reached, the library routine is executed directly, incurring no cost for dynamic linking. Under this scheme, all processes that use a language library execute only one copy of the library code.

This feature can be extended to library updates (such as bug fixes). A library may be replaced by a new version, and all programs that reference the library will automatically use the new version. Without dynamic linking, all such programs would need to be relinked to gain access to the new library. So that programs will not accidentally execute new, incompatible versions of libraries, version information is included in both the program and the library. More than one version of a library may be loaded into memory, and each program uses its version information to decide which copy of the library to use. Minor changes retain the same version number, whereas major changes increment the version number. Thus, only programs that are compiled with the new library version are affected by the incompatible changes incorporated in it. Other programs linked before the new library was installed will continue using the older library. This system is also known as **shared libraries.**

24 votes -- GateMaster Prime (1.6k points)

2.12.3 Linking: GATE2004-9 top

http://gateoverflow.in/1006

Selected Answer

answer - C. Each module is compiled separately and then linked together to make the executable. The below commands shows how to do this for two modules c1.c and c2.c using gcc.

```
gcc -c c1.c -o c1.o
gcc -c c2.c -o c2.o
gcc c1.o c2.o -o C.exe
```

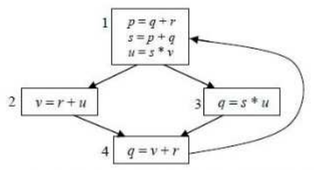
12 votes -- ankitrokdeonsns (9.1k points)

2.13 Live Variable(1) top

2.13.1 Live Variable: GATE2015-1_50 top http://gateoverflow.in/8356

A variable x is said to be live at a statement S_i in a program if the following three conditions hold simultaneously:

i. There exists a statement S_j that uses x
ii. There is a path from S_i to S_j in the flow graph corresponding to the program
iii. The path has no intervening assignment to x including at S_i and S_j



The variables which are live both at the statement in basic block 2 and at the statement in basic block 3 of the above control flow graph are

A. p, s, u
B. r, s, u
C. r, u
D. q, v

gate2015-1 compiler-design live-variable normal

Answer

Answers: Live Variable

2.13.1 Live Variable: GATE2015-1_50 top http://gateoverflow.in/8356

Selected Answer

r, u.

p, and s are assigned to in 1 and there is no intermediate use of them before that. Hence p, and s are not live in both 2 and 3.
q is assigned to in 4 and hence is not live in both 2 and 3.

v is live at 3 but not at 2.

u is live at 3 and also at 2 if we consider a path of length 0 from 2 - 2.

So, r, u is the answer.

7 votes -- Arjun Suresh (294k points)

2.14 Macros(3) top

2.14.1 Macros: GATE1995_1.11 top http://gateoverflow.in/2598

What are x and y in the following macro definition?

```
macro Add x, y
        Load y
        Mul x
        Store y
end macro
```

A. Variables
B. Identifiers
C. Actual parameters
D. Formal parameters

gate1995 compiler-design macros easy

Answer

2.14.2 Macros: GATE1996_2.16 top http://gateoverflow.in/2745

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

(i)

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)

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

2.14.3 Macros: GATE1997_1.9 top http://gateoverflow.in/2225

The conditional expansion facility of macro processor is provided to

a. test a condition during the execution of the expanded program
b. to expand certain model statements depending upon the value of a condition during the execution of the expanded program
c. to implement recursion
d. to expand certain model statements depending upon the value of a condition during the process of macro expansion

gate1997 compiler-design macros easy

Answer

Answers: Macros

2.14.1 Macros: GATE1995_1.11 top http://gateoverflow.in/2598

Selected Answer

ans is D

5 votes -- jayendra (8.1k points)

2.14.2 Macros: GATE1996_2.16 top http://gateoverflow.in/2745

Selected Answer

if M2 macro is called with x=0, then it'll go into an infinite loop.
Hence correct option would be A.

1 votes -- suraj (5.1k points)

2.14.3 Macros: GATE1997_1.9 top http://gateoverflow.in/2225

Selected Answer

Macro is expanded during the process of macro expansion. Hence, correct answer would be (d).

7 votes -- suraj (5.1k points)

2.15 Parameter Passing(8) top

2.15.1 Parameter Passing: CMI2010-A-08 top http://gateoverflow.in/46140

In programming language terminology, call by value refers to the fact that:

A. A function call can return a value.
B. When a function is called, arguments are copied into local storage.
C. Functions can indirectly modify the value of external variables.
D. Every argument passed to a function must have a value.

cmi2010 compiler-design runtime-environments parameter-passing

Answer

2.15.2 Parameter Passing: GATE 2016-1-36 top http://gateoverflow.in/39701

What will be the output of the following pseudo-code when parameters are passed by reference and dynamic scoping is assumed?

```
a = 3;
void n(x) { x = x * a; print (x); }
void m(y) { a = 1 ; a = y - a;  n(a); print (a); }
void main () { m(a); }
```

A. $6, 2$
B. $6, 6$
C. $4, 2$
D. $4, 4$

gate2016-1 parameter-passing normal

Answer

2.15.3 Parameter Passing: GATE1988-2xv top http://gateoverflow.in/94333

What is printed by following program, assuming call-by reference method of passing parameters for all variables in the parameter list of procedure P?

```
program     Main(inout, output);
var      a, b:integer;
         procedure P(x, y, z:integer);
         begin
              y:=y+1
              z:=x+x
         end P;
```

```
begin
    a:=2; b:=3;
    p(a+b, a, a);
    Write(a)
end.
```

gate1988 descriptive compiler-design runtime-environments parameter-passing numerical-answers

Answer

2.15.4 Parameter Passing: GATE1991-09a top http://gateoverflow.in/536

Consider the following pseudo-code (all data items are of type integer):

```
procedure P(a, b, c);
    a := 2;
    c := a + b;
end {P}

begin
    x := 1;
    y := 5;
    z := 100;
    P(x, x*y, z);
    Write ('x = ', x, 'z = ', z);
end
```

Determine its output, if the parameters are passed to the Procedure P by

i. value
ii. reference
iii. name

gate1991 compiler-design parameter-passing normal runtime-environments

Answer

2.15.5 Parameter Passing: GATE1991_03,x top http://gateoverflow.in/524

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

Indicate all the true statements from the following:

(a). Recursive descent parsing cannot be used for grammar with left recursion.

(b). The intermediate form for representing expressions which is best suited for code optimization is the postfix form.

(c). A programming language not supporting either recursion or pointer type does not need the support of dynamic memory allocation.

(d). Although C does not support call-by-name parameter passing, the effect can be correctly simulated in C

(e). No feature of Pascal typing violates strong typing in Pascal.

gate1991 compiler-design parameter-passing programming difficult

Answer

2.15.6 Parameter Passing: GATE1995_2.4 top http://gateoverflow.in/2616

What is the value of X printed by the following program?

```
program COMPUTE (input, output);
var X:integer;
procedure FIND (X:real);
    begin
        X:=sqrt(X);
    end;
begin
    X:=2
    FIND(X);
    writeln(X);
end.
```

A. 2
B. $\sqrt{2}$
C. Run time error
D. None of the above

gate1995 programming parameter-passing runtime-environments easy

Answer

2.15.7 Parameter Passing: GATE2004-2,ISRO2017-54 top http://gateoverflow.in/999

Consider the following function

```
void swap(int a, int b)
{
    int temp;
    temp = a;
    a = b;
    b = temp;
}
```

In order to exchange the values of two variables x and y.

A. call swap(x, y)

B. call swap(&x, &y)

C. swap (x, y) cannot be used as it does not return any value

D. swap (x, y) cannot be used as the parameters are passed by value

gate2004 compiler-design programming-in-c parameter-passing easy isro2017 runtime-environments

Answer

2.15.8 Parameter Passing: GATE2007-IT-33 top http://gateoverflow.in/3466

Consider the program below in a hypothetical language which allows global variable and a choice of call by reference or call by value methods of parameter passing.

```
int i ;
program main ()
{
    int j = 60;
    i = 50;
    call f (i, j);
    print i, j;
}
procedure f (x, y)
{
    i = 100;
    x = 10;
    y = y + i ;
}
```

Which one of the following options represents the correct output of the program for the two parameter passing mechanisms?

A. Call by value : i = 70, j = 10; Call by reference : i = 60, j = 70
B. Call by value : i = 50, j = 60; Call by reference : i = 50, j = 70
C. Call by value : i = 10, j = 70; Call by reference : i = 100, j = 60
D. Call by value : i = 100, j = 60; Call by reference : i = 10, j = 70

gate2007-it programming parameter-passing normal compiler-design runtime-environments

Answer

Answers: Parameter Passing

2.15.1 Parameter Passing: CMI2010-A-08 top http://gateoverflow.in/46140

Selected Answer

B)When a function is called, arguments are copied into local storage.

In call by value , a copy of variable send from where it is called and those are local to the calling function

1 votes -- srestha (58.4k points)

2.15.2 Parameter Passing: GATE 2016-1-36 top http://gateoverflow.in/39701

Selected Answer

It is a bit confusing as variable declaration is not explicit. But we can see that "a=3" and "a=1" are declaring new variables, one in global and other in local space.

Main is calling m(a). Since there is no local 'a', 'a' here is the global one.

In m, we have "a = 1" which declares a local "a" and gives 1 to it. "a = y-a" assigns 3-1 = 2 to 'a'.

Now, in n(x), 'a' is used and as per dynamic scoping this 'a' comes from 'm()' and not the global one. So, "x=x*a" assigns "2*2 = 4" to "x" and 4 is printed. Being passed by reference, "a" in m() also get updated to 4. So, D is the answer here.

41 votes -- Arjun Suresh (294k points)

2.15.3 Parameter Passing: GATE1988-2xv top http://gateoverflow.in/94333

Selected Answer

let variable "a" has address 100 and "b" has 200 .

and avariable in which "a+b" is stored has address 300.

now p(300,100,100) which represent x,y,z

y:=y+1 // it makes a=3;

z:=x+x // x means the value contained at address 300 i.e. 5

5+5 =10 hence value at address 100 i.e. variable "a" will get the value 10 .

hence value of a i.e. 10 will be printed.

4 votes -- psb (427 points)

2.15.4 Parameter Passing: GATE1991-09a top http://gateoverflow.in/536

Selected Answer

1. Pass by value: Function cannot modify a variable in the calling function. So,

x = 1, z = 100

2. Pass by reference: An alias of the variable (a different name but having same memory location) is used to pass the variable to a function. So, whatever change occurs for the variable in the called function is reflected in the calling function.

x = 2, z = 7 (2 + 5)

3. Pass by name: The expression used to call a function is copy pasted for each formal parameter. So, the body of P becomes,

```
x := 2;
z := x + x*y;
```

So, printed value will be

x = 2, z = 12

13 votes -- Arjun Suresh (294k points)

2.15.5 Parameter Passing: GATE1991_03,x top http://gateoverflow.in/524

Selected Answer

A is TRUE. Left recursive grammars if used directly in recursive descent parsing causes an infinite loop. So, left recursion must be removed before giving to a recursive descent parser.

B is a strong statement- but I do not have any proof or reference for this- so for now I consider this FALSE.

C is false. The language can have dynamic datatypes which requires dynamically growing memory when data type size increases.

D is true and using macro we can do this.

E - out of syllabus now,

6 votes -- Arjun Suresh (294k points)

2.15.6 Parameter Passing: GATE1995_2.4 top http://gateoverflow.in/2616

i think ans should be A.

as per call by value concept. X in the procedure FIND is a local variable. no change will be refleced in global var X.

5 votes -- jayendra (8.1k points)

2.15.7 Parameter Passing: GATE2004-2,ISRO2017-54 top http://gateoverflow.in/999

Selected Answer

ans (d).

option a will not swap the values bcoz it is passed by value...

option b will not swap the value

```
void swap(int a, int b) in which arguments will not take
```

option c is false , given reason is wrong

and option d is correct .. we cant use swap(x,y) bcoz it is pass value function call which will not swap the values

11 votes -- sonam vyas (13.2k points)

2.15.8 Parameter Passing: GATE2007-IT-33 top http://gateoverflow.in/3466

Selected Answer

Correct answer is (d)

CALL BY VALUE :- i as global variable declared. Then in main() a local variable j as integer declared i.e j=60 And global variable i initialized to 50 by i=50. Now procedure f called and values of i and j are passed to it. i.e., in f(i,j) -> f(x, y) content of memory location of i (here 50) is copied to memory location of x (which is different from i) and content of memory location of j (here, 60) is copied to memory location of y. Then in f(x,y) i=100 changes the global i to 100, X= 10 changes the local X from 50 to 10 and Y= y+ i means y=60+100=160. Now when return back to main, i and j will be 100 and 60 respectively.

CALL BY REFERENCE:- Now procedure f called and passed reference of i and j to it. i.e., in f(i,j) -> f(x, y) x and y are new names (aliases) pointing to the same memory location of i and j respectively. So, i = 100 changes the global i to 100 and x= 10 means x as well as global i =10 (as the i being passed is the global variable and x and i share the same address).

y= y+ i means y = 60+10=70 and this changes the value of j also to 70 as j and y have the same address. Now when return back to main, i and j will be 10 and 70 respectively.

17 votes -- Kalpna Bhargav (3.2k points)

2.16 Parsing(42) top

2.16.1 Parsing: GATE 2016-1-45 top http://gateoverflow.in/39697

The attribute of three arithmetic operators in some programming language are given below.

OPERATOR	PRECEDENCE	ASSOCIATIVITY	ARITY
+	high	Left	Binary
-	Medium	Right	Binary
*	Low	Left	Binary

The value of the expression $2 - 5 + 1 - 7 * 3$ in this language is ________.

gate2016-1 compiler-design parsing normal numerical-answers

Answer

2.16.2 Parsing: GATE1987-1-xiv top http://gateoverflow.in/80295

An operator precedence parser is a

A. Bottom-up parser.
B. Top-down parser.
C. Back tracking parser.
D. None of the above.

gate1987 compiler-design parsing

Answer

2.16.3 Parsing: GATE1989-1-iii top http://gateoverflow.in/87046

Merging states with a common core may produce ___________ conflicts and does not produce _____________ conflicts in an LALR purser.

gate1989 descriptive compiler-design parsing

Answer

2.16.4 Parsing: GATE1992_02,xiii top http://gateoverflow.in/570

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

For a context free grammar, FOLLOW(A) is the set of terminals that can appear immediately to theright 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

Answer

2.16.5 Parsing: GATE1992_02,xiv top http://gateoverflow.in/571

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

Consider the $SLR(1)$ and $LALR(1)$ parsing tables for a context free grammar. Which of the following statement is/are true?

(a). The *goto* part of both tables may be different.

(b). The *shift* entries are identical in both the tables.

(c). The *reduce* entries in the tables may be different.

(d). The *error* entries in tables may be different

gate1992 compiler-design normal parsing

Answer

2.16.6 Parsing: GATE1998-1.26 top http://gateoverflow.in/1663

Which of the following statements is true?

A. SLR paper 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

2.16.7 Parsing: GATE1998_1.27 top http://gateoverflow.in/1664

Type checking is normally done during

(a) lexical analysis

(b) syntax analysis

(c) syntax directed translation

(d) code optimization

gate1998 compiler-design parsing easy

Answer

2.16.8 Parsing: GATE1998_22 top http://gateoverflow.in/1737

a. An identifier in a programming language consists of up to six letters and digits of which the first character must be a letter. Derive a regular expression for the identifier.

b. Build an LL(1) parsing table for the language defined by the LL(1) grammar with productions

$$\text{Program} \rightarrow \text{ begin } d \text{ semi } X \text{ end}$$

$$X \rightarrow d \text{ semi } X \mid sY$$

$Y \rightarrow \text{semi } sY \mid \epsilon$

gate1998 compiler-design parsing descriptive

Answer

2.16.9 Parsing: GATE1999_1.17 top http://gateoverflow.in/1470

Which of the following is the most powerful parsing method?

A. LL (1)
B. Canonical LR
C. SLR
D. LALR

gate1999 compiler-design parsing easy

Answer

2.16.10 Parsing: GATE2000-1.19, UGCNET-Dec2013-II-30 top http://gateoverflow.in/642

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

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

gate2000 compiler-design parsing normal ugcnetdec2013ii

Answer

2.16.11 Parsing: GATE2001-16 top http://gateoverflow.in/757

Consider the following grammar with terminal alphabet $\Sigma\{a, (,), +, ^* \}$ and start symbol E. The production rules of the grammar are:

$E \rightarrow aA$

$E \rightarrow (E)$

$A \rightarrow +E$

$A \rightarrow^* E$

$A \rightarrow \epsilon$

a. Compute the FIRST and FOLLOW sets for E and A.
b. Complete the LL(1) parse table for the grammar.

gate2001 compiler-design parsing normal

Answer

2.16.12 Parsing: GATE2002-22 top http://gateoverflow.in/875

a. Construct all the parse trees corresponding to i + j * k for the grammar
   E $\rightarrow$ E+E
   E $\rightarrow$ E*E
   E $\rightarrow$ id
b. In this grammar, what is the precedence of the two operators * and +?
c. If only one parse tree is desired for any string in the same language, what changes are to be made so that the resulting LALR(1) grammar is unambiguous?

gate2002 compiler-design parsing normal descriptive

Answer

2.16.13 Parsing: GATE2003-16 top http://gateoverflow.in/906

Which of the following suffices to convert an arbitrary CFG to an LL(1) grammar?

A. Removing left recursion alone
B. Factoring the grammar alone
C. Removing left recursion and factoring the grammar
D. None of the above

gate2003 compiler-design parsing easy

Answer

2.16.14 Parsing: GATE2003-17 top http://gateoverflow.in/907

Assume that the SLR parser for a grammar G has n_1 states and the LALR parser for G has n_2 states. The relationship between n_1 and n_2 is

A. n_1 is necessarily less than n_2
B. n_1 is necessarily equal to n_2
C. n_1 is necessarily greater than n_2
D. None of the above

gate2003 compiler-design parsing easy

Answer

2.16.15 Parsing: GATE2003-57 top http://gateoverflow.in/945

Consider the grammar shown below.

S $\rightarrow$ C C

C $\rightarrow$ c C | d

This grammar is

A. LL(1)
B. SLR(1) but not LL(1)
C. LALR(1) but not SLR(1)
D. LR(I) but not LALR(1)

gate2003 compiler-design grammar parsing normal

Answer

2.16.16 Parsing: GATE2005-14 top http://gateoverflow.in/1350

The grammar $A \rightarrow AA \mid (A) \mid \epsilon$ is not suitable for predictive-parsing because the grammar is:

A. ambiguous

B. left-recursive

C. right-recursive

D. an operator-grammar

gate2005 compiler-design parsing grammar easy

Answer

2.16.17 Parsing: GATE2005-60 top http://gateoverflow.in/1383

Consider the grammar:

$$S \rightarrow (S) \mid a$$

Let the number of states in SLR (1), LR(1) and LALR(1) parsers for the grammar be n_1, n_2 and n_3 respectively. The following relationship holds good:

A. $n_1 < n_2 < n_3$
B. $n_1 = n_3 < n_2$
C. $n_1 = n_2 = n_3$
D. $n_1 \geq n_3 \geq n_2$

gate2005 compiler-design parsing normal

Answer

2.16.18 Parsing: GATE2005-83a top

http://gateoverflow.in/1405

Statement for Linked Answer Questions 83a & 83b:

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

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

The above grammar and the semantic rules are fed to a *yaac* tool (which is an LALR(1) parser generator) for parsing and evaluating arithmetic expressions. Which one of the following is true about the action of *yaac* for the given grammar?

A. It detects *recursion* and eliminates recursion

B. It detects *reduce-reduce* conflict, and resolves

C. It detects *shift-reduce* conflict, and resolves the conflict in favor of a *shift* over a *reduce* action

D. It detects *shift-reduce* conflict, and resolves the conflict in favor of a *reduce* over a *shift* action

gate2005 compiler-design parsing normal

Answer

2.16.19 Parsing: GATE2005-83b top

http://gateoverflow.in/87037

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

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

Assume the conflicts of this question are resolved using yacc tool and an LALR(1) parser is generated for parsing arithmetic expressions as per the given grammar. Consider an expression $3 \times 2 + 1$. What precedence and associativity properties does the generated parser realize?

A. Equal precedence and left associativity; expression is evaluated to 7

B. Equal precedence and right associativity; expression is evaluated to 9

C. Precedence of '$\times$' is higher than that of '+', and both operators are left associative; expression is evaluated to 7

D. Precedence of '$+$' is higher than that of '$\times$', and both operators are left associative; expression is evaluated to 9

gate2005 compiler-design parsing normal

Answer

2.16.20 Parsing: GATE2005-IT-83a top http://gateoverflow.in/3849

Consider the context-free grammar

E → E + E
E → (E * E)
E → id

where E is the starting symbol, the set of terminals is {id, (,+,),*}, and the set of nonterminals is {E}.

Which of the following terminal strings has more than one parse tree when parsed according to the above grammar?

A. id + id + id + id
B. id + (id* (id * id))
C. (id* (id * id)) + id
D. ((id * id + id) * id)

gate2005-it compiler-design grammar parsing easy

Answer

2.16.21 Parsing: GATE2005-IT-83b top http://gateoverflow.in/3850

Consider the context-free grammar

E → E + E
*E → (E * E)*
E → id

where E is the starting symbol, the set of terminals is {id, (,+,),*}, and the set of non-terminals is {E}.

For the terminal string id + id + id + id, how many parse trees are possible?

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

gate2005-it compiler-design parsing normal

Answer

2.16.22 Parsing: GATE2006-58 top http://gateoverflow.in/1836

Consider the following grammar:

$S \rightarrow FR$

$R \rightarrow *S \mid \varepsilon$

$F \rightarrow id$

In the predictive parser table, M, of the grammar the entries M[S,id] and M[R,$] respectively are

A. $\{S \rightarrow FR\}$ and $\{R \rightarrow \varepsilon\}$
B. $\{S \rightarrow FR\}$ and $\{\}$
C. $\{S \rightarrow FR\}$ and $\{R \rightarrow *S\}$
D. $\{F \rightarrow id\}$ and $\{R \rightarrow \varepsilon\}$

gate2006 compiler-design parsing normal

Answer

2.16.23 Parsing: GATE2006-7 top http://gateoverflow.in/886

Consider the following grammar

S→ S * E
S→ E

E→ F + E
E→ F
F→ id
Consider the following LR(0) items corresponding to the grammar above

i. S → S *.E
ii. E → F. + E
iii. E → F + .E

Given the items above, which two of them will appear in the same set in the canonical sets-of-items for the grammar?

A. i and ii
B. ii and iii
C. i and iii
D. None of the above

gate2006 compiler-design parsing normal

Answer

2.16.24 Parsing: GATE2007-18 top http://gateoverflow.in/1216

Which one of the following is a top-down parser?

A. Recursive descent parser.

B. Operator precedence parser.

C. An LR(k) parser.

D. An LALR(k) parser.

gate2007 compiler-design parsing normal

Answer

2.16.25 Parsing: GATE2008-11 top http://gateoverflow.in/409

Which of the following describes a handle (as applicable to LR-parsing) appropriately?

A. It is the position in a sentential form where the next shift or reduce operation will occur

B. It is non-terminal whose production will be used for reduction in the next step

C. It is a production that may be used for reduction in a future step along with a position in the sentential form where the next shift or reduce operation will occur

D. It is the production p that will be used for reduction in the next step along with a position in the sentential form where the right hand side of the production may be found

gate2008 compiler-design parsing normal

Answer

2.16.26 Parsing: GATE2008-55 top http://gateoverflow.in/478

An LALR(1) parser for a grammar G can have shift-reduce (S-R) conflicts if and only if

A. The SLR(1) parser for G has S-R conflicts

B. The LR(1) parser for G has S-R conflicts

C. The LR(0) parser for G has S-R conflicts

D. The LALR(1) parser for G has reduce-reduce conflicts

gate2008 compiler-design parsing normal

Answer

2.16.27 Parsing: GATE2008-IT-79 top http://gateoverflow.in/3393

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

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

For the string "aabbaab" how many steps are required to derive the string and how many parse trees are there?

A. 6 and 1
B. 6 and 2
C. 7 and 2
D. 4 and 2

gate2008-it compiler-design context-free-language parsing normal

Answer

2.16.28 Parsing: GATE2009-42 top

http://gateoverflow.in/1328

Which of the following statements are TRUE?

I. There exist parsing algorithms for some programming languages whose complexities are less than $\Theta(n^3)$

II. A programming language which allows recursion can be implemented with static storage allocation.

III. No L-attributed definition can be evaluated in the framework of bottom-up parsing.

IV. Code improving transformations can be performed at both source language and intermediate code level.

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

gate2009 compiler-design parsing normal

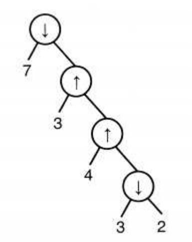
Answer

2.16.29 Parsing: GATE2011_27 top

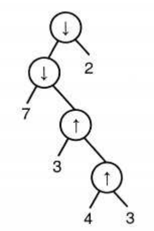
http://gateoverflow.in/2129

Consider two binary operators '$\uparrow$' and '$\downarrow$' with the precedence of operator $\downarrow$ being lower than that of the operator $\uparrow$. Operator $\uparrow$ is right associative while operator $\downarrow$ is left associative. Which one of the following represents the parse tree for expression $(7 \downarrow 3 \uparrow 4 \uparrow 3 \downarrow 2)$

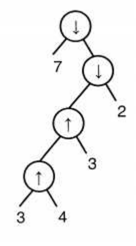
(A)



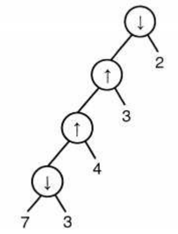
(B)



(C)



(D)



gate2011 compiler-design parsing normal

Answer

2.16.30 Parsing: GATE2012-52 top

http://gateoverflow.in/2181

For the grammar below, a partial $LL(1)$ parsing table is also presented along with the grammar. Entries that need to be filled are indicated as **E1**, **E2**, and **E3**.
ε is the empty string, $ indicates end of input, and,
$|$ 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 FIRST and FOLLOW sets for the non-terminals A and B are

(A)

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

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

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

(B)

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

$\text{FIRST}(B) = \{a, b, \varepsilon\}$

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

$\text{FOLLOW}(B) = \{\$\}$

(C)

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

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

$\text{FOLLOW}(B) = \varnothing$

(D)

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

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

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

gate2012 compiler-design parsing normal

Answer

2.16.31 Parsing: GATE2012-53 top

http://gateoverflow.in/43312

For the grammar below, a partial $LL(1)$ parsing table is also presented along with the grammar. Entries that need to be filled are indicated as **E1**, **E2**, and **E3**. ε is the empty string, $ indicates end of input, and, $|$ separates alternate right hand sides of productions.

$S \rightarrow aAbB \mid bAaB \mid \varepsilon$

$A \rightarrow S$

$B \rightarrow S$

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

The appropriate entries for E1, E2, and E3 are

(A)

$\text{E1} : S \rightarrow aAbB, A \rightarrow S$

$\text{E2} : S \rightarrow bAaB, B \rightarrow S$

$\text{E1} : B \rightarrow S$

(B)

$\text{E1} : S \rightarrow aAbB, S \rightarrow \varepsilon$

$\text{E2} : S \rightarrow bAaB, S \rightarrow \varepsilon$

$\text{E3} : S \rightarrow \varepsilon$

(C)

$\text{E1}: S \to aAbB, S \to \varepsilon$

$\text{E2}: S \to bAaB, S \to \varepsilon$

$\text{E3}: B \to S$

(D)

$\text{E1}: A \to S, S \to \varepsilon$

$\text{E2}: B \to S, S \to \varepsilon$

$\text{E3}: B \to S$

normal gate2012 compiler-design parsing

Answer

2.16.32 Parsing: GATE2013_40 top http://gateoverflow.in/1551

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

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

Which of the following statements related to merging of the two sets in the corresponding LALR parser is/are **FALSE**?

1. Cannot be merged since look aheads are different.

2. Can be merged but will result in S-R conflict.

3. Can be merged but will result in R-R conflict.

4. Cannot be merged since goto on c will lead to two different sets.

(A) 1 only (B) 2 only (C) 1 and 4 only (D) 1, 2, 3 and 4

gate2013 compiler-design parsing normal

Answer

2.16.33 Parsing: GATE2013_9 top http://gateoverflow.in/1418

What is the maximum number of reduce moves that can be taken by a bottom-up parser for a grammar with no epsilon and unit-production (i.e., of type $A \to \epsilon$ and $A \to a$) to parse a string with n tokens?

(A) $n/2$

(B) $n-1$

(C) $2n-1$

(D) 2^n

gate2013 compiler-design parsing normal

Answer

2.16.34 Parsing: GATE2014-1-34 top http://gateoverflow.in/1807

A canonical set of items is given below

$S \to L. > R$

$Q \rightarrow R.$

On input symbol $<$ the set has

A. a shift-reduce conflict and a reduce-reduce conflict.
B. a shift-reduce conflict but not a reduce-reduce conflict.
C. a reduce-reduce conflict but not a shift-reduce conflict.
D. neither a shift-reduce nor a reduce-reduce conflict.

gate2014-1 compiler-design parsing normal

Answer

2.16.35 Parsing: GATE2015-3_16 top http://gateoverflow.in/8413

Among simple LR (SLR), canonical LR, and look-ahead LR (LALR), which of the following pairs identify the method that is very easy to implement and the method that is the most powerful, in that order?

A. SLR, LALR
B. Canonical LR, LALR
C. SLR, canonical LR
D. LALR, canonical LR

gate2015-3 compiler-design parsing normal

Answer

2.16.36 Parsing: GATE2015-3_31 top http://gateoverflow.in/8488

Consider the following grammar G

$S \rightarrow F \mid H$

$F \rightarrow p \mid c$

$H \rightarrow d \mid c$

Where S, F, and H are non-terminal symbols, p, d, and c are terminal symbols. Which of the following statement(s) is/are correct?

S1: LL(1) can parse all strings that are generated using grammar G

S2: LR(1) can parse all strings that are generated using grammar G

A. Only S1
B. Only S2
C. Both S1 and S2
D. Neither S1 and S2

gate2015-3 compiler-design parsing normal

Answer

2.16.37 Parsing: GATE2017-1-17 top http://gateoverflow.in/118297

Consider the following grammar:

$P \rightarrow xQRS$

$Q \rightarrow yz|z$

$R \rightarrow w|\varepsilon$

$S \rightarrow y$

What is FOLLOW(Q)?

(A) $\{R\}$ (B) $\{w\}$ (C) $\{w, y\}$ (D) $\{w, \$\}$

gate2017-1 compiler-design parsing

Answer

2.16.38 Parsing: GATE2017-1-43 top http://gateoverflow.in/118326

Consider the following grammar:

- stmt -> **if** expr **then** expr **else** expr; stmt | 0
- expr -> term **relop** term | term
- term -> id | number
- id ->**a** | **b** | **c**
- number -> [0-9]

where **relop** is a relational operator (e.g.. < . > ...). 0 refers to the empty statement, and **if**, **then**, **else** are terminals. Consider a program P following the above grammar containing ten **if** terminals. The number of control flow paths in P is_________ . For example. the program
if e_1 **then** e_2 **else** e_3
has 2 control flow paths. e_1 -> e_2 and e_1 -> e_3.

gate2017-1 compiler-design parsing normal numerical-answers

Answer

2.16.39 Parsing: GATE2017-2-6 top http://gateoverflow.in/118343

Which of the following statements about parser is/are CORRECT?

I. Canonical LR is more powerful than SLR
II. SLR is more powerful than LALR
III. SLR is more powerful than Canonical LR

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

gate2017-2 compiler-design parsing

Answer

2.16.40 Parsing: TIFR2012-B-17 top http://gateoverflow.in/25215

Which of the following correctly describes $LR(k)$ parsing?

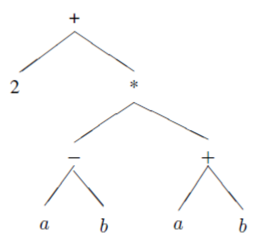
a. The input string is alternately scanned left to right and right to left with k reversals.
b. Input string is scanned once left to right with rightmost derivation and k symbol look-ahead.
c. $LR(k)$ grammers are expressively as powerful as context-free grammers.
d. Parser makes k left-to-right passes over input string.
e. Input string is scanned from left to right once with k symbol to the right as look-ahead to give left-most derivation.

tifr2012 compiler-design parsing

Answer

2.16.41 Parsing: TIFR2012-B-8 top http://gateoverflow.in/25108

Consider the parse tree



Assume that $*$ has higher precedence than $+$, $-$ and operators associate right to left (i.e $(a+b+c=(a+(b+c)))$. Consider

(i) $2+a-b$

(ii) $2+a-b*a+b$

(iii) $2+((a-b)*(a+b))$

(iv) $2+(a-b)*(a+b)$

The parse tree corresponds to

a. Expression (i)
b. Expression (ii)
c. Expression (iv) only
d. Expression (ii), (iii), and (iv)
e. Expression (iii) and (iv) only

tifr2012 compiler-design parsing

Answer

2.16.42 Parsing: TIFR2015-B-15 top http://gateoverflow.in/30079

Consider the following grammar (the start symbol is E) for generating expressions.

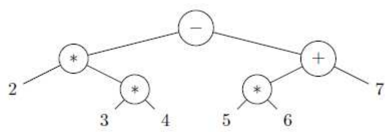
$$E \rightarrow T - E | T + E | T$$

$$T \rightarrow T * F | F$$

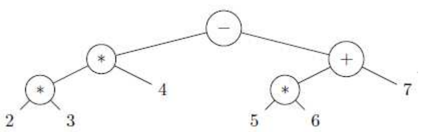
$$F \rightarrow 0|1|2|3|4|5|6|7|8|9$$

With respect to this grammar, which of the following trees is the valid evaluation tree for the expression $2*3*4-5*6+7$?

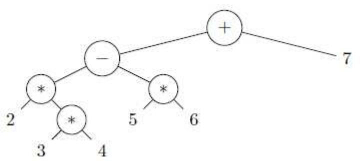
(a)



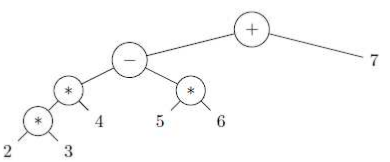
(b)



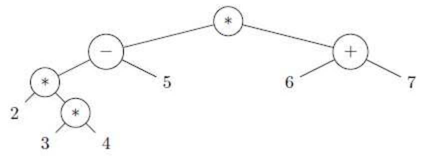
(c)



(d)



(e)



tifr2015 parsing

Answer

Answers: Parsing

2.16.1 Parsing: GATE 2016-1-45 top

http://gateoverflow.in/39697

Selected Answer

2 - 5 + 1 - 7 * 3 will be evaluated according to the precedence and associativity as given in the question as follows:
((2 - ((5 + 1) - 7)) * 3) => ((2 - (-1))*3) => 9

33 votes -- Monanshi Jain (8.5k points)

2.16.2 Parsing: GATE1987-1-xiv top

http://gateoverflow.in/80295

operator precedence is a bottom up parser based on shift reduce parsers...

3 votes -- kirti singh (3.4k points)

2.16.3 Parsing: GATE1989-1-iii top

http://gateoverflow.in/87046

Merging states with a common core may produce **Reduce - Reduce** conflicts and does not produce **Shift- Reduce** conflicts in an LALR purser.

2 votes -- Prashant Singh (49.2k points)

2.16.4 Parsing: GATE1992_02,xiii top

http://gateoverflow.in/570

Selected Answer

Ans - a,b, LFollow may be different but RFollow and Follow will be same

Consider a Grammar -

S -> AB

A -> a

B -> b

Now only string derivable is { ab }.

Let's find Follow(A) in all cases :

i) Follow(A) - set of terminals that can appear immediately to the right of non-terminal A in some "sentential " form

S -> AB -> Ab -> ab

Here, we notice only 'b' can appear to the right of A.

Follow(A) = { b }

---

ii) LFollow(A) - set of terminals that can appear immediately to the right of non-terminal A in some 'left sentential" form

S -> AB -> aB -> ab

Here, we notice no terminal can appear to the right of A.

LFollow(A) = {}

---

iii) RFollow(A) - set of terminals that can appear immediately to the right of non-terminal A in some "right most sentential" form

S -> AB -> Ab -> ab

Here, we notice only 'b' can appear to the right of A.

RFollow(A) = { b }

14 votes -- Himanshu Agarwal (16.2k points)

2.16.5 Parsing: GATE1992_02,xiv top

http://gateoverflow.in/571

Selected Answer

Goto part & shift entry must be same.
Reduce entry & error entry may b different due to conflicts.

11 votes -- Digvijay (47k points)

2.16.6 Parsing: GATE1998-1.26 top

http://gateoverflow.in/1663

Selected Answer

1. SLR paper is more powerful than LALR . **False .**
2. LALR parser is more powerful than Canonical LR parser . **False .**
3. Canonical LR parser is more powerful than LALR parser. **True.**
4. The parsers SLR, Canonical CR, and LALR have the same power. **Flase.**

answer - C

9 votes -- ankitrokdeonsns (9.1k points)

2.16.7 Parsing: GATE1998_1.27 top

http://gateoverflow.in/1664

Selected Answer

The answer is C .

The use of syntax analyser is used to create parse Tree. But along with Grammar as input to Syntax Analyser we add even semantic rules which form the basis of Syntax Directed Translation That help us in Evaluation of Expression .Remember that

Syntax Directed Translation is used in following cases

1. Conversion of infix to Postfix

2.Calculation of infix expression

3.For creating a Acyclic graph

4.Type Checking

5.Conversion of Binary number to Decimal

6.Counting the numbers of bits (0 or 1) in a binary number

7.Creation of syntax tree

8. To generate Intermediate code

9. Storing the data into Symbol table

16 votes -- spriti1991 (2.1k points)

2.16.8 Parsing: GATE1998_22 top http://gateoverflow.in/1737

Program→ begin d semi X end --------------A

X→d semi X -------B

X→ sY--------------C

Y→ semi sY------------D

Y→ ϵ ---------------E

Variable	First	Follow
Program	begin	$
X	d,s	end
Y	semi,ϵ	end

Here First(Y) containsϵ so we need to add Y→ ϵ at follow(Y)

Variable	begin	d	semi	s	end	$
Program	A					
X		B		C		
Y			D		Y→ ϵ	

6 votes -- papesh (24.1k points)

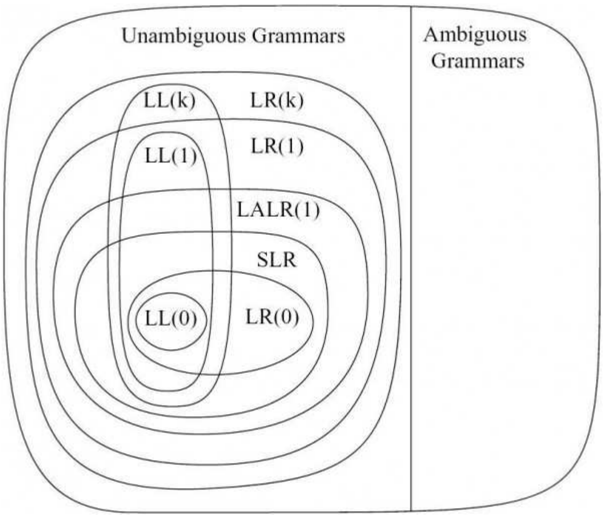
2.16.9 Parsing: GATE1999_1.17 top http://gateoverflow.in/1470

Selected Answer

Canonical LR is most powerful method

LR>LALR>SLR

so ans is b



4 votes -- Pooja Palod (32.4k points)

2.16.10 Parsing: GATE2000-1.19, UGCNET-Dec2013-II-30 top http://gateoverflow.in/642

Selected Answer

ans a)

6 votes -- Aditi Dan (5.3k points)

2.16.11 Parsing: GATE2001-16 top http://gateoverflow.in/757

Selected Answer

First (E) = { a,(}

First (A) = { +,*,∊ }

Follow (E) = Follow (A) = { $,) }

LL(1) Parsing Table :

	a	(	)	+	*	$
E	E-> aA	E-> (E)				
A			A->∈	A->+E	A->*E	A->∈

11 votes -- Aditya Gaurav (2.8k points)

2.16.12 Parsing: GATE2002-22 top http://gateoverflow.in/875

Selected Answer

a. two parse tree for i+j*k.
b. + and * having same precedence..
c. to make grammer LALR compatible give priority to + over * or vice versa.
following grammar is LALR(1)

```
E -----> E + T
          | T
T ------> T * F
         | F
```

F ------> id

11 votes -- Digvijay (47k points)

2.16.13 Parsing: GATE2003-16 top http://gateoverflow.in/906

Selected Answer

LL(1) parser is top down parser.

For top down parsers, the grammar should be unambiguous, deterministic and should not be left recursive.

All the 3 conditions must be satisfied for LL(1) parsers.

Now, even if all 3 conditions are satisfied we cannot get an LL(1) or even LL(k) (for any k) grammar for even a DCFG. This is because there are DCFLs which does not have an LL(k) grammar (see ref below). On the other hand for any DCFL, we can always have an LR(1) grammar.

http://mathoverflow.net/questions/31733/can-i-have-an-ll-grammar-for-every-deterministic-context-free-language

So, option D is correct.

20 votes -- Monanshi Jain (8.5k points)

2.16.14 Parsing: GATE2003-17 top http://gateoverflow.in/907

Selected Answer

no of states in slr and lalr are equal

and no of states in slr and lalr are less than or equal to lr(1)

9 votes -- Pooja Palod (32.4k points)

2.16.15 Parsing: GATE2003-57 top http://gateoverflow.in/945

Selected Answer

ans is a

First(S)=First(C)={c,d}

there are no multiple in single row of parsing table hence grammar is LL1

note : if we have A->B/C for grammar to be LL(1) first(B)intersection First(C) should be null otherwise grammar is not LL1.If First(B) contains epislon then Follow(A) intersection First(C) should be null.Using this we can say grammar is LL(1) or not without constructing parsing table.

An ϵ free LL(1) grammar is also SLR(1) and hence LALR(1) and LR(1) too.

13 votes -- Pooja Palod (32.4k points)

2.16.16 Parsing: GATE2005-14 top http://gateoverflow.in/1350

Selected Answer

both A and B can be answers but A is a better answer. Because we have standard procedure for removing left-recursion but ambiguity is not easy to remove. - checking if a given CFG is ambiguous is a undecidable problem.

16 votes -- Vikrant Singh (13.4k points)

2.16.17 Parsing: GATE2005-60 top http://gateoverflow.in/1383

Selected Answer

ans b)

Both in SLR(1) and LALR(1), states are the LR(0) items while in LR(1) the states are LR(1) set of items. Number of LR(0) items can never be greater than number of LR(1) items. So, $n_1 = n_3 \leq n_2$, B choice. If we construct the states for the grammar we can replace $\leq$ with $<$.

12 votes -- Aditi Dan (5.3k points)

2.16.18 Parsing: GATE2005-83a top

http://gateoverflow.in/1405

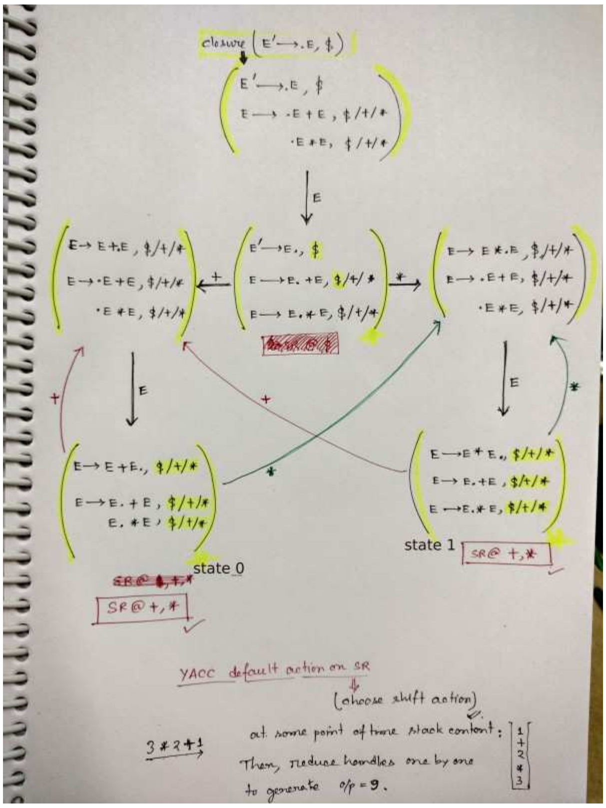
Selected Answer

Given grammar :

$$E \to \text{num}$$
$$E \to E + E \quad | \quad E * E$$

First $LR(1)$ item

$$E' \to \bullet E \text{ ,\$}$$



- num does not create any conflict.
- Additionally here no states differ by lookahead symbols only.
- $\Rightarrow \text{LALR}(1)$ and $\text{LR}(1)$ tables are same.
- $LR(1)$ table only for state0 and state1:

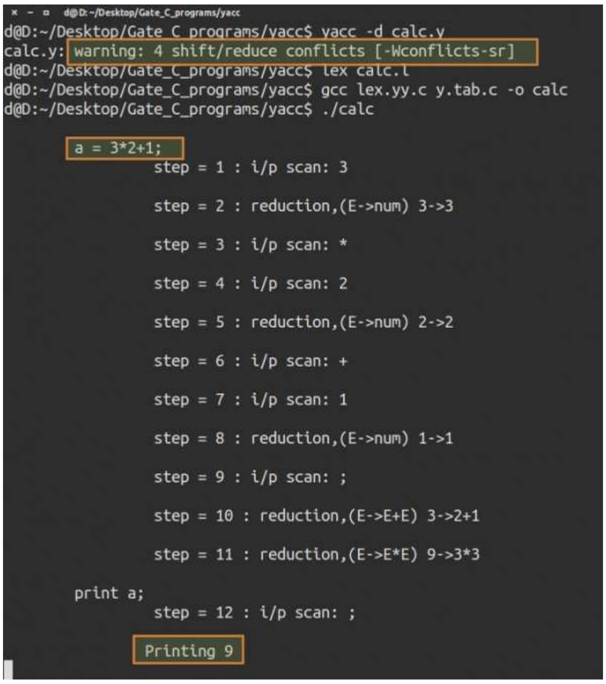
	+	*	$
0	SR	SR	R
1	SR	SR	R

So total $2 + 2 = 4$ SR conflict originated in two states of the DFA.

- **Shift-reduce conflict:** *Yacc's* default action in the case of a shift-reduce conflict is to choose the shift action.
- **Reduce-reduce conflict :** *Yacc's* default action in the case of a reduce-reduce conflict is to reduce using the production that comes first, textually, in the input grammar specification.

---

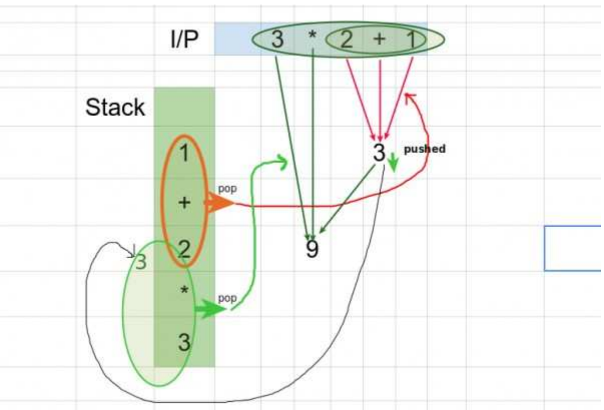
and LEX-YACC-gcc output after implmenting the given grammar :



As we can see from the output reduction on
$E \to \text{num}$ is carried out as soon as top of stack contains a num. So, no conflict related to $E \to num$.

one example : Because of YACC shift preference, even if $3 * 2$ $(E * E)$ handle found on top of the stack at some point of time, it will shift on reading $+$ instead of reducing with $E \to E * E$. In this way, the complete input will be pushed into the stack. After that only reduce work starts as shown below.

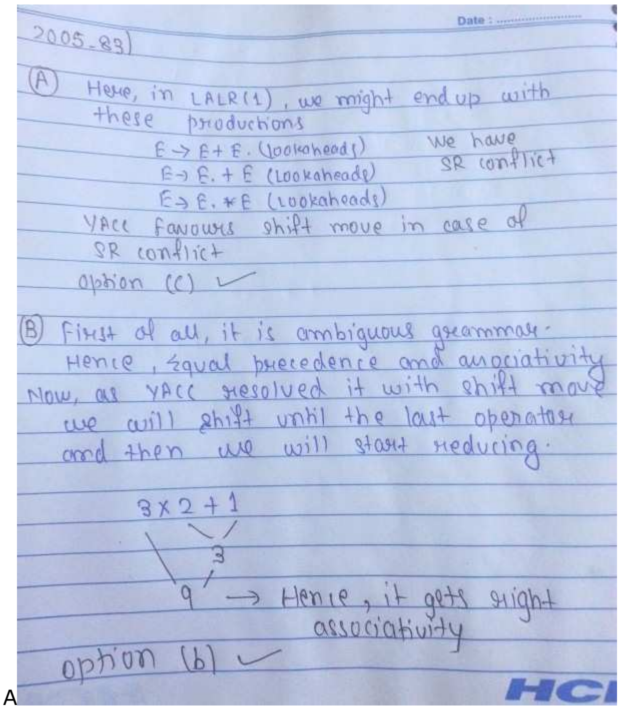
- **Equal precedence** because of the given grammar $E \to E + E \mid E * E$, (single level)
- and **Right associativity** :



[How YACC handles conflicts]

👍 27 votes -- Debashish Deka (51.4k points)

Adding Nandan Jha answer....


2005-83)

(A) Here, in LALR(1), we might end up with these productions

E → E+E. (lookaheads) We have SR conflict

E → E.+E (lookaheads)

E → E.*E (lookaheads)

YACC favours shift move in case of SR conflict

option (C) ✓

(B) First of all, it is ambiguous grammar. Hence, equal precedence and associativity. Now, as YACC resolved it with shift move we will shift until the last operator and then we will start reducing.

3×2+1

3

9 → Hence, it gets right associativity

option (b) ✓

A

👍 22 votes -- Kathleen Bankson (64.6k points)

2.16.19 Parsing: GATE2005-83b top http://gateoverflow.in/87037

Selected Answer

LALR Parser is type of **Bottom up Parser** which uses **Right most Derivation**

For 3×2+1

E->E * E (Both shift and reduce possible but yacc prefers shift)

->E * E + E

->E * E + 1

->E * 2 + 1

->E * 3

->3 * 3

->9

All the productions are in same level therefore all have same precedence

Therefore Ans is **B.Equal precedence and right associativity; expression is evaluated to 9**

👍 8 votes -- Prajwal Bhat (11.9k points)

2.16.20 Parsing: GATE2005-IT-83a top http://gateoverflow.in/3849

Selected Answer

Answer is A.

13 votes -- Gate Keeda (19.1k points)

2.16.21 Parsing: GATE2005-IT-83b top

http://gateoverflow.in/3850

Selected Answer

5 parse trees are possible.

8 votes -- ujjwal saini (287 points)

2.16.22 Parsing: GATE2006-58 top

http://gateoverflow.in/1836

Selected Answer

First S = { id }
Follow R = { \$ }

so M[S,id] = S -> FR
M[S,\$] = R -> ϵ

So ans is A

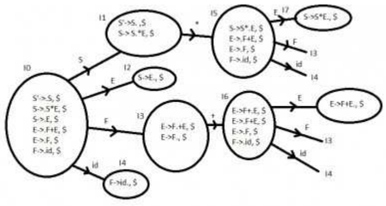
10 votes -- Pooja Palod (32.4k points)

2.16.23 Parsing: GATE2006-7 top

http://gateoverflow.in/886

Selected Answer

ans is D.



11 votes -- jayendra (8.1k points)

2.16.24 Parsing: GATE2007-18 top

http://gateoverflow.in/1216

Selected Answer

1. Recursive descent parser-TOP DOWN PARSER
2. Operator precedence parser-BOTTOM UP PARSER
3. An LR(k) parser.-BOTTOM UP PARSER
4. An LALR(k) parser-BOTTOM UP PARSER

3 votes -- vnc (6.3k points)

2.16.25 Parsing: GATE2008-11 top

http://gateoverflow.in/409

Selected Answer

A *sentential form* is the start symbol S of a grammar or any string in (V ∪ T)* that can be derived from S.

Consider the linear grammar

({S, B}, {a, b}, S, {S ⟶ aS, S⟶B, B⟶bB, B⟶ λ}).

A derivation using this grammar might look like this:

S ⟹ aS ⟹ aB ⟹ abB ⟹ abbB ⟹ abb

Each of {S, aS, aB, abB, abbB, abb} is a sentential form.

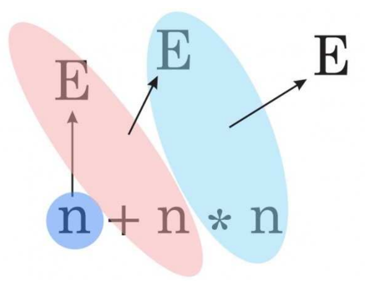
Because this grammar is linear, each sentential form has at most one variable. Hence there is never any choice about which variable to expand next.

Here, in *option D* the sentential forms are same but generated differently coz we are using here Bottom Up production.

Handle:
for example the grammar is:

$$\begin{aligned} E &\rightarrow E + n \\ E &\rightarrow E * n \\ E &\rightarrow n \end{aligned}$$

then say to derive string $n + n * n$:



these are three different handles shown in 3 different colors = $\{n, E + n, E * n\}$

that's what **option D** says

19 votes -- Amar Vashishth (28.7k points)

2.16.26 Parsing: GATE2008-55 top

http://gateoverflow.in/478

Selected Answer

Both LALR(1) and LR(1) parser uses LR(1) set of items to form their parsing tables. And LALR(1) states can be find by merging LR(1) states of LR(1) parser that have the same set of first components of their items.

i.e. if LR(1) parser has 2 states I and J with items A->a.bP,x and A->a.bP,y respectively, where x and y are look ahead symbols, then as these items are same with respect to their first component, they can be merged together and form one single state, let's say K. Here we have to take union of look ahead symbols. After merging, State K will have one single item as A->a.bP,x,y . This way LALR(1) states are formed (i.e. after merging the states of LR(1)).

Now, S-R conflict in LR(1) items can be there whenever a state has items of the form :

```
A-> a.bB , p
C-> d. , b

i.e. it is getting both shift and reduce at symbol b,
hence a conflict.
```

Now, as LALR(1) have items similar to LR(1) in terms of their first component, shift-reduce form will only take place if it is already there in LR(1) states. If there is no S-R conflict in LR(1) state it will never be reflected in the LALR(1) state obtained by combining LR(1) states.

3 votes -- Madhab Paul Choudhury (5.1k points)

Answer is B.

11 votes -- Gate Keeda (19.1k points)

2.16.27 Parsing: GATE2008-IT-79 top

http://gateoverflow.in/3393

Selected Answer

S→ aS 1

S→ aA 2

S→ aaAb 3

S→ aabAab 4

S→ aabbAaab 5

S→ aabbaab 6

Thus 6 steps are needed and only one way to derive the string so only one parse tree.

23 votes -- Shreyans Dhankhar (2.6k points)

2.16.28 Parsing: GATE2009-42 top

http://gateoverflow.in/1328

Selected Answer

Answer is B.

A: Yes there does exist parsing algos less than $\Theta(n^3)$.

B: It cannot be implemented with static storage allocation. It needs dynamic memory allocation.

C: If the L-attributed definitions contain synthesized attributes then it can be evaluated.

D: True.

13 votes -- Gate Keeda (19.1k points)

2.16.29 Parsing: GATE2011_27 top

http://gateoverflow.in/2129

Selected Answer

Answer is **B.**

To make the parse tree start compiling the identifiers into blocks based on associativity and precedence.
Grouping: $(7 \downarrow (3 \uparrow (4 \uparrow 3))) \downarrow 2$
Tree can be made by opening inner braces and move towards outer braces.

17 votes -- Sona Praneeth Akula (4k points)

2.16.30 Parsing: GATE2012-52 top

http://gateoverflow.in/2181

Selected Answer

$\text{First}(S) = \text{First}(A) = \text{First}(B) = \{a, b, \epsilon\}$

$\text{Follow}(A) = \{a, b\}$

$\text{Follow}(B) = \text{Follow}(S) = \{a, b, \$\}$

So, the answer to question 52 is option A.

7 votes -- Pooja Palod (32.4k points)

2.16.31 Parsing: GATE2012-53 top http://gateoverflow.in/43312

Selected Answer

Make your own parse table. Firstly calculate First and Follow from the given grammar.

First(S)={a,b,epsilon}

First(A)={a,b,epsilon}

First(B)={a,b,epsilon}

Follow(S)= {a,b,$}

Follow(A)= {a,b}

Follow(B)= {a,b,$}

Now make LL(1) parse table

Non Terminal	a	b	$
S	S-> aAbB S-> ϵ	S-> bAbB S-> ϵ	S-> ϵ
A	A->S	A->S	
B	B->S	B-> S	B->S

Here is the explanation of entries asked in question

1) For E1 and E2 Look into First(S)={a,b,ϵ}.

a is because of S-> aAbB and b is because of B-> bAaB

So M[S,a] and M[S,b] will contain S-> aAbB and B-> bAaB respectively. For epsilon Look into Follow(S)= {a,b,$}. So S-> ϵ will be in M[S,a], M[S,b] and M[S,$]

2) Now for E2 look into First(B)= {a,b,$}. a and b are because of B->S.

So M[B,a] and M[B.b] will contain B->S and for epsilon look into Follow(B)= {a,b$}. Hence M[B,$] will contain B->S

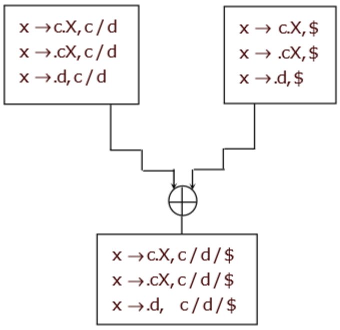
Now we got the answer **E1 is S**
$\to$ **aAbB, S**
$\to$ **epsilon, E2 is S**
$\to$ **bAaB, S**
$\to$**epslion and E3 is B**
$\to$**S**.

Hence **Option (C)** is correct.

7 votes -- Ashwani Kumar (3.3k points)

2.16.32 Parsing: GATE2013_40 top http://gateoverflow.in/1551

Selected Answer



The TRUE statements are about merging of two states for LALR(1) parser from RR(1) parser.i.e.

1. These can be merged because kernel of these are same, look ahead don't matter in merging
2. Two states are not containing reduces item , so after merging , the merged states can not be contain any S-R conflict.
3. There is no reduction possible so no R-R conflict
4. Merging of states does not depend on further GOTO part on any terminal.

Therefore , ALL given statement in question are FALSE , so option (d) is correct.

17 votes -- Viral Kapoor (2k points)

2.16.33 Parsing: GATE2013_9 top

http://gateoverflow.in/1418

Selected Answer

Ans will be B

A->BC

B->aa

C->bb

now suppose string is aabb

then

A->BC(reduction 3)

->aaC(reduction 2)

->aabb (reduction 1)

n = 4

and number of reductions are 3 so n-1

15 votes -- rahulkr (665 points)

2.16.34 Parsing: GATE2014-1-34 top

http://gateoverflow.in/1807

Selected Answer

Ans : The given input symbol no where in the given grammar so with given symbol we have neither a shift-reduce nor a reduce-reduce conflict. So, correct answer is (D.) ...

18 votes -- Jay (1.2k points)

2.16.35 Parsing: GATE2015-3_16 top

http://gateoverflow.in/8413

Selected Answer

Answer is C.

SLR is the simplest to implement and Canonical LR is the most powerful.

http://en.wikipedia.org/wiki/LALR_parser_generator

23 votes -- Arjun Suresh (294k points)

2.16.36 Parsing: GATE2015-3_31 top http://gateoverflow.in/8488

Selected Answer

A parser works on the basis of given grammar. It takes the grammar as it is. Parser does not work on the basis of the yield of the grammar. Also, while constructing the LL(1) parser table, that entry for terminal 'c' will contain multiple entries. SO LL(1) parser cannot be constructed for the given grammar.

$S \rightarrow F \mid H$

$F \rightarrow p \mid c$

$H \rightarrow d \mid c$

That {p, d, c} are the strings generated by the grammar is absolutely correct. But LL(1) and LR(1) can parse these strings successfully only if the grammar is unambiguous and like given below...

$S \rightarrow P \mid D \mid C$

$P \rightarrow p$

$D \rightarrow d$

$C \rightarrow c$

Please note the difference between these two grammars. Both derive the same strings, but in different manner. With the grammar given in the question, both top-down and bottom-up parsers will get confused while deriving "c". Top-down parser will get confused between $F \rightarrow c$ and $H \rightarrow c$. Similarly, bottom-up parser will get confused while reducing "c". This confusion in case of bottom-up parsing is technically termed as "reduce-reduce" conflict.

While top-down parsing, first(F) and first(H) are not disjoint, so the grammar cannot be LL(1). Therefore, LL(1) parser cannot parse it.

Hence, the answer should be option (D). Neither S1 nor S2.

27 votes -- ashishacm (313 points)

2.16.37 Parsing: GATE2017-1-17 top http://gateoverflow.in/118297

Selected Answer

Follow of Q is first of R so we get {w}

but since R can be Null so we have to check first of S which is {y}

so FOLLOW Q={w,y}

Correct option (C)

5 votes -- sriv_shubham (2.7k points)

2.16.38 Parsing: GATE2017-1-43 top http://gateoverflow.in/118326

Selected Answer

This question is picked from area of **Counting in Combinatorics**.

Given:
if e1 then e2 else e3 has 2 control flow paths e1->e2 and e1->e3.
(Meaning of **"how many control flow"** for if structure is clearly mentioned)

What is asked:
Number of control flow paths for 10 if terminals?

Solution:
To get 10 if's we need to use grammar to get,
    if <expr> then <expr> else <expr> ; stmt
    if <expr> then <expr> else <expr> ; if <expr> then <expr> else <expr> ; stmt
    ....
    ....
    ....
    (keep doing it 10 times to get 10 if's)
Observe that there is a **semi-colon after every if structure**.

We know that every if structure has 2 control flows as given in question. Hence,
    We have 2 control flow choices for 1st if terminal.
    We have 2 control flow choices for 2nd if terminal.
    ....
    ....
    ....
    We have 2 control flow choices for 10th if terminal.

By using multiplicative law of counting we get,
    Total choices as 2*2*2*2*2......10 times = 2^10 = 1024

Once again, **one need not know "what control flow"** is, but needs to know **"how many control flows" are in if structure** which is given in question.

8 votes -- prs11 (195 points)

---

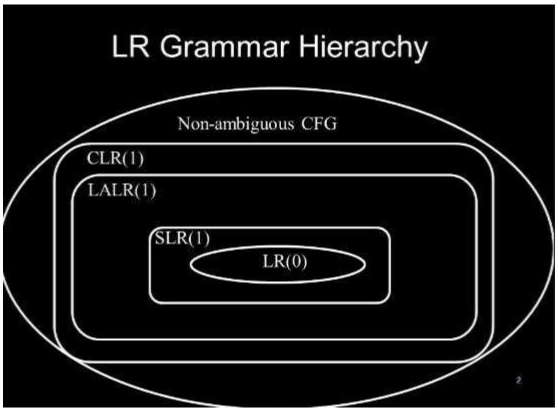
each if-else condition leads to two different paths, there are 10 if-else conditions one after the other, therefore totally 2^{10} = 1024 paths possible

11 votes -- Vinay Rachapalli (1.1k points)

2.16.39 Parsing: GATE2017-2-6 top

http://gateoverflow.in/118343

Selected Answer



so only 1st one is correct ans

8 votes -- 2018 (5.2k points)

2.16.40 Parsing: TIFR2012-B-17 top

http://gateoverflow.in/25215

Selected Answer

A) Does not make any sense. false.

B) This is definition of LR(K) Parser. True

C) False. LR(K) is subset of CFL.

D) False.

E) LR(K) , bottom up parser . We have Right most derivation. This is False.

Answer :- B

9 votes -- Akash (43.8k points)

2.16.41 Parsing: TIFR2012-B-8 top

http://gateoverflow.in/25108

Selected Answer

e is correct

Because as the expression evaluated right to left , so in (ii) 2+(a-(b*(a+b))) this evaluation performed, which is not a correct evaluation as the parse tree

5 votes -- srestha (58.4k points)

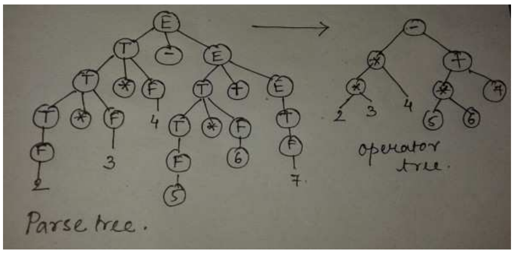
2.16.42 Parsing: TIFR2015-B-15 top

http://gateoverflow.in/30079

Selected Answer

Answer is option B.

The corresponding parse tree is drawn for the given expression according to the given grammar .



9 votes -- Riya Roy(Arayana) (7.1k points)

2.17 Programming In C(1) top

2.17.1 Programming In C: GATE2005-61 top

http://gateoverflow.in/4066

Consider line number 3 of the following C-program.

```
int main() {          /*Line 1 */
int I, N;                 /*Line 2 */
fro (I=0, I<N, I++); /*Line 3 */
}
```

Identify the compiler’s response about this line while creating the object-module:

A. No compilation error

B. Only a lexical error

C. Only syntactic errors

D. Both lexical and syntactic errors

gate2005 compiler-design programming-in-c normal

Answer

Answers: Programming In C

2.17.1 Programming In C: GATE2005-61 top

http://gateoverflow.in/4066

Selected Answer

C language allows only certain words in it- these are called tokens. If we input any invalid tokens it causes lexical error.

eg:
44a44
causes lexical error as in C as an alphabet cannot come in between digits.

Syntactic error is caused by bad combination of tokens. For example, we cannot have a constant on the left hand side of an assignment statement, a for loop must have two expressions inside () separated by semi colon etc.

In the given question, line 3 won't cause a lexical error or syntactic error. The statement will be treated as a function call with three arguments. Function definition being absent will cause link time error, but the question asks only for compile-time errors. So, (a) must be the answer.

PS: Implicit function declaration was removed from C99 standard onwards. As per current standard, we should not use a function without declaration. Still, we cannot guarantee "compilation error"- just expect compiler warnings in C. In C++ this should produce a compilation (semantic) error. The output of compiling the above code using different standards are given below:

```
arjun@linux:~$ gcc -c chk.c
chk.c: In function ‘main’:
chk.c:3:2: warning: implicit declaration of function ‘fro’ [-Wimplicit-function-declaration]
  fro (I=0, I<N, I++); /*Line 3 */
  ^
arjun@linux:~$ gcc -c -ansi chk.c
arjun@linux:~$ gcc -c -std=c99 chk.c
chk.c: In function ‘main’:
chk.c:3:2: warning: implicit declaration of function ‘fro’ [-Wimplicit-function-declaration]
  fro (I=0, I<N, I++); /*Line 3 */
  ^
arjun@linux:~$ gcc -c -std=c11 chk.c
chk.c: In function ‘main’:
chk.c:3:2: warning: implicit declaration of function ‘fro’ [-Wimplicit-function-declaration]
  fro (I=0, I<N, I++); /*Line 3 */
```

http://stackoverflow.com/questions/15570553/lexical-and-semantic-errors-in-c

31 votes -- Arjun Suresh (294k points)

2.18 Recursion(1) top

2.18.1 Recursion: GATE2014-3-18 top

http://gateoverflow.in/2052

Which of the following statements are CORRECT?

1. Static allocation of all data areas by a compiler makes it impossible to implement recursion.
2. Automatic garbage collection is essential to implement recursion.
3. Dynamic allocation of activation records is essential to implement recursion.
4. Both heap and stack are essential to implement recursion.

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

gate2014-3 compiler-design recursion normal

Answer

Answers: Recursion

2.18.1 Recursion: GATE2014-3-18 top http://gateoverflow.in/2052

Selected Answer

It will be D.

option 2 is wrong because it is not necessary to have automatic garbage collection to implement recursion.

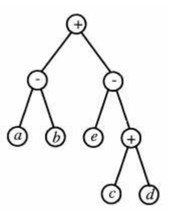
option 4 is wrong because it says that both are required to implement recursion, which is wrong. Either of them will suffice.

14 votes -- Gate Keeda (19.1k points)

2.19 Register Allocation(2) top

2.19.1 Register Allocation: GATE2011_36 top http://gateoverflow.in/2138

Consider evaluating the following expression tree on a machine with load-store architecture in which memory can be accessed only through load and store instructions. The variables $a, b, c, d,$ and e are initially stored in memory. The binary operators used in this expression tree can be evaluated by the machine only when operands are in registers. The instructions produce result only in a register. If no intermediate results can be stored in memory, what is the minimum number of registers needed to evaluate this expression?



(A) 2

(B) 9

(C) 5

(D) 3

gate2011 compiler-design register-allocation normal

Answer

2.19.2 Register Allocation: GATE2017-1-52 top http://gateoverflow.in/118746

Consider the expression $(a-1) * (((b+c)/3) + d))$. Let X be the minimum number of registers required by an *optimal* code generation (without any register spill) algorithm for a load/store architecture, in which *(i) only load and store instructions can have memory operands* and *(ii) arithmetic instructions can have only register or immediate operands.* The value of X is _____________ .

gate2017-1 compiler-design register-allocation normal numerical-answers

Answer

Answers: Register Allocation

2.19.1 Register Allocation: GATE2011_36 top http://gateoverflow.in/2138

Selected Answer

Given is Load Store Architecture, that means we can access memory using Load and Store Instructions.

Key Idea:- Pick new register only when it is required.

We want to add **c** and **d**, and initially both are in memory, therefore copy these into registers.

- load R1, c (R1 ⟵ c)
- load R2, d (R2 ⟵ d)

(here no compensation can be done, we need two registers)

- add R1, R1, R2 (R1 ⟵ R1 + R2)

(at this point R1 is holding **c+d** and R2 is holding **d**, i.e. R1 ⟵ **c + d** and R2 ⟵ **d**)
Now, **e** comes into picture and my question is, Can i make use of R1 or R2 to store **e** ?
I can not use R1 to store **e** as its value will be needed later but I can use R2.

- load R2, e

(currently R1 ⟵ **c + d** and R2 ⟵ **e**)

- Sub R1, R2, R1 (R1 ⟵ R2 - R1)

Doing this all gives, final value of right sub-tree is stored in R1, and R2 stores **e**.
Now, coming to left subtree, to perform "a-b" we need to copy both variables in registers.
We can copy one of the variable in R2, but we can not obviously copy in R1 as value of R1 will be required later.

- Load R2, a
- Load R3, b (**here comes extra register, and we can not avoid using it**.)

Current mapping is R2 ⟵ a, R3 ⟵ b and R1 contains final value of Right subtree.

- SUB R2, R2, R3 (R2 ⟵ R2 - R3)
- ADD R1, R1 , R2

Hence answer is 3 i.e. **D**

11 votes -- Sachin Mittal (7.1k points)

R1<- -c, R2<- -d, R2<- -R1+R2, R1<- -e, R2<- -R1-R2

To calculate the rest of the expression we must load a and b into the registers but we need the content of R2 later. So we must use another register. R1<- -a, R3<- -b, R1<- -R1-R3, R1<- -R1+R2

Ans D

19 votes -- Keith Kr (6.3k points)

2.19.2 Register Allocation: GATE2017-1-52 top

http://gateoverflow.in/118746

Selected Answer

Load R1,b

Load R2,c

ADD R1,R2

Div R1,3

Load R2,d

Add R1,R2

Load R2,a

Sub R2,1

Mul R2,R1

hence minimum 2 registers required

22 votes -- sriv_shubham (2.7k points)

2.20 Runtime Environments(10) top

2.20.1 Runtime Environments: CMI2011-A-08 top http://gateoverflow.in/46195

In programming languages like C, C++, Python . . . the memory used by a program is typically separated into two parts, the stack and the heap. Consider the following statements:

1. A stack is efficient for managing nested function calls.
2. Stack space is limited while heap space is not.
3. The stack cannot be used for persistent data structures.

Then:

A. 1 and 2 are true but 3 is false.
B. 1 and 3 are true but 2 is false.
C. 2 and 3 are true but 1 is false.
D. All three statements are true.

cmi2011 compiler-design runtime-environments

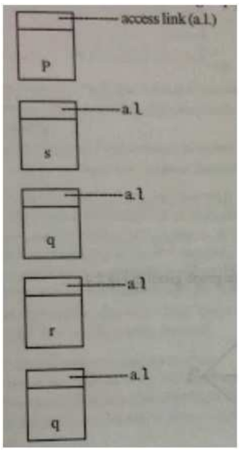
Answer

2.20.2 Runtime Environments: GATE1988-2xii top http://gateoverflow.in/93966

Consider the following program skeleton and below figure which shows activation records of procedures involved in the calling sequence.

$$P \to s \to q \to r \to q.$$

Write the access links of the activation records to enable correct access and variables in the procedures from other procedures involved in the calling sequence.




```
procedure P;
    procedure q;
        procedure r;
            begin
                q
            end r;
    begin
        r
    end q;
    procedure s;
    begin
        q
    end s;
```

```
    begin
        s
    end p;
```

gate1988 normal descriptive runtime-environments compiler-design

Answer

2.20.3 Runtime Environments: GATE1993_7.7 top http://gateoverflow.in/2295

A part of the system software which under all circumstances must reside in the main memory is:

a. text editor
b. assembler
c. linker
d. loader
e. none of the above

gate1993 compiler-design runtime-environments easy

Answer

2.20.4 Runtime Environments: GATE1995_1.14 top http://gateoverflow.in/2601

A linker is given object modules for a set of programs that were compiled separately. What information need to be included in an object module?

A. Object code

B. Relocation bits

C. Names and locations of all external symbols defined in the object module

D. Absolute addresses of internal symbols

gate1995 compiler-design runtime-environments normal

Answer

2.20.5 Runtime Environments: GATE1997_1.8 top http://gateoverflow.in/2224

A language L allows declaration of arrays whose sizes are not known during compilation. It is required to make efficient use of memory. Which one of the following is true?

a. A compiler using static memory allocation can be written for L
b. A compiler cannot be written for L; an interpreter must be used
c. A compiler using dynamic memory allocation can be written for L
d. None of the above

gate1997 compiler-design easy runtime-environments

Answer

2.20.6 Runtime Environments: GATE1998-1.25, ISRO2008-41 top http://gateoverflow.in/1662

In a resident – OS computer, which of the following systems must reside in the main memory under all situations?

A. Assembler
B. Linker
C. Loader
D. Compiler

gate1998 compiler-design runtime-environments normal isro2008

Answer

2.20.7 Runtime Environments: GATE1998-2.15 top http://gateoverflow.in/1687

Faster access to non-local variables is achieved using an array of pointers to activation records called a

A. stack
B. heap
C. display
D. activation tree

gate1998 programming compiler-design normal runtime-environments

Answer

2.20.8 Runtime Environments: GATE1998_1.28 top http://gateoverflow.in/1665

A linker reads four modules whose lengths are $200, 800, 600$ and 500 words, respectively. If they are loaded in that order, what are the relocation constants?

A. $0, 200, 500, 600$
B. $0, 200, 1000, 1600$
C. $200, 500, 600, 800$
D. $200, 700, 1300, 2100$

gate1998 compiler-design runtime-environments normal

Answer

2.20.9 Runtime Environments: GATE2001-1.17 top http://gateoverflow.in/710

The process of assigning load addresses to the various parts of the program and adjusting the code and the data in the program to reflect the assigned addresses is called

A. Assembly
B. parsing
C. Relocation
D. Symbol resolution

gate2001 compiler-design runtime-environments easy

Answer

2.20.10 Runtime Environments: GATE2014-2-18 top http://gateoverflow.in/1975

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

A. Dynamic memory allocation
B. Type checking
C. Symbol table management
D. Inline expansion

gate2014-2 compiler-design easy runtime-environments

Answer

Answers: Runtime Environments

2.20.1 Runtime Environments: CMI2011-A-08 top http://gateoverflow.in/46195

Option B) 1 and 3 are true but 2 is false.

Because **Size of heap and stack both are limited**. There is nothing which is **unlimited**. Yes but **Size of stack and Size of heap is constant**. It means that If there is **total size available is 10**, and If i used **7 block for stack** then i can only use **3 block for heap** but not more than that. i.e **Size of stack and size of heap are inversely proportional. I mean that if size of stack increases then size of heap decreases, and vice versa**.

👍 4 votes -- Muktinath Vishwakarma (34.1k points)

2.20.2 Runtime Environments: GATE1988-2xii top http://gateoverflow.in/93966

Selected Answer

An activation record has the following parts:-
1)A **control link** from record A points to the previous record on the stack. The chain of control links traces the dynamic execution of the program.

2)An **access link** from record A points to the record of the closest enclosing block in the program. The chain of access links traces the static structure (think: scopes) of the program.

Going by the definition of the access link we have the record of the closest enclosing block in the program as mentioned.

The access link for the above ques is as follows:

p->q->r->q->s

👍 1 votes -- Don't defeat anybody but yourself. (6.2k points)

2.20.3 Runtime Environments: GATE1993_7.7 top http://gateoverflow.in/2295

Selected Answer

Answer: D

The loader is a program that loads the object program from the secondary memory into the main memory for execution of the program. The loader resides in main memory.

👍 12 votes -- Rajarshi Sarkar (35k points)

2.20.4 Runtime Environments: GATE1995_1.14 top http://gateoverflow.in/2601

Selected Answer

(c) is the answer. For linker to link external symbols (for example in C, to link an extern variable in one module to a global variable in another module), it must know the location of all external symbols. In C external symbols includes all global variables and function names.

(a) is trivially there is an object module. (b) must be there if we need to have relocation capability.

(d) is no way needed.

👍 22 votes -- Arjun Suresh (294k points)

2.20.5 Runtime Environments: GATE1997_1.8 top http://gateoverflow.in/2224

Selected Answer

C.

Using dynamic memory allocation, memory will be allocated to array at runtime.

👍 13 votes -- Gate Keeda (19.1k points)

2.20.6 Runtime Environments: GATE1998-1.25, ISRO2008-41 top http://gateoverflow.in/1662

Selected Answer

C) is answer ,

In many operating systems the loader is permanently resident in memory, although some operating systems that support virtual memory may allow the loader to be located in a region of memory that is pageable.

reference @http://en.wikipedia.org/wiki/Loader_(computing)

9 votes -- Mithlesh Upadhyay (5.4k points)

2.20.7 Runtime Environments: GATE1998-2.15 top

http://gateoverflow.in/1687

Selected Answer

it is ***C***

properties of displays
1> Use a pointer array to store the activation records along the static chain.
2> Fast access for non-local but may be complicated to maintain.
3> Calling a subprogram in the same level – simply replace and restore.
4> Calling a subprogram in the higher level – add an entry and may need to save the old pointers.
5> Calling a subprogram in the lower level – shrink the pointer and restore it when the subprogram returns.

http://users.dickinson.edu/~wahlst/356/ch10.pdf

12 votes -- sumit kumar singh dixit (2.3k points)

2.20.8 Runtime Environments: GATE1998_1.28 top

http://gateoverflow.in/1665

Selected Answer

answer - B

first module loaded starting at address 0. Size is 200. hence it will occup first 200 address last address being 199. Second module will be present from 200 and so on.

12 votes -- ankitrokdeonsns (9.1k points)

2.20.9 Runtime Environments: GATE2001-1.17 top

http://gateoverflow.in/710

Selected Answer

Relocation is the process of assigning load addresses to position-dependent code of a program and adjusting the code and data in the program to reflect the assigned addresses.

Hence Option C is Ans

Symbol resolution is the process of searching files and libraries to replace symbolic references or names of libraries with actual usable addresses in memory before running a program.

7 votes -- Rajesh Pradhan (18.6k points)

2.20.10 Runtime Environments: GATE2014-2-18 top

http://gateoverflow.in/1975

Selected Answer

Dynamic means- at runtime. Dynamic memory allocation happens during the execution time and hence (A) is the answer.

19 votes -- Arjun Suresh (294k points)

2.21 Static Single Assignment(2) top

2.21.1 Static Single Assignment: GATE 2016-1-19 top http://gateoverflow.in/39675

Consider the following code segment.

```
x = u - t;
y = x * v;
x = y + w;
y = t - z;
y = x * y;
```

The minimum number of *total* variables required to convert the above code segment to *static single assignment* form is __________.

gate2016-1 compiler-design static-single-assignment normal numerical-answers

Answer

2.21.2 Static Single Assignment: GATE2017-1-12 top http://gateoverflow.in/118292

Consider the following intermediate program in three address code

```
p = a - b
q = p * c
p = u * v
q = p + q
```

Which one of the following corresponds to a *static single assignment* form of the above code?

(A)

```
p1 = a - b
q1 = p1 * c
p1 = u * v
q1 = p1 + q1
```

(B)

```
p3 = a - b
q4 = p3 * c
p4 = u * v
q5 = p4 + q4
```

(C)

```
p1 = a - b
q1 = p2 * c
p3 = u * v
q2 = p4 + q3
```

(D)

```
p1 = a - b
q1 = p * c
p2 = u * v
q2 = p + q
```

gate2017-1 compiler-design intermediate-code normal static-single-assignment

Answer

Answers: Static Single Assignment

2.21.1 Static Single Assignment: GATE 2016-1-19 top http://gateoverflow.in/39675

Selected Answer

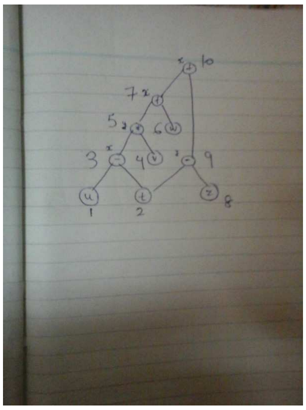
```
x(temp3) = u(temp1) - t(temp2);
y(temp5) = x * v(temp4);
x(temp7) = y + w(temp6);
y(temp9) = t - z(temp8);
y(temp10) = x * y;
```

so ans should be.10

21 votes -- papesh (24.1k points)

Static single assignment means assignment to register can be done one time only.

so, draw the GRAPH and count number of nodes which will give the number of register required.

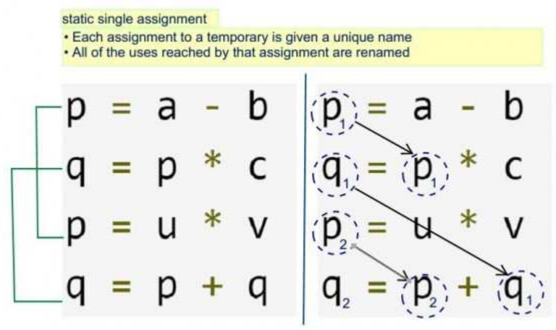


20 votes -- Nishank Garg (107 points)

2.21.2 Static Single Assignment: GATE2017-1-12 top

http://gateoverflow.in/118292

Selected Answer



https://en.wikipedia.org/wiki/Static_single_assignment_form

http://www.cse.iitd.ernet.in/~nvkrishna/courses/winter07/ssa.pdf

https://www.cs.cmu.edu/~fp/courses/15411-f08/lectures/09-ssa.pdf

http://www.seas.harvard.edu/courses/cs252/2011sp/slides/Lec04-SSA.pdf

so B is ans.

5 votes -- 2018 (5.2k points)

2.22 Syntax Directed Translation(6) top

2.22.1 Syntax Directed Translation: GATE 2016-1-46 top http://gateoverflow.in/39700

Consider the following Syntax Directed Translation Scheme $(SDTS)$, with non-terminals $\{S, A\}$ and terminals $\{a, b\}$.

$$S \to aA \quad \{\text{print } 1\}$$

$$S \to a \quad \{\text{print } 2\}$$

$$A \to Sb \quad \{\text{print } 3\}$$

Using the above $SDTS$, the output printed by a bottom-up parser, for the input aab is:

A. $1\ 3\ 2$
B. $2\ 2\ 3$
C. $2\ 3\ 1$
D. syntax error

gate2016-1 compiler-design syntax-directed-translation normal

Answer

2.22.2 Syntax Directed Translation: GATE1995_2.10 top http://gateoverflow.in/2622

A shift reduce parser carries out the actions specified within braces immediately after reducing with the corresponding rule of grammar

- $S \to xxW\{\text{print"1"}\}$
- $S \to y\{\text{print"2"}\}$
- $W \to Sz\{\text{print"3"}\}$

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

2.22.3 Syntax Directed Translation: GATE1996_20 top http://gateoverflow.in/2772

Consider the syntax-directed translation schema (SDTS) shown below:

- $E \to E + E$ {print "+"}
- $E \to E * E$ {print "."}
- $E \to id$ {print id.name}
- $E \to (E)$

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

Answer

2.22.4 Syntax Directed Translation: GATE1998_23 top

http://gateoverflow.in/1738

Let the attribute 'val' give the value of a binary number generated by S in the following grammar:

$S \to L.L \mid L$

$L \to LB \mid B$

$B \to 0 \mid 1$

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

Answer

2.22.5 Syntax Directed Translation: GATE2000-19 top

http://gateoverflow.in/690

Consider the syntax directed translation scheme (SDTS) given in the following. Assume attribute evaluation with bottom-up parsing, i.e., attributes are evaluated immediately after a reduction.

$E \to E_1 * T$ {E.val = E_1.val * T.val}

$E \to T$ {E.val = T.val}

$T \to F - T_1$ {T.val = F.val - T_1.val}

$T \to F$ {T.val = F.val}

$F \to 2$ {F.val = 2}

$F \to 4$ {F.val = 4}

a. Using this SDTS, construct a parse tree for the expression 4 - 2 - 4 * 2 and also compute its E.val.
b. It is required to compute the total number of reductions performed to parse a given input. Using synthesized attributes only, modify the SDTS given, without changing the grammar, to find E.red, the number of reductions performed while reducing an input to E.

gate2000 compiler-design syntax-directed-translation normal descriptive

Answer

2.22.6 Syntax Directed Translation: GATE2003-18 top

http://gateoverflow.in/908

In a bottom-up evaluation of a syntax directed definition, inherited attributes can

A. always be evaluated
B. be evaluated only if the definition is L-attributed
C. be evaluated only if the definition has synthesized attributes
D. never be evaluated

gate2003 compiler-design syntax-directed-translation normal

Answer

Answers: Syntax Directed Translation

2.22.1 Syntax Directed Translation: GATE 2016-1-46 top

http://gateoverflow.in/39700

Selected Answer

aab could be derived as follows by the bottom up parser:

S->aA prints 1
A->a**S**b prints 3
A->a**a**b prints 2
Now since bottom up parser will work in reverse of right most derivation, so it will print in bottom up fashion i.e., 231 which is option C.

Note that this could also be visualized easily by drawing the derivation tree.

26 votes -- Monanshi Jain (8.5k points)

2.22.2 Syntax Directed Translation: GATE1995_2.10 top http://gateoverflow.in/2622

Selected Answer

A.

Making a tree and performing post order traversal will yield answer as A.

S-->x x W (Pf'1')

W-->S z (Pf'3')

S-->x x W (Pf'1')

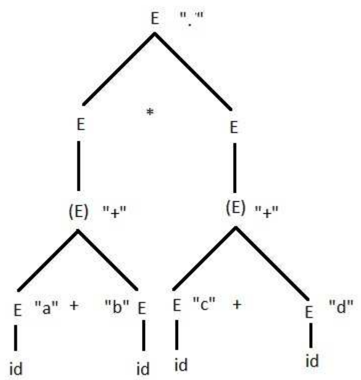
W-->S z (Pf'3')

S-->y (Pf'2').

13 votes -- Gate Keeda (19.1k points)

2.22.3 Syntax Directed Translation: GATE1996_20 top http://gateoverflow.in/2772

ab+cd+.



9 votes -- jayendra (8.1k points)

2.22.4 Syntax Directed Translation: GATE1998_23 top http://gateoverflow.in/1738

Selected Answer

S-- > L.L { $S.dv = L_1.dv + L_2.dv/2^{L_2.nb}$ }

| L { S.dv = L.dv }

L-- > LB { $L.dv = 2 * L_1.dv + B.dv$

L.nb = L_1.nb + B.nb }}

| B { L.dv = B.dv

L.nb = B.nb }

B-- > 0 { B.dv = 0

B.nb = 1 }

| 1 { B.dv = 1

B.nb = 1 }

here dv = decimal value

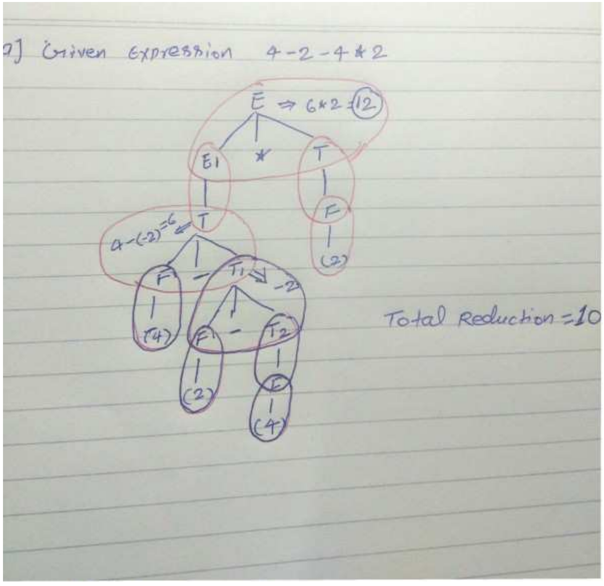
nb = number of bits.

8 votes -- Gate Keeda (19.1k points)

2.22.5 Syntax Directed Translation: GATE2000-19 top

http://gateoverflow.in/690

Selected Answer



a)expression value =12

b) a total number of reductions performed =10

8 votes -- Prateek kumar (6k points)

2.22.6 Syntax Directed Translation: GATE2003-18 top

http://gateoverflow.in/908

Selected Answer

A is false. If the grammar is not L-attributed; we cannot evaluate the inherited attributes in a bottom-up parse. In fact even for some L-attributed grammar, bottom-up parse is not possible for inherited attributes.

http://infolab.stanford.edu/~ullman/dragon/slides2.pdf http://gateoverflow.in/?qa=blob&qa_blobid=14587629398289520039

B is true. Is there any non L-attributed grammar which can be parsed by a bottom-up parser? No, as shown in the above link. In fact only for the L-attributed grammar made from a LL(1) grammar, we can always guarantee a bottom-up parsing. Even for LR(1) grammar, bottom-up parsing is not a guarantee for all inherited attributes.

C is false. Some L-attributed grammars (including those with non-synthesized attributes) can be evaluated by a bottom-up parser.

D is false for above-told reasons.

A nice PDF for the same :- https://acm.sjtu.edu.cn/w/images/a/a1/Compiler2013-lec07.pdf

3 votes -- Arjun Suresh (294k points)

2.23 Target Code Generation(4) top

2.23.1 Target Code Generation: GATE1997_4.9 top http://gateoverflow.in/2250

The expression $(a * b) * c \; op \ldots$

where 'op' is one of '+', '*' and '↑' (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 '↑' or '*'

C. 'op' is '↑' or '+'

D. not possible to evaluate without storing

gate1997 compiler-design target-code-generation register-allocation normal

Answer

2.23.2 Target Code Generation: GATE2003-59 top http://gateoverflow.in/947

Consider the syntax directed definition shown below.

S $\rightarrow$ **id :=** E {*gen*(**id**.place = E.place;);}
E $\rightarrow$ $E_1 + E_2$ {t = *newtemp*();
gen(t = E_1.place + E_2place;);
E.place = *t*;}
E $\rightarrow$ id {E.place = **id**.place;}

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. $t_1 = Y; t_2 = Z; t_3 = t_1 + t_2; X = t_3$

gate2003 compiler-design target-code-generation normal

Answer

2.23.3 Target Code Generation: GATE2004-10 top http://gateoverflow.in/4069

Consider the grammar rule E → E1 − E2 for arithmetic expressions. The code generated is targeted to a CPU having a single user register. The subtraction operation requires the first operand to be in the register. If E1 and E2 do not have any common sub expression, in order to get the shortest possible code

A. E1 should be evaluated first
B. E2 should be evaluated first

C. Evaluation of E1 and E2 should necessarily be interleaved
D. Order of evaluation of E1 and E2 is of no consequence

gate2004 compiler-design target-code-generation normal

Answer

2.23.4 Target Code Generation: GATE2010-37 top

http://gateoverflow.in/2338

The program below uses six temporary variables a, b, c, d, e, f.

```
a = 1
b = 10
c = 20
d = a + b
e = c + d
f = c + e
b = c + e
e = b + f
d = 5 + e
return d + f
```

Assuming that all operations take their operands from registers, what is the minimum number of registers needed to execute this program without spilling?

A. 2
B. 3
C. 4
D. 6

gate2010 compiler-design target-code-generation register-allocation normal

Answer

Answers: Target Code Generation

2.23.1 Target Code Generation: GATE1997_4.9 top

http://gateoverflow.in/2250

Selected Answer

A)

↑ has higer precedence than {*,+,-,/}

So, if op = ↑ implies, we need to evaluate the right hand side of ↑ first and then do the lhs part, which would definately require us to store the value of lhs

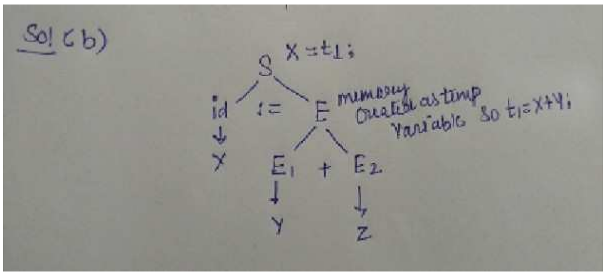
but if its a '+' or '*' , we dont need to store the values evaluated, and on the go can do the operation directly on one register.

7 votes -- confused_luck (891 points)

2.23.2 Target Code Generation: GATE2003-59 top

http://gateoverflow.in/947

Selected Answer



using given semantic rules.

7 votes -- Prashant Singh (49.2k points)

2.23.3 Target Code Generation: GATE2004-10 top http://gateoverflow.in/4069

Selected Answer

E2 should be evaluated first

After evaluating E2 first and then E1, we will have E1 in the register and thus we can simply do SUB operation with E2 which will be in memory (as we have only a single register). If we do E1 first and then E2, we must move E2 to memory and E1 back to register before doing SUB, which will increase the code size.

23 votes -- Arjun Suresh (294k points)

2.23.4 Target Code Generation: GATE2010-37 top http://gateoverflow.in/2338

Selected Answer

Here in these types of compiler questions, idea is "map/assign multiple temporaries to one registers."

here a, b, and c all are having 3 different values so i need atleast 3 registers r1, r2 and r3.
a is mapped to r1, b to r2 and c to r3.

d = a + b, after this line if u notice 'a' is never present on right hand side, so i can map (register of a which is r1) d to r1.
e = c + d, after this line 'd' is never present on rhs, so i can map (register of d which is r1) e to r1.

at this time mapping is
r1 --- e
r2 --- b
r3 --- c

(at this moment i have registers for e, b and c. if i introduce new variable then i may need different register)
now at this point if u see
f = c + e
b = c + e
these two are essentially doing same thing, after these two line 'b' and 'f' are same so i can skip computing 'f'. and whereever f is present i will replace it with 'b'. (bcoz neither of 'f' and 'b' are changing after these two lines, so value of these will be 'c+e' forever)

(seems like i introduced one more variable f, and register is needed for that, but actually i did not really introduce 'f'. i am skipping computation of 'f')
now at second last line "d = 5 + e"
here i introduced 'd', i can map it to any of the register r1 or r3, bcoz after this line neither of 'e' or 'c' is required. (value of 'b' is required bcoz i need to return 'd+f', and 'f' is essentially equal to 'b')

finally code becomes

r1 = 1
r2 = 10
r3 = 20
r1 = r1 + r2
r1 = r3 + r1
(skipping 'f' computation)
r2 = r3 + r1
r2 = r3 + r1
r1 = r2 + r2
r3 = 5 + r1
return r3 + r2

Therefore minimum 3 registers needed.

11 votes -- Sachin Mittal (7.1k points)

After making the interference graph it can be colored with 3 different colors. Therefore minimum number of color needed to execute the program without spilling would be 3 (B).

10 votes -- suraj (5.1k points)

2.24 Variable Scope(2) top

2.24.1 Variable Scope: GATE1987-1-xix top http://gateoverflow.in/80373

Study the following program written in a block-structured language:

```
Var x, y:interger;
procedure P(n:interger);
begin
      x:=(n+2)/(n-3);
end;

procedure Q
Var x, y:interger;
begin
     x:=3;
     y:=4;
     P(y);
     Write(x)                                   __(1)
end;

begin
     x:=7;
     y:=8;
     Q;
Write(x);                                       __(2)
end.
```

What will be printed by the write statements marked (1) and (2) in the program if the variables are statically scoped?

A. $3, 6$
B. $6, 7$
C. $3, 7$
D. None of the above.

gate1987 compiler-design variable-scope

Answer

2.24.2 Variable Scope: GATE1987-1-xx top http://gateoverflow.in/80374

For the program given below what will be printed by the write statements marked (1) and (2) in the program if the variables are dynamically scoped?

```
Var x, y:interger;
procedure P(n:interger);
begin
      x := (n+2)/(n-3);
end;

procedure Q
Var x, y:interger;
begin
     x:=3;
     y:=4;
     P(y);
     Write(x);                                   __(1)
end;

begin
     x:=7;
     y:=8;
     Q;
     Write(x);                                      __(2)
end.
```

A. $3, 6$
B. $6, 7$
C. $3, 7$
D. None of the above

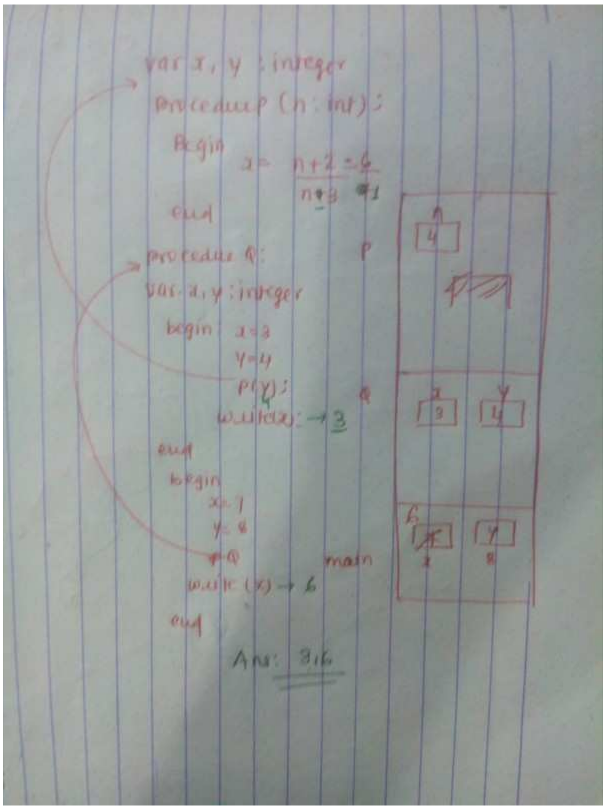
gate1987 compiler-design variable-scope

Answer

Answers: Variable Scope

2.24.1 Variable Scope: GATE1987-1-xix top http://gateoverflow.in/80373

Selected Answer

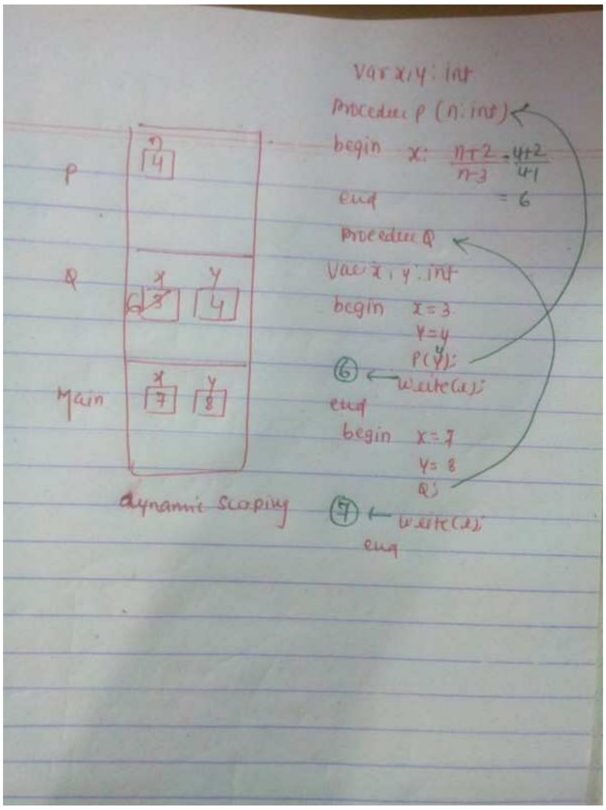


in static scoping free varible is replace by global variable, so option a is correct.

3 votes -- Hira Thakur (7.2k points)

2.24.2 Variable Scope: GATE1987-1-xx top http://gateoverflow.in/80374

Selected Answer



ans is b

3 votes

-- Hira Thakur (7.2k points)

2.25 Viable Prefix(1) top

2.25.1 Viable Prefix: GATE2015-1_13 top http://gateoverflow.in/8187

Which one of the following is TRUE at any valid state in shift-reduce parsing?

A. Viable prefixes appear only at the bottom of the stack and not inside
B. Viable prefixes appear only at the top of the stack and not inside
C. The stack contains only a set of viable prefixes
D. The stack never contains viable prefixes

gate2015-1 compiler-design parsing normal viable-prefix

Answer

Answers: Viable Prefix

2.25.1 Viable Prefix: GATE2015-1_13 top http://gateoverflow.in/8187

Selected Answer

Answer - C

Explanation -

A handle is actually the one which is always on the top of the stack. A viable prefix(prefix of the Right-hand side of a production or productions), is actually a prefix of the handle and so can never extend past the right end of the handle(i.e. the top of the stack).

The structure of the stack can be considered as a set of viable prefixes -

Stack = {$Prefix_1 Prefix_2 Prefix_{3........} Prefix_{n-1} Prefix_n$} and so it is not wrong to say that the stack contains a set of viable prefixes.

Source :- https://www.youtube.com/watch?v=UeRyF72ObXo&list=PLFB9EC7B8FE963EB8&index=35 @7:50

18 votes -- Ravi Ranjan (2.9k points)

C) should be the answer

10 votes -- GateMaster Prime (1.6k points)

3 Programming & DS: DS (201) top

3.1 Abstract Data Type(1) top

3.1.1 Abstract Data Type: GATE2005-2 top

http://gateoverflow.in/1344

An Abstract Data Type (ADT) is:

A. same as an abstract class
B. a data type that cannot be instantiated
C. a data type for which only the operations defined on it can be used, but none else
D. all of the above

gate2005 data-structure normal abstract-data-type

Answer

Answers: Abstract Data Type

3.1.1 Abstract Data Type: GATE2005-2 top

http://gateoverflow.in/1344

Selected Answer

An abstract data type (ADT) supports only the operations which are defined.

Abstract class is one that may not have definitions of all the objects it have. Moreover it can not be instantiated. To instantiate we have to create a subclass then instantiate the class.

Abstract Data Type is like data structure eg. STACK where we have PUSH() POP() operation defined .

Hence they are not the same thing.

http://www.devx.com/tips/Tip/5681

17 votes

-- Manali (2.8k points)

3.2 Arrays(14) top

3.2.1 Arrays: GATE1993-12 top

http://gateoverflow.in/2309

The following Pascal program segments finds the largest number in a two-dimensional integer array $A[0 \ldots n-1, 0 \ldots n-1]$ using a single loop. Fill up the boxes to complete the program and write against $\boxed{\text{A}}, \boxed{\text{B}}, \boxed{\text{C}}$ 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-structure arrays normal

Answer

3.2.2 Arrays: GATE1994-25 top

http://gateoverflow.in/2521

An array A contains n integers in non-decreasing order, $A[1] \leq A[2] \leq \cdots \leq A[n]$. Describe, using Pascal like pseudo code, a linear time algorithm to find i, j, such that $A[i] + A[j] = a$ given integer M, if such i, j exist.

gate1994 data-structure arrays normal

Answer

3.2.3 Arrays: GATE1994_1.11 top http://gateoverflow.in/2452

In a compact single dimensional array representation for lower triangular matrices (i.e all the elements above the diagonal are zero) of size $n \times n$, non-zero elements, (i.e elements of lower triangle) of each row are stored one after another, starting from the first row, the index of the $(i, j)^{th}$ element of the lower triangular matrix in this new representation is:

A. $i + j$
B. $i + j - 1$
C. $(j - 1) + \frac{i(i-1)}{2}$
D. $i + \frac{j(j-1)}{2}$

gate1994 data-structure arrays normal

Answer

3.2.4 Arrays: GATE1997-17 top http://gateoverflow.in/2277

An array A contains $n \geq 1$ positive integers in the locations $A[1], A[2], \dots A[n]$. The following program fragment prints the length of a shortest sequence of consecutive elements of A, $A[i], A[i+1], \dots, A[j]$ such that the sum of their values is $\geq M$, a given positive number. It prints 'n+1' if no such sequence exists. Complete the program by filling in the boxes. In each case use the simplest possible expression. Write only the line number and the contents of the box.

```
begin
i:=1;j:=1;
sum := □
min:=n; finish:=false;
while not finish do
    if □ then
        if j=n then finish:=true
        else
        begin
            j:=j+1;
            sum:= □
        end
    else
    begin
        if(j-i) < min then min:=j-i;
        sum:=sum -A[i];
        i:=i+1;
    end
    writeln (min +1);
end.
```

gate1997 data-structure arrays normal

Answer

3.2.5 Arrays: GATE1998_2.14 top http://gateoverflow.in/1686

Let A be a two dimensional array declared as follows:

```
A: array [1 …. 10] [1 ….. 15] of integer;
```

Assuming that each integer takes one memory location, the array is stored in row-major order and the first element of the array is stored at location 100, what is the address of the element $A[i][j]$?

A. $15i + j + 84$

B. $15j + i + 84$

C. $10i + j + 89$

D. $10j + i + 89$

gate1998 data-structure arrays easy

Answer

3.2.6 Arrays: GATE2000-1.2 top http://gateoverflow.in/625

An $n \times n$ array v is defined as follows:

$v[i,j] = i - j$ for all $i, j, i \leq n, 1 \leq j \leq n$

The sum of the elements of the array v is

A. 0
B. $n-1$
C. $n^2 - 3n + 2$
D. $n^2 \frac{(n+1)}{2}$

gate2000 data-structure arrays easy

Answer

3.2.7 Arrays: GATE2000-15 top http://gateoverflow.in/686

Suppose you are given arrays p [1......N] and q [1......N] both uninitialized, that is, each location may contain an arbitrary value), and a variable count, initialized to 0. Consider the following procedures set and is_set:

```
set(i) {
    count = count + 1;
    q[count] = i;
    p[i] = count;
}
is_set(i) {
    if (p[i] ≤ 0 or p[i] > count)
        return false;
    if (q[p[i]] ≠ i)
        return false;
    return true;
}
```

a. Suppose we make the following sequence of calls:
set(7); set(3); set(9);
After these sequence of calls, what is the value of count, and what do q[1], q[2] ,q[3], p[7], p[3] and p[9] contain?
b. Complete the following statement "The first count elements of ___________contain values i such that set (__________________) has been called".
c. Show that if set(i) has not been called for some i, then regardless of what p[i] contains, is_set(i) will return false.

gate2000 data-structure arrays easy descriptive

Answer

3.2.8 Arrays: GATE2005-5 top http://gateoverflow.in/1347

A program P reads in 500 integers in the range [0, 100] representing the scores of 500 students. It then prints the frequency of each score above 50. What would be the best way for P to store the frequencies?

A. An array of 50 numbers

B. An array of 100 numbers

C. An array of 500 numbers

D. A dynamically allocated array of 550 numbers

gate2005 data-structure arrays easy

Answer

3.2.9 Arrays: GATE2013-50 top http://gateoverflow.in/1557

The procedure given below is required to find and replace certain characters inside an input character string supplied in array A. The characters to be replaced are supplied in array oldc, while their respective replacement characters are supplied in array newc. Array A has a fixed length of five characters, while arrays oldc and newc contain three characters each. However, the procedure is flawed.

```
void find_and_replace (char *A, char *oldc, char *newc) {
    for (int i=0; i<5; i++)
        for (int j=0; j<3; j++)
            if (A[i] == oldc[j])
                A[i] = newc[j];
}
```

The procedure is tested with the following four test cases.
(1) oldc = "abc", newc = "dab"   (2) oldc = "cde", newc = "bcd"
(3) oldc = "bca", newc = "cda"   (4) oldc = "abc", newc = "bac"

The tester now tests the program on all input strings of length five consisting of characters 'a', 'b', 'c', 'd' and 'e' with duplicates allowed. If the tester carries out this testing with the four test cases given above, how many test cases will be able to capture the flaw?

A. Only one
B. Only two
C. Only three
D. All four

gate2013 data-structure arrays normal

Answer

3.2.10 Arrays: GATE2013-51 top http://gateoverflow.in/43291

The procedure given below is required to find and replace certain characters inside an input character string supplied in array A. The characters to be replaced are supplied in array oldc, while their respective replacement characters are supplied in array newc. Array A has a fixed length of five characters, while arrays oldc and newc contain three characters each. However, the procedure is flawed.

```
void find_and_replace (char *A, char *oldc, char *newc) {
    for (int i=0; i<5; i++)
        for (int j=0; j<3; j++)
            if (A[i] == oldc[j])
                A[i] = newc[j];
}
```

The procedure is tested with the following four test cases.
(1) oldc = "abc", newc = "dab"   (2) oldc = "cde", newc = "bcd"
(3) oldc = "bca", newc = "cda"   (4) oldc = "abc", newc = "bac"

If array A is made to hold the string "abcde", which of the above four test cases will be successful in exposing the flaw in this procedure?

A. None
B. 2 only
C. 3 and 4 only
D. 4 only

gate2013 data-structure arrays normal

Answer

3.2.11 Arrays: GATE2014-3-42 top http://gateoverflow.in/2076

Consider the C function given below. Assume that the array $listA$ contains $n (> 0)$ elements, sorted in ascending order.

```
int ProcessArray(int *listA, int x, int n)
{
        int i, j, k;
        i = 0;      j = n-1;
         do {
                k = (i+j)/2;
```

```
            if (x <= listA[k]) j = k-1;
            if (listA[k] <= x) i = k+1;
          }
      while (i <= j);
      if (listA[k] == x) return(k);
      else   return -1;
}
```

Which one of the following statements about the function $ProcessArray$ is **CORRECT**?

A. It will run into an infinite loop when x is not in $listA$.
B. It is an implementation of binary search.
C. It will always find the maximum element in $listA$.
D. It will return -1 even when x is present in $listA$.

gate2014-3 data-structure arrays easy

Answer

3.2.12 Arrays: GATE2015-2_31 top

http://gateoverflow.in/8148

A Young tableau is a 2D array of integers increasing from left to right and from top to bottom. Any unfilled entries are marked with ∞, and hence there cannot be any entry to the right of, or below a ∞. The following Young tableau consists of unique entries.

1	2	5	14
3	4	6	23
10	12	18	25
31	∞	∞	∞

When an element is removed from a Young tableau, other elements should be moved into its place so that the resulting table is still a Young tableau (unfilled entries may be filled with a ∞). The minimum number of entries (other than 1) to be shifted, to remove 1 from the given Young tableau is ______.

gate2015-2 databases arrays normal numerical-answers

Answer

3.2.13 Arrays: ISI 2015 PCB C2 B top

http://gateoverflow.in/120886

You are given a array *A* of size *n*. Your are told that *A* comprises three consecutive runs - first a run of *a*'s, the a run of *b*'s and finally a run of *c*'s. Moreover, you are provided an index of *i* such that *A[i] = b*. Design an *O(logn)* time algorithm to determine the number of *b*'s (i.e., length of the second run) in *A.*

data-structure arrays isi2015

Answer

3.2.14 Arrays: TIFR2011-B-30 top

http://gateoverflow.in/20611

Consider an array $A[1...n]$. It consists of a permutation of numbers $1....n$. Now compute another array $B[1...n]$ as follows: $B[A[i]] := i$ for all i. Which of the following is true?

A. B will be a sorted array.
B. B is a permutation of array A.
C. Doing the same transformation twice will not give the same array.
D. B is not a permutation of array A.
E. None of the above.

tifr2011 data-structure arrays

Answer

Answers: Arrays

3.2.1 Arrays: GATE1993-12 top

http://gateoverflow.in/2309

Selected Answer

We have to traverse all elements in array. The code is doing this row wise.

```
begin
    max:=A[0,0], i:=0, j:=0;
    while (i < n) do
    begin
        if A[i, j]>max then max:=A[i, j];
        if (j < n-1) then j:=j+1;
        else begin
            j:=0;
            i:=i++;
        end
    end
end
```

7 votes -- Arjun Suresh (294k points)

3.2.2 Arrays: GATE1994-25 top

http://gateoverflow.in/2521

Selected Answer

```
i = 1;
j = n;
while(i != j) {
   if(A[i] + A[j] == M) break;
   else if(A[i] + A[j] < M) i++;
   else j--;
}
```

16 votes -- ankitrokdeonsns (9.1k points)

3.2.3 Arrays: GATE1994_1.11 top

http://gateoverflow.in/2452

Selected Answer

j-1 + i(i-1)/2 ... because if you form a lower triangular matrix it contains elements in rows 1,2,3,...

So C is the correct answer.

PS: Though not mentioned in question, from options it is clear that **array index starts from 1 and not 0**.

Explanation :

In a lower triangular matrix, i th row contains (i +1) number of non zero elements.

If we assume Array index starting from 1 then, i th row contains i number of non zero elements.

before i th row there are i -1 rows (row 1 to i-1) , and in total these rows has 1+2+3.....+(i-1)= i((i-1)/2 elements(row 1 has 1 element, row 2 has 2 elements, ... row i-1 has i-1 elements etc.)

Now at i th row, before j th element there are (j-1) elements(starting from arr[i,1] to arr[i,j-1]) .

Hence in total before arr[i,j] there are (i(i-1)/2 + j-1) elements and those elements will have indexes .

So the index of the $(i,j)^{th}$ element of the lower triangular matrix in this new representation is (j-1) + i(i-1)/2 which is option C .

19 votes -- Bhagirathi Nayak (13.3k points)

answer is C...... it is (j-1) + i(i-1)/2 when indices start from 1 (as we guess from the options)

11 votes -- Gate Keeda (19.1k points)

3.2.4 Arrays: GATE1997-17 top http://gateoverflow.in/2277

Selected Answer

```
begin
i:=1;j:=1;
sum := A[1]
min:=n; finish:=false;
while not finish do
    if sum < M then
        if j=n then finish:=true
        else
        begin
            j:=j+1;
            sum:= sum + A[j]
        end
    else
    begin
        if(j-i) < min then min:=j-i;
        sum:=sum - A[i];
        i:=i+1;
    end
    writeln (min +1);
end.
```

Algorithm

'i' indicates the starting marker and 'j' acts as ending marker for the sum sequence. 'sum' is initialised as the first element in the array because the algorithm proceeds by taking the sum of remaining elements. 'finish' is a boolean variable that indicates exit from the loop.

After entering the loop for the first time with 'finish' as false, the sum is checked if it's strictly less than "M". If that's the case j is incremented and the sum is modified to sum + A[j]. When 'sum' becomes greater than or equal to 'M', 'min' is modified to the latest number of elements that make the sum greater than or equal to 'M' and then, the first element is stripped off from the sum and 'i' is incremented by one to move the initial marker of the sum sequence. The loop runs till 'j' reaches the end of the array.

The algorithm keeps track of 'min' i.e. the number of elements in the minimum sum sequence. This is very similar to the way we find the minimum value in an array by modifying the min value whenever a lesser value is encountered.

8 votes -- krish__ (747 points)

3.2.5 Arrays: GATE1998_2.14 top http://gateoverflow.in/1686

Selected Answer

A [LB_1.............UB_1,LB_2................UB_2]

BA = Base address.

C = size of each element.

Row major order.

Loc(a[i][j]) = BA + [(i-LB_1) (UB_2 - LB_2 + 1) + (j - LB_2)] * C.

Column Major order

Loc(a[i][j]) = BA + [(j-LB_2) (UB_1 - LB_1 + 1) + (i - LB_1)] * C.

substituting the values. answer is A.

19 votes -- Gate Keeda (19.1k points)

3.2.6 Arrays: GATE2000-1.2 top

http://gateoverflow.in/625

Selected Answer

The sum of the i^{th} row and i^{th} column is 0 as shown below. Since, the numbers of rows = no. of columns, the total sum will be 0.

0	-1	-2	-3	-4
1	0	-1	-2	-3
2	1	0	-1	-2
3	2	1	0	-1
4	3	2	1	0

15 votes -- Arjun Suresh (294k points)

3.2.7 Arrays: GATE2000-15 top

http://gateoverflow.in/686

Selected Answer

a)

Initially count= 0;

When we call set(7) - count=1, q[1] =7, p[7]= 1;

when we call set(3) - count=2, q[2]=3, p[3] =2;

when we call set(9) - count=3, q[3]=9, p[9] = 3;

b) Ans- "The first count elements of (array q) contain values i such that set (i) has been called".

c) If set(i) has not been called for some i, then regardless of what p[i] contains, When we call is_set(i) then

```
if (q[p[i]] ≠ i)
        return false;
will always execute, because if set(i) is not called then p[i] ≠ count(any) and for then same count q[count] ≠ i. So if statement will be true and will return false.
```

6 votes -- Dhananjay Kumar Sharma (25.2k points)

3.2.8 Arrays: GATE2005-5 top

http://gateoverflow.in/1347

Selected Answer

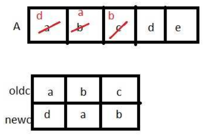
as we our area of interest is only the 50 numbers so take An array of 50 numbers where A[0] corresponds to 51...A[49] corresponds to 100 then after reading an input just increment the counter in correct position as said above

16 votes -- Bhagirathi Nayak (13.3k points)

3.2.9 Arrays: GATE2013-50 top

http://gateoverflow.in/1557

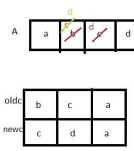
Selected Answer



for (1)

Here when the element of array A and oldc match , we replace that array element of A with array element of newc . For every element of A array update occurs maximum one time.

Similarly for (2) array element of A has updated with array element of newc less than or equal to one time,



for (3)

Now, for (3) when i=0 , value of A match with oldc[2] i.e.'a' , and replace with newc[2] i.e. also 'a'. So, no changes

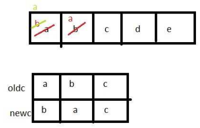
when i=1 value of array A[1]='b'

match with oldc[0]='b' and replace with newc[0]='c'.

Now, A[1]='c' which equal with next element of oldc[1]='c'.

So, replace again with newc[1]='d'.

Now, we can say here in array A[1] value replace with newc[0] value , and that newc[0] value replace with next newc[1] value.



for (4)

Similarly for (4) here 2 times replacement for A[0] with element newc[0] and newc[1]

Updating of newc value with another newc value is calling flaw here

So Ans B

8 votes -- srestha (58.4k points)

The test cases 3 and 4 are the only cases that capture the flaw. The code doesn't work properly when an old character is replaced by a new character and the new character is again replaced by another new character. This doesn't happen in test cases (1) and (2), it happens only in cases (3) and (4).

50. B

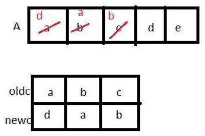
51. C

12 votes -- Vikrant Singh (13.4k points)

3.2.10 Arrays: GATE2013-51 top

http://gateoverflow.in/43291

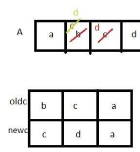
Selected Answer



for (1)

Here when the element of array A and oldc match , we replace that array element of A with array element of newc . For every element of A array update occurs maximum one time.

Similarly for (2) array element of A has updated with array element of newc less than or equal to one time,



for (3)

Now, for (3) when i=0 , value of A match with oldc[2] i.e.'a' , and replace with newc[2] i.e. also 'a'. So, no changes

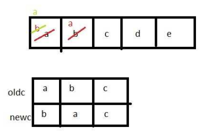
when i=1 value of array A[1]='b'

match with oldc[0]='b' and replace with newc[0]='c'.

Now, A[1]='c' which equal with next element of oldc[1]='c'.

So, replace again with newc[1]='d'.

Now, we can say here in array A[1] value replace with newc[0] value , and that newc[0] value replace with next newc[1] value.



for (4)

Similarly for (4) here 2 times replacement for A[0] with element newc[0] and newc[1]

Updating of newc value with another newc value is calling flaw here

So Ans (C)

8 votes -- srestha (58.4k points)

3.2.11 Arrays: GATE2014-3-42 top

http://gateoverflow.in/2076

Selected Answer

This is an implementation of the Binary search algorithm.

Note that the loop will be terminated when we have found x. In that case both the if conditions will be true making condition inside the while as false i.e., i>j.

1 votes -- Monanshi Jain (8.5k points)

B)....

13 votes -- Siddhartha Datta (129 points)

3.2.12 Arrays: GATE2015-2_31 top

http://gateoverflow.in/8148

Selected Answer

The answer should be 5.

1.We first need to shift 2 in place of 1 keeping 5 AND 14 intact as it isn't mentioned in the question that the entire row elements move.

2. 4 is shifted up,next to 2(keeping 12 and infinity intact in column 2).

3. Now in second row 6 is shifted left.

4.18 shifts up to the second row

5. And finally 25 is shifted left to the third column.

So this takes 5 moves and still maintains the tableau property. Also infinity is placed to the right of 25 and below 23(unfilled entries to be filled with ∞). The final table would look as follows.

2	4	5	14
3	6	18	23
10	12	25	∞
31	∞	∞	∞

20 votes -- Aman verma (221 points)

3.2.13 Arrays: ISI 2015 PCB C2 B top

http://gateoverflow.in/120886

Hint: Modify Binary Search.

Solution:

You should use binary search twice first to find the first occurence of b. Then apply it again to find the last occurence.

The following code does this.

BinarySearchForFirst

```
int binarySearchForFirst(int l, int r){
    int mid;
    while(l <= r){
        mid = l+(r-l)/2;
        if(arya[mid]=='b' && arya[mid-1]=='a' ){//the desired case
            return mid;
        }
        if(arya[mid-1]=='b'){//we're to the right of required index
            r = mid;
            continue;
        }
        if(arya[mid]=='a'){//we're to the left or required index
            l = mid;
            continue;
        }
    }

}
```

This returns the first index say i

Similarly find the second index j.

Then the answer is $j - i + 1$

4 votes -- Akshay Arora (2.3k points)

3.2.14 Arrays: TIFR2011-B-30 top

http://gateoverflow.in/20611

Selected Answer

Option b)
B is a permutation of array A.

Infact, B gives the reverse index of all the elements of array A. Since the array A contains numbers $[1..n]$ mapped to the locations $[1..n]$ and A is a permutation of the numbers $[1..n]$, the array B will also be a permutation of the numbers $[1..n]$.

For example:

index	1	2	3	4	5	6	7	8
A	5	1	3	7	6	2	8	4
B	2	6	3	8	1	5	4	7

To see that option c is incorrect, let array C be the array attained from doing the same transformation twice, that is, $C[B[i]] = i, \forall i \in [1..n]$. We get,

index	1	2	3	4	5	6	7	8
A	5	1	3	7	6	2	8	4
B	2	6	3	8	1	5	4	7
C	5	1	3	7	6	2	8	4

We can see that $C = A$, which makes option c incorrect.

14 votes -- Pragy Agarwal (19.5k points)

3.3 Binary Search Tree(29) top

3.3.1 Binary Search Tree: GATE 2016-2-40 top http://gateoverflow.in/39586

The number of ways in which the numbers $1, 2, 3, 4, 5, 6, 7$ can be inserted in an empty binary search tree, such that the resulting tree has height 6, is _________.

Note: The height of a tree with a single node is 0.

gate2016-2 data-structure binary-search-tree normal numerical-answers

Answer

3.3.2 Binary Search Tree: GATE1996_2.14 top http://gateoverflow.in/2743

A binary search tree is generated by inserting in order the following integers:

$$50, 15, 62, 5, 20, 58, 91, 3, 8, 37, 60, 24$$

The number of nodes in the left subtree and right subtree of the root respectively is

A. (4, 7)
B. (7, 4)
C. (8, 3)
D. (3, 8)

gate1996 data-structure binary-search-tree normal

Answer

3.3.3 Binary Search Tree: GATE1996_4 top http://gateoverflow.in/2756

A binary search tree is used to locate the number 43. Which of the following probe sequences are possible and which are not? Explain.

(a)	61	52	14	17	40	43
(b)	2	3	50	40	60	43
(c)	10	65	31	48	37	43
(d)	81	61	52	14	41	43
(e)	17	77	27	66	18	43

gate1996 data-structure binary-search-tree normal

Answer

3.3.4 Binary Search Tree: GATE2001-14 top

http://gateoverflow.in/755

a. Insert the following keys one by one into a binary search tree in the order specified.
    15, 32, 20, 9, 3, 25, 12, 1
   Show the final binary search tree after the insertions.
b. Draw the binary search tree after deleting 15 from it.
c. Complete the statements S1, S2 and S3 in the following function so that the function computes the depth of a binary tree rooted at t.

```
typedef struct tnode{
    int key;
    struct tnode *left, *right;
} *Tree;

int depth (Tree t)
{
    int x, y;
    it (t == NULL) return 0;
    x = depth (t -> left);
S1:     ___________;

S2:     if (x > y) return __________;

S3:     else return _______;

}
```

gate2001 data-structure binary-search-tree normal descriptive

Answer

3.3.5 Binary Search Tree: GATE2003-19, ISRO2009-24 top

http://gateoverflow.in/909

Suppose the numbers 7, 5, 1, 8, 3, 6, 0, 9, 4, 2 are inserted in that order into an initially empty binary search tree. The binary search tree uses the usual ordering on natural numbers. What is the in-order traversal sequence of the resultant tree?

A. 7 5 1 0 3 2 4 6 8 9

B. 0 2 4 3 1 6 5 9 8 7

C. 0 1 2 3 4 5 6 7 8 9

D. 9 8 6 4 2 3 0 1 5 7

gate2003 binary-search-tree easy isro2009

Answer

3.3.6 Binary Search Tree: GATE2003-6 top

http://gateoverflow.in/897

Let $T(n)$ be the number of different binary search trees on n distinct elements.

Then $T(n) = \sum_{k=1}^{n} T(k-1)T(x)$, where x is

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

gate2003 normal binary-search-tree

Answer

3.3.7 Binary Search Tree: GATE2003-63, ISRO2009-25 top http://gateoverflow.in/950

A data structure is required for storing a set of integers such that each of the following operations can be done in $O(\log n)$ time, where n is the number of elements in the set.

I. Deletion of the smallest element

II. Insertion of an element if it is not already present in the set

Which of the following data structures can be used for this purpose?

A. A heap can be used but not a balanced binary search tree

B. A balanced binary search tree can be used but not a heap

C. Both balanced binary search tree and heap can be used

D. Neither balanced search tree nor heap can be used

gate2003 data-structure easy isro2009 binary-search-tree

Answer

3.3.8 Binary Search Tree: GATE2004-4, ISRO2009-26 top http://gateoverflow.in/1001

The following numbers are inserted into an empty binary search tree in the given order: 10, 1, 3, 5, 15, 12, 16. What is the height of the binary search tree (the height is the maximum distance of a leaf node from the root)?

A. 2
B. 3
C. 4
D. 6

gate2004 data-structure binary-search-tree easy isro2009

Answer

3.3.9 Binary Search Tree: GATE2004-85 top http://gateoverflow.in/1079

A program takes as input a balanced binary search tree with n leaf nodes and computes the value of a function $g(x)$ for each node x. If the cost of computing $g(x)$ is:

$$\min \left(\begin{array}{c}\text{number of leaf-nodes}\\ \text{in left-subtree of } x\end{array}, \begin{array}{c}\text{number of leaf-nodes}\\ \text{in right-subtree of } x\end{array} \right)$$

Then the worst-case time complexity of the program is?

A. $\Theta(n)$

B. $\Theta(n \log n)$

C. $\Theta(n^2)$

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

gate2004 binary-search-tree normal

Answer

3.3.10 Binary Search Tree: GATE2005-IT-12 top http://gateoverflow.in/3757

The numbers $1, 2, \dots n$ are inserted in a binary search tree in some order. In the resulting tree, the right subtree of the root contains p nodes. The first number to be inserted in the tree must be

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

gate2005-it data-structure normal binary-search-tree

Answer

3.3.11 Binary Search Tree: GATE2005-IT-55 top http://gateoverflow.in/3816

A binary search tree contains the numbers 1, 2, 3, 4, 5, 6, 7, 8. When the tree is traversed in pre-order and the values in each node printed out, the sequence of values obtained is 5, 3, 1, 2, 4, 6, 8, 7. If the tree is traversed in post-order, the sequence obtained would be

A. 8, 7, 6, 5, 4, 3, 2, 1
B. 1, 2, 3, 4, 8, 7, 6, 5
C. 2, 1, 4, 3, 6, 7, 8, 5
D. 2, 1, 4, 3, 7, 8, 6, 5

gate2005-it data-structure binary-search-tree normal

Answer

3.3.12 Binary Search Tree: GATE2006-IT-45 top http://gateoverflow.in/3588

Suppose that we have numbers between 1 and 100 in a binary search tree and want to search for the number 55. Which of the following sequences CANNOT be the sequence of nodes examined?

A. {10, 75, 64, 43, 60, 57, 55}
B. {90, 12, 68, 34, 62, 45, 55}
C. {9, 85, 47, 68, 43, 57, 55}
D. {79, 14, 72, 56, 16, 53, 55}

gate2006-it data-structure binary-search-tree normal

Answer

3.3.13 Binary Search Tree: GATE2007-IT-29 top http://gateoverflow.in/3462

When searching for the key value 60 in a binary search tree, nodes containing the key values 10, 20, 40, 50, 70 80, 90 are traversed, not necessarily in the order given. How many different orders are possible in which these key values can occur on the search path from the root to the node containing the value 60?

A. 35
B. 64
C. 128
D. 5040

gate2007-it data-structure binary-search-tree normal

Answer

3.3.14 Binary Search Tree: GATE2008-46 top http://gateoverflow.in/458

You are given the postorder traversal, P, of a binary search tree on the n elements $1, 2, \ldots, n$. You have to determine the unique binary search tree that has P as its postorder traversal. What is the time complexity of the most efficient algorithm for doing this?

A. $\Theta(\log n)$

B. $\Theta(n)$

C. $\Theta(n \log n)$

D. None of the above, as the tree cannot be uniquely determined

gate2008 data-structure binary-search-tree normal

Answer

3.3.15 Binary Search Tree: GATE2008-IT-12 top

http://gateoverflow.in/3272

Which of the following is TRUE?

A. The cost of searching an AVL tree is θ (log n) but that of a binary search tree is O(n)
B. The cost of searching an AVL tree is θ (log n) but that of a complete binary tree is θ (n log n)
C. The cost of searching a binary search tree is O (log n) but that of an AVL tree is θ(n)
D. The cost of searching an AVL tree is θ (n log n) but that of a binary search tree is O(n)

gate2008-it data-structure binary-search-tree easy

Answer

3.3.16 Binary Search Tree: GATE2008-IT-71 top

http://gateoverflow.in/3385

A Binary Search Tree (BST) stores values in the range 37 to 573. Consider the following sequence of keys.

I. 81, 537, 102, 439, 285, 376, 305
II. 52, 97, 121, 195, 242, 381, 472
III. 142, 248, 520, 386, 345, 270, 307
IV. 550, 149, 507, 395, 463, 402, 270

Suppose the BST has been unsuccessfully searched for key 273. Which all of the above sequences list nodes in the order in which we could have encountered them in the search?

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

gate2008-it data-structure binary-search-tree normal

Answer

3.3.17 Binary Search Tree: GATE2008-IT-72 top

http://gateoverflow.in/3386

A Binary Search Tree (BST) stores values in the range 37 to 573. Consider the following sequence of keys.

I. 81, 537, 102, 439, 285, 376, 305
II. 52, 97, 121, 195, 242, 381, 472
III. 142, 248, 520, 386, 345, 270, 307
IV. 550, 149, 507, 395, 463, 402, 270

Which of the following statements is TRUE?

A. I, II and IV are inorder sequences of three different BSTs
B. I is a preorder sequence of some BST with 439 as the root
C. II is an inorder sequence of some BST where 121 is the root and 52 is a leaf
D. IV is a postorder sequence of some BST with 149 as the root

gate2008-it data-structure binary-search-tree easy

Answer

3.3.18 Binary Search Tree: GATE2008-IT-73 top

http://gateoverflow.in/3387

How many distinct BSTs can be constructed with 3 distinct keys?

A. 4
B. 5
C. 6
D. 9

gate2008-it data-structure binary-search-tree normal

Answer

3.3.19 Binary Search Tree: GATE2009-37 top http://gateoverflow.in/1323

What is the maximum height of any AVL-tree with 7 nodes? Assume that the height of a tree with a single node is 0.

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

gate2009 data-structure binary-search-tree normal

Answer

3.3.20 Binary Search Tree: GATE2012-5 top http://gateoverflow.in/37

The worst case running time to search for an element in a balanced binary search tree with $n2^n$ elements is

A. $\Theta(n \log n)$
B. $\Theta(n2^n)$
C. $\Theta(n)$
D. $\Theta(\log n)$

gate2012 data-structure normal binary-search-tree

Answer

3.3.21 Binary Search Tree: GATE2013-43 top http://gateoverflow.in/1554

The preorder traversal sequence of a binary search tree is 30, 20, 10, 15, 25, 23, 39, 35, 42. Which one of the following is the postorder traversal sequence of the same tree?

A. 10, 20, 15, 23, 25, 35, 42, 39, 30
B. 15, 10, 25, 23, 20, 42, 35, 39, 30
C. 15, 20, 10, 23, 25, 42, 35, 39, 30
D. 15, 10, 23, 25, 20, 35, 42, 39, 30

gate2013 data-structure binary-search-tree normal

Answer

3.3.22 Binary Search Tree: GATE2013_7 top http://gateoverflow.in/1416

Which one of the following is the tightest upper bound that represents the time complexity of inserting an object into a binary search tree of n nodes?

(A) $O(1)$

(B) $O(\log n)$

(C) $O(n)$

(D) $O(n \log n)$

gate2013 data-structure easy binary-search-tree

Answer

3.3.23 Binary Search Tree: GATE2014-3-39 top http://gateoverflow.in/2073

Suppose we have a balanced binary search tree T holding n numbers. We are given two numbers L and H and wish to sum up all the numbers in T that lie between L and H. Suppose there are m such numbers in T. If the tightest upper bound on the time to compute the sum is $O(n^a \log^b n + m^c \log^d n)$, the value of $a + 10b + 100c + 1000d$ is _______.

gate2014-3 data-structure binary-search-tree numerical-answers normal

Answer

3.3.24 Binary Search Tree: GATE2015-1_10 top http://gateoverflow.in/8129

Which of the following is/are correct in order traversal sequence(s) of binary search tree(s)?

I. 3, 5, 7, 8, 15, 19, 25
II. 5, 8, 9, 12, 10, 15, 25
III. 2, 7, 10, 8, 14, 16, 20
IV. 4, 6, 7, 9, 18, 20, 25

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

gate2015-1 data-structure binary-search-tree easy

Answer

3.3.25 Binary Search Tree: GATE2015-1_23 top http://gateoverflow.in/8221

What are the worst-case complexities of insertion and deletion of a key in a binary search tree?

A. Θ(log n) for both insertion and deletion
B. Θ(n) for both insertion and deletion
C. Θ(n) for insertion and Θ(log n) for deletion
D. Θ(log n) for insertion and Θ(n) for deletion

gate2015-1 data-structure binary-search-tree easy

Answer

3.3.26 Binary Search Tree: GATE2015-3_13 top http://gateoverflow.in/8409

While inserting the elements 71, 65, 84, 69, 67, 83 in an empty binary search tree (BST) in the sequence shown, the element in the lowest level is

A. 65
B. 67
C. 69
D. 83

gate2015-3 data-structure binary-search-tree easy

Answer

3.3.27 Binary Search Tree: GATE2017-1-6 top http://gateoverflow.in/118286

Let T be a binary search tree with 15 nodes. The minimum and maximum possible heights of$T$ are:

Note: The height of a tree with a single node is 0.

(A) 4 and 15 respectively.

(B) 3 and 14 respectively.

(C) 4 and 14 respectively.

(D) 3 and 15 respectively.

gate2017-1 data-structure binary-search-tree easy

Answer

3.3.28 Binary Search Tree: GATE2017-2-36 top http://gateoverflow.in/118378

The pre-order traversal of a binary search tree is given by 12, 8, 6, 2, 7, 9, 10, 16, 15, 19, 17, 20. Then the post-order traversal of this tree is

A. 2, 6, 7, 8, 9, 10, 12, 15, 16, 17, 19, 20
B. 2, 7, 6, 10, 9, 8, 15, 17, 20, 19, 16, 12
C. 7, 2, 6, 8, 9, 10, 20, 17, 19, 15, 16, 12
D. 7, 6, 2, 10, 9, 8, 15, 16, 17, 20, 19, 12

gate2017-2 data-structure binary-search-tree

Answer

3.3.29 Binary Search Tree: TIFR2010-B-26 top

http://gateoverflow.in/18749

Suppose there is a balanced binary search tree with n nodes, where at each node, in addition to the key, we store the number of elements in the sub tree rooted at that node.

Now, given two elements a and b, such that $a < b$, we want to find the number of elements x in the tree that lie between a and b, that is, $a \leq x \leq b$. This can be done with (choose the best solution).

A. $O(\log n)$ comparisons and $O(\log n)$ additions.
B. $O(\log n)$ comparisons but no further additions.
C. $O(\sqrt{n})$ comparisons but $O(\log n)$ additions.
D. $O(\log n)$ comparisons but a constant number of additions.
E. $O(n)$ comparisons and $O(n)$ additions, using depth-first- search.

tifr2010 binary-search-tree

Answer

Answers: Binary Search Tree

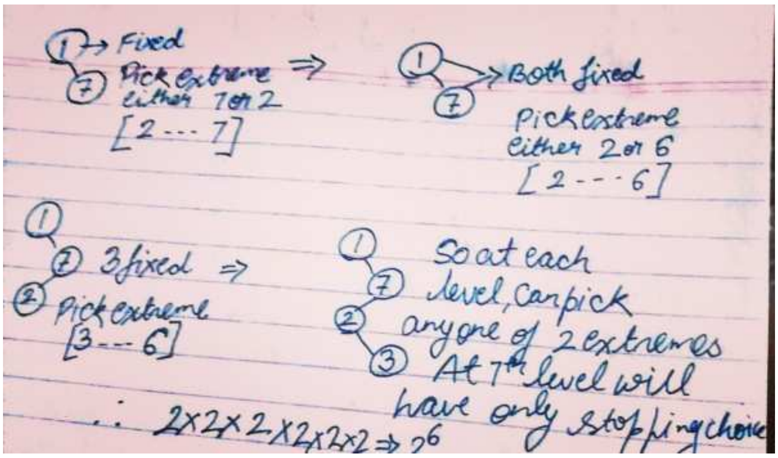
3.3.1 Binary Search Tree: GATE 2016-2-40 top

http://gateoverflow.in/39586

Selected Answer

We need to fill 7 levels with 7 elements. So, at each level we have exactly 2 possible options like 1 and 7 for root- one corresponding to making it left skewed and other right skewed. And this is the same for all levels up to 6 giving $2^6 = 64$ possible ways.

55 votes -- Arjun Suresh (294k points)



WELL its RECURRENCE QUESTION ,,,,but for that need to observe the pattern ..first and then THE RECURRENCE RELATION WILL BE N(h)=2N(h-1)

33 votes -- Deepesh Kataria (1.8k points)

3.3.2 Binary Search Tree: GATE1996_2.14 top

http://gateoverflow.in/2743

Selected Answer

B.

Root will be 50. now insert one by one, greater to 50 in the right sub tree, lesser in left sub tree.

Or you can simply count the number looking at the i/p. less than 50 are 7. more than 50 are 4.

10 votes -- Gate Keeda (19.1k points)

3.3.3 Binary Search Tree: GATE1996_4 top

http://gateoverflow.in/2756

Selected Answer

B and E are not possible.

rest all i/p's will have binary trees with only one child. but B and E will have two childs at a point. therefore the probe sequence will not be possible.

For better clarification, make BST's for the given i/p's and probe for 43.

15 votes -- Gate Keeda (19.1k points)

3.3.4 Binary Search Tree: GATE2001-14 top

http://gateoverflow.in/755

ans for C :

S1: y = depth(t -> right)

S2: return(1 + x)

S3: return(1 + y)

12 votes -- jayendra (8.1k points)

3.3.5 Binary Search Tree: GATE2003-19, ISRO2009-24 top

http://gateoverflow.in/909

Selected Answer

In-order traversal returns the elements in sorted order.

Therefore, it's option C

12 votes -- Gate_15_isHere (639 points)

3.3.6 Binary Search Tree: GATE2003-6 top

http://gateoverflow.in/897

Selected Answer

The summation is for each node, if that node happens to be the root. When a node is root, it will have (k-1) nodes on the left sub tree (k being any number) and correspondingly (n-k) elements on the right sub tree. So, we can write recurrence T(k-1) * T(n-k) for the number of distinct binary search trees, as the numbers on left and right sub trees form BSTs independent of each other and only a difference in one of the sub trees produces a difference in the tree. Hence, answer is B.

Knowing the direct formula can also help in getting the answer but is not recommended.

http://gatecse.in/wiki/Number_of_Binary_trees_possible_with_n_nodes

19 votes -- Arjun Suresh (294k points)

left subtree + root + right subtree = total node

(k-1) + 1 + x = n
x = n - k

22 votes -- Digvijay (47k points)

3.3.7 Binary Search Tree: GATE2003-63, ISRO2009-25 top http://gateoverflow.in/950

Selected Answer

Balanced search tree have height $\log n$

Deletion of smallest element will take $O(\log n)$ time

Finding a element is present/not and doing insertion: $O(\log n)$

Heap(MIN) is also an almost complete binary tree have height $\log n$

Deletion of smallest element will take $O(\log n)$ time (root element removal, replace with last element +balancing)

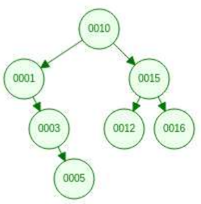
Finding a element is present/not and insertion: Finding only takes $O(n)$, insertion then balancing take $O(\log n)$. So, total
$O(n) + O(\log n) = O(n)$.

Ans B
(even if its maxheap our ans does not change only time for deletion of min will increase $O(n)$)

23 votes -- Anurag Semwal (8k points)

3.3.8 Binary Search Tree: GATE2004-4, ISRO2009-26 top http://gateoverflow.in/1001

Selected Answer



Height is 3

13 votes -- Prashant Singh (49.2k points)

3.3.9 Binary Search Tree: GATE2004-85 top http://gateoverflow.in/1079

Selected Answer

B. At the root node (first level) the cost would be $\Theta\left(\frac{n}{2}\right)$ as the tree is **balanced**.

At next level, we have 2 nodes and for each of them cost of computing $g(x)$ will be $\Theta\left(\frac{n}{4}\right)$. So, total cost at second level

$= \Theta\left(\frac{n}{2}\right)$. Similarly at **each level** (total cost per level and not the cost per node in a level) the cost would be $\Theta\left(\frac{n}{2}\right)$ and so for $\log n$ levels it would be $\Theta(n \log n)$.

PS: Even if we change $\min$ to $\max$ in the defintion of $g(x)$ we get the same answer.

25 votes -- Shaun Patel (6.9k points)

Do a post order traversal and store and return $\min(\text{g}(x \to left), \text{g}(x \to right))$ for all non leaf nodes and store 0 for all leaf nodes and return 1. BST being balanced, with n leaf nodes we can have total 2n nodes and complexity of tree traversal is linear in number of nodes- $\Theta(n)$.

But this is just computing the time complexity of $g(x)$ for each node- not exactly what is asked in question.

Actually the procedure I gave is computing the **COST of** computing the value of $g(x)$ which would have been correct had the question been defined as

$$g(x) = \min\left(\begin{matrix}\text{number of leaf-nodes} \\ \text{in left-subtree of x}\end{matrix}, \begin{matrix}\text{number of leaf-nodes} \\ \text{in right-subtree of x}\end{matrix}\right).$$

The correct answer for this would be $\Theta(n \log n)$ as at each level, the cost is $\Theta(n)$ and we have $\log n$ levels since the tree is balanced.

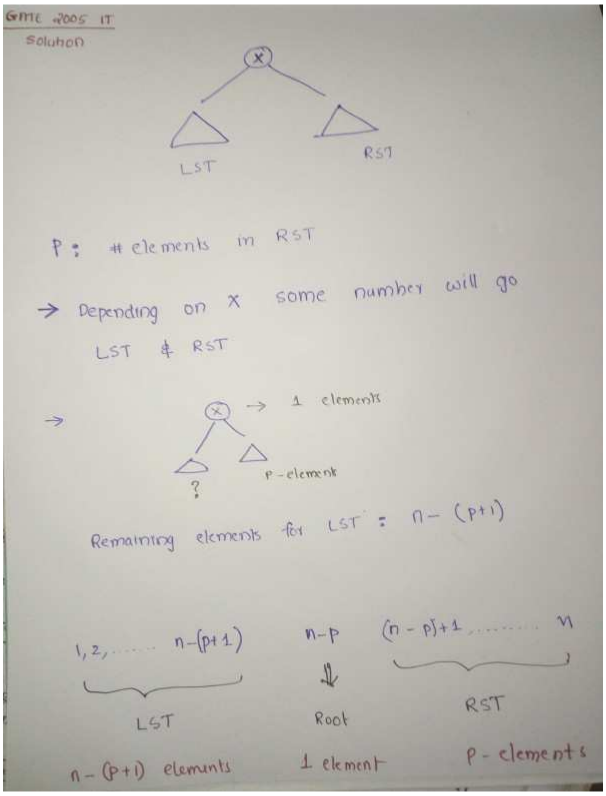
12 votes -- Arjun Suresh (294k points)

3.3.10 Binary Search Tree: GATE2005-IT-12 top

http://gateoverflow.in/3757

Selected Answer

Option c



18 votes -- pC (21.4k points)

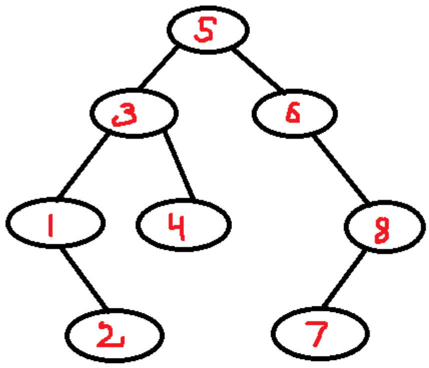
from 1,...n elements p elements are on the right. so root or first inserted will be at n-p

12 votes -- Sankaranarayanan P.N (11.2k points)

3.3.11 Binary Search Tree: GATE2005-IT-55 top http://gateoverflow.in/3816

Selected Answer

Answer is D.



15 votes -- Gate Keeda (19.1k points)

3.3.12 Binary Search Tree: GATE2006-IT-45 top http://gateoverflow.in/3588

Selected Answer

in option C search sequence progress in ...47,68,43,..

at 47 we see that search key 55 is greater and it will be on right side of 47. so in further comparison a value less than 47 will not come

hence option c is wrong

17 votes -- Sankaranarayanan P.N (11.2k points)

3.3.13 Binary Search Tree: GATE2007-IT-29 top http://gateoverflow.in/3462

Selected Answer

10, 20, 40, 50, 70 80, 90

In BST search we if we go from say 10 to 40 while searching for 60, we will never encounter 20. So, 10, 20, 40 and 50 visited, means they are visited in order. Similarly, 90, 80 and 70 are visited in order. So, our required answer will be

$$\frac{\text{No. of possible permutations of 7 numbers}}{\text{No. of possible permutations of numbers smaller than 60} \times \text{No. of possible permutations of numbers larger than 60}}$$

(Since only one permutation is valid for both the smaller set of numbers as well as larger set of numbers)

$= \frac{7!}{4!3!}$

$= 35$

45 votes -- Arjun Suresh (294k points)

Question is similar to this question : http://gateoverflow.in/1275/gate2007_84-85

We will convert Moves to Text.
It is given that During Search we have **Traversed** these nodes

$$\{10, 20, 40, 50, 70, 80, 90\}$$

as it can be seen that Red ones are bigger than 60 and blue ones are smaller than 60.

Path to node 60 has involved those nodes. So, one of the possible solution to the problem is

$$\{L, L, L, S, S, S, S\}$$

any other solution will contains these moves only. coz at a time on a node we can get directions as S(meaning 60 is smaller) or L(meaning 60 is larger) on comparison and since its given that those nodes were encountered it means directions were picked from that set.

Hence, total number of possible solutions = all Permutations of that set, which is given by $\frac{7!}{4! \times 3!} = 35$

answer = **option A**

13 votes -- Amar Vashishth (28.7k points)

3.3.14 Binary Search Tree: GATE2008-46 top

http://gateoverflow.in/458

Selected Answer

Last element in post order is the root of tree- find this element in inorder-$\log n$ time.
Now as in quick sort consider this as pivot and split the post order array into 2- possible because all elements smaller than pivot goes to left and all elements larger than pivot goes to right and suppose we have x elements smaller than pivot, these elements will be same in both inorder as well as postorder (order may change). We already got the root, now left child is the left split and right child is the right split.

So, doing this recursively gives time complexity of this approach as

$$T(n) = T(k) + T(n-k-1) + \log n$$

Solving would give $T(n) = O(n \log n)$ in worst case, by putting $k = 0$ and shown at bottom.

But searching for an element in the inorder traversal of given BST can be done in $O(1)$ because we have n elements from $1..n$ so there is no need to search for an element- if last element in post order is say 5 we take it as root and since 4 elements (1..4) are smaller we split the post order array in to two- (first 4 elements), (6th element onward) and solve recursively. Time complexity for this would be

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

which gives $T(n) = O(n)$.

Since we know that all elements must be traversed at least once, $T(n) = \Omega(n)$ also and so

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

The following code is doing this.

```
//Install graphviz (sudo apt-get install graphviz on Ubuntu) to view output tree
#include<stdio.h>
#include<stdlib.h>
struct tree
{
    struct tree* left;
    struct tree* right;
    int x;
};
struct tree* makenode(int x)
{
    struct tree * root =  malloc(sizeof(struct tree));
    root -> x = x;
    root -> left = root -> right = NULL;
    return root;
}

struct tree* makeBST(int *post, int start, int n, int inorder){
    if(n <= 0)
            return NULL;
    int pivot = post[start + n -1];
    struct tree * root = makenode(pivot);
    root -> left = makeBST(post, start, pivot-1 - inorder, inorder );
    root -> right = makeBST(post, pivot - inorder - 1, n - (pivot - inorder), pivot);
    return root;
}
void preorder(struct tree* node)
{
    if(node == NULL)
        return;
    printf("%d ", node->x);
    preorder(node->left);
    preorder(node->right);
}
void printdot(struct tree* node, FILE * f)
{
    if(node == NULL)
        return;
    if(node-> left != NULL)
    {
        fprintf(f, "%d -- %d;\n", node->x, node->left->x);
    }
    if(node-> right != NULL)
    {
        fprintf(f, "%d -- %d;\n", node->x, node->right->x);
    }
    printdot(node->left, f);
    printdot(node->right, f);
}

int main(){
    int i, n, *a;
    printf("Enter n: ");
    scanf("%d", &n);
    a = malloc(n * sizeof(int));
    printf ("Enter post order traversal: ");
    for(i = 0; i < n; i++)
    {
        scanf("%d", &a[i]);
    }
    struct tree * tree = makeBST(a, 0, n, 0);
    printf("Pre order traversal is : ");
    preorder(tree);
    printf("\n");
    FILE * f = fopen("tree.dot", "w");
    fprintf(f, "graph tree { \n");
    printdot(tree, f);
    fprintf(f, "}\n");
    fclose(f);

    #if defined(__linux__) || (defined(__APPLE__) && defined(__MACH__) || (defined (__gnu_linux__)) )
        system("dot -Tpng tree.dot -o output.png; eog output.png");
    #endif

}
```

$$T(n) = T(k) + T(n-k-1) + \log n$$

Solving would give $T(n) = O(n \log n)$, by putting $k = 0$,
$T(n) = T(0) + T(n-1) + \log n, \implies T(n) = O(1) + \log n + \log(n-1) + \log(n-2) + \cdots + \log 1 \implies T(n) = n + \mathrm{l}$

(Stirling's Approximation)

👍 29 votes -- Arjun Suresh (294k points)

3.3.15 Binary Search Tree: GATE2008-IT-12 top

http://gateoverflow.in/3272

Selected Answer

A) is true as AVL tree is a balanced search tree that has time complexity of searching $\Theta(\log n)$, but in binary search tree, we can have a completely left/right skewed tree, in which search is $O(n)$.

👍 13 votes -- Happy Mittal (10.9k points)

3.3.16 Binary Search Tree: GATE2008-IT-71 top

http://gateoverflow.in/3385

Selected Answer

Answer: D

I. no need to go from 285 to 376 as 273 is less than 285.

II. no need to go from 381 to 472 as 273 is less than 381.

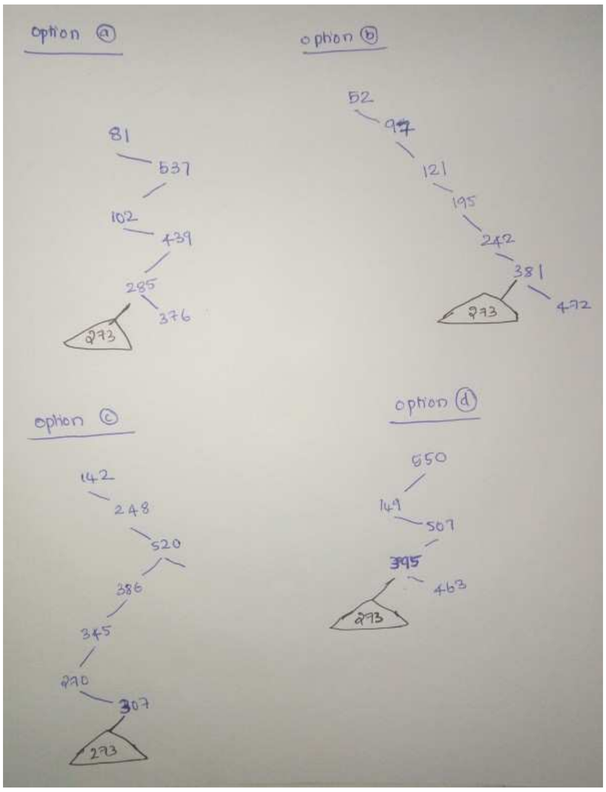
IV. no need to go from 395 to 463 as 273 is less than 395.

👍 20 votes -- Rajarshi Sarkar (35k points)

Option D

Which all of the above sequences list nodes in the order in which we could have encountered them in the search?

Question goes like this . IF there had been **273** in the actaul sequence then which of the following search sequences would have been successfull.



In sequence 1 no need to go from 285 to 376 as 273 is less than 285.

In sequence 2 no need to go from 381 to 472 as 273 is less than 381.

In sequence 4 no need to go from 395 to 463 as 273 is less than 395.

In sequence 3 number 273 might have been to left of 307 and seach would have been successfull . Hence**Option D**

10 votes -- pC (21.4k points)

3.3.17 Binary Search Tree: GATE2008-IT-72 top http://gateoverflow.in/3386

Selected Answer

A) Incorrect because I & IV are not in ascending order.(Inoder sequence of BST is in increasing order)

B)I is a preorder sequence of some BST with 439 as the root . False because if 439 is root, it should be first element in preorder.

D) IV is a postorder sequence of some BST with 149 as the root, False because if 149 is root, it should be last element in postorder

C) This is correct.

13 votes -- Akash (43.8k points)

3.3.18 Binary Search Tree: GATE2008-IT-73 top http://gateoverflow.in/3387

Selected Answer

for distinct bst we apply this formula

C(2n,n) /n+1

n=3 here so C(6,3)=20

abd 20/4=5

so ans is 5

17 votes -- Abhimanyu Kumar (189 points)

3.3.19 Binary Search Tree: GATE2009-37 top http://gateoverflow.in/1323

Selected Answer

Answer is B.
With 1 node height is 0.

Max height will come when each level contain min nodes.

Minimum Nodes in an AVL tree with height n is H(n) = H(n-1) + H(n-2) + 1.
H(0) = 1.
H(1) = 2
H(2) = H(1) + H(0) + 1 = 2+1+1 = 4
H(3) = H(2) + H(1) +1 = 4+2+1 = 7.
So the max height with 7 nodes is 3.

23 votes -- Gate Keeda (19.1k points)

3.3.20 Binary Search Tree: GATE2012-5 top http://gateoverflow.in/37

Selected Answer

Binary search takes $\Theta(\log n)$ for n elements in the worst case. So, with $(n2^n)$ elements, the worst case time will be

$\Theta(\log(n2^n))$

$= \Theta(\log n + \log 2^n)$

$= \Theta(\log n + n)$

$= \Theta(n)$

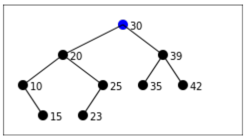
👍 21 votes -- Arjun Suresh (294k points)

3.3.21 Binary Search Tree: GATE2013-43 top http://gateoverflow.in/1554

Selected Answer

Since it is a binary search tree, its inorder traversal produces a sorted sequence i.e. 10, 15, 20, 23, 25, 30, 35, 39, 42.

Now given inorder and preorder traversals, we get following tree :



From this, we can give postorder traversal sequence as 15,10,23,25,20,35,42,39,30 i.e. option (D).

👍 16 votes -- Happy Mittal (10.9k points)

3.3.22 Binary Search Tree: GATE2013_7 top http://gateoverflow.in/1416

Selected Answer

Option (C) is True .
Suppose that we need to insert a node z such that k = key[z]. Using binary search we find a nil such that replacing it by z does not break the BST-property

BST-Insert(x, z, k)

```
: if x = nil then return "Error"
: y ← x
: while true do {
: if key[y] < k
: then z ← left[y]
: else z ← right[y]
: if z = nil break
: }
: if key[y] > k then left[y] ← z
: else right[p[y]] ← z
```

Time Complexity Analysis :

1. Best Case = O(1) , When it is smallest/greatest element and BST contains only all greater/smaller element than inserting element respectively.
2. Avg Case = O(log n) , When it belongs between some elements .
3. Worst Case = O(n) , When it is smallest/greatest element and BST contains only all smaller/greater element than inserting element respectively.

👍 14 votes -- Bhagirathi Nayak (13.3k points)

Since, in worst case the tree can grow upto the height of n (skewed tree), therefore tightest upper bound is $O(n)$

So, answer is (C)

11 votes -- Dhananjay (995 points)

3.3.23 Binary Search Tree: GATE2014-3-39 top http://gateoverflow.in/2073

Selected Answer

In worst case for finding L and H it will take $O(\log n)$ time as the given tree is **balanced** binary search tree.
Now there are m elements between L and H. So to traverse m element it will take $O(m)$ time (traversal algorithm given below). So, total

$$O(m + \log n) \implies a = 0, b = 1, c = 1, d = 0$$
$$\therefore 0 + (10 \times 1) + (100 \times 1) + (1000 \times 0) = 110 .$$

To find all the numbers from L to H we can do an inorder traversal from root and discard all elements before L and after H. But this has $O(n)$ time complexity. So, we can do a modification to inorder traversal and combine with binary search as follows:

1. Find L using binary search and keep all nodes encountered in the search in a stack.
2. After finding L add it to stack as well and initialize sum = 0.
3. Now, for all nodes in stack, do an inorder traversal starting from their right node and adding the node value to sum. If H is found, stop the algorithm.

33 votes -- Kalpish Singhal (2.1k points)

3.3.24 Binary Search Tree: GATE2015-1_10 top http://gateoverflow.in/8129

Selected Answer

Quick Solution
Inorder traversal of key are always in ascending order.

So Here I & IV th sequence are in ascending order so Option A is Ans.

6 votes -- Rajesh Pradhan (18.6k points)

3.3.25 Binary Search Tree: GATE2015-1_23 top http://gateoverflow.in/8221

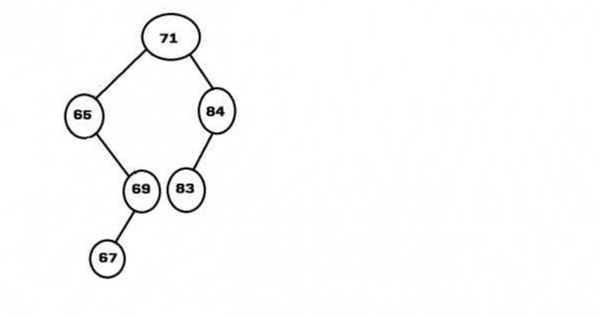
Selected Answer

option b, both happens when the BST is skewed.

18 votes -- GATERush (1.2k points)

3.3.26 Binary Search Tree: GATE2015-3_13 top http://gateoverflow.in/8409

Selected Answer



on last level 67 , hence option B is True.

👍 12 votes -- Bran Stark (391 points)

3.3.27 Binary Search Tree: GATE2017-1-6 top http://gateoverflow.in/118286

Selected Answer

Min height of a binary tree is given by $\log_2(n+1)-1=4-1=3$

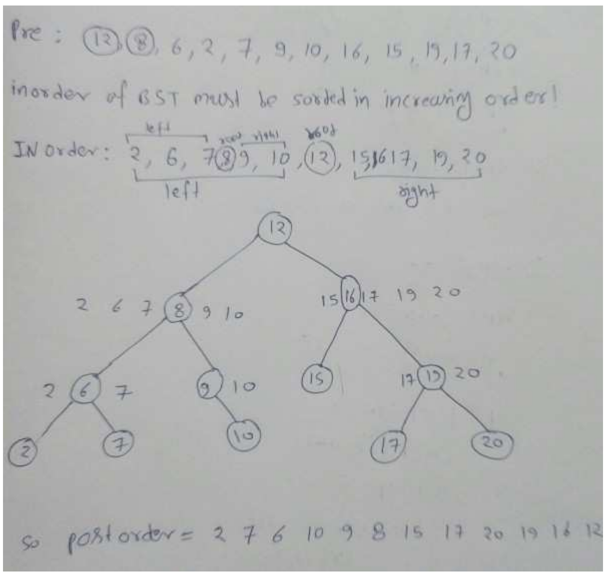
max height of the binary tree is n - 1(skewed binary tree= 15 - 1 =14

Ans:B)3,14

👍 6 votes -- Arnabi (6.4k points)

3.3.28 Binary Search Tree: GATE2017-2-36 top http://gateoverflow.in/118378

Selected Answer



so ans is B

👍 3 votes -- 2018 (5.2k points)

3.3.29 Binary Search Tree: TIFR2010-B-26 top http://gateoverflow.in/18749

$O(\log n)$ comparisons and $O(\log n)$ additions. The algorithm is :

1. Find a and b : This will take $O(\log n)$ comparisons as tree is balanced BST.

2. Follow path from a to b, and along the path, keep adding the required number of nodes to result by looking at number stored at each node. Path length is $O(\log n)$, hence number of additions will also be $O(\log n)$.

4 votes -- Happy Mittal (10.9k points)

3.4 Binary Tree(47) top

3.4.1 Binary Tree: GATE 2016-2-36 top http://gateoverflow.in/39597

Consider the following New-order strategy for traversing a binary tree:

- Visit the root;
- Visit the right subtree using New-order;
- Visit the left subtree using New-order;

The New-order traversal of the expression tree corresponding to the reverse polish expression

```
3 4 * 5 - 2 ^ 6 7 * 1 + -
```

is given by:

A. + - 1 6 7 * 2 ^ 5 - 3 4 *
B. - + 1 * 6 7 ^ 2 - 5 * 3 4
C. - + 1 * 7 6 ^ 2 - 5 * 4 3
D. 1 7 6 * + 2 5 4 3 * - ^ -

gate2016-2 data-structure binary-tree normal

Answer

3.4.2 Binary Tree: GATE1987-2c top http://gateoverflow.in/80579

State whether the following statements are TRUE or FALSE:

It is possible to construct a binary tree uniquely whose pre-order and post-order traversals are given

gate1987 binary-tree data-structure

Answer

3.4.3 Binary Tree: GATE1987-2g top http://gateoverflow.in/80588

State whether the following statements are TRUE or FALSE:

If the number of leaves in a tree is not a power of 2, then the tree is not a binary tree.

gate1987 data-structure binary-tree

Answer

3.4.4 Binary Tree: GATE1987-7b top http://gateoverflow.in/82427

Construct a binary tree whose preorder traversal is

- K L N M P R Q S T

and inorder traversal is

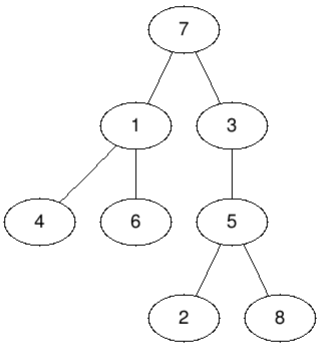
- N L K P R M S Q T

gate1987 data-structure binary-tree

Answer

3.4.5 Binary Tree: GATE1991-1,ix top http://gateoverflow.in/502

If the binary tree in figure is traversed in inorder, then the order in which the nodes will be visited is ______

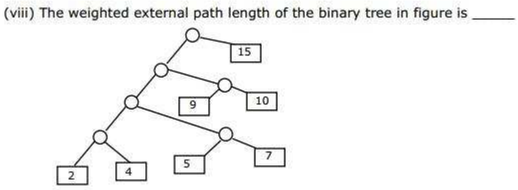


gate1991 algorithms binary-tree easy

Answer

3.4.6 Binary Tree: GATE1991_01,viii top http://gateoverflow.in/506

The weighted external path length of the binary tree in figure is ______

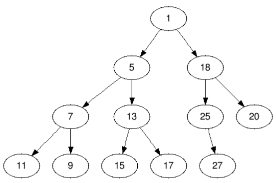


gate1991 binary-tree data-structure normal

Answer

3.4.7 Binary Tree: GATE1991_14,a top http://gateoverflow.in/541

Consider the binary tree in the figure below:



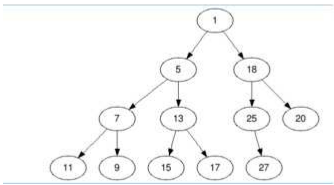
(a). What structure is represented by the binary tree?

gate1991 data-structure binary-tree time-complexity normal

Answer

3.4.8 Binary Tree: GATE1991_14,b top http://gateoverflow.in/43026

Consider the binary tree in the figure below:



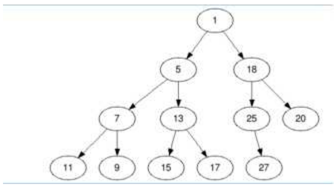
Give different steps for deleting the node with key 5 so that the structure is preserved.

gate1991 data-structure binary-tree normal

Answer

3.4.9 Binary Tree: GATE1991_14,c top http://gateoverflow.in/43027

Consider the binary tree in the figure below:



Outline a procedure in Pseudo-code to delete an arbitrary node from such a binary tree with n nodes that preserves the structures. What is the worst-case-time-complexity of your procedure?

gate1991 normal data-structure binary-tree time-complexity

Answer

3.4.10 Binary Tree: GATE1993_16 top http://gateoverflow.in/2313

Prove by the principal of mathematical induction that for any binary tree, in which every non-leaf node has 2-descendants, the number of leaves in the tree is one more than the number of non-leaf nodes.

gate1993 data-structure binary-tree normal

Answer

3.4.11 Binary Tree: GATE1994_8 top http://gateoverflow.in/2504

A rooted tree with 12 nodes has its nodes numbered 1 to 12 in pre-order. When the tree is traversed in post-order, the nodes are visited in the order 3, 5, 4, 2, 7, 8, 6, 10, 11, 12, 9, 1.

Reconstruct the original tree from this information, that is, find the parent of each node, and show the tree diagrammatically.

gate1994 data-structure binary-tree normal

Answer

3.4.12 Binary Tree: GATE1995_1.17 top http://gateoverflow.in/2604

A binary tree T has n leaf nodes. The number of nodes of degree 2 in T is

A. $\log_2 n$
B. $n-1$
C. n
D. 2^n

gate1995 data-structure binary-tree normal

Answer

3.4.13 Binary Tree: GATE1995_6 top http://gateoverflow.in/2667

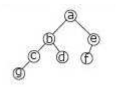
What is the number of binary trees with 3 nodes which when traversed in post-order give the sequence A, B, C? Draw all these binary trees.

gate1995 data-structure binary-tree normal

Answer

3.4.14 Binary Tree: GATE1996_1.14 top http://gateoverflow.in/2718

In the balanced binary tree in the below figure, how many nodes will become unbalanced when a node is inserted as a child of the node “g”?



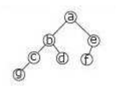
A. 1
B. 3
C. 7
D. 8

gate1996 data-structure binary-tree normal

Answer

3.4.15 Binary Tree: GATE1996_1.15 top http://gateoverflow.in/2719

Which of the following sequences denotes the post order traversal sequence of the below tree?



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

gate1996 data-structure binary-tree easy

Answer

3.4.16 Binary Tree: GATE1997-4.5 top http://gateoverflow.in/2246

A binary search tree contains the value 1, 2, 3, 4, 5, 6, 7, 8. The tree is traversed in pre-order and the values are printed out. Which of the following sequences is a valid output?

A. 5 3 1 2 4 7 8 6
B. 5 3 1 2 6 4 8 7
C. 5 3 2 4 1 6 7 8
D. 5 3 1 2 4 7 6 8

gate1997 data-structure binary-tree normal

Answer

3.4.17 Binary Tree: GATE1997_16 top http://gateoverflow.in/2276

A size-balanced binary tree is a binary tree in which for every node the difference between the number of nodes in the left and right subtree is at most 1. The distance of a node from the root is the length of the path from the root to the node. The height of a binary tree is the maximum distance of a leaf node from the root.

a. Prove, by using induction on h, that a size-balance binary tree of height h contains at least 2^h nodes.

b. In a size-balanced binary tree of height $h \leq 1$, how many nodes are at distance $h - 1$ from the root? Write only the answer without any explanations.

gate1997 data-structure binary-tree normal

Answer

3.4.18 Binary Tree: GATE1998_20 top

http://gateoverflow.in/1734

Draw the binary tree with node labels $\text{a, b, c, d, e, f and g}$ for which the inorder and postorder traversals result in the following sequences:

Inorder: a f b c d g e

Postorder: a f c g e d b

gate1998 data-structure binary-tree descriptive

Answer

3.4.19 Binary Tree: GATE2000-1.14 top

http://gateoverflow.in/637

Consider the following nested representation of binary trees: (X Y Z) indicates Y and Z are the left and right subtrees, respectively, of node X. Note that Y and Z may be NULL, or further nested. Which of the following represents a valid binary tree?

A. (1 2 (4 5 6 7))
B. (1 (2 3 4) 5 6) 7)
C. (1 (2 3 4) (5 6 7))
D. (1 (2 3 NULL) (4 5))

gate2000 data-structure binary-tree easy

Answer

3.4.20 Binary Tree: GATE2000-2.16 top

http://gateoverflow.in/663

Let LASTPOST, LASTIN and LASTPRE denote the last vertex visited `in a postorder, inorder and preorder traversal respectively, of a complete binary tree. Which of the following is always true?

A. LASTIN = LASTPOST
B. LASTIN = LASTPRE
C. LASTPRE = LASTPOST
D. None of the above

gate2000 data-structure binary-tree normal

Answer

3.4.21 Binary Tree: GATE2002-2.12 top

http://gateoverflow.in/842

A weight-balanced tree is a binary tree in which for each node, the number of nodes in the left sub tree is at least half and at most twice the number of nodes in the right sub tree. The maximum possible height (number of nodes on the path from the root to the furthest leaf) of such a tree on n nodes is best described by which of the following?

A. $\log_2 n$
B. $\log_{\frac{4}{3}} n$
C. $\log_3 n$
D. $\log_{\frac{3}{2}} n$

gate2002 data-structure binary-tree normal

Answer

3.4.22 Binary Tree: GATE2002-6 top

http://gateoverflow.in/859

Draw all binary trees having exactly three nodes labeled A, B and C on which preorder traversal gives the sequence C, B, A.

gate2002 data-structure binary-tree easy descriptive

Answer

3.4.23 Binary Tree: GATE2004-35 top http://gateoverflow.in/1032

Consider the label sequences obtained by the following pairs of traversals on a labeled binary tree. Which of these pairs identify a tree uniquely?

I. preorder and postorder

II. inorder and postorder

III. preorder and inorder

IV. level order and postorder

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

gate2004 data-structure binary-tree normal

Answer

3.4.24 Binary Tree: GATE2004-43 top http://gateoverflow.in/1040

Consider the following C program segment

```
struct CellNode{
    struct CellNode *leftChild
    int element;
    struct CellNode *rightChild;
    };

int Dosomething (struct CellNode *ptr)
{
    int value = 0;
    if(ptr != NULL)
    {
        if (ptr -> leftChild != NULL)
            value = 1 + DoSomething (ptr -> leftChild);
        if (ptr -> rightChild != NULL)
            value = max(value, 1 + Dosomething (ptr -> rightChild));
    }
    return(value);
}
```

The value returned by the function DoSomething when a pointer to the root of a non-empty tree is passed as argument is

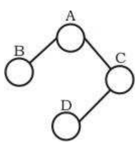
A. The number of leaf nodes in the tree
B. The number of nodes in the tree
C. The number of internal nodes in the tree
D. The height of the tree

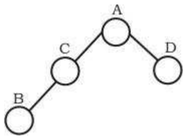
gate2004 data-structure binary-tree normal

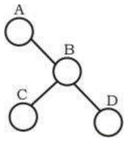
Answer

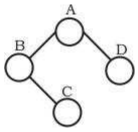
3.4.25 Binary Tree: GATE2004-IT-54 top http://gateoverflow.in/3697

Which one of the following binary trees has its inorder and preorder traversals as BCAD and ABCD, respectively?

A. 

B. 

C. 

D. 

gate2004-it binary-tree easy

Answer

3.4.26 Binary Tree: GATE2005-33 top http://gateoverflow.in/1369

Postorder traversal of a given binary search tree, T produces the following sequence of keys

10, 9, 23, 22, 27, 25, 15, 50, 95, 60, 40, 29

Which one of the following sequences of keys can be the result of an in-order traversal of the tree T?

A. 9, 10, 15, 22, 23, 25, 27, 29, 40, 50, 60, 95

B. 9, 10, 15, 22, 40, 50, 60, 95, 23, 25, 27, 29

C. 29, 15, 9, 10, 25, 22, 23, 27, 40, 60, 50, 95

D. 95, 50, 60, 40, 27, 23, 22, 25, 10, 9, 15, 29

gate2005 data-structure binary-tree easy

Answer

3.4.27 Binary Tree: GATE2005-IT-50 top http://gateoverflow.in/3811

In a binary tree, for every node the difference between the number of nodes in the left and right subtrees is at most 2. If the height of the tree is h > 0, then the minimum number of nodes in the tree is

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

gate2005-it data-structure binary-tree normal

Answer

3.4.28 Binary Tree: GATE2006-13 top http://gateoverflow.in/974

A scheme for storing binary trees in an array X is as follows. Indexing of X starts at 1 instead of 0. the root is stored at X[1]. For a node stored at X[i], the left child, if any, is stored in X[2i] and the right child, if any, in X[2i+1]. To be able to store any binary tree on n vertices the minimum size of X should be

A. $\log_2 n$
B. n
C. $2n+1$
D. $2^n - 1$

gate2006 data-structure binary-tree normal

Answer

3.4.29 Binary Tree: GATE2006-IT-71 top http://gateoverflow.in/3615

An array X of n distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0. The index of the parent of element $X[i], i \neq 0$, is?

A. $\left\lfloor \frac{i}{2} \right\rfloor$

B. $\left\lceil \frac{i-1}{2} \right\rceil$

C. $\left\lceil \frac{i}{2} \right\rceil$

D. $\left\lceil \frac{i}{2} \right\rceil - 1$

gate2006-it data-structure binary-tree normal

Answer

3.4.30 Binary Tree: GATE2006-IT-73 top http://gateoverflow.in/3617

An array X of n distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0. If the root node is at level 0, the level of element X[i], i ≠ 0, is

A. $\lfloor \log_2 i \rfloor$
B. $\lceil \log_2 (i + 1) \rceil$
C. $\lfloor \log_2 (i + 1) \rfloor$
D. $\lceil \log_2 i \rceil$

gate2006-it data-structure binary-tree normal

Answer

3.4.31 Binary Tree: GATE2006-IT-9 top http://gateoverflow.in/3548

In a binary tree, the number of internal nodes of degree 1 is 5, and the number of internal nodes of degree 2 is 10. The number of leaf nodes in the binary tree is

A. 10
B. 11
C. 12
D. 15

gate2006-it data-structure binary-tree normal

Answer

3.4.32 Binary Tree: GATE2007-12 top http://gateoverflow.in/1210

The height of a binary tree is the maximum number of edges in any root to leaf path. The maximum number of nodes in a binary tree of height h is:

A. $2^h - 1$

B. $2^{h-1} - 1$

C. $2^{h+1} - 1$

D. 2^{h+1}

gate2007 data-structure binary-tree easy

Answer

3.4.33 Binary Tree: GATE2007-13 top http://gateoverflow.in/1211

The maximum number of binary trees that can be formed with three unlabeled nodes is:

A. 1
B. 5
C. 4
D. 3

gate2007 data-structure binary-tree normal

Answer

3.4.34 Binary Tree: GATE2007-39, UGCNET-June2015-II-22 top http://gateoverflow.in/1237

The inorder and preorder traversal of a binary tree are

d b e a f c g and a b d e c f g, respectively

The postorder traversal of the binary tree is:

A. d e b f g c a
B. e d b g f c a
C. e d b f g c a
D. d e f g b c a

gate2007 data-structure binary-tree normal ugcnetjune2015ii

Answer

3.4.35 Binary Tree: GATE2007-46 top http://gateoverflow.in/1244

Consider the following C program segment where CellNode represents a node in a binary tree:

```
struct CellNode {
    struct CellNode *leftChild;
    int element;
    struct CellNode *rightChild;
};

int Getvalue (struct CellNode *ptr) {
    int value = 0;
    if (ptr != NULL) {
        if ((ptr->leftChild == NULL) &&
             (ptr->rightChild == NULL))
            value = 1;
        else
            value = value + GetValue(ptr->leftChild)
                          + GetValue(ptr->rightChild);
    }
    return(value);
}
```

The value returned by GetValue when a pointer to the root of a binary tree is passed as its argument is:

A. the number of nodes in the tree
B. the number of internal nodes in the tree
C. the number of leaf nodes in the tree
D. the height of the tree

gate2007 data-structure binary-tree normal

Answer

3.4.36 Binary Tree: GATE2008-IT-46 top http://gateoverflow.in/3356

The following three are known to be the preorder, inorder and postorder sequences of a binary tree. But it is not known which is which.

I. MBCAFHPYK
II. KAMCBYPFH
III. MABCKYFPH

Pick the true statement from the following.

A. I and II are preorder and inorder sequences, respectively
B. I and III are preorder and postorder sequences, respectively
C. II is the inorder sequence, but nothing more can be said about the other two sequences
D. II and III are the preorder and inorder sequences, respectively

gate2008-it data-structure normal binary-tree

Answer

3.4.37 Binary Tree: GATE2008-IT-76 top

http://gateoverflow.in/3390

A binary tree with n > 1 nodes has n_1, n_2 and n_3 nodes of degree one, two and three respectively. The degree of a node is defined as the number of its neighbours.

n_3 can be expressed as

A. $n_1 + n_2 - 1$
B. $n_1 - 2$
C. $[((n_1 + n_2)/2)]$
D. $n_2 - 1$

gate2008-it data-structure binary-tree normal

Answer

3.4.38 Binary Tree: GATE2008-IT-77 top

http://gateoverflow.in/3391

A binary tree with n > 1 nodes has n_1, n_2 and n_3 nodes of degree one, two and three respectively. The degree of a node is defined as the number of its neighbours.

Starting with the above tree, while there remains a node v of degree two in the tree, add an edge between the two neighbours of v and then remove v from the tree. How many edges will remain at the end of the process?

A. $2 * n_1 - 3$
B. $n_2 + 2 * n_1 - 2$
C. $n_3 - n_2$
D. $n_2 + n_1 - 2$

gate2008-it data-structure binary-tree normal

Answer

3.4.39 Binary Tree: GATE2010-10 top

http://gateoverflow.in/2183

In a binary tree with n nodes, every node has an odd number of descendants. Every node is considered to be its own descendant. What is the number of nodes in the tree that have exactly one child?

A. 0
B. 1
C. $\frac{(n-1)}{2}$
D. $n-1$

gate2010 data-structure binary-tree normal

Answer

3.4.40 Binary Tree: GATE2012-47 top

http://gateoverflow.in/2163

The height of a tree is defined as the number of edges on the longest path in the tree. The function shown in the pseudo-code below is invoked as height(root) to compute the height of a binary tree rooted at the tree pointer root.

```
int height (treeptr n)
{ if (n == NULL) return -1;
  if (n → left == NULL)
      if (n → right == NULL) return 0;

      else return  B1  ;                         // Box 1

  else { h1 = height (n → left);
         if (n → right == NULL) return (1+h1);
         else { h2 = height (n → right);

                return  B2  ;                    // Box 2
               }
       }
}
```

A. **B1**: $(1 + \text{height}(n \rightarrow \text{ right}))$; **B2**: $(1 + \max(h1, h2))$
B. **B1**: $(\text{height}(n \rightarrow \text{ right}))$; **B2**: $(1 + \max(h1, h2))$
C. **B1**: $\text{height}(n \rightarrow \text{ right})$; **B2**: $\max(h1, h2)$
D. **B1**: $(1 + \text{height}(n \rightarrow \text{ right}))$; **B2**: $\max(h1, h2)$

gate2012 data-structure binary-tree normal

Answer

3.4.41 Binary Tree: GATE2014-1-12 top

http://gateoverflow.in/1776

Consider a rooted n node binary tree represented using pointers. The best upper bound on the time required to determine the number of subtrees having exactly 4 nodes is $O(n^a \log^b n)$. Then the value of $a + 10b$ is ________.

gate2014-1 data-structure binary-tree numerical-answers normal

Answer

3.4.42 Binary Tree: GATE2015-1_25 top

http://gateoverflow.in/8223

The height of a tree is the length of the longest root-to-leaf path in it. The maximum and minimum number of nodes in a binary tree of height 5 are

A. 63 and 6, respectively
B. 64 and 5, respectively
C. 32 and 6, respectively
D. 31 and 5, respectively

gate2015-1 data-structure binary-tree easy

Answer

3.4.43 Binary Tree: GATE2015-2_10 top

http://gateoverflow.in/8059

A binary tree T has 20 leaves. The number of nodes in T having two children is _______.

gate2015-2 data-structure binary-tree normal numerical-answers

Answer

3.4.44 Binary Tree: GATE2015-3_25 top

http://gateoverflow.in/8428

Consider a binary tree T that has 200 leaf nodes. Then the number of nodes in T that have exactly two children are _______.

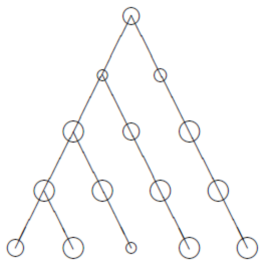
gate2015-3 data-structure binary-tree normal numerical-answers

Answer

3.4.45 Binary Tree: TIFR2013-B-13 top

http://gateoverflow.in/25775

Given a binary tree of the following form and having n nodes, the height of the tree is



a. $\Theta(\log n)$
b. $\Theta(n)$
c. $\Theta(\sqrt{n})$
d. $\Theta(n / \log n)$
e. None of the above.

tifr2013 binary-tree

Answer

3.4.46 Binary Tree: TIFR2014-B-1 top http://gateoverflow.in/27133

Let T be a rooted binary tree whose vertices are labelled with symbols $a, b, c, d, e, f, g, h, i, j, k$. Suppose the in-order (visit left subtree, visit root, visit right subtree) and post-order (visit left subtree, visit right subtree, visit root) traversals of T produce the following sequences.

in-order: $a, b, c, d, e, f, g, h, i, j, k$

post-order: $a, c, b, e, f, h, j, k, i, g, d$

How many leaves does the tree have?

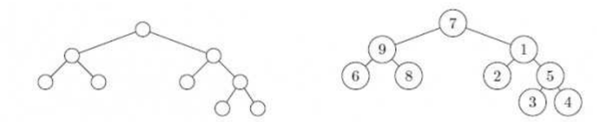
a. THREE.
b. FOUR.
c. FIVE.
d. SIX.
e. Cannot be determined uniquely from the given information.

tifr2014 binary-tree

Answer

3.4.47 Binary Tree: TIFR2015-B-4 top http://gateoverflow.in/29849

First, consider the tree on the left.



On the right, the nine nodes of the tree have been assigned numbers from the set $\{1, 2, \ldots .9\}$ so that for every node, the numbers in its left subtree and right subtree lie in disjoint intervals (that is, all numbers in one subtree are less than all numbers in the other subtree). How many such assignments are possible? Hint: Fix a value for the root and ask what values can then appear in its left and right subtrees.

A. $2^9 = 512$
B. $2^4 .3^2 .5.9 = 6480$
C. $2^3 .3.5.9 = 1080$
D. $2^4 = 16$
E. $2^3 .3^3 = 216$

tifr2015 binary-tree permutations-and-combinations

Answer

Answers: Binary Tree

3.4.1 Binary Tree: GATE 2016-2-36 top http://gateoverflow.in/39597

Selected Answer

Expression given in reverse polish notation (i,e in Post-order)

convert first it into In-order

$3\,4\,*\,5\,-\,2\,\wedge\,6\,7\,*\,1\,+\,-$

$(3*4)\,5\,-\,2\,\wedge\,6\,7\,*\,1\,+\,-$

$((3*4)-5)\,2\,\wedge\,6\,7\,*\,1\,+\,-$

$(((3*4)-5)\wedge 2)\,6\,7\,*\,1\,+\,-$

$(((3*4)-5)\wedge 2)\,(6*7)\,1\,+\,-$

$(((3*4)-5)\wedge 2)\,((6*7)+1)\,-$

$((((3*4)-5)\wedge 2)-((6*7)+1))$

so Inorder expression in $((((3*4)-5)\wedge 2)-((6*7)+1))$

New-Order traversal is as by ROOT RIGHT LEFT

$((((3*4)-5)\wedge 2)-((6*7)+1))$

$-((6*7)+1)(((3*4)-5)\wedge 2)$

$-+1(6*7)(((3*4)-5)\wedge 2)$

$-+1*7\,6(((3*4)-5)\wedge 2)$

$-+1*7\,6\wedge 2((3*4)-5)$

$-+1*7\,6\wedge 2-5(3*4)$

$-+1*7\,6\wedge 2-5*4\,3$

option C is correct

25 votes -- Praveen Saini (53.6k points)

Its quite simple actually.

Postorder: left, right, root

Neworder: Root, right, left

(left, right, root) and (Root, right, left) are reverse of each other, right ?

So, these two traversals will be exact reverse of each other! Option (c) ! Answer in few seconds, basic concept ! Observation !

30 votes -- Ashish Deshmukh (1.5k points)

3.4.2 Binary Tree: GATE1987-2c top http://gateoverflow.in/80579

Yes it is possible since we can create Binary search tree , we know every Binary search tree is binary tree also but there are many binary tree posiible , so we know that thier is many binary tree possible without inorder.

So answer is NO for this quetion

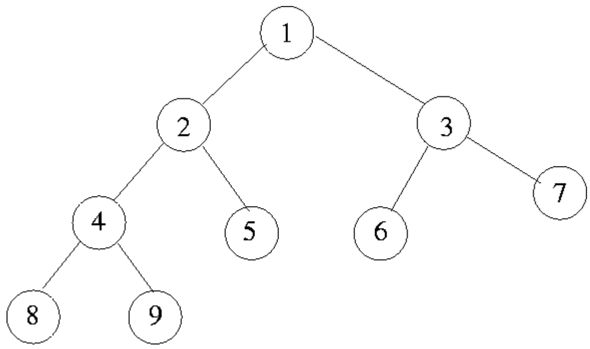
Reffer: http://www.geeksforgeeks.org/if-you-are-given-two-traversal-sequences-can-you-construct-the-binary-tree/

8 votes -- Prashant Singh (49.2k points)

3.4.3 Binary Tree: GATE1987-2g top http://gateoverflow.in/80588

Selected Answer

Condition for binary tree is atmost two immediate child for every internal node



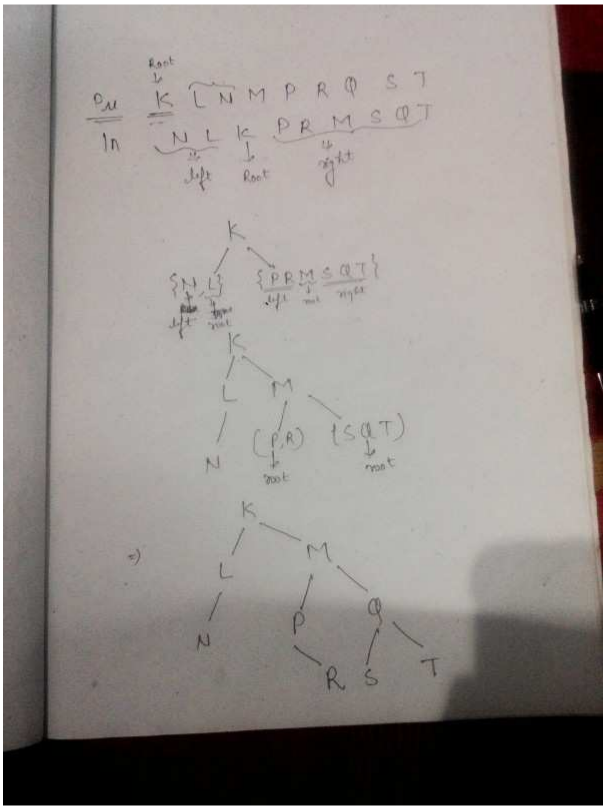
No it is not the condition for binary tree.

8 votes -- Prashant Singh (49.2k points)

3.4.4 Binary Tree: GATE1987-7b top http://gateoverflow.in/82427

Selected Answer

.....



7 votes -- kirti singh (3.4k points)

3.4.5 Binary Tree: GATE1991-1,ix top http://gateoverflow.in/502

Selected Answer

41673258

10 votes -- Keith Kr (6.3k points)

3.4.6 Binary Tree: GATE1991_01,viii top http://gateoverflow.in/506

Selected Answer

This is straightforward. The nodes of the given tree are given in square boxes. The weights associated with the nodes are the numbers example 15,9,10 etc.

Weighted path length = sigma(for(each node in the tree) (path length)*(weight of the node)).

So answer (written in **path_length*weight** form) = 4*2 + 4*4 + 4*5 + 4*7 + 3*9 + 3*10 + 1*15 =**144**

21 votes -- arvchamp (171 points)

3.4.7 Binary Tree: GATE1991_14,a top http://gateoverflow.in/541

Selected Answer

(A) This is min heap. It is obvious looking at tree.

(B) Assuming that we have stored this heap in array structure, Procedure ->

1.Search for element 5 using sequencial search in array.

2. Swap it with last element in this case 27.

3. Bubble down it so that min heap property is satisfied.

(C) Deleting element from mean heap , O(logn) , but for searching in Heap we need O(N)

SO time complexity of sequencial search + Delete = > O(N) + O(logN) = O(N).

We cant use binary search as it is heap.

15 votes -- Akash (43.8k points)

3.4.8 Binary Tree: GATE1991_14,b top

http://gateoverflow.in/43026

Selected Answer

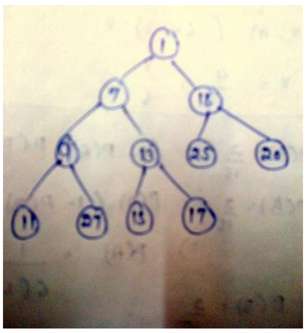
Since given Binary tree is minheap tree.

First swap 27 and 5

Then delete 5

Apply Minheapify

And Structure will be



6 votes -- Manoj Kumar (37.5k points)

3.4.9 Binary Tree: GATE1991_14,c top

http://gateoverflow.in/43027

Selected Answer

By looking at the values it is clear that It is a **Min-Heap** Data structures. We know that, Heap Data structures are stored in the array.

==> Delete procedure for Min-Heap Data Structure (If you already know value and position of the node):

1) Replace that node with the last element of that tree.

2) Apply Heapify property on that node.

For Example, Let If I want to delete 1, then I will replace that with 27. and apply heapify on that node. Or if i want to delete 5 then I will replace that with 17, and apply heapify on that node.

Time Complexity: In this case time complexity will not be more than O(log n).

==> Delete procedure for Min-Heap Data Structure (If you know the value but not position) :

1) Find the position of the number by sequential search. (In worst case it will take O(n) time).

2) Replace that node with the last element of that tree.

3) Apply heapify property at that node.

Time Complexity: Wort time complexity of this algorithm will be **O(n + log n) i.e. O(n).**

Note: This is a standard problem of Minimum element deletion from Min-heap tree. Minimum element always resides at top (Root node). We just replace that value with the last element of the tree and apply heapify at the root node. Time complexity of that algorithm is **O(Log n)**.

Here I have written second method only to show that if we have to delete any of the node, and we just know the value but not the position. Since in question it is mentioned that **Arbitrary node**.

18 votes -- Muktinath Vishwakarma (34.1k points)

3.4.10 Binary Tree: GATE1993_16 top http://gateoverflow.in/2313

Selected Answer

Base Case :- When we have just root then, there are no non leaf nodes. So No of leaves = 1, No of non leaf nodes is = 0. Base case holds.

Induction Hypothesis :- Assume that now for k internal nodes we will have k+1 leaves.

Inducting on no of leaves, Now we add 2 more leaves to this tree. One of k+1 leaf will become internal node. So now we will have k+1 internal node. No of leafs will be K+ 1 - 1(1 leaf just became internal node) + 2(New leafs) . So we proved 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.

6 votes -- Akash (43.8k points)

3.4.11 Binary Tree: GATE1994_8 top http://gateoverflow.in/2504

Selected Answer

Answer: The tree is a ternary tree.

```
          1
   _______|_______
   |       |       |
   |       |       |
   |       |       |
   2       6       9
  / \     / \     / | \
 3   4   7   8   10 11 12
     |
     5
```

6 votes -- Rajarshi Sarkar (35k points)

3.4.12 Binary Tree: GATE1995_1.17 top http://gateoverflow.in/2604

Selected Answer

In Binary Tree a node can have atmost 2 child
Total number of node =>n = node with o child + node with 1 child + node with 2 child

$n= n_0 + n_1 + n_2$

Total number of edges
e=n-1
and also $e = n_0 * 0+ n_1 *1 + n_2 * 2$

Therefore
$n-1 = n_0 * 0+ n_1 *1 + n_2 * 2$
$n_0 + n_1 + n_2 - 1 = n_1 *1 + n_2 * 2$

$n_2 = n_0 - 1$ (here leaf node is given n)
therefore
$n_2 = n - 1$
option b

👍 20 votes -- Umang Raman (15.2k points)

3.4.13 Binary Tree: GATE1995_6 top http://gateoverflow.in/2667

Selected Answer

There are only Five such binary trees.

One with C as root and left child as A and right child B.

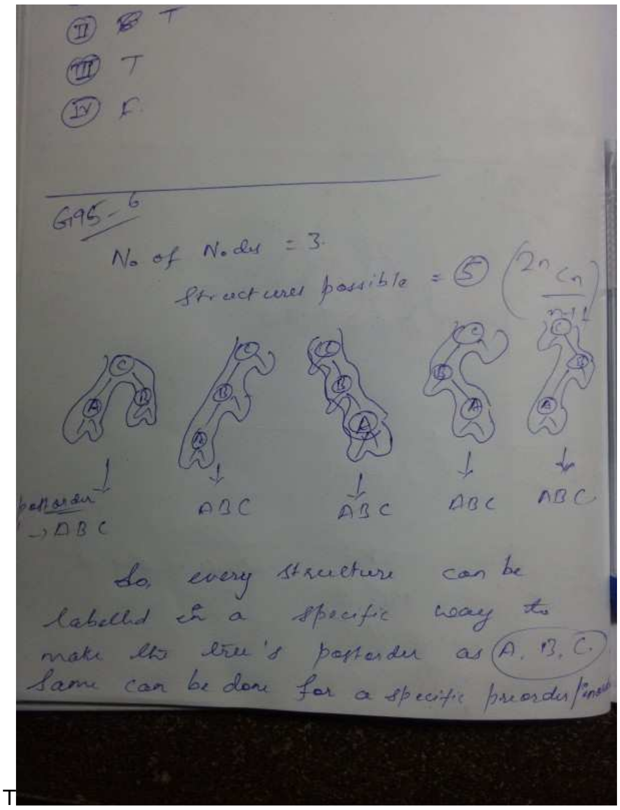
Second with C as root, B as left child and A as again left child of B.

Third with C as root, B as left child and A as right child of B.

Fourth with C as root, B as right child and A as right child of B.

Fifth with C as root, B as right child and A as left child of B.

👍 17 votes -- Gate Keeda (19.1k points)



T

Whenever only one order is asked for a tree, total no. of trees = total no. of structures possible.

👍 10 votes -- Ravi Ranjan (2.9k points)

3.4.14 Binary Tree: GATE1996_1.14 top http://gateoverflow.in/2718

Selected Answer

B.

a,b,c will become unbalanced with Balance factor as +2,+2,+2 respectively. Balance factor should be -1,0,+1.

Balance factor = Height(LST) - Height(RST).

11 votes -- Gate Keeda (19.1k points)

3.4.15 Binary Tree: GATE1996_1.15 top

http://gateoverflow.in/2719

Selected Answer

C.

Left-->Right-->Root.

Ref: http://gateoverflow.in/2718/gate1996_1-14

11 votes -- Gate Keeda (19.1k points)

3.4.16 Binary Tree: GATE1997-4.5 top

http://gateoverflow.in/2246

Selected Answer

Note:-->PreOrder means Root-Left-Right Traversal of tree.

By Option Elimination:-

B. False .Bcz. 5 is root so in preorder sequence first 5 elements must contain 1 to 5 But 6 comes here. So false.

So Now common things in option A,C,D is 5,3 means 5 root then LHS subtree root is 3 . now 3 s LHS is 1,2 so they should come first rather than 4. So option C is False.

Now Check for Option A,D

Root 5's RHS is 6,7,8 now as per Option A,D 7 is Root so 6 sud be Left and 8 should be Right so pre order for Right sub tree is 7,6,8(Root-L-R). Which satisfies option D.

11 votes -- Rajesh Pradhan (18.6k points)

Answer: D

The tree is:

```
      5
     / \
    /   \
   3     7
  / \   / \
 1   4 6   8
  \
   2
```

11 votes -- Rajarshi Sarkar (35k points)

3.4.17 Binary Tree: GATE1997_16 top

http://gateoverflow.in/2276

(a) Prove, by using induction on h, that a size-balanced binary tree of height h contains at least 2^h nodes.
When
h = 0 .... least no. of nodes = 2 ^ 0 = 1
h = 1 .... least no. of nodes = 2 ^ 1 = 2
h = 2 .... least no. of nodes = 2 ^ 2 = 4

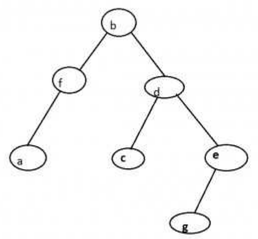
Assume that the rule is true for h = k
Then the min no. of nodes = 2 ^ k nodes
If we increase the height by 1 by adding a node, we must also add nodes to fill the (max level -1) level.
This would mean doubling the nodes
Thus 2^ (k+1)
Hence, proved

(b) In a size-balanced binary tree of height h ≥ 1, how many nodes are at distance h-1 from the root? Write only the answer
without any explanation
2^(h-1)

2 votes -- Sachin Mittal (7.1k points)

3.4.18 Binary Tree: GATE1998_20 top http://gateoverflow.in/1734

Selected Answer



binary tree

11 votes -- Anu (10.6k points)

3.4.19 Binary Tree: GATE2000-1.14 top http://gateoverflow.in/637

Selected Answer

(A) -> (4 5 6 7) this part of answer is not correct. We have (X Y Z) not (W X Y Z). SO this is wrong

(B) -> 3 closing paranthesis, 2 opening paranthesis. This is wrong.

(D) -> Here in (1 (2 3 NULL) (4 5)) , (4 5) this is not allowed. So this is wrong. (It should be (4,5,NULL))

(C) Correct ->

15 votes -- Akash (43.8k points)

3.4.20 Binary Tree: GATE2000-2.16 top http://gateoverflow.in/663

Selected Answer

The answer is D.

Take any random sequence and check for the inorder, postorder and preorder Last Node.

13 votes -- Gate Keeda (19.1k points)

Inorder : Left -> Root -> Right

Preorder : Root -> Left -> Right

Postorder: Left -> Right -> Root

If the binary tree is full (last level is fully filled), the last visited node in Inorder and Preorder must be the rightmost one in the last level. But for a complete binary tree this need not be the case (in a complete binary tree last level need not be fully filled) and LASTPRE will be from the second last level in case the complete binary tree is not full. So, choice (D).

14 votes -- Arjun Suresh (294k points)

3.4.21 Binary Tree: GATE2002-2.12 top http://gateoverflow.in/842

Selected Answer

Total number of nodes can be described by the recurrence

T(n) = T((n-1)/3)) + T(2(n-1)/3) + 1
T(1) = 1

As this makes maximum nodes go to one subtree and that is what we want to get the maximum height with a given number of nodes.

Now, the height of the tree will be

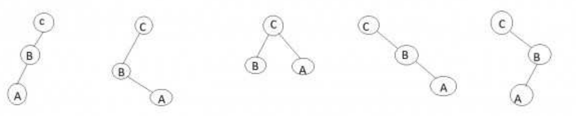
H(n) = H(2/3(n-1)) + 1
H(1) = 0

We can draw a recurrence tree and the cost at each level is 1, and the height will be $\log_{(3/2)} n$.
So, D option is the answer.

26 votes -- Arjun Suresh (294k points)

3.4.22 Binary Tree: GATE2002-6 top http://gateoverflow.in/859

Selected Answer



5 Binary trees

9 votes -- Anu (10.6k points)

3.4.23 Binary Tree: GATE2004-35 top http://gateoverflow.in/1032

Selected Answer

Following combination can uniquely identify a tree.

Inorder and Preorder.

Inorder and Postorder.

Inorder and Level-order.

And following do not.

Postorder and Preorder.

Preorder and Level-order.

Postorder and Level-order.

Answer: **B**

7 votes -- Shikhar Vashishth (5.7k points)

3.4.24 Binary Tree: GATE2004-43 top

http://gateoverflow.in/1040

Selected Answer

It calculates Height of tree. (D)

Easy way to get this answer .

Draw a tree where all 4 parameters are different.

Get a Tree for which Height, No of Internal Nodes & No of Leafs are different & Trace out this algorightm.

11 votes -- Akash (43.8k points)

3.4.25 Binary Tree: GATE2004-IT-54 top

http://gateoverflow.in/3697

Selected Answer

inorder traversal is left node right

preorder is node left right

answer: D

12 votes -- Sankaranarayanan P.N (11.2k points)

3.4.26 Binary Tree: GATE2005-33 top

http://gateoverflow.in/1369

Selected Answer

in order traversal of b binary search tree returns the element in sorted order - ascending (inorder is left parent then right. in a bst left is less than parent and right is greater than parent). In this option 1 is the only sorted list. hence it is the only possiblity

16 votes -- Sankaranarayanan P.N (11.2k points)

3.4.27 Binary Tree: GATE2005-IT-50 top

http://gateoverflow.in/3811

Selected Answer

it should be B)

Since the difference between the nodes in left and right subtree must hold for every node, until the last to last to last level, all levels must be fully filled. So, we get $2^{h-1} - 1$ nodes (No. of nodes in a complete binary tree of height $h-2$). Now, our aim is to increase two more levels by adding minimum no. of nodes- just add two in nodes one below other to any of the nodes. So, we get $2^{h-1} + 1$ nodes - B option.

17 votes -- Sneha Goel (1.2k points)

Option Elimination

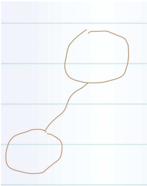
Take a tree which satisfies given constraint

and eliminate the incorrect options

h=1 n=2

Option A & C eliminated

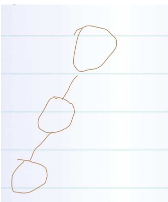
Option B,D still satisfying



In below img h=2 n=3

Here option D eliminated

So option B is Ans



14 votes -- Rajesh Pradhan (18.6k points)

3.4.28 Binary Tree: GATE2006-13 top

http://gateoverflow.in/974

Selected Answer

should be D...

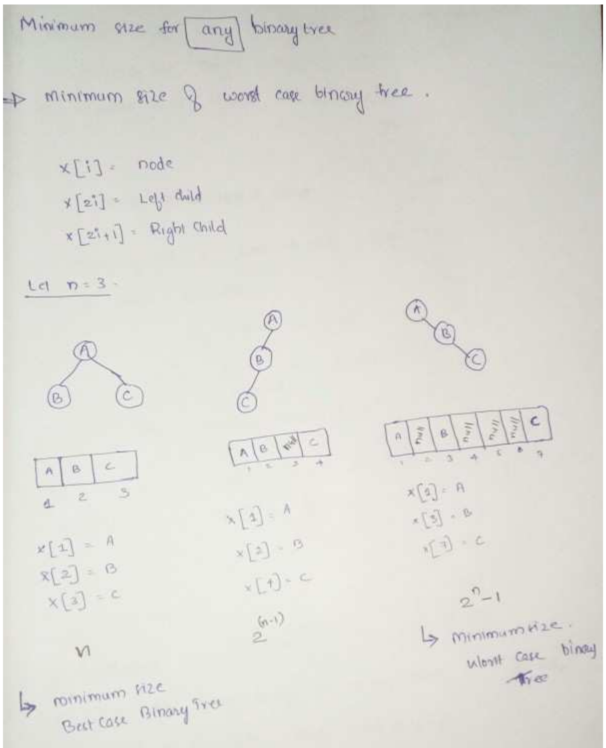
Since binary tree can be of any form, the worst case happens for right skewed binary tree. Now, root goes to index 1, its child goes to index 3, its child goes to index 7 and so on the nth vertex goes to 2^n - 1 th index of array.

19 votes -- Shaun Patel (6.9k points)

Option D

To be able to store **" any "** binary tree on n vertices the minimum size of X should be

" **Any Binary Tree and Size should be minimum "** .
So We must consider worst case binary tree for this situation and find the minimum space required .



15 votes -- pC (21.4k points)

3.4.29 Binary Tree: GATE2006-IT-71 top

http://gateoverflow.in/3615

Selected Answer

option D

left child of ith element will be at 2*i+1 and right child at 2(i+1)

14 votes -- Sankaranarayanan P.N (11.2k points)

3.4.30 Binary Tree: GATE2006-IT-73 top

http://gateoverflow.in/3617

Selected Answer

Floor(log(i+1)) draw the tree and realise that the last element at each level is the best choice to arrive at a conclusion

15 votes -- Bhagirathi Nayak (13.3k points)

3.4.31 Binary Tree: GATE2006-IT-9 top

http://gateoverflow.in/3548

Selected Answer

In a binary Tree,

no of nodes of degree 2 = no of leaves - 1.

No of nodes of degree 1 do not affect no of leaves !

No of leafs = No of nodes of degree 2 + 1 = 10 + 1 = 11

20 votes -- Akash (43.8k points)

A node in a binary tree has degree 0, 1 or 2.

Ref: http://faculty.cs.niu.edu/~mcmahon/CS241/Notes/bintree.html

We are given no. of 1 degree node = 5, no. of 2 degree nodes = 10.

Total no. of edges = 1*5 + 2*10 = 25 (In tree degree is for outgoing edges only, and hence each degree corresponds to an edge)

So, total no. of nodes = 25 + 1 = 26 (No. of nodes in a tree is 1 less than no. of edges).

Now, no. of leaf nodes (nodes with 0 degree) = 26 - 5 - 10 = 11.

25 votes -- Arjun Suresh (294k points)

3.4.32 Binary Tree: GATE2007-12 top http://gateoverflow.in/1210

Selected Answer

2^(h+1) - 1 just try this taking a small complete binary

never try to remember these formulae as remembering formulae is an overhead try to take exmaples in such cases

13 votes -- Bhagirathi Nayak (13.3k points)

3.4.33 Binary Tree: GATE2007-13 top http://gateoverflow.in/1211

Selected Answer

can be found with formula... (2nCn/n+1)... n being the number of nodes. for the given question... where n=3... answer is 5. Let me also specify here.. that number of Binary Search Trees with n nodes is equal to number of unlabeled Binary trees.

http://gatecse.in/wiki/Number_of_Binary_trees_possible_with_n_nodes

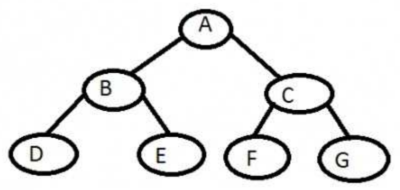
14 votes -- Gate Keeda (19.1k points)

3.4.34 Binary Tree: GATE2007-39, UGCNET-June2015-II-22 top http://gateoverflow.in/1237

Selected Answer

The answer is A.

Take the first node in preorder traversal - a will be the root of the tree
All nodes to the left of 'a' in inorder traversal will be in the left subtree of 'a' and all elements on the right will be in the right subtree of 'a'.
Take the second element from preorder traversal - 'b' - goes to left subtree of 'a' as it is in the left of 'a' in inorder list.
Proceeding likewise we can construct the binary tree as:



6 votes -- Gate Keeda (19.1k points)

3.4.35 Binary Tree: GATE2007-46 top

http://gateoverflow.in/1244

Selected Answer

Answer: C

As the function returns 1 if and only if any node has both left & right children as NULL (that node is a leaf node). Hence, value gets incremented at each leaf node.

11 votes -- Rajarshi Sarkar (35k points)

3.4.36 Binary Tree: GATE2008-IT-46 top

http://gateoverflow.in/3356

Selected Answer

In preorder, root comes at the beginning of the traversal sequence and in postorder, root comes at the last of the traversal sequence. So, out of the given sequences only 1 and 2 are having such kind of order i.e K at the beginning and at the last.

Therefore, 2 is the preorder and 1 is postorder and the left sequence i.e 3 will definitely be inorder.

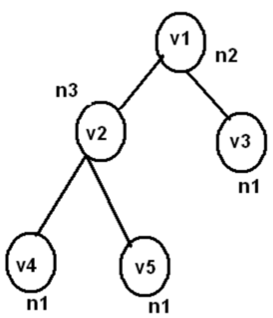
So, option d is correct.

16 votes -- Vivek sharma (2.3k points)

3.4.37 Binary Tree: GATE2008-IT-76 top

http://gateoverflow.in/3390

Selected Answer



assume the above tree so value of n1 is 3 n2 =1 n3 =1 check with options now u vil get option B as correct

17 votes -- Shreyans Dhankhar (2.6k points)

No. of node in binary with 1 degree i.e. leaf node

2 degree i.e. only root note

node with 3 degree i.e. internal node except root (degree 2)

so number of degree 3 vertices are calculated = interms of internal node -1

internal node = leaf node -1 i.e. n1-1

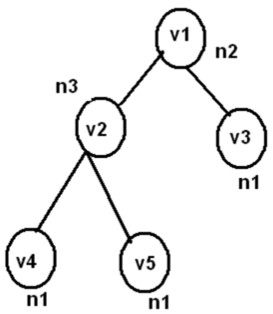
since from internal node root is 2 degree vertex so removes it

So no. of 3 degree vertices are = n1-1-1= n1-2

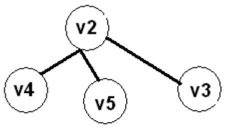
11 votes -- Prashant Singh (49.2k points)

3.4.38 Binary Tree: GATE2008-IT-77 top http://gateoverflow.in/3391

Selected Answer



from above tree we will get the tree below



now check with the options u vil get a as answer

18 votes -- Shreyans Dhankhar (2.6k points)

Initially,

n1*1+n2*2+n3*3=2(n1+n2+n3-1) ------> n3=n1-2

now we have removed all 2 degree nodes, so number of edges in final graph is n1+n3-1.

put n3=n1-2

number of edges=2*n1-3

11 votes -- Sumit1311 (1.6k points)

3.4.39 Binary Tree: GATE2010-10 top http://gateoverflow.in/2183

Selected Answer

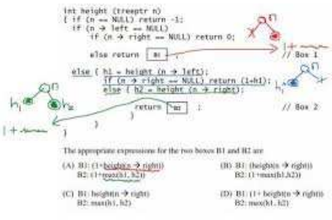
0 because every node has an odd number of descendants so least odd number 1 and every node is considered to be its own descendant so all nodes have even number of descendants(0,2,4,6...) so every node has either 0 children or 2 children...

15 votes -- Murali (439 points)

3.4.40 Binary Tree: GATE2012-47 top http://gateoverflow.in/2163

Selected Answer

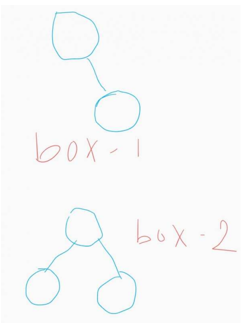
answer = **option A**
From the diagram below we are able to see how this works :



15 votes -- Amar Vashishth (28.7k points)

I got a hint ; How to quickly approach this type of question :--In this type of questions where we already know we want to find something(i.e. Height) then simply draw min possible tree which reach us upto the Given Boxes.

For Box1,Box2 tree will be as given in below img :-->



Now Analyse the code for above trees we get Option A as Ans.

15 votes -- Rajesh Pradhan (18.6k points)

3.4.41 Binary Tree: GATE2014-1-12 top http://gateoverflow.in/1776

Selected Answer

ans: 1..

Explanation:

(1) Come to the 4th level up from the leaf node of the given binary tree, which can be done using tree traversal in $O(n)$.

(2) For each node present in the level check whether it's subtree having exactly 4 nodes.. which can be done in constant time for each node, since it's subtree having constant number of nodes..

(3) nodes in the level is less than n.. so its complexity is O(n)

therefore, a = 1 and b = 0

a + 10b = 1... <-Answer

19 votes -- Vicky Bajoria (4.9k points)

We need to traverse all nodes at least once, and we need only one traversal. If num(child1) + num (child2) + 1 = 4, then output yes.

So, a must be 1 and b = 0, a + 10b = 1.

17 votes -- Arjun Suresh (294k points)

3.4.42 Binary Tree: GATE2015-1_25 top

http://gateoverflow.in/8223

Selected Answer

option A is correct because height 5 means level 6 so maximum node = 2^l -1 =2^6 -1=63
and for minimum, at each level only single node so total 6

21 votes -- Anoop Sonkar (4.9k points)

3.4.43 Binary Tree: GATE2015-2_10 top

http://gateoverflow.in/8059

Selected Answer

19

In Binary tree If there are N leaf nodes then the number of Nodes having two children will be N-1. So in this case answer will be 20-1, means 19.

14 votes -- Raghuveer Dhakad (1.2k points)

3.4.44 Binary Tree: GATE2015-3_25 top

http://gateoverflow.in/8428

Selected Answer

Let number of nodes with exactly two children be x, and with exactly one children be y.

Total degree = 200 + 3x + 2y - 1 (As all nodes with 2 children have degree 3 except the root)

No. of nodes = x + y + 200

No. of edges = Total degree/2 = (200 + 3x + 2y - 1)/2

No. of edges in a tree = No. of nodes - 1

So, (200 + 3x + 2y -1) = 2x +2y + 400 - 2

x = 199

29 votes -- Arjun Suresh (294k points)

The general formula for a Binary tree having two children with n leaves is

=> n-1.

Here n = 200 So answer is 199.

10 votes -- Hai Hai (199 points)

3.4.45 Binary Tree: TIFR2013-B-13 top http://gateoverflow.in/25775

Selected Answer

The correct answer is option c, $\Theta(\sqrt{n})$.

$$\begin{aligned} n &= 1 + 2 + 3 + \cdots + (h+1) \\ &= \frac{(h+1)(h+2)}{2} \\ 2n &= h^2 + 3n + 2 \\ 0 &= h^2 + 3n + (2 - 2n) \end{aligned}$$

$$\implies h = \frac{-3 + \sqrt{3^2 - 4 \cdot (2 - 2n)}}{2} \qquad \because h \geq 0$$

$$= \frac{-3 + \sqrt{8n+1}}{2}$$

$$\implies h = \Theta(\sqrt{n})$$

29 votes -- Pragy Agarwal (19.5k points)

3.4.46 Binary Tree: TIFR2014-B-1 top http://gateoverflow.in/27133

Selected Answer

We can construct binary tree by postorder and inorder traversal

There we get 5 leaves of the tree are a,c,e,h,j

So answer (C)5

7 votes -- srestha (58.4k points)

3.4.47 Binary Tree: TIFR2015-B-4 top http://gateoverflow.in/29849

Selected Answer

Option **B**

for every node -all numbers in one subtree are less than all numbers in the other subtree .

Firstly **chose** a value for **root**- 9 elements = **9 ways**

Now, we hv **8 elements left** - we hv to **chose 3 for left subtree & 5 for right subtree.**

Note: Here we can either chose 3 nodes from beginning or end out of 8 elements we have ! =**2 ways**

Now,we hv 3 elements for left subtree & 5 for right(**Consider subtrees of subtree**).

Left Subtree :

whatever way we place , always one side is smaller than other {6 is smaller than 8 in above example given in question} so, total ways =**3**

! {three places put one by one} = **6 ways**

Right Subtree :

Right subtree has two more sub-trees ,so that elements on one side should be smaller than other**

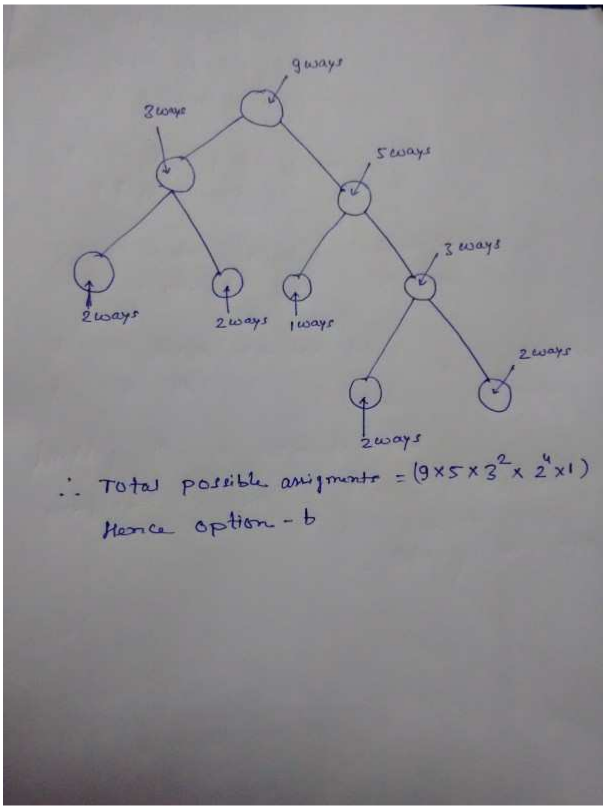
Steps : 1) Select one element for root = **5 ways**

2) 4 elements left ,Select one element for left =**2 ways** {Either we can chose from left or right}

3) 3 elements left, for right subtree =**3!** ways = **6 ways**

Total ways = 9*2* 3! * 5 * 2 * 3! = 2^4 * 3^2 * 5 * 9 = 6480 = **B (Ans)**

19 votes -- Himanshu Agarwal (16.2k points)



Based on concepts of Combination

11 votes -- Shashi Kant Verma (257 points)

3.5 Graph Search(1) top

3.5.1 Graph Search: GATE1989-3-ixa top

http://gateoverflow.in/87143

Answer the following:

Which one of the following statements (s) is/are FALSE?

A. Overlaying is used to run a program, which is longer than the address space of the computer.
B. Optimal binary search tree construction can be performed efficiently by using dynamic programming.
C. Depth first search cannot be used to find connected components of a graph.
D. Given the prefix and postfix walls over a binary tree, the binary tree can be uniquely constructed.

normal gate1989 overlay binary-tree graph-search

Answer

Answers: Graph Search

3.5.1 Graph Search: GATE1989-3-ixa top http://gateoverflow.in/87143

A. **FALSE** according to definition of address space given in the link. whatever memory used by the overlay comes under the address space of computer "https://en.wikipedia.org/wiki/Address_space".

B. **TRUE** Optimal binary search tree construction can be performed efficiently by using dynamic programming.
ref: http://www.geeksforgeeks.org/dynamic-programming-set-24-optimal-binary-search-tree/

C. **FLASE** Depth first search can be used to find connected components of a graph.

D. **FALSE** Infix + (postfix or prefix) is req. to construct the binary tree uniquely.

2 votes -- Lokesh . (9.8k points)

3.6 Graphs(6) top

3.6.1 Graphs: GATE 2016-1-38 top http://gateoverflow.in/39731

Consider the weighted undirected graph with 4 vertices, where the weight of edge $\{i, j\}$ is given by the entry W_{ij} in the matrix W.

$$W = \begin{bmatrix} 0 & 2 & 8 & 5 \\ 2 & 0 & 5 & 8 \\ 8 & 5 & 0 & x \\ 5 & 8 & x & 0 \end{bmatrix}$$

The largest possible integer value of x, for which at least one shortest path between some pair of vertices will contain the edge with weight x is ___________

gate2016-1 data-structure graphs normal numerical-answers

Answer

3.6.2 Graphs: GATE1992_03,iii top http://gateoverflow.in/580

How many edges can there be in a forest with p components having n vertices in all?

gate1992 data-structure graphs easy

Answer

3.6.3 Graphs: GATE1997_6.2 top http://gateoverflow.in/2258

Let G be the graph with 100 vertices numbered 1 to 100. Two vertices i and j are adjacent if $|i - j| = 8$ or $|i - j| = 12$. The number of connected components in G is

a. 8
b. 4
c. 12
d. 25

gate1997 data-structure normal graphs

Answer

3.6.4 Graphs: GATE2008-42 top http://gateoverflow.in/1872

G is a graph on n vertices and $2n-2$ edges. The edges of G can be partitioned into two edge-disjoint spanning trees. Which of the following is NOT true for G?

A. For every subset of k vertices, the induced subgraph has at most $2k-2$ edges.
B. The minimum cut in G has at least 2 edges.
C. There are at least 2 edge-disjoint paths between every pair of vertices.
D. There are at least 2 vertex-disjoint paths between every pair of vertices.

gate2008 data-structure graphs normal

Answer

3.6.5 Graphs: GATE2008-IT-4 top

http://gateoverflow.in/3264

What is the size of the smallest MIS(Maximal Independent Set) of a chain of nine nodes?

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

gate2008-it data-structure normal graphs

Answer

3.6.6 Graphs: GATE2014-1-3 top

http://gateoverflow.in/1754

Let $G = (V, E)$ be a directed graph where V is the set of vertices and E the set of edges. Then which one of the following graphs has the same strongly connected components as G ?

A. $G_1 = (V, E_1)$ where $E_1 = \{(u, v) \mid (u, v) \notin E\}$
B. $G_2 = (V, E_2)$ where $E_2 = \{(u, v) \mid (v, u) \in E\}$
C. $G_3 = (V, E_3)$ where $E_3 = \{(u, v) \mid$ there is a path of length ≤ 2 from u to v in $E\}$
D. $G_4 = (V_4, E)$ where V_4 is the set of vertices in G which are not isolated

gate2014-1 data-structure graphs ambiguous

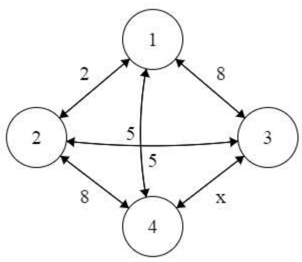
Answer

Answers: Graphs

3.6.1 Graphs: GATE 2016-1-38 top

http://gateoverflow.in/39731

Selected Answer



Let us list down the shortest edge between each pair of vertices x,y in the graph

x	y	shortest path from x to y
1	2	2
1	3	there is a direct path from 1 to 3 of weight 8.We can also chose to go via node 4 with total path weight 5+x. If 5+ x < 8 (x < 3) then shortest path is 5+x otherwise shortest path is the

x	y	shortest path from x to y
1	4	5
2	3	5
2	4	there is a direct path from 2 to 4 of weight 8.We can also chose to go via node 3 with total path weight 5+x. If 5+ x < 8 (x < 3) then shortest path is 5+x otherwise shortest path is the weight of the direct path i.e 8
3	4	We can chose to go through the direct path of weight x or via node to with weight 5+8 = 13. If x < 13 then we will choose x to be the shortest path otherwise 13 is the shortest path

- Case 1: Let us say x < 3. Say x = 2.

When we put x = 2 the above table is modified as

x	y	shortest path from x to y
1	2	2
1	3	7
1	4	5
2	3	5
2	4	7
3	4	2 // Note that the shortest path between node 3 and 4 is x = 2

- Case 2: 3 <= x < 13. Let's say x = 12. The table is now modified as

x	y	shortest path from x to y
1	2	2
1	3	8
1	4	5
2	3	5
2	4	8
3	4	12 // Note that the shortest path between node 3 and 4 is x =12

Now the question asks you to find the largest possible integer value of x such that shortest path between atleast one pair of nodes in the graph is equal to x. for values x = 2,3,4,....,12 the shortest path between node 3 and 4 is equal to x.

The largest among this is x = 12. So the answer is 12

24 votes -- janakyMurthy (631 points)

Answer is x=12. Here, when we read the last sentence of the question, i.e the largest possible integer value of x. when x=11 , shortest path is edge with weight x only. But when x=12, there are 2 shortest paths, and we can say that the edge with weight x is also a shortest path. Atleast 1 shortest path contain edge x. So answer will be 12.

26 votes -- Sreyas S (1.7k points)

3.6.2 Graphs: GATE1992_03,iii top

http://gateoverflow.in/580

Selected Answer

Answer: n-p

Corollary: If G is a forest with n vertices and p components, then G has n-p edges.

As, 0 edges for p-1 vertices (p-1 components) and n-p edges for n-p+1 vertices (1 component). So, total of n-p edges for p components.

4 votes -- Rajarshi Sarkar (35k points)

3.6.3 Graphs: GATE1997_6.2 top http://gateoverflow.in/2258

Selected Answer

From the description it is clear that vertices are connected as follows:

1-9-17-...-97
2-10-18-...-98
3-11-19-...-99
4-12-20-...-100
5-13-21-...-93
6-14-22-...-94
7-15-23-...-95
8-16-24-...96

We have covered all vertices using 8 vertex sets considering only $|i - j| = 8$. Using $|i - j| = 12$ we can see the vertex 1 is connected to 13, 2-14, 3-15 and 4-16, so the top 4 vertex sets are in fact connected to the bottom 4 sets, thus reducing the connected components to 4.

16 votes -- Arjun Suresh (294k points)

3.6.4 Graphs: GATE2008-42 top http://gateoverflow.in/1872

Selected Answer

There are 2 spanning trees (a spanning tree connects all n vertices) for G which are edge disjoint. A spanning tree for n nodes require $n - 1$ edges and so 2 edge-disjoint spanning trees requires $2n - 2$ edges. As G has only $2n - 2$ edges, it is clear that it doesn't have any edge outside that of the two spanning trees. Now lets see the cases:

Lets take any subgraph of G with k vertices. The remaining subgraph will have $n - k$ vertices. Between these two subgraphs (provided both has at least one vertex) there should be at least 2 edges, as we have 2 spanning trees in G. So, (b) is TRUE. Also, in the subgraph with k vertices, we cannot have more than $2k - 2$ edges as this would mean that in the other subgraph with $n - k$ vertices, we would have less than $2n - 2k$ edges, making 2 spanning trees impossible in it. So, (a) is also TRUE.

A spanning tree covers all the vertices. So, 2 edge-disjoint spanning trees in G means, between every pair of vertices in G we have two edge-disjoint paths (length of paths may vary). So, (c) is also TRUE.

So, that leaves option (d) as answer. It is not quite hard to give a counter example for (d).

16 votes -- Arjun Suresh (294k points)

3.6.5 Graphs: GATE2008-IT-4 top http://gateoverflow.in/3264

Selected Answer

Answer: C

1--2--3--4--5--6--7--8--9

(2,5,8) is the maximal independent set for a chain of 9 nodes. If we add any other node to the set then it will not be MIS.

18 votes -- Rajarshi Sarkar (35k points)

3.6.6 Graphs: GATE2014-1-3 top http://gateoverflow.in/1754

Selected Answer

A is false. Consider just two vertices connected to each other. So, we have one SCC. The new graph won't have any edges and so 2 SCC.

B is true. In a directed graph an SCC will have a path from each vertex to every other vertex. So, changing the direction of all the edges, won't change the SCC.

D is false. Consider any graph with isolated vertices- we loose those components.

C is a bit tricky. Any edge is a path of length 1. So, the new graph will have all the edges from old one. Also, we are adding new edges (u,v). So, does this modify any SCC? No, because we add an edge (u,v), only if there is already a path of length <= 2 from u to v- so we do not create a new path. So, both B and C must answer, though GATE key says only B.

23 votes -- Arjun Suresh (294k points)

3.7 Hashing(17) top

3.7.1 Hashing: GATE1989-1-vii, ISRO2015-14 top http://gateoverflow.in/10905

A hash table with ten buckets with one slot per bucket is shown in the following figure. The symbols S1 to S7 initially entered using a hashing function with linear probing.The maximum number of comparisons needed in searching an item that is not present is

0	S7
1	S1
2	
3	S4
4	S2
5	
6	S5
7	
8	S6
9	S3

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

hashing isro2015 gate1989

Answer

3.7.2 Hashing: GATE1996_1.13 top http://gateoverflow.in/2717

An advantage of chained hash table (external hashing) over the open addressing scheme is

A. Worst case complexity of search operations is less

B. Space used is less

C. Deletion is easier

D. None of the above

gate1996 data-structure hashing normal

Answer

3.7.3 Hashing: GATE1996_15 top http://gateoverflow.in/2767

Insert the characters of the string K R P C S N Y T J M into a hash table of size 10.

Use the hash function

$$h(x) = (ord(x) - ord("\ a\ ") + 1) \mod 10$$

and linear probing to resolve collisions.

a. Which insertions cause collisions?

b. Display the final hash table.

gate1996 data-structure hashing normal

Answer

3.7.4 Hashing: GATE1997_12 top

http://gateoverflow.in/2272

Consider a hash table with n buckets, where external (overflow) chaining is used to resolve collisions. The hash function is such that the probability that a key value is hashed to a particular bucket is $\frac{1}{n}$. The hash table is initially empty and K distinct values are inserted in the table.

A. What is the probability that bucket number 1 is empty after the K^{th} insertion?

B. What is the probability that no collision has occurred in any of the K insertions?

C. What is the probability that the first collision occurs at the K^{th} insertion?

gate1997 data-structure hashing probability normal

Answer

3.7.5 Hashing: GATE2004-7 top

http://gateoverflow.in/1004

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

gate2004 data-structure hashing easy

Answer

3.7.6 Hashing: GATE2005-IT-16 top

http://gateoverflow.in/3761

A hash table contains 10 buckets and uses linear probing to resolve collisions. The key values are integers and the hash function used is key % 10. If the values 43, 165, 62, 123, 142 are inserted in the table, in what location would the key value 142 be inserted?

A. 2
B. 3
C. 4
D. 6

gate2005-it data-structure hashing easy

Answer

3.7.7 Hashing: GATE2006-IT-20 top

http://gateoverflow.in/3559

Which of the following statement(s) is TRUE?

I. A hash function takes a message of arbitrary length and generates a fixed length code.
II. A hash function takes a message of fixed length and generates a code of variable length.
III. A hash function may give the same hash value for distinct messages.
  A. I only
  B. II and III only
  C. I and III only
  D. II only

gate2006-it data-structure hashing normal

Answer

3.7.8 Hashing: GATE2007-40 top

http://gateoverflow.in/1238

Consider a hash table of size seven, with starting index zero, and a hash function $(3x + 4) \mod 7$. Assuming the hash table is initially empty, which of the following is the contents of the table when the sequence 1, 3, 8, 10 is inserted into the table using closed hashing? Note that − denotes an empty location in the table.

A. 8, −, −, −, −, −, 10

B. 1, 8, 10, −, −, −, 3

C. 1, −, −, −, −, −, 3

D. 1, 10, 8, −, −, −, 3

gate2007 data-structure hashing easy

Answer

3.7.9 Hashing: GATE2007-IT-28 top

http://gateoverflow.in/3461

Consider a hash function that distributes keys uniformly. The hash table size is 20. After hashing of how many keys will the probability that any new key hashed collides with an existing one exceed 0.5.

A. 5
B. 6
C. 7
D. 10

gate2007-it data-structure hashing probability normal

Answer

3.7.10 Hashing: GATE2008-IT-48 top

http://gateoverflow.in/3358

Consider a hash table of size 11 that uses open addressing with linear probing. Let h(k) = k mod 11 be the hash function used. A sequence of records with keys

43 36 92 87 11 4 71 13 14

is inserted into an initially empty hash table, the bins of which are indexed from zero to ten. What is the index of the bin into which the last record is inserted?

A. 3
B. 4
C. 6
D. 7

gate2008-it data-structure hashing normal

Answer

3.7.11 Hashing: GATE2009-36 top

http://gateoverflow.in/1322

The keys 12, 18, 13, 2, 3, 23, 5 and 15 are inserted into an initially empty hash table of length 10 using open addressing with hash function h(k) = k mod 10 and linear probing. What is the resultant hash table?

A

0	
1	
2	2
3	23
4	
5	15

B

0	
1	
2	12
3	13
4	
5	5

C

0	
1	
2	12
3	13
4	2
5	3

D

0	
1	
2	2, 12
3	13, 3, 23
4	
5	5, 15

A.

7	
8	18
9	

B.

7	
8	18
9	

C.

6	23
7	5
8	18
9	15

D.

7	
8	18
9	

gate2009 data-structure hashing normal

Answer

3.7.12 Hashing: GATE2010-52 top

http://gateoverflow.in/2360

A hash table of length 10 uses open addressing with hash function $h(k) = k \, mod \, 10$, and linear probing. After inserting 6 values into an empty hash table, the table is shown as below

0	
1	
2	42
3	23
4	34
5	52
6	46
7	33
8	
9	

Which one of the following choices gives a possible order in which the key values could have been inserted in the table?

A. 46, 42, 34, 52, 23, 33
B. 34, 42, 23, 52, 33, 46
C. 46, 34, 42, 23, 52, 33
D. 42, 46, 33, 23, 34, 52

gate2010 data-structure hashing difficult

Answer

3.7.13 Hashing: GATE2010-53 top

http://gateoverflow.in/43327

A hash table of length 10 uses open addressing with hash function $h(k) = k \, mod \, 10$, and linear probing. After inserting 6 values into an empty hash table, the table is shown as below

0	
1	
2	42
3	23
4	34
5	52
6	46
7	33
8	
9	

How many different insertion sequences of the key values using the same hash function and linear probing will result in the hash table shown above?

A. 10
B. 20
C. 30
D. 40

data-structure hashing difficult gate2010

Answer

3.7.14 Hashing: GATE2014-1-40 top http://gateoverflow.in/1918

Consider a hash table with 9 slots. The hash function is $h(k) = k \mod 9$. The collisions are resolved by chaining. The following 9 keys are inserted in the order: 5, 28, 19, 15, 20, 33, 12, 17, 10. The maximum, minimum, and average chain lengths in the hash table, respectively, are

A. 3, 0, and 1
B. 3, 3, and 3
C. 4, 0, and 1
D. 3, 0, and 2

gate2014-1 data-structure hashing normal

Answer

3.7.15 Hashing: GATE2014-3-40 top http://gateoverflow.in/2074

Consider a hash table with 100 slots. Collisions are resolved using chaining. Assuming simple uniform hashing, what is the probability that the first 3 slots are unfilled after the first 3 insertions?

A. $(97 \times 97 \times 97)/100^3$
B. $(99 \times 98 \times 97)/100^3$
C. $(97 \times 96 \times 95)/100^3$
D. $(97 \times 96 \times 95/(3! \times 100^3)$

gate2014-3 data-structure hashing probability normal

Answer

3.7.16 Hashing: GATE2015-2_33 top http://gateoverflow.in/8152

Which one of the following hash functions on integers will distribute keys most uniformly over 10 buckets numbered 0 to 9 for i ranging from 0 to 2020?

A. $h(i) = i^2 \text{mod } 10$
B. $h(i) = i^3 \text{mod } 10$
C. $h(i) = (11 * i^2) \text{mod } 10$
D. $h(i) = (12 * i^2) \text{mod } 10$

gate2015-2 data-structure hashing normal

Answer

3.7.17 Hashing: GATE2015-3_17 top http://gateoverflow.in/8414

Given that hash table T with 25 slots that stores 2000 elements, the load factor α for T is __________.

gate2015-3 data-structure hashing normal numerical-answers

Answer

Answers: Hashing

3.7.1 Hashing: GATE1989-1-vii, ISRO2015-14 top http://gateoverflow.in/10905

Selected Answer

No of comparison in worst case for an element not in hash table is size of largest cluster +1. This is because the probe stops as soon as an empty slot is found (we r using linear probing here).

Size of largest cluster is 4 (s6, s3, s7, s1)

No of comparison is 4 + 1 = 5

29 votes -- Digvijay (47k points)

3.7.2 Hashing: GATE1996_1.13 top

http://gateoverflow.in/2717

Selected Answer

A.False :- search operation can go worst in chaining if all elements are stored under a single bucket.

B.False . Pointer space is overhead in chaining.

C .is true BCZ in Open Adressing sometimes though element is present we cant delete it if Empty Bucket comes in between while searching for that element ;Such Limitation is not there in Chaining.

9 votes -- Rajesh Pradhan (18.6k points)

3.7.3 Hashing: GATE1996_15 top

http://gateoverflow.in/2767

Selected Answer

Here Order(x)-Order ('a') means count difference between that character & a.

Assuming a = 0, b = 1 & so on.

a) J & M cause collusion.

b) Final Hash Table

Index	Key
0	T
1	K
2	J
3	C
4	N
5	Y
6	P
7	M
8	R
9	S

10 votes -- Akash (43.8k points)

3.7.4 Hashing: GATE1997_12 top

http://gateoverflow.in/2272

Selected Answer

A) probability that other buckets are selected = (n-1)/n

this should happen k times and each of k events are independent so $(n-1)^k/n^k$

B) when k=1 prob of no collision = n/n

for k=2 prob of no collision = n/n * (n-1)/n for k=k prob of no collision = n/n * (n-1)/n * (n-2)/n ... * (n-k+1)/n for k<=n

for k>n prob = 0

C) prob of collision at k=1 = (k-1)/n

prob of collision at k=2 = n/n * (k-1)/n

prob of collision at k=3 = n/n * (n-1)/n * (k-1)/n

prob of collision at k=k = n/n * (n-1)/n * (n-2)/n ... * 2/n * (k-1)/n for k<=n

for k>n prob = 1

9 votes -- Danish (3.6k points)

3.7.5 Hashing: GATE2004-7 top

http://gateoverflow.in/1004

Selected Answer

option c is correct because the last digit of every digit given is equal in i and ii

9 votes -- Bhagirathi Nayak (13.3k points)

3.7.6 Hashing: GATE2005-IT-16 top

http://gateoverflow.in/3761

Selected Answer

43 in loc 3

165 in loc 5

62 in loc 2

123 in loc 4 (collission and next free space)

142 in loc 6 (collision in 2, and 3,4,5 already occupied)

hence answer D

12 votes -- Sankaranarayanan P.N (11.2k points)

3.7.7 Hashing: GATE2006-IT-20 top

http://gateoverflow.in/3559

Selected Answer

Answer is C)
I) A hash function takes a message of arbitrary length and generates a fixed length code.. This is correct, this is directly from defination of hash function. Ref -> https://en.wikipedia.org/wiki/Hash_function

II) As I is correct II is wrong !

III) This is true. example :-> Hash function N%10, this will generate same values for 1 as well as 11 !

(Even in cryptographic hash functions collusion happens, just it is not easy to find colluding instances !)

13 votes -- Akash (43.8k points)

3.7.8 Hashing: GATE2007-40 top

http://gateoverflow.in/1238

Selected Answer

The answer is B.

1 will occupy location 0, 3 will occupy location 6, 8 hashed to location 0 which is already occupied so, it will be hashed

to one location next to it. i.e. to location 1.

Since 10 also clashes, so it will be hashed to location 2.

10 votes -- Gate Keeda (19.1k points)

3.7.9 Hashing: GATE2007-IT-28 top

http://gateoverflow.in/3461

Selected Answer

The question is a bit ambiguous.

> After hashing of how many keys, will the probability that any new key hashed collides with an existing one exceed 0.5.

Here, 'new key hashed' is the ambiguity. It can mean the probability of a collision in the next 'hash', or the probability of a collision in any of the hashes of the 'new keys' starting from the first insertion. For the first case answer must be 10 to get probability equal to 0.5, and so 11 must be the answer for probability > 0.5. Thus we can conclude from given choices, it is the second case.

So, we need to find n such that after n hashes, probability of collision (in any of the n hashes) > 0.5.

Probability that there will be a collision after n hashes = 1 - Probability that there was no collision in the first n hashes

$= 1 - 1.\frac{19}{20}.\frac{18}{20}\dots\frac{20-n+1}{20}$.

So, we need,

$0.5 < 1 - 1.\frac{19}{20}.\frac{18}{20}\dots\frac{20-n+1}{20}$.

$\implies \frac{19}{20}.\frac{18}{20}\dots\frac{20-n+1}{20} < 0.5$.

For $n = 5$, we get, 0.5814 and for $n = 6$, we get 0.43605. So, answer should be $n = 6$.

Ref: http://www.cse.iitd.ernet.in/~bagchi/courses/discrete-book/ch5.pdf

21 votes -- Arjun Suresh (294k points)

3.7.10 Hashing: GATE2008-IT-48 top

http://gateoverflow.in/3358

Selected Answer

Index	Key
0	87
1	11
2	13
3	36
4	92
5	4
6	71
7	**14**
8	
9	
10	43

D is answer

9 votes -- Prashant Singh (49.2k points)

3.7.11 Hashing: GATE2009-36 top

http://gateoverflow.in/1322

Selected Answer

C is the correct option ..directly from the definition of linear probing. In linear probing, when a hashed location is already filled, locations are linearly probed until a free one is found.

http://courses.cs.washington.edu/courses/cse326/00wi/handouts/lecture16/sld015.htm

16 votes -- Bhagirathi Nayak (13.3k points)

3.7.12 Hashing: GATE2010-52 top

http://gateoverflow.in/2360

Selected Answer

Option C

46, 34, 42, 23, 52, 33

46 - position 6

34 position 4

42 position 2

23 position 3

52 position 2 - collision next empty is 5

33 positon 3- collision next empty is 7

11 votes -- Sankaranarayanan P.N (11.2k points)

3.7.13 Hashing: GATE2010-53 top

http://gateoverflow.in/43327

Selected Answer

53 - option (C).

Slots 3,4,5 and 6 must be filled before 33 comes. Similarly slots 2,3 and 4 must be filled before 52 comes. And 52 must come before 33, as it is not occupying slot 2. So, 33 must be at the end and 52 can come at position 4 or 5.

Let 52 come at position 4. Slots 2, 3 and 4 must be filled before 52 leaving only slot 6 left for the element coming at position 5 which should be 46. So, the first 3 elements can come in any order giving 3! = 6 ways.

Let 52 come at position 5. Now, the first four elements can come in any order. So, 4! = 24 ways.

So, total number of different insertion sequences possible = 24 + 6 = 30

26 votes -- Arjun Suresh (294k points)

answer = **option C**

element
33 has managed to hold position at slot #7 it means elements should occupy slot #3 to slot #6 before it in the sequence.
Currently it seems like all element except
42 should come before

33 in the sequence.

But, element 52 requires that 42 comes before it. and 33 requires that 52 comes before it. This means that 42 has to come before 33. this makes element 33 to occupy last position in the sequence.

now for element 52 to occupy its place these can be two cases :
case1 : $\boxed{\{42, 23, 34\}}, 52$
case2: $\boxed{\{42, 23, 34, 46\}}, 52$

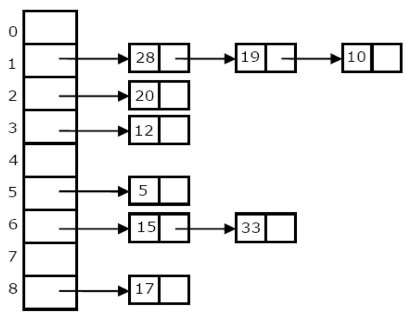
case 1 means that those three elements comes before
52 =
$3! = 6$ways
case 2 means that those four elements comes before
52 =
$4! = 24$ways

combining all info we get,
total number of sequences possible that will form the same hash table as above
$= (6 + 24) \times 1 = 30$

15 votes -- Amar Vashishth (28.7k points)

3.7.14 Hashing: GATE2014-1-40 top http://gateoverflow.in/1918

Selected Answer



So, Maximum & minimum chain lengths are 3 & 0 respectively.

Average chain length = (0+3+1+1+0+1+2+0+1)/9 = 1 .

So, Ans is A

17 votes -- Jay (1.2k points)

3.7.15 Hashing: GATE2014-3-40 top http://gateoverflow.in/2074

Selected Answer

We have 100 slots each of which are picked with equal probability by the hash function (since hashing is uniform). So, to avoid first 3 slots, the hash function has to pick from the remaining 97 slots. And repetition is allowed, since chaining is used- meaning a list of elements are stored in a slot and not a single element.

So, required probability $= \frac{97}{100} \times \frac{97}{100} \times \frac{97}{100}$

$= (97 \times 97 \times 97)/100^3$

28 votes -- Arjun Suresh (294k points)

3.7.16 Hashing: GATE2015-2_33 top http://gateoverflow.in/8152

Selected Answer

Since mod 10 is used, the last digit matters.

If you do cube all numbers from 0 to 9, you get following

```
Number    Cube    Last Digit in Cube
  0        0           0
  1        1           1
  2        8           8
  3        27          7
  4        64          4
  5        125         5
  6        216         6
  7        343         3
  8        512         2
  9        729         9
```

Therefore all numbers from 0 to 2020 are equally divided in 10 buckets. If we make a table for square, we don't get equal distribution. In the following table. 1, 4, 6 and 9 are repeated, so these buckets would have more entries and buckets 2, 3, 7 and 8 would be empty.

```
Number   Square     Last Digit in Cube
  0        0           0
  1        1           1
  2        4           4
  3        9           9
  4        16          6
  5        25          5
  6        36          6
  7        49          9
  8        64          4
  9        81          1
```

http://geeksquiz.com/gate-gate-cs-2015-set-2-question-43/

24 votes -- Anu (10.6k points)

3.7.17 Hashing: GATE2015-3_17 top http://gateoverflow.in/8414

Selected Answer

A critical statistic for a hash table is the **load factor**, that is the number of entries divided by the number of buckets:

Load factor = n/k

where:

n = number of entries
k = number of buckets

As the load factor grows larger, the hash table becomes slower, and it may even fail to work (depending on the method used).

here Load factor = 2000/25 = 80

10 votes -- Akash (43.8k points)

load factor =total no element/total no of slots
=> 2000/25 = **80**

13 votes -- Anoop Sonkar (4.9k points)

3.8 Heap(24) top

3.8.1 Heap: GATE 2016-1-37 top http://gateoverflow.in/39706

An operator delete(i) for a binary heap data structure is to be designed to delete the item in the i-th node. Assume that the heap is implemented in an array and i refers to the i-th index of the array. If the heap tree has depth d (number of edges on the path from the root to the farthest leaf), then what is the time complexity to re-fix the heap efficiently after the removal of the element?

A. $O(1)$
B. $O(d)$ but not $O(1)$
C. $O(2^d)$ but not $O(d)$
D. $O(d\,2^d)$ but not $O(2^d)$

gate2016-1 data-structure heap normal

Answer

3.8.2 Heap: GATE 2016-2-34 top http://gateoverflow.in/39585

A complete binary min-heap is made by including each integer in $[1, 1023]$ exactly once. The depth of a node in the heap is the length of the path from the root of the heap to that node. Thus, the root is at depth 0. The maximum depth at which integer 9 can appear is __________.

gate2016-2 data-structure heap normal numerical-answers

Answer

3.8.3 Heap: GATE1996_2.11 top http://gateoverflow.in/2740

The minimum number of interchanges needed to convert the array into a max-heap is

89, 19, 40, 17, 12, 10, 2, 5, 7, 11, 6, 9, 70

(a) 0

(b) 1

(c) 2

(d) 3

gate1996 data-structure heap easy

Answer

3.8.4 Heap: GATE1999_12 top http://gateoverflow.in/1511

a. In binary tree, a full node is defined to be a node with 2 children. Use induction on the height of the binary tree to prove that the number of full nodes plus one is equal to the number of leaves.

b. Draw the min-heap that results from insertion of the following elements in order into an initially empty min-heap: 7, 6, 5, 4, 3, 2, 1. Show the result after the deletion of the root of this heap.

gate1999 data-structure heap normal

Answer

3.8.5 Heap: GATE2001-1.15 top http://gateoverflow.in/708

Consider any array representation of an n element binary heap where the elements are stored from index 1 to index n of the array. For the element stored at index i of the array $(i \leq n)$, the index of the parent is

A. $i - 1$
B. $\lfloor \frac{i}{2} \rfloor$
C. $\lceil \frac{i}{2} \rceil$
D. $\frac{(i+1)}{2}$

gate2001 data-structure heap easy

Answer

3.8.6 Heap: GATE2003-23 top http://gateoverflow.in/1110

In a min-heap with n elements with the smallest element at the root, the 7^{th} smallest element can be found in time

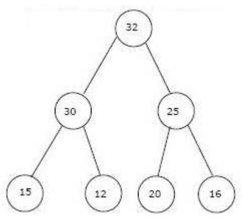
A. $\Theta(n \log n)$
B. $\Theta(n)$
C. $\Theta(\log n)$
D. $\Theta(1)$

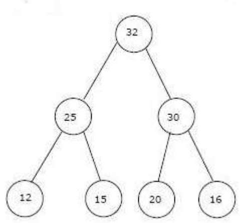
gate2003 data-structure heap

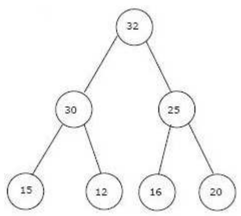
Answer

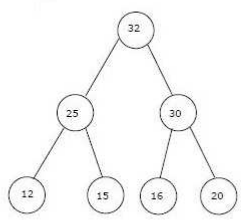
3.8.7 Heap: GATE2004-37 top http://gateoverflow.in/1034

The elements 32, 15, 20, 30, 12, 25, 16, are inserted one by one in the given order into a maxHeap. The resultant maxHeap is

A. 

B. 

C. 

D. 

gate2004 data-structure heap normal

Answer

3.8.8 Heap: GATE2004-IT-53 top http://gateoverflow.in/3696

An array of integers of size n can be converted into a heap by adjusting the heaps rooted at each internal node of the complete binary tree starting at the node ⌊(n - 1) /2⌋, and doing this adjustment up to the root node (root node is at index 0) in the order ⌊(n - 1)/2⌋, ⌊(n - 3)/ 2⌋, ..., 0. The time required to construct a heap in this manner is

A. O(log n)
B. O(n)
C. O (n log log n)
D. O(n log n)

gate2004-it data-structure heap normal

Answer

3.8.9 Heap: GATE2005-34 top

http://gateoverflow.in/1370

A priority queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is: 10, 8, 5, 3, 2. Two new elements 1 and 7 are inserted into the heap in that order. The level-order traversal of the heap after the insertion of the elements is:

A. 10, 8, 7, 5, 3, 2, 1
B. 10, 8, 7, 2, 3, 1, 5
C. 10, 8, 7, 1, 2, 3, 5
D. 10, 8, 7, 3, 2, 1, 5

gate2005 data-structure heap normal

Answer

3.8.10 Heap: GATE2006-10 top

http://gateoverflow.in/889

In a binary max heap containing n numbers, the smallest element can be found in time

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

gate2006 data-structure heap easy

Answer

3.8.11 Heap: GATE2006-76 top

http://gateoverflow.in/1852

Statement for Linked Answer Questions 76 & 77:

A 3-ary max heap is like a binary max heap, but instead of 2 children, nodes have 3 children. A 3-ary heap can be represented by an array as follows: The root is stored in the first location, a[0], nodes in the next level, from left to right, is stored from a[1] to a[3]. The nodes from the second level of the tree from left to right are stored from a[4] location onward. An item x can be inserted into a 3-ary heap containing n items by placing x in the location a[n] and pushing it up the tree to satisfy the heap property.

76. Which one of the following is a valid sequence of elements in an array representing 3-ary max heap?

A. 1, 3, 5, 6, 8, 9
B. 9, 6, 3, 1, 8, 5
C. 9, 3, 6, 8, 5, 1
D. 9, 5, 6, 8, 3, 1

gate2006 data-structure heap normal

Answer

3.8.12 Heap: GATE2006-77 top

http://gateoverflow.in/87191

Statement for Linked Answer Questions 76 & 77:

A 3-ary max heap is like a binary max heap, but instead of 2 children, nodes have 3 children. A 3-ary heap can be represented by an array as follows: The root is stored in the first location, a[0], nodes in the next level, from left to right, is stored from a[1] to a[3]. The nodes from the second level of the tree from left to right are stored from a[4] location onward. An item x can be inserted into a 3-ary heap containing n items by placing x in the location a[n] and pushing it up the tree to satisfy the heap property.

77. Suppose the elements 7, 2, 10 and 4 are inserted, in that order, into the valid 3-ary max heap found in the previous question, Q.76. Which one of the following is the sequence of items in the array representing the resultant heap?

(A) 10, 7, 9, 8, 3, 1, 5, 2, 6, 4
(B) 10, 9, 8, 7, 6, 5, 4, 3, 2, 1
(C) 10, 9, 4, 5, 7, 6, 8, 2, 1, 3
(D) 10, 8, 6, 9, 7, 2, 3, 4, 1, 5

gate2006 data-structure heap normal

Answer

3.8.13 Heap: GATE2006-IT-44 top

http://gateoverflow.in/3587

Which of the following sequences of array elements forms a heap?

A. {23, 17, 14, 6, 13, 10, 1, 12, 7, 5}
B. {23, 17, 14, 6, 13, 10, 1, 5, 7, 12}
C. {23, 17, 14, 7, 13, 10, 1, 5, 6, 12}
D. {23, 17, 14, 7, 13, 10, 1, 12, 5, 7}

gate2006-it data-structure heap easy

Answer

3.8.14 Heap: GATE2006-IT-72 top

http://gateoverflow.in/3616

An array X of n distinct integers is interpreted as a complete binary tree. The index of the first element of the array is 0. If only the root node does not satisfy the heap property, the algorithm to convert the complete binary tree into a heap has the best asymptotic time complexity of

A. O (n)
B. O (log n)
C. O (n log n)
D. O (n log log n)

gate2006-it data-structure heap easy

Answer

3.8.15 Heap: GATE2007-47 top

http://gateoverflow.in/1245

Consider the process of inserting an element into a $Max\ Heap$, where the $Max\ Heap$ is represented by an $array$. Suppose we perform a binary search on the path from the new leaf to the root to find the position for the newly inserted element, the number of $comparisons$ performed is:

A. $\Theta(\log_2 n)$

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

C. $\Theta(n)$

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

gate2007 data-structure heap normal

Answer

3.8.16 Heap: GATE2009-59 top

http://gateoverflow.in/1341

Consider a binary max-heap implemented using an array.
Which one of the following array represents a binary max-heap?

A. $\{25, 12, 16, 13, 10, 8, 14\}$
B. $\{25, 14, 13, 16, 10, 8, 12\}$
C. $\{25, 14, 16, 13, 10, 8, 12\}$
D. $\{25, 14, 12, 13, 10, 8, 16\}$

gate2009 data-structure heap normal

Answer

3.8.17 Heap: GATE2009-60 top http://gateoverflow.in/43466

Consider a binary max-heap implemented using an array.
What is the content of the array after two delete operations on $\{25, 14, 16, 13, 10, 8, 12\}$

A. $\{14, 13, 12, 10, 8\}$
B. $\{14, 12, 13, 8, 10\}$
C. $\{14, 13, 8, 12, 10\}$
D. $\{14, 13, 12, 8, 10\}$

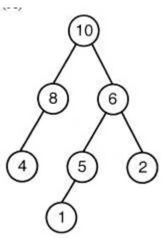
gate2009 data-structure heap normal

Answer

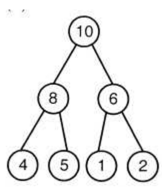
3.8.18 Heap: GATE2011_23 top http://gateoverflow.in/2125

A max-heap is a heap where the value of each parent is greater than or equal to the value of its children. Which of the following is a max-heap?

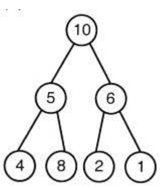
(A)



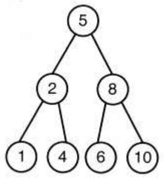
(B)



(C)



(D)



gate2011 data-structure heap easy

Answer

3.8.19 Heap: GATE2014-2-12 top

http://gateoverflow.in/1967

A priority queue is implemented as a Max-Heap. Initially, it has 5 elements. The level-order traversal of the heap is: 10, 8, 5, 3, 2. Two new elements 1 and 7 are inserted into the heap in that order. The level-order traversal of the heap after the insertion of the elements is:

A. 10, 8, 7, 3, 2, 1, 5
B. 10, 8, 7, 2, 3, 1, 5
C. 10, 8, 7, 1, 2, 3, 5
D. 10, 8, 7, 5, 3, 2, 1

gate2014-2 data-structure heap normal

Answer

3.8.20 Heap: GATE2015-1_32 top

http://gateoverflow.in/8273

Consider a max heap, represented by the array: 40, 30, 20, 10, 15, 16, 17, 8, 4.

Array index	1	2	3	4	5	6	7	8	9
Value	40	30	20	10	15	16	17	8	4

Now consider that a value 35 is inserted into this heap. After insertion, the new heap is

A. 40, 30, 20, 10, 15, 16, 17, 8, 4, 35
B. 40, 35, 20, 10, 30, 16, 17, 8, 4, 15
C. 40, 30, 20, 10, 35, 16, 17, 8, 4, 15
D. 40, 35, 20, 10, 15, 16, 17, 8, 4, 30

gate2015-1 data-structure heap easy

Answer

3.8.21 Heap: GATE2015-2_17 top

http://gateoverflow.in/8091

Consider a complete binary tree where the left and right subtrees of the root are max-heaps. The lower bound for the number of operations to convert the tree to a heap is

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

gate2015-2 data-structure heap normal

Answer

3.8.22 Heap: GATE2015-3_19 top

http://gateoverflow.in/8418

Consider the following array of elements.

$\langle 89, 19, 50, 17, 12, 15, 2, 5, 7, 11, 6, 9, 100 \rangle$

The minimum number of interchanges needed to convert it into a max-heap is

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

gate2015-3 data-structure heap normal

Answer

3.8.23 Heap: ISI2014-CS-2b top

http://gateoverflow.in/47438

Let H_1 and H_2 be two complete binary trees that are heaps as well. Assume H_1 and H_2 are max-heaps, each of size n. Design and analyze an efficient algorithm to merge H_1 and H_2 to a new max-heap H of size $2n$.

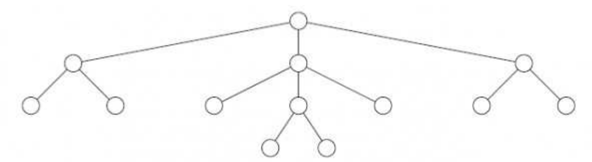
descriptive isi2014 algorithms binary-tree heap

Answer

3.8.24 Heap: TIFR2014-B-19 top

http://gateoverflow.in/27352

Consider the following tree with 13 nodes.



Suppose the nodes of the tree are randomly assigned distinct labels from $\{1, 2, \ldots, 13\}$, each permutation being equally likely. What is the probability that the labels form a min-heap (i.e., every node receives the minimum label in its subtree)?

a. $\left(\frac{1}{6!}\right)\left(\frac{1}{3!}\right)^2$
b. $\left(\frac{1}{3!}\right)^2\left(\frac{1}{2!}\right)^3$
c. $\left(\frac{1}{13}\right)\left(\frac{1}{6}\right)\left(\frac{1}{3}\right)^3$
d. $\frac{2}{13}$
e. $\frac{1}{2^{13}}$

tifr2014 heap

Answer

Answers: Heap

3.8.1 Heap: GATE 2016-1-37 top

http://gateoverflow.in/39706

Selected Answer

Answer would be B) O(d) but not O(1).. as we need to apply heapify.. and suppose if we are deleting root, in worst case would take O(d) time..

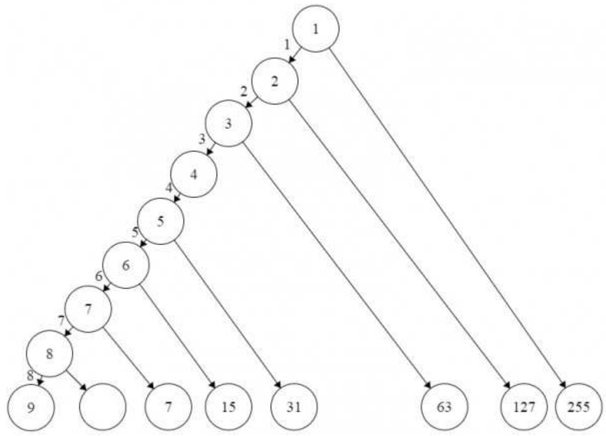
24 votes -- Abhilash Panicker (8.8k points)

3.8.2 Heap: GATE 2016-2-34 top

http://gateoverflow.in/39585

Selected Answer

Here answer is 8. With 1024 nodes, we can easily build min heap Check following diagram



Now once we place 1-9 then remaining elements can be placed easily to fill up heap (While keeping heap property of course) Total elements we need for this heap is 512, we have given 1024 ! So Yes, 8 is answer !

26 votes -- Akash (43.8k points)

3.8.3 Heap: GATE1996_2.11 top

http://gateoverflow.in/2740

Selected Answer

"The minimum number of interchanges needed to convert the array
89, 19, 40, 17, 12, 10, 2, 5, 7, 11, 6, 9, 70
into a heap with the maximum element at the root node is:"

This is the correction.

Answer: C.

Only element 70 violates the rule. Hence, it must be shifted to its proper position.
Step1: swap(10, 70)
Step2: swap(40, 70)
Hence, only 2 interchanges are required.

14 votes -- Gate Keeda (19.1k points)

3.8.4 Heap: GATE1999_12 top

http://gateoverflow.in/1511

Selected Answer

(A)

Note My Convention:-

no. Of full node=F

no. Of leaf node=L

Base Case: H = 0.

A binary tree of height 0 is just a single node with no children, and therefore has 1 leaf.

F+ 1 = L

0+1=1

so the base case satisfies the induction hypothesis (see below).

Induction Hypothesis(I.H): Suppose that for some k >= 0, all binary trees of height <= k have (F +1)= L leaves .

Induction Step: Let T be a binary tree of height k+1. Then T's left and right subtrees are each binary trees of height <= k, and thus by the I.H. both subtree have (F +1)leaves. The number of leaves in T is equal to the sum of the number of leaves in T's subtrees,

$(F+1)_{\text{left sub tree}} + (F+1)_{\text{right sub tree}} = L_{\text{left sub tree}} + L_{\text{right sub tree}}$

2F+2=2L

2(F+1)=2(L)

∴ F+1=L (proved)

Hence the hypothesis holds for k+1, and so the theorem is proved.

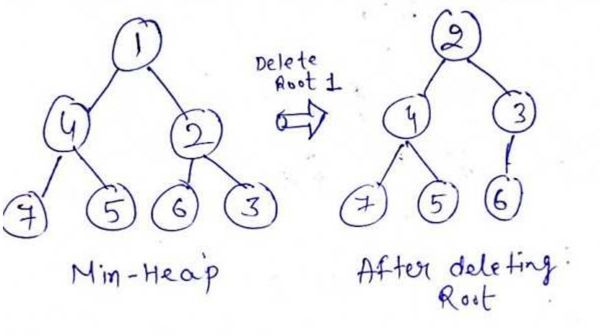
(B)

Here in question they mentioned to insert element in given order into an empty Heap.

So here we have to use Insertion Method to create the heap instead of using Heapify Method to build the heap.

Plz refer below img the LHS shows the resultant heap after doing insertion of the keys into initial empty heap.

RHS heap is the result of deletion of root.



8 votes -- Rajesh Pradhan (18.6k points)

3.8.5 Heap: GATE2001-1.15 top

http://gateoverflow.in/708

Selected Answer

for node at index i

left child(L) at 2i

right child(R) at 2i+1

for node at index i

parent will be at floor i/2

14 votes -- Pooja Palod (32.4k points)

3.8.6 Heap: GATE2003-23 top

http://gateoverflow.in/1110

Selected Answer

Time to find the smallest element on a min-heap- one retrieve operation - $\Theta(1)$
Time to find the second smallest element on a min-heap- requires $2^2 - 1 = 3$ check operations to find the second smallest element out of 3 elements - $\Theta(1)$

Time to find the 7^{th} smallest element - requires $O(2^7 - 1) = O(127)$ check operations to find the seventh smallest element out of 127 possible ones - $\Theta(1)$

In short if the number of required operations is independent of the input size n, then it is always $\Theta(1)$.

(Here, we are doing a level order traversal of the heap and checking the elements)

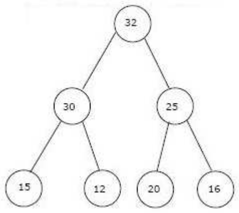
If we are not allowed to traverse the heap and allowed only default heap-operations, we will be restricted with doing Extract-min 7 times which would be $O(\log n)$.

36 votes -- gatecse (13.4k points)

3.8.7 Heap: GATE2004-37 top http://gateoverflow.in/1034

Selected Answer

answer = **option A**



Just keep inserting elements making sure resulting Tree is nearly Complete.(Heap Property) .

While inserting any node, if you find that Value of New Node > Value of it's parent, bubble it up to keep Max heap property

11 votes -- Akash (43.8k points)

3.8.8 Heap: GATE2004-IT-53 top http://gateoverflow.in/3696

Selected Answer

By using **Build Heap method** we can create heap from complete binary tree.which will takeO(n).

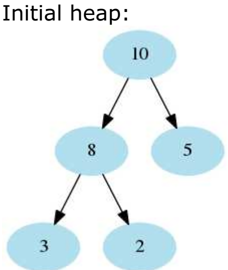
18 votes -- Sneha Goel (1.2k points)

3.8.9 Heap: GATE2005-34 top http://gateoverflow.in/1370

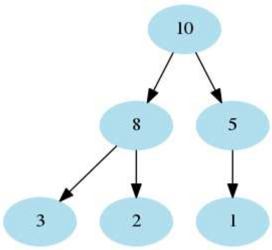
Selected Answer

ans is D....whenever we insert an element in heap,it will always inserted in last level from left to right..so here we insert element 1 and 7 as a child of node 5.then we perform heapify algorithm until we get the min/max heap..so here finally in above question we get the heap whose level order traversal is 10,8,7,3,2,1,5

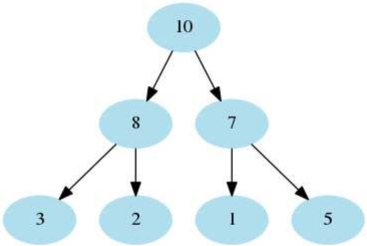
Initial heap:



After insert of 1



After insert of 7



13 votes -- neha pawar (4.4k points)

3.8.10 Heap: GATE2006-10 top http://gateoverflow.in/889

Selected Answer

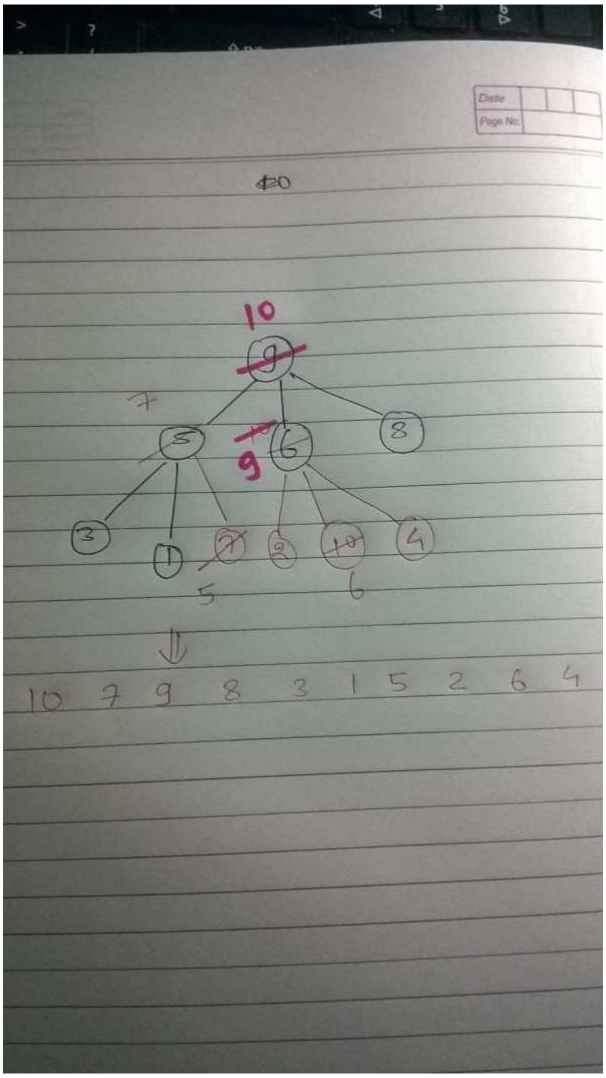
(A) $O(n)$

In a max heap, the smallest element is always present at a leaf node. Heap being a complete binary tree, there can be up to $\frac{n}{2}$ leaf nodes and to examine all of them we would need $O(n)$ time.

14 votes -- Keith Kr (6.3k points)

3.8.11 Heap: GATE2006-76 top http://gateoverflow.in/1852

Selected Answer



For 77, heap will be constructed like this, based on the correct answer of 76(which is option D)

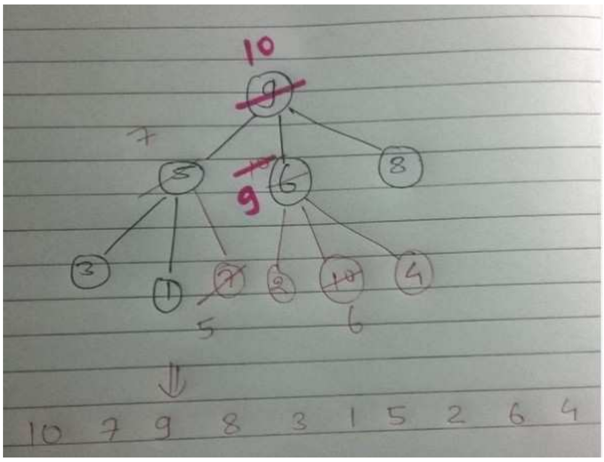
10 votes -- Anurag Pandey (13.1k points)

3.8.12 Heap: GATE2006-77 top

http://gateoverflow.in/87191

Selected Answer

Ans to ques 76 is 9, 5, 6, 8, 3, 1
and ans for ques 77 given by Anurag Pandeya



👍 4 votes -- Lokesh . (9.8k points)

3.8.13 Heap: GATE2006-IT-44 top http://gateoverflow.in/3587

Selected Answer

for a heap(max heap) parent should be greater than or equal to children. in a heap of [1..n] left child of ith node will be at 2*i th position and right child will be at 2*i+1 position

so for given options we can verify it

option C seems to be following the property

👍 11 votes -- Sankaranarayanan P.N (11.2k points)

3.8.14 Heap: GATE2006-IT-72 top http://gateoverflow.in/3616

Selected Answer

The question is saying best case which will be when only one swap will be required which will be order of 1.
As no option matches just call heapify at the root - O(log n).

👍 11 votes -- No Need (14.1k points)

3.8.15 Heap: GATE2007-47 top http://gateoverflow.in/1245

Selected Answer

number of elements in the path from new leaf to root $= \log n$, and all elements are sorted from leaf to root so we can do a binary search which will result in $O(\log \log n)$ number of comparisons.

Since in heap is a complete binary tree, in an array implementation, from every node index, we can know its depth and this will be the n for binary search.

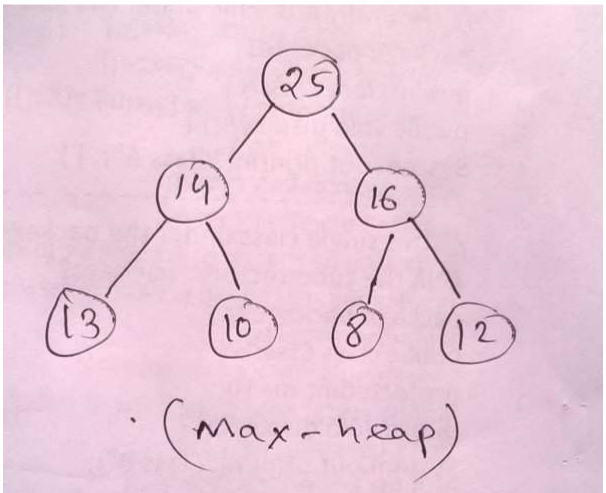
👍 30 votes -- Vikrant Singh (13.4k points)

3.8.16 Heap: GATE2009-59 top http://gateoverflow.in/1341

Selected Answer

Answer : (C)

The binary max-Heap looks like this :



5 votes -- Dipak Majhi (865 points)

Taking the given array as level order traversal, we can build binary tree.

(A) 13 comes as child of 12, which is not allowed in a binary max-heap

(B) 16 comes as child of 14 violating max-heap property

(C) is a valid binary max-heap as all children are smaller than their parent

(D) 16 comes as child of 12, violating max-heap property

13 votes -- Arjun Suresh (294k points)

3.8.17 Heap: GATE2009-60 top

http://gateoverflow.in/43466

Selected Answer

During delete, the root element is removed, replaced with the last element and heap property is corrected by pushing the root downwards. So, for first delete,

25 14 16 13 10 8 12 -> 12 14 16 13 10 8 -> 16 14 12 13 10 8 (the element not satisfying max-heap property is exchanged with the largest of its children) (heap property satisfied)

Second delete:

16 14 12 13 10 8 -> 8 14 12 13 10 -> 14 8 12 13 10 -> 14 13 12 8 10 (heap property satisfied)

http://homepages.ius.edu/RWISMAN/C455/html/notes/Chapter6/heapify.htm

13 votes -- Arjun Suresh (294k points)

3.8.18 Heap: GATE2011_23 top

http://gateoverflow.in/2125

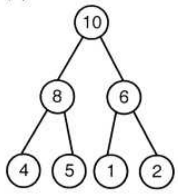
Selected Answer

in option a - it is not a max heap because it is not complete binary tree .

in option c-it is complete binary tree but not follow the max heap property i.e. the values of parent nodes always greater then child nodes

and there node of value 5 is less then on e of its children.

in option d- similar to above c option explaination here node of value 2 is less then to the value 4 .



correct option is (B) that is satisfy both properties and all of the max heap .

14 votes -- ASHU2015 (277 points)

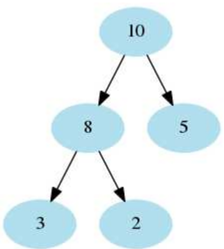
3.8.19 Heap: GATE2014-2-12 top

http://gateoverflow.in/1967

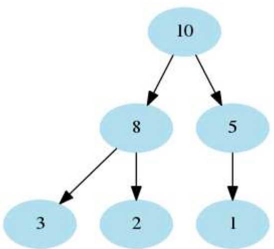
Selected Answer

ans is A....whenever insertion will be done in heap ,it will always inserted in last level from left to right.so we insert 1 and 7as a child of node 5 now we perform heapify algorithm until heap property will satisfied..and then we get the heap whose level order traversal is 10,8,7,3,2,1,5

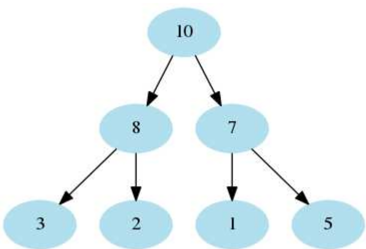
Initial heap



After insert of 1



After insert of 7



12 votes -- neha pawar (4.4k points)

3.8.20 Heap: GATE2015-1_32 top

http://gateoverflow.in/8273

Selected Answer

Heap is complete binary tree. To insert a new element, we put it at the end of the tree and move up towards root till heap property is satisfied. Here, 35 comes as child of 15, with the path 40-30-15-35. So, we swap 15, 35 and then 30, 35 to get the new path 40-35-30-15. So, new heap will be 40 35 20 10 30 16 17 8 4 15.

19 votes -- Arjun Suresh (294k points)

3.8.21 Heap: GATE2015-2_17 top http://gateoverflow.in/8091

Selected Answer

Ans A.

Here, lower bound imply best algorithm which works for all cases and hence we should consider worst-case.

Max-Heapify(root)

25 votes -- Vikrant Singh (13.4k points)

3.8.22 Heap: GATE2015-3_19 top http://gateoverflow.in/8418

Selected Answer

first interchange 15-100
2nd 50-100
3rd 89-100
so total interchange 3 so option D is correct.

17 votes -- Anoop Sonkar (4.9k points)

3.8.23 Heap: ISI2014-CS-2b top http://gateoverflow.in/47438

Selected Answer

First copy the two arrays of H1 and H2 into a new array of size 2n...then apply build heap operation to get H...Time complexity=O(2n)=O(n)

http://www.geeksforgeeks.org/merge-two-binary-max-heaps/

5 votes -- debanjan sarkar (3.7k points)

3.8.24 Heap: TIFR2014-B-19 top http://gateoverflow.in/27352

Selected Answer

(**C)** is Correct -

Probability = $\dfrac{Number\ of\ Favorable\ Outcomes(minheaps)}{Total\ Trees(13!)}$

Now, total Min-Heaps :

Firstly we select **minimum element** i.e. 1 **for root** = **1 way**

We have 3 subtrees of 3,6,3 sizes respectively

First Subtree with 3 elements:

Steps:

1) Choose 3 elements = **$^{12}C_3$ ways**

2) Give minimum to root = **1 way**

3) 2 elements , 2 children(left & right) = **2 ways** { Any of the 2 elements can be given to left or right child}

Second Subtree with 3 elements :

Steps:

1) Choose 3 elements from 9 left elements = $^9C_3$ **ways**

2) Similar to above assign these = **2 ways**

Subtree with 6 elements:{ We already have 6 elements left now}

1 Root , 1left_most child , 1 right_most child , 3 in middle **

Steps:

1) Choose root = **1 way** {minimum}

2) Now 5 elements left, choose leftmost child = **5 ways** (choose anyone)

3) Now 4 elements left, choose right_most child = **4 ways** (choose anyone)

4) Now 3 elements left for middle :

a) assign root = **1 way**

b) assign left and right anyone = **2 ways**

For, Total Heaps multiply all ways **above.**

Total probability = $\frac{Total\ Heaps}{Total\ Trees(13!)}$

= $\frac{12! * 2 * 9! * 2 * 5 * 4 * 2}{13! * 3! * 9! * 3! * 6!}$

= $\left(\frac{1}{13}\right)\left(\frac{1}{6}\right)\left(\frac{1}{3}\right)^3$

19 votes -- Himanshu Agarwal (16.2k points)

3.9 Linked Lists(20) top

3.9.1 Linked Lists: CMI2012-B-07 top

http://gateoverflow.in/46590

We use the notation $[x1, x2, \ldots, xn]$ to denote a list of integers. [] denotes the empty list, and $[n]$ is the list consisting of one integer n. For a nonempty lxist l, head(l) returns the first element of l, and tail(l) returns the list obtained by removing the first element from l. The function length(l) returns the length of a list. For example,

- head([11,-1,5]) = 11, tail([11,-1,5]) = [-1,5].
- head([7]) = 7, tail([7]) = [].
- length([]) = 0, length([7]) = 1, length([11,-1,5]) = 3.

We use or, and and not to denote the usual operations on boolean values$true$ and $false$.
Consider the following functions, each of which takes a list of integers as input and returns a boolean value.

```
f(l)
    if (length(l) < 2) then return(true)
    else return(g(l) or h(l))
g(l)
    if (length(l) < 2) then return(true)
    else
        if (head(l) < head(tail(l))) then return h(tail(l))
        else return(false)
h(l)
    if (length(l) < 2) then return(true)
    else
        if (head(l) > head(tail(l))) then return g(tail(l))
        else return(false)
```

When does $f(l)$ return the value true for an input l? Explain your answer.

cmi2012 descriptive data-structure linked-lists

Answer

3.9.2 Linked Lists: GATE 2016-2-15 top http://gateoverflow.in/39557

N items are stored in a sorted doubly linked list. For a *delete* operation, a pointer is provided to the record to be deleted. For a *decrease-key* operation, a pointer is provided to the record on which the operation is to be performed.

An algorithm performs the following operations on the list in this order: $\Theta\left(N\right)$ *delete*, $O(\log N)$ *insert*, $O(\log N)$ *find*, and $\Theta\left(N\right)$ *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. $\Theta\left(N^2 \log N\right)$

gate2016-2 data-structure linked-lists time-complexity normal

Answer

3.9.3 Linked Lists: GATE1987-1-xv top http://gateoverflow.in/80298

In a circular linked list oraganisation, insertion of a record involves modification of

A. One pointer.
B. Two pointers.
C. Multiple pointers.
D. No pointer.

gate1987 data-structure linked-lists

Answer

3.9.4 Linked Lists: GATE1993_13 top http://gateoverflow.in/2310

Consider a singly linked list having n nodes. The data items $d_1, d_2, \dots d_n$ are stored in these n nodes. Let X be a pointer to the j^{th} node $\left(1 \leq j \leq n\right)$ 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 $d_1, d_2, \dots, d_j, d, \dots, d_n$ in order without using the header.

gate1993 data-structure linked-lists normal

Answer

3.9.5 Linked Lists: GATE1994-1.17, UGCNET-Sep2013-II-32 top http://gateoverflow.in/2460

Linked lists are not suitable data structures for which one of the following problems?

A. Insertion sort

B. Binary search

C. Radix sort

D. Polynomial manipulation

gate1994 data-structure linked-lists normal ugcnetsep2013ii

Answer

3.9.6 Linked Lists: GATE1995-2.22 top http://gateoverflow.in/2634

Which of the following statements is true?

I. As the number of entries in a hash table increases, the number of collisions increases.

II. Recursive programs are efficient

III. The worst case complexity for Quicksort is $O(n^2)$

IV. Binary search using a linear linked list is efficient

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

gate1995 data-structure linked-lists hashing

Answer

3.9.7 Linked Lists: GATE1997-18 top

http://gateoverflow.in/2278

Consider the following piece of 'C' code fragment that removes duplicates from an ordered list of integers.

```
Node   *remove-duplicates (Node* head, int *j)
{
    Node *t1, *t2;
    *j=0;
    t1 = head;
    if (t1! = NULL) t2 = t1 ->next;
    else return head;
    *j = 1;
    if(t2 == NULL)
        return head;
    while t2 != NULL)
    {
        if (t1.val != t2.val) ----------------> S1)
        {
            (*j)++; t1 -> next = t2; t1 = t2: -----> (S2)
        }
        t2 = t2 ->next;
    }
    t1 -> next = NULL;
    return head;
}
```

Assume the list contains n elements ($n \geq 2$) in the following questions.

a. How many times is the comparison in statement S1 made?

b. What is the minimum and the maximum number of times statements marked S2 get executed?

c. What is the significance of the value in the integer pointed to by j when the function completes?

gate1997 data-structure linked-lists normal

Answer

3.9.8 Linked Lists: GATE1997_1.4 top

http://gateoverflow.in/2220

The concatenation of two lists is to be performed on $O(1)$ time. Which of the following implementations of a list should be used?

A. Singly linked list

B. Doubly linked list

C. Circular doubly linked list

D. Array implementation of list

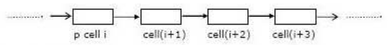
gate1997 data-structure linked-lists easy

Answer

3.9.9 Linked Lists: GATE1998_19a top

http://gateoverflow.in/1733

a. Let p be a pointer as shown in the figure in a single linked list.



What do the following assignment statements achieve?

```
q: = p -> next
p -> next:= q -> next
q -> next:=(q -> next) -> next
(p -> next) -> next:= q
```

gate1998 data-structure linked-lists normal

Answer

3.9.10 Linked Lists: GATE1999_11b top

http://gateoverflow.in/93575

Write a constant time algorithm to insert a node with data D just before the node with address p of a singly linked list.

gate1999 data-structure linked-lists

Answer

3.9.11 Linked Lists: GATE2002-1.5 top

http://gateoverflow.in/809

In the worst case, the number of comparisons needed to search a single linked list of length n for a given element is

A. $\log n$
B. $\frac{n}{2}$
C. $\log_2 n - 1$
D. n

gate2002 easy data-structure linked-lists

Answer

3.9.12 Linked Lists: GATE2003-90 top

http://gateoverflow.in/973

Consider the function f defined below.

```
    struct item {
        int data;
        struct item * next;
};
int f(struct item *p) {
    return ((p == NULL) || (p->next == NULL)||
        ((p->data <= p ->next -> data) &&
        f(p->next)));
}
```

For a given linked list p, the function f returns 1 if and only if

A. the list is empty or has exactly one element

B. the elements in the list are sorted in non-decreasing order of data value

C. the elements in the list are sorted in non-increasing order of data value

D. not all elements in the list have the same data value

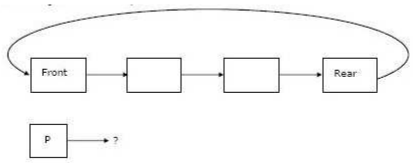
gate2003 data-structure linked-lists normal

Answer

3.9.13 Linked Lists: GATE2004-36 top

http://gateoverflow.in/1033

A circularly linked list is used to represent a Queue. A single variable p is used to access the Queue. To which node should p point such that both the operations enQueue and deQueue can be performed in constant time?



A. rear node
B. front node
C. not possible with a single pointer
D. node next to front

gate2004 data-structure linked-lists normal

Answer

3.9.14 Linked Lists: GATE2004-40 top http://gateoverflow.in/1037

Suppose each set is represented as a linked list with elements in arbitrary order. Which of the operations among $\text{union, intersection, membership, cardinality}$ will be the slowest?

A. union only
B. $\text{intersection, membership}$
C. $\text{membership, cardinality}$
D. $\text{union, intersection}$

gate2004 data-structure linked-lists normal

Answer

3.9.15 Linked Lists: GATE2004-IT-13 top http://gateoverflow.in/3654

Let P be a singly linked list. Let Q be the pointer to an intermediate node x in the list. What is the worst-case time complexity of the best-known algorithm to delete the node x from the list ?

A. O(n)
B. O($\log^2$ n)
C. O(log n)
D. O(1)

gate2004-it data-structure linked-lists normal ambiguous

Answer

3.9.16 Linked Lists: GATE2005-IT-54 top http://gateoverflow.in/3815

The following C function takes a singly-linked list of integers as a parameter and rearranges the elements of the list. The list is represented as pointer to a structure. The function is called with the list containing the integers 1, 2, 3, 4, 5, 6, 7 in the given order. What will be the contents of the list after the function completes execution?

```
struct node {int value; struct node *next;);
void rearrange (struct node *list) {
    struct node *p, *q;
    int temp;
    if (!list || !list -> next) return;
    p = list; q = list -> next;
    while (q) {
        temp = p -> value;
        p -> value = q -> value;
        q -> value = temp;
        p = q -> next;
        q = p ? p -> next : 0;
      }
}
```

A. 1, 2, 3, 4, 5, 6, 7
B. 2, 1, 4, 3, 6, 5, 7
C. 1, 3, 2, 5, 4, 7, 6

D. 2, 3, 4, 5, 6, 7, 1

gate2005-it data-structure linked-lists normal

Answer

3.9.17 Linked Lists: GATE2008-62 top http://gateoverflow.in/485

The following C function takes a single-linked list of integers as a parameter and rearranges the elements of the list. The function is called with the list containing the integers 1, 2, 3, 4, 5, 6, 7 in the given order. What will be the contents of the list after function completes execution?

```
struct node {
    int value;
    struct node *next;
};

void rearrange(struct node *list) {
    struct node *p, *q;
    int temp;
    if (!list || !list -> next) return;
    p = list; q = list -> next;
    while(q) {
        temp = p -> value; p->value =  q -> value;
        q->value = temp; p = q ->next;
        q = p? p ->next : 0;
    }
}
```

A. 1, 2 ,3, 4, 5, 6, 7
B. 2, 1, 4 ,3, 6, 5, 7
C. 1, 3, 2, 5, 4, 7, 6
D. 2, 3, 4, 5, 6, 7, 1

gate2008 data-structure linked-lists normal

Answer

3.9.18 Linked Lists: GATE2010-36 top http://gateoverflow.in/2337

The following C function takes a singly-linked list as input argument. It modifies the list by moving the last element to the front of the list and returns the modified list. Some part of the code is left blank.

```
typedef struct node
{
    int value;
    struct node *next;
} node;
Node *move_to-front(Node *head)
{
    Node *p, *q;
    if ((head == NULL) || (head -> next == NULL))
        return head;
    q = NULL;
    p = head;
    while (p->next != NULL)
    {
        q=p;
        p=p->next;
    }
    _______________

    return head;

}
```

Choose the correct alternative to replace the blank line.

A. q=NULL; p->next = head; head = p;
B. q->next = NULL; head = p; p->next = head;
C. head = p; p->next =q; q->next = NULL;
D. q->next = NULL; p->next = head; head = p;

gate2010 data-structure linked-lists normal

Answer

3.9.19 Linked Lists: GATE2017-1-08 top http://gateoverflow.in/118711

Consider the C code fragment given below.

```
typedef struct node {
    int data;
    node* next;
} node;

void join(node* m, node* n) {
    node* p = n;
    while(p->next != NULL) {
        p = p->next;
    }
    p->next = m;
}
```

Assuming that m and n point to valid NULL-terminated linked lists, invocation of join will

(A) append list m to the end of list n for all inputs.

(B) either cause a null pointer dereference or append list m to the end of list n.

(C) cause a null pointer dereference for all inputs.

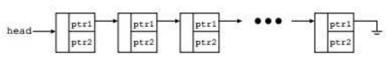
(D) append list n to the end of list m for all inputs.

gate2017-1 data-structure linked-lists normal

Answer

3.9.20 Linked Lists: ISI2015-CS-3a top http://gateoverflow.in/47273

Consider a linked list containing n nodes, where each node contains two pointers $ptr1$ and $ptr2$. For each node, $ptr1$ points to the next node of the list. Describe how pointer $ptr2$ should be set up for each node so that you will be able to locate the i-th node from the start node in the list traversing no more than $[\log i] + [i/2]$ nodes.



descriptive isi2015 data-structure linked-lists

Answer

Answers: Linked Lists

3.9.1 Linked Lists: CMI2012-B-07 top http://gateoverflow.in/46590

Selected Answer

For any list L , if there exists 3 consecutive numbers which are sorted or reverse sorted ,then the function will return false .

Here we assume that any 2 consecutive elements will always be different. In the question they didn't specify what happens when we compare 2 consecutive similar numbers.

Let me consider a List L [X1,X2,X3,.........Xn] , n>2

The 2 possible input sequences for which the function returns true will be,

X1>X2<X3>X4<X5............

X1<X2>X3<X4>X5............

1 votes -- balaeinstein (917 points)

3.9.2 Linked Lists: GATE 2016-2-15 top http://gateoverflow.in/39557

Selected Answer

Tip Q means Theata !

Here I believe answer is C

Delete O(1)

Insert O(N)

Find O(N)

Decrease Key => O(N) //Because we need to search position in Linked list. (It is similar to a Delete followed by an Insert with the decreased value)

O(n) delete => O(N * 1) =O(N)

O(logN) find => O(logN * N) => O(NlogN)

O(logN) insert => O(NlogN)

O(N) decrease key => O(N*N) => O(N^2)

Even though it says at start we got N elements, then we are deleting Q(N) elements, here Q(N) can be anything like N/2,N/4,N/3 and list need not be empty, then above explanation holds !

In case it actually deleted all elements at start analysis will be something like below =>

all N are deleted, Time complexity O(1) each delete , total delete O(N)

Now LogN insert, it'll take 1 + 2 + LogN time, then (LogN * logN-1)/2 => O($(\log N)^2$)

Now LogN finds => it'll take LogN time per find (because find take O(N) but here N = LogN)
=> O($(\log N)^2$)

Now N decrease key, Size of list is Log N, each decrease key can take O(size of list)

So size of list * no of decrease key => N * log N => O(NlogN)

there is no option like O(NlogN)

so correct answer is O(N^2)

26 votes -- Akash (43.8k points)

Delete - θ(1) time as pointer is directly given
Insert - O(N) time,we may need to insert at the end of the sorted list..
Find - θ(N) time.. list we need to search sequentially..
Decrease key - θ(N) time, pointer is directly given, delete then insert

Now using above..
θ(N) * θ(1) + O(logN) * O(N) + O(logN) * θ(N) + θ(N) * θ(N)
using property of asymptotic notation, and removing lower terms, we get O(N^2)..
So Answer O(N^2) C)

13 votes -- Abhilash Panicker (8.8k points)

3.9.3 Linked Lists: GATE1987-1-xv top http://gateoverflow.in/80298

Selected Answer

suppose we have to insert node p after node q then

p->next=q->next

q->next=p

so two pointers

b)

5 votes -- Sanket_ (4k points)

3.9.4 Linked Lists: GATE1993_13 top http://gateoverflow.in/2310

Selected Answer

Following 2 lines are enough to realise above constraint :->>

```
1. Y->next = X-> next

2. X->next = Y
```

8 votes -- Rajesh Pradhan (18.6k points)

3.9.5 Linked Lists: GATE1994-1.17, UGCNET-Sep2013-II-32 top http://gateoverflow.in/2460

Selected Answer

LInked list are suitable for

Insertion sort:->>No need to swap here just find appropriate place and join the link

Polynomial manipulation:->> Linked List is natural soln for polynomial manipulation .http://iiith.vlab.co.in/?sub=21&brch=46&sim=490&cnt=697

Radix sort:->here we are putting digits according to same position(unit,tens) into buckets;

which can be effectively handle by linked list.

Not Suitable for

Binary search:-> Bcz finding mid element itself takes O(n) time.

So Option **B** is ans.

8 votes -- Rajesh Pradhan (18.6k points)

B. Because in binary search we need to have access to the mid of the list in constant time. and finding the mid itself in a linked list takes $O(n)$ time which makes no sense to Binary search which otherwise takes $O(\log n)$.

15 votes -- Gate Keeda (19.1k points)

3.9.6 Linked Lists: GATE1995-2.22 top http://gateoverflow.in/2634

Selected Answer

Its D according to me.

Binary search using linked list is not efficient as it will not give O(logn), because we will not be able to find the mid in constant time. Finding mid in linked list takes O(n) time.

Recursive programs are not efficient because they take a lot of space, Recursive methods will often throw StackOverflowException while processing big sets. moreover it has its own advantages too.

19 votes -- Gate Keeda (19.1k points)

3.9.7 Linked Lists: GATE1997-18 top http://gateoverflow.in/2278

Selected Answer

a. As we are comparing here pair wise so for n elements we require compulsory n-1 comparision

b. S2 is executed only for distinct elements so **max n-1** times and **min 0** when all r duplicates or list contain no or 1 element.

c. j holds the count on number of distinct elements in the ordered list.

7 votes -- Rajesh Pradhan (18.6k points)

3.9.8 Linked Lists: GATE1997_1.4 top http://gateoverflow.in/2220

Selected Answer

A) & B) Here it is not possble to do it in O(1) , unless we have pointer to end of one list. As we have not given that pointer, A & B are not option.

D) It is not possible to do here in O(1), because we will need to allocate memory for bigger array to hold both list & Copy it.

C) It is possible in O(1) as we can break list at any location & connect it anywhere. We don't need to traverse to end of anything here !

23 votes -- Akash (43.8k points)

3.9.9 Linked Lists: GATE1998_19a top http://gateoverflow.in/1733

Selected Answer

Swaps the two nodes next to p in the linked list.

10 votes -- Arjun Suresh (294k points)

3.9.10 Linked Lists: GATE1999_11b top http://gateoverflow.in/93575

Selected Answer

let A,B,C,D,E,F be the data ..
A---> B ----> C----> E ---->F
let pointer to E be p..
a node with data D has to be inserted before E..
i ll do one thing , add D just after node E .. it ll take constant time..
Pnext --->Address_of_D
Address_of_D.next------> Address_of_F

A---> B ----> C----> E -----> D---->F

take a temporary variable and swap the value E and D..
temp = p.data
p.data= p.next.data
p.next.data= temp
now linked list wil look like ..
A---> B ----> C----> D-----> E ---->F
still one more work left.. now pointer p pointing to D so increment pointer p to point data E..
p= p--->next

12 votes -- Digvijay (47k points)

3.9.11 Linked Lists: GATE2002-1.5 top http://gateoverflow.in/809

Selected Answer

A & C is not correct as we can not do binary search in Linked list.

B seems like average case, be we are asked for worst case.

Worst case is we do not find the element in list. We might end up searching entire list & comparing with each element. So answer -> D. n

11 votes -- Akash (43.8k points)

3.9.12 Linked Lists: GATE2003-90 top http://gateoverflow.in/973

Selected Answer

It returns 1 if and only if the linked list is sorted in non-decreasing order- B option.

It returns 1 if the list is empty or has just 1 element also, but if and only if makes A option false.

13 votes -- Bhagirathi Nayak (13.3k points)

3.9.13 Linked Lists: GATE2004-36 top http://gateoverflow.in/1033

Selected Answer

The pointer points to the Rear node.

EnQueue: Insert newNode after Rear, and make Rear point to the newly inserted node:

```
//struct node *newNode;
newNode->next = rear->next;
rear->next = newNode;
rear=newNode;
```

DeQueue: Delete the Front node, and make the second node the front node.

```
//rear->next points to the front node.
//front->next points to the second node.
struct node* front;
front = rear->next;
rear->next = front->next;
free(front);
```

36 votes -- Pragy Agarwal (19.5k points)

3.9.14 Linked Lists: GATE2004-40 top http://gateoverflow.in/1037

Selected Answer

answer - D

membership is linear search - $O(n_1 + n_2)$

cardinality is linear - $O(n_1 + n_2)$

for union we need to ensure no duplicate elements should be present - $O(n_1 \times n_2)$ for each element we need to check if that element exists in other set

for intersection also for every element in set1 we need to scan set2 - $O(n_1 \times n_2)$

26 votes -- ankitrokdeonsns (9.1k points)

3.9.15 Linked Lists: GATE2004-IT-13 top http://gateoverflow.in/3654

Selected Answer

Since Q is pointing to node X, it can de done in O(1) time..

Algo:

Q -> data = Q ->next -> data; // Copy the value of next node into Q.

del = Q -> next; // take another pointer variable pointing to next node of Q.

Q -> next = Q -> next ->next;

free (del);

25 votes -- gate_asp (755 points)

In the worst case x could be last or second last node, In that case full traversal of the list is required. Therefore answer is (A).

16 votes -- suraj (5.1k points)

3.9.16 Linked Lists: GATE2005-IT-54 top

http://gateoverflow.in/3815

Selected Answer

i think it's **B)** 2 1 4 3 6 5 7:

as,

p and q are swapping each other.where q is p->next all the time.

10 votes -- sumit kumar singh dixit (2.3k points)

3.9.17 Linked Lists: GATE2008-62 top

http://gateoverflow.in/485

Selected Answer

The loop is interchanging the adjacent elements of the list. But after each interchange, next interchange starts from the unchanged elements only (due to p = q -> next;).

1st iteration 1 2 3 4 5 6 7
=> 2 1 3 4 5 6 7

2nd iteration 2 1 4 3 5 6 7

3rd iteration 2 1 4 3 6 5 7

p pointing to null q pointing to 7, as p is false hence q=p? p->next:0; will return q=0 ending the loop

answer = **option B**

9 votes -- Manali (2.8k points)

3.9.18 Linked Lists: GATE2010-36 top

http://gateoverflow.in/2337

Selected Answer

as per given code p points to last node which should be head in modified.

q is the previous node of tail which should be tail for modified

answer D

17 votes -- Sankaranarayanan P.N (11.2k points)

3.9.19 Linked Lists: GATE2017-1-08 top

http://gateoverflow.in/118711

Selected Answer

Here is the implemented code in `c` (`-std=c99`).

```
#include <stdio.h>
#include <stdlib.h>

#define M 5
#define N 4

int M_data[M] = {1,2,3,4,5};
int N_data[N] = {6,7,8,9};

typedef struct node {
 int data;
 struct node * next;
}node;

void join(node *m,node *n) {
 node * p = n;
 while(p->next != NULL) p = p->next;
 p->next = m;
}

node * bulk_insert(int list_data[],int size) {
 node * head = NULL;
 for(int i=0;i<size;i++) {
   node * newnode = malloc(sizeof(node));
   newnode->data = list_data[i];
   newnode->next = NULL;

   if(head == NULL) {
    head = newnode;
   }else {
    node * temp = head;
    while(temp->next != NULL) temp = temp->next;
    temp->next = newnode;
   }
 }
 return head;
}
void display(node *);
void list_dealloc(node *); /*deallocation prototype*/

int main() {
 node * m = NULL;
 node * n = NULL;
 // insert m_list data
 m = bulk_insert(M_data,M);
 n = bulk_insert(N_data,N);  // commenting this causes runtime error
              // is list n is empty
 printf("\n before join operation :\n");
 display(m);
 display(n);

 join(m,n);

 printf("\n after join operation :\n");
 display(m);
 display(n);

 //list_dealloc(m); no need now
 list_dealloc(n); // OK
 return 0;

}

void display(node *head) {
 while(head != NULL) {
  printf("%d->",head->data);
  head = head->next;
 }
 printf("null\n");
}
void list_dealloc(node * head) {
 while(head != NULL) {
  node * temp = head;
  head = head->next;
  free(temp);
 }
}
```

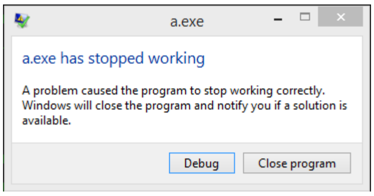
With both **n** and **m** and n being **non-empty** linked list, then,

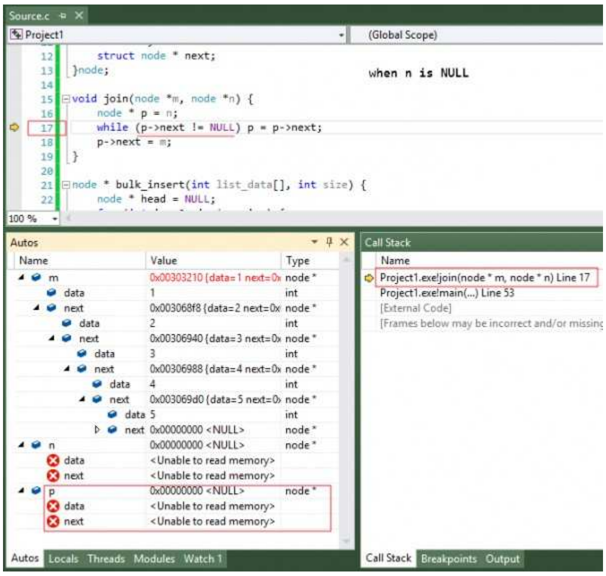
O/P:

```
 before join operation :
1->2->3->4->5->null
6->7->8->9->null

 after join operation :
1->2->3->4->5->null
6->7->8->9->1->2->3->4->5->null
```

With n being **empty** linked list, then,

O/P:





13 votes -- Debashish Deka (51.4k points)

here it is explicitely mentioned that LL are terminated by NULL

so suppose i have m as 1->2-> NULL

and n= 3->4->NULL

so according to the code fragement we need to append M to list N

but in the process is the lsit N is empty but valid like this

node*head;

head->NULL:

it may dereferrence a NULL pointer
so

i think

B is correct answer here

correct me if i am wrong

19 votes -- Aboveallplayer (18.5k points)

3.9.20 Linked Lists: ISI2015-CS-3a top http://gateoverflow.in/47273

Selected Answer

Link 1st node's ptr2 pointer to 2nd node. then 2nd node to 4th node. 4th node to 8th node, 8th node to 16th so on.

For example I need 100th node then do like this- go to **1-->2..>4..>8-->16-->32-->64-->128. T**hen it takes ***log i*** time.

Then to go to 100 start at 64 and linear traversal has to be done for 36 times.

This linear traversal should take ***i/2*** node traversals in the worst case.

Overall it would take traversing no more than **log i + *i/2*** nodes.

4 votes -- Gaurab Ghosh (2k points)

3.10 Queues(11) top

3.10.1 Queues: GATE 2016-1-10 top http://gateoverflow.in/39667

A queue is implemented using an array such that ENQUEUE and DEQUEUE operations are performed efficiently. Which one of the following statements is **CORRECT** (
n refers to the number of items in the queue) ?

A. Both operations can be performed in $O(1)$ time.
B. At most one operation can be performed in $O(1)$ time but the worst case time for the operation will be $\Omega(n)$.
C. The worst case time complexity for both operations will be $\Omega(n)$.
D. Worst case time complexity for both operations will be $\Omega(\log n)$

gate2016-1 data-structure queues normal

Answer

3.10.2 Queues: GATE 2016-1-41 top http://gateoverflow.in/39684

Let Q denote a queue containing sixteen numbers and S be an empty stack. Head(Q) returns the element at the head of the queue Q without removing it from Q. Similarly Top (S) returns the element at the top of S without removing it from S. Consider the algorithm given below.

```
while Q is not Empty do
  if S is Empty OR Top(S) ≤ Head (Q) then
     x:= Dequeue (Q);
     Push (S, x);
  else
     x:= Pop(S);
     Enqueue (Q, x);
  end
end
```

The maximum possible number of iterations of the **while** loop in the algorithm is ________.

gate2016-1 data-structure queues difficult numerical-answers

Answer

3.10.3 Queues: GATE1992-09 top http://gateoverflow.in/588

Suggest a data structure for representing a subset S of integers from 1 to n. Following operations on the set S are to be performed in constant time (independent of cardinality of S).

(i). MEMBER (X):	Check whether X is in the set S or not
(ii). FIND-ONE(S):	If S is not empty, return one element of the set S (any arbitrary element will do)
(iii). ADD (X):	Add integer X to set S
(iv). DELETE (X):	Delete integer X from S.

Give pictorial examples of your data structure. Give routines for these operations in an English like language. You may assume that the data structure has been suitable initialized. Clearly state your assumptions regarding initialization.

gate1992 data-structure normal descriptive queues

Answer

3.10.4 Queues: GATE1994_26 top http://gateoverflow.in/2522

A queue Q containing n items and an empty stack S are given. It is required to transfer all the items from the queue to the stack, so that the item at the front of queue is on the TOP of the stack, and the order of all other items are preserved. Show how this can be done in $O(n)$ time using only a constant amount of additional storage. Note that the only operations which can be performed on the queue and stack are Delete, Insert, Push and Pop. Do not assume any implementation of the queue or stack.

gate1994 data-structure queues stack normal

Answer

3.10.5 Queues: GATE1996-1.12 top http://gateoverflow.in/2716

Consider the following statements:

i. First-in-first out types of computations are efficiently supported by STACKS.
ii. Implementing LISTS on linked lists is more efficient than implementing LISTS on an array for almost all the basic LIST operations.
iii. Implementing QUEUES on a circular array is more efficient than implementing QUEUES on a linear array with two indices.
iv. Last-in-first-out type of computations are efficiently supported by QUEUES.

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

gate1996 data-structure easy queues stack linked-lists

Answer

3.10.6 Queues: GATE2001-2.16 top http://gateoverflow.in/734

What is the minimum number of stacks of size n required to implement a queue of size n?

A. One
B. Two
C. Three
D. Four

gate2001 data-structure easy stack queues

Answer

3.10.7 Queues: GATE2006-49 top http://gateoverflow.in/1826

An implementation of a queue Q, using two stacks S1 and S2, is given below:

```
void insert (Q, x) {
    push (S1, x);
}
void delete (Q) {
    if (stack-empty(S2)) then
        if (stack-empty(S1)) then {
            print("Q is empty");
            return;
        }
        else while (!(stack-empty(S1))){
            x=pop(S1);
            push(S2,x);
        }
    x=pop(S2);
}
```

let n *insert* and $m(\leq n)$ *delete* operations be performed in an arbitrary order on an empty queue Q. Let x and y be the number of *push* and *pop* operations performed respectively in the process. Which one of the following is true for all m and n?

A. $n+m \leq x < 2n$ and $2m \leq y \leq n+m$
B. $n+m \leq x < 2n$ and $2m \leq y \leq 2n$
C. $2m \leq x < 2n$ and $2m \leq y \leq n+m$
D. $2m \leq x < 2n$ and $2m \leq y \leq 2n$

gate2006 data-structure queues stack normal

Answer

3.10.8 Queues: GATE2007-IT-30 top http://gateoverflow.in/3463

Suppose you are given an implementation of a queue of integers. The operations that can be performed on the queue are:

i. isEmpty (Q) — returns true if the queue is empty, false otherwise.
ii. delete (Q) — deletes the element at the front of the queue and returns its value.
iii. insert (Q, i) — inserts the integer i at the rear of the queue.

Consider the following function:

```
void f (queue Q) {
int i ;
if (!isEmpty(Q)) {
   i = delete(Q);
   f(Q);
   insert(Q, i);
  }
}
```

What operation is performed by the above function f ?

A. Leaves the queue Q unchanged
B. Reverses the order of the elements in the queue Q
C. Deletes the element at the front of the queue Q and inserts it at the rear keeping the other elements in the same order
D. Empties the queue Q

gate2007-it data-structure queues normal

Answer

3.10.9 Queues: GATE2012_35 top http://gateoverflow.in/1756

Suppose a circular queue of capacity $(n - 1)$ elements is implemented with an array of n elements. Assume that the insertion and deletion operations are carried out using REAR and FRONT as array index variables, respectively. Initially, REAR = FRONT = 0. The conditions to detect *queue full* and *queue empty* are

(A)

full: (REAR+1) mod n == FRONT

empty: REAR == FRONT$

(B)

full: (REAR+1) mod n == FRONT

empty: (FRONT+1) mod n == REAR

(C)

full: REAR == FRONT

empty: (REAR+1) mod n == FRONT

(D)

full: (FRONT+1) mod n == REAR

empty: REAR == FRONT

gate2012 data-structure queues normal

Answer

3.10.10 Queues: GATE2013-44 top

http://gateoverflow.in/61

Consider the following operation along with Enqueue and Dequeue operations on queues, where k is a global parameter.

```
MultiDequeue(Q){
    m = k
    while (Q is not empty) and (m > 0) {
        Dequeue(Q)
        m = m - 1
    }
}
```

What is the worst case time complexity of a sequence of n queue operations on an initially empty queue?

(A) $\Theta(n)$

(B) $\Theta(n + k)$

(C) $\Theta(nk)$

(D) $\Theta(n^2)$

gate2013 data-structure algorithms normal queues

Answer

3.10.11 Queues: GATE2017-2-13 top

http://gateoverflow.in/118253

A circular queue has been implemented using a singly linked list where each node consists of a value and a single pointer pointing to the next node. We maintain exactly two external pointers FRONT and REAR pointing to the front node and the rear node of the queue, respectively. Which of the following statements is/are CORRECT for such a circular queue, so that insertion and deletion operations can be performed in $O(1)$ time?

(I) Next pointer of front node points to the rear node.

(II) Next pointer of rear node points to the front node.

(A) (I) only.

(B) (II) only.

(C) Both (I) and (II).

(D) Neither (I) nor (II).

gate2017-2 data-structure queues

Answer

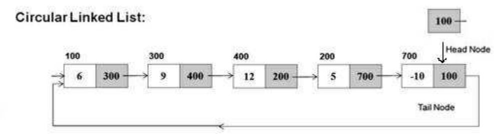
Answers: Queues

3.10.1 Queues: GATE 2016-1-10 top http://gateoverflow.in/39667

Selected Answer

Answer A - Circular Queue Implementation

- Both operations can be performed in O(1) time in Circular Queue implimentation where Enqueue and Dequeue operation are done at last node. Single pointer needed at last node.



Reffer : http://www.mathcs.emory.edu/~cheung/Courses/171/Syllabus/8-List/array-queue2.html

23 votes -- Abhilash Panicker (8.8k points)

3.10.2 Queues: GATE 2016-1-41 top http://gateoverflow.in/39684

Selected Answer

While loop will run for the maximum number of times when the Queue elements are sorted in descending order.

Let's suppose that initially, Queue elements are 16, 15, 14, 13..............2, 1

Now, 16 will be first pushed into the stack, So, now stack top is 16 and Head(Q) is 15, So 16 will be popped out of the stack (since, "if S is Empty OR Top(S) ≤ Head (Q) "returns false, hence else part will be executed) and enqueued into the Queue.

So, after two iterations Queue elements will be -> 15, 14, 13, ...2, 1, 16 and stack will be empty.

Similarly, each of the elements 15,14,13..........2 will be pushed into the stack and immediately popped out of the stack(when popped out of the stack then also enqueue into the queue).So after 30 iterations stack will be empty and Queue contains will be like==> 1, 16, 15, 14, ...2.

Now 1 will be Dequeued and pushed into the stack.Once 1 is pushed into the stack, it will never be popped(or we can say never be enqueued into the Queue again) because in order to Pop 1, there should be an element into the Queue which is less than 1 and that element comes at the front of the queue, since there is no element currently present in the Queue which is less than 1, there is no way to pop 1.

So, after 31 iterations Queue is==> 16, 15, 14, ...2 and stack contains 1.

Now, the problem boils down to Queue with 15 elements.

Using the similar logic we can say after another 29 iterations (Total =31+29)Queue will be like==> 16, 15, 14, ...3 and stack contains 1,2 (stack top is 2) and then 2 will remain there in the stack forever.

Similar way if we go on then, after 31 + 29 + 27 + 25 + ...+1 iterations Queue will be empty.

This is in A.P series with d=2. Sum = (16 *(1+31))/2= 16*32/2= 256

14 votes -- Sourav Basu (365 points)

256 when 16,15,14,...,1 are present in queue

alternately 15 dequeue & push,15 pop & enqueue followed by 1 dequeue & push i.e. 31 iterations

brings it to the state 16,15,...,2 in queue and 1 in stack

29 iterations to get to 16,15,...,3 in queue and 2,1 in stack and so on

31+29+27+...+1=16^2=256

26 votes -- Krishna murthy (381 points)

3.10.3 Queues: GATE1992-09 top

http://gateoverflow.in/588

A queue with a hashtable.

Intialize hashtable with 0.

When inserting X into the queue update hashtable[X]=0 to hashtable[X]=1.

(i) If hashtable[X]=1 then return true.

(ii) Return the element at the front or rear of the queue.

(iii) Add the element X to the queue at the rear end and update hashtable[X]=0 to hashtable[X]=1.

(iv) Delete the element X from the front end of the queue and update hashtable[X]=1 to hashtable[X]=0.

4 votes -- Rajarshi Sarkar (35k points)

3.10.4 Queues: GATE1994_26 top

http://gateoverflow.in/2522

Selected Answer

We can do this be first extracting items one by one from Q, and inserting them to S. After all items are done, S will contain the items in reverse order. Now, pop the elements from S and insert to Q. After this operation, items in Q will be in reverse order from the starting. Now, extract items from Q and push on to stack and we are done.

```
Do
    Delete an item from Q
    Push the item to S
While (! empty Q);
Do
    Pop an item from S
    Insert the item to Q
While (! empty S);
Do
    Delete an item from Q
    Push the item to S
While (! empty Q);
```

19 votes -- Arjun Suresh (294k points)

3.10.5 Queues: GATE1996-1.12 top

http://gateoverflow.in/2716

Selected Answer

A.

i) and iv) are false.

http://en.wikipedia.org/wiki/List_(abstract_data_type)#Operations

13 votes -- Gate Keeda (19.1k points)

3.10.6 Queues: GATE2001-2.16 top

http://gateoverflow.in/734

Selected Answer

A queue can be implemented using two stacks.

Let queue be represented as " q "
and stacks used to implement q be "stack1" and "stack2".

q can be implemented in two ways:

Method 1 (By making EnQueue operation costly)

This method makes sure that newly entered element is always at the bottom of stack 1, so that deQueue operation just pops from stack1. To put the element at top of stack1, stack2 is used.

```
enQueue(q, x)

  1) While stack1 is not empty, push everything from satck1 to stack2.
  2) Push x to stack1 (assuming size of stacks is unlimited).
  3) Push everything back to stack1.


dnQueue(q)

  1) If stack1 is empty then error
  2) Pop an item from stack1 and return it
```

Method 2 (By making deQueue operation costly)

In this method, in en-queue operation, the new element is entered at the top of stack1. In de-queue operation, if stack2 is empty then all the elements are moved to stack2 and finally top of stack2 is returned.

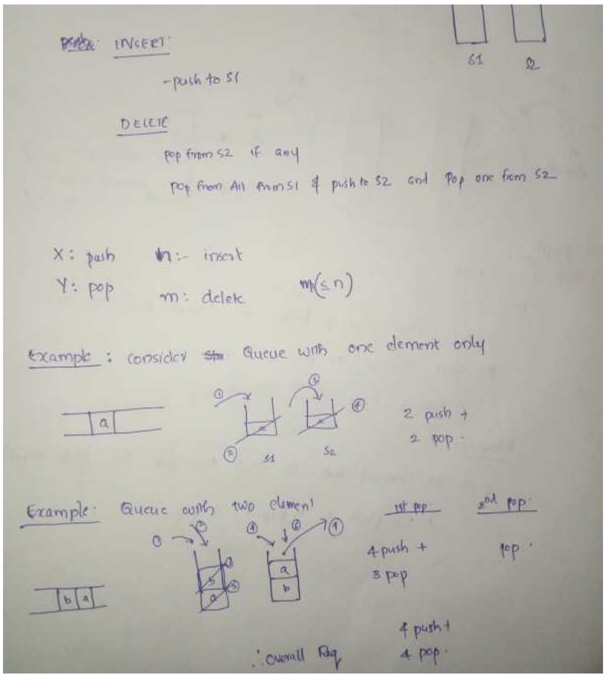
```
enQueue(q,  x)

  1) Push x to stack1 (assuming size of stacks is unlimited).


deQueue(q)

  1) If both stacks are empty then error.
  2) If stack2 is empty
       While stack1 is not empty, push everything from satck1 to stack2.
  3) Pop the element from stack2 and return it.
```

6 votes -- Dipak Majhi (865 points)

3.10.7 Queues: GATE2006-49 top

http://gateoverflow.in/1826

Selected Answer



~~Push~~ INSERT:

- push to S1

DELETE

pop from S2 if any

pop from All from S1 & push to S2 and Pop one from S2

S1 S2

X: push n:- insert

Y: pop m: delete $m(\le n)$

Example: consider ~~stk~~ Queue with one element only

a

2 push + 2 pop.

S1 S2

Example: Queue with two element

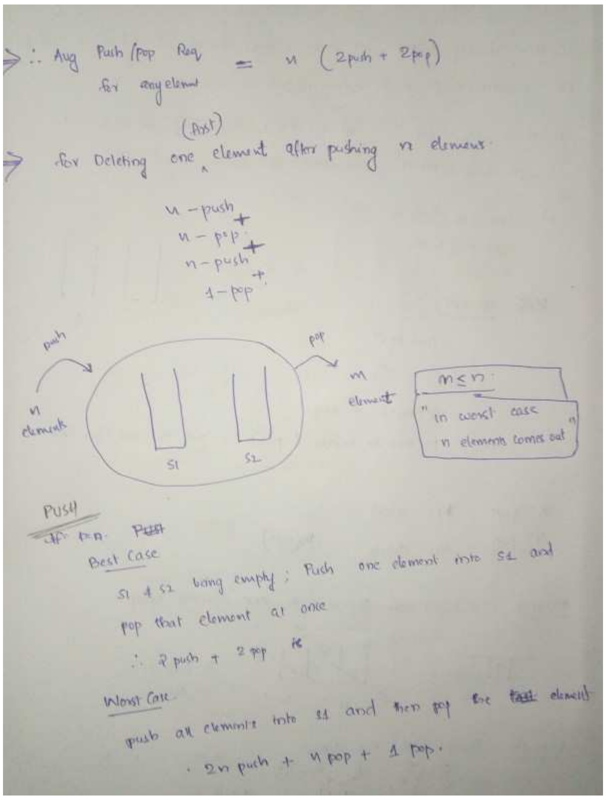
b a

1st pop: 4 push + 3 pop

2nd pop: pop.

∴ Overall Req: 4 push + 4 pop.

Page 1



⇒ ∴ Avg Push/Pop Req for any element = n (2push + 2pop)

⇒ for Deleting one (Post) element after pushing n elements

n - push +

n - pop +

n - push +

1 - pop

push, n element, S1, S2, pop, m element

$m \le n$

" in worst case n elements comes out "

PUSH

~~If m=n Post~~

Best Case

S1 & S2 being empty; Push one element into S1 and pop that element at once

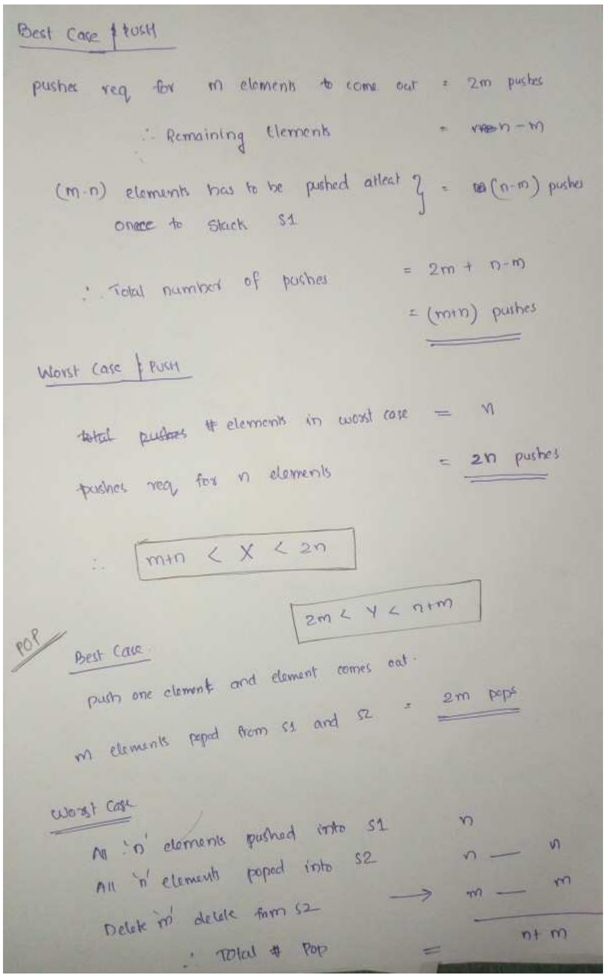
∴ 2 push + 2 pop

Worst Case

push all elements into S1 and then pop the ~~last~~ element

. 2n push + n pop + 1 pop.

Page 2



Best Case | PUSH

pushes req for m elements to come out = 2m pushes

∴ Remaining elements = n − m

(m-n) elements has to be pushed atleast once to Stack S1 } = (n-m) pushes

∴ Total number of pushes = 2m + n-m

= (m+n) pushes

Worst Case | PUSH

total pushes # elements in worst case = n

pushes req for n elements = 2n pushes

∴ $\boxed{m+n < X < 2n}$

$\boxed{2m < Y < n+m}$

POP

Best Case

push one element and element comes out.

m elements poped from S1 and S2 = 2m pops

Worst Case

All 'n' elements pushed into S1 n

All 'n' element poped into S2 n — n

Delete 'm' delete from S2 → m — m

∴ Total # Pop = n+ m

[Please excuse for the poor handwriting]

14 votes -- pC (21.4k points)

Answer is (a)

The order in which insert and delete operations are performed matters here.

The best case: Insert and delete operations are performed alternatively. In every delete operation, 2 pop and 1 push operations are performed. So, total m+ n push (n push for insert() and m push for delete()) operations and 2m pop operations are performed.

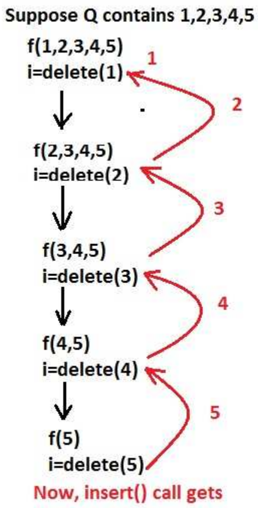
The worst case: First n elements are inserted and then m elements are deleted. In first delete operation, n + 1 pop operations and n push operation are performed. Other than first, in all delete operations, 1 pop operation is performed. So, total m + n pop operations and 2n push operations are performed (n push for insert() and m push for delete())

25 votes -- Kalpna Bhargav (3.2k points)

3.10.8 Queues: GATE2007-IT-30 top

http://gateoverflow.in/3463

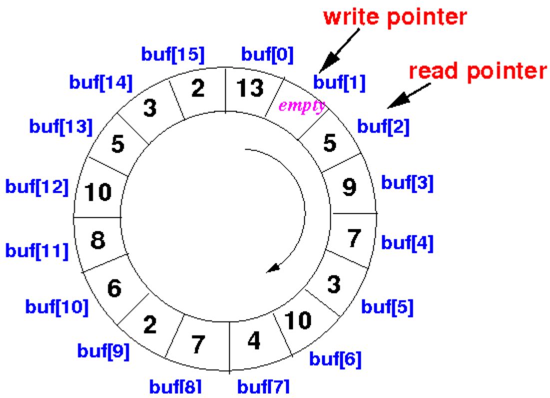
Selected Answer



insert() will inserts the value in just reverse order.

13 votes -- srestha (58.4k points)

3.10.9 Queues: GATE2012_35 top http://gateoverflow.in/1756



rear = Write

front = Read

full: (REAR+1) mod n == FRONT

empty: REAR == FRONT

Only option A matches.

11 votes -- Prashant Singh (49.2k points)

3.10.10 Queues: GATE2013-44 top http://gateoverflow.in/61

Selected Answer

There are three possible operations on queue- Enqueue, Dequeue and MultiDequeue. MultiDequeue is calling Dequeue multiple times based on a global variable k. Since, the queue is initially empty, whatever be the order of these operations, there cannot be more no. of Dequeue operations than Enqueue operations. Hence, the total no. operations will be n only.

30 votes -- Arjun Suresh (294k points)

3.10.11 Queues: GATE2017-2-13 top http://gateoverflow.in/118253

Selected Answer

Answer is Next pointer to Rear node has Pointer to Front node.

Hence, only II is correct.

19 votes -- Prashant Singh (49.2k points)

3.11 Stack(17) top

3.11.1 Stack: GATE1991_03,vii top http://gateoverflow.in/522

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

The following sequence of operations is performed on a stack:

PUSH (10), PUSH (20), POP, PUSH (10), PUSH (20), POP, POP, POP, PUSH (20), POP

The sequence of values popped out is

(a). 20,10,20,10,20

(b). 20,20,10,10,20

(c). 10,20,20,10,20

(d). 20,20,10,20,10

gate1991 data-structure stack easy

Answer

3.11.2 Stack: GATE1994_1.14 top http://gateoverflow.in/2457

Which of the following permutations can be obtained in the output (in the same order) using a stack assuming that the input is the sequence $1, 2, 3, 4, 5$ in that order?

(a) $3, 4, 5, 1, 2$

(b) $3, 4, 5, 2, 1$

(c) $1, 5, 2, 3, 4$

(d) $5, 4, 3, 1, 2$

gate1994 data-structure stack normal

Answer

3.11.3 Stack: GATE1995_2.21 top http://gateoverflow.in/2633

The postfix expression for the infix expression $A + B * (C + D)/F + D * E$ is:

A. $AB + CD + *F/D + E*$
B. $ABCD + *F/DE * ++$
C. $A * B + CD/F * DE ++$
D. $A + *BCD/F * DE ++$

gate1995 data-structure stack easy

Answer

3.11.4 Stack: GATE1997_4.7 top http://gateoverflow.in/2248

A priority queue Q is used to implement a stack that stores characters. PUSH (C) is implemented as INSERT (Q, C, K) where K is an appropriate integer key chosen by the implementation. POP is implemented as DELETEMIN(Q). For a sequence of operations, the keys chosen are in

A. non-increasing order

B. non-decreasing order

C. strictly increasing order

D. strictly decreasing order

gate1997 data-structure stack normal

Answer

3.11.5 Stack: GATE2000-13 top http://gateoverflow.in/684

Suppose a stack implementation supports, in addition to PUSH and POP, an operation REVERSE, which reverses the order of the elements on the stack.

a. To implement a queue using the above stack implementation, show how to implement ENQUEUE using a single operation and DEQUEUE using a sequence of 3 operations.
b. The following post fix expression, containing single digit operands and arithmetic operators + and *, is evaluated using a stack.
   5 2 * 3 4 + 5 2 * * +
   Show the contents of the stack
   i. After evaluating 5 2 * 3 4 +
   ii. After evaluating 5 2 * 3 4 + 5 2
   iii. At the end of evaluation

gate2000 data-structure stack normal descriptive

Answer

3.11.6 Stack: GATE2003-64 top http://gateoverflow.in/951

Let **S** be a stack of size $n \geq 1$. Starting with the empty stack, suppose we push the first n natural numbers in sequence, and then perform n pop operations. Assume that Push and Pop operations take X seconds each, and Y seconds elapse between the end of one such stack operation and the start of the next operation. For $m \geq 1$, define the stack-life of m as the time elapsed from the end of Push(m) to the start of the pop operation that removes m from **S**. The average stack-life of an element of this stack is

A. $n(X+Y)$

B. $3Y+2X$

C. $n(X+Y)-X$

D. $Y+2X$

gate2003 data-structure stack normal

Answer

3.11.7 Stack: GATE2004-3 top http://gateoverflow.in/1000

A single array A[1 .. MAXSIZE] is used to implement two stacks. The two stacks grow from opposite ends of the array. Variables top1 and top 2 (top < top 2) point to the location of the topmost element in each of the stacks. If the space is to be used efficiently, the condition for "stack full" is

A. (top1 = MAXSIZE / 2) and (top2 = MAXSIZE / 2 + 1)

B. top1 + top2 = MAXSIZE

C. (top1 = MAXSIZE / 2) or (top2 = MAXSIZE)

D. top1 = top2 - 1

gate2004 data-structure stack easy

Answer

3.11.8 Stack: GATE2004-38, ISRO2009-27 top

http://gateoverflow.in/1035

Assume that the operators $+, -, \times$ are left associative and $\hat{}$ is right associative. The order of precedence (from highest to lowest) is $\hat{}, \times, +, -$. The postfix expression corresponding to the infix expression $a + b \times c - d \,\hat{}\, e \,\hat{}\, f$ is

A. $abc \times +def \,\hat{}\,\hat{}\, -$

B. $abc \times +de \,\hat{}\, f \,\hat{}\, -$

C. $ab + c \times d - e \,\hat{}\, f \,\hat{}$

D. $- + a \times bc \,\hat{}\,\hat{}\, def$

gate2004 stack isro2009

Answer

3.11.9 Stack: GATE2004-5 top

http://gateoverflow.in/1002

The best data structure to check whether an arithmetic expression has balanced parentheses is a

A. queue
B. stack
C. tree
D. list

gate2004 data-structure easy stack

Answer

3.11.10 Stack: GATE2004-IT-52 top

http://gateoverflow.in/3695

A program attempts to generate as many permutations as possible of the string, 'abcd' by pushing the characters a, b, c, d in the same order onto a stack, but it may pop off the top character at any time. Which one of the following strings CANNOT be generated using this program?

A. abcd
B. dcba
C. cbad
D. cabd

gate2004-it data-structure normal stack

Answer

3.11.11 Stack: GATE2005-IT-13 top

http://gateoverflow.in/3758

A function f defined on stacks of integers satisfies the following properties. f(∅) = 0 and f (push (S, i)) = max (f(S), 0) + i for all stacks S and integers i.

If a stack S contains the integers 2, -3, 2, -1, 2 in order from bottom to top, what is f(S)?

A. 6
B. 4
C. 3
D. 2

gate2005-it data-structure stack normal

Answer

3.11.12 Stack: GATE2007-38, ISRO2016-27 top http://gateoverflow.in/1236

The following postfix expression with single digit operands is evaluated using a stack:

8 2 3 ^ / 2 3 * + 5 1 * -

Note that ^ is the exponentiation operator. The top two elements of the stack after the first * is evaluated are

A. 6, 1
B. 5, 7
C. 3, 2
D. 1, 5

gate2007 data-structure stack normal isro2016

Answer

3.11.13 Stack: GATE2007-IT-32 top http://gateoverflow.in/3465

Consider the following C program:

```
#include <stdio.h>
          #define EOF -1
          void push (int); /* push the argument on the stack */
          int pop  (void); /* pop the top of the stack */
          void flagError ();
          int main ()
         {          int c, m, n, r;
                     while ((c = getchar ()) != EOF)
                    { if  (isdigit (c) )
                               push (c);
                     else if ((c == '+') || (c == '*'))
                    {          m = pop ();
                                n = pop ();
                                r = (c == '+') ? n + m : n*m;
                                push (r);
                      }
                      else if (c != ' ')
                               flagError ();
             }
              printf("% c", pop ());
}
```

What is the output of the program for the following input?
5 2 * 3 3 2 + * +

A. 15
B. 25
C. 30
D. 150

gate2007-it stack normal

Answer

3.11.14 Stack: GATE2014-2-41 top http://gateoverflow.in/2007

Suppose a stack implementation supports an instruction REVERSE, which reverses the order of elements on the stack, in addition to the PUSH and POP instructions. Which one of the following statements is TRUE (*with respect to this modified stack*)?

A. A queue cannot be implemented using this stack.
B. A queue can be implemented where ENQUEUE takes a single instruction and DEQUEUE takes a sequence of two instructions.
C. A queue can be implemented where ENQUEUE takes a sequence of three instructions and DEQUEUE takes a single instruction.
D. A queue can be implemented where both ENQUEUE and DEQUEUE take a single instruction each.

gate2014-2 data-structure stack easy

Answer

3.11.15 Stack: GATE2015-2_38 top http://gateoverflow.in/8164

Consider the C program below

```
#include <stdio.h>
int *A, stkTop;
int stkFunc (int opcode, int val)
{
    static int size=0, stkTop=0;
    switch (opcode) {
        case -1: size = val; break;
        case 0: if (stkTop < size ) A[stkTop++]=val; break;
        default: if (stkTop) return A[--stkTop];
    }
    return -1;
}
int main()
{
    int B[20]; A=B; stkTop = -1;
    stkFunc (-1, 10);
    stkFunc (0, 5);
    stkFunc (0, 10);
    printf ("%d\n", stkFunc(1, 0)+ stkFunc(1, 0));
}
```

The value printed by the above program is ________.

gate2015-2 data-structure stack easy numerical-answers

Answer

3.11.16 Stack: GATE2015-3_12 top http://gateoverflow.in/8408

The result evaluating the postfix expression 10 5 + 60 6 / * 8 - is

A. 284
B. 213
C. 142
D. 71

gate2015-3 data-structure stack normal

Answer

3.11.17 Stack: TIFR2017-B-3 top http://gateoverflow.in/95679

We have an implementation that supports the following operations on a stack (in the instructions below, s is the name of the stack).

- $\text{isempty}(s)$: returns True if s is empty, and False otherwise.
- $\text{top}(s)$: returns the top element of the stack, but does not pop the stack; returns null if the stack is empty.
- $\text{push}(s, x)$: places x on top of the stack.
- $\text{pop}(s)$: pops the stack; does nothing if s is empty.

Consider the following code:

```
pop_ray_pop(x):
    s=empty
    for i=1 to length(x):
        if (x[i] == '('):
            push(s, x[i])
        else:
            while (top(s)=='('):
                pop(s)
            end while
            push(s, ')')
        end if
    end for
    while not isempty(s):
        print top(s)
        pop(s)
    end while
```

What is the output of this program when

```
pop_ray_pop("(((()((())(((("))
```

is executed?

A. ((((
B.))) ((((
C.)))
D. ((()))
E. ()()

tifr2017 data-structure stack

Answer

Answers: Stack

3.11.1 Stack: GATE1991_03,vii top

http://gateoverflow.in/522

Selected Answer

Lets try something different when you read the word pop then delete the last pushed element and print it ..now delete the push word which we have already executed ..now go on from left to right and do the same

So, Output will be 20, 20, 10, 10, 20

12 votes -- Bhagirathi Nayak (13.3k points)

Nothing to explain. It will be B.

11 votes -- Gate Keeda (19.1k points)

3.11.2 Stack: GATE1994_1.14 top

http://gateoverflow.in/2457

Selected Answer

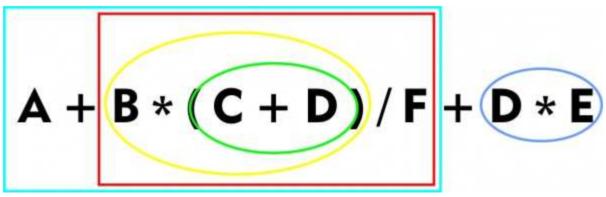
push 1 push 2 push 3 pop 3 push 4 pop 4 push 5 pop 5 pop 2 pop 1 then o/p is 3,4,5,2,1 option b

15 votes -- Sankaranarayanan P.N (11.2k points)

3.11.3 Stack: GATE1995_2.21 top

http://gateoverflow.in/2633

Selected Answer



answer = $A \quad B \quad C \quad D \quad + \quad * \quad F \quad / \quad + \quad D \quad E \quad * \quad +$

17 votes -- Amar Vashishth (28.7k points)

3.11.4 Stack: GATE1997_4.7 top

http://gateoverflow.in/2248

Selected Answer

Implementing stack using priority queue require first element inserted in stack will be deleted at last, and to implement it using deletemin() operation of queue will require first element inserted in queue must have highest priority.

So the keys must be in strictly decreasing order.

11 votes -- Suraj Kaushal (361 points)

3.11.5 Stack: GATE2000-13 top

http://gateoverflow.in/684

Selected Answer

a)For enqueue push operation is sufficient

For dequeue operation do the following

-reverse, pop, reverse

b) Contents of stack from top to bottom:

i) 7 10

ii) 2 5 7 10

ii) 80

10 votes -- Pooja Palod (32.4k points)

3.11.6 Stack: GATE2003-64 top

http://gateoverflow.in/951

Selected Answer

let us represent stack-life of i^{th} element as S(i). The i^{th} element will be in stack till $(n-i)$ elements are pushed and popped. Plus one more Y for the time interval between the push of i_{th} element and the $i+1^{th}$ element. So,

$$S(i) = Y + 2.(n-i)(Y+X) = Y + 2.(n-i)Z = Y + 2nZ - 2iZ$$

where $Z = Y + X$

average stack-life will, $A = \Sigma\frac{S(i)}{n}$

$$nA = nY + 2.n.n.Z - 2.Z.\Sigma i$$

$$nA = nY + 2.n.n.Z - 2.Z\frac{(n(n+1))}{2}$$

$$nA = nY + 2.n.n.Z - Z(n.n) - n.Z$$

$$A = Y + 2.n.Z - (n+1).Z$$

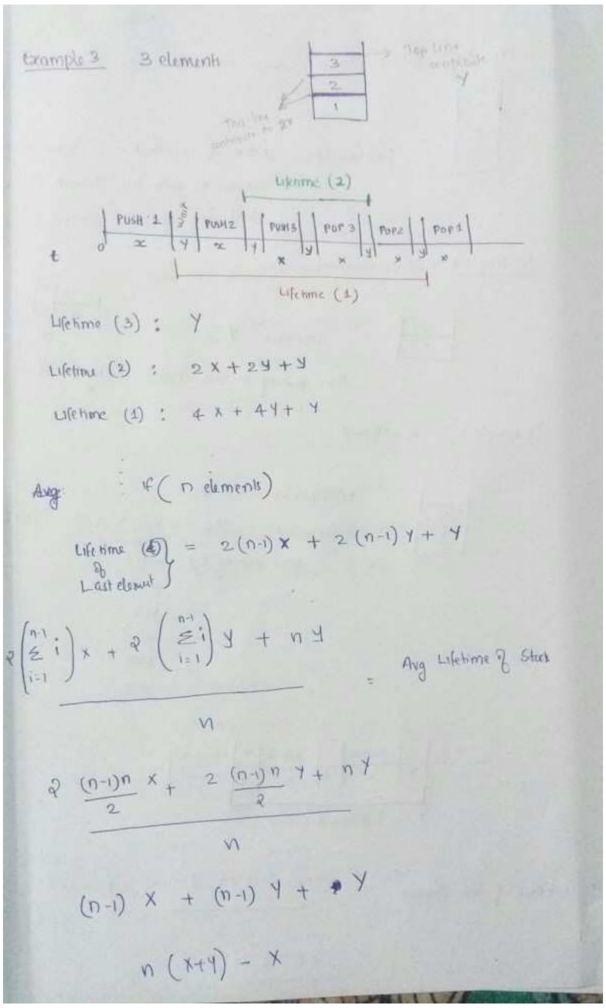
$$A = Y + (n-1).Z = Y + (n-1)(X+Y) = n(X+Y) - X$$

21 votes -- Vikrant Singh (13.4k points)

Lifetime of m : End Of Push to Start of Pop

- n - PUSH will take X seconds each
- n - POP will take X seconds each
- Time Between two PUSH or two POP or one PUSH one POP is Y second

Consider an example with stack contails 3 elemets as shown in Image below



Option C

👍 18 votes -- pC (21.4k points)

3.11.7 Stack: GATE2004-3 top

http://gateoverflow.in/1000

Selected Answer

ans d)

Since the stacks are growing from opposite ends, initially top1 = 1 and top2 = MAXSIZE. Now, to make the space usage most efficient we should allow one stack to use the maximum possible space as long as other stack doesn't need it. So, either of the stack can grow as long as there is space on the array and hence the condition must be top1 = top2 - 1;

👍 18 votes -- Aditi Dan (5.3k points)

3.11.8 Stack: GATE2004-38, ISRO2009-27 top

http://gateoverflow.in/1035

Selected Answer

Ans : A

Here is the procedure first :
Scan Infix Expression from left to right whenever you see operand just print it.
But In case of operator
if(stack is empty) then push it.
if(precedence(tos) < precedence(current operator)) push it.
else if (precedence(tos) > precedence(current operator)) pop and print.

else if (precedence(tos) == precedence(current operator)) then check for associativity.In case Operators are Left to right then pop and print it otherwise push the current operator (Right to Left Associativity)
And once you have scanned infix expression completely. Make sure pop all the element and print it in same order.

Here the infix expression is a+b×c−d^e^f
a : print it
+ : push into the Operator Stack
b : print it
* : its having higher precedence than + then push into Operator Stack
c : print it
'-' : '-' is having less precedence than '*' so pop from operator stack and print '*'.after this stack will be having '+' on top.which is having same precedence as '-' but both are left to right associative then just pop + and print it.Now stack is empty. Push '-' to it.
d : print it
'^' : top of the stack is having '-' which has lower precedence than '^' so simply push '^' into stack
e : print it.
'^' : Now top of the stack is '^' and has same precedence so associativity will come to picture. Since '^' is right associative as given in question. So '^' will be pushed.
f : print it.

Now we have scanned entire infix expression.Now pop the stack untill it becomes empty.This way you will get
abc*+def^^-

16 votes -- IgnitorSandeep (519 points)

3.11.9 Stack: GATE2004-5 top http://gateoverflow.in/1002

Selected Answer

STACK Scan the expression from left to right whenever a left paranthesis is encountered just PUSH it into stack and whenever a right paranthesis is encountered just POP it from stack ..if at the end of expression we are left with an empty stack then it is a correctly parenthesized expression

13 votes -- Bhagirathi Nayak (13.3k points)

3.11.10 Stack: GATE2004-IT-52 top http://gateoverflow.in/3695

Selected Answer

A. push a & pop a, push b & pop b, push c & pop c, and finally push d and pop d
 sequence of popped elements will come to abcd
B. first push abcd, and after that pop one by one sequence of popped elements will come to dcba

C. push abc, and after that pop one by one sequence of popped elements will come to cba, now push d and pop d, final sequence comes to cbad

D. this sequence is not possible because 'a' can not be pooped before 'b' any how

9 votes -- Manu Thakur (6k points)

3.11.11 Stack: GATE2005-IT-13 top http://gateoverflow.in/3758

Selected Answer

- i Element to be pushed
- Initial State $f(\phi) = 0$ For Empty Stack F(S) is 0
- Then we push each element (i)one by one and calculate $f(s)$ for each insertion as given

$$F_{new}(S) = max(F_{previous}(S), 0) + i$$

Is the function to compute $F(s)$ for each insertions

1. INSERT 2 into Stack
 $F_{previous}(S) = 0$ [Stack was empty]
 $i = 2$ (inserting element is i)
 $F_{new}(S) = max(F_{previous}(S), 0) + i$

$F_{new}(S) = max(0,0) + 2 = 2$

2. INSERT -3 into Stack

$F_{previous}(S) = 2$ [Stack was empty]

$i = -3$ (inserting element is i)

$F_{new}(S) = max(F_{previous}(S),0) + i$

$F_{new}(S) = max(2,0) + -3 = -1$

Similarly ,

i : The element to be pushed
S: Stack

Initially f(S)=0.

f(S)	max(f(S),0)	i	Updated_f(S)=max(f(S),0)+i
0	0	2	2
2	2	-3	-1
-1	0	2	2
2	2	-1	1
1	1	2	$\boxed{3}$

Thus, the answer is **Option C.**

The value of $F(S)$ after inserting all elements into stack is **3**

30 votes -- Shridhar (393 points)

3.11.12 Stack: GATE2007-38, ISRO2016-27 top

http://gateoverflow.in/1236

Selected Answer

push 8 so stack is 8

push 2 so stack is 8 2

push 8 2 3

^ pop 3 and 2 perform opn 2^3 and push to stack. stack is 8 8

/ pop 8 and 8 perform 8/8 and push result to stack . stack is 1

push 2 stack is 1 2

push 3 stack is 1 2 3

* pop 3 and 2 perform by 2*3 and push . stack is 1 6

hence answer is A

14 votes -- Sankaranarayanan P.N (11.2k points)

3.11.13 Stack: GATE2007-IT-32 top

http://gateoverflow.in/3465

Selected Answer

B) 25
let first part
5 ----push
2------push
push------5*2=10. (pops 5 and 2)

push 3
push 3
push 2
push 3+2 = 5 (pops 2 and 3)
push 5*3 = 15 (pops (5 and 3)
push 15 + 10 = 25 (pops (15 and 10)

16 votes -- Arpit Dhuriya (3k points)

3.11.14 Stack: GATE2014-2-41 top http://gateoverflow.in/2007

Selected Answer

(C) is the answer. While ENQUEUE we REVERSE the stack, PUSH the element and then again REVERSE the stack. For DEQUE we simply POP the element.

(Option (B) can be used to get the first element from the stack by doing a POP after REVERSE for DEQUEUE and PUSH for ENQUEUE. But we have to restore the stack using REVERSE (otherwise next POP won't work) which means DEQUEUE actually needs 3 instructions and not 2)

18 votes -- Arjun Suresh (294k points)

3.11.15 Stack: GATE2015-2_38 top http://gateoverflow.in/8164

Selected Answer

Answer: 15

The code is pushing 5 and 10 on stack and then popping the top two elements and printing their sum.

Refer here: http://ideone.com/kIUdQT

21 votes -- Rajarshi Sarkar (35k points)

```
Initially stack is empty = -1

stkFunc (-1, 10); this function

case -1: size = val; break; and static size= 10 // size memory declare one time only// and control comes out of switch b/c of break

stkFunc (0, 5); this function run

case 0: if (stkTop < size ) A[stkTop++]=val; break; here stktop is static value so memory declare at compile time only now check if condition 0< 10 true then A[stktop++== A[0+1]=val= 5 i.e. push 5 into stack break comes so control comes outside

stkFunc (0, 10); this comes

case 0: if (stkTop < size ) A[stkTop++]=val; break; same as above make A[stkTop++]= 10 i,e. push 10 into stack and break comes so control comes outside

printf ("%d\n", stkFunc(1, 0)+ stkFunc(1, 0));

this function

stkFunc(1, 0) this will run

default: if (stkTop) return A[--stkTop] return top of stack which is 10

stkFunc(1, 0) this will run

default: if (stkTop) return A[--stkTop] return top of stack which is 5

printf ("%d\n", stkFunc(1, 0)+ stkFunc(1, 0));= 5+10=15 15 will be printed
```

17 votes -- Prashant Singh (49.2k points)

3.11.16 Stack: GATE2015-3_12 top http://gateoverflow.in/8408

Selected Answer

we have to keep symbol into stack and when we get two operands followed by operator ..we will apply operator on last two operands

symbol	stack
10	10 (keep in stack)
5	10 5 (keep in stack)
+	10 5 + = 10+5 = 15 (apply operator on last 2 operands)
60	15 60 (keep in stack)
6	15 60 6 (keep in stack)
/	15 60 6 / = 15 10 (apply operator on last 2 operands)
*	15 10 * = 150 (apply operator on last 2 operands)
8	150 8 (Keep in stack)
-	150 8 - = 150 - 8 = 142 (apply operator on last 2 operands)

So answer is 142

19 votes -- Praveen Saini (53.6k points)

3.11.17 Stack: TIFR2017-B-3 top http://gateoverflow.in/95679

Selected Answer

D option

First push ((((on stack. Now when) comes pop all ((((and push) on stack. Now push (((and stack become)(((. Now when) come it pop all (((from stack and new stack become)). Again) comes and stack become))) . Now push ((((on stack and the stack becomes (((())). Now pop one by one and get option D as the answer.

7 votes -- Mehak Sharma (1.5k points)

3.12 Trees(14) top

3.12.1 Trees: GATE1992_02,vii top http://gateoverflow.in/562

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

A
$2-3$ tree is such that

a. All internal nodes have either 2 or 3 children
b. All paths from root to the leaves have the same length.

The number of internal nodes of a $2-3$ tree having 9 leaves could be

(a). 4

(b). 5

(c). 6

(d). 7

gate1992 trees data-structure normal

Answer

3.12.2 Trees: GATE1994_5 top http://gateoverflow.in/2501

A $3-\text{ary}$ tree is a tree in which every internal node has exactly three children. Use induction to prove that the number of leaves in a $3-\text{ary}$ tree with n internal nodes is $2(n-1)$.

gate1994 data-structure trees proof

Answer

3.12.3 Trees: GATE1998_1.24 top http://gateoverflow.in/1661

Which of the following statements is false?

(a) A tree with a n nodes has $(n-1)$ edges
(b) A labeled rooted binary tree can be uniquely constructed given its postorder and preorder traversal results.
(c) A complete binary tree with n internal nodes has $(n+1)$ leaves.
(d) The maximum number of nodes in a binary tree of height h is $2^{h+1}-1$

gate1998 data-structure trees normal

Answer

3.12.4 Trees: GATE1998_2.11 top http://gateoverflow.in/1683

A complete n-ary tree is one in which every node has 0 or n sons. If x is the number of internal nodes of a complete n-ary tree, the number of leaves in it is given by

A. $x(n-1)+1$
B. $xn-1$
C. $xn+1$
D. $x(n+1)$

gate1998 data-structure trees normal

Answer

3.12.5 Trees: GATE1998_21 top http://gateoverflow.in/1735

a. Derive a recurrence relation for the size of the smallest AVL tree with height h.
b. What is the size of the smallest AVL tree with height 8?

gate1998 data-structure trees descriptive numerical-answers

Answer

3.12.6 Trees: GATE2002-2.9 top http://gateoverflow.in/839

The number of leaf nodes in a rooted tree of n nodes, with each node having 0 or 3 children is:

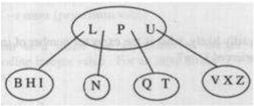
A. $\frac{n}{2}$
B. $\frac{(n-1)}{3}$
C. $\frac{(n-1)}{2}$
D. $\frac{(2n+1)}{3}$

gate2002 data-structure trees normal

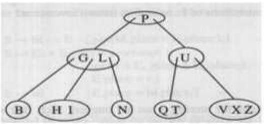
Answer

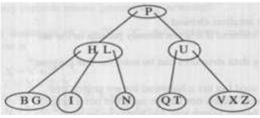
3.12.7 Trees: GATE2003-65 top http://gateoverflow.in/952

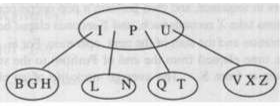
Consider the following 2-3-4 tree (i.e., B-tree with a minimum degree of two) in which each data item is a letter. The usual alphabetical ordering of letters is used in constructing the tree.



What is the result of inserting G in the above tree?

A. 

B. 

C. 

D. None of the above

gate2003 algorithms trees normal

Answer

3.12.8 Trees: GATE2004-6 top http://gateoverflow.in/1003

Level order traversal of a rooted tree can be done by starting from the root and performing

A. preorder traversal
B. in-order traversal
C. depth first search
D. breadth first search

gate2004 data-structure trees easy

Answer

3.12.9 Trees: GATE2005-36 top http://gateoverflow.in/1372

In a complete k-ary tree, every internal node has exactly k children. The number of leaves in such a tree with n internal node is:

A. nk
B. $(n-1)k+1$
C. $n(k-1)+1$
D. $n(k-1)$

gate2005 data-structure trees normal

Answer

3.12.10 Trees: GATE2007-43 top http://gateoverflow.in/1241

A complete n-ary tree is a tree in which each node has n children or no children. Let I be the number of internal nodes and L be the number of leaves in a complete n-ary tree. If L = 41 and I = 10, what is the value of n?

A. 3
B. 4
C. 5

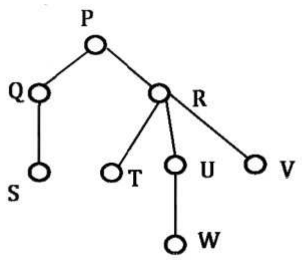
D. 6

gate2007 data-structure trees normal

Answer

3.12.11 Trees: GATE2014-3-12 top http://gateoverflow.in/2046

Consider the following rooted tree with the vertex labeled P as the root:



The order in which the nodes are visited during an in-order traversal of the tree is

A. SQPTRWUV
B. SQPTUWRV
C. SQPTWUVR
D. SQPTRUWV

gate2014-3 data-structure trees easy

Answer

3.12.12 Trees: GATE2014-3-41 top http://gateoverflow.in/2075

Consider the pseudocode given below. The function $DoSomething()$ takes as argument a pointer to the root of an arbitrary tree represented by the $leftMostChild-rightSibling$ representation. Each node of the tree is of type $treeNode$.

```
typedef struct treeNode* treeptr;

struct treeNode
{
    treeptr leftMostChild, rightSibling;
};

int DoSomething (treeptr tree)
{
    int value=0;
    if (tree != NULL) {
        if (tree->leftMostChild == NULL)
            value = 1;
        else
        value = DoSomething(tree->leftMostChild);
        value = value + DoSomething(tree->rightSibling);
    }
    return(value);
}
```

When the pointer to the root of a tree is passed as the argument to $DoSomething$, the value returned by the function corresponds to the

A. number of internal nodes in the tree.
B. height of the tree.
C. number of nodes without a right sibling in the tree.
D. number of leaf nodes in the tree

gate2014-3 data-structure trees normal

Answer

3.12.13 Trees: GATE2017-1-20 top http://gateoverflow.in/118300

Let T be a tree with 10 vertices. The sum of the degrees of all the vertices in T is ________

gate2017-1 data-structure trees numerical-answers

Answer

3.12.14 Trees: TIFR2012-B-15 top http://gateoverflow.in/25212

Let T be a tree of n nodes. Consider the following algorithm, that constructs a sequence of leaves $u_1, u_2 \dots$. Let u_1 be some leaf of tree. Let u_2 be a leaf that is farthest from u_1. Let u_3 be the leaf that is farthest from u_2, and, in general, let u_{i+1} be a leaf of T that is farthest from u_i (if there are many choices for u_{i+1}, pick one arbitrarily). The algorithm stops when some u_i is visited again. What can u say about the distance between u_i and u_{i+1}, as $i = 1, 2, \dots$?

A. For some trees, the distance strictly reduces in each step.
B. For some trees, the distance increases initially and then decreases.
C. For all trees, the path connecting u_2 and u_3 is a longest path in the tree.
D. For some trees, the distance reduces initially, but then stays constant.
E. For the same tree, the distance between the last two vertices visited can be different, based on the choice of the first leaf u_1.

tifr2012 data-structure trees

Answer

Answers: Trees

3.12.1 Trees: GATE1992_02,vii top http://gateoverflow.in/562

Selected Answer

Answer (a)4, (d) 7

4-> When each leaf has 3 childs. So 9/3 = 3 Internal nodes, Then one internal node those internal nodes.

7-> When each leaf has 2 childs & one leaf out of 4 get 3 childs. Ex -> 8/4 = 2 child per internal node. Then one of that internal node get extra third child. Then 2 internal nodes to connect these 4. Then 1 internal node to connect this 2. So 4+2+1 = 7.

No other way is possible.

8 votes -- Akash (43.8k points)

3.12.2 Trees: GATE1994_5 top http://gateoverflow.in/2501

No of nodes at level $i = 3^i$

Let height of tree be h

So total no of internal nodes $= 3^0 + 3^1 + 3^2 + \dots + 3^{h-1} = \frac{3^h - 1}{2}$

$2n = 3^h - 1$

No of leaf nodes $= 3^h = 2n + 1 = 2(n-1) + 3$

Let us prove by induction

Base case

$n = 1$ (one internal node i.e., root node)

No of leaves $= 2(1-1) + 3 = 3$

Let it be true for n internal nodes

Now we prove for m nodes where $m = n + 1$

We have $L(m) = 2(n + 1 - 1) + 3$

Also $L(m) = L(n) + 3 - 1 = 2(n-1) + 3 + 3 - 1 = 2n + 3$

So if $L(n)$ is true then $L(n+1)$ is also true

Hence proved by induction.

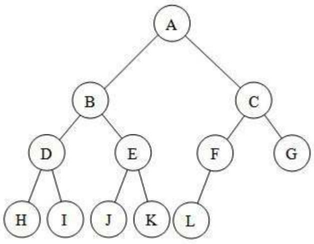
4 votes -- Pooja Palod (32.4k points)

3.12.3 Trees: GATE1998_1.24 top

http://gateoverflow.in/1661

Selected Answer

- Tree with n nodes must have n-1 edges.
- A labeled rooted binary tree can be uniquely constructed given its postorder and preorder traversal results. (inorder must be needed with either preorder or postorder for that)
- A complete binary tree with n nodes can have n leaves also
- Example:



Since: **A complete binary tree** is a binary tree in which every level, except possibly the last, is completely filled, and all nodes are as far left as possible. So **false**

- The maximum number of nodes in a binary tree of height h is

$1+2+4+.....+2^h = 2^{h+1} - 1$ So true

Answer is b and c both.

Since 2 answers are there I would choose b, because in some places by "complete" binary tree they mean "full binary tree" which has all the levels completely filled.

12 votes -- Prashant Singh (49.2k points)

3.12.4 Trees: GATE1998_2.11 top

http://gateoverflow.in/1683

Selected Answer

Answer :->

A)

x(n-1) +1

Originally when we have root , there is only 1 node, which is leaf. (There is no internal node.) **From this base case "+1" part of formula comes.**

When we n children to root, we make root internal. So then Total Leaves = = 1(n-1) + 1 = n.

In complete n ary tree every time you add n children to node, you add n-1 leaves & make that node to which you are inserting childen internal.(+n for leaves, -1 for node which you are attaching). So if you had originally few leaves, you add n-1 "New" leaves to them. This is how x(n-1) +1 makes sense.

12 votes -- Akash (43.8k points)

3.12.5 Trees: GATE1998_21 top

http://gateoverflow.in/1735

Selected Answer

a) Consider a function N(h) which represents the smallest number of nodes n for an AVL tree with height h and satisfies n = N(h).

For h=0 we have, number of nodes = 1. So N(0) = 1

For h = 1, we have, number of nodes = 2. We could take 3, but we require the smallest graph (a graph with smallest number of nodes) so we take 2. It means that to create a tree with height 1 we need **at least** 2 nodes.

So N(1) = 2

Now, for h = 2, we need to create a node with a child subtree of height 1. This may be the right or left subtree. But since this is an AVL tree, to balance a child subtree of height let's say Hs, we need the other child to have a height of Hs-1, Hs or Hs+1. But we take Hs-1 for minimal case. In simple words, a node with height 5 must have a child with height 4 (Hs) and another child with height 3 (Hs-1). So N(2) can be obtained as:

N(2) = N(1) + (0) + 1 (1 is added to count the parent node, N(1) or N(Hs) and N(0) or N(Hs-1) represent two subtrees.)

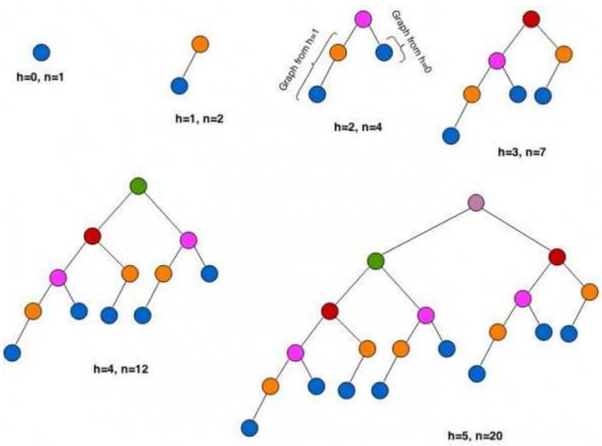
Similarly:

N(3) = N(2) + N(1) + 1

and generalizing:

N(h) = N(h-1) + N(h-2) + 1

This recursion can be graphically seen as below:



b) Using the above recursion, we need to find N(8)

N(0) = 1

N(1) = 2

N(2) = N(1) + N(0) + 1 = 1 + 2 + 1 = 4

N(3) = N(2) + N(1) + 1 = 2 + 4 + 1 = 7

N(4) = N(3) + N(2) + 1 = 4 + 7 + 1 = 12

N(5) = N(4) + N(3) + 1 = 7 + 12 + 1 = 20

N(6) = N(5) + N(4) + 1 = 12 + 20 + 1 = 33

N(7) = N(6) + N(5) + 1 = 20 + 33 + 1 = 54

N(8) = N(7) + N(6) + 1 = 33 + 54 + 1 = 88

So answer for b) is 88.

👍 17 votes -- Ashis Kumar Sahoo (823 points)

3.12.6 Trees: GATE2002-2.9 top

http://gateoverflow.in/839

Selected Answer

L = leaf nodes

I = internal nodes

T = total nodes = L + I

in a tree no. of edges = T - 1

all edges are produced by only internal nodes so

k*I = T-1 ....(1) (for k-ary tree, in this question k = 3)

L + I = T....................(2)

solving 1 and 2 we get

L = ((k-1)T+1)/k

So put k = 3, T = n

you get L = (2n+1)/3

Ans **D**

👍 20 votes -- Vikrant Singh (13.4k points)

3.12.7 Trees: GATE2003-65 top

http://gateoverflow.in/952

Selected Answer

B is the correct answer.

Once we add G, the leaf node becomes B G H I, since we can have only 3 keys. the node has to split at G or H, and G or H will be added to parent node.

Since P is the parent node in options 1 and 2, its evident the 3rd element i.e. H should be selected for splitting (because after adding any key from the leftmost child node, P becomes the 3rd element in the node)

Now parent node becomes H L P U, select P as for splitting, and you get option B.

Hence **answer is B**

👍 13 votes -- ryan sequeira (3k points)

3.12.8 Trees: GATE2004-6 top

http://gateoverflow.in/1003

Selected Answer

answer = **option D**

Breadth first seach.

👍 8 votes -- anshu (3.2k points)

3.12.9 Trees: GATE2005-36 top

http://gateoverflow.in/1372

Selected Answer

Answer :-> C)n(k-1) +1

Originally when we have root , there is only 1 node, which is leaf.(There is no internal node.) From that "+1" part of formula comes from this base case.

When we k children to nodes, we make root internal. So then Total Leaves = n(k-1) + 1 = (k-1) + 1 = k

In k complete k ary tree every time you add k children , you add k-1 leaves.(+k for leaves, -1 for node which you are attaching)

6 votes -- Akash (43.8k points)

3.12.10 Trees: GATE2007-43 top

http://gateoverflow.in/1241

Selected Answer

If you do little bit experiments on no of leaves, Internal nodes, you will realize that they have equation like following :-

No of leaves (L) = (n-1) * Internal Nodes (I) + 1

here we need to find n.

Putting values

41 = (n-1) * 10 + 1

(n-1) * 10 = 40

n-1 = 4

n = 5

So answer = C

13 votes -- Akash (43.8k points)

Sum of degrees in tree = L + I * (n+1) - 1 = 10n + 50 (Each leaf node has degree 1 and all internal nodes have degree k+1, except root which has degree k)

So, number of edges = 5n + 25 (Number of edges in a graph (hence applicable for tree also) is half the sum of degrees as each edge contribute 2 to the sum of degrees)

In a tree with n nodes we have n-1 edges, so with 41+10 = 51 nodes, there must be 50 edges.

So, 5n + 25 = 50

5n = 25 => n = 5

17 votes -- Arjun Suresh (294k points)

3.12.11 Trees: GATE2014-3-12 top

http://gateoverflow.in/2046

Selected Answer

A.

the inorder traversal order of a ternary tree is left-->root-->middle-->right.

20 votes -- Gate Keeda (19.1k points)

3.12.12 Trees: GATE2014-3-41 top

http://gateoverflow.in/2075

Selected Answer

Here, the condition for count value = 1 is

if (tree→leftMostchild == Null)

- so, if there is no left-most child of the tree (or the sub-tree or the current node called in recursion)
- Which means there is no child to that particular node (since if there is no left-most child, there is no child at all as per the tree representation given).
- ∴ the node under consideration is a leaf node.
- The function recursively counts, and adds to value, whenever a leaf node is encountered.
- So, The function returns the number of leaf nodes in the tree.

13 votes -- Kalpish Singhal (2.1k points)

3.12.13 Trees: GATE2017-1-20 top

http://gateoverflow.in/118300

Selected Answer

Tree with n vertices which means n-1 edges.

n = 10 $\therefore$ edges = n - 1 = 9.

$\therefore$ Sum of degree of all vertices $\leq$ 2E $\leq$ 2*9 $\leq$ 18

9 votes -- Kantikumar (3.5k points)

3.12.14 Trees: TIFR2012-B-15 top

http://gateoverflow.in/25212

This post explains it nicely

https://www.quora.com/How-does-following-algorithm-for-finding-longest-path-in-tree-work

2 votes -- sudipta roy (379 points)

4 Programming & DS: Programming (106) top

4.1 Aliasing(1) top

4.1.1 Aliasing: GATE2000-1.16 top http://gateoverflow.in/639

Aliasing in the context of programming languages refers to

A. multiple variables having the same memory location
B. multiple variables having the same value
C. multiple variables having the same identifier
D. multiple uses of the same variable

gate2000 programming easy aliasing

Answer

Answers: Aliasing

4.1.1 Aliasing: GATE2000-1.16 top http://gateoverflow.in/639

Selected Answer

A OPTION

9 votes -- vinay kumar (663 points)

4.2 Goto(1) top

4.2.1 Goto: GATE1994-1.5 top http://gateoverflow.in/2442

An unrestricted use of the "goto" statement is harmful because

A. it makes it more difficult to verify programs
B. it increases the running time of the programs
C. it increases the memory required for the programs
D. it results in the compiler generating longer machine code

gate1994 programming easy goto

Answer

Answers: Goto

4.2.1 Goto: GATE1994-1.5 top http://gateoverflow.in/2442

Selected Answer

Use of goto takes out the structural decomposition of the code and hence it becomes very difficult to verify or debug the code. As far as performance or memory impact is concerned, goto has no effect on them.

15 votes -- Arjun Suresh (294k points)

4.3 Identify Function(4) top

4.3.1 Identify Function: GATE1995-3 top http://gateoverflow.in/2639

Consider the following high level programming segment. Give the contents of the memory locations for variables W, X, Y and Z after the execution of the program segment. The values of the variables A and B are 5CH and 92H, respectively. Also indicate error conditions if any.

```
var
    A, B, W, X, Y   :unsigned byte;
    Z               :unsigned integer, (each integer is represented by two bytes)
begin
    X               :=A+B
    Y               :=abs(A-B);
    W               :=A-B
    Z               :=A*B
end;
```

gate1995 programming normal identify-function

Answer

4.3.2 Identify Function: GATE1998-2.13 top http://gateoverflow.in/1685

What is the result of the following program?

```
    program side-effect (input, output);
    var x, result: integer;
    function f (var x:integer:integer;
    begin
        x:x+1;f:=x;
    end
begin
    x:=5;
    result:=f(x)*f(x);
    writeln(result);
    end
```

A. 5
B. 25
C. 36
D. 42

gate1998 programming normal identify-function

Answer

4.3.3 Identify Function: GATE2004-IT-15 top http://gateoverflow.in/3656

Let x be an integer which can take a value of 0 or 1. The statement

```
if (x == 0) x = 1; else x = 0;
```

is equivalent to which one of the following ?

A. $x = 1 + x;$
B. $x = 1 - x;$
C. $x = x - 1;$
D. $x = 1\%x;$

gate2004-it programming easy identify-function

Answer

4.3.4 Identify Function: GATE2017-2-43 top http://gateoverflow.in/118388

Consider the following snippet of a C program. Assume that swap (&x, &y) exchanges the content of x and y:

```
int main () {
    int array[] = \{3, 5, 1, 4, 6, 2};
    int done =0;
    int i;
    while (done==0) {
        done =1;
        for (i=0; i<=4; i++) {
```

```
            if (array[i] < array[i+1]) {
                swap(&array[i], &array[i+1]);
                done=0;
            }
        }
        for (i=5; i>=1; i--) {
            if (array[i] > array[i-1]) {
                swap(&array[i], array[i-1]);
                done =0;
            }
        }
    }
    printf("%d", array[3]);
}
```

The output of the program is ________

gate2017-2 programming algorithms numerical-answers identify-function

Answer

Answers: Identify Function

4.3.1 Identify Function: GATE1995-3 top http://gateoverflow.in/2639

There wont be any problem

The quick approach is:---

Here H denotes Hexadecimal No.

X=A+B=5CH+92H=EEH(One Byte is enough)

Y=abs(A-B) & W=A-B

(Subtraction operation never cause Overflow So 1 Byte is enough)

Z=A*B

n -bit * n-bit requires 2n bit.

So 8-bit*8-bit =16 bit required(& as per question z is 16 bit unsigned number)

4 votes -- Rajesh Pradhan (18.6k points)

4.3.2 Identify Function: GATE1998-2.13 top http://gateoverflow.in/1685

Selected Answer

call by value: 36,
call by reference: undefined behaviour for C/C++ but 42 for languages having * as a sequence point.

f(x) * f(x);

If the value of x is being modified inside the function (call by reference) we cannot be sure if this modified value or the old value will be passed as argument for the second call to f(). This is because left and right operand of any arithmetic expression in C/C++ can be evaluated in any order. For languages like Java, strict left-right order is maintained.

3 votes -- Arjun Suresh (294k points)

4.3.3 Identify Function: GATE2004-IT-15 top http://gateoverflow.in/3656

Selected Answer

Firstly our requirement is for x=1 it makes '0' and for x= 0 it makes '1'

Let's consider options one by one:

A) X= 1+X

For x = 1, it gives 2 So, False

C) X = X - 1

For x=0 , it gives -1. So, False

D) X = 1% X

For x= 0 , it gives 1 % 0 . I think it is undefined.

Even if we consider X = X%1

Then for x= 0 ,it gives 0%1 = 0 But we require 1.

B) X= 1- X

Here B is correct , as

For x= 0, it gives 1.

For x= 1, it gives 0.

So, **Option (B)** is correct..

12 votes -- Himanshu Agarwal (16.2k points)

4.3.4 Identify Function: GATE2017-2-43 top http://gateoverflow.in/118388

Selected Answer

Well ,the above program is sorting the array in descending order.

Initially, *while loop* starts execution by *evaluating the iniatial condition*

while(done==0)

For the first time the first for loop will be executed completey ,the content of array will be as follows :

5,3,4,6,2,1

After the second for executed completey the content of array will be as follows:

6,5,3,4,2,1

But the value variable done is still 0 so while loop will execute again,so now the content of array after executing the first for loop will be 6,5,4,3,2,1 and no change in second for loop but still the done variable is 0.

So while loop execute again,now done variable is modified to 1 and there will be no change in done variable because inside first and second for loop no if condition will satisfied .

Finally the while condition is evaluted false and value of array[3] will be printed which is 3.

13 votes -- Manoj Kumar (37.5k points)

4.4 Loop Invariants(8) top

4.4.1 Loop Invariants: GATE 2016-2-35 top http://gateoverflow.in/39578

The following function computes X^Y for positive integers X and Y.

```
int exp (int X, int Y) {
     int res =1, a = X, b = Y;

     while (b != 0) {
         if (b % 2 == 0) {a = a * a; b = b/2; }
         else            {res = res * a; b = b - 1; }
     }
```

```
    return res;
}
```

Which one of the following conditions is TRUE before every iteration of the loop?

A. $X^Y = a^b$
B. $(res * a)^Y = (res * X)^b$
C. $X^Y = res * a^b$
D. $X^Y = (res * a)^b$

gate2016-2 programming loop-invariants normal

Answer

4.4.2 Loop Invariants: GATE1991-1,vi top

http://gateoverflow.in/504

Consider the following PASCAL program segment:

```
if i mod 2 = 0 then
    while i >= 0 do
    begin
        i := i div 2;
        if i mod 2 < > 0  then i := i - 1;
        else i := i - 2;
    end;
```

An appropriate loop-invariant for the while-loop is ________

gate1991 programming loop-invariants normal

Answer

4.4.3 Loop Invariants: GATE2004-32 top

http://gateoverflow.in/1029

Consider the following program fragment for reversing the digits in a given integer to obtain a new integer.

Let $n = d_1\, d_2\, \dots\, d_m$.

```
int n, rev;
rev = 0;
while(n > 0) {
    rev = rev * 10 + n%10;
    n = n/10;
}
```

The loop invariant condition at the end of the i^{th} iteration is:

A. $n = d_1\, d_2\, \dots\, d_{m-i} \qquad \textbf{and} \qquad \text{rev} = d_m\, d_{m-1}\, \dots\, d_{m-i+1}$

B. $n = d_{m-i+1}\, \dots\, d_{m-1}\, d_m \qquad \textbf{or} \qquad \text{rev} = d_{m-i}\, \dots\, d_2\, d_1$

C. $n \neq \text{rev}$

D. $n = d_1\, d_2\, \dots\, d_m \qquad \textbf{or} \qquad \text{rev} = d_m\, \dots\, d_2\, d_1$

gate2004 programming loop-invariants normal

Answer

4.4.4 Loop Invariants: GATE2015-1_33 top

http://gateoverflow.in/8276

Consider the following pseudo code, where x and y are positive integers.

```
begin
    q := 0
    r := x
   while r ≥ y do
      begin
      r := r - y
```

```
        q := q + 1
    end
end
```

The post condition that needs to be satisfied after the program terminates is

A. { r = qx + y ∧ r < y}
B. { x = qy + r ∧ r < y}
C. { y = qx + r ∧ 0 < r < y}
D. { q + 1 < r - y ∧ y > 0}

gate2015-1 programming loop-invariants normal

Answer

4.4.5 Loop Invariants: GATE2017-2-37 top http://gateoverflow.in/118381

Consider the C program fragment below which is meant to divide x by y using repeated subtractions. The variables x, y, q and r are all unsigned int.

```
while (r >= y) {
    r=r-y;
    q=q+1;
}
```

Which of the following conditions on the variables x, y, q and r before the execution of the fragment will ensure that the loop terminated in a state satisfying the condition $x == (y * q + r)$?

A. (q==r) && (r==0)
B. (x>0) && (r==x) && (y>0)
C. (q==0) && (r==x) && (y >0)
D. (q==0) && (y>0)

gate2017-2 programming loop-invariants

Answer

4.4.6 Loop Invariants: TIFR2010-B-30 top http://gateoverflow.in/19042

Consider the following program for summing the entries of the array b: array $[0..N-1]$ of integers, where N is a positive integer. (The symbol '<>' denotes 'not equal to').

```
var
    i, s: integer;
Program
    i:= 0;
    s:= 0;
[*] while i <> N do
        s := s + b[i];
        i := i + 1;
    od
```

Which of the following gives the invariant that holds at the beginning of each loop, that is, each time the program arrives at point [*] ?

A. $s = \sum_{j=0}^{N} b[j] \;\&\; 0 \leq i \leq N$
B. $s = \sum_{j=0}^{i=1} b[j] \;\&\; 0 \leq i < N$
C. $s = \sum_{j=0}^{i} b[j] \;\&\; 0 < i \leq N$
D. $s = \sum_{j=1}^{N} b[j] \;\&\; 0 \leq i < N$
E. $s = \sum_{j=0}^{i-1} b[j] \;\&\; 0 \leq i \leq N$

tifr2010 programming loop-invariants

Answer

4.4.7 Loop Invariants: TIFR2010-B-37 top http://gateoverflow.in/19251

Consider the program where a, b are integers with $b > 0$.

```
x:=a; y:=b; z:=0;
while y > 0 do
    if odd (x) then
        z:= z + x;
        y: y - 1;
    else y:= y % 2;
        x:= 2 * x;
    fi
```

Invariant of the loop is a condition which is true before and after every iteration of the loop. In the above program the loop invariant is given by

$$0 \leq y \text{ and } z + x * y = a * b$$

Which of the following is true of the program?

a. The program will not terminate for some values of a, b.
b. The program will terminate with $z = 2^b$
c. The program will terminate with z = a * b.
d. The program will not terminate for some values of a, b but when it does terminate, the condition z = a * b will hold.
e. The program will terminate with $z = a^b$

tifr2010 programming loop-invariants

Answer

4.4.8 Loop Invariants: TIFR2017-B-5 top http://gateoverflow.in/95683

Consider the following psuedocode fragment, where y is an integer that has been initialized.

```
int i=1
int j=1
while (i<10):
    j=j*i
    i=i+1
    if (i==y):
        break
    end if
end while
```

Consider the following statements:

i. $(i == 10)$ or $(i == y)$
ii. If $y > 10$, then $i == 10$
iii. If $j = 6$, then $y == 4$

Which of the above statements is/are TRUE at the end of the while loop? Choose from the following options.

A. i only
B. iii only
C. ii and iii only
D. i, ii, and iii
E. None of the above

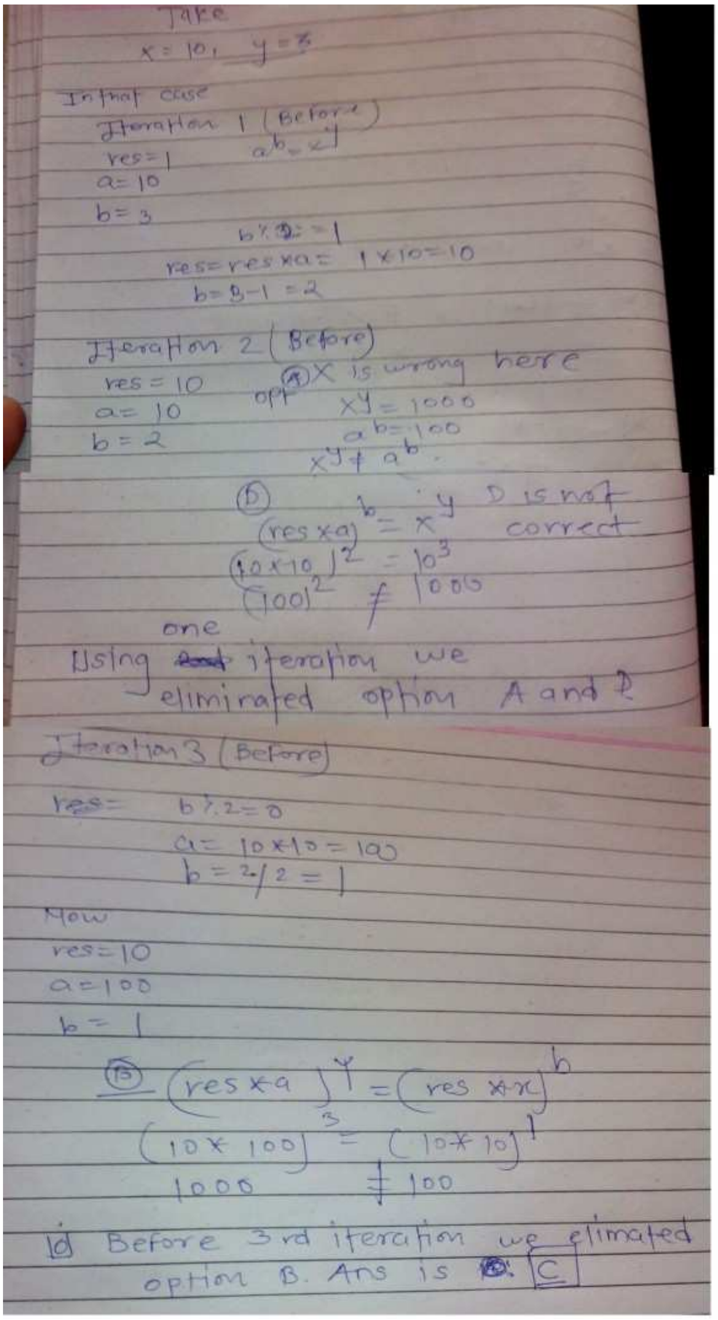
tifr2017 programming loop-invariants

Answer

Answers: Loop Invariants

4.4.1 Loop Invariants: GATE 2016-2-35 top http://gateoverflow.in/39578

Selected Answer



Take

$x = 10, \; y = 3$

In that case

Iteration 1 (Before)

res = 1 $\quad a^b = x^y$

a = 10

b = 3

b % 2 = 1

res = res × a = 1 × 10 = 10

b = 3 − 1 = 2

Iteration 2 (Before)

res = 10 $\quad$ opt (A) X is wrong here

a = 10 $\quad x^y = 1000$

b = 2 $\quad a^b = 100$

$x^y \neq a^b$.

(D) $(res \times a)^b = x^y$ $\quad$ D is not correct

$(10 \times 10)^2 = 10^3$

$(100)^2 \neq 1000$

Using ~~...~~ one iteration we eliminated option A and D

Iteration 3 (Before)

res = $\quad$ b % 2 = 0

a = 10 × 10 = 100

b = 2/2 = 1

Now

res = 10

a = 100

b = 1

(B) $(res \times a)^Y = (res \times x)^b$

$(10 \times 100)^3 = (10 \times 10)^1$

$1000 \neq 100$

Id Before 3rd iteration we elimated option B. Ans is $\boxed{C}$

Answer ==> C

20 votes -- Akash (43.8k points)

4.4.2 Loop Invariants: GATE1991-1,vi top

http://gateoverflow.in/504

Selected Answer

A loop invariant is a condition that is always be same before the loop starts , while in the loop and after the loop ends for each iteration.

Here i mod2 = 0 is the loop invariant.

13 votes -- Monanshi Jain (8.5k points)

4.4.3 Loop Invariants: GATE2004-32 top http://gateoverflow.in/1029

Selected Answer

A loop invariant is something that hold at the start of a loop, across each iteration (inside an iteration it can change but before the iteration ends original condition must be true) and at the end also. So, we can check for the satisfiability of the condition at the loop header for start of the loop, for each iteration and also at the exit.

Here, in each iteration the right most digit of n, is moving to the right end of rev. So, answer is A. i.e. the 2 conditions given in A choice are true on entry to loop, after each iteration (not necessarily during an iteration), and at end of loop.

6 votes -- Arjun Suresh (294k points)

4.4.4 Loop Invariants: GATE2015-1_33 top http://gateoverflow.in/8276

Selected Answer

The loop terminates when r < y. So, r < y is one post condition.

In each iteration q is incremented by 1 and y is subtracted from r. Initial value of r is x. So, loop iterates x/y times and q will be equal to x/y and r = x%y => x = qy + r;

So, B choice.

21 votes -- Arjun Suresh (294k points)

4.4.5 Loop Invariants: GATE2017-2-37 top http://gateoverflow.in/118381

Selected Answer

Here, x == (y*q + r) says q = quotient and r = remainder.

To divide a number with repeated subtraction, quotient should be initialized to 0 and should be incremented for each subtraction.

Initially q=0 $\Rightarrow$ r = x.

$\therefore$ Initial conditions should be C] (q == 0) && (r == x) && (y > 0).

8 votes -- Kantikumar (3.5k points)

4.4.6 Loop Invariants: TIFR2010-B-30 top http://gateoverflow.in/19042

Selected Answer

Whenever we encounter the [*], the variable s holds the sum of all elements $b[0]$ to $b[i-1]$.

When we first enter the loop, $i = 0$, and s doesn't have any elements summed up.

When we last enter the loop, $i = (N-1)$ and s contains the sum of elements $b[0]$ through $b[N-2]$.

We leave the loop when $i = N$, and s gets the sum of elements $b[0]$ to $b[N-1]$

The only option that matches this behavior is **option E**

$$s = \sum_{j=0}^{i-1} b[j] \ \& \ 0 \leq i \leq N$$

8 votes -- Pragy Agarwal (19.5k points)

4.4.7 Loop Invariants: TIFR2010-B-37 top

http://gateoverflow.in/19251

Typing error in ques:y=y%2

Ans D

if x is odd then{

z =a*b will be o/p

}

if x is even {

case 1: y is even then x =2*x and z=0 will be o/p

case 2: y is odd then loop will not terminate .

}

4 votes

-- Saurav Shrivastava (1.4k points)

4.4.8 Loop Invariants: TIFR2017-B-5 top

http://gateoverflow.in/95683

Selected Answer

Consider the situations when loop gets broken -

1. if i becomes 10, or i becomes equal to y. => i is correct.

2. if y > 10, the control will come out of the loop when i becomes 10. => ii is correct.

3. During I iteration - j =1, i =2

II iteration - j = 2, i =3

III iteration - j = 6, i =4

IV iteration must not occur, because j will become 24. Hence during 3rd iteration break statement must had been executed and hence, y must be 4 (equal to i during the 3rd iteration).

This implies iii is also correct.

Hence, option d is correct.

7 votes

-- tarun_svbk (1k points)

4.5 Parameter Passing(2) top

4.5.1 Parameter Passing: GATE1993_26 top

http://gateoverflow.in/2322

A stack is used to pass parameters to procedures in a procedure call.

a. If a procedure P has two parameters as described in procedure definition:

```
procedure P (var x :integer; y: integer);
```

and if P is called by ; $P(a,b)$

State precisely in a sentence what is pushed on stack for parameters a and b

b. In the generated code for the body of procedure P, how will the addressing of formal parameters x and y differ?

gate1993 programming parameter-passing normal

Answer

4.5.2 Parameter Passing: GATE2013-42 top

http://gateoverflow.in/60

What is the return value of $f(p,p)$, if the value of p is initialized to 5 before the call? Note that the first parameter is passed by reference, whereas the second parameter is passed by value.

```
int f (int &x, int c) {
       c = c - 1;
       if (c==0) return 1;
       x = x + 1;
       return f(x,c) * x;
}
```

gate2013 programming normal marks-to-all numerical-answers parameter-passing runtime-environments

Answer

Answers: Parameter Passing

4.5.1 Parameter Passing: GATE1993_26 top

http://gateoverflow.in/2322

a is pointer variable so address and b is variable so its value pushed into stack.

2 votes -- Digvijay (47k points)

4.5.2 Parameter Passing: GATE2013-42 top

http://gateoverflow.in/60

Selected Answer

In GATE 2013 marks were given to all as the same code in C/C++ produces undefined behavior. This is because * is not a sequence point in C/C++. The correct code must replace

```
return f(x,c) * x;
with
```

```
res = f(x,c); // ';' forms a sequence point
//and all side-effects are guaranteed to be completed here
//-- updation of the x parameter inside f is guaranteed
//to be reflected in the caller from the next point onwards.
return res * x;
```

In this code, there will be 4 recursive calls with parameters (6,4), (7,3), (8,2) and (9,1). The last call returns 1. But due to pass by reference, x in all the previous functions is now 9. Hence, the value returned by f(p,p) will be 9 * 9 * 9 * 9 * 1 = 6561.

Good Read

- http://stackoverflow.com/questions/41775973/is-this-undefined-behaviour-in-c-if-not-predict-the-output-logically
- http://gateoverflow.in/108445/c-programming?show=108582#a108582

30 votes -- Arjun Suresh (294k points)

4.6 Programming Constructs(1) top

4.6.1 Programming Constructs: GATE1999-2.5 top

http://gateoverflow.in/1483

Given the programming constructs

- (i) assignment
- (ii) for loops where the loop parameter cannot be changed within the loop
- (iii) if-then-else

- (iv) forward go to
- (v) arbitrary go to
- (vi) non-recursive procedure call
- (vii) recursive procedure/function call
- (viii) repeat loop,

which constructs will you not include in a programming language such that it should be possible to program the terminates (i.e., halting) function in the same programming language

A. (ii), (iii), (iv)
B. (v), (vii), (viii)
C. (vi), (vii), (viii)
D. (iii), (vii), (viii)

gate1999 programming normal programming-constructs

Answer

Answers: Programming Constructs

4.6.1 Programming Constructs: GATE1999-2.5 top http://gateoverflow.in/1483

Ans)B

Arbitary goto,recursive call and repeat may enter infinite loop,and hence terminates program may not be able to answer if 'the program does terminate'.

10 votes -- bahirNaik (3.7k points)

4.7 Programming In C(59) top

4.7.1 Programming In C: GATE 2016-1-12 top http://gateoverflow.in/39638

Consider the following "C" program.

```
void f(int, short);
void main()
{
    int i = 100;
    short s = 12;
    short *p = &s;
    ____________;  // call to f()
}
```

Which one of the following expressions , when placed in the blank above, will NOT result in a type checking error?

A. f(s, *s)
B. i = f(i,s)
C. f(i, *s)
D. f(i, *p)

gate2016-1 programming-in-c easy

Answer

4.7.2 Programming In C: GATE 2016-1-15 top http://gateoverflow.in/39642

Consider the following C program.

```
# include <stdio.h>
void mystery (int *ptra, int *ptrb) {
     int *temp;
     temp = ptrb;
     ptrb =ptra;
     ptra = temp;
}
int main () {
```

```
    int a = 2016, b=0, c= 4, d = 42;
    mystery (&a, &b);
    if (a < c)
          mystery (&c, &a);
    mystery (&a, &d);
    print f("%d\n", a);
}
```

The output of the program is __________.

gate2016-1 programming-in-c easy numerical-answers

Answer

4.7.3 Programming In C: GATE 2016-1-34 top http://gateoverflow.in/39704

The following function computes the maximum value contained in an integer array $P[]$ of size n $(n >= 1)$.

```
int max (int *p,int n) {
    int a = 0, b=n-1;

    while (__________) {
        if (p[a]<= p[b]) {a = a+1;}
        else             {b = b-1;}
    }
    return p[a];
}
```

The missing loop condition is

A. $a! = n$
B. $b! = 0$
C. $b > (a + 1)$
D. $b! = a$

gate2016-1 programming-in-c normal

Answer

4.7.4 Programming In C: GATE 2016-2-12 top http://gateoverflow.in/39565

The value printed by the following program is ________.

```
      void f (int * p, int m) {
           m = m + 5;
          *p = *p + m;
           return;
      }
      void main () {
       int i=5, j=10;

       f (&i, j);
       print f ("%d", i+j);
     }
```

gate2016-2 programming-in-c normal numerical-answers

Answer

4.7.5 Programming In C: GATE 2016-2-37 top http://gateoverflow.in/39602

Consider the following program:

```
int f (int * p, int n)
```

```
{
    if (n <= 1) return 0;
    else return max (f (p+1, n-1), p[0] - p[1]);
}
int main ()
{
    int a[] = {3, 5, 2, 6, 4};
    print f(" %d", f(a, 5));
}
```

Note: max (x, y) returns the maximum of x and y.

The value printed by this program is _________.

gate2016-2 programming-in-c normal numerical-answers

Answer

4.7.6 Programming In C: GATE2000-1.11 top http://gateoverflow.in/634

The following C declarations

```
struct node {
    int i:
    float j;
};
struct node *s[10];
```

define s to be

A. An array, each element of which is a pointer to a structure of type node
B. A structure of 2 fields, each field being a pointer to an array of 10 elements
C. A structure of 3 fields: an integer, a float, and an array of 10 elements
D. An array, each element of which is a structure of type node

gate2000 programming programming-in-c easy

Answer

4.7.7 Programming In C: GATE2000-1.12 top http://gateoverflow.in/635

The most appropriate matching for the following pairs

```
      X: m = malloc(5); m = NULL;      1: using dangling pointers
      Y: free(n); n -> value = 5;       2: using uninitialized pointers
      Z: 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

gate2000 programming programming-in-c normal

Answer

4.7.8 Programming In C: GATE2000-1.17, ISRO2015-79 top http://gateoverflow.in/640

Consider the following C declaration

```
struct (
    short x[5];
    union {
        float y;
        long z;
    } u;
 )t;
```

Assume that the objects of the type short, float and long occupy 2 bytes, 4 bytes and 8 bytes, respectively. The memory requirement for variable t, ignoring alignment consideration, is

A. 22 bytes
B. 14 bytes
C. 18 bytes
D. 10 bytes

gate2000 programming programming-in-c easy isro2015

Answer

4.7.9 Programming In C: GATE2000-2.20 top http://gateoverflow.in/667

The value of j at the end of the execution of the following C program

```
int incr (int i)
{
    static int count = 0;
    count = count + i;
    return (count);
}
main () {
    int i, j;
    for (i = 0; i <= 4; i++)
       j = incr (i);
}
```

is

A. 10
B. 4
C. 6
D. 7

gate2000 programming programming-in-c easy

Answer

4.7.10 Programming In C: GATE2001-2.18 top http://gateoverflow.in/736

Consider the following three C functions:

[P1]

```
int *g(void)
{
    int x = 10;
    return (&x);
}
```

[P2]

```
int *g(void)
{
    int *px;
    *px = 10;
    return px;
}
```

[P3]

```
int *g(void)
{
    int *px;
    px = (int*) malloc (sizeof(int));
    *px = 10;
    return px;
}
```

Which of the above three functions are likely to cause problems with pointers?

A. Only P3
B. Only P1 and P3
C. Only P1 and P2
D. P1, P2 and P3

gate2001 programming programming-in-c normal

Answer

4.7.11 Programming In C: GATE2002-1.17 top http://gateoverflow.in/822

In the C language

A. At most one activation record exists between the current activation record and the activation record for the main
B. The number of activation records between the current activation record and the activation records fro the main depends on the actual function calling sequence.
C. The visibility of global variables depends on the actual function calling sequence
D. Recursion requires the activation record for the recursive function to be saved in a different stack before the recursive function can be called.

gate2002 programming programming-in-c easy descriptive

Answer

4.7.12 Programming In C: GATE2002-2.18 top http://gateoverflow.in/848

The C language is:

A. A context free language
B. A context sensitive language
C. A regular language
D. Parsable fully only by a Turing machine

gate2002 programming programming-in-c normal

Answer

4.7.13 Programming In C: GATE2002-2.8 top http://gateoverflow.in/838

Consider the following declaration of a two-dimensional array in C:

char a[100][100];

Assuming that the main memory is byte-addressable and that the array is stored starting from memory address 0, the address of a [40][50] is

A. 4040
B. 4050
C. 5040
D. 5050

gate2002 programming-in-c programming easy

Answer

4.7.14 Programming In C: GATE2003-2 top http://gateoverflow.in/893

Assume the following C variable declaration

```
int *A[10], B[10][10];
```

Of the following expressions

I. A[2]
II. A[2][3]
III. B[1]
IV. B[2][3]

which will not give compile-time errors if used as left hand sides of assignment statements in a C program?

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

gate2003 programming programming-in-c easy

Answer

4.7.15 Programming In C: GATE2003-89 top http://gateoverflow.in/972

Consider the C program shown below:

```
#include<stdio.h>
#define print(x) printf("%d", x)

int x;
void Q(int z)
{
        z+=x;
        print(z);
}

void P(int *y)
{
        int x = *y + 2;
        Q(x);
        *y = x - 1;
        print(x);
}
main(void) {
        x = 5;
        P(&x);
        print(x);
}
```

The output of this program is

A. 12 7 6
B. 22 12 11
C. 14 6 6
D. 7 6 6

gate2003 programming programming-in-c normal

Answer

4.7.16 Programming In C: GATE2004-33 top http://gateoverflow.in/1030

Consider the following C program segment:

```
char p[20];
char* s = "string";
int length = strlen(s);
for(i = 0; i < length; i++)
    p[i] = s[length-i];
printf("%s", p);
```

The output of the program is

A. gnirts
B. string
C. gnirt
D. no output is printed

gate2004 programming programming-in-c easy

Answer

4.7.17 Programming In C: GATE2004-IT-58 top http://gateoverflow.in/3701

Consider the following C program which is supposed to compute the transpose of a given 4 x 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];
}
```

gate2004-it programming easy programming-in-c

Answer

4.7.18 Programming In C: GATE2004-IT-59 top

http://gateoverflow.in/3702

What is the output of the following program?

```
#include<stdio.h>
int funcf (int x);
int funcg (int y);
main ()
{
    int x = 5, y = 10, count;
    for (count = 1; count <= 2; ++count) {
        y += funcf(x) + funcg(x);
        printf ("%d", y);
    }
}
funcf (int x) {
    int y;
    y = funcg(x);
    return (y);
}
funcg (int x) {
    static int y = 10;
    y += 1;
    return (y + x);
}
```

A. 43 80
B. 42 74
C. 33 37
D. 32 32

gate2004-it programming programming-in-c normal

Answer

4.7.19 Programming In C: GATE2004-IT-60 top

http://gateoverflow.in/3703

Choose the correct option to fill the ?1 and ?2 so that the program prints an input string in reverse order. Assume that the input string is terminated by a new line character.

```
#include <stdio.h>
void wrt_it (void);
int main (void)
{
    printf("Enter Text");
    printf ("\n");
```

```
    wrt_ it();
    printf ("\n");
    return 0;
}
void wrt_it (void)
{
    int c;
    if (?1)
        wrt_it();
    ?2
}
```

A. ?1 is getchar() ! = '\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);

gate2004-it programming programming-in-c normal

Answer

4.7.20 Programming In C: GATE2004-IT-61 top http://gateoverflow.in/3704

Consider the following C program:

```
#include <stdio.h>
typedef struct {
    char *a;
    char *b;
    } t;
void f1 (t s);
void f2 (t *p);
main()
{
    static t s = {"A", "B"};
    printf ("%s %s\n", s.a, s.b);
    f1(s);
    printf ("%s %s\n", s.a, s.b);
    f2(&s);
}
void f1 (t s)
{
    s.a = "U";
    s.b = "V";
    printf ("%s %s\n", s.a, s.b);
    return;
}
void f2(t *p)
{
    p -> a  = "V";
    p -> b = "W";
    printf("%s %s\n", p -> a, p -> b);
    return;
}
```

What is the output generated by the program ?

A. A B
   U V
   V W
   V W
B. A B
   U V
   A B
   V W
C. A B
   U V
   U V
   V W
D. A B
   U V
   V W
   U V

gate2004-it programming programming-in-c normal

Answer

4.7.21 Programming In C: GATE2005-1, ISRO2017-55 top http://gateoverflow.in/1343

What does the following C-statement declare?

```
int (*f) (int * );
```

A. A function that takes an integer pointer as argument and returns an integer

B. A function that takes an integer as argument and returns an integer pointer

C. A pointer to a function that takes an integer pointer as argument and returns an integer

D. A function that takes an integer pointer as argument and returns a function pointer

gate2005 programming programming-in-c easy isro2017

Answer

4.7.22 Programming In C: GATE2005-32 top http://gateoverflow.in/1368

Consider the following C program:

```
double foo (double);  /* Line 1 */
int main() {
    double da, db;
    //input da
    db = foo(da);
}
double foo (double a) {
    return a;
}
```

The above code compiled without any error or warning. If Line 1 is deleted, the above code will show:

A. no compile warning or error

B. some compiler-warnings not leading to unintended results

C. some compiler-warnings due to type-mismatch eventually leading to unintended results

D. compiler errors

gate2005 programming programming-in-c compiler-design easy

Answer

4.7.23 Programming In C: GATE2005-IT-53 top http://gateoverflow.in/3814

The following C function takes two ASCII strings and determines whether one is an anagram of the other. An anagram of a string s is a string obtained by permuting the letters in s.

```
int anagram (char *a, char *b) {
    int count [128], j;
    for (j = 0;  j < 128; j++) count[j] = 0;
    j = 0;
    while (a[j] && b[j]) {
        A;
        B;
    }
    for (j = 0; j < 128; j++) if (count [j]) return 0;
    return 1;
}
```

Choose the correct alternative for statements A and B.

A. A : count [a[j]]++ and B : count[b[j]]--
B. A : count [a[j]]++ and B : count[b[j]]++
C. A : count [a[j++]]++ and B : count[b[j]]--
D. A : count [a[j]]++and B : count[b[j++]]--

gate2005-it programming normal programming-in-c

Answer

4.7.24 Programming In C: GATE2005-IT-58 top http://gateoverflow.in/3819

Let a be an array containing n integers in increasing order. The following algorithm determines whether there are two distinct numbers in the array whose difference is a specified number $S > 0$.

```
i = 0; j = 1;
while (j < n ){
        if (E) j++;
        else if (a[j] - a[i] == S) break;
        else i++;
}
if (j < n) printf("yes") else printf ("no");
```

Choose the correct expression for E.

A. a[j] - a[i] > S
B. a[j] - a[i] < S
C. a[i] - a[j] < S
D. a[i] - a[j] > S

gate2005-it programming normal programming-in-c

Answer

4.7.25 Programming In C: GATE2006-57 top http://gateoverflow.in/1835

Consider this C code to swap two integers and these five statements: the code

```
  void swap (int *px, int *py)
     {
        *px = *px - *py;
        *py = *px + *py;
         *px = *py - *px;
     }
```

S1: will generate a compilation error

S2: may generate a segmentation fault at runtime depending on the arguments passed

S3: correctly implements the swap procedure for all input pointers referring to integers stored in memory locations accessible to the process

S4: implements the swap procedure correctly for some but not all valid input pointers

S5: may add or subtract integers and pointers

A. S1
B. S2 and S3
C. S2 and S4
D. S2 and S5

gate2006 programming programming-in-c normal

Answer

4.7.26 Programming In C: GATE2006-IT-49 top http://gateoverflow.in/3592

Which one of the choices given below would be printed when the following program is executed ?

```
#include <stdio.h>
struct test {
               int i;
               char *c;
}st[] = {5, "become", 4, "better", 6, "jungle", 8, "ancestor", 7, "brother"};
main ()
{
    struct test *p = st;
    p += 1;
    ++p -> c;
    printf("%s,", p++ -> c);
    printf("%c,", *++p -> c);
```

```
    printf("%d,", p[0].i);
    printf("%s \n", p -> c);
}
```

A. jungle, n, 8, nclastor
B. etter, u, 6, ungle
C. cetter, k, 6, jungle
D. etter, u, 8, ncestor

gate2006-it programming programming-in-c normal

Answer

4.7.27 Programming In C: GATE2006-IT-50 top http://gateoverflow.in/3593

Which one of the choices given below would be printed when the following program is executed?

```
#include <stdio.h>
void swap (int *x, int *y)
{
    static int *temp;
    temp = x;
    x = y;
    y = temp;
}
void printab ()
{
    static int i, a = -3, b = -6;
    i = 0;
    while (i <= 4)
    {
        if ((i++)%2 == 1) continue;
        a = a + i;
        b = b + i;
    }
    swap (&a, &b);
    printf("a =  %d, b = %d\n", a, b);
}
main()
{
    printab();
    printab();
}
```

A. a = 0, b = 3
   a = 0, b = 3
B. a = 3, b = 0
   a = 12, b = 9
C. a = 3, b = 6
   a = 3, b = 6
D. a = 6, b = 3
   a = 15, b = 12

gate2006-it programming programming-in-c normal

Answer

4.7.28 Programming In C: GATE2006-IT-51 top http://gateoverflow.in/3594

Which one of the choices given below would be printed when the following program is executed?

```
#include <stdio.h>
int a1[] = {6, 7, 8, 18, 34, 67};
int a2[] = {23, 56, 28, 29};
int a3[] = {-12, 27, -31};
int *x[] = {a1, a2, a3};
void print(int *a[])
{
            printf("%d,", a[0][2]);
            printf("%d,", *a[2]);
            printf("%d,", *++a[0]);
            printf("%d,", *(++a)[0]);
            printf("%d\n", a[-1][+1]);
}
main()
{
             print(x);
}
```

A. 8, -12, 7, 23, 8
B. 8, 8, 7, 23, 7
C. -12, -12, 27, -31, 23
D. -12, -12, 27, -31, 56

gate2006-it programming programming-in-c normal

Answer

4.7.29 Programming In C: GATE2007-IT-31 top http://gateoverflow.in/3464

Consider the C program given below :

```
#include <stdio.h>
int main ()    {
    int sum = 0, maxsum = 0,  i,  n = 6;
    int a [] = {2, -2, -1, 3, 4, 2};
    for (i = 0; i < n; i++)     {
            if (i == 0 || a [i]  < 0  || a [i] < a [i - 1])  {
                     if (sum > maxsum) maxsum = sum;
                     sum = (a [i] > 0) ? a [i] : 0;
            }
            else sum += a [i];
    }
    if (sum > maxsum) maxsum = sum ;
    printf ("%d\n", maxsum);

}
```

What is the value printed out when this program is executed?

A. 9
B. 8
C. 7
D. 6

gate2007-it programming programming-in-c normal

Answer

4.7.30 Programming In C: GATE2008-18 top http://gateoverflow.in/416

Which combination of the integer variables x, y and z makes the variable a get the value 4 in the following expression?

$$a = (x > y)?((x > z)?x : z) : ((y > z)?y : z)$$

A. $x = 3, y = 4, z = 2$
B. $x = 6, y = 5, z = 3$
C. $x = 6, y = 3, z = 5$
D. $x = 5, y = 4, z = 5$

gate2008 programming programming-in-c easy

Answer

4.7.31 Programming In C: GATE2008-60 top http://gateoverflow.in/483

What is printed by the following C program?

```
int f(int x, int *py, int **ppz)
{
    int y, z;
    **ppz += 1; z = **ppz;    // corrected z = *ppz; to z = **ppz;
    *py += 2; y = *py;
    x += 3;
    return x+y+z;
}

void main()
{
    int c, *b, **a;
    c = 4; b = &c; a = &b;
    printf("%d", f(c, b, a));
```

```
}
```

A. 18
B. 19
C. 21
D. 22

gate2008 programming programming-in-c normal

Answer

4.7.32 Programming In C: GATE2008-IT-49 top http://gateoverflow.in/3359

What is the output printed by the following C code?

```
# include <stdio.h>
int main ()
{
    char a [6] = "world";
    int i, j;
    for (i = 0, j = 5; i < j; a [i++] = a [j--]);
    printf ("%s\n", a);
}
```

A. dlrow
B. Null string
C. dlrld
D. worow

gate2008-it programming programming-in-c normal

Answer

4.7.33 Programming In C: GATE2008-IT-50 top http://gateoverflow.in/3360

Consider the C program below. What does it print?

```
# include <stdio.h>
# define swapl (a, b) tmp = a; a = b; b = tmp
void swap2 ( int a, int b)
{
        int tmp;
        tmp = a; a = b; b = tmp;
 }
void swap3 (int*a, int*b)
{
        int tmp;
        tmp = *a; *a = *b; *b = tmp;
}
int main ()
{
        int num1 = 5, num2 = 4, tmp;
        if (num1 < num2) {swap1 (num1, num2);}
        if (num1 < num2) {swap2 (num1 + 1, num2);}
        if (num1 > = num2) {swap3 (&num1, &num2);}
        printf ("%d, %d", num1, num2);
}
```

A. 5, 5
B. 5, 4
C. 4, 5
D. 4, 4

gate2008-it programming programming-in-c normal

Answer

4.7.34 Programming In C: GATE2008-IT-51 top http://gateoverflow.in/3361

Consider the C program given below. What does it print?

```
#include <stdio.h>
int main ()
{
```

```
        int i, j;
        int a [8] = {1, 2, 3, 4, 5, 6, 7, 8};
        for(i = 0; i < 3; i++) {
             a[i] = a[i] + 1;
             i++;
        }
        i--;
        for (j = 7; j > 4; j--) {
              int i = j/2;
              a[i] = a[i] - 1;
        }
        printf ("%d, %d", i, a[i]);
}
```

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

gate2008-it programming programming-in-c normal

Answer

4.7.35 Programming In C: GATE2008-IT-52 top

http://gateoverflow.in/3362

C program is given below:

```
# include <stdio.h>
int main ()
{
        int i, j;
        char a [2] [3] = {{'a', 'b', 'c'}, {'d', 'e', 'f'}};
        char b [3] [2];
        char *p = *b;
        for (i = 0; i < 2; i++) {
              for (j = 0; j < 3; j++) {
              *(p + 2*j + i) = a [i] [j];
              }
        }
}
```

What should be the contents of the array b at the end of the program?

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

gate2008-it programming programming-in-c normal

Answer

4.7.36 Programming In C: GATE2010-11 top

http://gateoverflow.in/2184

What does the following program print?

```
#include<stdio.h>

void f(int *p, int *q) {
    p=q;
    *p=2;
}

int i=0, j=1;

int main() {
    f(&i, &j);
    printf("%d %d\n", i,j);
    return 0;
```

```
}
```

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

gate2010 programming programming-in-c easy

Answer

4.7.37 Programming In C: GATE2011_22 top http://gateoverflow.in/2124

What does the following fragment of C program print?

```
    char c[] = "GATE2011";
    char *p = c;
    printf("%s", p + p[3] - p[1]);
```

(A) GATE2011

(B) E2011

(C) 2011

(D) 011

gate2011 programming programming-in-c normal

Answer

4.7.38 Programming In C: GATE2012-3 top http://gateoverflow.in/35

What will be the output of the following C program segment?

```
char inChar = 'A';
   switch ( inChar ) {
      case 'A' : printf ("Choice A\ n");
      case 'B' :
      case 'C' : printf ("Choice B");
      case 'D' :
      case 'E' :
      default : printf ("No Choice");
   }
```

(A) No Choice
(B) Choice A
(C) Choice A
Choice B No Choice
(D) Program gives no output as it is erroneous

gate2012 programming easy programming-in-c

Answer

4.7.39 Programming In C: GATE2012-48 top http://gateoverflow.in/2176

Consider the following C code segment.

```
int a, b, c = 0;
void prtFun(void);
main()
{
    static int a = 1;        /* Line 1 */
    prtFun();
    a += 1;
    prtFun();
    printf(" \n %d %d ", a, b);
}

void prtFun(void)
```

```
{
    static int a = 2;        /* Line 2 */
    int b = 1;
    a += ++b;
    printf(" \n %d %d ", a, b);
}
```

What output will be generated by the given code segment?

(A)	
3	1
4	1
4	2

(B)	
4	2
6	1
6	1

(C)	
4	2
6	2
2	0

(D)	
3	1
5	2
5	2

gate2012 programming programming-in-c normal

Answer

4.7.40 Programming In C: GATE2012-49 top http://gateoverflow.in/43314

Consider the following C code segment.

```
int a, b, c = 0;
void prtFun(void);
main()
{
    static int a = 1;        /* Line 1 */
    prtFun();
    a += 1;
    prtFun();
    printf(" \n %d %d ", a, b);
}

void prtFun(void)
{
    static int a = 2;        /* Line 2 */
    int b = 1;
    a += ++b;
    printf(" \n %d %d ", a, b);
}
```

What output will be generated by the given code segment if:

Line 1 is replaced by **auto int a = 1;**

Line 2 is replaced by **register int a = 2;**

(A)

3	1
4	1
4	2

(B)	
4	2
6	1
6	1

(C)	
4	2
6	2
2	0

(D)	
4	2
4	2
2	0

normal gate2012 programming-in-c programming

Answer

4.7.41 Programming In C: GATE2014-1-10 top

http://gateoverflow.in/1770

Consider the following program in C language:

```
#include <stdio.h>

main()
{
    int i;
    int*pi = &i;

    scanf("%d",pi);
    printf("%d\n", i+5);
}
```

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

A. Compilation fails.
B. Execution results in a run-time error.
C. On execution, the value printed is 5 more than the address of variable i.

D. On execution, the value printed is 5 more than the integer value entered.

gate2014-1 programming programming-in-c easy

Answer

4.7.42 Programming In C: GATE2014-2-11 top http://gateoverflow.in/1965

Suppose n and p are unsigned int variables in a C program. We wish to set p to ${}^nC_3$. If n is large, which one of the following statements is most likely to set p correctly?

A. p = n * (n-1) * (n-2) / 6;
B. p = n * (n-1) / 2 * (n-2) / 3;
C. p = n * (n-1) / 3 * (n-2) / 2;
D. p = n * (n-1) * (n-2) / 6.0;

gate2014-2 programming programming-in-c normal

Answer

4.7.43 Programming In C: GATE2014-2-42 top http://gateoverflow.in/2008

Consider the C function given below.

```
int f(int j)
{
    static int i = 50;
    int k;
    if (i == j)
    {
        printf("something");
        k = f(i);
        return 0;
    }
    else return 0;
}
```

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

A. The function returns 0 for all values of j.
B. The function prints the string **something** for all values of j.
C. The function returns 0 when $j = 50$.
D. The function will exhaust the runtime stack or run into an infinite loop when $j = 50$.

gate2014-2 programming programming-in-c

Answer

4.7.44 Programming In C: GATE2015-1_11 top http://gateoverflow.in/8185

The output of the following C program is______________.

```
void f1 ( int a, int b)  {
                int c;
                c = a; a = b;
                 b = c;
}
void f2 ( int * a, int * b) {
               int c;
               c = * a; *a = *b; *b = c;
}
int main () {
        int a = 4, b = 5, c = 6;
        f1 ( a, b);
        f2 (&b, &c);
        printf ("%d, c - a - b);
 }
```

gate2015-1 programming programming-in-c easy numerical-answers

Answer

4.7.45 Programming In C: GATE2015-1_35 top http://gateoverflow.in/8283

What is the output of the following C code? Assume that the address of x is 2000 (in decimal) and an integer requires four bytes of memory.

```
int main () {
        unsigned int x [4] [3] =
        {{1, 2, 3}, {4, 5, 6}, {7, 8, 9}, {10, 11, 12}};
        printf ("%u, %u, %u, x + 3, * (x + 3), * (x + 2) + 3);
}
```

A. 2036, 2036, 2036
B. 2012, 4, 2204
C. 2036, 10, 10
D. 2012, 4, 6

gate2015-1 programming programming-in-c normal

Answer

4.7.46 Programming In C: GATE2015-2_15 top

http://gateoverflow.in/8086

Consider the following function written in the C programming langauge :

```
void foo(char *a)
 {
    if (*a && *a != ' ')
      {
       foo(a+1);
       putchar(*a);
      }
}
```

The output of the above function on input "ABCD EFGH" is

A. ABCD EFGH
B. ABCD
C. HGFE DCBA
D. DCBA

gate2015-2 programming programming-in-c normal

Answer

4.7.47 Programming In C: GATE2015-3_26 top

http://gateoverflow.in/8478

Consider the following C program

```
#include<stdio.h>
int main()  {
    static int a[] = {10, 20, 30, 40, 50};
    static int *p[] = {a, a+3, a+4, a+1, a+2};
    int **ptr = p;
    ptr++;
    printf("%d%d", ptr-p, **ptr);

}
```

The output of the program is ________.

gate2015-3 programming programming-in-c normal numerical-answers

Answer

4.7.48 Programming In C: GATE2015-3_30 top

http://gateoverflow.in/8486

Consider the following two C code segments. Y and X are one and two dimensional arrays of size n and $n \times n$ respectively, where $2 \leq n \leq 10$. Assume that in both code segments, elements of Y are initialized to 0 and each element $X[i][j]$ of array X is initialized to $i + j$. Further assume that when stored in main memory all elements of X are in same main memory page frame.

Code segment 1:

```
// initialize elements of Y to 0
// initialize elements of X[i][j] of X to i+j
```

```
for (i=0; i<n; i++)
    Y[i] += X[0][i];
```

Code segment 2:

```
// initialize elements of Y to 0
// initialize elements of X[i][j] of X to i+j
for (i=0; i<n; i++)
    Y[i] += X[i][0];
```

Which of the following statements is/are correct?

S1: Final contents of array Y will be same in both code segments

S2: Elements of array X accessed inside the for loop shown in code segment 1 are contiguous in main memory

S3: Elements of array X accessed inside the for loop shown in code segment 2 are contiguous in main memory

A. Only S2 is correct
B. Only S3 is correct
C. Only S1 and S2 are correct
D. Only S1 and S3 are correct

gate2015-3 programming-in-c normal

Answer

4.7.49 Programming In C: GATE2015-3_48 top http://gateoverflow.in/8557

Consider the following C program:

```
#include<stdio.h>
int main()
{
    int i, j, k = 0;
    j=2 * 3 / 4 + 2.0 / 5 + 8 / 5;
    k-=--j;
    for (i=0; i<5; i++)
    {
        switch(i+k)
        {
            case 1:
            case 2: printf("\n%d", i+k);
            case 3: printf("\n%d", i+k);
            default: printf("\n%d", i+k);
        }
    }
    return 0;
}
```

The number of times printf statement is executed is ________.

gate2015-3 programming programming-in-c normal numerical-answers

Answer

4.7.50 Programming In C: GATE2015-3_54 top http://gateoverflow.in/8563

Consider the following C program

```
#include<stdio.h>
int f1(void);
int f2(void);
int f3(void);
int x=10;
int main()
{
    int x=1;
    x += f1() + f2 () + f3() + f2();
    printf("%d", x);
    return 0;
}
int f1() { int x = 25; x++; return x;}
int f2() { static int x = 50; x++; return x;}
int f3() { x *= 10; return x;}
```

The output of the program is _______.

gate2015-3 programming programming-in-c normal numerical-answers

Answer

4.7.51 Programming In C: GATE2015-3_7 top http://gateoverflow.in/8401

Consider the following C program segment.

```
# include <stdio.h>
int main()
{
    char s1[7] = "1234", *p;
    p = s1 + 2;
    *p = '0';
    printf("%s", s1);
}
```

What will be printed by the program?

A. 12
B. 120400
C. 1204
D. 1034

gate2015-3 programming programming-in-c normal

Answer

4.7.52 Programming In C: GATE2017-1-13 top http://gateoverflow.in/118293

Consider the following C code:

```
#include<stdio.h>
int *assignval (int *x, int val) {
    *x = val;
    return x;
}

void main () {
    int *x = malloc(sizeof(int));
    if (NULL == x) return;
    x = assignval (x,0);
    if (x) {
        x = (int *)malloc(sizeof(int));
        if (NULL == x) return;
        x = assignval (x,10);
    }
    printf("%d\n", *x);
    free(x);
}
```

The code suffers from which one of the following problems:

(A) compiler error as the return of malloc is not typecast appropriately.

(B) compiler error because the comparison should be made as x == NULL and not as shown.

(C) compiles successfully but execution may result in dangling pointer.

(D) compiles successfully but execution may result in memory leak.

gate2017-1 programming-in-c programming

Answer

4.7.53 Programming In C: GATE2017-1-36 top http://gateoverflow.in/118319

Consider the C functions foo and bar given below:

```
int foo(int val) {
    int x=0;
    while(val > 0) {
        x = x + foo(val--);
    }
```

```
    return val;
}
```

```
int bar(int val) {
    int x = 0;
    while(val > 0) {
        x= x + bar(val-1);
    }
    return val;
}
```

Invocations of foo(3) and bar(3) will result in:

(A) Return of 6 and 6 respectively.

(B) Infinite loop and abnormal termination respectively.

(C) Abnormal termination and infinite loop respectively.

(D) Both terminating abnormally.

gate2017-1 programming-in-c programming normal

Answer

4.7.54 Programming In C: GATE2017-1-53 top http://gateoverflow.in/118473

Consider the following C program.

```
#include<stdio.h>
#include<string.h>

void printlength(char *s, char *t) {
    unsigned int c=0;
    int len = ((strlen(s) - strlen(t)) > c) ? strlen(s) : strlen(t);
    printf("%d\n", len);
}

void main() {
    char *x = "abc";
    char *y = "defgh";
    printlength(x,y);
}
```

Recall that strlen is defined in string.h as returning a value of type size_t, which is an unsigned int. The output of the program is __________ .

gate2017-1 programming programming-in-c normal

Answer

4.7.55 Programming In C: GATE2017-1-55 top http://gateoverflow.in/118442

The output of executing the following C program is _______________ .

```
#include<stdio.h>

int total(int v) {
    static int count = 0;
    while(v) {
        count += v&1;
        v >>= 1;
    }
    return count;
}

void main() {
    static int x=0;
    int i=5;
    for(; i>0; i--) {
        x = x + total(i);
    }
    printf("%d\n", x);
}
```

gate2017-1 programming programming-in-c normal numerical-answers

Answer

4.7.56 Programming In C: GATE2017-2-14 top http://gateoverflow.in/118245

Consider the following function implemented in C:

```
void printxy(int x, int y) {
    int *ptr;
    x=0;
    ptr=&x;
    y=*ptr;
    *ptr=1;
    printf("%d, %d", x, y);
}
```

The output of invoking printxy(1,1) is

A. 0, 0
B. 0, 1
C. 1, 0
D. 1, 1

gate2017-2 programming-in-c

Answer

4.7.57 Programming In C: GATE2017-2-2 top http://gateoverflow.in/118171

Match the following:

P. static char var;	i. Sequence of memory locations to store addresses
Q. m=malloc(10); m=NULL;	ii. A variable located in data section of memory
R. char *ptr[10];	iii. Request to allocate a CPU register to store data
S. register int varl;	iv. A lost memory which cannot be freed

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

gate2017-2 programming programming-in-c

Answer

4.7.58 Programming In C: GATE2017-2-54 top http://gateoverflow.in/118272

Consider the following C program.

```
#include<stdio.h>
int main () {
    int m=10;
    int n, n1;
    n=++m;
    n1=m++;
    n--;
    --n1;
    n-=n1;
    printf("%d", n);
    return 0;
}
```

The output of the program is _______

gate2017-2 programming-in-c numerical-answers

Answer

4.7.59 Programming In C: GATE2017-2-55 top http://gateoverflow.in/118335

Consider the following C program.

```
#include<stdio.h>
#include<string.h>
int main() {
    char* c="GATECSIT2017";
    char* p=c;
    printf("%d", (int)strlen(c+2[p]-6[p]-1));
    return 0;
}
```

The output of the program is ________

gate2017-2 programming-in-c numerical-answers

Answer

Answers: Programming In C

4.7.1 Programming In C: GATE 2016-1-12 top http://gateoverflow.in/39638

Selected Answer

Option 1: 1st argument is short and not int, 2nd is type error(since s is a short variable).. so WRONG
Option 2: return type is not void.. so WRONG
Option 3: 1 st argument is int, second is again syntax error.. so WRONG
Option 4: Both the arguments and return type match..p is a pointer to short, so *p is value of short.. So ANSWER

30 votes -- Abhilash Panicker (8.8k points)

4.7.2 Programming In C: GATE 2016-1-15 top http://gateoverflow.in/39642

Selected Answer

The mystery about mystery function is it does not affect values in main. As in C, parameters are passed by value- even if they are pointer. So, here the pointer values are exchanged within the function only. (we can use * operator to exchange the values at the location of the pointers and this will affect the values in main).

So NO CHANGES in a,b,c,d.
And ANSWER is 2016

38 votes -- Abhilash Panicker (8.8k points)

4.7.3 Programming In C: GATE 2016-1-34 top http://gateoverflow.in/39704

Selected Answer

Answer - d,

Hint : Given in the question itself that we start comparing the contents of an array from a[0] and a [n-1] (converging from both side) then condition must be till both meet at a point and that point will be a=b.
Hence loop condition should be a!=b.

Option C fails for $n = 2, p = [1, 2]$.

21 votes -- sukanyac (171 points)

4.7.4 Programming In C: GATE 2016-2-12 top http://gateoverflow.in/39565

Selected Answer

i is called by reference and j is called by value.

so in function f() only value of i might change,
Now in function f(*p,m)
*p is pointing to i
thus *p is 5.
m is 10 because of call by value of j.

1.m=10+5 hence m=15
2.*p=5 + 15 hence *p=20, that is, value of variable i is now 20
3.returns nothing

Now, back to main
i=20 and j is as it is 10

Hence output of printf will be i+j=20+10 = **30**

Check code in action => http://codepad.org/mDLsWYp5

20 votes -- Shashank Chavan (3.4k points)

4.7.5 Programming In C: GATE 2016-2-37 top http://gateoverflow.in/39602

Selected Answer

$f(a,5)$

$p\ ,n=5$

3	5	2	6	4

max(f(p$+1$,$5-1$),$3-5$) or max(f(p$+1$,4),-2)

$p\ ,n=4$

5	2	6	4

max(max(f(p$+1$,$4-1$),$5-2$),-2) or max(max(f(p$+1$,3),3),-2)

$p\ ,n=3$

2	6	4

max(max(max(f(p$+1$,$3-1$),$2-6$),3),-2) or max(max(max(f(p$+1$,2),-4),3),-2)

$p\ ,n=2$

6	4

max(max(max(max(f(p$+1$),1),2),-4),3),-2)

$n=1$,return 0

max(max(max(max(0,2),-4),3),-2)

max(max(max(2,-4),3),-2)

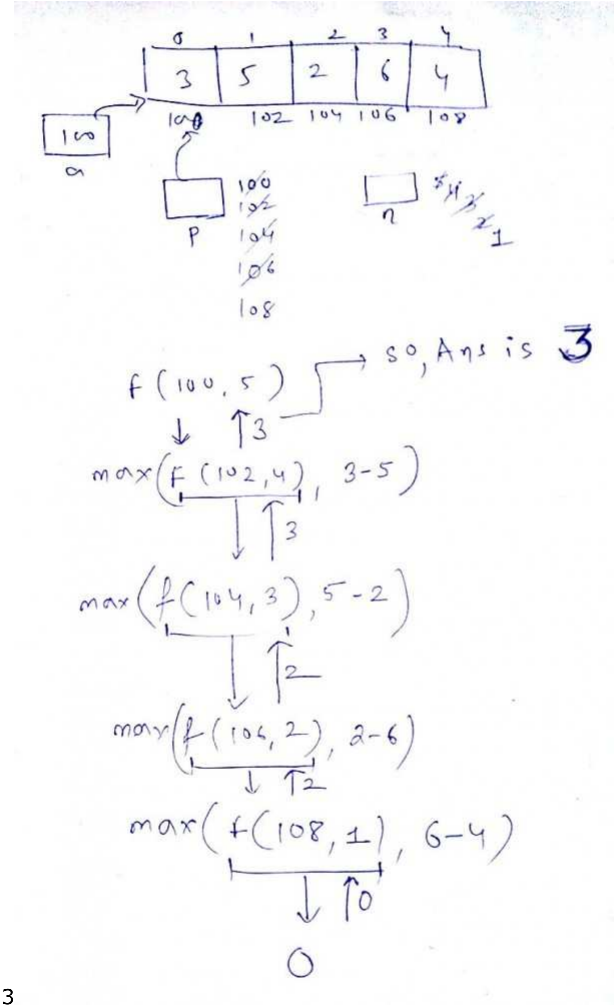
max(max(2,3),-2)

max(3,-2)

3

Check this code => http://codepad.org/vVicmkN7

24 votes -- Praveen Saini (53.6k points)



Ans is 3

👍 11 votes -- Rajesh Pradhan (18.6k points)

4.7.6 Programming In C: GATE2000-1.11 top

http://gateoverflow.in/634

Selected Answer

(a) is the answer. [] has greater precedence than * in C. So, s becomes an array of pointers.

👍 21 votes -- gatecse (13.4k points)

4.7.7 Programming In C: GATE2000-1.12 top

http://gateoverflow.in/635

Selected Answer

ans: d)

X: m = NULL; makes the pointer m point to NULL. But the memory created using malloc is still there and but cannot be used as we don't have a link to it. Hence, lost memory

Y: n is freed and so pointer n is now pointing to an invalid memory making it a Dangling pointer.

Z: p is not initialized. p = malloc(sizeof(char)); should have been used before assigning 'a' to *p.

👍 23 votes -- Aditi Dan (5.3k points)

4.7.8 Programming In C: GATE2000-1.17, ISRO2015-79 top http://gateoverflow.in/640

Selected Answer

answer is (c)

Here structure creates the memory for 'array and union', but union only creates the memory for only 'long z' which is the largest size data type inside it.

hence,

short x [5] = 5*2 = 10 bytes [shorts take 2 bytes]

long z = 8 bytes

so (10+8) = 18 bytes

26 votes -- Kalpna Bhargav (3.2k points)

4.7.9 Programming In C: GATE2000-2.20 top http://gateoverflow.in/667

Selected Answer

Answer: A

At i=0, j=0
At i=1, j=1
At i=2, j=3
At i=3, j=6
At i=4, j=10

12 votes -- Rajarshi Sarkar (35k points)

4.7.10 Programming In C: GATE2001-2.18 top http://gateoverflow.in/736

Selected Answer

[P1] may cause an error because function is returning the address of locally declared variable.

[P2] will cause a problem because px is an int pointer that is not assigned with any address and we are doing dereferencing.
[P3] will work because memory in bytes of size of int will be reserved and its address will be stored in px that can be further use, once function execution completes, this m/m will still exist in Heap until we free it using free() function.

hence answer is C

30 votes -- Manu Thakur (6k points)

4.7.11 Programming In C: GATE2002-1.17 top http://gateoverflow.in/822

Selected Answer

(A) Each function call starts a new activation record and since C allows nested function calls more than once activation record can exist between the current activation record and main.

(B) TRUE

(C) Since, C uses static scoping, the actual function calling sequence has no impact on the visibility of global variables. If a variable is not found in the current activation record, it is looked in global address space and this is independent of the calling sequence.

(D) All function calls- whether recursive or not uses the same stack for saving the activation record. There is no need for a different stack as for C compiler a recursive function call and a normal function call make no difference.

29 votes -- Arjun Suresh (294k points)

4.7.12 Programming In C: GATE2002-2.18 top

http://gateoverflow.in/848

Selected Answer

Answer: (B)

Ref: http://trevorjim.com/c-and-cplusplus-are-not-context-free/

8 votes

-- Rajarshi Sarkar (35k points)

4.7.13 Programming In C: GATE2002-2.8 top

http://gateoverflow.in/838

Selected Answer

answer is (b)

Formula to evaluate 2-d array's location is:----

loc(a[i][j]) = BA + [(i-lb1)*NC+(j-lb2))*c

where BA= Base Address

NC= no. of columns

C= memory size allocated to data type of array

a[lb1.....ub1] [lb2..... ub2]

here BA=0 , NC =100, c=1, a[0.....99][0......99] so lb1=0 , lb2=0

loc(a[40][50])= 0+ [(40-0)*100 + (50-0)]*1

= 0+[4000+50]*1 = 4050

16 votes

-- Kalpna Bhargav (3.2k points)

4.7.14 Programming In C: GATE2003-2 top

http://gateoverflow.in/893

Selected Answer

A is an array of pointers to int, and B is a 2-D array.

A[2] =
can take a pointer

A[2][3] =
can take an int

B[1] =
B[1] is the base address of array and it cannot be changed as array in C is a constant pointer.

B[2][3] =
can take an integer

So, A is the answer.

30 votes

-- Arjun Suresh (294k points)

4.7.15 Programming In C: GATE2003-89 top

http://gateoverflow.in/972

Selected Answer

```
main: x = 5; //Global x becomes 5
```

```
P: int x = *y + 2; //local x in P becomes 5+2 = 7
```

```
Q: z+=x; //local z in Q becomes 7 + 5 = 12
```

```
Q: print(z); //prints 12
```

```
P: *y = x - 1; //content of address of local variable y (same as global variable x) becomes 7 - 1 =
```

```
P: print(x); //prints local variable x in P = 7
```

```
main: print(x); //prints the global variable x = 6
```

15 votes -- Arjun Suresh (294k points)

4.7.16 Programming In C: GATE2004-33 top

http://gateoverflow.in/1030

Selected Answer

Here,

p[0] = s[length] = '\0'; //compiler puts a '\0' at the end of all string literals

Now, for any string function in C, it checks till the first '\0' to identify the end of string. So, since the first char is '\0', printf %s, will print empty string. If we use printf("%s", p+1); we will get option (c) with some possible garbage until some memory location happens to contain "\0". For the given code, answer is (D).

15 votes -- Arjun Suresh (294k points)

4.7.17 Programming In C: GATE2004-IT-58 top

http://gateoverflow.in/3701

Selected Answer

option C:

look at the initial value of `j`, if `j` starts with `0`, then double *for* loop will swap `M[i][j]` with `M[j][i]` and also `M[j][i]` and `M[i][j]` so the matrix **M** will remain unchanged, so to avoid this double swapping we need to initialize `j = i` and swap only upper triangular matrix with lower triangular matrix.

```
for(j = i; j < 4; ++j){

    // code for swapping M[i][j] with M[j][i
    t = M[i][j];
    M[i][j] = M[j][i];
    M[j][i] = t;
}
```

19 votes -- Vikrant Singh (13.4k points)

4.7.18 Programming In C: GATE2004-IT-59 top

http://gateoverflow.in/3702

Selected Answer

```
funcf(x) + funcg(x)
```

funcf or funcg can be executed first. Lets assume funcf is executed first. It calls funcg - so even if the order of call is revrsed, result will be same.

In first call of funcg, y becomes 11 and it returns 5+11 = 16.

In second call of funcg, y becomes 12 and it returns 5+12 = 17.

So, in main y is incremented by 16+17 = 33 to become 10+33 = 43. (Choice A)

In the second iteration y will be incremented by 18+19 = 37 to give 43+37 = 80.

17 votes -- Arjun Suresh (294k points)

4.7.19 Programming In C: GATE2004-IT-60 top http://gateoverflow.in/3703

Selected Answer

it should be option **D**

?1 is (c = getchar()) ! = '\n'
?2 is putchar(c);

10 votes -- sumit kumar singh dixit (2.3k points)

4.7.20 Programming In C: GATE2004-IT-61 top http://gateoverflow.in/3704

Selected Answer

first print A B

f1 is call by value the changes applciable only for local

from f1 U V is printed

back in main A B is printed

then in f2 V W is printed

hence answer is B

14 votes -- Sankaranarayanan P.N (11.2k points)

4.7.21 Programming In C: GATE2005-1, ISRO2017-55 top http://gateoverflow.in/1343

Selected Answer

1. A function that takes an integer pointer as argument and returns an integer -> int f (int *)
2. A function that takes an integer as argument and returns an integer pointer -> int * f (int)
3. A pointer to a function that takes an integer pointer as argument and returns an integer =>

```
int (*f) (int * );
```

So Answer is C

18 votes -- Akash (43.8k points)

4.7.22 Programming In C: GATE2005-32 top http://gateoverflow.in/1368

Selected Answer

ans is d)

When a function is called without being defined, C compiler assumes it to return "int" but here foo is returning "double" and hence the compiler will throw type mis-match error.

From C99 on ward, implicit declaration of functions is not even allowed.

20 votes -- Aditi Dan (5.3k points)

4.7.23 Programming In C: GATE2005-IT-53 top

http://gateoverflow.in/3814

Selected Answer

The answer is **D**

```
#include <stdio.h>

int main(void) {

return 0;
}

int anagram (char *a, char *b) {
/*
ASCII characters are of 7-bits
so we use count array to represent all the ASCII characters
(ranging 0-127)
*/
int count [128], j;

/*
so this loop will initialize count of all the ASCII characters to be
0 (zero)
*/
for (j = 0;  j < 128; j++) count[j] = 0;

j = 0;
/*
"a[j] && b[j]"  ensures that anagram returns 0 (false) in case both
strings have different length. Because different length strings cannot
be anagram of each other
*/

/*
Logic:

Below while loop increments ASCII equivalent position for its occurence
in array 'a'in count array; and decrements ASCII equivalent position
for its occurence in array 'b'in count array.

Example: a = "ISS" and b = "SIS"
ASCII equivalent of:
I - 73
S - 83

j = 0: Statement A will increment count[ASCII of 'I']==>count[73]
count[73] = 0 --> 1
Statement B will decrement count[ASCII of 'S'] ==> count[83]
count[83] = 0 --> -1 and will increment j j = 0 --> 1

j = 1: Statement A will increment count[ASCII of 'S'] ==> count[83]
count[83] = -1 --> 0
Statement B will decrement count[ASCII of 'I'] ==> count[73]
count[73] = 1 --> 0 and will increment j j = 1 --> 2

j = 2:  Statement A will increment count[ASCII of 'S'] ==> count[83]
count[83] = 0 --> 1
Statement B will decrement count[ASCII of 'S'] ==> count[83]
count[83] = 1 --> 0 and will increment j j = 2 --> 3

*** END OF LOOP ***

*/
while (a[j] && b[j]) {


A; //count [a[j]]++

/*
Note: j will be increment after count[]-- will execute
Resource: http://www.c4learn.com/c-programming/increment-operator-inside-printf
*/
B;  //count[b[j++]]--
}
```

```
/*
This loop checks that the number of occurences of the individual ASCII
characters is same or not.
If count[i] = 0 ---> same number of occurences for ASCII chracter i
---> return 1 (true)

if count[i]!= 0 ---> different number of occurences for ASCII chracter i
---> return 0 (false)
*/

for (j = 0; j < 128; j++) if (count [j]) return 0;
return 1;
}
```

19 votes -- Sohil Ladhani (183 points)

4.7.24 Programming In C: GATE2005-IT-58 top http://gateoverflow.in/3819

Selected Answer

Answer is (B)

For some 'i' if we find that difference of (A[j] - A[i] <S)we increment 'j' to make this difference wider so that it becomes equal to S .

If at times difference becomes greater than S we know that it wont reduce further for same 'i' and so we increment the 'i'.

We do it for each 'i' if not found in previous iteration. until i=n

18 votes -- Sandeep_Uniyal (7.3k points)

4.7.25 Programming In C: GATE2006-57 top http://gateoverflow.in/1835

Selected Answer

S1 is false.

S2 is true, depending on the argument passed it may generate segmentation fault.

S3 is false because implementation is having some problem. Let x=3 and I want to implement SWAP[x,x]. Now ans would be 0 but that must be x. Problem is because we are not checking whether both pointer are pointing the same address or different so S4 is true.

S5 is obviously false so Option(c) is right

27 votes -- Kalpna Bhargav (3.2k points)

4.7.26 Programming In C: GATE2006-IT-49 top http://gateoverflow.in/3592

Selected Answer

code :

```
#include <stdio.h>


struct test {
 int i;
 char *c;
}st[] = {5, "become", 4, "better", 6, "jungle", 8, "ancestor", 7, "brother"};


int main () {
 //printf("size = %d\n",sizeof(struct test) );
 struct test *p = st;
 p += 1;
 ++p->c;       // ++(p->c)
```

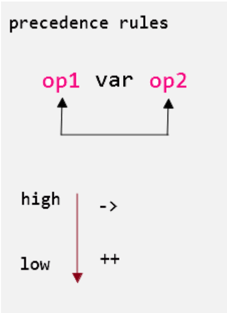
```
    printf("%s,", p++->c);    // (p++)->c
    printf("%c,", *++p->c);   // *(++(p->c))
    printf("%d,", p[0].i);
    printf("%s \n", p->c);
}
```

We will assume few things:

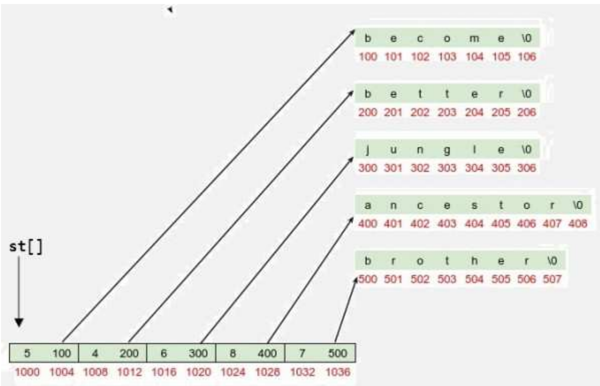
- Size of integer 4 Bytes.
- Size of a pointer 4 Bytes.

Neglecting any [alignment issues](#) with the storage of this structure we will have 8 Bytes per structure.

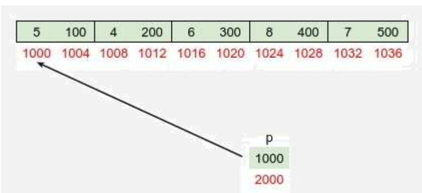
And one precedence rule we need to use:



Initial situation :

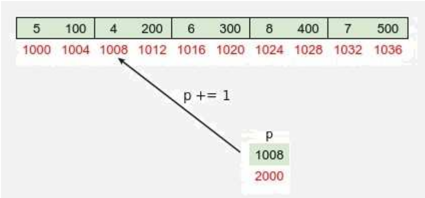


```
struct test *p = st;
```

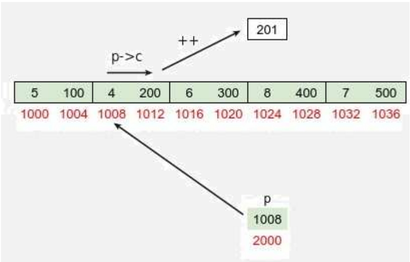


```
p += 1;
```

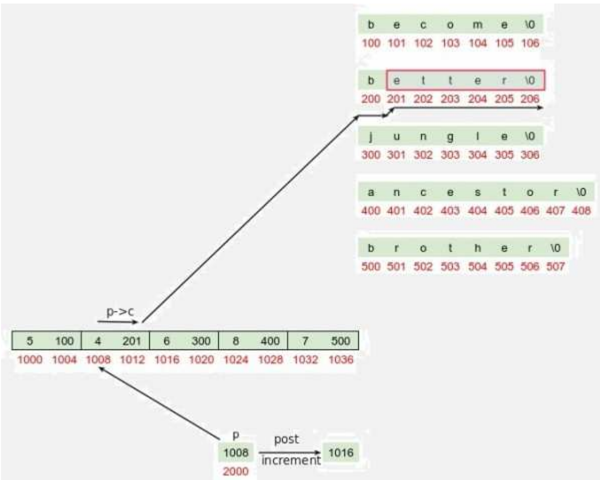
We know that if `ptr` is a pointer then, `ptr + x = ptr + x*sizeof(*ptr);`



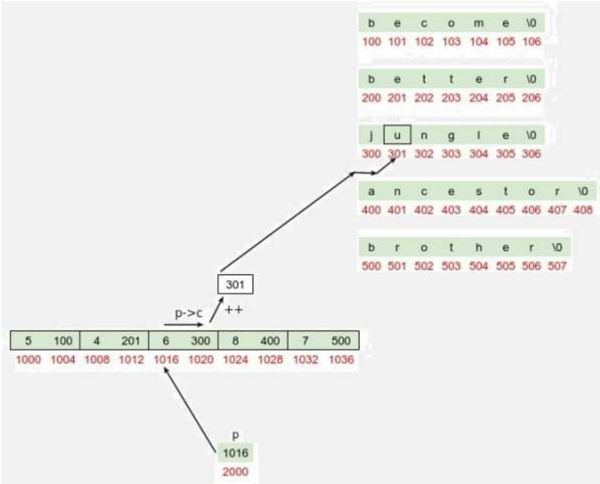
```
++p->c;
```



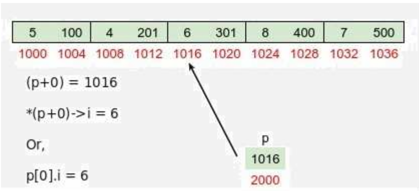
```
printf("%s,", p++->c);          // (p++)->c
```



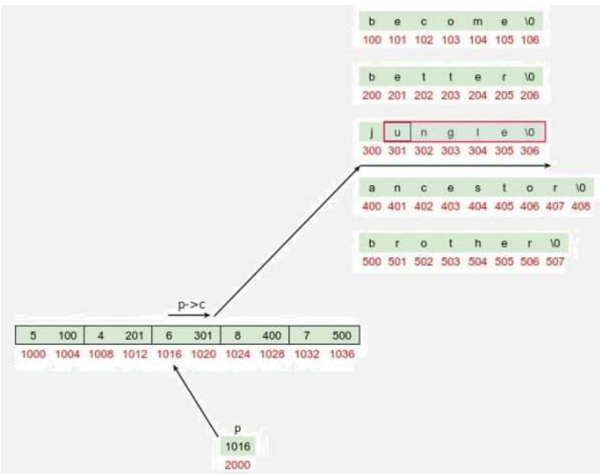
```
printf("%c,", *++p->c);      // *(++(p->c))
```



```
printf("%d,", p[0].i);
```



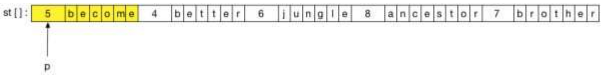
```
printf("%s \n", p->c);
```



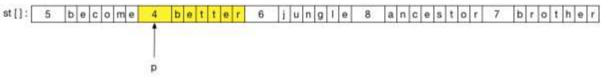
👍 25 votes -- Debashish Deka (51.4k points)

```
#include <stdio.h>
struct test {
                int i;
                char *c;
}st[] = {5, "become", 4, "better", 6, "jungle", 8, "ancestor", 7, "brother"};
main ()
{
```

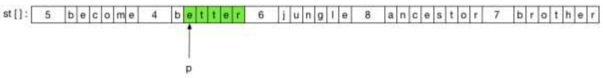
```
    struct test *p = st;
```



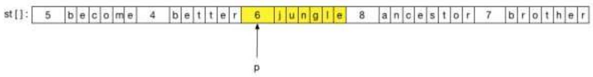

```
p += 1;
```



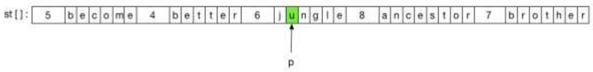

```
++p -> c;
printf("%s,", p++ -> c);
```



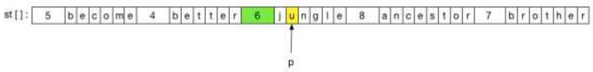
Prints value and increments the pointer. Pointing ti the next structure



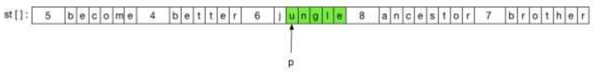

```
printf("%c,", *++p -> c); // *(++( p->c ))
```




```
printf("%d,", p[0].i); //Prints the integer value associated with struct pointed by p
```




```
printf("%s \n", p -> c); //Prints the character string pointed by p
```



PS : Thank you @monanshi for the explanation

30 votes -- Salman (1k points)

4.7.27 Programming In C: GATE2006-IT-50 top

http://gateoverflow.in/3593

Selected Answer

First of all the swap function just swaps the pointers inside the function and has no effect on the variables being passed.

Inside printab, a and b are added odd integers from 1-5, i.e., 1+3+5 = 9. So, in first call to printab, a = -3 + 9 = 6 and b = -6 + 9 = 3.

Static variables have one memory throughout program run (initialized during program start) and they keep their values across function calls. So, during second call to printab, a = 6 + 9 = 15, b = 3 + 9 = 12.

Hence (D) choice.

24 votes -- Arjun Suresh (294k points)

```
while (i <= 4
{
        if ((i++)%2 == 1) continue; // key point of program here if comdition true
then go to while loop directly
        a = a + i; // will process when i= even
        b = b + i; // will process when i= even
```

```
}

Inside printab, a and b are added odd integers from

for i= 1 a= -3 + 1 = -2  and b = -6+1= -5

for i= 3 a= -2 + 3 = 1  and b = -5+3= --2

for i= 5 a= 1 + 5 = 6  and b = -2 +5= 3

here printf(a,b) = 6,3

if static int i= 0; given in code then only old value of i is used.
since static int i and i= 0 is given so for next printab () i= 0 is taken.
 By looking 1st  printf(a,b) = 6,3

Ans is D

reffer for continue:https://www.codingunit.com/c-tutorial-for-loop-while-loop-break-and-continue
```

10 votes -- Prashant Singh (49.2k points)

4.7.28 Programming In C: GATE2006-IT-51 top

http://gateoverflow.in/3594

Selected Answer

a = {a1, a2, a3};

```
printf("%d,", a[0][2]);
```

a[0] is a1. So, this will print a1[2] = 8;

```
printf("%d,", *a[2]);
```

a[2] is a3. So, this will print *a3 = a3[0] = -12 ([] has greater precedence than *)

```
printf("%d,", *++a[0]);
```

a[0] which is a1 is incremented. a1 is a pointer to int (base address of an integer array) and so increment means adding sizeof(int) and hence a1 now points to the second element in the array. So, *++a[0] prints second element of a1 which is 7 and now a1 starts from 7.

```
printf("%d,", *(++a)[0]);
```

++a will increment a, which being an array of pointers (to int) will add sizeof (pointer) to a. So, a now contains {a2, a3} and a[0] will be a2 and *a2 will be the first element in a2 which is 23

```
printf("%d\n", a[-1][+1]);
```

a[-1] will subtract a size of pointer from the base address of a. Normally this results in invalid memory access, but since we have incremented a previously, a[-1] is valid and will point to a1. So, a[-1][+1] will be a1[1] which has the value 8. (a1 was incremented in 3rd printf and hence starts from 7 and not 6. +1 is same as 1, just given to create confusion)

39 votes -- Arjun Suresh (294k points)

4.7.29 Programming In C: GATE2007-IT-31 top

http://gateoverflow.in/3464

Selected Answer

Answer: C

I have tried to explain this question in a better way and the explanation is here...

i	A[i]	for-> if -----satisfied?	maxsum	sum
-	-	-	0	0
0	A[0]= 2	Yes (i == 0)	0	2
1	A[1]= -2	Yes (a[i] < 0)	2	0
2	A[2]= -1	Yes (a[i] < 0)	-- (for->if->if -----not satisfied)	0
3	A[3]= 3	No (else executed)	-- (for->if->if -----not satisfied)	3
4	A[4]= 4	No (else executed)	-- (for->if->if -----not satisfied)	7
5	A[5]= 2	Yes (a[i] < a[i - 1])	7	2

[End of for loop]

If (sum (i.e. 2) > maxsum(i.e. 7))   // No

maxsum = sum;   // Not Executed

printf will output maxsum = 7

14 votes -- MKT (191 points)

4.7.30 Programming In C: GATE2008-18 top http://gateoverflow.in/416

Selected Answer

Using option A : x=3, y=4, z=2

a=(3>4)? No

therefore don't evaluate the first part and check second part ((y>z)?y:z)

(4>2)? Yes

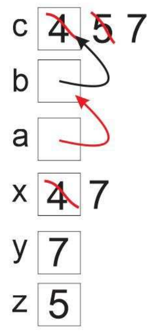
a= value of y =4

Answer is (A) x=3, y=4, z=2

12 votes -- Keith Kr (6.3k points)

4.7.31 Programming In C: GATE2008-60 top http://gateoverflow.in/483

Selected Answer



return x+y+z = return 7 + 7 + 5 = return 19

so **option B** = 19 is correct

16 votes -- Amar Vashishth (28.7k points)

Answer is **B.**

z = *ppz is a typo and it must be z = **ppz;

$**ppz+=1;$ modifies the value of c to 5. $\therefore$ z=5.
$**py+=2;$ modifies the value of c to 7. $\therefore$ y=7.
But x will be called as x=4, $\therefore$ x=7.
Answer: 7+7+5=19.

15 votes -- Sona Praneeth Akula (4k points)

4.7.32 Programming In C: GATE2008-IT-49 top

http://gateoverflow.in/3359

Selected Answer

char a[6] =

w	o	r	l	d	\0

a[0] 1 2 3 4 5

After the loop will execute first time,

a[0] = a[5]

a[0] =`\0`

Next two more iterations of the loop till i < j condition becomes false are not important for the output as the first position is '\0';

printf(‘’%s’’, a) , the string starting at address a prints the string starting with `\0` and it indicates the end of string ,so it will print null string.

so option (B)

18 votes -- Mitali (225 points)

4.7.33 Programming In C: GATE2008-IT-50 top

http://gateoverflow.in/3360

Selected Answer

Answer: C

Only

```
if (num1 > = num2) {swap3 (&num1, &num2);}
```

statement works, which in turn swaps num1 and num2.

13 votes -- Rajarshi Sarkar (35k points)

4.7.34 Programming In C: GATE2008-IT-51 top http://gateoverflow.in/3361

Selected Answer

Answer is (c) 3,2

First 2 variable integer type declared named i and j

Then **int type array** a[8] declared and initialized.

a[0] = 1 , a[1] = 2, a[2] = 3, a[3] = 4, a[4] = 5, a[5] = 6, a[6] = 7,a[7] = 8

Then for loop started

i=0 , i<3 (true)

a[0]=a[0]+1 = 1+1=2

i++(outside for loop) , i++(inside for loop);

i=2 ,i<3 (true)

a[2]=a[2]+1 = 3+1=4

i++, i++(outside for loop) ,

i=4, i<3 (false) **//Now come out of loop**

i-- ; (so i=3)

Now another for loop started where in loop integer type variable named i declared

Block Scope: A Block is a set of statements enclosed within left and right braces ({ and } respectively). Blocks may be nested in C (a block may contain other blocks inside it). A variable declared in a block is accessible in the block and all inner blocks of that block, but not accessible outside the block.

What if the inner block itself has one variable with the same name?
If an inner block declares a variable with the same name as the variable declared by the outer block, then the visibility of the outer block variable ends at the point of declaration by inner block.

So here inner block **int i** has the scope in this block only and outer block int i visibility is not allowed in that block

j=7 j>4(true)

int i = 7/2=3

a[3]=a[3]-1=4-1=3

j=6 j>4(true)

int i = 6/2=3

a[3]=a[3]-1=3-1=2

j=5 j>4(true)

int i = 5/2=2

a[2]=a[2]-1=4-1=3

j=4 j>4(false)

Now when the for loop ends its variable named **i** scope is also end and the outer block variable now visible. So in printf outer variable **i** is used.

so the output would be: 3,2

45 votes -- Kalpna Bhargav (3.2k points)

4.7.35 Programming In C: GATE2008-IT-52 top http://gateoverflow.in/3362

Selected Answer

The correct answer is option (B)

first integer type two variables declared i and j

then an integer type 2-d array a[2][3] is declared and initialized and 2-d array b[3][2] is created but not initialized. i.e

	address	value		address	value
a[0]0[]	2000	a	b[0][0]	3000	garbage value
a[0][1]	2001	b	b[0][1]	3001	garbage value
a[0][2]	2002	c	b[1][0]	3002	garbage value
a[1][0]	2003	d	b[1][1]	3003	garbage value
a[1][1]	2004	e	b[2][0]	3004	garbage value
a[1][2]	2005	f	b[2][1]	3005	garbage value

now the char type pointer is declared and the base address of array b is put in it. so p=3000

now the for loop is started where i is initialized to 0 ,so

```
i=0 : i<2 (true)
      j=0; j<3 (true)
         *(3000+2*0+0) =a [0][0]  =>  *(3000) = a
          j++
        j=1; j<3 (true)
         *(3000+2*1+0) =a [0][1]  =>  *(3002) = b
          j++
        j=2; j<3 (true)
         *(3000+2*2+0) =a [0][2]  =>  *(3004) = c
          j++
        j=3; j<3 (false)
   i++
i=1 : i<2 (true)
      j=0; j<3 (true)
         *(3000+2*0+1) =a [1][0]  =>  *(3001) = d
          j++
        j=1; j<3 (true)
         *(3000+2*1+1) =a [1][1]  =>  *(3003) = e
          j++
        j=2; j<3 (true)
         *(3000+2*2+1) =a [1][2]  =>  *(3005) = f
          j++
        j=3; j<3 (false)
   i++
```

now the values in array b is

b[0][0]	3000	a
b[0][1]	3001	d
b[1][0]	3002	b
b[1][1]	3003	e
b[2][0]	3004	c
b[2][1]	3005	f

hence the output will be (B) choice.

Note:

```
*(p + 2*j + i)
```

p + sizeofinner dimension * j + i, hence is same as p[j][i]. Hence with this statement we can identify that the code is transposing the matrix a and storing in b using pointer p.

24 votes -- Kalpna Bhargav (3.2k points)

4.7.36 Programming In C: GATE2010-11 top

http://gateoverflow.in/2184

Selected Answer

```
 p=q;    -- now p and q are pointing to same address i.e. address of j
 *p=2;   -- value of j will be updated to 2
hence answer is (D) 0 2
```

20 votes -- Manu Thakur (6k points)

4.7.37 Programming In C: GATE2011_22 top

http://gateoverflow.in/2124

Selected Answer

2011 is the answer.

In C, there is a rule that whatever character code be used by the compiler, codes of all alphabets and digits must be in order. So, if character code of 'A' is x, then for 'B' it must be x+1.

Now %s means printf takes and address and prints all bytes starting from that address as characters till any byte becomes the code for '\0'. Now, the passed value to printf here is
p + p[3] - p[1]

p is the starting address of array c. p[3] = 'E' and p[1] = 'A'. So, p[3] - p[1] = 4, and p + 4 will be pointing to the fourth position in the array c. So, printf starts printing from 2 and prints 2011.

(Here "GATE2011" is a string literal and by default a '\0' is added at the end of it by the compiler).

NB: In this question %s is not required.

```
printf(p + p[3] - p[1]);
```

Also gives the same result as first argument to printf is a character pointer and only if we want to pass more arguments we need to use a format string.

29 votes -- Arjun Suresh (294k points)

4.7.38 Programming In C: GATE2012-3 top

http://gateoverflow.in/35

Selected Answer

There is a `space` in between the `/` and `n`. (see-Q-no.-3)

```
case 'A' : printf ("Choice A\ n");
                            ^
```

So , output of the given program is

```
Choice A nChoice BNo Choice
```

Which includes

```
'n'
```

And there is no new line or spaces between outputs. Hence, there is no option matching.

http://stackoverflow.com/questions/33694700/im-missing-something

16 votes -- Arjun Suresh (294k points)

4.7.39 Programming In C: GATE2012-48 top http://gateoverflow.in/2176

Selected Answer

main
a=1
prtFun()
a=2
b=1
a= a + ++b = 2+2 = 4
b = 2
printf --> 4 2
back to main
a = a+1 --> 1+1 -->2 (local static a is taken)
prtFun()
a=4 // previous value in the function is retained bcos of static
b=1
a= a + ++b = 4+2 = 6
b = 2
printf --> 6 2
back to main
a = 2
b = 0 (initial value of global b. in prtFun local b is only updated)
printf --> 2 0

Answer: C

23 votes -- Sankaranarayanan P.N (11.2k points)

4.7.40 Programming In C: GATE2012-49 top http://gateoverflow.in/43314

Selected Answer

49
main
a=1
prtFun()
a=2
b=1
a= a + ++b = 2+2 = 4
b = 2
printf --> 4 2
back to main
a = a+1 --> 1+1 -->2
prtFun()
a=1 //previous a is lost
b=1

a= a + ++b = 2+2 = 4
b = 2
printf --> 4 2
back to main
a = 2
b = 0 (initial value of global b. in prtFun local b is only updated)
printf --> 2 0

Anwer: D

13 votes -- Sankaranarayanan P.N (11.2k points)

4.7.41 Programming In C: GATE2014-1-10 top http://gateoverflow.in/1770

Selected Answer

```
int i; //i is declared
int*pi = &i;  //pi is a pointer variable assigned the address of i
  scanf("%d",pi); //i is overwritten with the value we provided because pi is pointing to i earlier
  printf("%d\n", i+5) //it will print the value stored in i+5
```

input=3; **output**=8

Option **D** is answer.

16 votes -- Bhagirathi Nayak (13.3k points)

4.7.42 Programming In C: GATE2014-2-11 top http://gateoverflow.in/1965

Selected Answer

B)
In c, * and / have the same precedence and are left associative.

Evaluation of n*(n-1)*(n-2) might exceed the unsigned int range.
So a) and d) are eliminated.
n*(n-1) is always divisible by 2.(Gives an integer value). Where as it is not always divisible by 3.(You dont always get an integer..truncation possible, less accuracy)
c) eliminated.

In option b)
n*(n-1)/2 gives an integer value.
This integer value multiplied by (n-2) again gives an integer value.
Which when divided by 3 gives an integer value(Sets p correctly).

Reason : n*(n-1)*(n-2) is the multiplication of 3 consecutive numbers. which is divisible by 2 as well as 3.
Hence (n*(n-1)/2*(n-2)) is divisible by 3.

54 votes -- Srinath Jayachandran (3.7k points)

4.7.43 Programming In C: GATE2014-2-42 top http://gateoverflow.in/2008

Selected Answer

There is no updation for i and j in the function. so if we call function with j = 50 the recursive call will be continued infinitely. There is no terminating condition for recursion. hence anwer D

15 votes -- Sankaranarayanan P.N (11.2k points)

4.7.44 Programming In C: GATE2015-1_11 top http://gateoverflow.in/8185

Selected Answer

here f1 will not change any values bcz it is call by value but f2 is call by referance and it swaps values of b and c and changes are also reflected in main function...so 5-4-6= -5 hence answer is -5

19 votes -- target gate (239 points)

4.7.45 Programming In C: GATE2015-1_35 top http://gateoverflow.in/8283

Selected Answer

Address of x is 2000.

x being a 2 D array,

x + 3 = x + 3 * sizeof its inner dimension

= 2000 + 3 * 3 * 4 (as inner dimension is 3 integers of size 4)

= 2000 + 36 = 2036.

*(x+3) returns the value at address 2036. But since x is 2-D array, one * will just return the 1D array which is the starting address of it, which is 2036 only.

(x + 2) = 2000 + 2 * 3 * 4 = 2024
*(x + 2) + 3 = 2024 + 3 * 4 = 2036 (The * changes the data type from 2D to 1D and hence + 3 will add 3*4 and not 3 * 3 * 4)

So, A.

45 votes -- Arjun Suresh (294k points)

4.7.46 Programming In C: GATE2015-2_15 top http://gateoverflow.in/8086

Selected Answer

Ans D as priority of != is greater than that of && in C. The execution happens as

```
    if ((*a) && (*a != ' '))
```

So, the if breaks either when *a = 0 (not '0' but ASCII 0 or null character '\0'), or when *a =' '.

So, the recursive call goes like

'A' - 'B' - 'C' - 'D' -' ' (breaks) and then starts outputting

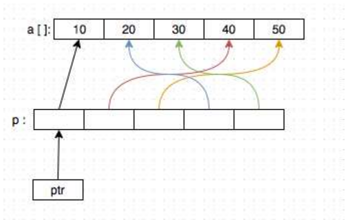
DCBA

19 votes -- Vikrant Singh (13.4k points)

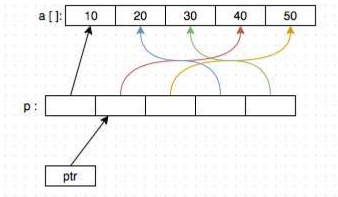
4.7.47 Programming In C: GATE2015-3_26 top http://gateoverflow.in/8478

Selected Answer

```
static int a[] = {10, 20, 30, 40, 50};
static int *p[] = {a, a+3, a+4, a+1, a+2};
int **ptr = p;
```




```
ptr++;
```



$$\text{ptr-p} = \frac{\text{address of ptr} - \text{address of p}}{\text{sizeof}(*\text{ptr}))} = 1$$

$$**\text{ptr} = \text{p}[2] = *(\text{a}+3) = 40$$

```
printf("%d%d", ptr-p, **ptr);  // 140
```

25 votes -- Salman (1k points)

4.7.48 Programming In C: GATE2015-3_30 top http://gateoverflow.in/8486

Selected Answer

option C. Only S1 and S2 are correct because Y have same element in both code and in code1

```
Y[i] += X[0][i];
```

this row major order (In C, arrays are stored in row-major order) which gives address of each element in sequential order(1,2,3,....,n) means we cross single element each time to move next shows contiguous in main memory but in code2 for

```
Y[i] += X[i][0];
```

```
we are crossing n element (row crossing with n element )to move next
```

17 votes -- Anoop Sonkar (4.9k points)

4.7.49 Programming In C: GATE2015-3_48 top http://gateoverflow.in/8557

Selected Answer

```
j=2 * 3 / 4 + 2.0 / 5 + 8 / 5;
```

j = (((2 * 3) / 4) + (2.0 / 5)) + (8/5); //As associativity of +,* and / are from left to right and + has less precedence than * and /.

j = ((6/4) + 0.4) + 1); //2.0 is double value and hence 5 is implicitly typecast to double and we get 0.4. But 8 and 5 are integers and hence 8/5 gives 1 and not 1.6

j = (1 + 0.4) + 1; // 6/4 also gives 1 as both are integers

j = 1.4 + 1; //1 + 0.4 gives 1.4 as 1 will be implicitly typecast to 1.4

j = 2.4; // since j is integer when we assign 2.4 to it, it will be implicitly typecast to int.

So, j = 2;

k -= --j;

This makes j = 1 and k = -1.

The variables j and k have values 1 and -1 respectively before the for loop. Inside the for loop, the variable i is initialized to 0 and the loop runs from 0 to 4.

$i = 0$, $k = -1$, $i + k = -1$, default case is executed, printf count = 1

$i = 1$, $k = -1$, $i + k = 0$, default case is executed, printf count = 2

$i = 2$, $k = -1$, $i + k = 1$, case 2, case 3 and default case is executed, printf count = 5

$i = 3$, $k = -1$, $i + k = 2$, case 2, case 3 and default case is executed, printf count = 8

$i = 4$, $k = -1$, $i + k = 3$, case 3 and default case is executed, printf count = 10

$i = 5$, loop exits and the control returns to main

Answer: 10

37 votes -- Shyam Singh (1.5k points)

4.7.50 Programming In C: GATE2015-3_54 top http://gateoverflow.in/8563

Selected Answer

The variable x is initialized to 1. First and only call to $f1()$ returns 26. First call to $f2()$ returns 51. First and only call to $f3()$ returns 100. Second call to $f2()$ returns 52 (The value of local static variable x in $f2()$ retains its previous value 51 and is incremented by 1).

$$x = 1 + 26 + 51 + 100 + 52 = 230$$

Answer: 230

29 votes -- Shyam Singh (1.5k points)

4.7.51 Programming In C: GATE2015-3_7 top http://gateoverflow.in/8401

Selected Answer

```
p = s1 + 2;
```

p now points to the third element in s1.

```
*p = '0';
```

The third element in s1 is made 0. So, 1234 becomes 1204. C choice.

27 votes -- Arjun Suresh (294k points)

4.7.52 Programming In C: GATE2017-1-13 top http://gateoverflow.in/118293

Selected Answer

Ans is **D.**

Option A: In C++ we need to do typecasting. C does automatic implicit typecasting.

See the screenshot for C & C++ compilers below. C compiler is working fine but C++ compiler is giving error.

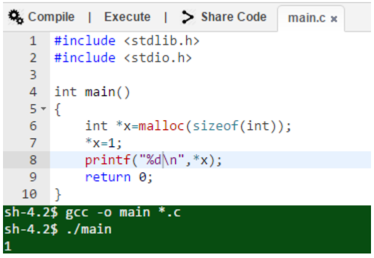
Option B: Null means address 0. if (a == 0) if (0 == a) There is no difference.

Option C: Do it step by step, always x is pointing to a valid memory location. Dangling Pointer means if it points to a memory location which is deleted(freed). So no dangling pointer. http://www.geeksforgeeks.org/dangling-void-null-wild-pointers/

Option D: x will loss the previous address it was pointing to. So it will result in memory leak**.** http://www.geeksforgeeks.org/what-is-memory-leak-how-can-we-avoid/

Proof for Option A:

C Compiler:



6 votes -- Ahwan Mishra (5.3k points)

4.7.53 Programming In C: GATE2017-1-36 top http://gateoverflow.in/118319

Selected Answer

Answer should be C

Consider foo

Initially val=3

foo(val--)

is equivalent to

1.......foo(val)

2..... val=val-1

so

1..........foo(3)

2...... val=2

foo(3) calls foo(3) which in turn calls foo(3) this goes on

so here we can see that foo(3) is called infinite number of times which causes memory overflow and abrupt termination

and 1 more thing to observe is infinite loop is not there since the val is decrement in the first iteration.

consider bar

Here we can see the val is not decrement in the loop

so

1. bar(3) will call bar(2)
2. bar(2) will call bar(1)
3. bar(1) will call bar(0)--------------- Here bar(0) return 0
4. bar(1) will call bar(0)
5. bar(1) will call bar(0)

This will go on so here there is a problem of infinite loop but not abrupt termination since it doesnt cause memory overflow

8 votes -- (points)

4.7.54 Programming In C: GATE2017-1-53 top

http://gateoverflow.in/118473

Selected Answer

(strlen(s)- strlen(t)) = 3-5 =-2

But in C, when we do operation with two unsigned integers, result is also unsigned. (strlen returns size_t which is unsigned in most systems). So, this result "-2" is treated as unsigned and its value is INT_MAX - 2 (not sure about all systems, but at least on systems using 2's complement representation). Now, the comparison is between this large number and another unsigned number c which is 0. So, the comparison return TRUE here.

Even if 'c' is declared as "int", while doing an operation with an unsigned int, it gets promoted to unsigned int and we get the same result.

Hence (strlen(s)- strlen(t)) >0 will return 1 on execution thus the conditional operator will return the true statement which is strlen(abc) =3.

Ans should be 3.

17 votes -- Arnabi (6.4k points)

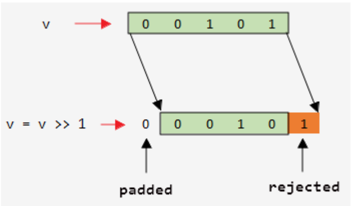
4.7.55 Programming In C: GATE2017-1-55 top

http://gateoverflow.in/118442

Selected Answer

```
// inside total()
```

```
while(v) {
        count += v&1;   \\ check the lowest bit of v
        v >>= 1;        \\ or v = v >> 1 : right shift the bit pattern of v
}
```

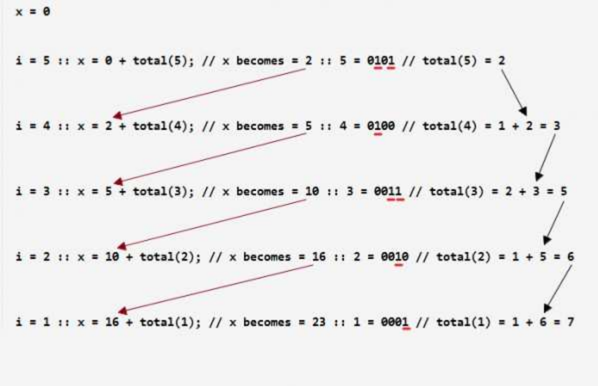


This piece of code will count the no of set bits in **v.**

In the `main` function, `i` values goes from 5 to 1, So there will be 5 calls to `total()`.

Each call to `total(i)` counts the no of set bits in `i`. But the **count** is a `static` variable,

So, `total(i)` = Total no of set bits in all $i \leq 5$.



$$\mathrm{x} = \sum_{i=1}^{5} [\,\mathrm{total}\,(i)] = 2 + 3 + 5 + 6 + 7 = \mathbf{23}$$

10 votes -- Debashish Deka (51.4k points)

4.7.56 Programming In C: GATE2017-2-14 top

http://gateoverflow.in/118245

Selected Answer

at first in loop we are giving x=0 then ptr is pointing to X.

so *ptr=0

now we copying the value of ptr to y ,so Y=0

```
x=0;      //value of x = 0
   ptr= &x;      // ptr points to variable x
   y= *ptr;      // Y contain value pointed by ptr i.e. x= 0;
```

now value of ptr is changed to 1. so the location of X itself got modified

```
*ptr=1;
```

as it is pointing to x so x will also be changed to 1

so 1,0 will be the value

C is correct answer here

13 votes -- Aboveallplayer (18.5k points)

4.7.57 Programming In C: GATE2017-2-2 top

http://gateoverflow.in/118171

Selected Answer

static char var = Avariable **located in data section** of memory

m= malloc(10); m= null; **Here Free(m) missing : So** .A lost memory which cannot be freed

Char * Ptr[10]; Sequence of **10 memory location** to store addresses

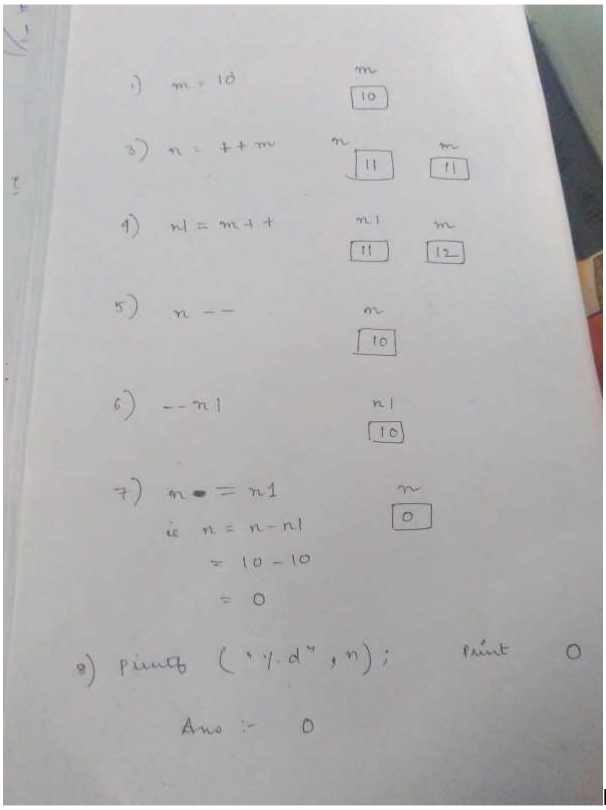
register int var1; = request to alloacte a **CPU register** to store data

Answer is A

8 votes -- Prashant Singh (49.2k points)

4.7.58 Programming In C: GATE2017-2-54 top http://gateoverflow.in/118272

Selected Answer



hence answer is 0.

6 votes -- Arnabi (6.4k points)

4.7.59 Programming In C: GATE2017-2-55 top http://gateoverflow.in/118335

Selected Answer

```
char c[]="GATECSIT2017";
char *p=c;
printf("%d",strlen(c+2[p]-6[p]-1));
```

2[p] = *(2+p) = p[2]
6[p] = *(6+p) = p[6]
c + 2[p] - 6[p] -1 = c + 'T' - 'I' - 1 = c + 11 - 1 = c + 10 (In any character coding all alphabet letters are assigned consecutive int values as per C)

printf will print 2 which is the length of "17".

20 votes -- Arjun Suresh (294k points)

4.8 Programming Paradigms(2) top

4.8.1 Programming Paradigms: GATE2004-1 top http://gateoverflow.in/998

The goal of structured programming is to

A. have well indented programs
B. be able to infer the flow of control from the compiled code

C. be able to infer the flow of control from the program text
D. avoid the use of GOTO statements

gate2004 programming easy programming-paradigms

Answer

4.8.2 Programming Paradigms: GATE2004-90 top

http://gateoverflow.in/1084

Choose the best matching between the programming styles in Group 1 and their characteristics in Group 2.

Group 1	Group 2
P. Functional Q. Logic R. Object-oriented S. Imperative	1. Common-based, procedural 2. Imperative, abstract data types 3. Side-effect free, declarative, expression evaluations 4. Declarative, clausal representation, theorem proving

A. P-2 Q-3 R-4 S-1
B. P-4 Q-3 R-2 S-1
C. P-3 Q-4 R-1 S-2
D. P-3 Q-4 R-2 S-1

gate2004 programming normal programming-paradigms

Answer

Answers: Programming Paradigms

4.8.1 Programming Paradigms: GATE2004-1 top

http://gateoverflow.in/998

Selected Answer

Answer is (c) The goal of structured programming is to able to infer the flow of control from the program text . It means user can execute the code according to his requirement. C and Pascal are good example of structured programming. In structured programming control passes one instruction to another instruction in sequential manner.

Avoiding the use of GOTO statements is not the goal of structured programming, it (avoiding the use of GOTO) is one of the requirements for a program to be structured.

14 votes -- Kalpna Bhargav (3.2k points)

4.8.2 Programming Paradigms: GATE2004-90 top

http://gateoverflow.in/1084

Selected Answer

D should be the answer.

7 votes -- sumit kumar singh dixit (2.3k points)

4.9 Pseudo Code(1) top

4.9.1 Pseudo Code: GATE2008-61 top

http://gateoverflow.in/484

Choose the correct option to fill ?1 and ?2 so that the program below prints an input string in reverse order. Assume that the input string is terminated by a new line character.

```
void reverse(void)
{
    int c;
    if(?1) reverse();
    ?2
```

```
}
main()
{
    printf("Enter text");
    printf("\n");
    reverse();
    printf("\n");
}
```

A. ?1 is (getchar() != ’\n’)

   ?2 is getchar(c);

B. ?1 is ((c = getchar()) !=’\n’)

   ?2 is getchar(c);

C. ?1 is (c != ’\n’)

   ?2 is putchar(c);

D. ?1 is ((c = getchar()) != ’\n’)

   ?2 is putchar(c);

gate2008 programming normal pseudo-code

Answer

Answers: Pseudo Code

4.9.1 Pseudo Code: GATE2008-61 top

http://gateoverflow.in/484

Selected Answer

Here we are using the '=' operator which has less priority than '!=' operator. So (c=getchar()) has to be in brackets and after reversing the string we use function putchar(c) for printing the character So option (d) is the right answer

13 votes -- Kalpna Bhargav (3.2k points)

4.10 Recursion(17) top

4.10.1 Recursion: GATE 2016-1-35 top

http://gateoverflow.in/39730

What will be the output of the following C program?

```
void count (int n) {
    static int d=1;

    printf ("%d",n);
    printf ("%d",d);
    d++;
    if (n>1) count (n-1);
    printf ("%d",d);


}

void main(){
    count (3);
}
```

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

gate2016-1 programming-in-c recursion normal

Answer

4.10.2 Recursion: GATE1991_01,x top http://gateoverflow.in/507

Consider the following recursive definition of fib:

```
fib(n) :=  if n = 0 then 1
           else if n = 1 then 1
           else fib(n-1) + fib(n-2)
```

The number of times fib is called (including the first call) for evaluation of $fib(7)$ is___________.

gate1991 programming recursion normal

Answer

4.10.3 Recursion: GATE1994_21 top http://gateoverflow.in/2517

Consider the following recursive function:

```
function fib (n:integer);integer;
begin
if (n=0) or (n=1) then fib := 1
else fib := fib(n-1) + fib(n-2)
end;
```

The above function is run on a computer with a stack of 64 bytes. Assuming that only return address and parameter are passed on the stack, and that an integer value and an address takes 2 bytes each, estimate the maximum value of n for which the stack will not overflow. Give reasons for your answer.

gate1994 programming recursion normal

Answer

4.10.4 Recursion: GATE1995-2.9 top http://gateoverflow.in/2621

A language with string manipulation facilities uses the following operations

```
head(s): first character of a string
tail(s): all but exclude the first character of a string
```

```
concat(s1, s2): s1s2
```

For the string "acbc" what will be the output of

```
concat(head(s), head(tail(tail(s))))
```

A. ac
B. bc
C. ab
D. cc

gate1995 algorithms normal recursion

Answer

4.10.5 Recursion: GATE2000-16 top http://gateoverflow.in/687

A recursive program to compute Fibonacci numbers is shown below. Assume you are also given an array f [0......m] with all elements initialized to 0

```
fib(n) {
    if (n > M) error ();
    if (n == 0) return 1;
    if (n == 1)return 1;
    if (▭)________________________(1)
        return ▭__________________(2)
    t = fib(n - 1) + fib(n - 2);
    ▭_____________________________(3)
    return t;
```

```
}
```

A. Fill in the boxes with expressions/statement to make fib() store and reuse computed Fibonacci values. Write the box number and the corresponding contents in your answer book.
B. What is the time complexity of the resulting program when computing fib(n)?

gate2000 algorithms normal descriptive recursion

Answer

4.10.6 Recursion: GATE2001-13 top

http://gateoverflow.in/754

Consider the following C program:

```
void abc(char*s)
{
    if(s[0]=='\0')return;
    abc(s+1);
    abc(s+1);
    printf("%c",s[0]);
}

main()
{
    abc("123");
}
```

a. What will be the output of the program?
b. If abc(s) is called with a null-terminated string s of length n characters (not counting the null ('\0') character), how many characters will be printed by abc(s)?

gate2001 programming recursion normal descriptive

Answer

4.10.7 Recursion: GATE2002-11 top

http://gateoverflow.in/864

The following recursive function in C is a solution to the Towers of Hanoi problem.

```
void move(int n, char A, char B, char C)  {
    if (......................) {
        move (.............................);
        printf("Move disk %d from pole %c to pole %c\n", n, A,C);
        move (.....................);
    }
}
```

Fill in the dotted parts of the solution.

gate2002 programming recursion normal descriptive

Answer

4.10.8 Recursion: GATE2004-31, ISRO2008-40 top

http://gateoverflow.in/1028

Consider the following C function:

```
int f(int n)
{
    static int i = 1;
    if(n >= 5) return n;
    n = n+i;
    i++;
    return f(n);
}
```

The value returned by $f(1)$ is

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

gate2004 programming programming-in-c recursion easy isro2008

Answer

4.10.9 Recursion: GATE2005-81a top http://gateoverflow.in/1403

```
double foo(int n)
{
    int i;
    double sum;
    if(n == 0)
    {
        return 1.0;
    }
    else
    {
        sum = 0.0;
        for(i = 0; i < n; i++)
        {
            sum += foo(i);
        }
        return sum;
    }

}
```

The space complexity of the above code is?

A. $O(1)$
B. $O(n)$
C. $O(n!)$
D. n^n

gate2005 programming recursion normal

Answer

4.10.10 Recursion: GATE2005-81b top http://gateoverflow.in/82146

```
double foo(int n)
{
    int i;
    double sum;
    if(n == 0)
    {
        return 1.0;
    }
    else
    {
        sum = 0.0;
        for(i = 0; i < n; i++)
        {
            sum += foo(i);
        }
        return sum;
    }

}
```

Suppose we modify the above function *foo()* and stores the value of *foo(i) 0 <= i < n*, as and when they are computed. With this modification the time complexity for function *foo()* is significantly reduced. The space complexity of the modified function would be:

A. $O(1)$
B. $O(n)$
C. $O(n^2)$
D. $n!$

gate2005 programming recursion normal

Answer

4.10.11 Recursion: GATE2007-42 top http://gateoverflow.in/1240

Consider the following C function:

```
int f(int n)
{
    static int r = 0;
```

```
    if (n <= 0) return1;
    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

gatee2007 programming recursion normal

Answer

4.10.12 Recursion: GATE2007-IT-27 top http://gateoverflow.in/3460

The function f is defined as follows:

```
int f (int n) {
    if (n <= 1) return 1;
    else if (n % 2  ==  0) return f(n/2);
    else return f(3n - 1);
}
```

Assuming that arbitrarily large integers can be passed as a parameter to the function, consider the following statements.

i. The function f terminates for finitely many different values of n ≥ 1.
ii. The function f terminates for infinitely many different values of n ≥ 1.
iii. The function f does not terminate for finitely many different values of n ≥ 1.
iv. The function f does not terminate for infinitely many different values of n ≥ 1.

Which one of the following options is true of the above?

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

gate2007-it programming recursion normal

Answer

4.10.13 Recursion: GATE2014-2-40 top http://gateoverflow.in/2000

Consider the following function

```
double f(double x){
    if( abs(x*x - 3) < 0.01)
        return x;
    else
        return f(x/2 + 1.5/x);
}
```

Give a value q (to 2 decimals) such that $f(q)$ will return q:_____.

gate2014-2 programming recursion numerical-answers normal

Answer

4.10.14 Recursion: GATE2017-1-35 top http://gateoverflow.in/118317

Consider the following two functions.

```
void fun1(int n) {
    if(n == 0) return;
    printf("%d", n);
    fun2(n - 2);
    printf("%d", n);
}
```

```
void fun2(int n) {
    if(n == 0) return;
    printf("%d", n);
    fun1(++n);
    printf("%d", n);
}
```

The output printed when $\text{fun1}(5)$ is called is

(A) 53423122233445 (B) 53423120112233

(C) 53423122132435 (D) 53423120213243

gate2017-1 programming normal tricky recursion

Answer

4.10.15 Recursion: ISICAL MTech 2014 CS top http://gateoverflow.in/27885

How many asterisks $(*)$ in terms of k will be printed by the following C function, when called as $\text{count}(m)$ where $m = 3^k$? Justify your answer.

Assume that 4 bytes are used to store an integer in C and k is such that 3^k can be stored in 4 bytes.

```
void count(int n){
    printf("*");

    if(n>1){
        count(n/3);
        count(n/3);
        count(n/3);
    }
}
```

programming-in-c recursion isi-2014

Answer

4.10.16 Recursion: TIFR2010-B-31 top http://gateoverflow.in/26484

Consider the following computation rules. **Parallel-outermost rule**: Replace all the outermost occurrences of F (i.e., all occurrences of F which do not occur as arguments of other F's) simultaneously. **Parallel - innermost rule**: Replace all the innermost occurrences of F (i.e.,all occurrences of F with all arguments free of F's) simultaneously. Now consider the evaluations of the recursive program over the integers.

```
F(x, y) <== if x = 0 then 0 else
            [ F(x + 1, F(x, y)) * F(x - 1, F(x, y))]
```

where the multiplication functions * is extended as follows:

```
0 * w & w * 0 are 0
a * w & w * a are w (for any non-zero integer a)
w * w is w
```

We say that F(x, y) = w when the evaluation of F(x, y) does not terminate. Computing F(1, 0) using the parallel - innermost and parallel - outermost rule yields

A. w and 0 respectively
B. 0 and 0 respectively
C. w and w respectively
D. w and 1 respectively
E. none of the above

tifr2010 programming recursion

Answer

4.10.17 Recursion: TIFR2011-B-38 top http://gateoverflow.in/20923

Consider the class of recursive and iterative programs. Which of the following is false?

A. Recursive programs are more powerful than iterative programs.
B. For every iterative program there is an equivalent recursive program.

C. Recursive programs require dynamic memory management.
D. Recursive programs do not terminate sometimes.
E. Iterative programs and recursive programs are equally expressive.

tifr2011 programming-in-c recursion

Answer

Answers: Recursion

4.10.1 Recursion: GATE 2016-1-35 top

http://gateoverflow.in/39730

Selected Answer

Here **d** is Static, so the value of **d** will persists between the function calls.

1. count(3) will print the value of n and d and increments d and callcount(2) = prints **3 1**.
2. count(2) will print the value of n and d and increments d and callcount(1) = prints **2 2**.
3. count(1) will print the value of n and d and increments d => prints**1 3**.

Now it will return and prints the final incremented value of**d** which is **4**, 3 times.
So, option A is correct = 3 1 2 2 1 3 4 4 4

23 votes -- Monanshi Jain (8.5k points)

4.10.2 Recursion: GATE1991_01,x top

http://gateoverflow.in/507

Selected Answer

The recurrence relation for the no. of calls is

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

$T(0) = T(1) = 0$ (for fib(0) and fib(1), there are no recursive calls).

$T(2) = 2$

$T(3) = 4$

$T(4) = 8$

$T(5) = 14$

$T(6) = 24$

$T(7) = 40$.

Counting the initial call we get 40 + 1 = 41.

14 votes -- Arjun Suresh (294k points)

4.10.3 Recursion: GATE1994_21 top

http://gateoverflow.in/2517

Selected Answer

Size of an activation record $= 2 + 2 = 4$ bytes.

So, no. of possible activation records which can be live at a time $= 64/4 = 16$.

So, we can have 16 function calls live at a time (recursion depth = 16), meaning the maximum value for n without stack overflow is 16 (calls from 1-16). For $n = 17$, stack will overflow.

This is different from the total no. of recursive calls which will be as follows:

n	No. of calls
1	1
2	3
3	5
4	9
5	15
6	25

17 votes -- Arjun Suresh (294k points)

4.10.4 Recursion: GATE1995-2.9 top http://gateoverflow.in/2621

Selected Answer

C.

concat(a,head(tail(tail(acbc))))

concat(a,head(tail(cbc)))

concat(a,head(bc))

concat(a,b)

ab.

11 votes -- Gate Keeda (19.1k points)

4.10.5 Recursion: GATE2000-16 top http://gateoverflow.in/687

Selected Answer

Array f is used to store the fib() values calculated in order to save repeated calls. Since n = 0 and n = 1 are special cases we can store fib(2) to f[0], fib(3) to f[1] and so on. The missing code completed would be:

```
if (f[n - 2] != 0){
    return f[n-2];
}
t = fib(n-1) + fib(n-2);
f[n-2] = t;
return t;
```

In this code, fib(i) will do a recursion only once as once fib(i) is calculated it is stored in array. So, the time complexity for fib(n) would be $\Theta(n)$.

PS: We can also store fib(n) in f(n), the above code just saves 2 elements' space in the array.

13 votes -- Arjun Suresh (294k points)

4.10.6 Recursion: GATE2001-13 top http://gateoverflow.in/754

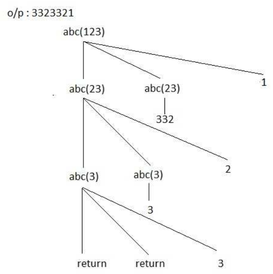
Selected Answer

answer a) 3323321

answer b) $2^n - 1$

Q. a) O/p :

3 3 2 3 3 2 1



b)

T(n) = 2 * T(n-1) +1 ; n>0

= 0 ; n=0 [Since for length zero string no character will be printed]

After solving it by substitution,

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

$= 2 \times (2 \times T(n-2) + 1) + 1$

$= 2^2 \times T(n-2) + 2 + 1$

$= 2^2 \times (2 * T(n-3) + 1) + 2 + 1$

$= 2^3 \times T(n-3) + 2^2 + 2 + 1$

Finally it will expand like

$= 2^n \times T(n-n) + 2^{n-1} + 2^{n-2} + \text{-----} \text{---} + 2^2 + 2 + 1$

$= 2^n \times T(0) + 2^{n-1} + 2^{n-2} + \text{----------} + 2^2 + 2 + 1$

$= 1 \times (2^n - 1) / (2 - 1)$

$= 2^n - 1$

16 votes -- jayendra (8.1k points)

4.10.7 Recursion: GATE2002-11 top http://gateoverflow.in/864

Selected Answer

```
void move(int n, char A, char B, char C) {
    if (n > 0) {
        move (n-1, A, C, B);
        printf("Move disk %d from pole %c to pole %c\n", n, A, C);
        move (n-1, B, A, C);
    }
}
```

11 votes -- sonam vyas (13.2k points)

4.10.8 Recursion: GATE2004-31, ISRO2008-40 top http://gateoverflow.in/1028

Selected Answer

answer is 7.as,

f(1):n=2,i=2

f(2):n=4,i=3

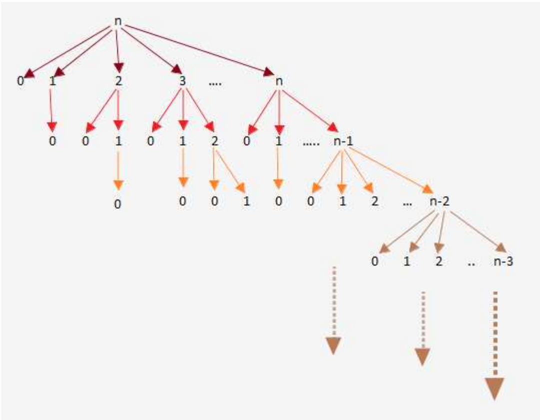
f(4):n=7,i=4

f(7):print(n)===>>> 7<ans>

13 votes -- sumit kumar singh dixit (2.3k points)

4.10.9 Recursion: GATE2005-81a top http://gateoverflow.in/1403

Selected Answer



A. The code here is storing only local variables. So, the space complexity will be the recursion depth- maximum happening for the last iteration of the for loop- foo(n-1) - foo(n-2) - .... - foo(0) all live giving space complexity O(n).

B. To store the n values we need space complexity O(n). So, the space complexity won't change and will be O(n).

24 votes -- Arjun Suresh (294k points)

4.10.10 Recursion: GATE2005-81b top

http://gateoverflow.in/82146

Selected Answer

The modification being proposed is tabulation method of Dynamic Programming.

So let we have an auxillary array which stores the value of foo(i) once it is computed and can be used at later stage .So foo(i) is not called again , instead lookup from the table takes place. It would be something like :

```
#include <stdio.h>
#define max 1000
int foo[max];
foo(int n) {
 if(foo[n] == -1) //compute it and store at foo[n] and return
 else // return foo[n] directly
}
int main(void) {
 //initialize all elements of foo[max] to -1
 return 0;
}
```

Using this approach , we need an auxillary array of size n to store `foo(i)` where i ranges from 0 to $n-1$.

So space complexity of this method = $O(n)$ And function `foo(n)` computes 2^{n-1}

Hence the correct option should be B)

13 votes -- HABIB MOHAMMAD KHAN (76.8k points)

4.10.11 Recursion: GATE2007-42 top

http://gateoverflow.in/1240

Selected Answer

The answer is D.

f(5) = 18.

f(3) + 2 = 16 + 2 = 18

f(2) + 5 = 11 + 5 = 16

f(1) + 5 = 6 + 5 = 11

f(0) + 5 = 1+5 = 6

Consider from last to first. Since it is recursive function.

12 votes -- Gate Keeda (19.1k points)

4.10.12 Recursion: GATE2007-IT-27 top http://gateoverflow.in/3460

Selected Answer

The function terminates for all powers of 2 (which is infinite), hence (i) is false and (ii) is TRUE.

Let n = 5.
Now, recursive calls will go like 5 - 14 - 7 - 20 - 10 - 5 -

And this goes into infinite recursion. And if we multiply 5 with any power of 2, also result will be infinite recursion. Since, there are infinite powers of 2 possible, there are infinite recursions possible (even considering this case only). So, (iv) is TRUE and (iii) is false.

So, correct answer is (D)

24 votes -- Arjun Suresh (294k points)

4.10.13 Recursion: GATE2014-2-40 top http://gateoverflow.in/2000

Selected Answer

(We can directly go to the "if" part to get one answer, but we need to solve "else" part too to get all possible answers which though is not asked in question)

Solving the else part:

$\frac{x}{2} + \frac{3}{2x} = \frac{x^2+3}{2x}$

So, the new value of x will be $\frac{x^2+3}{2x}$ and we need it equal to x.

$\frac{x^2+3}{2x} = x \implies x^2 + 3 = 2x^2 \implies x^2 = 3 \implies x = 1.732$

Now solving the if part.

```
abs(x*x - 3) < 0.01
```

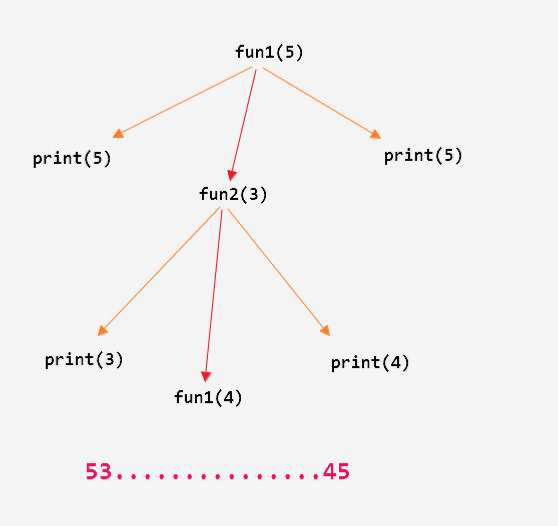
So, $x^2 - 3 < 0.01 \text{ and } -\left(x^2 - 3\right) < 0.01 \implies x^2 < 3.01 \text{ and } x^2 > 2.99 \implies x < 1.735 \text{ and } x > 1.729$

Corrected to 2 decimal places answer should be 1.73 or 1.74.

24 votes -- Arjun Suresh (294k points)

4.10.14 Recursion: GATE2017-1-35 top http://gateoverflow.in/118317

Selected Answer



- Unroll recursion up to a point where we can distinguish the given options and choose the correct one!
- Options **B** and **D** are eliminated.
- **A** is the answer.

8 votes -- Debashish Deka (51.4k points)

4.10.15 Recursion: ISICAL MTech 2014 CS top http://gateoverflow.in/27885

Selected Answer

I tried it for 3^5 ,

in every call it print "*" one time

and each function call 3 functions for n/3 recursively till get 1 at each node . it becomes a ternary tree

call for 3^5 -----------------------1 = 3^0

call for 3^4 -----------------------3 = 3^1

call for 3^3 ---------------------9 = 3^2

call for 3^2 --------------------27 =3^3

call for 3^1 ---------------------81 = 3^4

call for 3^0 --------------------243 = 3^5

so one "*" print at each function call

no of "*" printed = $3^0 + 3^1 + 3^2 + \ldots\ldots 3^k$ [that makes GP series]

= $1 * (1 - 3^{k+1})/(1-3)$

= $(3^{k+1} - 1)/2$

[Note : I am not sure about it , feel free for edit]

4 votes -- Praveen Saini (53.6k points)

4.10.16 Recursion: TIFR2010-B-31 top http://gateoverflow.in/26484

Answer is A) w and 0

If we solve using parallel innermost rule

F(1,0) = F(2,F(1,0)) * F(0,F(1,0))

=F(2, F(2,F(1,0)) * F(0,F(1,0))) * F(0, F(2,F(1,0)) * F(0,F(1,0)))

Since computation of F(1,0) goes on

we assign F(1,0) to w

So F(1,0)= w

Using parallel outermost rule

F(1,0)= F(2,F(1,0)) * F(0,F(1,0))

= F(2,F(1,0)) * 0

= 0

2 votes -- zambus (273 points)

4.10.17 Recursion: TIFR2011-B-38 top http://gateoverflow.in/20923

Selected Answer

answer = **option E**

Computable function: those which can be incorporated in a program using for/while loops.

Total Function: Defined for all possible inputs

Well Defined: if its definition assigns it a unique value.

It was a belief in early 1900s that every Computable function was also Primitively Recursive. But the discovery of Ackermann function provided a counter to it.

The class of primitive recursive functions is a small subclass of the class of recursive functions. This means that there are some functions which are Well-Defined Total Functions and are Computable BUT **Not** primitively recursive; eg. Ackermann function.

This makes all options from option A to option D as True.

But **option E** as
FALSE. As iterative programs are equivalent to only Primitively Recursive class.

9 votes -- Amar Vashishth (28.7k points)

4.11 Runtime Environments(9) top

4.11.1 Runtime Environments: CMI2014-A-06 top http://gateoverflow.in/46972

Suppose we are working with a programming language that supports automatic garbage collection. This means that:

A. Uninitialized variables are assigned null values.
B. Unreferenced dynamically allocated memory is added back to free space.
C. Unreachable $if - then - else$ branches are pruned.
D. Expressions where array indices exceed array bounds are flagged.

cmi2014 programming runtime-environments

Answer

4.11.2 Runtime Environments: GATE1990-2-v top http://gateoverflow.in/83980

Match the pairs in the following questions:

(a) Pointer data type (p) Type conversion

(b) Activation record	(q) Dynamic data structure
(c) Repeat-until	(r) Recursion
(d) Coercion	(s) Nondeterministic loop

gate1990 match-the-following programming runtime-environments recursion

Answer

4.11.3 Runtime Environments: GATE1991_09b top http://gateoverflow.in/43603

For the following code, indicate the output if

a. static scope rules
b. dynamic scope rules

are used

```
var a,b : integer;

procedure P;
    a := 5;
    b := 10;
end {P};

procedure Q;
    var a, b : integer;
    P;
end {Q};

begin
    a := 1;
    b := 2;
    Q;
    Write ('a = ', a, 'b = ', b);
end
```

gate1991 runtime-environments normal

Answer

4.11.4 Runtime Environments: GATE1997-1.10 top http://gateoverflow.in/2226

Heap allocation is required for languages.

A. that support recursion
B. that support dynamic data structure
C. that use dynamic scope rules
D. None of the above

gate1997 programming easy runtime-environments

Answer

4.11.5 Runtime Environments: GATE2003-73 top http://gateoverflow.in/960

The following program fragment is written in a programming language that allows global variables and does not allow nested declarations of functions.

```
global int i=100, j=5;
void P(x) {
 int i=10;
    print(x+10);
    i=200;
    j=20;
    print (x);
}
main() {P(i+j);}
```

If the programming language uses static scoping and call by need parameter passing mechanism, the values printed by the above program are

A. 115, 220
B. 25, 220
C. 25, 15
D. 115, 105

gate2003 programming normal runtime-environments

Answer

4.11.6 Runtime Environments: GATE2003-74 top

http://gateoverflow.in/43575

The following program fragment is written in a programming language that allows global variables and does not allow nested declarations of functions.

```
global int i=100, j=5;
void P(x) {
 int i=10;
    print(x+10);
    i=200;
    j=20;
    print (x);
}
main() {P(i+j);}
```

If the programming language uses dynamic scoping and call by name parameter passing mechanism, the values printed by the above program are

A. 115, 220
B. 25, 220
C. 25, 15
D. 115, 105

gate2003 programming runtime-environments normal

Answer

4.11.7 Runtime Environments: GATE2008-54 top

http://gateoverflow.in/477

Which of the following are true?

I. A programming language which does not permit global variables of any kind and has no nesting of procedures/functions, but permits recursion can be implemented with static storage allocation

II. Multi-level access link (or display) arrangement is needed to arrange activation records only if the programming language being implemented has nesting of procedures/functions

III. Recursion in programming languages cannot be implemented with dynamic storage allocation

IV. Nesting procedures/functions and recursion require a dynamic heap allocation scheme and cannot be implemented with a stack-based allocation scheme for activation records

V. Programming languages which permit a function to return a function as its result cannot be implemented with a stack-based storage allocation scheme for activation records

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

gate2008 programming difficult runtime-environments

Answer

4.11.8 Runtime Environments: GATE2010-14 top

http://gateoverflow.in/2187

Which languages necessarily need heap allocation in the runtime environment?

A. Those that support recursion.
B. Those that use dynamic scoping.
C. Those that allow dynamic data structure.

D. Those that use global variables.

gate2010 programming easy runtime-environments

Answer

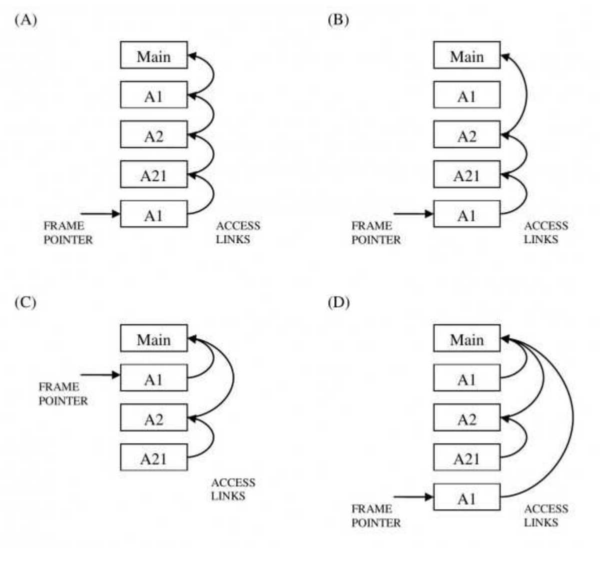
4.11.9 Runtime Environments: GATE2012_36 top http://gateoverflow.in/1758

Consider the program given below, in a block-structured pseudo-language with lexical scoping and nesting of procedures permitted.

```
Program main;
  Var ...

  Procedure A1;
    Var ...
    Call A2;
  End A1

  Procedure A2;
    Var ...

    Procedure A21;
      Var ...
      Call A1;
    End A21

    Call A21;
  End A2

  Call A1;
End main.
```

Consider the calling chain: Main -> A1 -> A2 -> A21 -> A1

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



gate2012 programming runtime-environments normal

Answer

Answers: Runtime Environments

4.11.1 Runtime Environments: CMI2014-A-06 top http://gateoverflow.in/46972

Selected Answer

Garbage collection also known as automatic memory management, is the automatic recycling of dynamically allocated memory.
Garbage collection is performed by a garbage collector which **recycles memory** that it can prove will **never be used**

again.
Systems and languages which use garbage collection can be described as garbage-collected.

As long as address space is available in the memory, the runtime continues to allocate space for new objects. However, memory is not infinite. Eventually the garbage collector must perform a collection in order to free some memory. The garbage collector's optimizing engine determines the best time to perform a collection, based upon the allocations being made.

So option B is Correct.

Unreferenced dynamically allocated memory is added back to free space.

3 votes -- Manoj Kumar (37.5k points)

4.11.2 Runtime Environments: GATE1990-2-v top http://gateoverflow.in/83980

Selected Answer

A. Pointer data type	Q. Dynamic Data Structure
B. Activation method	R. Recursion
C. Repeat until	S. Nondeterministic loop
D. Coercion	P. Type Conversion

11 votes -- Digvijay (47k points)

4.11.3 Runtime Environments: GATE1991_09b top http://gateoverflow.in/43603

Selected Answer

In static scoping, if a variable is not found (variable definition - memory allocation) in the local scope, it is looked upon in global scope. In dynamic scoping, if a variable is not found in local scope, it is looked upon in the function which called the current executing one.

1. a = 5, b = 10. main is using global variables. P is also using global variables.

2. a = 1, b = 2. main is using global variables. P is using the local variables defined in Q.

(The modification in Q, happens to the variables in P but in main we use the global variables)

8 votes -- Arjun Suresh (294k points)

4.11.4 Runtime Environments: GATE1997-1.10 top http://gateoverflow.in/2226

Selected Answer

memory is taken from heap for dynamic allocation

so option b is correct

10 votes -- Sankaranarayanan P.N (11.2k points)

4.11.5 Runtime Environments: GATE2003-73 top http://gateoverflow.in/960

Selected Answer

Call-by-name : Is a lazy evaluation (expression passed as an argument evaluated only when used) technique.

Call-by-need: Is a version of call-by-name but when an expression is evaluated during first use, is saved and reused for all later uses.

```
global int i=100, j=5;
```

```
//memory created for i and j variable and 100 and 5 stored in them respectively (1)

void P(x) {// p(i+j) (3)
    int i=10;
    // new variable created i with value 10 store in it. (4)

    print(x+10);
    // print(x+10); = print(i+j +10);= 10 + 5 +10 = 25
    // here need of i+j so i+j replced by 15 evrywhere .(5)

    i=200;
    // local i value changed to 200.

    j=20;
    //global j value changed to 20 as there is no local j.
    //if dynamic scoping used, then the scope of j comes from scope of j in main as
    //main called this function. Here, main also uses global j and hence no change.

    print (x);
    // print (x);= print (i+j); = printf(15) = 15 (7)
    // due to call by need. If call by name used answer is 200+20 = 220
}
main() {P(i+j);}
// 1st function call since it is call by need no evaluation done
//here i and j value refer to global values(2)
```

Ans is C

Refer : *https://www.cs.bgu.ac.il/~comp161/wiki.files/ps9.pdf*

14 votes -- Prashant Singh (49.2k points)

4.11.6 Runtime Environments: GATE2003-74 top http://gateoverflow.in/43575

Selected Answer

global int i=100, j=5; **// memory created for i and j variable and 100 and 5 store in it respectively (1)**
void P(x) { **// p(i+j) (3)**
  int i=10; **// new variable created i with value 10 store in it. (4)**
  print(x+10); **// print(x+10); = print(i+j +10);= 10 +5 +10 = 25 (5)**
  i=200; **// local i and global j value changed to 200 and 20 respectively (6)**
  j=20;
  print (x); **// print (x);= print (i +j); = 200 +20 = 220 (7)**
}
main() {P(i+j);} **// 1st function call since it is call by name dont calculate value just send i+j : here i and j value reffer to global values(2)**

Ans is B

Reffer: http://stackoverflow.com/questions/838079/what-is-pass-by-name-and-how-does-it-work-exactly

12 votes -- Prashant Singh (49.2k points)

4.11.7 Runtime Environments: GATE2008-54 top http://gateoverflow.in/477

Selected Answer

I. False. Recursion cannot be implemented using static allocation.
II. True. Yes, we do need multi level access link in case of nested functions. Each level to traverse ARB of same level of nesting.
III. False. Recursion can only be implemented using dynamic memory allocation.
IV. False. Recursion is done using memory in stack (ARBs in stack), not in heap.
V. True. Yes, they cannot, once a function returns its activation record is no longer valid, so we cannot return a function as a result.

So, option A is correct.

6 votes -- Monanshi Jain (8.5k points)

Answer is A.

I. Recursion can never be implemented with Static Storage Allocation.

II, Is TRUE.

III. Recursion can be implemented with Dynamic Storage Allocation but not with Static Storage Allocation.

IV. Can be done with Stack based allocation scheme.

V. Is TRUE as with a stack based allocation once a function returns its activation record is no longer valid- so we cannot return a function as a result.

13 votes -- Gate Keeda (19.1k points)

4.11.8 Runtime Environments: GATE2010-14 top

http://gateoverflow.in/2187

Selected Answer

Those that allow dynamic data structure.

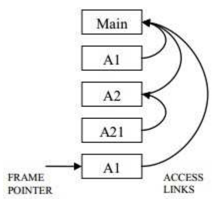
malloc etc uses memory from heap area

16 votes -- Sankaranarayanan P.N (11.2k points)

4.11.9 Runtime Environments: GATE2012_36 top

http://gateoverflow.in/1758

Selected Answer



Since, Activation records are created at procedure entry time and destroyed at procedure exit time.
therefore here Calling sequence is given as ,
Main->A1->A2->A21->A1
now A1 and A2 are defined under Main...So A1,A2 Access link are pointed to main
A21 is Defined under A2 hence its Access link will point to A2

26 votes -- Kalpish Singhal (2.1k points)

4.12 Type Checking(1) top

4.12.1 Type Checking: GATE2003-24 top

http://gateoverflow.in/914

Which of the following statements is FALSE?

A. In statically typed languages, each variable in a program has a fixed type
B. In un-typed languages, values do not have any types
C. In dynamically typed languages, variables have no types
D. In all statically typed languages, each variable in a program is associated with values of only a single type during the execution of the program

gate2003 programming normal type-checking

Answer

Answers: Type Checking

4.12.1 Type Checking: GATE2003-24 top http://gateoverflow.in/914

Selected Answer

Answer is C. In dynamically typed languages variables do have type- just that it is inferred during runtime.

8 votes -- Arjun Suresh (294k points)

5 Theory of Computation (269) top

5.1 Closure Property(9) top

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

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

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

gate1989 easy theory-of-computation closure-property

Answer

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

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

(i) The union of two recursive languages is recursive.

(ii) The language $\{O^n \mid n \text{ is a prime}\}$ is not regular.

(iii) Regular languages are closed under infinite union.

gate1992 theory-of-computation normal closure-property

Answer

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

Which of the following is true?

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

gate2002 theory-of-computation easy closure-property

Answer

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

Let L be a context-free language and M a regular language. Then the language L ∩ M is

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

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

Answer

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

Which of the following statements is/are **FALSE**?

1. For every non-deterministic Turing machine, there exists an equivalent deterministic Turing machine.
2. Turing recognizable languages are closed under union and complementation.
3. Turing decidable languages are closed under intersection and complementation.
4. Turing recognizable languages are closed under union and intersection.

(A) 1 and 4 only (B) 1 and 3 only (C) 2 only (D) 3 only

gate2013 theory-of-computation normal closure-property

Answer

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

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

I. $\bar{L_3} \cup L_4$ is recursively enumerable.

II. $\bar{L_2} \cup L_3$ is recursive.

III. $L_1^* \cap L_2$ is context-free.

IV. $L_1 \cup \bar{L_2}$ is context-free.

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

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

Answer

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

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

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

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

gate2017-2 theory-of-computation closure-property

Answer

5.1.8 Closure Property: TIFR2013-B-11 top http://gateoverflow.in/25772

Which of the following statements is FALSE?

a. The intersection of a context free language with a regular language is context free.
b. The intersection of two regular languages is regular.
c. The intersection of two context free languages is context free
d. The intersection of a context free language and the complement of a regular language is context free.
e. The intersection of a regular language and the complement of a regular language is regular.

tifr2013 theory-of-computation closure-property

Answer

5.1.9 Closure Property: TIFR2014-B-14 top http://gateoverflow.in/27321

Which the following is FALSE?

a. Complement of a recursive language is recursive.
b. A language recognized by a non-deterministic Turing machine can also be recognized by a deterministic Turing machine.

c. Complement of a context free language can be recognized by a Turing machine.
d. If a language and its complement are both recursively enumerable then it is recursive.
e. Complement of a non-recursive language can never be recognized by any Turing machine.

tifr2014 theory-of-computation closure-property

Answer

Answers: Closure Property

5.1.1 Closure Property: GATE1989-3-ii top

http://gateoverflow.in/87117

Selected Answer

Regular language is closed under **Union , Intersection, Concatenation, Complementation.**

CFL is closed under **Union Concatenation but not under Intersection or Complementation**

So Both closed under Union Concatenation.

9 votes -- Prashant Singh (49.2k points)

5.1.2 Closure Property: GATE1992-16 top

http://gateoverflow.in/595

Selected Answer

(i) True. Recursive languages are closed under union.

(ii) True. The language is Turing Machine acceptable.

(iii) False. Regular languages are closed under finite union.

6 votes -- Rajarshi Sarkar (35k points)

5.1.3 Closure Property: GATE2002-2.14 top

http://gateoverflow.in/844

Selected Answer

Complement of recursive language is always recursive

8 votes -- Bhagirathi Nayak (13.3k points)

5.1.4 Closure Property: GATE2006-IT-32 top

http://gateoverflow.in/3571

Selected Answer

Let $\Sigma=\{a,b\}$
Let L1 = Σ^* be a regular language
Let L2 = $\{ww^R \mid w \in (a+b)^*\}$ be a context free language.
L1∩L2 = $\{ww^R \mid w \in (a+b)^*\}$ which is clearly context free language and not DCFL or Regular
Hence the answer is option D

11 votes -- Mari Ganesh Kumar (2.2k points)

5.1.5 Closure Property: GATE2013-17 top

http://gateoverflow.in/1439

Selected Answer

Recursive enumerable languages are not closed under complement . while recursive languages are.

both Recursive and Recursive enumerable languages are closed under intersection, union, and kleene star.

http://gatecse.in/wiki/Closure_Property_of_Language_Families

Non-Deterministic TM is equivalent to DTM

only 2 is false. Option C is correct.

Note: Turing decidable language mean Recursive language and Turing recognizable language mean recursive enumerable language.

16 votes -- Praveen Saini (53.6k points)

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

Selected Answer

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

L_3 is recursive, so
$\overline{L_3}$ is also recursive (closed under complement),

So,
$\overline{L_3}$ is recursive enumerable.

L_4 is recursive enumerable,

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

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

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

L_3 is recursive.

so
$\overline{L_2} \cup L_3$ is also recursive (closed under union).

III.
$L_1^* \cap L_2$

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

L_2 is Context-free

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

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

L_1 is regular.

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

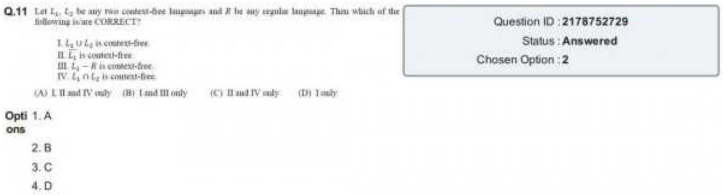
so,
$L_1 \cup \overline{L_2}$ may or may not be Context-free.

Here answer is D

32 votes -- Praveen Saini (53.6k points)

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

Selected Answer


Q.11 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

Question ID : 2178752729
Status : Answered
Chosen Option : 2

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

this is correct Q,

intersection of two CFL are not closed operation, and CFL also not closed under complimentation,
CFL-reg we can write like this CFL $CFL \cap \overline{regular}$ so regular language closed under complimentation and intersection of CFL with regular is always CFL.

4 votes -- 2018 (5.2k points)

5.1.8 Closure Property: TIFR2013-B-11 top http://gateoverflow.in/25772

Selected Answer

Context language are not closed under intersection so option C

7 votes -- Umang Raman (15.2k points)

5.1.9 Closure Property: TIFR2014-B-14 top http://gateoverflow.in/27321

Selected Answer

A) True. For a recursive language, we have a TM which says for any string "w", "yes" if it belongs to the language and "no" if it does not. For the complement of a recursive language we just have to reverses 'yes' and 'no' conditions and this is possible with a slight modification to the original TM. So, the new language also recursive

B)True. Non-determinism does not add any recognizing power to a Turing machine though it can affect the time complexity in solving a problem.

C)True. Complement of CFL is recursive. and recursive language is recognized by Turing machine.So, complement of language can be recognized by TM

D)True. If a language is r.e., we have a TM which says "yes" whenever a given string belongs to L. Similarly, if its complement is r.e., we have a TM which says "yes", whenever a string does not belong to the language. So, combining both we can always say "yes" if a string belongs to the language and "no" if a string does not belong to L => L is recursive.

E)False.

Non-recursive Language means:- a) **RE** or b) **Non RE**

Now ***Non RE complement*** may be ***RE*** which **Can be recognized by TM**...so ***option E is false***.

Example:-> L={<M,w>| M is a TM and it does not halt on string w}. //Non RE (complement of halting problem)

Now L^c={<M,w>| M is a TM and it halts on string w}//RE but not Recursive //recognized by TM (halting problem)

So answer is (E)

6 votes -- srestha (58.4k points)

5.2 Context Free Language(31) top

5.2.1 Context Free Language: GATE 2016-1-16 top http://gateoverflow.in/39640

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

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

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

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

Answer

5.2.2 Context Free Language: GATE 2016-1-42 top http://gateoverflow.in/39705

Consider the following context-free grammars;

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

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

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

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

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

Answer

5.2.3 Context Free Language: GATE 2016-2-43 top http://gateoverflow.in/39605

Consider the following languages:

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

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

Which one of the following is TRUE?

A. Both L_1 and L_2 are context-free.
B. L_1 is context-free while L_2 is not context-free.
C. L_2 is context-free while L_1 is not context-free.
D. Neither L_1 nor L_2 is context-free.

gate2016-2 theory-of-computation context-free-language normal

Answer

5.2.4 Context Free Language: GATE1987-1-xii top http://gateoverflow.in/80291

A context-free grammar is ambiguous if

A. The grammar contains useless non-terminals.
B. It produces more than one parse tree for some sentence.
C. Some production has two non terminals side by side on the right-hand side.
D. None of the above.

gate1987 theory-of-computation context-free-language ambiguous

Answer

5.2.5 Context Free Language: GATE1987-2k top http://gateoverflow.in/80599

State whether the following statements are TRUE or FALSE:

The intersection of two CFL's is also a CFL.

gate1987 theory-of-computation context-free-language

Answer

5.2.6 Context Free Language: GATE1992_02,xix top http://gateoverflow.in/572

02. Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

(xix) Context-free languages are

a. closed under union
b. closed under complementation
c. closed under intersection
d. closed under Kleene closure

gate1992 context-free-language theory-of-computation normal

Answer

5.2.7 Context Free Language: GATE1992_02,xviii top http://gateoverflow.in/576

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

If G is a context free grammar and w is a string of length l in $L(G)$, how long is a derivation of w in G, if G is in Chomsky normal form?

(a). $2l$

(b). $2l+1$

(c). $2l-1$

(d). l

gate1992 theory-of-computation context-free-language easy

Answer

5.2.8 Context Free Language: GATE1995-2.20 top http://gateoverflow.in/2632

Which of the following definitions below generate the same language as L, where $L = \{x^n y^n \text{ such that } n \geq 1\}$?

I. $E \rightarrow xEy \mid xy$

II. $xy \mid (x^+ xyy^+)$

III. $x^+ y^+$

A. I only

B. I and II

C. II and III

D. II only

gate1995 theory-of-computation easy context-free-language

Answer

5.2.9 Context Free Language: GATE1996_2.8 top http://gateoverflow.in/2737

If L_1 and L_2 are context free languages and R a regular set, one of the languages below is not necessarily a context free language. Which one?

A. $L_1 . L_2$

B. $L_1 \cap L_2$

C. $L_1 \cap R$

D. $L_1 \cup L_2$

gate1996 theory-of-computation context-free-language easy

Answer

5.2.10 Context Free Language: GATE1996_2.9 top http://gateoverflow.in/2738

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 $L = \{w \mid w \text{ is nonempty and has an equal number of 0's and 1's}\}$

Then $\text{init}(L)$ is

A. the set of all binary strings with unequal number of 0's and 1's

B. the set of all binary strings including null string

C. the set of all binary strings with exactly one more 0 than the number of 1's or one more 1 than the number of 0's

D. None of the above

gate1996 theory-of-computation context-free-language normal

Answer

5.2.11 Context Free Language: GATE1999_1.5 top http://gateoverflow.in/1459

Context-free languages are closed under:

A. Union, intersection

B. Union, Kleene closure

C. Intersection, complement

D. Complement, Kleene closure

gate1999 theory-of-computation context-free-language easy

Answer

5.2.12 Context Free Language: GATE1999_7 top http://gateoverflow.in/1506

Show that the language

$$L = \{xcx \mid x \in \{0,1\}^* \text{ and } c \text{ is a terminal symbol}\}$$

is not context free. c is not 0 or 1.

gate1999 theory-of-computation context-free-language normal

Answer

5.2.13 Context Free Language: GATE2000-7 top http://gateoverflow.in/678

a. Construct as minimal finite state machine that accepts the language, over {0,1}, of all strings that contain neither the sub string 00 nor the sub string 11.
b. Consider the grammar

```
S →          aSAb
S →             ∊
A →            bA
A →             ∊
```

where S, A are non-terminal symbols with S being the start symbol; a, b are terminal symbols and ∊ is the empty string. This grammar generates strings of the form a^ib^j for some i, j ≥ 0, where i and j satisfy some condition. What is the condition on the values of i and j?

gate2000 theory-of-computation descriptive regular-languages context-free-language

Answer

5.2.14 Context Free Language: GATE2001-1.5 top http://gateoverflow.in/698

Which of the following statements is true?

A. If a language is context free it can always be accepted by a deterministic push-down automaton
B. The union of two context free languages is context free
C. The intersection of two contest free languages is a context free
D. The complement of a context free language is a context free

gate2001 theory-of-computation context-free-language easy

Answer

5.2.15 Context Free Language: GATE2003-51 top http://gateoverflow.in/940

Let $G = (\{S\}, \{a, b\}, R, S)$ be a context free grammar where the rule set R is $S \to aSb \mid SS \mid \epsilon$

Which of the following statements is true?

A. G is not ambiguous
B. There exist $x, y \in L(G)$ such that $xy \notin L(G)$
C. There is a deterministic pushdown automaton that accepts L(G)
D. We can find a deterministic finite state automaton that accepts L(G)

gate2003 theory-of-computation context-free-language normal

Answer

5.2.16 Context Free Language: GATE2005-57 top http://gateoverflow.in/1380

Consider the languages:

- $L_1 = \{ww^R \mid w \in \{0, 1\}^*\}$
- $L_2 = \{w\#w^R \mid w \in \{0, 1\}^*\}$, where $\#$ is a special symbol
- $L_3 = \{ww \mid w \in \{0, 1\}^*\}$

Which one of the following is TRUE?

A. L_1 is a deterministic CFL

B. L_2 is a deterministic CFL

C. L_3 is a CFL, but not a deterministic CFL

D. L_3 is a deterministic CFL

gate2005 theory-of-computation context-free-language easy

Answer

5.2.17 Context Free Language: GATE2006-19 top

http://gateoverflow.in/980

Let

$L_1 = \{0^{n+m}1^n0^m \mid n,m \geq 0\}$,

$L_2 = \{0^{n+m}1^{n+m}0^m \mid n,m \geq 0\}$ and

$L_3 = \{0^{n+m}1^{n+m}0^{n+m} \mid n,m \geq 0\}$.

Which of these languages are NOT context free?

A. L_1 only
B. L_3 only
C. L_1 and L_2
D. L_2 and L_3

gate2006 theory-of-computation context-free-language normal

Answer

5.2.18 Context Free Language: GATE2006-IT-34 top

http://gateoverflow.in/3573

In the context-free grammar below, S is the start symbol, a and b are terminals, and ϵ denotes the empty string.

S → aSAb | ϵ
A → bA | ϵ

The grammar generates the language

A. ((a + b)* b)
B. $(a^mb^n \mid m \leq n\}$
C. $(a^mb^n \mid m = n)$
D. a* b*

gate2006-it theory-of-computation context-free-language normal

Answer

5.2.19 Context Free Language: GATE2006-IT-4 top

http://gateoverflow.in/3543

In the context-free grammar below, S is the start symbol, a and b are terminals, and ϵ denotes the empty string

S → aSa | bSb | a | b | ϵ

Which of the following strings is NOT generated by the grammar?

A. aaaa
B. baba
C. abba
D. babaaabab

gate2006-it theory-of-computation context-free-language easy

Answer

5.2.20 Context Free Language: GATE2007-IT-46 top

http://gateoverflow.in/3481

The two grammars given below generate a language over the alphabet {x, y, z}

G1 : S → x | z | x S | z S | y B
B → y | z | y B | z B
G2 : S → y | z | y S | z S | x B
B → y | y S

Which one of the following choices describes the properties satisfied by the strings in these languages?

A. G1 : No y appears before any x
G2 : Every x is followed by at least one y
B. G1 : No y appears before any x
G2 : No x appears before any y

C. G1 : No y appears after any x
   G2 : Every x is followed by at least one y
D. G1 : No y appears after any x
   G2 : Every y is followed by at least one x

gate2007-it theory-of-computation normal context-free-language

Answer

5.2.21 Context Free Language: GATE2007-IT-48 top http://gateoverflow.in/3490

Consider the grammar given below

S → x B | y A
A → x | x S | y A A
B → y | y S | x B B

Consider the following strings.

i. xxyyx
ii. xxyyxy
iii. xyxy
iv. yxxy
v. yxx
vi. xyx

Which of the above strings are generated by the grammar ?

A. i, ii and iii
B. ii, v and vi
C. ii, iii and iv
D. i, iii and iv

gate2007-it theory-of-computation context-free-language normal

Answer

5.2.22 Context Free Language: GATE2007-IT-49 top http://gateoverflow.in/3491

Consider the following grammars. Names representing terminals have been specified in capital letters.

G1 : stmnt → WHILE (expr) stmnt
stmnt → OTHER
expr → ID

G2 : stmnt → WHILE (expr) stmnt
stmnt → OTHER
expr → expr + expr
expr → expr * expr
expr → ID

Which one of the following statements is true?

A. G_1 is context-free but not regular and G_2 is regular
B. G_2 is context-free but not regular and G_1 is regular
C. Both G_1 and G_2 are regular
D. Both G_1 and G_2 are context-free but neither of them is regular

gate2007-it theory-of-computation context-free-language normal

Answer

5.2.23 Context Free Language: GATE2008-IT-34 top http://gateoverflow.in/3344

Consider a CFG with the following productions.

$$S \rightarrow AA \mid B$$
$$A \rightarrow 0A \mid A0 \mid 1$$
$$B \rightarrow 0B00 \mid 1$$

S is the start symbol, A and B are non-terminals and 0 and 1 are the terminals. The language generated by this grammar is

A. $\{0^n 10^{2n} \mid n \geq 1\}$
B. $\{0^i 10^j 10^k \mid i, j, k \geq 0\} \cup \{0^n 10^{2n} \mid n \geq 0\}$
C. $\{0^i 10^j \mid i, j \geq 0\} \cup \{0^n 10^{2n} \mid n \geq 0\}$
D. The set of all strings over $\{0, 1\}$ containing at least two 0's

gate2008-it theory-of-computation context-free-language normal

Answer

5.2.24 Context Free Language: GATE2008-IT-78 top http://gateoverflow.in/3392

A CFG G is given with the following productions where S is the start symbol, A is a non-terminal and a and b are terminals.

$$S \rightarrow aS \mid AA \rightarrow aAb \mid bAa \mid \epsilon$$

Which of the following strings is generated by the grammar above?

A. aabbaba
B. aabaaba
C. abababb
D. aabbaab

gate2008-it theory-of-computation normal context-free-language

Answer

5.2.25 Context Free Language: GATE2009-12, ISRO2016-37 top http://gateoverflow.in/1304

$$S \rightarrow aSa \mid bSb \mid a \mid b$$

The language generated by the above grammar over the alphabet $\{a, b\}$ is the set of

A. all palindromes
B. all odd length palindromes
C. strings that begin and end with the same symbol
D. all even length palindromes

gate2009 theory-of-computation context-free-language easy isro2016

Answer

5.2.26 Context Free Language: GATE2015-3_32 top http://gateoverflow.in/8489

Which of the following languages are context-free?

$L_1 : \{a^m b^n a^n b^m \mid m, n \geq 1\}$

$L_2 : \{a^m b^n a^m b^n \mid m, n \geq 1\}$

$L_3 : \{a^m b^n \mid m = 2n + 1\}$

A. L_1 and L_2 only
B. L_1 and L_3 only
C. L_2 and L_3 only
D. L_3 only

gate2015-3 theory-of-computation context-free-language normal

Answer

5.2.27 Context Free Language: GATE2017-1-10 top http://gateoverflow.in/118290

Consider the following context-free grammar over the alphabet $\sum$ = $\{a, b, c\}$ with S as the start symbol:

$S \rightarrow abScT \mid abcT$

$T \rightarrow bT \mid b$

Which one of the following represents the language generated by the above grammar?

(A) $\{(ab)^n(cb)^n \mid n \geq 1\}$

(B) $\{(ab)^n cb^{m_1} cb^{m_2} \dots cb^{m_n} \mid n, m_1, m_2, \dots, m_n \geq 1\}$

(C) $\{(ab)^n(cb^m)^n \mid m, n \geq 1\}$

(D) $\{(ab)^n(cb^n)^m \mid m, n \geq 1\}$

gate2017-1 theory-of-computation context-free-language normal

Answer

5.2.28 Context Free Language: GATE2017-1-34 top

http://gateoverflow.in/118316

If G is a grammar with productions

$S \rightarrow SaS|aSb|bSa|SS| \in$

where S is the start variable, then which one of the following strings is not generated by G?

(A) $abab$ (B) $aaab$ (C) $abbaa$ (D) $babba$

gate2017-1 theory-of-computation context-free-language normal

Answer

5.2.29 Context Free Language: GATE2017-1-38 top

http://gateoverflow.in/118321

Consider the following languages over the alphabet $\sum = \{a, b, c\}$. Let $L_1 = \{a^n b^n c^m | m, n \geq 0\}$ and $L_2 = \{a^m b^n c^n | m, n \geq 0\}$.

Which of the following are context-free languages?

I. $L_1 \cup L_2$

II. $L_1 \cap L_2$

(A) I only

(B) II only

(C) I and II

(D) Neither I nor II

gate2017-1 theory-of-computation context-free-language normal

Answer

5.2.30 Context Free Language: GATE2017-2-16 top

http://gateoverflow.in/118243

Identify the language generated by the following grammar, where S is the start variable.

- $S \rightarrow XY$
- $X \rightarrow aX \mid a$
- $Y \rightarrow aYb \mid \epsilon$

A. $\{a^m b^n \mid m \geq n, n > 0\}$
B. $\{a^m b^n \mid m \geq n, n \geq 0\}$
C. $\{a^m b^n \mid m > n, n \geq 0\}$
D. $\{a^m b^n \mid m > n, n > 0\}$

gate2017-2 theory-of-computation context-free-language

Answer

5.2.31 Context Free Language: ISI2015-CS-5b top http://gateoverflow.in/47330

Construct a context free grammar (CFG) to generate the following language:

$L = \{a^n b^m c^{n+m} : \text{n, m are integers, and } n \geq 1, m \geq 1\}$

descriptive isi2015 theory-of-computation context-free-language

Answer

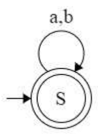
Answers: Context Free Language

5.2.1 Context Free Language: GATE 2016-1-16 top http://gateoverflow.in/39640

Selected Answer

$S \rightarrow aS \mid bS \mid \varepsilon$

is $(a+b)^*$



25 votes -- Praveen Saini (53.6k points)

5.2.2 Context Free Language: GATE 2016-1-42 top http://gateoverflow.in/39705

Selected Answer

Ans (D)

G1 results in strings b, ab, bb, aab, abb, bbb, ... i.e $a^m b^n$, $m \geq 0$ **and** $n > 0$ (and because only a's are not possible but only b's are)

G2 result in strings a, b, aa, ab, bb, aaa, aab, abb, bbb ... i.e $a^m b^n$, $m > 0$ **or** $n > 0$ (or because only b's is possible b,bb,bbb, , only a's are possible)

25 votes -- juxtapose (529 points)

5.2.3 Context Free Language: GATE 2016-2-43 top http://gateoverflow.in/39605

Selected Answer

$L_1 = \{a^n b^m c^{n+m} \; : \; m,n \geq 1\}$ is Context-free language

(push $a's$ into stack, then push $b's$ into stack , read $c's$ and pop $b's$, when no $b's$ left on stack, keep reading $c's$ and pop $a's$, when no c's left in input , and stack is empty, then accepted).

$L_2 = \{a^n b^n c^{2n} \; : \; n \geq 1\}$ is Context-sensitive language and not context-free. (cannot implemented by one stack)

So answer is option B

30 votes -- Praveen Saini (53.6k points)

I think only L1 is context free .

Since L1 is explained by others I will take L2

In L2 we can push all a's and all b's onto the stack and on seeing each c we can pop out 1 b and after all b's are popped off we can pop all a's .

that way a^nb^n will be same in number as c^2n and ultimately we can attain empty string or bottom of the stack .

But the problem with this approach is that it will accept strings which are not in the language like abbbcccc.

OPTION : B

14 votes -- ravitheja990 (119 points)

5.2.4 Context Free Language: GATE1987-1-xii top http://gateoverflow.in/80291

Selected Answer

an ambiguous grammar produces more than one parse tree for any string.. that's B..

5 votes -- kirti singh (3.4k points)

5.2.5 Context Free Language: GATE1987-2k top http://gateoverflow.in/80599

Selected Answer

No intersection of two CFLs may or may not be a CFL i.e. CFL is not closed under intersection operation.

Example:

L1: { $a^nb^nc^m$ | n,m >=1 } $\cap$ L2: { $a^nb^mc^m$ | n,m >=1 }

L3= { $a^mb^mc^m$ | m >=1 } Which is CSL

8 votes -- Prashant Singh (49.2k points)

5.2.6 Context Free Language: GATE1992_02,xix top http://gateoverflow.in/572

Selected Answer

Answer: A, D

Context Free languages are not closed under intersection and complementation.

7 votes -- Rajarshi Sarkar (35k points)

5.2.7 Context Free Language: GATE1992_02,xviii top http://gateoverflow.in/576

Selected Answer

Chomsky Normal Form (If all of its production rules are of the form):
A -> BC or
A -> a or
S -> ε

where A, B and C are nonterminal symbols, a is a terminal symbol (a symbol that represents a constant value), S is the start symbol, and ε is the empty string. Also, neither B nor C may be the start symbol, and the third production rule can only appear if ε is in L(G), namely, the language produced by the context-free grammar G.

Applying productions of the first form will increase the number of nonterminals from k to $k+1$, since you replace one nonterminal (-1) with two nonterminals (+2) for a net gain of +1 nonterminal. Since you start with one nonterminal, this means you need to do $l-1$ productions of the first form. You then need l more of the second form to convert the nonterminals to terminals, giving a total of $l+(l-1)=2l-1$ productions.

13 votes -- Rajarshi Sarkar (35k points)

5.2.8 Context Free Language: GATE1995-2.20 top http://gateoverflow.in/2632

Selected Answer

A.

In the other two you can have any number of x and y. There is no such restriction over the number of both being equal.

13 votes -- Gate Keeda (19.1k points)

5.2.9 Context Free Language: GATE1996_2.8 top http://gateoverflow.in/2737

Selected Answer

B.

CFL's are not closed under intersection.

9 votes -- Gate Keeda (19.1k points)

5.2.10 Context Free Language: GATE1996_2.9 top http://gateoverflow.in/2738

Selected Answer

(b) is the answer. Because for any binary string of 0's and 1's we can append another string to make it contain equal number of 0's and 1's. i.e., any string over {0,1} is a prefix of a string in L.

Example:

01111 - is prefix of 011110000 which is in L.
1111- is prefix of 11110000 which is in L.
01010- is prefix of 010101 which is in L.

10 votes -- Arjun Suresh (294k points)

5.2.11 Context Free Language: GATE1999_1.5 top http://gateoverflow.in/1459

Selected Answer

Cfl are not closed under intersection and complement now choose the correct option so b)union and klenne closure

9 votes -- Bhagirathi Nayak (13.3k points)

5.2.12 Context Free Language: GATE1999_7 top http://gateoverflow.in/1506

Selected Answer

language contains strings where sub string on left of c is same as that on right of c

say 01100c01100

sub string on left of c and right of c cannot be matched with one Stack

while that can be done using two stack

if we push all 0's and 1's on left of c in stack 1 , and all 0's and 1' on right of c in stack 2

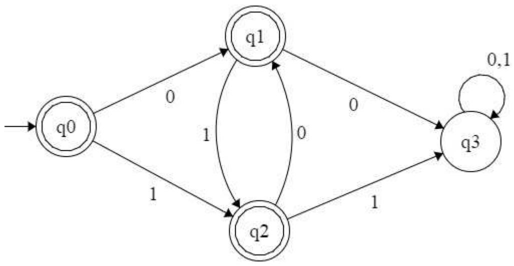
then ***Top of stack*** of both stack will have same symbol .. that can be matched

11 votes -- Praveen Saini (53.6k points)

5.2.13 Context Free Language: GATE2000-7 top http://gateoverflow.in/678

Selected Answer

(a) langauge L = $(0+1)^*$ - $(0+1)^*(00+11)$ $(0+1)^*$ .... is it true ?? DFA contains 4 states , 3 are final , 1 is dead state



(b) i <= j

as S->aSAb

there will be always for one a in left and minimum one b in right and A->bA |^ can generate any no of b's including null , if A is ^ then i=j and if A is generate any b then j>i so condition is i<=j

11 votes -- Mithlesh Upadhyay (5.4k points)

5.2.14 Context Free Language: GATE2001-1.5 top

http://gateoverflow.in/698

Selected Answer

Answer is (B)

(A) is wrong as a language can be context free even if it is being accepted by non deterministic PDA for ex- { WW^r: W ∈ $\sum^*$(a,b) and W^r is reverse}

(C) and (D) not always true as Context free languages are not closed under Complement and Intersection.

11 votes -- Prateeksha Keshari (2.1k points)

5.2.15 Context Free Language: GATE2003-51 top

http://gateoverflow.in/940

Selected Answer

It will be easy to analyze the problem if we replace terminal a and b by **(** and **)** respectively.

S⟶(S) | SS | ∊

L(G) = balanced parentheses [each left parenthesis has a matching right parenthesis and are well nested]

example () , ()(), (()), (()()()).

a) S ⇒(S) ⇒ ()

S⇒ SS⇒ S⇒ (S) ⇒ ()

S ⇒ SS⇒ S⇒ (S) ⇒ ()

String () can be derived by above three way each having different derivation tree.

So G is Ambiguous

b) Concatenation of two balance parenthesis will be balanced also . eq. x = (()) y= () xy= (())().

c) We can design Deterministic PDA for L. put left parenthesis (only) in stack and pop with right parenthesis.

d) We cannot design DFA for L because we need a stack to match left parenthesis with right parenthesis.

only option C is true.

18 votes -- Praveen Saini (53.6k points)

5.2.16 Context Free Language: GATE2005-57 top http://gateoverflow.in/1380

Selected Answer

B. http://gatecse.in/wiki/Identify_the_class_of_the_language

8 votes -- Gate Keeda (19.1k points)

5.2.17 Context Free Language: GATE2006-19 top http://gateoverflow.in/980

Selected Answer

L1 is context-free. We count the number of 0's and check if the remaining number of 1's followed by 0's count to the initial number of 0's.

L2 is not context-free. Here the number of 0's and the following 1's must be same, which can be checked using a PDA. But after that we must also ensure that the following number of 0's must be less than the previous count of 0's and 1's (otherwise n < 0, which violates the condition for acceptance) and we cannot do these two checks using a single PDA.

L3 is again not context-free as it is nothing but equal number of 0's followed by equal number of 1's followed by equal number of 0's.

15 votes -- Arjun Suresh (294k points)

5.2.18 Context Free Language: GATE2006-IT-34 top http://gateoverflow.in/3573

Selected Answer

$A \to bA \mid \varepsilon$

$\therefore \quad A = b^*$

$S \to aSAb \mid \varepsilon$

$\equiv S \to aSb^*b \mid \varepsilon$

$\equiv S \to aSb^+ \mid \varepsilon$

$S = a^n(b^+)^n, \quad n \geq 0$

$S = a^nb^nb^*, \quad n \geq 0$

$S = a^mb^n, \quad m \leq n$

Hence, option B is correct.

21 votes -- Pragy Agarwal (19.5k points)

5.2.19 Context Free Language: GATE2006-IT-4 top http://gateoverflow.in/3543

Selected Answer

L(G) = PALINDROME

baba does not belong to palindrome , so B is the answer

👍 10 votes -- Praveen Saini (53.6k points)

5.2.20 Context Free Language: GATE2007-IT-46 top http://gateoverflow.in/3481

Selected Answer

from Above grammar

Regular expression for G1: $(x+z)^+ + (x+z)^*y(y+z)^+$

Regular expression for G2 : $(y+z+xy)^+$

Option A is correct

👍 6 votes -- Praveen Saini (53.6k points)

5.2.21 Context Free Language: GATE2007-IT-48 top http://gateoverflow.in/3490

Selected Answer

ii), iii) and iv)

so option C is correct

Above grammar is for ***equal no of x and y***

from Non-terminal S -> xB

=>xy [as B->y one y for one x]

S->xB

=> xxBB [as B ->yBB one B result in one y for one x]

S->xB

=>xyS [as B->yS one y for one x and start again]

Note :Same applies for string start with y i.e . S->yA

👍 12 votes -- Praveen Saini (53.6k points)

5.2.22 Context Free Language: GATE2007-IT-49 top http://gateoverflow.in/3491

Selected Answer

Regular grammar is either right linear or left linear. A left linear grammar is one in which there is at most 1 non-terminal on the right side of any production, and it appears at the left most position. Similarly, in right linear grammar non-terminal appears at the right most position.

Here, we can write a right linear grammar for G1 as

S -> w(E
E -> id)S
S -> o

(w - WHILE, o - OTHER)

So, L(G1) is regular.

Now for G2 also we can write a right linear grammar:
S -> w(E

E -> id)S
E -> id+E
E -> id*E
S -> o

making its language regular.

So, both G1 and G2 have an equivalent regular grammar. But as such both these grammars are neither right linear nor left linear and hence not a regular grammar. So, D must be the answer.

http://www.cs.odu.edu/~toida/nerzic/390teched/regular/grammar/reg-grammar.html

17 votes -- Arjun Suresh (294k points)

5.2.23 Context Free Language: GATE2008-IT-34 top http://gateoverflow.in/3344

Selected Answer

$B \to 0B00 \mid 1$

generates $\{0^n10^{2n} \mid n \geq 0\}$

$S \to AA,$
$A \to 0A \mid A0 \mid 1$

generates $0A0A \to 00A0A \to 00101$, which is there in only B and D choices. D is not the answer as "00" is not generated by the given grammar. So, only option left is B and if we see carefully, non-terminal B is generating the second part of B choice and AA is generating the first part.

$\{0^i10^j10^k \mid i,j,k \geq 0\} \cup \{0^n10^{2n} \mid n \geq 0\}$

12 votes -- Arjun Suresh (294k points)

5.2.24 Context Free Language: GATE2008-IT-78 top http://gateoverflow.in/3392

Selected Answer

S→ aS

S→ aA

S→ aaAb

S→ aabAab

S→ aabbAaab

S→ aabbaab
hence d is d answer

24 votes -- Shreyans Dhankhar (2.6k points)

5.2.25 Context Free Language: GATE2009-12, ISRO2016-37 top http://gateoverflow.in/1304

Selected Answer

ans is B..string generated by this language is a,b,aba,bab,aabaa,.....all this strings are odd length palindromes

12 votes -- neha pawar (4.4k points)

5.2.26 Context Free Language: GATE2015-3_32 top http://gateoverflow.in/8489

Selected Answer

first check for L1. now look a^m&b^m and a^n&b^n must b comparable using one stack for CFL.
now take a stack push all a^m in to the stack then push all b^n in to stack now a^n is coming so pop b^n for each a^n by this b^n and a^n will b comparable. now we have left only a^m in stack and b^m is coming so pop a^m for each b^m by which we can compare a^m to b^m ..we conclude that we are comparing this L1 using a single stack so this is CFG.

now for L2.this can not be done in to a single stack because m and n are not comparable we can not find when to push or pop so this is CSL.

now for L3.push all a's into stack and pop 2a 's for every b and at last we left with a single a .
bcz here aaaaabb is a valid string where m=2n+1 and n=2.So realized using single stack hence L3 is CFG.

so the option is B.. L1 and L3 are CFG

24 votes -- Anoop Sonkar (4.9k points)

5.2.27 Context Free Language: GATE2017-1-10 top

http://gateoverflow.in/118290

Selected Answer

Answer should be B

Consider the 1st production S-> abScT

This production generates equal number of (ab)'s and c's but after each c there is T which goes to T->bT

so with each c there can be one or more b's (one because of production T->b and more because of T->bT)

and these b's are independent.

For example

ababcbbcbb is the part of the langugage

and ababcbbbbbbcbb is also the part of the language so we rule out A and C both say equal number of b's after each c

In option D equal number of (ab)'s and c's is not satisfied . The only option that satisfies these 2 conditions is B

uddipto's edit:

people who says this will be the string at any case

S-> abcT

-> abcb

no problem for i B in this case also here $cm^n=cm^1$ means n value 1 thats it

and remember in B c is not coming eternally.it is coming until m value reaches n of b..right there

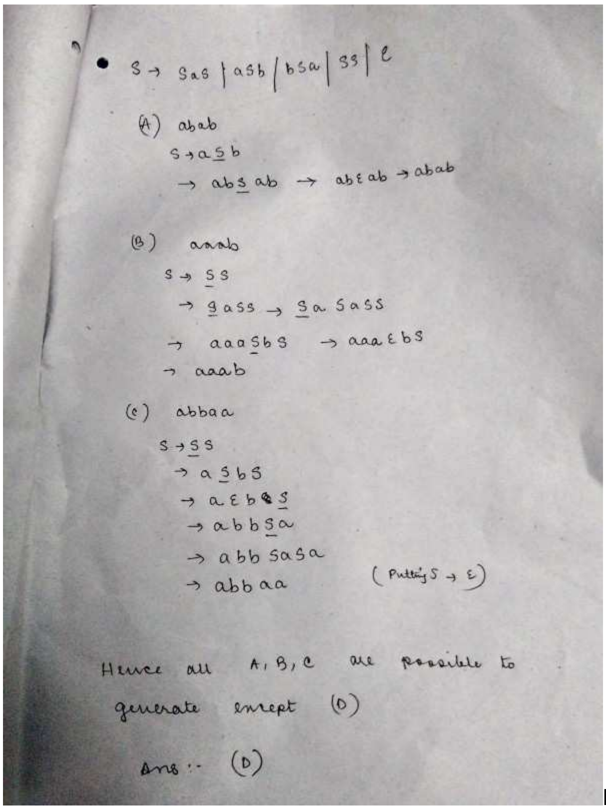
.if m=n=1 then cb stops

9 votes -- (points)

5.2.28 Context Free Language: GATE2017-1-34 top

http://gateoverflow.in/118316

Selected Answer



$S \to SaS \mid aSb \mid bSa \mid SS \mid \epsilon$

(A) abab

$S \to aSb$

$\to abSab \to ab\epsilon ab \to abab$

(B) aaab

$S \to SS$

$\to SaSS \to SaSaSS$

$\to aaaSbS \to aaa\epsilon bS$

$\to aaab$

(C) abbaa

$S \to SS$

$\to aSbS$

$\to a\epsilon bS$

$\to abbSa$

$\to abbSaSa$

$\to abbaa$ (Putting $S \to \epsilon$)

Hence all A, B, C are possible to generate except (D)

Ans :- (D)

hence ans is d.

8 votes -- Arnabi (6.4k points)

5.2.29 Context Free Language: GATE2017-1-38 top http://gateoverflow.in/118321

Selected Answer

Answer:Option (A)

1).Here let's say L= L1 ∪ L2.

Here as we see , L1 and L2 both are DCFLs. And hence CFLs.

And from the Closure Properties of CFLs, we can conclude that CFLs are Closed under Union Operation.

And hence, *L1* ∪ *L2* is CFL.

2).Now, let's take L=L1 ∩ L2 ,and that can be expressed as,

$L=\{a^ib^jc^k \mid i=j \text{ AND } j=k, i,j,k>=0\}$, *in other words*

$L=\{a^nb^nc^n \mid n>=0\}$

And we know that it comes under CSL(As we will require Two Stacks at a Time). So L is CSL and hence, L1 ∩ L2 is NOT CFL.

8 votes -- Tilak D. Nanavati (2.8k points)

5.2.30 Context Free Language: GATE2017-2-16 top http://gateoverflow.in/118243

Selected Answer

S -> XY

X->aX|a

Y ->aYb | ε

X generates atleast one 'a'. While Y generates equal no of a's and b's(including epsilon).

L = { a , ab, aab, aabb, aaabb ....}

Hence, Ans should be Option C.

6 votes -- tvkkk (1.1k points)

5.2.31 Context Free Language: ISI2015-CS-5b top http://gateoverflow.in/47330

Selected Answer

Given Context free language is :

L={ a^n b^m c^{n+m} : n,m are integers,n $\geq$1 m $\geq$1} .

For clarity given language can be interpreted as

L={ a^n b^m c^m c^n : n,m are integers,n $\geq$1 m $\geq$1}.

Now the given language is clearly **DCFL** .

And context free grammar (CFG) of the following language:

S→aSc | aAc

A→bAc | bc

5 votes -- Manoj Kumar (37.5k points)

5.3 Decidability(22) top

5.3.1 Decidability: GATE 2016-1-17 top http://gateoverflow.in/39651

Which of the following decision problems are undecidable?

I. Given NFAs N_1 and N_2 , is $L(N_1) \cap L(N_2) = \Phi$
II. Given a CFG $G = (N, \Sigma, P, S)$ and a string $x \in \Sigma^*$, does $x \in L(G)$ } ?
III. Given CFGs G_1 and G_2, is $L(G_1) = L(G_2)$?
IV. Given a TM M, is $L(M) = \Phi$?

A. I and IV only
B. II and III only
C. III and IV only
D. II and IV only

gate2016-1 theory-of-computation decidability easy

Answer

5.3.2 Decidability: GATE1987-2l top http://gateoverflow.in/80603

State whether the following statement are TRUE or FALSE.

A is recursive if both A and its complement are accepted by Turing machines.

gate1987 decidability

Answer

5.3.3 Decidability: GATE1989-3-iii top http://gateoverflow.in/87123

Answer the following questions:

Which of the following problems are undecidable?

A. Membership problem in context-free languages.
B. Whether a given context-free language is regular.
C. Whether a finite state automation halts on all inputs.
D. Membership problem for type 0 languages.

gate1989 normal theory-of-computation decidability

Answer

5.3.4 Decidability: GATE1990-3-vii top http://gateoverflow.in/84835

Choose the correct alternatives (More than one may be correct).

It is undecidable whether:

A. An arbitrary Turing machine halts after 100 steps.
B. A Turing machine prints a specific letter.
C. A Turing machine computes the products of two numbers
D. None of the above.

gate1990 normal theory-of-computation decidability

Answer

5.3.5 Decidability: GATE1995_11 top http://gateoverflow.in/2647

Let L be a language over Σ i.e., $L \subseteq \Sigma^*$. Suppose L satisfies the two conditions given below.

i. L is in NP and

ii. For every n, there is exactly one string of length n that belongs to L.

Let L^c be the complement of L over Σ^*. Show that L^c is also in NP.

gate1995 theory-of-computation normal decidability

Answer

5.3.6 Decidability: GATE1996_1.9 top http://gateoverflow.in/2713

Which of the following statements is false?

A. The Halting Problem of Turing machines is undecidable

B. Determining whether a context-free grammar is ambiguous is undecidable

C. Given two arbitrary context-free grammars G_1 and G_2 it is undecidable whether $L(G_1) = L(G_2)$

D. Given two regular grammars G_1 and G_2 it is undecidable whether $L(G_1) = L(G_2)$

gate1996 theory-of-computation decidability easy

Answer

5.3.7 Decidability: GATE1997_6.5 top http://gateoverflow.in/2261

Which one of the following is not decidable?

A. Given a Turing machine M, a string s and an integer k, M accepts s within k steps
B. Equivalence of two given Turing machines
C. Language accepted by a given finite state machine is not empty
D. Language generated by a context free grammar is non-empty

gate1997 theory-of-computation decidability easy

Answer

5.3.8 Decidability: GATE2000-2.9 top http://gateoverflow.in/656

Consider the following decision problems:

(P1): Does a given finite state machine accept a given string?

(P2): Does a given context free grammar generate an infinite number of strings?

Which of the following statements is true?

A. Both (P1) and (P2) are decidable
B. Neither (P1) nor (P2) is decidable
C. Only (P1) is decidable
D. Only (P2) is decidable

gate2000 theory-of-computation decidability normal

Answer

5.3.9 Decidability: GATE2001-2.7 top http://gateoverflow.in/725

Consider the following problem X.

Given a Turing machine M over the input alphabet Σ, any state q of M and a word $w \in \Sigma^*$, does the computation of M on w visit the state of q?

Which of the following statements about X is correct?

A. X is decidable
B. X is undecidable but partially decidable
C. X is undecidable and not even partially decidable
D. X is not a decision problem

gate2001 theory-of-computation decidability normal

Answer

5.3.10 Decidability: GATE2003-52 top http://gateoverflow.in/356

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

gate2003 theory-of-computation normal decidability

Answer

5.3.11 Decidability: GATE2005-45 top http://gateoverflow.in/1375

- Consider three decision problems P_1, P_2 and P_3. It is known that P_1 is decidable and P_2 is undecidable. Which one of the following is TRUE?

A. P_3 is decidable if P_1 is reducible to P_3
B. P_3 is undecidable if P_3 is reducible to P_2
C. P_3 is undecidable if P_2 is reducible to P_3
D. P_3 is decidable if P_3 is reducible to P_2's complement

gate2005 theory-of-computation decidability normal

Answer

5.3.12 Decidability: GATE2007-6 top

http://gateoverflow.in/1204

Which of the following problems is undecidable?

A. Membership problem for CFGs
B. Ambiguity problem for CFGs
C. Finiteness problem for FSAs
D. Equivalence problem for FSAs

gate2007 theory-of-computation decidability normal

Answer

5.3.13 Decidability: GATE2008-10 top

http://gateoverflow.in/408

Which of the following are decidable?

I. Whether the intersection of two regular languages is infinite
II. Whether a given context-free language is regular
III. Whether two push-down automata accept the same language
IV. Whether a given grammar is context-free

A. I and II
B. I and IV
C. II and III
D. II and IV

gate2008 theory-of-computation decidability easy

Answer

5.3.14 Decidability: GATE2012_24 top

http://gateoverflow.in/1608

Which of the following problems are decidable?

1. Does a given program ever produce an output?
2. If L is a context-free language, then, is $\bar{L}$ also context-free?
3. If L is a regular language, then, $\bar{L}$ is also regular?
4. If L is a recursive language, then, is $\bar{L}$also recursive?

(A) 1, 2, 3, 4
(B) 1, 2
(C) 2, 3, 4
(D) 3, 4

gate2012 theory-of-computation decidability normal

Answer

5.3.15 Decidability: GATE2013_41 top

http://gateoverflow.in/1553

Which of the following is/are undecidable?

1. G is a CFG. Is $L(G) = \phi$?
2. G is a CFG. Is $L(G) = \Sigma^*$?
3. M is a Turing machine. Is $L(M)$ regular?
4. A is a DFA and N is an NFA. Is $L(A) = L(N)$?

(A) 3 only (B) 3 and 4 only (C) 1, 2 and 3 only (D) 2 and 3 only

gate2013 theory-of-computation decidability normal

Answer

5.3.16 Decidability: GATE2014-3-35 top http://gateoverflow.in/2069

Which one of the following problems is undecidable?

A. Deciding if a given context-free grammar is ambiguous.
B. Deciding if a given string is generated by a given context-free grammar.
C. Deciding if the language generated by a given context-free grammar is empty.
D. Deciding if the language generated by a given context-free grammar is finite.

gate2014-3 theory-of-computation context-free-language decidability normal

Answer

5.3.17 Decidability: GATE2015-2_21 top http://gateoverflow.in/8111

Consider the following statements.

I. The complement of every Turing decidable language is Turing decidable
II. There exists some language which is in NP but is not Turing decidable
III. If L is a language in NP, L is Turing decidable

Which of the above statements is/are true?

A. Only II
B. Only III
C. Only I and II
D. Only I and III

gate2015-2 theory-of-computation decidability easy

Answer

5.3.18 Decidability: GATE2015-3_53 top http://gateoverflow.in/8562

Language L_1 is polynomial time reducible to language L_2. Language L_3 is polynomial time reducible to language L_2, which in turn polynomial time reducible to language L_4. Which of the following is/are true?

I. if $L_4 \in P$, then $L_2 \in P$
II. if $L_1 \in P$ or $L_3 \in P$, then $L_2 \in P$
III. $L_1 \in P$, if and only if $L_3 \in P$
IV. if $L_4 \in P$, then $L_3 \in P$

A. II only
B. III only
C. I and IV only
D. I only

gate2015-3 theory-of-computation decidability normal

Answer

5.3.19 Decidability: GATE2017-1-39 top http://gateoverflow.in/118322

Let A and B be finite alphabets and let $\#$ be a symbol outside both A and B. Let f be a total function from A^* to B^*. We say f is *computable* if there exists a Turing machine M which given an input $x \in A^*$, always halts with $f(x)$ on its tape. Let L_f denote the language $\left\{x\#f(x) \mid x \in A^*\right\}$. Which of the following statements is true:

(A) f is computable if and only if L_f is recursive.

(B) f is computable if and only if L_f is recursively enumerable.

(C) If f is computable then L_f is recursive, but not conversely.

(D) If f is computable then L_f is recursively enumerable, but not conversely.

gate2017-1 theory-of-computation decidability difficult

Answer

5.3.20 Decidability: GATE2017-2-41 top http://gateoverflow.in/118605

Let $L(R)$ be the language represented by regular expression R. Let $L(G)$ be the language generated by a context free grammar G. Let $L(M)$ be the language accepted by a Turing machine M. Which of the following decision problems are undecidable?

I. Given a regular expression R and a atring w, is $w \in L(R)$?
II. Given a context-free grammar G, is $L(G) = \emptyset$
III. Given a context-free grammar G, is $L(G) = \Sigma^*$ for some alphabet Σ?
IV. Given a Turing machine M and a string w, is $w \in L(M)$?

A. I and IV only
B. II and III only
C. II, III and IV only
D. III and IV only

gate2017-2 theory-of-computation decidability

Answer

5.3.21 Decidability: TIFR2010-B-25 top http://gateoverflow.in/18745

Which of the following problems is decidable? (Here, CFG means context free grammar and CFL means context free language.)

A. Give a CFG G, find whether $L(G) = R$, where R is regular set.
B. Given a CFG G, find whether $L(G) = \{\}$.
C. Find whether the intersection of two CFLs is empty.
D. Find whether the complement of CFL is a CFL.
E. Find whether CFG G_1 and CFG G_2 generate the same language, i.e, $L\left(G_1\right) = L\left(G_2\right)$.

tifr2010 theory-of-computation context-free-language decidability

Answer

5.3.22 Decidability: TIFR2011-B-25 top http://gateoverflow.in/20404

Let A_{TM} be defined as follows:

$$A_{TM} = \{\langle M, w\rangle \mid \text{The Turning machine } M \text{ accepts the word } w\}$$

And let L be some $\mathbf{NP}-$ complete language. Which of the following statements is FALSE?

a. $L \in \mathbf{NP}$
b. Every problem in $\mathbf{NP}$ is polynomial time reducible to L.
c. Every problem in $\mathbf{NP}$ is polynomial time reducible to A_{TM}.
d. Since L is $\mathbf{NP}-$ complete, A_{TM} is polynomial time reducible to L.
e. $A_{TM} \notin \mathbf{NP}$.

tifr2011 theory-of-computation decidability

Answer

Answers: Decidability

5.3.1 Decidability: GATE 2016-1-17 top

http://gateoverflow.in/39651

Selected Answer

I. is Decidable, we may use cross product of NFA (or by converting them into DFA) , if We didn't get final states of both together at any state in it. then $L(N_1) \cap L(N_2) = \phi$, Disjoint languages.

II. Membership in CFG is Decidable (CYK algorithm)
III. Equivalence of Two context free grammars is Undecidable.
IV. For TM M , $L(M) = \phi$ is Undecidable.

30 votes -- Praveen Saini (53.6k points)

5.3.2 Decidability: GATE1987-2l top

http://gateoverflow.in/80603

Selected Answer

Yes if A and its complement are accepted by Turing machines.then A is recursive.

Suppose a language A is recursively enumerable. That means there exists a Turing machine T1 that, given any string of the language, halts and accepts that string.

Now let's also suppose that the complement of A, A'= {w: w | A}, is recursively enumerable. That means there is some other Turing machine T2 that, given any string of A' halts and accepts that string. So any string belongs to either A or A'. Hence, any string will cause either T1 or T2 (or both) to halt. We construct a new Turing machine that emulates both T1 and T2, alternating moves between them. When either one stops, we can tell (by whether it accepted or rejected the string) to which language the string belongs.

Thus, we have constructed a Turing machine that, for each input, halts with an answer whether or not the string belongs to A'. Therefore A and A' are recursive languages.

6 votes -- Prashant Singh (49.2k points)

5.3.3 Decidability: GATE1989-3-iii top

http://gateoverflow.in/87123

1. Membership problem in context-free languages. is **Decidable.**
2. Whether a given context-free language is regular. **Undecidable [Regularity is decidable till DCFL]**
3. Whether a finite state automation halts on all inputs. **Decidable**
4. Membership problem for type 0 languages. **Undecidable[undecidable for RE or semididicable]**

Reff : http://gatecse.in/grammar-decidable-and-undecidable-problems/

5 votes -- Prashant Singh (49.2k points)

5.3.4 Decidability: GATE1990-3-vii top

http://gateoverflow.in/84835

A.An arbitrary Turing machine halts after 100 steps. **DECIDABLE,**we can run TM for 100 steps and conclude that

B.A Turing machine prints a specific letter. **UNDECIDABLE,**

C.A Turing machine computes the products of two numbers,**UNDECIDABLE,** Even though we can desing a TM for calculation product of 2 numbers but here it is asking whether given TM computes product of 2 numbers,so the behaviour of TM unknown hence,Undecidable

7 votes -- Prajwal Bhat (11.9k points)

5.3.5 Decidability: GATE1995_11 top

http://gateoverflow.in/2647

Selected Answer

Since L is in NP it is decidable (recursive) and so is its complement L^c. Now, L^c may or may not be in NP. But we are given that for any string length n, exactly one string belong to L, which means for any string length all but one string belong to L^c.

Now, definition of NP says that all "yes" instances of the problem can be solved in polynomial time using a nondeterministic TM. So, given an instance of $\langle L^c, x \rangle$, we non-deterministically take all words of length n, where n is the length of w, and see if it is in L. As soon as we get the word (such a word is sure to exist as exactly one word of length n belong to L), we see if this word is same as x. If it is not same (and only if it is not same), $x \in L^c$ and we get this answer in polynomial time making L^c an NP problem.

7 votes -- Arjun Suresh (294k points)

5.3.6 Decidability: GATE1996_1.9 top

http://gateoverflow.in/2713

Selected Answer

D..

equivalence of Regular languages is decidable.

1.Membership,

2.Emptiness,

3.Finiteness,

4.Equivalence,

5.Ambiguity,

6.Regularity,

7.Everything,

8.Disjointedness...

All are decidable for Regular languages.

First 3 for CFL.

Only 1st for CSL and REC.

None for RE.

11 votes -- Gate Keeda (19.1k points)

5.3.7 Decidability: GATE1997_6.5 top

http://gateoverflow.in/2261

Selected Answer

Equivalence of two TMs is undecidable

15 votes -- Bhagirathi Nayak (13.3k points)

5.3.8 Decidability: GATE2000-2.9 top

http://gateoverflow.in/656

Selected Answer

For P1, we just need to give a run on the machine. Finite state machines always halts unlike TM.

For P2, check if the CFG generates any string of length between n and $2n-1$, where n is the pumping lemma constant.

If so, L(CFG) is infinite, else finite. But finding the pumping lemma constant is not trivial - but there are other procedures which can do this - http://cs.stackexchange.com/questions/52507/is-it-decidable-whether-a-given-context-free-grammar-generates-an-infinite-numbe/52520

Hence, both P1 and P2 are decidable - (A).

http://gatecse.in/wiki/Grammar:_Decidable_and_Undecidable_Problems

12 votes -- Arjun Suresh (294k points)

5.3.9 Decidability: GATE2001-2.7 top

http://gateoverflow.in/725

Selected Answer

X is undecidable but partially decidable.

We have the TM M. Just make the state q the final state and make all other final states non-final and get a new TM M'. Give input w to M'. If w would have taken M to state q (yes case of the problem), our new TM M' would accept it. So, the given problem is partially decidable.

If M goes for an infinite loop and never reaches state q (no case for the problem), M' cannot output anything. This problem is the state entry problem, which like word accepting problem and halting problem is undecidable.

26 votes -- Arjun Suresh (294k points)

5.3.10 Decidability: GATE2003-52 top

http://gateoverflow.in/356

Selected Answer

Since, f is a polynomial time computable bijection and f^{-1} is also polynomial time computable, L_1 and L_2 should have the same complexity (isomorphic). This is because, given a problem for L_1, we can always do a polynomial time reduction to L_2 and vice verse. Hence, the answer is 'C', as in 'A', L_1 and L_2 can be finite, in 'B', L_1 and L_2 can be in P and in 'D', L_1 and L_2 can be recursive. Only, in 'C' there is no intersection for L_1 and L_2, and hence it can't be true.

Alternatively, we can prove 'C' to be false as follows:
Given L_2 is decidable. Now, for a problem in L_1, we can have a TM, which takes an input x, calculates $f(x)$ in polynomial time, check $f(x)$ is in L_2 (this is decidable as L_2 is decidable), and if it is, then output yes and otherwise no. Thus L_1 must also be decidable.

10 votes -- gatecse (13.4k points)

5.3.11 Decidability: GATE2005-45 top

http://gateoverflow.in/1375

Selected Answer

(A) If P_1 is reducible to P_3, then P_3 is at least as hard as P_1. So, no guarantee if P_3 is decidable.

(B) If P_3 is reducible to P_2, then P_3 cannot be harder than P_2. But P_2 being undecidable, this can't say P_3 is undecidable.

(C) If P_2 is reducible to P_3, then P_3 is at least as hard as P_2. Since, P_2 is undecidable, this means P_3 is also undecidable - hence the answer.

(D) Complement of an undecidable problem is undecidable. Now, reducing to an undecidable problem can't prove P_3 is decidable.

http://gatecse.in/wiki/Some_Reduction_Inferences

19 votes -- Arjun Suresh (294k points)

5.3.12 Decidability: GATE2007-6 top

http://gateoverflow.in/1204

Selected Answer

Membership problem is decidable as it can be solved by parsers.

Finiteness problem is decidable for FSAs (also for CFGs), as we just need to check for a loop in the DFA.

Equivalence problem for FSAs is decidable as we can take the complement of one FSA (complement of FSA is another FSA), and do an intersection with the other (FSAs are closed under intersection also), giving a new FSA. If this new FSA accept no string, then the given FSAs are equivalent, else not equivalent.

Only ambiguity problem for CFGs are undecidable.

http://gatecse.in/wiki/Grammar:_Decidable_and_Undecidable_Problems

14 votes -- Arjun Suresh (294k points)

5.3.13 Decidability: GATE2008-10 top

http://gateoverflow.in/408

Selected Answer

Lets see options one by one :

I) The language here will be regular as intersection of regular languages will lead to regular language only..And we know that given a regular language , whether it is finite or not is a decidable problem..This can be seen by observing the DFA..If DFA contains a state which contains a loop and that state is reachable from start state and that state is either a final state or leading to final state , then the language will be infinite..

II) The regularity property is undecidable for context free languages..Hence it is undecidable..Details regarding this : https://cs.stackexchange.com/questions/19482/why-is-deciding-regularity-of-a-context-free-language-undecidable

III) Now equivalence of two CFLs is also undecidable property..Hence given 2 PDAs which is nothing but characterising CFLs , whether the 2 CFLs will be same or not cannot be decided..

IV) Given a grammar , it is context free iff its productions are of the type V --> (V U Σ)* .....Hence it is a decidable property..

Hence B) should be correct answer..

2 votes -- HABIB MOHAMMAD KHAN (76.8k points)

(1) Intersection of two regular languages is regular. And checking if a regular language is infinite is decidable.

(2) Undecidable

(3) Undecidable

(4) Decidable as we just have to check if the grammar obeys the rules of CFG. (Obviously undecidable had it been language instead of grammar)

Reference: http://gatecse.in/wiki/Grammar:_Decidable_and_Undecidable_Problems

11 votes -- gatecse (13.4k points)

5.3.14 Decidability: GATE2012_24 top

http://gateoverflow.in/1608

Selected Answer

CFL’s are not closed under complementation and a program can loop forever. So, it may not produce any output.

Regular and recursive languages are closed under complementation.

Hence, only 3,4 are decidable.

13 votes -- Bhagirathi Nayak (13.3k points)

5.3.15 Decidability: GATE2013_41 top http://gateoverflow.in/1553

Selected Answer

It will be D.

First is Emptiness for CFG.

Second is everything for CFG.

Third is Regularity for REC

Fourth is equivalence for regular.

15 votes -- Gate Keeda (19.1k points)

5.3.16 Decidability: GATE2014-3-35 top http://gateoverflow.in/2069

Selected Answer

(A) is the answer. Proving (A) is undecidable is not so easy. But we can easily prove the other three options given here are decidable.

http://gatecse.in/wiki/Grammar:_Decidable_and_Undecidable_Problems

14 votes -- Arjun Suresh (294k points)

5.3.17 Decidability: GATE2015-2_21 top http://gateoverflow.in/8111

Selected Answer

1 is true. The solution to a decision problem is either "yes" or "no", and hence if we can decide a problem, we have also decided its complement- just reverse "yes" and "no". (This is applicable for decidability and not for acceptance)

2 is false. Because NP class is defined as the class of languages that can be solved in polynomial time by a non-deterministic Turing machine. So, none of the NP class problems is undecidable.

3 is true for same reason as 2.

So, answer is D.

23 votes -- Arjun Suresh (294k points)

5.3.18 Decidability: GATE2015-3_53 top http://gateoverflow.in/8562

Selected Answer

1. L1 is polynomial time reducible to L2. So, L2 is at least as hard as L1.
2. L3 is polynomial time reducible to L2. So, L2 is at least as hard as L3.
3. L2 is polynomial time reducible to L4. So, L4 is at least as hard as L2.

If L4 is in P, L3, L2 and L1 must also be in P. So, I and IV are true.

We can have L1 in P and L2 not in P, and none of the given conditions are violated. So, II is false.

Assume L3 not in P. Now, Since L2 must be at least as hard as L3, it must also be not in P. But L1 is less harder than L1 as per condition 1, and it can be in P without violating any given conditions. So, III is false.

Hence C choice.

More Info: http://gatecse.in/wiki/Some_Reduction_Inferences

14 votes -- Arjun Suresh (294k points)

5.3.19 Decidability: GATE2017-1-39 top http://gateoverflow.in/118322

f being computable, given x, we get $f(x)$.

L_f is recursive - given any string we get to know if the string is in L or not.

Now lets see the two cases:

- Does f being computable implies L_f is recursive?

We are given x and we need to know if $x\#f(x)$ belongs to L_f. Since f being computable we can calculate $f(x)$ and our problem reduces to 3 string comparisons - first x, followed by # and then f(x) which can be done by a TM. So, L_f must be recursive.

- Does L_f being recursive implies f be computable?

If L_f is recursive, given any string we can say whether it belongs to L_f or not. Now, to compute $f(x)$, we can do a dovetailing approach starting with strings in lexicographic (or any other order) as follows $s1, s2, s3, \dots$ and forming inputs to the TM as

$x\#s_1, x\#s_2, x\#s_3, \dots$

By dovetailing it means to simulation TM for one step in first iteration, 2 steps in second iteration, 3 steps in third iteration etc., and in each iteration adding a new string to the simulation (TM is parallelly simulating all strings).

https://courses.engr.illinois.edu/cs373/sp2009/lectures/lect_24.pdf

Now, for any x, we should have an $f(x)$ since f is a total function. So, in our simulation we are sure that sometime we will add the string $x\#f(x)$ to the simulation and then the TM will halt for it. And whenever it does halt, we can just take the part of the input string after #, and that is $f(x)$. We have a way to compute $f(x)$ for any x. So, f is computable. The same method would work even if L_f is recursively enumerable and not necessarily recursive.

So, the correct statements are

1. If L_f is recursively enumerable f is computable
2. If f is computable L_f is recursive

So, options A and B are TRUE but official key was only A.

7 votes -- Arjun Suresh (294k points)

5.3.20 Decidability: GATE2017-2-41 top http://gateoverflow.in/118605

Selected Answer

1st statement is Membership problem of regular language = **decidable**

2nd statenment is Emptyness problem of CFL = **decidable**

3rd statenment is accept everthing problem of CFL = un**decidable**

4rth statenment is Membership problem of RE language = un**decidable**

D is answer

8 votes -- Prashant Singh (49.2k points)

5.3.21 Decidability: TIFR2010-B-25 top

http://gateoverflow.in/18745

Selected Answer

A) we dont have any standard algo to change CFG into CFL.

from a given CFG deciding a launguage is finite is decidable but regular its undecidable (check out the link provided by Arjun sir in the comment for better clarification.)

B)From a given given CFG we can determine the CFL and CFL emptiness is Decidable.

C) Intersection of two CFL is undecidable coz it is not closed under intersection.

D) CFL is not closed under Complement so its undecidable.

E) CFL is not closed under equivalence so it is undecidale to compare 2 language.

therefore according to me B is decidable and A,C,D and E are undecidable.

8 votes -- Umang Raman (15.2k points)

5.3.22 Decidability: TIFR2011-B-25 top

http://gateoverflow.in/20404

Selected Answer

A_{TM} is the language of the Halting Problem. It is undecidable, but Recursively Enumerable.

L is $\mathbf{NPC}$

a. True. Any language in $\mathbf{NPC}$ is also in $\mathbf{NP}$ by definition.
b. True. By definition, any problem in $\mathbf{NP}$ is polynomial time reducible to any $\mathbf{NPC}$ problem.
c. True. A_{TM} is undecidable. Any language that is decidable is polynomial time reducible to A_{TM} !
d. **False.**
   A_{TM} is undecidable. No Turing Machine can guarantee an answer in a finite time, let alone a polynomial time.
e. True. A_{TM} is undecidable. It is certainly not in $\mathbf{NP}$.

Hence, the correct answer is option d.

9 votes -- Pragy Agarwal (19.5k points)

5.4 Finite Automata(64) top

5.4.1 Finite Automata: CMI2010-B-04b top

http://gateoverflow.in/47073

Indicate whether the following statement is true or false, providing a short explanation to substantiate your answers.

A DFA that has n states and accepts an infinite language must accept at least one string x such that $2n < |x| < 3n$, where $|x|$ denotes the length of x.

descriptive cmi2010 finite-automata

Answer

5.4.2 Finite Automata: CMI2010-B-04c top

http://gateoverflow.in/47074

Indicate whether the following statement is true or false, providing a short explanation to substantiate your answers.

If a language L is accepted by an NFA with n states then there is a DFA with no more than 2^n states accepting L.

descriptive cmi2010 finite-automata

Answer

5.4.3 Finite Automata: CMI2012-B-02a top http://gateoverflow.in/46562

For a binary string $x = a_0 a_1 \dots a_{n-1}$ define $val(x)$ to be $\Sigma_{0 \leq i < n} 2^{n-1-i} . a_i$
Let $\Sigma = \{(0,0),(0,1),(1,0),(1,1)\}$.

a. Construct a finite automaton that accepts the set of all strings $(a_0,b_0)(a_1,b_1)\dots(a_{n-1},b_{n-1}) \in \Sigma^*$ such that $val(b_0 b_1 \dots b_{n-1}) = 2 \cdot val(a_0 a_1 \dots a_{n-1})$.

cmi2012 descriptive theory-of-computation finite-automata

Answer

5.4.4 Finite Automata: GATE 2016-2-42 top http://gateoverflow.in/39591

Consider the following two statements:

I. If all states of an **NFA** are accepting states then the language accepted by the **NFA** is $\sum^*$.

II. There exists a regular language A such that for all languages B, $A \cap B$ is regular.

Which one of the following is **CORRECT**?

A. Only I is true
B. Only II is true
C. Both I and II are true
D. Both I and II are false

gate2016-2 theory-of-computation finite-automata normal

Answer

5.4.5 Finite Automata: GATE 2016-2_16 top http://gateoverflow.in/39562

The number of states in the minimum sized DFA that accepts the language defined by the regular expression.

$(0+1)^*(0+1)(0+1)^*$

is ________.

gate2016-2 theory-of-computation finite-automata normal numerical-answers

Answer

5.4.6 Finite Automata: GATE1987-2j top http://gateoverflow.in/80594

State whether the following statements are TRUE or FALSE:

A minimal DFA that is equiavlent to an NDFA with n nodes has always 2^n states.

gate1987 theory-of-computation finite-automata

Answer

5.4.7 Finite Automata: GATE1991_17,b top http://gateoverflow.in/544

Let L be the language of all binary strings in which the third symbol from the right is a 1. Give a non-deterministic finite automaton that recognizes L. How many states does the minimized equivalent deterministic finite automaton have? Justify your answer briefly?

gate1991 theory-of-computation finite-automata normal

Answer

5.4.8 Finite Automata: GATE1993_27 top http://gateoverflow.in/2323

Draw the state transition of a deterministic finite state automaton which accepts all strings from the alphabet $\{a, b\}$, such that no string has 3 consecutive occurrences of the letter b.

gate1993 theory-of-computation finite-automata easy

Answer

5.4.9 Finite Automata: GATE1994_3.3 top

http://gateoverflow.in/2480

State True or False with one line explanation

A FSM (Finite State Machine) can be designed to add two integers of any arbitrary length (arbitrary number of digits).

gate1994 theory-of-computation finite-automata normal

Answer

5.4.10 Finite Automata: GATE1995_2.23 top

http://gateoverflow.in/2636

A finite state machine with the following state table has a single input x and a single out z.

present state	next state, z	
	$x = 1$	$x = 0$
A	D, 0	B, 0
B	B, 1	C, 1
C	B, 0	D, 1
D	B, 1	C, 0

If the initial state is unknown, then the shortest input sequence to reach the final state C is:

A. 01
B. 10
C. 101
D. 110

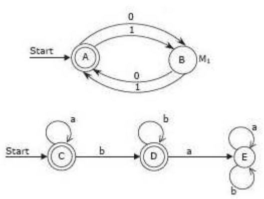
gate1995 theory-of-computation finite-automata normal

Answer

5.4.11 Finite Automata: GATE1996_12 top

http://gateoverflow.in/2764

Given below are the transition diagrams for two finite state machines M_1 and M_2 recognizing languages L_1 and L_2 respectively.



a. Display the transition diagram for a machine that recognizes $L_1 . L_2$, obtained from transition diagrams for M_1 and M_2 by adding only ε transitions and no new states.

b. Modify the transition diagram obtained in part (a) obtain a transition diagram for a machine that recognizes $(L_1 . L_2)^*$ by adding only ε transitions and no new states.

   (Final states are enclosed in double circles).

gate1996 theory-of-computation finite-automata normal

Answer

5.4.12 Finite Automata: GATE1996_2.23 top

http://gateoverflow.in/2752

Consider the following state table for a sequential machine. The number of states in the minimized machine will be

		Input	
		0	**1**
Present State	**A**	D, 0	B, 1
	B	A, 0	C, 1
	C	A, 0	B, 1
	D	A, 1	C, 1
		Next state, Output	

A. 4
B. 3
C. 2
D. 1

gate1996 theory-of-computation normal finite-automata

Answer

5.4.13 Finite Automata: GATE1997_20 top http://gateoverflow.in/2280

Construct a finite state machine with minimum number of states, accepting all strings over (a,b) such that the number of a's is divisible by two and the number of b's is divisible by three.

gate1997 theory-of-computation finite-automata normal

Answer

5.4.14 Finite Automata: GATE1997_21 top http://gateoverflow.in/2281

Given that L is a language accepted by a finite state machine, show that L^P and L^R are also accepted by some finite state machines, where

$$L^P = \{s \mid ss' \in L \text{ some string } s'\}$$

$$L^R = \{s \mid s \text{ obtained by reversing some string in } L\}$$

gate1997 theory-of-computation finite-automata proof

Answer

5.4.15 Finite Automata: GATE1998_1.10 top http://gateoverflow.in/1647

Which of the following set can be recognized by a Deterministic Finite state Automaton?

A. The numbers $1, 2, 4, 8, \dots 2^n, \dots$ written in binary
B. The numbers $1, 2, 4, 8, \dots 2^n, \dots$ written in unary
C. The set of binary string in which the number of zeros is the same as the number of ones.
D. The set $\{1, 101, 11011, 1110111, \dots\}$

gate1998 theory-of-computation finite-automata normal

Answer

5.4.16 Finite Automata: GATE1998_2.5 top http://gateoverflow.in/1677

Let L be the set of all binary strings whose last two symbols are the same. The number of states in the minimal state deterministic finite state automaton accepting L is

A. 2
B. 5

C. 8
D. 3

gate1998 theory-of-computation finite-automata normal

Answer

5.4.17 Finite Automata: GATE1998_4 top http://gateoverflow.in/1695

Design a deterministic finite state automaton (using minimum number of states) that recognizes the following language:

$L = \{w \in \{0,1\}^* \mid w$ interpreted as binary number (ignoring the leading zeros) is divisible by five $\}$.

gate1998 theory-of-computation finite-automata normal

Answer

5.4.18 Finite Automata: GATE1999_1.4 top http://gateoverflow.in/1458

Consider the regular expression $(0+1)(0+1)\dots N$ times. The minimum state finite automaton that recognizes the language represented by this regular expression contains

A. n states
B. $n+1$ states
C. $n+2$ states
D. None of the above

gate1999 theory-of-computation finite-automata easy

Answer

5.4.19 Finite Automata: GATE2001-1.6 top http://gateoverflow.in/699

Given an arbitrary non-deterministic finite automaton (NFA) with N states, the maximum number of states in an equivalent minimized DFA at least

A. N^2
B. 2^N
C. $2N$
D. $N!$

gate2001 finite-automata theory-of-computation easy

Answer

5.4.20 Finite Automata: GATE2001-2.5 top http://gateoverflow.in/723

Consider a DFA over $\Sigma = \{a, b\}$ accepting all strings which have number of a's divisible by 6 and number of b's divisible by 8. What is the minimum number of states that the DFA will have?

A. 8
B. 14
C. 15
D. 48

gate2001 theory-of-computation finite-automata

Answer

5.4.21 Finite Automata: GATE2001-5 top http://gateoverflow.in/746

Construct DFA's for the following languages:

a. $L = \{w \mid w \in \{a, b\}^*, \text{ w has baab as a substring }\}$
b. $L = \{w \mid w \in \{a, b\}^*, \text{ w has an odd number of a's and an odd number of b's }\}$

gate2001 theory-of-computation easy descriptive finite-automata

Answer

5.4.22 Finite Automata: GATE2002-2.13 top

http://gateoverflow.in/843

The smallest finite automaton which accepts the language {x | length of x is divisible by 3} has

A. 2 states
B. 3 states
C. 4 states
D. 5 states

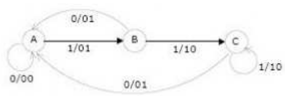
gate2002 theory-of-computation normal finite-automata

Answer

5.4.23 Finite Automata: GATE2002-2.5 top

http://gateoverflow.in/835

The finite state machine described by the following state diagram with A as starting state, where an arc label is and x stands for 1-bit input and y stands for 2-bit output



A. outputs the sum of the present and the previous bits of the input
B. outputs 01 whenever the input sequence contains 11
C. outputs 00 whenever the input sequence contains 10
D. none of the above

gate2002 theory-of-computation normal finite-automata

Answer

5.4.24 Finite Automata: GATE2002-21 top

http://gateoverflow.in/874

We require a four state automaton to recognize the regular expression (a/b)*abb

a. Give an NFA for this purpose
b. Give a DFA for this purpose

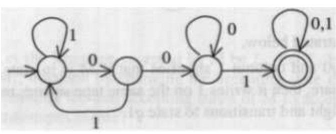
gate2002 theory-of-computation finite-automata normal descriptive

Answer

5.4.25 Finite Automata: GATE2003-50 top

http://gateoverflow.in/939

Consider the following deterministic finite state automaton M.



Let S denote the set of seven bit binary strings in which the first, the fourth, and the last bits are 1. The number of strings in S that are accepted by M is

A. 1
B. 5
C. 7
D. 8

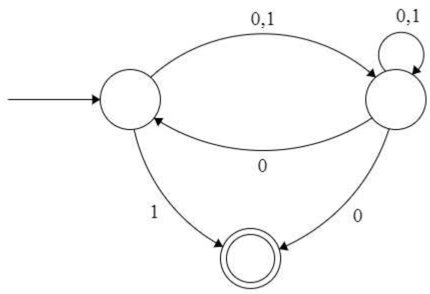
gate2003 theory-of-computation finite-automata normal

Answer

5.4.26 Finite Automata: GATE2003-55 top

http://gateoverflow.in/943

Consider the NFA M shown below.



Let the language accepted by M be L. Let L_1 be the language accepted by the NFA M_1 obtained by changing the accepting state of M to a non-accepting state and by changing the non-accepting states of M to accepting states. Which of the following statements is true?

A. $L_1 = \{0,1\}^* - L$
B. $L_1 = \{0,1\}^*$
C. $L_1 \subseteq L$
D. $L_1 = L$

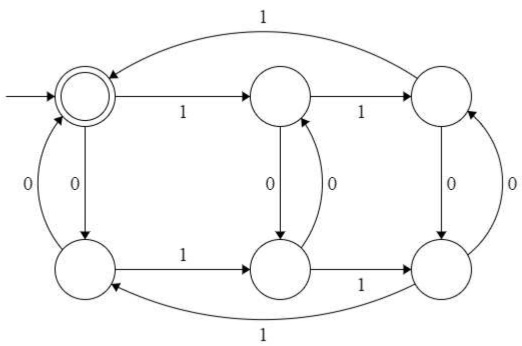
gate2003 theory-of-computation finite-automata normal

Answer

5.4.27 Finite Automata: GATE2004-86 top

http://gateoverflow.in/1080

The following finite state machine accepts all those binary strings in which the number of 1's and 0's are respectively



A. divisible by 3 and 2

B. odd and even

C. even and odd

D. divisible by 2 and 3

gate2004 theory-of-computation finite-automata easy

Answer

5.4.28 Finite Automata: GATE2004-IT-41 top

http://gateoverflow.in/3684

Let M = (K, Σ, δ, s, F) be a finite state automaton, where

K = {A, B}, Σ = {a, b}, s = A, F = {B},

δ(A, a) = A, δ(A, b) = B, δ(B, a) = B and δ(B, b) = A

A grammar to generate the language accepted by M can be specified as G = (V, Σ, R, S), where V = K U Σ, and S = A. Which one of the following set of rules will make L(G) = L(M) ?

A. {A → aB, A → bA, B → bA, B → aA, B → ε)
B. {A → aA, A → bB, B → aB, B → bA, B → ε)
C. {A → bB, A → aB, B → aA, B → bA, B → ε)
D. {A → aA, A → bA, B → aB, B → bA, A → ε)

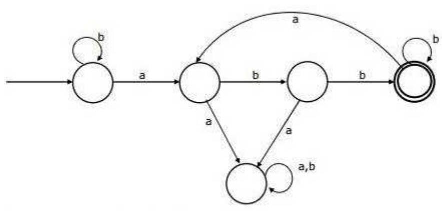
gate2004-it theory-of-computation finite-automata normal

Answer

5.4.29 Finite Automata: GATE2005-53 top

http://gateoverflow.in/1376

Consider the machine M:



The language recognized by M is:

A. $\{w \in \{a,b\}^* \mid \text{every a in w is followed by exactly two b's}\}$
B. $\{w \in \{a,b\}^* \mid \text{every a in w is followed by at least two b's}\}$
C. $\{w \in \{a,b\}^* \mid \text{w contains the substring 'abb'}\}$
D. $\{w \in \{a,b\}^* \mid \text{w does not contain 'aa' as a substring}\}$

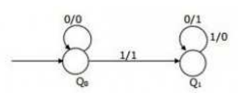
gate2005 theory-of-computation finite-automata normal

Answer

5.4.30 Finite Automata: GATE2005-63 top

http://gateoverflow.in/1386

The following diagram represents a finite state machine which takes as input a binary number from the least significant bit.



Which of the following is TRUE?

A. It computes 1's complement of the input number
B. It computes 2's complement of the input number
C. It increments the input number
D. it decrements the input number

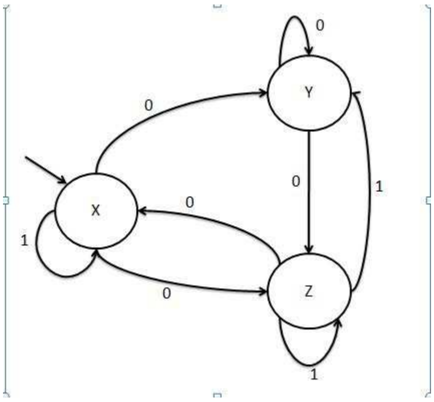
gate2005 theory-of-computation finite-automata easy

Answer

5.4.31 Finite Automata: GATE2005-IT-37 top

http://gateoverflow.in/3784

Consider the non-deterministic finite automaton (NFA) shown in the figure.



State X is the starting state of the automaton. Let the language accepted by the NFA with Y as the only accepting state be L1. Similarly, let the language accepted by the NFA with Z as the only accepting state be L2. Which of the following statements about L1 and L2 is TRUE?

A. L1 = L2
B. L1 ⊂ L2
C. L2 ⊂ L1
D. None of the above

gate2005-it theory-of-computation finite-automata normal

Answer

5.4.32 Finite Automata: GATE2005-IT-39 top

http://gateoverflow.in/3786

Consider the regular grammar:

S → Xa | Ya
X → Za
Z → Sa | ϵ
Y → Wa
W → Sa

where S is the starting symbol, the set of terminals is {a} and the set of non-terminals is {S, W, X, Y, Z}.
We wish to construct a deterministic finite automaton (DFA) to recognize the same language. What is the minimum number of states required for the DFA?

A. 2
B. 3
C. 4
D. 5

gate2005-it theory-of-computation finite-automata normal

Answer

5.4.33 Finite Automata: GATE2006-34 top

http://gateoverflow.in/1291

Consider the regular language $L = (111 + 11111)^*$. The minimum number of states in any DFA accepting this languages is:

A. 3
B. 5
C. 8
D. 9

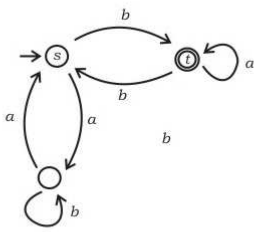
gate2006 theory-of-computation finite-automata normal

Answer

5.4.34 Finite Automata: GATE2006-IT-3 top

http://gateoverflow.in/3542

In the automaton below, s is the start state and t is the only final state.



Consider the strings u = abbaba, v = bab, and w = aabb. Which of the following statements is true?

A. The automaton accepts u and v but not w
B. The automaton accepts each of u, v, and w
C. The automaton rejects each of u, v, and w
D. The automaton accepts u but rejects v and w

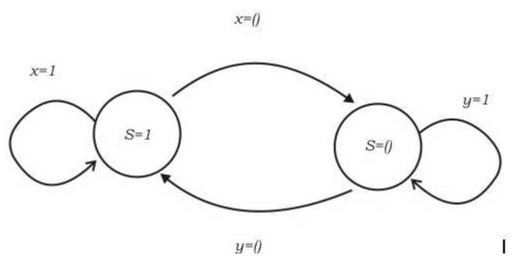
gate2006-it theory-of-computation finite-automata normal

Answer

5.4.35 Finite Automata: GATE2006-IT-37 top

http://gateoverflow.in/3576

For a state machine with the following state diagram the expression for the next state S^+ in terms of the current state S and the input variables x and y is



A. $S^+ = S' . y' + S . x$
B. $S^+ = S. x . y' + S' . y . x'$
C. $S^+ = x . y'$
D. $S^+ = S' . y + S . x'$

gate2006-it theory-of-computation finite-automata normal

Answer

5.4.36 Finite Automata: GATE2007-29 top

http://gateoverflow.in/1227

A minimum state deterministic finite automaton accepting the language $L = \{w \mid w \in \{0,1\}^*, \text{ number of } 0s \text{ and } 1s \text{ in } w \text{ are divisible by } 3 \text{ and } 5, \text{ respectively}\}$ has

A. 15 states
B. 11 states
C. 10 states
D. 9 states

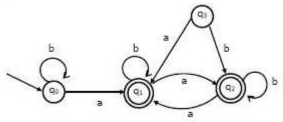
gate2007 theory-of-computation finite-automata normal

Answer

5.4.37 Finite Automata: GATE2007-74 top

http://gateoverflow.in/1270

Consider the following Finite State Automaton:



The language accepted by this automaton is given by the regular expression

A. $b^*ab^*ab^*ab^*$

B. $(a+b)^*$

C. $b^*a(a+b)^*$

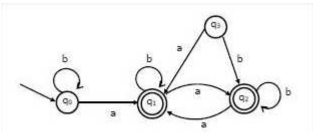
D. $b^*ab^*ab^*$

gate2007 theory-of-computation finite-automata normal

Answer

5.4.38 Finite Automata: GATE2007-75 top http://gateoverflow.in/43514

Consider the following Finite State Automaton



The minimum state automaton equivalent to the above FSA has the following number of states

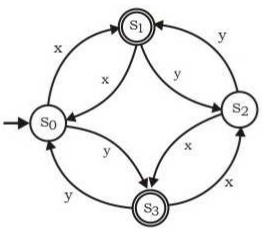
A. 1
B. 2
C. 3
D. 4

normal gate2007 theory-of-computation finite-automata

Answer

5.4.39 Finite Automata: GATE2007-IT-47 top http://gateoverflow.in/3489

Consider the following DFA in which s_0 is the start state and s_1, s_3 are the final states.



What language does this DFA recognize?

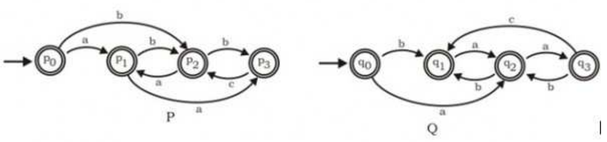
A. All strings of x and y
B. All strings of x and y which have either even number of x and even number of y or odd number of x and odd number of y
C. All strings of x and y which have equal number of x and y
D. All strings of x and y with either even number of x and odd number of y or odd number of x and even number of y

gate2007-it theory-of-computation finite-automata normal

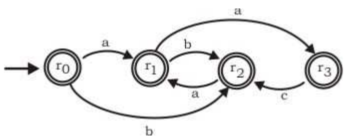
Answer

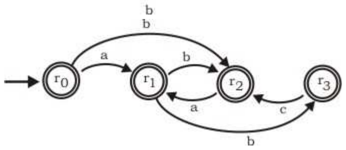
5.4.40 Finite Automata: GATE2007-IT-50 top http://gateoverflow.in/3492

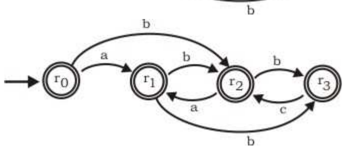
Consider the following finite automata P and Q over the alphabet {a, b, c}. The start states are indicated by a double arrow and final states are indicated by a double circle. Let the languages recognized by them be denoted by L(P) and L(Q) respectively.

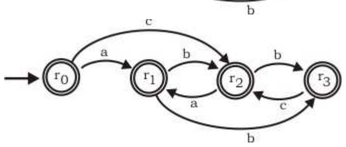


The automation which recognizes the language L(P) ∩ L(Q) is :

A. 

B. 

C. 

D. 

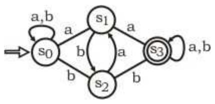
gatee2007-it theory-of-computation finite-automata normal

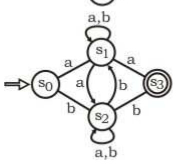
Answer

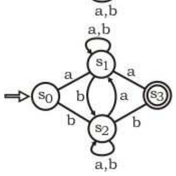
5.4.41 Finite Automata: GATE2007-IT-71 top http://gateoverflow.in/3523

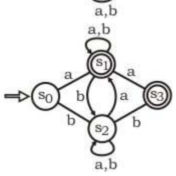
Consider the regular expression R = (a + b)* (aa + bb) (a + b)*

Which of the following non-deterministic finite automata recognizes the language defined by the regular expression R? Edges labeled λ denote transitions on the empty string.

A. 

B. 

C. 

D. 

gate2007-it theory-of-computation finite-automata normal

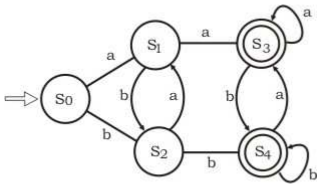
Answer

5.4.42 Finite Automata: GATE2007-IT-72 top http://gateoverflow.in/3524

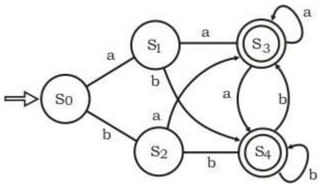
Consider the regular expression R = (a + b)* (aa + bb) (a + b)*

Which deterministic finite automaton accepts the language represented by the regular expression R?

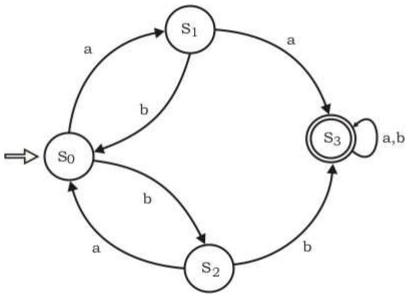
A.



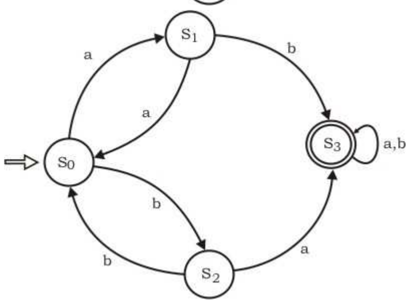
B.



C.



D.



gate2007-it theory-of-computation finite-automata normal

Answer

5.4.43 Finite Automata: GATE2008-49 top http://gateoverflow.in/462

Given below are two finite state automata ($\rightarrow$ indicates the start state and F indicates a final state)

Y:

	a	b
$\rightarrow$ 1	1	2
2 (F)	2	1

Z:

	a	b
$\rightarrow$ 1	2	2
2 (F)	1	1

Which of the following represents the product automaton $Z \times Y$?

A.

	a	b
$\rightarrow$ P	S	R
Q	R	S
R(F)	Q	P
S	Q	P

B.

	a	b
$\rightarrow$ P	S	Q
Q	R	S
R(F)	Q	P
S	P	Q

C.

	a	b
$\rightarrow$ P	Q	S
Q	R	S
R(F)	Q	P
S	Q	P

D.

	a	b
$\rightarrow$ P	S	Q
Q	S	R
R(F)	Q	P
S	Q	P

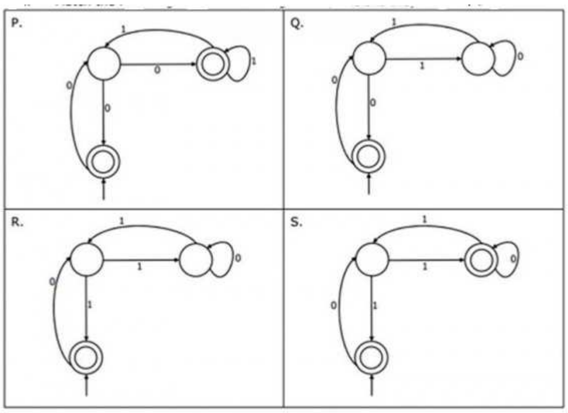
gate2008 normal theory-of-computation finite-automata

Answer

5.4.44 Finite Automata: GATE2008-52 top

http://gateoverflow.in/464

Match the following NFAs with the regular expressions they correspond to



1. $\epsilon + 0(01^*1 + 00)^*01^*$
2. $\epsilon + 0(10^*1 + 00)^*0$
3. $\epsilon + 0(10^*1 + 10)^*1$
4. $\epsilon + 0(10^*1 + 10)^*10^*$

A. P-2, Q-1, R-3, S-4
B. P-1, Q-3, R-2, S-4
C. P-1, Q-2, R-3, S-4

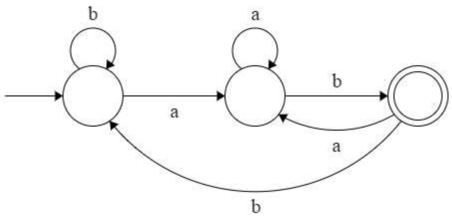
D. P-3, Q-2, R-1, S-4

gate2008 theory-of-computation finite-automata normal

Answer

5.4.45 Finite Automata: GATE2008-IT-32 top http://gateoverflow.in/3342

If the final states and non-final states in the DFA below are interchanged, then which of the following languages over the alphabet {a, b} will be accepted by the new DFA?



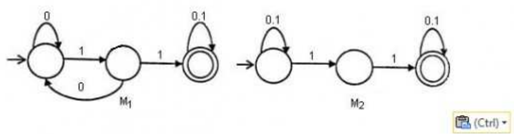
A. Set of all strings that do not end with ab
B. Set of all strings that begin with either an a or a b
C. Set of all strings that do not contain the substring ab,
D. The set described by the regular expression b*aa*(ba)*b*

gate2008-it theory-of-computation finite-automata normal

Answer

5.4.46 Finite Automata: GATE2008-IT-36 top http://gateoverflow.in/3346

Consider the following two finite automata. M_1 accepts L_1 and M_2 accepts L_2.
Which one of the following is TRUE?



A. $L_1 = L_2$
B. $L_1 \subset L_2$
C. $L_1 \cap L_2' = \emptyset$
D. $L_1 \cup L_2 \neq L_1$

gate2008-it theory-of-computation finite-automata normal

Answer

5.4.47 Finite Automata: GATE2008-IT-6 top http://gateoverflow.in/3266

Let N be an NFA with n states and let M be the minimized DFA with m states recognizing the same language. Which of the following in NECESSARILY true?

A. $m \leq 2^n$
B. $n \leq m$
C. M has one accept state
D. $m = 2^n$

gate2008-it theory-of-computation finite-automata normal

Answer

5.4.48 Finite Automata: GATE2009-27 top http://gateoverflow.in/1313

Given the following state table of an FSM with two states A and B,one input and one output.

PRESENT STATE A	PRESENT STATE B	Input	Next State A	Next State B	Output
0	0	0	0	0	1
0	1	0	1	0	0
1	0	0	0	1	0
1	1	0	1	0	0
0	0	1	0	1	0
0	1	1	0	0	1
1	0	1	0	1	1
1	1	1	0	0	1

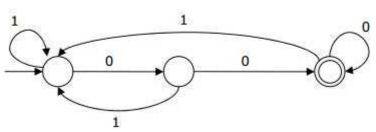
If the initial state is A=0 ,B=0 what is the minimum length of an input string which will take the machine to the state A=0,B=1 with output=1.

A. 3
B. 4
C. 5
D. 6

gate2009 theory-of-computation finite-automata normal

Answer

5.4.49 Finite Automata: GATE2009-41 top http://gateoverflow.in/1327



The above DFA accepts the set of all strings over {0,1} that

A. begin either with 0 or 1.

B. end with 0.

C. end with 00.

D. contain the substring 00.

gate2009 theory-of-computation finite-automata easy

Answer

5.4.50 Finite Automata: GATE2010-41 top

http://gateoverflow.in/2342

Let w be the any string of length n in $\{0,1\}^*$. Let L be the set of all substrings of w. What is the minimum number of states in non-deterministic finite automation that accepts L?

A. $n-1$
B. n
C. $n+1$
D. 2^{n-1}

gate2010 theory-of-computation finite-automata normal

Answer

5.4.51 Finite Automata: GATE2011_42 top

http://gateoverflow.in/2144

Definition of a language L with alphabet $\{a\}$ is given as following.

$$L = \{a^{nk} \mid k > 0, \; and \; n \text{ is a positive integer constant}\}$$

What is the minimum number of states needed in a DFA to recognize L?

(A) $k+1$

(B) $n+1$

(C) 2^{n+1}

(D) 2^{k+1}

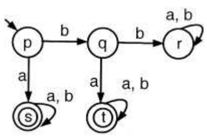
gate2011 theory-of-computation finite-automata normal

Answer

5.4.52 Finite Automata: GATE2011_45 top

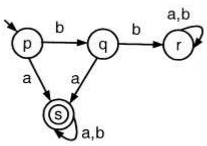
http://gateoverflow.in/2147

A deterministic finite automaton (DFA) D with alphabet $\Sigma = \{a, b\}$ is given below.

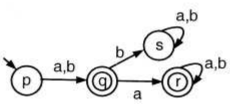


Which of the following finite state machines is a valid minimal DFA which accepts the same languages as D?

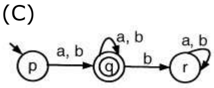
(A)



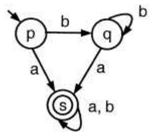
(B)



(C)



(D)



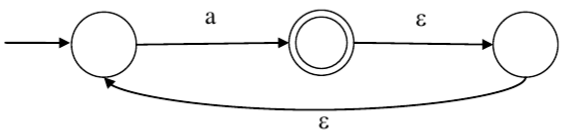
gate2011 theory-of-computation finite-automata easy

Answer

5.4.53 Finite Automata: GATE2012_12 top

http://gateoverflow.in/44

What is the complement of the language accepted by the NFA shown below?
Assume $\Sigma = \{a\}$ and ϵ is the empty string.



(A) ϕ
(B) $\{\epsilon\}$
(C) a^*
(D) $\{a, \epsilon\}$

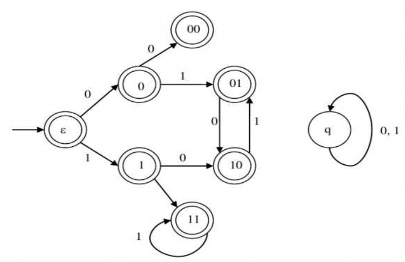
gate2012 finite-automata easy theory-of-computation

Answer

5.4.54 Finite Automata: GATE2012_46 top

http://gateoverflow.in/2159

Consider the set of strings on $\{0,1\}$ in which, *every substring of 3 symbols* has at most *two* zeros. For example, 001110 and 011001 are in the language, but 100010 is not. All strings of length less than 3 are also in the language. A partially completed DFA that accepts this language is shown below.



The missing arcs in the DFA are

(A)

	00	01	10	11	q
00	1	0			
01				1	
10	0				
11			0		

(B)

	00	01	10	11	q
00		0			1
01		1			
10				0	
11		0			

(C)

	00	01	10	11	q
00		1			0
01		1			
10			0		
11		0			

(D)

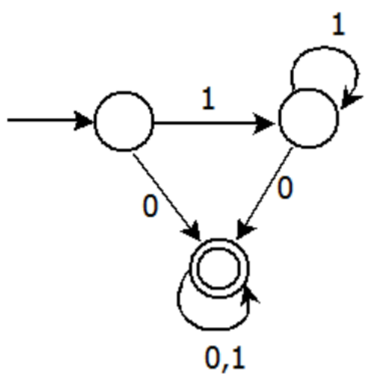
	00	01	10	11	q
00		1			0
01				1	
10	0				
11			0		

gate2012 theory-of-computation finite-automata normal

Answer

5.4.55 Finite Automata: GATE2013_33 top http://gateoverflow.in/1544

Consider the DFA A given below.



Which of the following are **FALSE**?

1. Complement of $L(A)$ is context-free.
2. $L(A) = L((11^*0 + 0)(0 + 1)^*0^*1^*)$
3. For the language accepted by A, A is the minimal DFA.
4. A accepts all strings over {0, 1} of length at least 2.

(A) 1 and 3 only

(B) 2 and 4 only

(C) 2 and 3 only

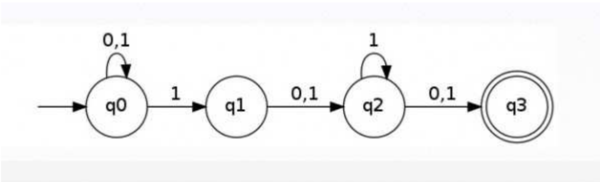
(D) 3 and 4 only

gate2013 theory-of-computation finite-automata normal

Answer

5.4.56 Finite Automata: GATE2014-1-16 top http://gateoverflow.in/1782

Consider the finite automaton in the following figure:



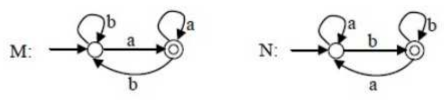
What is the set of reachable states for the input string 0011?

A. $\{q_0, q_1, q_2\}$
B. $\{q_0, q_1\}$
C. $\{q_0, q_1, q_2, q_3\}$
D. $\{q_3\}$

gate2014-1 theory-of-computation finite-automata easy

Answer

5.4.57 Finite Automata: GATE2015-1_52 top http://gateoverflow.in/8362



Consider the DFAs M and N given above. The number of states in a minimal DFA that accept the language L(M) ∩ L(N) is______________.

gate2015-1 theory-of-computation finite-automata easy numerical-answers

Answer

5.4.58 Finite Automata: GATE2015-2_53 top http://gateoverflow.in/8256

The number of states in the minimal deterministic finite automaton corresponding to the regular expression $(0+1)^*(10)$ is _____.

gate2015-2 theory-of-computation finite-automata normal numerical-answers

Answer

5.4.59 Finite Automata: GATE2015-3_18 top http://gateoverflow.in/8415

Let L be the language represented by the regular expression $\Sigma^* 0011 \Sigma^*$ where $\Sigma = \{0, 1\}$. What is the minimum number of states in a DFA that recognizes $\bar{L}$ (complement of L)?

A. 4
B. 5
C. 6
D. 8

gate2015-3 theory-of-computation finite-automata normal

Answer

5.4.60 Finite Automata: GATE2017-1-22 top http://gateoverflow.in/118302

Consider the language L given by the regular expression $(a+b)^*b(a+b)$ over the alphabet {a,b}. The smallest number of states needed in a deterministic finite-state automaton (DFA) accepting L is ___________ .

gate2017-1 theory-of-computation finite-automata numerical-answers

Answer

5.4.61 Finite Automata: GATE2017-2-25 top http://gateoverflow.in/118160

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 gate2017-2 finite-automata numerical-answers

Answer

5.4.62 Finite Automata: GATE2017-2-39 top http://gateoverflow.in/118384

Let δ denote the transition function and $\hat{\delta}$ denote the extended transition function of the ϵ-NFA whose transition table is given below:

δ	ϵ	a	b
$\rightarrow q_0$	$\{q_2\}$	$\{q_1\}$	$\{q_0\}$
q_1	$\{q_2\}$	$\{q_2\}$	$\{q_3\}$
$\{q_2\}$	$\{q_0\}$	$\emptyset$	$\emptyset$
q_3	$\emptyset$	$\emptyset$	$\{q_2\}$

Then $\hat{\delta}(q_2, aba)$ is

A. $\emptyset$
B. $\{q_0, q_1, q_3\}$
C. $\{q_0, q_1, q_2\}$
D. $\{q_0, q_2, q_3\}$

gate2017-2 theory-of-computation finite-automata

Answer

5.4.63 Finite Automata: ISI2011-CS-4b top http://gateoverflow.in/48157

Suppose $M = (Q, \Sigma, \delta, q_0, F)$ is a deterministic finite automaton, and suppose there exists a state $q \in Q$, a string $z \in \Sigma$, and integers $i, j > 0$ such that $\delta(q, z^i) = \delta(q, z^j) = q$. Prove that $\delta(q, z^{gcd(i,j)}) = q.$

descriptive isi2011 theory-of-computation finite-automata

Answer

5.4.64 Finite Automata: ISI2014-CS-4a top http://gateoverflow.in/47443

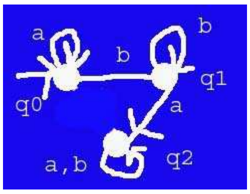
Construct a deterministic finite automaton accepting the following language: $\{w \in \{0,1\}^* : w \text{ has an equal number of 01's and 10's}\}$. For example, 101 is in the language because it contains one instance of 10 and one instance of 01 as well.

descriptive isi2014 theory-of-computation finite-automata

Answer

Answers: Finite Automata

5.4.1 Finite Automata: CMI2010-B-04b top http://gateoverflow.in/47073



consider above dfa in which

initial state = q0

final states = q0,q1

trap sate = q2

*language generated by above dfa is a*b* which is a infinite language*

n= 3 (number of states)

now consider string X={aaabbbb} i.e a^3b^4

|X| = 7

*now 2n= 2*3 = 6*

*3n = 3*3 = 9*

2n < |x| < 3n ===> 6< 7 <9
hence proved

2 votes -- Tauhin Gangwar (9.3k points)

5.4.2 Finite Automata: CMI2010-B-04c top http://gateoverflow.in/47074

Selected Answer

If a language L is accepted by an NFA with n states then there is a DFA with no more than 2^n states accepting .

This is correct statement. with [Proof.]

2 votes -- Manoj Kumar (37.5k points)

5.4.3 Finite Automata: CMI2012-B-02a top http://gateoverflow.in/46562

Selected Answer

Given that for a binary string $x = a_0 a_1 a_2 \cdots a_{n-1}$

$$val(x) = \sum_{i=0}^{n-1} 2^{n-1-i} \cdot a_i$$

Here, $val(x)$ is the decimal equivalent of the binary number x.

For Example,

$x = 1010$

$val(x) = 2^3 \cdot 1 + 2^2 \cdot 0 + 2^1 \cdot 1 + 2^0 \cdot 0$

$= 8 + 2 = 10$

They specified that

$\Sigma = \{(0,0)\ (0,1)\ (1,0)\ (1,1)\}$

That is every pair in the input $(a_0, b_0)(a_1, b_1) \ldots\ldots (a_{n-1}, b_{n-1})$ will take any one of these 4 possibilities.

Our task is to construct a Finite Automaton for the input such that

$val(b_0 b_1 \ldots b_{n-1}) = 2 \cdot val(a_0 a_1 \ldots a_{n-1})$

Consider an input

$\overset{a_0\, b_0}{(0,1)}\ \overset{a_1\, b_1}{(1,1)}\ \overset{a_2\, b_2}{(1,0)}\ \overset{a_3\, b_3}{(0,0)}$

$val(a_0 a_1 a_2 a_3) = val(0110) = 6$

$val(b_0 b_1 b_2 b_3) = val(1100) = 12$

Here, $val(b_0 b_1 b_2 b_3) = 2 \cdot val(a_0 a_1 a_2 a_3)$

So the input $(0,1)(1,1)(1,0)(0,0)$ should have to be accepted by the Finite Automaton.

Idea of constructing DFA:-

Note: The DFA should reject the input starting with 1.

Ex:- $(1,1)\ (0,1)\ (1,1)\ (0,0)$

Reason : It is not possible for the bit sequence $b_0b_1b_2 \cdots b_{n-1}$ to represent a value equal to twice the value of the sequence $a_0a_1a_2 \cdots a_{n-1}$ if $a_0 = 1$

If $a_0 = 1$, the number of bits required to represent the value equal to twice the value of $a_0a_1a_2 \cdots a_{n-1}$ is $n+1$

Ex :-

Let $n = 4$ and $a_0a_1a_2a_3 = (1000) = 8$

Number of bits required to represent 16 is 5 but the number of bits available is $b_0b_1b_2b_3$ which is 4.

So, the input should not start with 1

consider the example

$$\underset{a_0\ b_0}{(0,1)}\ \underset{a_1\ b_1}{(1,1)}\ \underset{a_2\ b_2}{(1,0)}\ \underset{a_3\ b_3}{(0,0)}$$

$(a_0a_1a_2a_3) = (0110) = 6$

$(b_0b_1b_2b_3) = (1100) = 12$

Here we can clearly see that

$b_0 = a_1$

$b_1 = a_2$

$b_2 = a_3$

$b_3 = 0$

This condition can be generalized as,

$b_0 = a_1$

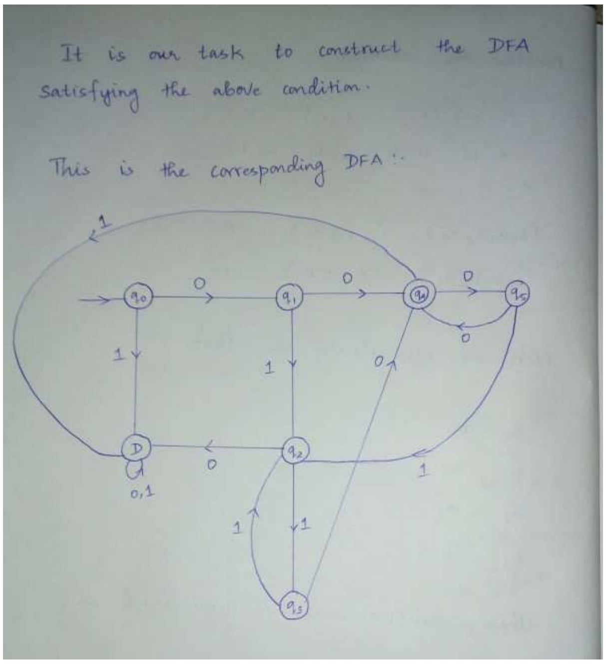
$b_1 = a_2$

$b_2 = a_3$

$\vdots$

$b_{n-2} = a_{n-1}$

$b_{n-1} = 0$



Regular expression is : 0 .(00 + 11)*.0

1 votes -- balaeinstein (917 points)

5.4.4 Finite Automata: GATE 2016-2-42 top http://gateoverflow.in/39591

Selected Answer

I , False, as in NFA, it is not necessary that all states have transitions for all symbols.

II True, there exists a regular language
$A = \{\}$, such that for all languages
B,
$A \cap B = \{\}$ is regular

So answer is option B.

41 votes -- Praveen Saini (53.6k points)

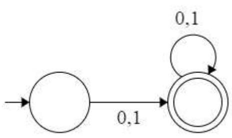
5.4.5 Finite Automata: GATE 2016-2_16 top http://gateoverflow.in/39562

Selected Answer

All strings over $\{0, 1\}$ having length ≥ 1

$(0+1)^*(0+1)(0+1)^* = (0+1)(0+1)^* = (0+1)^*(0+1) = (0+1)^+$

having DFA



No of states in minimal DFA $= 2$

30 votes -- Praveen Saini (53.6k points)

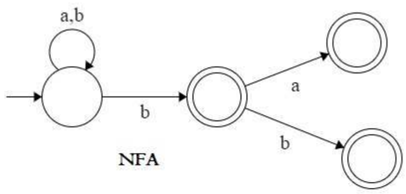
5.4.6 Finite Automata: GATE1987-2j top http://gateoverflow.in/80594

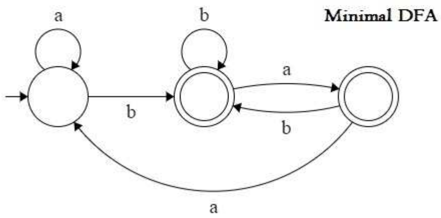
Selected Answer

No a minimal DFA that is equiavlent to an NDFA with n nodes has always 2^n states.

Correct statement is A minimal DFA that is equiavlent to an NDFA with n nodes has atmost 2^n states.

Example :





5 votes -- Prashant Singh (49.2k points)

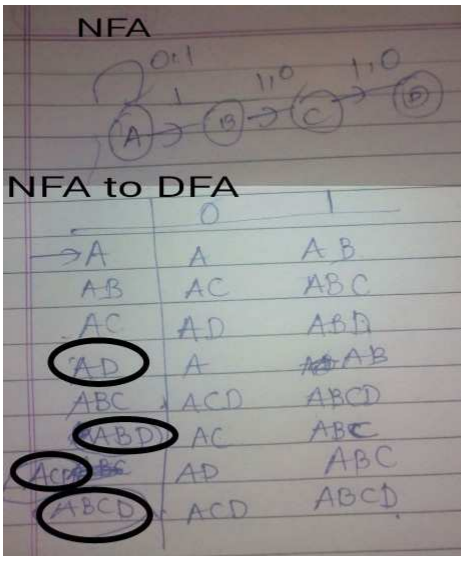
5.4.7 Finite Automata: GATE1991_17,b top http://gateoverflow.in/544

Selected Answer

Answer :-

Check following NFA. I've done subset construction too. 8 States are needed even after minimization..

Every state containing D is final state.



Third symbol from the right is a '1'. So, we can also consider Myhill-Nerode theorem here. Intuitively we need to remember the last 3 bits of the string each of which forms a different equivalence class as per Myhill-Nerode theorem as shown by the following table. Here, for any set of strings (in a row), we disntiguishes only the rows above it - as the relation is symmetric. Further strings in the language and not in the language are disntinguished separately as ϵ distinguishes them.

	Last 3 bits	Distinguishing string	In the language?
1	000		N
2	001	"00" - disntinguishes from strings in 1.	N
3	010	"0" - disntinguishes from strings in 1 and 2. "00" distinguishes from strings in 4.	N
4	011	"0" - distinguishes from strings in 1 and 2. "00" distinguishes from strings in 3.	N
5	100		Y
6	101	"00" disntinguishes from strings in 5.	Y
7	110	"0" distinguishes from strings in 5 and "00" distinguishes from strings in 6	Y
8	111	"00" distinguishes from strings in 5 and 7. "0" distinguishes from strings in 6.	Y

6 votes -- Akash (43.8k points)

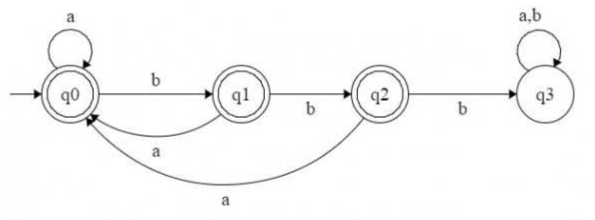
5.4.8 Finite Automata: GATE1993_27 top http://gateoverflow.in/2323

Selected Answer

Design a DFA that accepts all strings contain bbb

regular expression $(a+b)^*bbb(a+b)^*$

then take complement of DFA such that no string has 3 consecutive occurrences of the letter b.



having regular expression $(a+ba+bba)^*(\epsilon+b+bb)$

15 votes -- Praveen Saini (53.6k points)

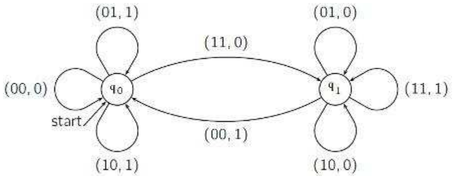
5.4.9 Finite Automata: GATE1994_3.3 top http://gateoverflow.in/2480

Selected Answer

Finite Automata (FA) or Finite State Machine to add two integers can be constructed using two states:

- ·q0: Start state to represent carry bit is 0
- q1: State to represent carry bit is 1

The inputs to FA will be pair of bits i.e. 00, 01, 10, and 11



The FA starts in state 1 (since carry is 0) and inputs a pair of bits. If the pair is 11, the FA outputs a 0 and switches to state 2 (since the carry is 1), where the next pair of bits is input and is added to a carry bit of 1.

Example: Consider the addition of 52 and 21
110100 - (binary representation of 52)
010101 - (binary representation of 21)

Since adding numbers is done from right to left, The first input symbol is 01, representing a 0 in the rightmost (binary) digit of 52 and a 1 in the rightmost digit of 21. The machine enters state q0 (since there is no carry) and outputs a 1. The next input is 00 because both numbers have zero as the second rightmost digit. The machine enters state q0 and outputs 0. The next input is 11. The machine enters state q1 (since the carry is 1) and outputs 0. Being in state q1 means that there is a carry from this position into the next. And the remaining bits can be worked out to get 1001001 (i.e. 73).

15 votes -- Saurav Kumar Gupta (2.1k points)

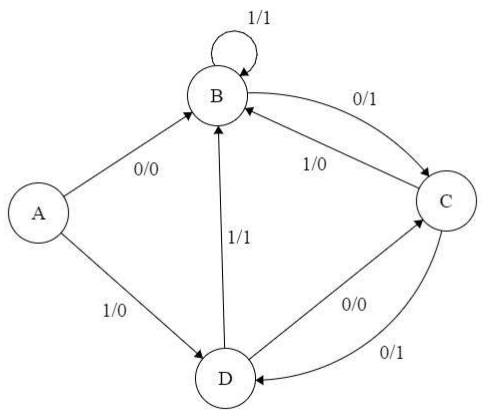
No. Perhaps that wont be possible to add any two arbitrary numbers because that will need a memory element which is not there in a FSM.

11 votes -- Gate Keeda (19.1k points)

5.4.10 Finite Automata: GATE1995_2.23 top

http://gateoverflow.in/2636

Selected Answer



if A is start state , shortest sequence is 10 or 00 to reach C

if B is start state , shortest sequence is 0 to reach C

if C is start state , shortest sequence is 10 or 00 to reach C

if D is start state , shortest sequence is 0 to reach C

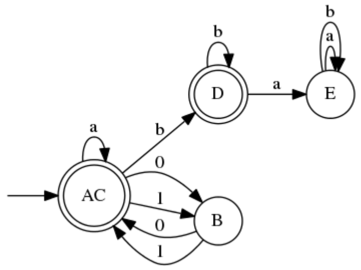
b) is correct.

👍 20 votes -- Praveen Saini (53.6k points)

5.4.11 Finite Automata: GATE1996_12 top

http://gateoverflow.in/2764

We can combine the final state of M_1 with the start state of M_2 as follows recognizing L_1L_2



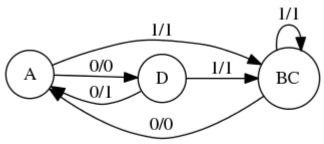
👍 5 votes -- Arjun Suresh (294k points)

5.4.12 Finite Automata: GATE1996_2.23 top

http://gateoverflow.in/2752

Selected Answer

3 states are required in the minimized machine. States B and C can be combined as follows:



👍 9 votes -- Arjun Suresh (294k points)

5.4.13 Finite Automata: GATE1997_20 top

http://gateoverflow.in/2280

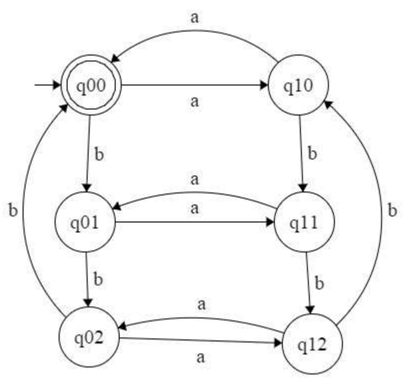
Selected Answer

A state q_{xy} means $n_a$mod2 =x , $n_b$mod3=y

q_{00} means $n_a$mod2 =0 , $n_b$mod3=0   [no of a's is divisible of 2 and no of b's are divisible of 3]

q_{00} x a $\rightarrow$ q_{10}

q_{00} x b$\rightarrow$ q_{01} and so on



9 votes -- Praveen Saini (53.6k points)

5.4.14 Finite Automata: GATE1997_21 top http://gateoverflow.in/2281

Selected Answer

Suppose we have a finite automation for L, then we can build a finite automation for L^P by marking all the states from which final state is reachable as the final states for new automaton, the reasoning is that suppose we can reach final state f form some state q, then that means there exists some string s' that takes automation from q to f, so if there is some string s that takes automation to state q from start state this string should belong to the new language L^P. (L^P is the set of all prefix strings for the string in L)

Also, we can obtain an automation for L^R by swapping the start and final states of original automation L and by reversing all the edges in the DFA.

15 votes -- Omesh Pandita (2.7k points)

5.4.15 Finite Automata: GATE1998_1.10 top http://gateoverflow.in/1647

Selected Answer

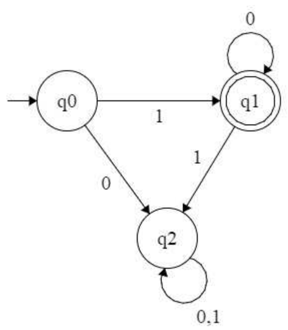
Option A is correct

A. is regular

$L = \{1, 10, 100, 1000, 10000, \dots\}$

regular expression 10^*

DFA :



B . $L = \{1, 11, 1111, 11111111, \dots\} = \{1^i \mid i = 2^n, n \geq 0\}$ is non regular language

C. Equal- Equal, is CFL, and non regular

D, $L = \{1^i 01^i \mid i > 0\} \cup \{1\}$ is also CFL, and non regular

👍 23 votes -- Praveen Saini (53.6k points)

5.4.16 Finite Automata: GATE1998_2.5 top

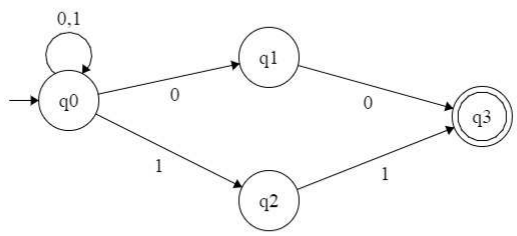
http://gateoverflow.in/1677

Selected Answer

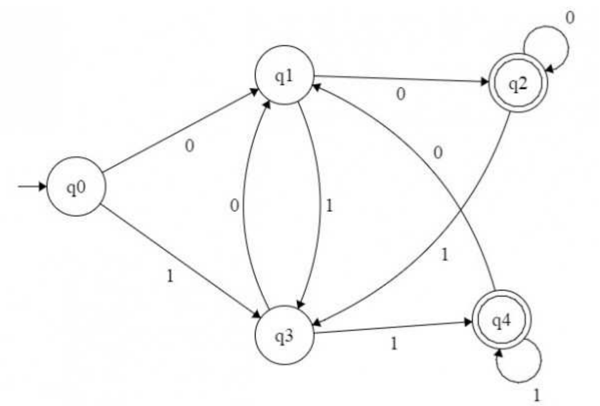
binary strings whose last two symbols are same

regular expression = (0+1)*(00+11)

Having NFA



Equivalent DFA



Total no of states = 5

👍 14 votes -- Praveen Saini (53.6k points)

5.4.17 Finite Automata: GATE1998_4 top

http://gateoverflow.in/1695

Selected Answer

suppose we have decimal no 3 after that we get a symbol 2 . it becomes 32 as 3 x 10 +2 = 32

in binary if we have 10 (i.e 2 in decimal say old no) and after that we get symbol 1 it become 101(i.e 5 in decimal say new no)

2 (old no.) x 2(base) +1(input symbol) = 5 (new no.)

Now in the given problem , binary no is divisible by 5 , i.e 0,101,1010,1111.....

We need 5 states in DFA , 0,1,2,3 and 4 .Each state represent remainder that comes when we divide no by 5.

input symbol = {0,1}

We get the transition

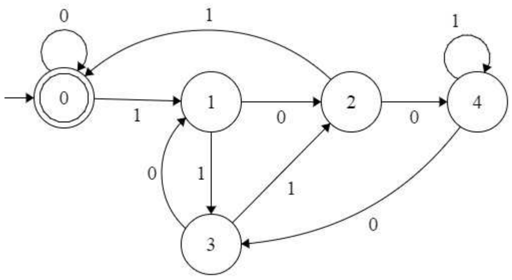
[Old state x base + input symbol] mod 5 = New state , where base is 2

[0 x 2 + 0]mod 5 = 0 [1 x 2 + 0]mod 5 = 2 [2 x 2 + 0]mod 5 = 4

[0 x 2 + 1]mod 5 = 1 [1 x 2 + 1]mod 5 = 3 [2 x 2 + 1]mod 5 = 0

[3 x 2 + 0]mod 5 = 1 [4 x 2 + 0]mod 5 = 3

[3 x 2 + 1]mod 5 = 2 [4 x 2 + 1]mod 5 = 4



12 votes -- Praveen Saini (53.6k points)

5.4.18 Finite Automata: GATE1999_1.4 top

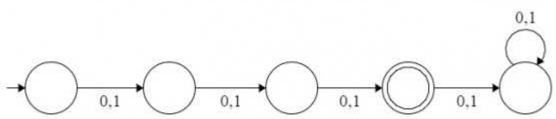
http://gateoverflow.in/1458

Selected Answer

As far as for above problem say regular expression for (0+1)(0+1)...3 times

=(0+1)(0+1)(0+1)

Having DFA



so for regular expression (0+1)(0+1)...N times have **N+2** states in DFA

N+1 states in NFA (we can remove dead state)

When question is about minimum state finite automata (and nothing is mentioned NFA/DFA) then which ever having minimum no.

N+1 states.

21 votes -- Praveen Saini (53.6k points)

5.4.19 Finite Automata: GATE2001-1.6 top

http://gateoverflow.in/699

Selected Answer

ans is B. 2^N.

In DFA any subset of the N states (for N element set 2^N subsets possible) can become a new state and they can remain even when the DFA is minimized. So, maximum we can get 2^N states for the minimized DFA. (at least in question must be a typo for at most).

9 votes -- jayendra (8.1k points)

5.4.20 Finite Automata: GATE2001-2.5 top

http://gateoverflow.in/723

Selected Answer

Answer is D. It can be proved using Myhill Nerode theorem. We need a separate state for #a mod 6 = 0..5 and #b mod 8 = 0..7. Each combination of them must also be a new state giving 6*8 = 48 minimum states required in the DFA.

Reading Myhill-Nerode theorem might be confusing though it is actually very simple.

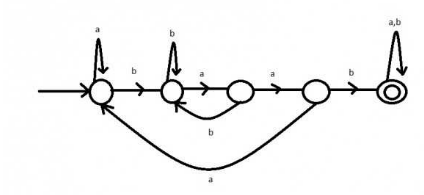
http://courses.cs.washington.edu/courses/cse322/05wi/handouts/MyhillNerode.pdf

13 votes -- Arjun Suresh (294k points)

5.4.21 Finite Automata: GATE2001-5 top

http://gateoverflow.in/746

DFA for A:



11 votes -- jayendra (8.1k points)

5.4.22 Finite Automata: GATE2002-2.13 top

http://gateoverflow.in/843

Selected Answer

it is 3 states as we need a state each for length mod 3 = 0, 1 and 2.

11 votes -- priya023 (217 points)

5.4.23 Finite Automata: GATE2002-2.5 top

http://gateoverflow.in/835

Selected Answer

answer should be option (A).

option (B) and (C) are clearly wrong . it says input 11 then o/p 01 and i/p 10 then o/p 00 but here at single bit o/p is 2 bit sequence

now for option (a) we can trace out .. suppose string is 0111

at A---0---> A----1---> B--1-->C---1-->C

O/P 00 01 10 10

we can see here at (A,0)---> (A,00) which sum of 0+0=00, (previous i/p bit + present i/p bit)

(A,1)--->(B,01) which is sum of 0+1= 1=01,

(B.1)--->(C,10) which is sum of 1+1= (previous i/p bit + present i/p bit)=10 ,

(C,1)---> (C,10) which is sum of 1+1=10

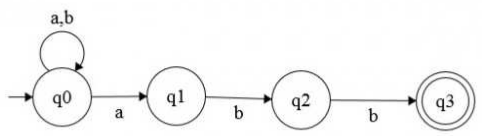
so answer should be (A).

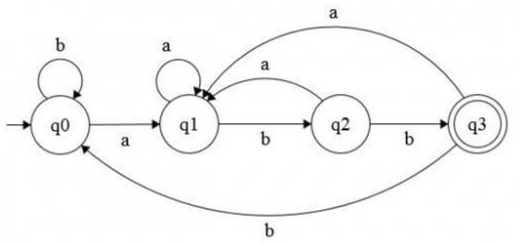
16 votes -- sonam vyas (13.2k points)

5.4.24 Finite Automata: GATE2002-21 top http://gateoverflow.in/874

Selected Answer

NFA for regular expression (a+b)*abb and its equivalent DFA will be as follow:





10 votes -- Praveen Saini (53.6k points)

5.4.25 Finite Automata: GATE2003-50 top http://gateoverflow.in/939

Selected Answer

Language of above DFA is all strings over {0,1} that contain substring 001.

Regular expression of above DFA is (0+1)*00<u>**1**</u>(0+1)*

1 that is underlined can not be first bit of 7-bit binary no, but can be fourth bit or last bit.

Case 1: if it is 4th bit ,then possible set of strings can be

First <u>001</u> **twobits** *Last* = **1** 00**1**(00+01+10+11)**1** = 4 strings

Case 2 : if it is last bit, then possible set of strings can be

First **twobits** *fourth* <u>001</u> = **1**(00+01+10+11)**1** 00**1** = 4 strings

String common in both cases **1**00**1**00**1**

Total strings = 4 + 4 - 1 = 7 strings

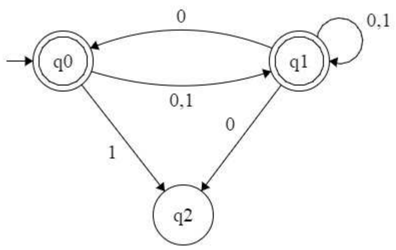
22 votes -- Praveen Saini (53.6k points)

5.4.26 Finite Automata: GATE2003-55 top http://gateoverflow.in/943

Selected Answer

Answer is B .

As the problem said



as in above NFA language L1 is {0,1}* . [we don't know L, we need not to find out]

option A is wrong as L is accepting 1 and L1 is also accepting 1

option C is wrong as L1 accepting ^,null, but L is not .

Option D is wrong for same reason as option C is wrong.

21 votes -- Praveen Saini (53.6k points)

5.4.27 Finite Automata: GATE2004-86 top

http://gateoverflow.in/1080

Selected Answer

Option c and option d are cancelled out clearly because with 3 1s we can reach the final state ...there is an string where we can reach the final state by 6 1's now 6 is nt odd but it is divisivble by 3 hence option a is correct

10 votes -- Bhagirathi Nayak (13.3k points)

5.4.28 Finite Automata: GATE2004-IT-41 top

http://gateoverflow.in/3684

Selected Answer

δ(A, a) = A,	A →aA
δ(A, b) = B,	A →bB
δ(B, a) = B	B →aB
δ(B, b) = A	B →bA
B is final state so	B → ε

12 votes -- Praveen Saini (53.6k points)

5.4.29 Finite Automata: GATE2005-53 top

http://gateoverflow.in/1376

Selected Answer

A is Wrong, since abbb is accepted. (1 a is followed by more than 2 bs)

C is Wrong, since abba contains abb as substring, but is still not accepted.

D is Wrong, since ab does not contain aa as substring, but is still not accepted.

Hence correct answer is B.

👍 16 votes -- saurabhrk (1.5k points)

5.4.30 Finite Automata: GATE2005-63 top

http://gateoverflow.in/1386

Selected Answer

answer = **option B**

for any binary no, FSM read input from LSB and remain unchanged till first 1, and it complement after that

100 -> **100** [1's complement of 100 + 1 = 011+ 1 = 100 = 2's complement of 100]

0**10** -> 1**10** [1's complement of 010 + 1 = 101 + 1 = 110 = 2's complement of 010]

1010**100** -> 0101**100** [1's complement of 1010100 + 1 = 0101011+ 1 = 0101100]

Note : Underline part is unchanged (till first 1 from lsb) then 0's changed to 1's and 1's changed to 0's

👍 9 votes -- Praveen Saini (53.6k points)

5.4.31 Finite Automata: GATE2005-IT-37 top

http://gateoverflow.in/3784

Selected Answer

Misprints : Edge Y -> Z (0 edge)
Edge Z -> Y (1 edge)

Answer: A

Explanation:

Writing Y and Z in terms of incoming arrows (Arden's method) :

Y = X0 + Y0 + Z1

Z = X0 + Z1 + Y0

Hence Y=Z. So, option (A).

👍 5 votes -- Dipak Majhi (865 points)

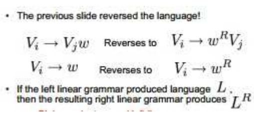
5.4.32 Finite Automata: GATE2005-IT-39 top

http://gateoverflow.in/3786

Selected Answer

S → Xa | Ya
X → Za
Z → Sa | ϵ
Y → Wa
W → Sa

This is left linear grammar having language **L**. Convert it into right linear using following rule :

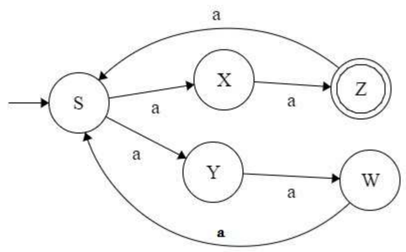


S → aX | aY
X → aZ
Z → aS | ϵ
Y → aW

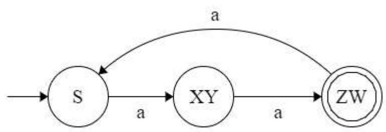
W → aS

is right linear grammar having language $\mathbf{L^R}$.

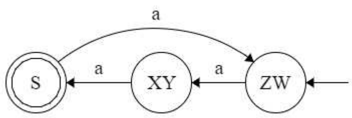
having NFA



Having DFA for language $\mathbf{L^R}$



DFA for language L (reversal)



L = { w : n_a(w)mod3 =2 , w belong to {a,b}* } same as Omesh Pandita answered

having 3 states

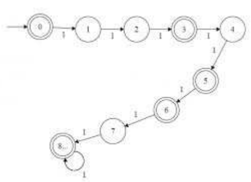
16 votes -- Praveen Saini (53.6k points)

5.4.33 Finite Automata: GATE2006-34 top

http://gateoverflow.in/1291

Selected Answer

Given language L = (111 + 11111)*
Strings , that belongs in the language
L = {null , 111 , 11111, 111111 , 11111111 , 111111111 , 1111111111 , ... form string length 8 , (number of 1's) , you can generate any length of string from length 3 and 5 (i.e. length 8 ,length 9, length 10 , length 11 ,.....etc)}
L = {null , 111 , 11111, 111111 , 11111111 , 111111111* }
Strings in length , that belongs in the language
L = {0 ,3, 5, 6, 8, 9, 10, 11, ...}
so , required DFA will be ,



So , there are 5 states are final states and 4 states are non-final states ,total number of states are 9 states .
hence option D is true.

19 votes -- Mithlesh Upadhyay (5.4k points)

there will be 9 states. with 1st,4th,6th,7th and 9th state being the final states. with a loop on the ninth state.

{0,3,5,6,8,9,10,11,12,........} this is the set which will be accepted by the min dfa for this expression.

11 votes -- Gate Keeda (19.1k points)

5.4.34 Finite Automata: GATE2006-IT-3 top

http://gateoverflow.in/3542

Selected Answer

for u	for v	for w
δ(s,abbaba)	δ(s,bab)	δ(s,aabb)
$\vdash\delta$(x,bbaba)	$\vdash\delta$(t,ab)	$\vdash\delta$(x,abb)
$\vdash\delta$(x,baba)	$\vdash\delta$(t,b)	$\vdash\delta$(s,bb)
$\vdash\delta$(x,aba)	**⊦ s - rejected**	$\vdash\delta$(t,b)
$\vdash\delta$(s,ba)		**⊦ s - rejected**
$\vdash\delta$(t,a)		
⊦t - accepted		

12 votes -- Praveen Saini (53.6k points)

5.4.35 Finite Automata: GATE2006-IT-37 top

http://gateoverflow.in/3576

Selected Answer

Answer is (A)

For S is 1 only when: Either (S=1 and x=1) OR (s=0 and y=0)

Therefor S(next) = S'y'+Sx

9 votes -- Sandeep_Uniyal (7.3k points)

Present State	Inputs		Next state
S	***x***	***y***	***S***$^+$
0	X	0	1
0	X	1	0
1	0	X	0
1	1	X	1

from above table

S^+ = S'y'+Sx

19 votes -- Praveen Saini (53.6k points)

5.4.36 Finite Automata: GATE2007-29 top

http://gateoverflow.in/1227

Selected Answer

Answer will be (A) 15 states.

We need a separate state for #0 = 0, 1, 2 and #1 = 0, 1, 2, 3, 4 giving total minimum number of states = 3 * 5 = 15.

This is a direct consequence of Myhill-Nerode theorem.

http://courses.cs.washington.edu/courses/cse322/05wi/handouts/MyhillNerode.pdf

6 votes -- Arjun Suresh (294k points)

5.4.37 Finite Automata: GATE2007-74 top http://gateoverflow.in/1270

Selected Answer

The answer for 74 is C.

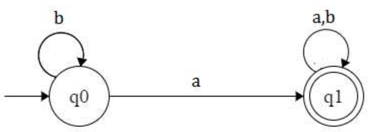
You can see that both the states, Q1 and Q2 are final and are accepting $(a+b)^*$.

9 votes -- Gate Keeda (19.1k points)

5.4.38 Finite Automata: GATE2007-75 top http://gateoverflow.in/43514

Selected Answer

Ans will be 2 state



8 votes -- Manoj Kumar (37.5k points)

5.4.39 Finite Automata: GATE2007-IT-47 top http://gateoverflow.in/3489

Selected Answer

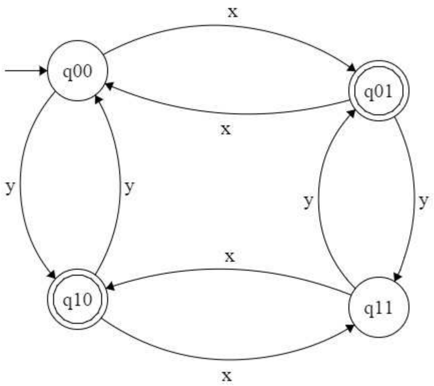
Above DFA can be redesigned as [S0 as q00, S1 as q10 , S2 as q11, S3 as q01]

where , each state as q_{ab} [a = $n_a$mod2 , b = $n_b$mod2]

q00 as $n_a$mod2 =0 $n_b$mod2=0 [no of x is even no of y is even]

and ∂(q00, x) -> q10 [(0+1)mod2 =1 as x increase from 0 to 1] ∂(q00, y) -> q01

and ∂(q10, x) -> q00 [(1+1)mod2 =0] ∂(q00, y) -> q01 and soon



q01 is final state mean where no of x is even and no of y is odd

q10 is final state mean where no of x is odd and no of y is even.

so D is correct answer

10 votes -- Praveen Saini (53.6k points)

5.4.40 Finite Automata: GATE2007-IT-50 top http://gateoverflow.in/3492

Selected Answer

Design a DFA using P and Q having p0q0 as start state

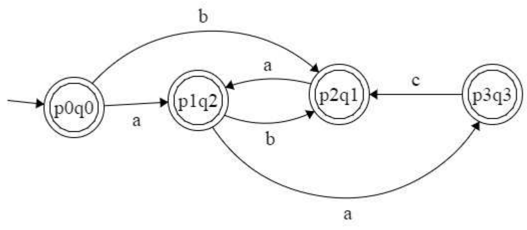
δ(p0q0,a) -> δ(p0,a)$\cup$ δ(q0,a)

Q \ $\sum$	a	b	c
→p0q0*	p1q2	p2q1	
p1q2*	p3q3	p2q1	
p2q1*	p1q2	p3 (No Need)	
p3q3*		q2(No Need)	p2q1

In case of intersection final state are those where final state of P and final state of Q comes together.

No Need mean when we reach to p3 (or q2)then we cannot reach to any final state bcoz we cannot have state of P and Q together (intersection) so no need to show it in diagram [may draw a dead state for it if required]

DFA results in



That is Option A

Note : i) DFA must have transition for each symbol Q X$\sum \rightarrow$ Q

15 votes -- Praveen Saini (53.6k points)

See the languages being accepted by P and Q. In P before a 'c' there must be either 'b' or 'aa'. In Q, before 'c' there must be 'aa'. So, obviously, in their intersection before 'c' there must be 'aa' which is satisfied only by option A.

10 votes -- Arjun Suresh (294k points)

5.4.41 Finite Automata: GATE2007-IT-71 top

http://gateoverflow.in/3523

Selected Answer

when we say non-deterministic finite automata recognizes the language defined by the regular expression R then it means that it won't accept any other string that does not fall under the R and it will only accept all strings that fall under R.

so we see B. accepts **aba** ,C. accepts **aba** ,D. accepts **a** just find some examples that do not follow the rule .. so option a is correct..

5 votes -- Shreya Roy (3.7k points)

5.4.42 Finite Automata: GATE2007-IT-72 top

http://gateoverflow.in/3524

Selected Answer

DFA given in option A

having S3 and S4 are equivalent states .. that can minimized.

and result in DFA given in

http://gateoverflow.in/3523/gate2007-it_71

11 votes -- Praveen Saini (53.6k points)

5.4.43 Finite Automata: GATE2008-49 top

http://gateoverflow.in/462

Selected Answer

	a	**b**

→11 (P)	12	22
12 (S)	11	21
21 (Q)	22	12
22 (F) (R)	21	11

So, 11 is P and 22 is R in choice. So, the answer should be (A) but in the row for S, it should be P and Q and not Q and P.

15 votes -- Arjun Suresh (294k points)

5.4.44 Finite Automata: GATE2008-52 top http://gateoverflow.in/464

Selected Answer

$S-4$ is confirmed

$R-3$ is true coz everything it accepts ends with 1; this is made mandatory only by 3
this rules out option B and option D

use string 01010 and compare P Vs Q; this makes $Q-2$ as confirmed.

hence, **option C** is correct.

7 votes -- Amar Vashishth (28.7k points)

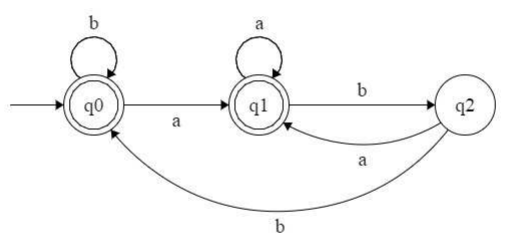
5.4.45 Finite Automata: GATE2008-IT-32 top http://gateoverflow.in/3342

Selected Answer

Above DFA is for regular expression (a+b)*ab . All strings end with ab.

Complement of DFA accepts all strings does not end with ab.

DFA(L') is



B. String begin with either a or b.

ab (string start with a) doesnt accept in it reach to nonfinal state q2.

bab (string start with b) doesnt accept in it reach to nonfinal state q2.

C. Set of strings that do not contain the substring ab

aba (have substring ab) does accept in it reach to final state q1.

D. The set described by the regular expression b*aa*(ba)*b*

b is string accepted by DFA(L') but above regular expression cannot derive it.

Option A is correct.

DFA (L') accepts all strings that doesnt end with ab.

16 votes -- Praveen Saini (53.6k points)

5.4.46 Finite Automata: GATE2008-IT-36 top

http://gateoverflow.in/3346

Selected Answer

L1: (0 + 10)*11(0 + 1)* L2: (0 + 1)*11(0 + 1)* it is quite clear that L1 = L2..

As both languages L1 and L2 are equal So Complement of Language L2 will be the complement of Language L1 also. For a given language L, L $\bigcap L^C = \Phi$

Hence, both options (A) and (C) are correct.

19 votes -- Vicky Bajoria (4.9k points)

5.4.47 Finite Automata: GATE2008-IT-6 top

http://gateoverflow.in/3266

Selected Answer

A state in a DFA will be a subset of the set of states of the equivalent NFA. So, the maximum number of states in the equivalent DFA of an NFA, will be 2^n, where n is the number of states in NFA, as a set with n items has maximum 2^n subsets.

So, answer here is (A).

12 votes -- Arjun Suresh (294k points)

5.4.48 Finite Automata: GATE2009-27 top

http://gateoverflow.in/1313

Selected Answer

From above table , We look at Next state part

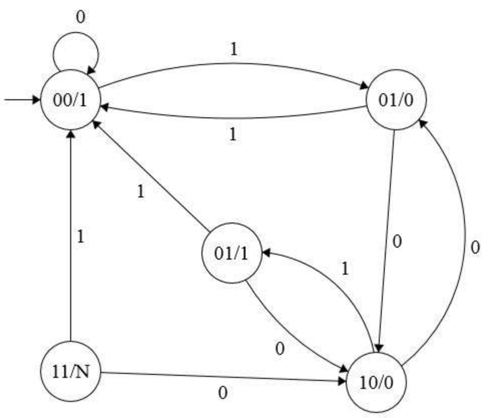
whenever we reach state 00 we get output 1 [at row 1,row 6, row 8], ***so we have state 00 with output 1***

when we reach at state 01, we get output 0 [at row 3, row 5] and output 1 [row 7],***so we have two state 01 with output 0 , 01 with output 1***

when we reach at state 10, we get output we get output 0 [at row 2, row 4],***so we have state 10 with output 0.***

We dont reach at state 11 [11 is not there in next state part], but ***we have state 11 with don't know (N) output.***

if we draw the Moore Machine for above FSM [from the table: present state x input symbol -> next state]



It is clear from FSM from state 00 to reach state 01 with output 1 i.e, 01/1 with need**minimum length input 101**

minimum length of input = length of 101 **that is 3**

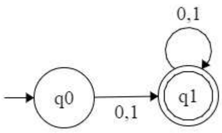
👍 11 votes -- Praveen Saini (53.6k points)

5.4.49 Finite Automata: GATE2009-41 top http://gateoverflow.in/1327

Selected Answer

A) begin either with 0 or 1

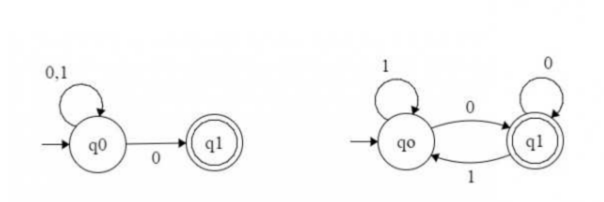
Regular expression (0+1)(0+1)* [begin with 0 or 1 *Anything*]



b) end with 0

regular expression = (0+1)*0 [*Anything* end with 0]

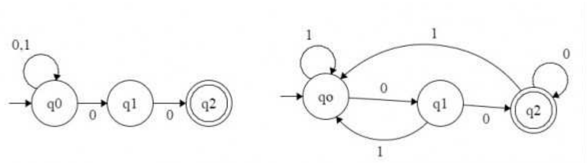
NFA Equivalent DFA



c) end with 00

regular expression (0+1)*00 [*Anything* end with 00]

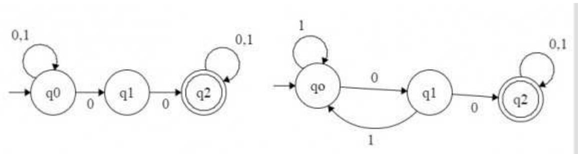
NFA Equivalent DFA



d) containing the substring

regular expression = (0+1)*00(0+1)* [*Anything* substring 00 *Anything*]

NFA Equivalent DFA



So C is the correct answer

👍 16 votes -- Praveen Saini (53.6k points)

5.4.50 Finite Automata: GATE2010-41 top http://gateoverflow.in/2342

Selected Answer

We need a state for counting the length. So, for length n we need n+1 states (one for length zero). We don't need a reject state for larger strings as we have NFA and not DFA. So, totally n+1 states are required. (For DFA it would be n+2).

28 votes -- Arjun Suresh (294k points)

5.4.51 Finite Automata: GATE2011_42 top

http://gateoverflow.in/2144

Selected Answer

(B) n+1
We need a state for strings of length 0, 1, 2, ... n (and their respective multiples with k). Each of these set of strings form an equivalence class as per Myhill-Nerode relation and hence needs a separate state in min-DFA.

Myhill-Nerode Class 1	**Myhill-Nerode Class 2 ...**	**Myhill-Nerode Class n**	**Myhill-Nerode Class n+1**
∈	a, #a = n+1, #a = 2n+1, ...	#a = n-1, #a = 2n-1, #a = 3n-1, ...	#a = n, #a = 2n, #a = 3n, ...

One thing to notice here is $k > 0$. Because of this we are not able to combine Class 1 and Class n+1. Had it been $k \geq 0$, we would have had only n equivalent classes and equivalently n states in the minimal DFA.

13 votes -- Arjun Suresh (294k points)

5.4.52 Finite Automata: GATE2011_45 top

http://gateoverflow.in/2147

Selected Answer

(A) is the answer.

In (B) and (C) when the first letter of input is 'b' we reach final state, while in the given DFA first letter 'b' is not a final state. So, (B) and (C) are not accepting same language as the given DFA.

In (D) we can reach final state when the last letter is 'a', whatever be the previous transitions. But in the given DFA, when the first 2 letters are 'b' we can never reach the final state. So, (D) is also accepting a different language than the given DFA.

16 votes -- Arjun Suresh (294k points)

5.4.53 Finite Automata: GATE2012_12 top

http://gateoverflow.in/44

Selected Answer

The language being accepted is a^+. So, complement of the language is $\{\epsilon\}$.

22 votes -- Arjun Suresh (294k points)

5.4.54 Finite Automata: GATE2012_46 top

http://gateoverflow.in/2159

Selected Answer

(D) is the answer. From 00 state, a '0' should take the DFA to the dead state-q. From 11, a '0' should go to 10 representing the 10 at the end of string so far. Similarly, from 00 a 1 should go to 01, from 01 a '1' should go to 11 and from 10 a '0' should go to '00'.

12 votes -- Arjun Suresh (294k points)

5.4.55 Finite Automata: GATE2013_33 top

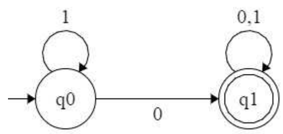
http://gateoverflow.in/1544

Selected Answer

1. Complement of L(A) (regular language) is regular , i.e also Context Free . True

2. Regular expression is (11*0 +0)(0+1)* True

3 . Minimized DFA is [both non-final states are equivalents can be minimized]



So 3 is False

4. From 3, shortest length string reached from q0 to q1(final) is 0, so 4 is false

Note : a) (0+1)*0*1* = (0+1)* +something =(0+1)*

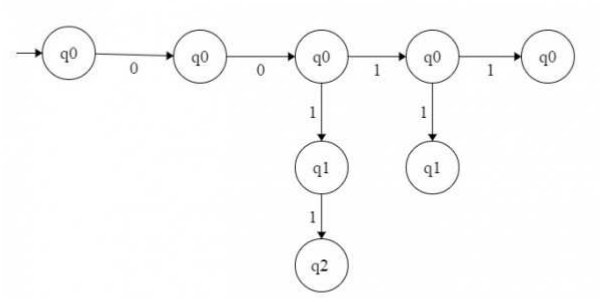
b) (11*0+0)(0+1)* = (11*+ ^)0(0+1)* =1*0(0+1)* look at Minimized DFA at 3.

24 votes -- Praveen Saini (53.6k points)

5.4.56 Finite Automata: GATE2014-1-16 top

http://gateoverflow.in/1782

Selected Answer



q0, q1 and q2 are reachable from q0 on input 0011

15 votes -- Praveen Saini (53.6k points)

5.4.57 Finite Automata: GATE2015-1_52 top

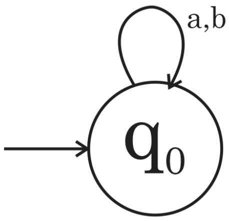
http://gateoverflow.in/8362

Selected Answer

L(M) = (a+b)* a = {a, aa, ba, aaa, aba, bba, ...}

L(N) = (a+b)* b = {b, ab, bb, aab, abb, bbb, ...}

So, L(M) ∩ L(N) = {}. So, in the minimal DFA, we just have 1 start state with all transitions going to it self and no final state.



👍 46 votes -- Arjun Suresh (294k points)

5.4.58 Finite Automata: GATE2015-2_53 top

http://gateoverflow.in/8256

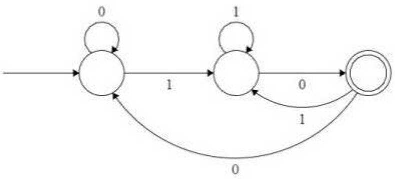
Selected Answer

All strings ending with 10. So, we need 3 states.

1. From first state on 1, we go to second state.
2. From second state on 0 we go to third state.
3. From third state on 0 we go to first state and on 1 we go to second state.

Only third state is final.

`L = (0+1)*10` And following minimal DFA will be



👍 17 votes -- Arjun Suresh (294k points)

5.4.59 Finite Automata: GATE2015-3_18 top

http://gateoverflow.in/8415

Selected Answer

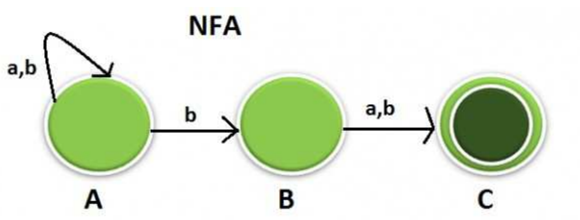
first we can draw dfa for L which has 5 states after that for L compliment we will convert all final to non final and all non final to final so total states is 5 .. option B

👍 24 votes -- Anoop Sonkar (4.9k points)

5.4.60 Finite Automata: GATE2017-1-22 top

http://gateoverflow.in/118302

Selected Answer



.

NFA to DFA Conversion:
In the STT below you can see **4 states** are there but before confirming the ans **lets try to minimize**, It cant be minimized further because A goes to Nonfinal Nonfinal & AB goes to Final Final hence can not be merged. Similarly *AC goes NF NF & *ABC goes to F F hence can not be merged. **Hence 4 is the final ans**.

Delta	a	b
A	A	AB
AB	*AC	*ABC
*AC	A	AB
*ABC	*AC	*ABC

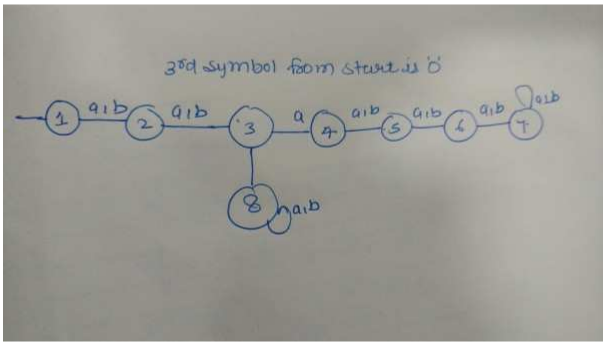
11 votes -- Ahwan Mishra (5.3k points)

5.4.61 Finite Automata: GATE2017-2-25 top

http://gateoverflow.in/118160

Selected Answer

Answer is 8 states included one trap state**(8)** and final state**(7)**.

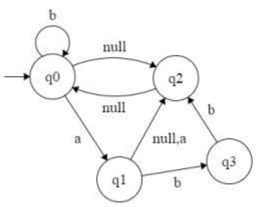


16 votes -- Prashant Singh (49.2k points)

5.4.62 Finite Automata: GATE2017-2-39 top

http://gateoverflow.in/118384

Selected Answer



C is answer.

9 votes -- Prashant Singh (49.2k points)

the transition is nothing but $(((Q_2,a),b),a)$

now applying Q2,a we go to Q_0 but as lamda transition is there so it will also go to Q2

so now $\{(Q_0,Q2),b\} = Q_0,Q2$

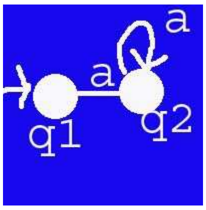
now{(Q_0,,Q2),a}=Q_0,Q_1,Q2

so C should be correct answer here

12 votes -- Aboveallplayer (18.5k points)

5.4.63 Finite Automata: ISI2011-CS-4b top http://gateoverflow.in/48157

consider the dfa whose language "strings which contains atleast one a" over Σ={a}



here q2 is final state

consider a string (q2,a^8)=(q2,a^{12})=q2

now (q2, $a^{gcd(8,12)}$)==> (q2, a^4)==q2

as gcd of 8,12 is 4...

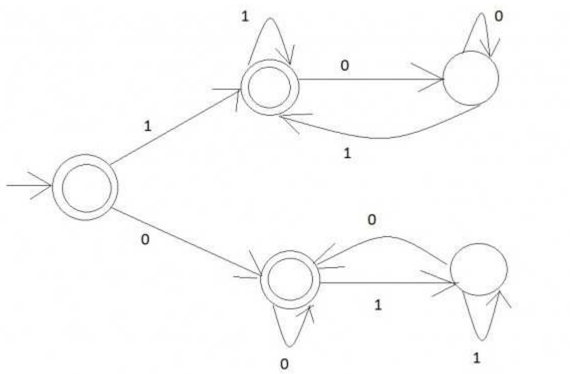
and a^4 also goes to q2 hence proved

3 votes -- Tauhin Gangwar (9.3k points)

5.4.64 Finite Automata: ISI2014-CS-4a top http://gateoverflow.in/47443

Selected Answer

The DFA for that language w is



7 votes -- srestha (58.4k points)

5.5 Grammar(2) top

5.5.1 Grammar: GATE2008-51 top http://gateoverflow.in/463

Match the following:

E.	Checking that identifiers are declared before their use	P.	

			$L = \{a^n b^m c^n d^m \mid n \geq 1, m \geq 1\}$
F.	Number of formal parameters in the declaration of a function agrees with the number of actual parameters in a use of that function	Q.	$X \rightarrow XbX \mid XcX \mid dXf \mid g$
G.	Arithmetic expressions with matched pairs of parentheses	R.	$L = \{wcw \mid w \in (a \mid b)^*\}$
H.	Palindromes	S.	$X \rightarrow bXb \mid cXc \mid \epsilon$

A. E-P, F-R, G-Q, H-S
B. E-R, F-P, G-S, H-Q
C. E-R, F-P, G-Q, H-S
D. E-P, F-R, G-S, H-Q

gate2008 normal theory-of-computation grammar

Answer

5.5.2 Grammar: ISI2013-CS-4a top http://gateoverflow.in/47637

Give a context-free grammar G that generates $L = \{0^i 1^j 0^k \mid i + k = j\}$. Prove that $L = L(G)$.

descriptive isi2013 context-free-language grammar theory-of-computation

Answer

Answers: Grammar

5.5.1 Grammar: GATE2008-51 top http://gateoverflow.in/463

Selected Answer

$H - S$ is true coz strings generated by this grammar satisfies the definition of an even length palindrome string. this rules out B and D options.

$G - Q$ is confirmed as both options A and C has it as true.

$E - R$ is true coz R is the only grammar that checks: what(w) has occurred earlier is present afterwards This equals the definition of E

Hence, **option C** is true.

14 votes -- Amar Vashishth (28.7k points)

5.5.2 Grammar: ISI2013-CS-4a top http://gateoverflow.in/47637

Selected Answer

$L = \{0^i 1^j 0^k \mid j = i + k, i, j, k \geq 0\} = \{\epsilon, 0110, 011100, 001110, \ldots\ldots\ldots\ldots\}$

Now $L = \{0^i 1^{i+k} 0^k \mid i, k \geq 0\}$

Here CFG will be

$S \rightarrow S_1 S_2$

$S_1 \rightarrow 0 S_1 1 | \epsilon$

$S_2 \rightarrow 1S_20|\epsilon$

7 votes -- srestha (58.4k points)

5.6 Identify Class Language(30) top

5.6.1 Identify Class Language: CMI2010-A-01 top http://gateoverflow.in/46131

Over the alphabet $\{0, 1\}$, consider the language

$L = \{w | \ w \text{ does not contain the substring } 0011\}$
Which of the following is true about L.

A. L is not context free
B. L is regular
C. L is not regular but it is context free
D. L is context free but not recursively enumerable

cmi2010 theory-of-computation identify-class-language

Answer

5.6.2 Identify Class Language: GATE1988-2ix top http://gateoverflow.in/93949

What is the type of the language L, where $L = \{a^nb^n \mid 0 < n < 327\text{-th prime number}\}$

gate1988 normal descriptive algorithms theory-of-computation identify-class-language

Answer

5.6.3 Identify Class Language: GATE1991-17,a top http://gateoverflow.in/26653

Show that the Turing machines, which have a read only input tape and constant size work tape, recognize precisely the class of regular languages.

gate1991 theory-of-computation descriptive identify-class-language

Answer

5.6.4 Identify Class Language: GATE1994_19 top http://gateoverflow.in/2515

(a) Given a set

$$S = \{x \mid \text{ there is an x-block of 5's in the decimal expansion of } \pi\}$$

(Note: x-block is a maximal block of x successive 5's)

Which of the following statements is true with respect to S? No reason to be given for the answer.

i. S is regular
ii. S is recursively enumerable
iii. S is not recursively enumerable
iv. S is recursive

(b) Given that a language L_1 is regular and and that the language $L_1 \cup L_2$ is regular, is the language L_2 always regular? Prove your answer.

gate1994 theory-of-computation identify-class-language normal

Answer

5.6.5 Identify Class Language: GATE1999_2.4 top http://gateoverflow.in/1482

Multiple choices may be correct:

If $L1$ is context free language and $L2$ is a regular language which of the following is/are false?

A. $L1 - L2$ is not context free

B. $L1 \cap L2$ is context free

C. $\sim L1$ is context free

D. $\sim L2$ is regular

gate1999 theory-of-computation identify-class-language normal

Answer

5.6.6 Identify Class Language: GATE2000-1.5 top http://gateoverflow.in/628

Let L denote the languages generated by the grammar $S \rightarrow 0S0 \mid 00$.
Which of the following is TRUE?

A. $L = 0^+$
B. L is regular but not 0^+
C. L is context free but not regular
D. L is not context free

gate2000 theory-of-computation easy identify-class-language

Answer

5.6.7 Identify Class Language: GATE2002-1.7 top http://gateoverflow.in/811

The language accepted by a Pushdown Automaton in which the stack is limited to 10 items is best described as

A. Context free
B. Regular
C. Deterministic Context free
D. Recursive

gate2002 theory-of-computation easy identify-class-language

Answer

5.6.8 Identify Class Language: GATE2004-87 top http://gateoverflow.in/1081

The language $\{a^m b^n c^{m+n} \mid m,n \geq 1\}$ is

A. regular

B. context-free but not regular

C. context-sensitive but not context free

D. type-0 but not context sensitive

gate2004 theory-of-computation normal identify-class-language

Answer

5.6.9 Identify Class Language: GATE2005-55 top http://gateoverflow.in/1378

Consider the languages:

$L_1 = \{a^n b^n c^m \mid n,m > 0\}$ and $L_2 = \{a^n b^m c^m \mid n,m > 0\}$

Which one of the following statements is FALSE?

A. $L_1 \cap L_2$ is a context-free language

B. $L_1 \cup L_2$ is a context-free language

C. $L_1 \text{ and } L_2$ are context-free languages

D. $L_1 \cap L_2$ is a context sensitive language

gate2005 theory-of-computation identify-class-language normal

Answer

5.6.10 Identify Class Language: GATE2005-IT-4 top

http://gateoverflow.in/3748

Let L be a regular language and M be a context-free language, both over the alphabet Σ. Let L^c and M^c denote the complements of L and M respectively. Which of the following statements about the language $L^c \cup M^c$ is TRUE?

A. It is necessarily regular but not necessarily context-free.
B. It is necessarily context-free.
C. It is necessarily non-regular.
D. None of the above

gate2005-it theory-of-computation normal identify-class-language

Answer

5.6.11 Identify Class Language: GATE2005-IT-6 top

http://gateoverflow.in/3751

The language $\{0^n 1^n 2^n \mid 1 \leq n \leq 10^6\}$ is

A. regular
B. context-free but not regular
C. context-free but its complement is not context-free
D. not context-free

gate2005-it theory-of-computation easy identify-class-language

Answer

5.6.12 Identify Class Language: GATE2006-30 top

http://gateoverflow.in/993

For $s \in (0+1)^*$ let $d(s)$ denote the decimal value of s (e.g. $d(101) = 5$). Let

$$L = \{s \in (0+1)^* \mid d(s) \bmod 5 = 2 \text{ and } d(s) \bmod 7 \neq 4\}$$

Which one of the following statements is true?

A. L is recursively enumerable, but not recursive
B. L is recursive, but not context-free
C. L is context-free, but not regular
D. L is regular

gate2006 theory-of-computation normal identify-class-language

Answer

5.6.13 Identify Class Language: GATE2006-33 top

http://gateoverflow.in/996

Let L_1 be a regular language, L_2 be a deterministic context-free language and L_3 a recursively enumerable, but not recursive, language. Which one of the following statements is false?

A. $L_1 \cap L_2$ is a deterministic CFL
B. $L_3 \cap L_1$ is recursive
C. $L_1 \cup L_2$ is context free
D. $L_1 \cap L_2 \cap L_3$ is recursively enumerable

gate2006 theory-of-computation normal identify-class-language

Answer

5.6.14 Identify Class Language: GATE2007-30 top

http://gateoverflow.in/1228

The language $L = \{0^i 2 1^i \mid i \geq 0\}$ over the alphabet $\{0, 1, 2\}$ is:

A. not recursive

B. is recursive and is a deterministic CFL

C. is a regular language

D. is not a deterministic CFL but a CFL

gate2007 theory-of-computation normal identify-class-language

Answer

5.6.15 Identify Class Language: GATE2008-9 top http://gateoverflow.in/407

Which of the following is true for the language

$$\{a^p \mid p \text{ is a prime }\}?$$

A. It is not accepted by a Turing Machine
B. It is regular but not context-free
C. It is context-free but not regular
D. It is neither regular nor context-free, but accepted by a Turing machine

gate2008 theory-of-computation easy identify-class-language

Answer

5.6.16 Identify Class Language: GATE2008-IT-33 top http://gateoverflow.in/3343

Consider the following languages.

- $L_1 = \{a^i\ b^j\ c^k \mid i = j, k \geq 1\}$
- $L_2 = \{a^i\ b^j \mid j = 2i, i \geq 0\}$

Which of the following is true?

A. L_1 is not a CFL but L_2 is
B. $L_1 \cap L_2 = \emptyset$ and L_1 is non-regular
C. $L_1 \cup L_2$ is not a CFL but L_2 is
D. There is a 4-state PDA that accepts L_1, but there is no DPDA that accepts L_2

gate2008-it theory-of-computation normal identify-class-language

Answer

5.6.17 Identify Class Language: GATE2009-40 top http://gateoverflow.in/1326

Let $L = L_1 \cap L_2$, where L_1 and L_2 are languages as defined below:

$L_1 = \{a^m b^m c a^n b^n \mid m, n \geq 0\}$

$L_2 = \{a^i b^j c^k \mid i, j, k \geq 0\}$

Then L is

A. Not recursive
B. Regular
C. Context free but not regular
D. Recursively enumerable but not context free.

gate2009 theory-of-computation easy identify-class-language

Answer

5.6.18 Identify Class Language: GATE2010-40 top http://gateoverflow.in/2341

Consider the languages

$L1 = \{0^i 1^j \mid i \neq j\},$

$L2 = \{0^i 1^j \mid i = j\}$,

$L3 = \{0^i 1^j \mid i = 2j + 1\}$,

$L4 = \{0^i 1^j \mid i \neq 2j\}$

A. Only $L2$ is context free.
B. Only $L2$ and $L3$ are context free.
C. Only $L1$ and $L2$ are context free.
D. All are context free

gate2010 theory-of-computation context-free-language identify-class-language normal

Answer

5.6.19 Identify Class Language: GATE2011_26 top http://gateoverflow.in/2128

Consider the languages $L1,\ L2\ and\ L3$ as given below.

$L1 = \{0^p 1^q \mid p, q \in N\}, L2 = \{0^p 1^q \mid p, q \in N\ and\ p = q\}\ and L3 = \{0^p 1^q 0^r \mid p, q, r \in N\ and\ p = q = r\}.$

Which of the following statements is **NOT TRUE**?

(A) Push Down Automata (PDA) can be used to recognize $L1$ and $L2$

(B) $L1$ is a regular language

(C) All the three languages are context free

(D) Turing machines can be used to recognize all the languages

gate2011 theory-of-computation identify-class-language normal

Answer

5.6.20 Identify Class Language: GATE2013_32 top http://gateoverflow.in/1543

Consider the following languages.

$L_1 = \{0^p 1^q 0^r \mid p, q, r \geq 0\}$

$L_2 = \{0^p 1^q 0^r \mid p, q, r \geq 0, p \neq r\}$

Which one of the following statements is **FALSE**?

(A) L_2 is context-free.
(B) $L_1 \cap L_2$ is context-free.
(C) Complement of L_2 is recursive.
(D) Complement of L_1 is context-free but not regular.

gate2013 theory-of-computation identify-class-language normal

Answer

5.6.21 Identify Class Language: GATE2014-3-36 top http://gateoverflow.in/2070

Consider the following languages over the alphabet $\sum = \{0, 1, c\}$

$L_1 = \{0^n 1^n \mid n \geq 0\}$

$L_2 = \{wcw^r \mid w \in \{0, 1\}^*\}$

$L_3 = \{ww^r \mid w \in \{0, 1\}^*\}$

Here, w^r is the reverse of the string w. Which of these languages are deterministic Context-free languages?

A. None of the languages
B. Only L_1
C. Only L_1 and L_2
D. All the three languages

gate2014-3 theory-of-computation identify-class-language context-free-language normal

Answer

5.6.22 Identify Class Language: GATE2017-1-37 top http://gateoverflow.in/118320

Consider the context-free grammars over the alphabet $\{a, b, c\}$ given below. S and T are non-terminals.

$G_1 : S \rightarrow aSb|T, T \rightarrow cT| \in$

$G_2 : S \rightarrow bSa|T, T \rightarrow cT| \in$

The language $L(G_1) \cap L(G_2)$ is

(A) Finite.

(B) Not finite but regular.

(C) Context-Free but not regular.

(D) Recursive but not context-free.

gate2017-1 theory-of-computation context-free-language identify-class-language normal

Answer

5.6.23 Identify Class Language: GATE2017-2-40 top http://gateoverflow.in/118615

Consider the following languages.

- $L_1 = \{a^p \mid p \text{ is a prime number}\}$
- $L_2 = \{a^n b^m c^{2m} \mid n \geq 0, m \geq 0\}$
- $L_3 = \{a^n b^n c^{2n} \mid n \geq 0\}$
- $L_4 = \{a^n b^n \mid n \geq 1\}$

Which of the following are CORRECT?

I. L_1 is context free but not regular
II. L_2 is not context free
III. L_3 is not context free but recursive
IV. L_4 is deterministic context free

A. I, II and IV only
B. II and III only
C. I and IV only
D. III and IV only

gate2017-2 theory-of-computation identify-class-language

Answer

5.6.24 Identify Class Language: TIFR2010-B-22 top http://gateoverflow.in/18622

Let L consist of all binary strings beginning with a 1 such that its value when converted to decimal is divisible by 5. Which of the following is true?

a. L can be recognized by a deterministic finite state automaton.
b. L can be recognized by a non-deterministic finite state automaton but not by a deterministic finite state automaton.
c. L can be recognized by a deterministic push-down automaton but not by a non-deterministic finite state automaton.
d. L can be recognized by a non-deterministic push-down automaton but not by a deterministic push-down automaton.
e. L cannot be recognized by any push-down automaton.

tifr2010 theory-of-computation identify-class-language

Answer

5.6.25 Identify Class Language: TIFR2010-B-35 top http://gateoverflow.in/19247

Consider the following languages over the alphabet $\{0, 1\}$.

$$L1 = \{x.x^R \mid x \in \{0, 1\}^*\}$$

$$L2 = \{x.x \mid x \in \{0, 1\}^*\}$$

Where x^R is the reverse of string x; e.g. $011^R = 110$. Which of the following is true?

a. Both $L1$ and $L2$ are regular.
b. $L1$ is context-free but not regular where as $L2$ is regualr.
c. Both $L1$ and $L2$ are context free and neither is regular.
d. $L1$ is context free but $L2$ is not context free.
e. Both $L1$ and $L2$ are not context free.

tifr2010 theory-of-computation identify-class-language

Answer

5.6.26 Identify Class Language: TIFR2012-B-18 top http://gateoverflow.in/25216

Let a^i denote a sequence $a.a \dots a$ with i letters and let $\aleph$ be the set of natural numbers $1, 2, \dots$. Let $L_1 = \{a^i b^{2i} \mid i \in \aleph\}$ and $L_2 = \left\{a^i b^{i^2} \mid i \in \aleph\right\}$ be two languages. Which of the following is correct?

a. Both L_1 and L_2 are context-free languages.
b. L_1 is context-free and L_2 is recursive but not context-free.
c. Both L_1 and L_2 are recursive but not context-free.
d. L_1 is regular and L_2 is context-free.
e. Complement of L_2 is context-free.

tifr2012 theory-of-computation identify-class-language

Answer

5.6.27 Identify Class Language: TIFR2014-B-13 top http://gateoverflow.in/27320

Let L be a given context-free language over the alphabet $\{a, b\}$. Construct L_1, L_2 as follows. Let $L_1 = L - \{xyx \mid x, y \in \{a, b\}^*\}$, and $L_2 = L \cdot L$. Then,

a. Both L_1 and L_2 are regular.
b. Both L_1 and L_2 are context free but not necessarily regular.
c. L_1 is regular and L_2 is context free.
d. L_1 and L_2 both may not be context free.
e. L_1 is regular but L_2 may not be context free.

tifr2014 theory-of-computation identify-class-language

Answer

5.6.28 Identify Class Language: TIFR2015-B-8 top http://gateoverflow.in/29865

Let $\sum_1 = \{a\}$ be a one letter alphabet and $\sum_2 = \{a, b\}$ be a two letter alphabet. A language over an alphabet is a set of finite length words comprising letters of the alphabet. Let L_1 and L_2 be the set of languages over $\sum_1$ and $\sum_2$ respectively. Which of the following is true about L_1 and L_2:

a. Both are finite.
b. Both are countably infinite.
c. L_1 is countable but L_2 is not.
d. L_2 is countable but L_1 is not.
e. Neither of them is countable.

tifr2015 identify-class-language

Answer

5.6.29 Identify Class Language: TIFR2017-B-14 top http://gateoverflow.in/95825

Consider the following grammar G with terminals $\{[,]\}$, start symbol S, and non-terminals $\{A, B, C\}$:

$$S \to AC \mid SS \mid AB$$
$$C \to SB$$
$$A \to [$$
$$B \to]$$

A language L is called prefix-closed if for every $x \in L$, every prefix of x is also in L. Which of the following is FALSE?

A. $L(G)$ is context free
B. $L(G)$ is infinite
C. $L(G)$ can be recognized by a deterministic push down automaton
D. $L(G)$ is prefix-closed
E. $L(G)$ is recursive

tifr2017 theory-of-computation identify-class-language

Answer

5.6.30 Identify Class Language: TIFR2017-B-4 top http://gateoverflow.in/95680

Let L be the language over the alphabet $\{1, 2, 3, (,)\}$ generated by the following grammar (with start symbol S, and non-terminals $\{A, B, C\}$):

$$S \to A\,B\,C A \to (B \to 1\,B \mid 2\,B \mid 3\,B B \to 1 \mid 2 \mid 3C \to)$$

Then, which of the following is TRUE?

A. L is finite
B. L is not recursively enumerable
C. L is regular
D. L contains only strings of even length
E. L is context-free but not regular

tifr2017 theory-of-computation identify-class-language

Answer

Answers: Identify Class Language

5.6.1 Identify Class Language: CMI2010-A-01 top http://gateoverflow.in/46131

Selected Answer

L is regular.

1 votes -- Praveen Saini (53.6k points)

5.6.2 Identify Class Language: GATE1988-2ix top http://gateoverflow.in/93949

Selected Answer

Here n is finite.. and finite language must be regular..

if n is not restricted, then it would be DCFL...

4 votes -- kirti singh (3.4k points)

5.6.3 Identify Class Language: GATE1991-17,a top http://gateoverflow.in/26653

https://en.wikipedia.org/wiki/Read-only_Turing_machine

3 votes -- srestha (58.4k points)

5.6.4 Identify Class Language: GATE1994_19 top http://gateoverflow.in/2515

(b) No. need not be. Take L_2 = {$a^n b^n$ | n > 0} and L_1 = all strings over {a,b}. Now, $L_1 \cup L_2$ is L_1 only and is regular but L_2 is not regular.

7 votes -- Arjun Suresh (294k points)

5.6.5 Identify Class Language: GATE1999_2.4 top http://gateoverflow.in/1482

Selected Answer

L2 is regular , so complement of L2, (~L2) , is also regular

Regular languages under complement . So **D is True**

L1 ∩ L2 is context free.

Intersection of Context free language with Regular language is Context free. So **b is True**

L1 - L2 = L1 ∩ (~L2) is context free

Intersection of Context free language with Regular language is Context free. So **a is False**

~L1 is not context free

Context free languages are not closed under complement. So **c is False (May/not be).**

15 votes -- Praveen Saini (53.6k points)

5.6.6 Identify Class Language: GATE2000-1.5 top http://gateoverflow.in/628

Selected Answer

B. is the answer for this question
Language generated by this grammar is L = (00)^+ that is regular but not 0^+

15 votes -- Manu Thakur (6k points)

5.6.7 Identify Class Language: GATE2002-1.7 top http://gateoverflow.in/811

Selected Answer

B. Regular.

With only finite positions in stack, we can have only finite configurations and these can also be modeled as states in a finite automata.

11 votes -- Arjun Suresh (294k points)

5.6.8 Identify Class Language: GATE2004-87 top http://gateoverflow.in/1081

Selected Answer

Language is not regular bcoz we need to match count of c's is equal to count of b's + count of a's

and that can implement by PDA

∂(q0,a,^)= (q0,a)   [push a in stack, as per language a comes first]

∂(q0,a,a)= (q0,aa)   [push all a's into stack]

∂(q0,b,a) = (q1,ba)   [push b in stack, state change to q1 that sure b comes after a]

∂(q1,b,b)=(q1,bb)   [push all b's in stack]

∂(q1,c,b) = (q2,^)   [pop one b for one c]

∂(q2,c,b) = (q2,c)   [pop one b's for each c and continue same]

∂(q2,c,a) = (q3,^)   [pop one a for one c , when there is no more b in stack]

∂(q3,c,a) = (q3,^)   [pop one a for each c and continue same]

∂(q3,^,^) = (qf,^)   [if sum of c's is sum of a's and b's then stack will be empty when there is no c in input]

answer = **option B** : language is context- free but not regular.

Note :1. state changes make sure b's comes after a and c's comes after b's]

7 votes -- Praveen Saini (53.6k points)

5.6.9 Identify Class Language: GATE2005-55 top http://gateoverflow.in/1378

Selected Answer

L1 is CFL   [put a's in stack , and pop a with each b]]

L2 is CFL   [put b's in stack and pop b with each c]

c) is True.

b) is True CFL is closed under Union   [S-> S1 | S2   where S1 is grammar for L1 and S2 for L2]

CFL is not closed under Intersection, so intersection of two CFLs may or may not be CFL. Lets examine:

L1 ∩ L2 = { $a^ib^ic^i$, i>0 } which is Context sensitive but not context free [can't match a's,b's and c's with one stack]

So a) is False

d) is True

15 votes -- Praveen Saini (53.6k points)

5.6.10 Identify Class Language: GATE2005-IT-4 top http://gateoverflow.in/3748

Selected Answer

Take L = Σ* then L^c = ∅ and M^c ∪ ∅ = M^c.

We know that complement of CFL need not be a CFL as CFL is not closed under complement.

So, (A) and (B) are false.

If we take L = ∅ then L^c = Σ* and M^c ∪ Σ* = Σ* which is regular - (C) is also false.

So, answer (D)

22 votes -- Arjun Suresh (294k points)

5.6.11 Identify Class Language: GATE2005-IT-6 top http://gateoverflow.in/3751

Selected Answer

Regular (in fact finite). Since n is finite, we have a finite set of strings satisfying the given conditions. So, we can easily make a finite automata for those strings.

12 votes -- Arjun Suresh (294k points)

5.6.12 Identify Class Language: GATE2006-30 top http://gateoverflow.in/993

Selected Answer

Refer this

http://gateoverflow.in/1695/gate1998_4

L1 = { s∈(0+1)* | d(s) mod 5=2 } is regular

having 2 as final state out of {0,1,2,3,4} states

as given in example in posted link [in same DFA , final state will be 2 instead of 0]

similarly L2 = { s∈(0+1)* | d(s) mod 7≠4 } is also regular

having states {0,1,2,3,4,5,6} and all are final state except 4

L1 ∩ L2 is L (given problem) is also regular

As regular languages are closed under intersection. D is correct option.

18 votes -- Praveen Saini (53.6k points)

5.6.13 Identify Class Language: GATE2006-33 top http://gateoverflow.in/996

Selected Answer

A) True : DCFL are closed under Intersection with Regular Languages

C) True : L1 is regular hence also CFL and every DCFL is also CFL and All CFL are closed under Union.

D) True : L1 is regular hence also RE; L2 is DCFL hence also RE; RE languages are closed under Intersection

B) False : L1 is recursive hence also decidable, L3 is RE but not Recursive hence it is undecidable. Intersection of Recursive language and Recursive Enumerable language is Recursive Enumerable language.

17 votes -- Danish (3.6k points)

5.6.14 Identify Class Language: GATE2007-30 top http://gateoverflow.in/1228

Selected Answer

$L = \{0^i21^i \mid i \geq 0\}$ has only one comparison that can be done using a DPDA. Hence, its DCFL.

Context free languages are a proper subset of Recursive Languages. $\therefore$ it is recursive too.

answer = **option B**

9 votes -- Amar Vashishth (28.7k points)

5.6.15 Identify Class Language: GATE2008-9 top http://gateoverflow.in/407

Selected Answer

We have algorithms to generate prime numbers $\implies$ we can generate sequence of p for the given language, hence strings as defined by the language definition.

So by Church Turing Thesis we can say that there exists a Turing Machine which can accept the given language.

answer = **option D**

11 votes -- Amar Vashishth (28.7k points)

5.6.16 Identify Class Language: GATE2008-IT-33 top http://gateoverflow.in/3343

Selected Answer

Both languages can be accepted by a DPDA :

L1 = start pushing element X into the stack on input 'a' ... start poping X on input 'b' ... move to final state when stack empty and input = 'c'

L2 = start pushing elements XX into the stack on input 'a' ... start poping X on input 'b' ... move to final state when stack empty and input = 'epsilon'

so (A) and (D) are False

L1 ∪ L2 is a CFL ... we can build it by having L1, L2 and an extra state ... and an 'epsilon' transition to both L1 and L2 from that extra state.

so (C) is false

L1 ∩ L2 = Phi because we have no string a^ib^j where i=j and i=2j for i,j>=1

and clearly L1 is not a regular language

so (B) is true.

16 votes -- Danish (3.6k points)

5.6.17 Identify Class Language: GATE2009-40 top http://gateoverflow.in/1326

Selected Answer

$L_1 \cap L_2 = \{a^m b^m c | m \geq 0\}$, which is context free but not regular.

Option C.

24 votes -- Arjun Suresh (294k points)

5.6.18 Identify Class Language: GATE2010-40 top http://gateoverflow.in/2341

Selected Answer

All are context free.
L1 -> Push 0 on stack and when 1 comes, start popping. If stack becomes empty and 1's are remaining start pushing 1. At end of string accept if stack is non- empty.

L2 -> Do the same as for L1, but accept if stack is empty at end of string.

L3 -> Do, the same as for L2, but for each 0, push two 0's on stack and start the stack with a 0.

L4 -> Do the same as for L1, but for each 0, push two 0's on stack

All are in fact DCFL. Pushing two 0's on stack might sound non-trivial but we can do this by pushing one symbol and going to a new state. Then on this new state on empty symbol, push one more symbol on stack and come back.

15 votes -- Arjun Suresh (294k points)

5.6.19 Identify Class Language: GATE2011_26 top http://gateoverflow.in/2128

Selected Answer

Answer is **C.**

L_1 is **RL**

L_2 is **CFL**

L_3 is **CSL**

Turning Machine is powerful Machine it can be used to accept all the languages (RL,CFL,CSL,RE)

16 votes -- Sona Praneeth Akula (4k points)

5.6.20 Identify Class Language: GATE2013_32 top http://gateoverflow.in/1543

Selected Answer

L1 is regular and hence context-free also. Regular expression for L1 is 0*1*0*. So, (D) is the false choice.

L2 is context-free but not regular. We need a stack to count if the number of 0's before and after the 1 (1 may be absent also) are not same. So, L1 ∩ L2 is context-free as regular ∩ context-free is context-free. -> (B) is true.

Complement of L2 is recursive as context-free complement is always recursive (actually even context-sensitive).

16 votes -- Arjun Suresh (294k points)

5.6.21 Identify Class Language: GATE2014-3-36 top http://gateoverflow.in/2070

Selected Answer

C.

L_3 is CFL and not DCFL as in no way we can deterministically determine the MIDDLE point of the input string.

14 votes -- Gate Keeda (19.1k points)

5.6.22 Identify Class Language: GATE2017-1-37 top http://gateoverflow.in/118320

Selected Answer

Since while intersection all strings produced by production aSb in G1 and bSa in G2 will be 0

so only common production will be

S-->T

T-->cT | epsilon

which is nothing but c* hence it is REGULAR and INFINITE

so OPTION (B)

8 votes -- sriv_shubham (2.7k points)

5.6.23 Identify Class Language: GATE2017-2-40 top http://gateoverflow.in/118615

Selected Answer

L1 is Csl,L2 is context free

L3 is not Context free and L4 is Dcfl

So Option D

11 votes -- Swapnil (2k points)

5.6.24 Identify Class Language: TIFR2010-B-22 top http://gateoverflow.in/18622

Selected Answer

l can be recognized by a dfa. we have a dfa to accept all such strings which when interpretated as decimal number are divisible by n. where n can be anything the dfa of such can be made by a trick.

states are equal to possible remainders

	0	1
q0	q0	q1
q1	q2	q3
q2	q4	q0
q3	q1	q2
q4	q3	q4

if u can see the symmetry in it. write states and make fill like q0 q1 q2 q3 ...

now it is saying that it has to always start with 1 which the above dfa will not satisfy so make it a nfa by making a transition from q0 on zero to a new dead state. now you have a nfa reduce it which will result in a deterministic dfa .

so option a

6 votes -- No Need (14.1k points)

5.6.25 Identify Class Language: TIFR2010-B-35 top http://gateoverflow.in/19247

Selected Answer

L1={x.x^R|xϵ{0,1}∗} Its a even palindrome so its CFL
L2={x.x|xϵ{0,1}∗} Its a string matching so its a CSL

Option D) L1 is context free but L2 is not context free.

7 votes -- Umang Raman (15.2k points)

5.6.26 Identify Class Language: TIFR2012-B-18 top http://gateoverflow.in/25216

Selected Answer

L1 - CFL, S-> aSbb|abb

L2 - Not CFL ,we can't count i^2 using CFL.

a) False because L2 is not CFL.

B) True. L2 is recursive

C) False because L1 is CFL.

D) False, L1 not regular.

E) False, as complement of L2 is also not context free. It still need to computer i^2 for checking for inequality.

Answer :- B

5 votes -- Akash (43.8k points)

5.6.27 Identify Class Language: TIFR2014-B-13 top http://gateoverflow.in/27320

Selected Answer

L is a context free language over {a,b}
L1 = L - {xyx | x,y ∈ {a,b}* }

= L - { all strings over {a,b} } [Note: all strings can be generated from y by putting x= ϵ]

= L - (a+b)* = {} , empty set. [Note : L1 - L2 = { string in L1 but not in L2 }]

So , L1 is a Regular Language .

L is a context free language over {a,b}

L2 = L·L
Context free languages are closed under Concatenation.

So L2 is Context Free Language.

Option C is correct.

18 votes -- Praveen Saini (53.6k points)

5.6.28 Identify Class Language: TIFR2015-B-8 top http://gateoverflow.in/29865

Selected Answer

languages over alphabet set are uncountable so ans should be e

3 votes -- Pooja Palod (32.4k points)

5.6.29 Identify Class Language: TIFR2017-B-14 top http://gateoverflow.in/95825

Selected Answer

The given grammar generates balanced parenthesis.

Lets take a smallest string : [[ ]] (say x)

Prefixes of x are : [, [[,[[ ]

BUT they don't belong to the langauge generated by the given grammar.

SO, the answer will be **Option D**

Correct me if am wrong

6 votes -- sarveswara rao vangala (1.4k points)

5.6.30 Identify Class Language: TIFR2017-B-4 top http://gateoverflow.in/95680

Selected Answer

language accepted by that grammar is
$((1+2+3)^+)$
hence regular!

4 votes -- Motamarri Anusha (11.6k points)

5.7 Minimal State Automata(1) top

5.7.1 Minimal State Automata: GATE1997_70 top http://gateoverflow.in/19700

Following is a state table for time finite state machine.

Present State	Next State Output	
	Input - 0	Input - 1
A	B.1	H.1
B	F.1	D.1
C	D.0	E.1
D	C.0	F.1
E	D.1	C.1
F	C.1	C.1
G	C.1	D.1
H	C.0	A.1

a. Find the equivalence partition on the states of the machine.

b. Give the state table for the minimal machine. (Use appropriate names for the equivalent states. For example if states X and Y are equivalent then use XY as the name for the equivalent state in the minimal machine).

gate1997 theory-of-computation minimal-state-automata

Answer

Answers: Minimal State Automata

5.7.1 Minimal State Automata: GATE1997_70 top http://gateoverflow.in/19700

Selected Answer

As nothing is mentioned in question, assuming that the first state itself is the start state i.e. State A so, State G is not reachable from the start and hence is removed before applying the minimization algorithm.

P0->[ABEFG] [CDH] ---->[ABEF] [CDH]

P1->[AB] [EF] [CDH]

P2->[A] [B] [EF] [CD] [H]

P3->[A] [B] [EF] [CD] [H] // P2==P3 So,Stop

State table for the minimal machine ::

Present State	input=0	input=1
A	B.1	H.1
B	EF.1	CD.1

CD	CD.0	EF.1
EF	CD.1	CD.1
H	CD.0	A.1

3 votes -- Vidhi Sethi (2.2k points)

5.8 Non Determinism(7) top

5.8.1 Non Determinism: GATE1992-02,xx top http://gateoverflow.in/577

02. Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

In which of the cases stated below is the following statement true?

"For every non-deterministic machine M_1 there exists an equivalent deterministic machine M_2 recognizing the same language".

(a). M_1 is non-deterministic finite automaton.

(b). M_1 is non-deterministic PDA.

(c). M_1 is a non-deteministic Turing machine.

(d). For no machines M_1 and M_2, the above statement true.

gate1992 theory-of-computation easy non-determinism

Answer

5.8.2 Non Determinism: GATE1994-1.16 top http://gateoverflow.in/2459

Which of the following conversions is not possible (algorithmically)?

A. Regular grammar to context free grammar
B. Non-deterministic FSA to deterministic FSA
C. Non-deterministic PDA to deterministic PDA
D. Non-deterministic Turing machine to deterministic Turing machine

gate1994 theory-of-computation easy non-determinism

Answer

5.8.3 Non Determinism: GATE1998-1.11 top http://gateoverflow.in/1648

Regarding the power of recognition of languages, which of the following statements is false?

A. The non-deterministic finite-state automata are equivalent to deterministic finite-state automata.
B. Non-deterministic Push-down automata are equivalent to deterministic Push-down automata.
C. Non-deterministic Turing machines are equivalent to deterministic Push-down automata.
D. Non-deterministic Turing machines are equivalent to deterministic Turing machines.
E. Multi-tape Turing machines are available are equivalent to Single-tape Turing machines.

gate1998 theory-of-computation easy non-determinism

Answer

5.8.4 Non Determinism: GATE2004-IT-9 top http://gateoverflow.in/3650

Which one of the following statements is FALSE?

A. There exist context-free languages such that all the context-free grammars generating them are ambiguous

B. An unambiguous context-free grammar always has a unique parse tree for each string of the language generated by it

C. Both deterministic and non-deterministic pushdown automata always accept the same set of languages

D. A finite set of string from some alphabet is always a regular language

gate2004-it theory-of-computation easy non-determinism

Answer

5.8.5 Non Determinism: GATE2005-54 top

http://gateoverflow.in/1377

Let N_f and N_p denote the classes of languages accepted by non-deterministic finite automata and non-deterministic push-down automata, respectively. Let D_f and D_p denote the classes of languages accepted by deterministic finite automata and deterministic push-down automata respectively. Which one of the following is TRUE?

A. $D_f \subset N_f$ and $D_p \subset N_p$

B. $D_f \subset N_f$ and $D_p = N_p$

C. $D_f = N_f$ and $D_p = N_p$

D. $D_f = N_f$ and $D_p \subset N_p$

gate2005 theory-of-computation easy non-determinism

Answer

5.8.6 Non Determinism: GATE2009-16, ISRO2017-12 top

http://gateoverflow.in/1308

Which one of the following is FALSE?

A. There is a unique minimal DFA for every regular language

B. Every NFA can be converted to an equivalent PDA.

C. Complement of every context-free language is recursive.

D. Every nondeterministic PDA can be converted to an equivalent deterministic PDA.

gate2009 theory-of-computation easy isro2017 non-determinism

Answer

5.8.7 Non Determinism: GATE2011-8 top

http://gateoverflow.in/2110

Which of the following pairs have **DIFFERENT** expressive power?

(A) Deterministic finite automata (DFA) and Non-deterministic finite automata (NFA)

(B) Deterministic push down automata (DPDA) and Non-deterministic push down automata (NPDA)

(C) Deterministic single tape Turing machine and Non-deterministic single tape Turing machine

(D) Single tape Turing machine and multi-tape Turing machine

gate2011 theory-of-computation easy non-determinism

Answer

Answers: Non Determinism

5.8.1 Non Determinism: GATE1992-02,xx top

http://gateoverflow.in/577

Selected Answer

Answer: A and C.

- For every NFA there exists a DFA.
- For every NPDA there does not exist a deterministic PDA.
- Every nondeterministic Turing machine has an equivalent deterministic Turing Machine.

8 votes -- Rajarshi Sarkar (35k points)

5.8.2 Non Determinism: GATE1994-1.16 top http://gateoverflow.in/2459

Selected Answer

This will be C. Because if that would have been possible then NPDA and DPDA must had same powers, which is not the case. You can take example of NFA and DFA. Both are convertible to each other and hence share the same power.

12 votes -- Gate Keeda (19.1k points)

5.8.3 Non Determinism: GATE1998-1.11 top http://gateoverflow.in/1648

Selected Answer

A) True. Proof - Subset Construction Procedure

B) False . No conversion from NPDA To DPDA>

C) False :- Power(TM) > NPDA > DPDA.

D) True E) True

Answer :- This question has multple answers, B and C>

9 votes -- Akash (43.8k points)

5.8.4 Non Determinism: GATE2004-IT-9 top http://gateoverflow.in/3650

Selected Answer

A) this is true for inherently ambiguous language
B) always correct, that's why called un ambiguous
C) NPDA is a supper set of DPDA, hence it's FALSE
D) finite language is always regular

13 votes -- Manu Thakur (6k points)

5.8.5 Non Determinism: GATE2005-54 top http://gateoverflow.in/1377

Selected Answer

Option D.

NFA and DFA both have equivalent power.(every nfa can be converted into equivalent dfa) but NPDA can accept more languages than DPDA.

9 votes -- shreya ghosh (3.4k points)

5.8.6 Non Determinism: GATE2009-16, ISRO2017-12 top http://gateoverflow.in/1308

Selected Answer

Option d ndpa is more powerful than dpda so they are not equivalent..actually dpda is a proper subset of ndpa...

C is TRUE as CFL is a proper subset of recursive languages and recursive languages are closed under complement.

👍 17 votes -- Bhagirathi Nayak (13.3k points)

5.8.7 Non Determinism: GATE2011-8 top
http://gateoverflow.in/2110

Selected Answer

Expressing power of any machine can be defined as the maximum number of languages it can accept..if machine M1 can accept more languages then M2 then we can say that expressing power of M1 is greater then M2.

a)languages accepted by NFA,will also be accepted by DFA because we can make DFA corresponding to NFA.so their expressing power is same.

b)In this case languages accepted by NPDA is more then DPDA ,so expressing power of NPDA is more then DPDA

c)both deterministic and non deterministic turing can accept same language.so there expressing power is same.

d) In turing machine if we increase the number of tape then also language accepted by that machine is same as single tape turing machine.so there expressing power is same.

ans is b

👍 15 votes -- neha pawar (4.4k points)

(B) Deterministic push down automata (DPDA) and Non-deterministic push down automata (NPDA)

In rest of the options both machine are equivalent in power.

👍 11 votes -- Omesh Pandita (2.7k points)

5.9 Np Completeness(2) top

5.9.1 Np Completeness: GATE2012-4 top
http://gateoverflow.in/36

Assuming P ≠ NP, which of the following is **TRUE**?

A. NP-complete = NP
B. NP-complete $\cap$ P = ϕ
C. NP-hard = NP
D. P = NP-complete

gate2012 theory-of-computation np-completeness

Answer

5.9.2 Np Completeness: GATE2013_18 top
http://gateoverflow.in/1440

Which of the following statements are **TRUE**?

1. The problem of determining whether there exists a cycle in an undirected graph is in P.
2. The problem of determining whether there exists a cycle in an undirected graph is in NP.
3. If a problem A is NP-Complete, there exists a non-deterministic polynomial time algorithm to solve A.

(A) 1, 2 and 3 (B) 1 and 2 only (C) 2 and 3 only (D) 1 and 3 only

gate2013 theory-of-computation np-completeness normal

Answer

Answers: Np Completeness

5.9.1 Np Completeness: GATE2012-4 top
http://gateoverflow.in/36

Selected Answer

Answer is (B) NP-complete $\cap P = \phi$

Since, P $\neq$ NP, there is at least one problem in NP, which is harder than all P problems. Lets take the hardest such problem, say X. Since, P $\neq$ NP, $X \notin$ P .

Now, by definition, NP-complete problems are the hardest problems in NP and so X problem is in NP-complete. And being in NP, X can be reduced to all problems in NP-complete, making any other NP-complete problem as hard as X. So, since $X \notin$P, none of the other NP-complete problems also cannot be in P.

16 votes -- Arjun Suresh (294k points)

5.9.2 Np Completeness: GATE2013_18 top http://gateoverflow.in/1440

Selected Answer

Cycle detection is graph is in P as it can be done using a graph traversal (O(V+E))

Ref: http://www.geeksforgeeks.org/detect-cycle-undirected-graph/

If a problem is in P then it is also in NP as P is a subset of NP. So, both 1 and 2 are TRUE.

Statement 3 is also true as NP-Complete requires a problem to be in NP and for any problem in NP, we have a non-deterministic polynomial time algorithm.

So, answer is A- 1, 2 and 3 are TRUE.

8 votes -- Arjun Suresh (294k points)

5.10 Pumping Lemma(1) top

5.10.1 Pumping Lemma: GATE2005-IT-40 top http://gateoverflow.in/3787

A language L satisfies the Pumping Lemma for regular languages, and also the Pumping Lemma for context-free languages. Which of the following statements about L is TRUE?

A. L is necessarily a regular language.
B. L is necessarily a context-free language, but not necessarily a regular language.
C. L is necessarily a non-regular language.
D. None of the above

gate2005-it theory-of-computation pumping-lemma easy

Answer

Answers: Pumping Lemma

5.10.1 Pumping Lemma: GATE2005-IT-40 top http://gateoverflow.in/3787

Selected Answer

answer is (D). If a language is regular, it definitely satisfies pumping lemma. But converse need not be true. If a language satisfies pumping lemma then it may or may not be regular.

12 votes -- Rajat Sharma (569 points)

By pumping lemma we can never say that a language is regular or cfg .it can only be used to prove that a certain lang is not reg or not cfg

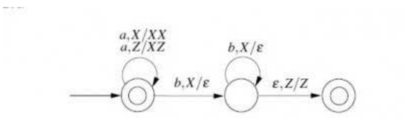
16 votes -- Bhagirathi Nayak (13.3k points)

5.11 Pushdown Automata(13) top

5.11.1 Pushdown Automata: GATE 2016-1-43 top

http://gateoverflow.in/39732

Consider the transition diagram of a PDA given below with input alphabet $\Sigma = \{a, b\}$ and stack alphabet $\Gamma = \{X, Z\}$. Z is the initial stack symbol. Let L denote the language accepted by the PDA



Which one of the following is **TRUE**?

A. $L = \{a^n b^n \mid n \geq 0\}$ and is not accepted by any finite automata
B. $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is not accepted by any deterministic PDA
C. L is not accepted by any Turing machine that halts on every input
D. $L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$ and is deterministic context-free

gate2016-1 theory-of-computation pushdown-automata normal

Answer

5.11.2 Pushdown Automata: GATE1996_13 top

http://gateoverflow.in/2765

Let $Q = (\{q_1, q_2\}, \{a, b\}, \{a, b, \perp\}, \delta, \perp, \phi)$ be a pushdown automaton accepting by empty stack for the language which is the set of all nonempty even palindromes over the set $\{a, b\}$. Below is an incomplete specification of the transitions δ. Complete the specification. The top of the stack is assumed to be at the right end of the string representing stack contents.

1. $\delta(q_1, a, \perp) = \{(q_1, \perp a)\}$
2. $\delta(q_1, b, \perp) = \{(q_1, \perp b)\}$
3. $\delta(q_1, a, a) = \{(q_1, aa)\}$
4. $\delta(q_1, b, a) = \{(q_1, ab)\}$
5. $\delta(q_1, a, b) = \{(q_1, ba)\}$
6. $\delta(q_1, b, b) = \{(q_1, bb)\}$
7. $\delta(q_1, a, a) = \{(\dots, \dots)\}$
8. $\delta(q_1, b, b) = \{(\dots, \dots)\}$
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

Answer

5.11.3 Pushdown Automata: GATE1997_6.6 top

http://gateoverflow.in/2262

Which of the following languages over $\{a, b, c\}$ is accepted by a deterministic pushdown automata?

(A) $\{wcw^R \mid w \in \{a, b\}^*\}$

(B) $\{ww^R \mid w \in \{a, b, c\}^*\}$

(C) $\{a^n b^n c^n \mid n \geq 0\}$

(D) $\{w \mid w \text{ is a palindrome over } \{a, b, c\}\}$

Note: w^R is the string obtained by reversing $'w'$.

gate1997 theory-of-computation pushdown-automata easy

Answer

5.11.4 Pushdown Automata: GATE1998_13 top

http://gateoverflow.in/1727

Let $M = (\{q_0, q_1\}, \{0, 1\}, \{z_0, X\}, \delta, q_0, z_0, \phi)$ be a Pushdown automation where δ is given by

$\delta(q_0, 1, z_0) = \{(q_0, xz_0)\}$

$\delta(q_0, \epsilon, z_0) = \{(q_0, \epsilon)\}$

$\delta(q_0, 1, X) = \{(q_0, XX)\}$

$\delta(q_1, 1, X) = \{(q_1, \epsilon)\}$

$\delta(q_0, 0, X) = \{(q_1, X)\}$

$\delta(q_0, 0, z_0) = \{(q_0, z_0)\}$ z

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

5.11.5 Pushdown Automata: GATE1999_1.6 top http://gateoverflow.in/377

Let L_1 be the set of all languages accepted by a PDA by final state and L_2 the set of all languages accepted by empty stack. Which of the following is true?

A) $L_1 = L_2$

B) $L_1 \supset L_2$

C) $L_1 \subset L_2$

D) None

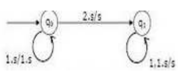
There are two modes of acceptance of DPDA - final state and empty stack. For languages accepted by empty stack there is a prefix property. Explain in simple terms about this property and its importance.

normal theory-of-computation gate1999 pushdown-automata

Answer

5.11.6 Pushdown Automata: GATE2000-8 top http://gateoverflow.in/679

A push down automation (pda) is given in the following extended notation of finite state diagram:



The nodes denote the states while the edges denote the moves of the pda. The edge labels are of the form d, s/s' where d is the input symbol read and s, s' are the stack contents before and after the move. For example the edge labeled 1, s/1.s denotes the move from state q_0 to q_0 in which the input symbol 1 is read and pushed to the stack.

a. Introduce two edges with appropriate labels in the above diagram so that the resulting pda accepts the language $\{x2x^R \mid x \in \{0,1\}^*, x^R \text{ denotes reverse of x}\}$, by empty stack.
b. Describe a non-deterministic pda with three states in the above notation that accept the language $\{0^n1^m \mid n \leq m \leq 2n\}$ by empty stack

gate2000 theory-of-computation descriptive pushdown-automata

Answer

5.11.7 Pushdown Automata: GATE2001-6 top http://gateoverflow.in/747

Give a deterministic PDA for the language $L = \{a^ncb^{2n} \mid n \geq 1\}$ over the alphabet $\Sigma = \{a, b, c\}$. Specify the acceptance state.

gate2001 theory-of-computation normal pushdown-automata

Answer

5.11.8 Pushdown Automata: GATE2004-IT-40 top http://gateoverflow.in/3683

Let M = (K, Σ, Γ, Δ, s, F) be a pushdown automaton, where

K = (s, f), F = {f}, Σ = {a, b}, Γ = {a} and
Δ = {((s, a, ε), (s, a)), ((s, b, ε), (s, a)), ((s, a, ε), (f, ε)), ((f, a, a), (f, ε)), ((f, b, a), (f, ε))}.

Which one of the following strings is not a member of L(M)?

A. aaa
B. aabab
C. baaba
D. bab

gate2004-it theory-of-computation pushdown-automata normal

Answer

5.11.9 Pushdown Automata: GATE2005-IT-38 top http://gateoverflow.in/3785

Let P be a non-deterministic push-down automaton (NPDA) with exactly one state, q, and exactly one symbol, Z, in its stack alphabet. State q is both the starting as well as the accepting state of the PDA. The stack is initialized with one Z before the start of the operation of the PDA. Let the input alphabet of the PDA be Σ. Let $L(P)$ be the language accepted by the PDA by reading a string and reaching its accepting state. Let $N(P)$ be the language accepted by the PDA by reading a string and emptying its stack.
Which of the following statements is TRUE?

A. $L(P)$ is necessarily Σ^* but $N(P)$ is not necessarily Σ^*.
B. $N(P)$ is necessarily Σ^* but $L(P)$ is not necessarily Σ^*.
C. Both $L(P)$ and $N(P)$ are necessarily Σ^*.
D. Neither $L(P)$ nor $N(P)$ are necessarily Σ^*

gate2005-it theory-of-computation pushdown-automata normal

Answer

5.11.10 Pushdown Automata: GATE2006-IT-31 top http://gateoverflow.in/3570

Which of the following languages is accepted by a non-deterministic pushdown automaton (PDA) but NOT by a deterministic PDA?

A. $\{a^nb^nc^n \mid n \geq 0\}$
B. $\{a^lb^mc^n \mid l \neq m \text{ or } m \neq n\}$
C. $\{a^nb^n \mid n \geq 0\}$
D. $\{a^mb^n \mid m,n \geq 0\}$

gate2006-it theory-of-computation pushdown-automata normal

Answer

5.11.11 Pushdown Automata: GATE2006-IT-33 top http://gateoverflow.in/3572

Consider the pushdown automaton (PDA) below which runs over the input alphabet (a, b, c). It has the stack alphabet {Z_0, X} where Z_0 is the bottom-of-stack marker. The set of states of the PDA is (s, t, u, f} where s is the start state and f is the final state. The PDA accepts by final state. The transitions of the PDA given below are depicted in a standard manner. For example, the transition (s, b, X) → (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) → (s, XXZ_0)
(s, ϵ, Z_0) → (f, ϵ)
(s, a, X) → (s, XXX)
(s, b, X) → (t, ϵ)
(t, b, X) → (t,.ϵ)

(t, c, X) → (u, ϵ)
(u, c, X) → (u, ϵ)
(u, ϵ, Z_0) → (f, ϵ)

The language accepted by the PDA is

A. $\{a^lb^mc^n \mid l = m = n\}$
B. $\{a^lb^mc^n \mid l = m\}$
C. $\{a^lb^mc^n \mid 2l = m + n\}$
D. $\{a^lb^mc^n \mid m = n\}$

gate2006-it theory-of-computation pushdown-automata normal

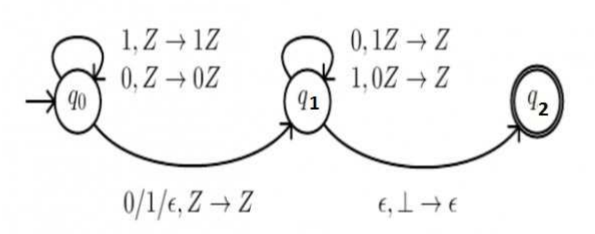
Answer

5.11.12 Pushdown Automata: GATE2015-1-51 top http://gateoverflow.in/8357

Consider the NPDA

$$\langle Q = \{q_0, q_1, q_2\}, \Sigma = \{0, 1\}, \Gamma = \{0, 1, \perp\}, \delta, q_0, \perp, F = \{q_2\}\rangle$$

, where (as per usual convention) Q is the set of states, Σ is the input alphabet, Γ is the stack alphabet, δ is the state transition function q_0 is the initial state, $\perp$ is the initial stack symbol, and F is the set of accepting states. The state transition is as follows:



Which one of the following sequences must follow the string 101100 so that the overall string is accepted by the automaton?

A. 10110
B. 10010
C. 01010
D. 01001

gate2015-1 theory-of-computation pushdown-automata normal

Answer

5.11.13 Pushdown Automata: ISI 2015 PCB C4 A top http://gateoverflow.in/121031

Design a context free grammar for the language consisting of all strings over ***{a,b}*** that are not the form ***ww*** for any string ***w***

pushdown-automata theory-of-computation isi2015

Answer

Answers: Pushdown Automata

5.11.1 Pushdown Automata: GATE 2016-1-43 top http://gateoverflow.in/39732

Selected Answer

Strings accepted at
I^{st} final state are
a^n , $n \geq 0$ and strings accepted at
II^{nd} final state are
a^nb^n , $n \geq 0$ (actually

$n \geq 1$ at this state,
$n = 0$ already included at first state).

$L = \{a^n \mid n \geq 0\} \cup \{a^n b^n \mid n \geq 0\}$
Language is deterministic context-free accepted by DPDA (dpda is already given) and so by TM too, and not regular (as we need stack to implement it), and so cannot accepted by FA

34 votes -- Praveen Saini (53.6k points)

Ya it should be D option. As 1st state is also the final state

13 votes -- Sreyas S (1.7k points)

5.11.2 Pushdown Automata: GATE1996_13 top

http://gateoverflow.in/2765

Selected Answer

$\delta(q_1, a, b) = \{(q_2, ba)\}$ means from state q_1 on input a with stack top being b, the PDA moves to state q_2 and pushes a on top of stack.

So, here the missing transitions are at the middle of the input string:

$\delta(q_1, a, a) = \{(q_2, \epsilon)\}$
$\delta(q_1, b, b) = \{(q_2, \epsilon)\}$

Once middle is reached, now we should start popping. And so, we must go to state q_2 as well as pop the previous character on the stack. (The character before and after the middle must be same as the string is even length palindrome)

(This is a non-deterministic PDA)

10 votes -- Arjun Suresh (294k points)

5.11.3 Pushdown Automata: GATE1997_6.6 top

http://gateoverflow.in/2262

Selected Answer

(A) $\{wcw^R \mid w \in \{a, b\}^*\}$ //Can be realized using DPDA cz we know the center of the string that is c here //Hence Option A is ANS

(B) $\{ww^R \mid w \in \{a, b, c\}^*\}$ //(set of even palindrom)NPDA bcz we can't find deterministically the center of palindrom string

cfg will -> S->aSa | bSb | cSc | ϵ

(C) $\{a^n b^n c^n \mid n \geq 0\}$ //CSL

(D) $\{w \mid w \text{ is a palindrome over } \{a, b, c\}\}$ //it is a cfl similar as option B

cfg will -> S->aSa | bSb | cSc | a | b | c | ϵ

7 votes -- Rajesh Pradhan (18.6k points)

5.11.4 Pushdown Automata: GATE1998_13 top

http://gateoverflow.in/1727

Selected Answer

q_0 is start state

$\delta(q_0, 0, Z_0) = (q_0, Z_0)$

[Do Nothing operation, just read any no of 0's but do not keep in stack (any no of 0's bcoz on reading 0's it remains on same state q_0)]

$\delta(q_0,1,z_0) = (q_0, Xz_0)$ [Read first 1 and keep one X in stack]

$\delta(q_0,1,X) = (q_0, XX)$ [Read any no of 1's and keep one X for each 1 in stack]

$\delta(q_0,0,X) = (q_1,X)$

[Read single 0 and do nothing in stack, state changed from q_0 to q_1]

$\delta(q_1,1,X)= (q_1,\epsilon)$

[Pop out one X from stack on reading each 1 on state q1 (matching each 1 with the 1 read before single 0)]

$\delta(q_0,\epsilon,Z_0) = (q0, \epsilon)$

[stack is empty , inputs are accepted here ,that is , ∊ or any of 0's (we read earlier with Do Nothing operation)]

L = { 0^m , m $\geq$0 }

No input accept after reaching on q_1 because stack will remain with Z_0, stack initial symbol

Note : if we add one more transition
$\delta(q_1,\epsilon,Z_0) = (q_1,\epsilon)$, then L will be { $0^m \bigcup 0^i1^j01^j$,m,i,j$\geq$0 }

14 votes -- Praveen Saini (53.6k points)

5.11.5 Pushdown Automata: GATE1999_1.6 top http://gateoverflow.in/377

Selected Answer

Answer to the question is (A) L_1 = L2.
Reason is for any PDA which accepts by final state there is an equivalent PDA (equivalent means that accepts the same language) which accepts by empty stack and vice-verse.

Now, this is not the case for DPDAs.

> The set of languages accepted by a DPDA by empty stack is a strict subset of the set of languages accepted by a DPDA by final state.

It can also be said that set of languages accepted by a DPDA by empty stack is the set of languages accepted by a DPDA by final state and which has the prefix property.

A language has prefix property means if $w \in L$, then no proper prefix of w$\in L$.

From the above definition of prefix property it must be clear why DPDA by empty stack has this property. If any prefix of a word w (w in L) is in L means the stack should have been empty even before completely processing w. But, being a deterministic PDA, once the stack becomes empty, the DPDA accepts and halts. So, in no way can a DPDA accepts w and its prefix.

PS: A DPDA with acceptance by empty stack cannot even accept all regular languages- examplea^*.

Good read: http://www.cs.ucr.edu/~jiang/cs150/slides4week7_PDA+EquivToCFG.pdf

25 votes -- gatecse (13.4k points)

5.11.6 Pushdown Automata: GATE2000-8 top http://gateoverflow.in/679

in a) x2xR

say for some word 0112110 we have to push every thing into the stack till 2 . then we get 1 then 1 will be at top of stack so pop it or if get 0 then 0 will at top of stack so pop it. For any word of language it is applicable. 2 is a mark that tell now we have to pop 0 for 0 and 1 for 1.

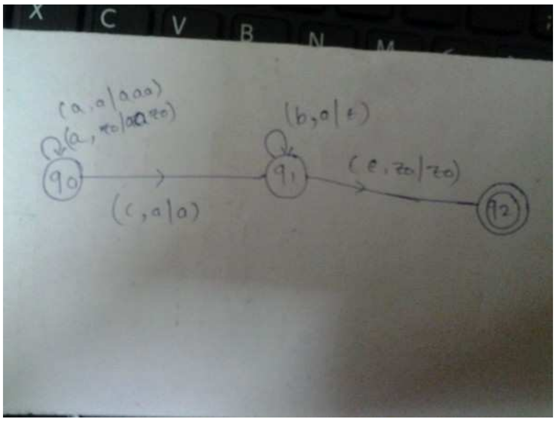
so on the edge q0 to q0 add 0,s/0.s

and on edge q1 to q1 add 0,0.s/s

6 votes -- Praveen Saini (53.6k points)

5.11.7 Pushdown Automata: GATE2001-6 top http://gateoverflow.in/747

Selected Answer



L={a^n c b^2n}

={acbb,aacbbbb,aaacbbbbbb,.......}

Here 'c' act as center. Push 2 a's for 1 'a' and when you see 'c' pop the b's

5 votes -- Saraswati Walijkar (421 points)

5.11.8 Pushdown Automata: GATE2004-IT-40 top http://gateoverflow.in/3683

ANS : B

The language is like........

in start state a's or b's come....just push a's on stack...except for the last a...which is used to shift from "start state" to "final state" without consuming any stack symbol....now in "final state" , for equal no's of a's and b's just pop a's from stack......that the interpretation of transitions given in language.

The transitions given are obviously WRONG .....but what they must have ment is same as i explained.

Based on this......

1) aaa : push a....skip a....pop a   ACCEPTED

2)aabab: push a....skip a...pop a...   REJECTED

3)baaba : push a...push a....skip a....pop a....pop a   ACCEPTED

4)bab : push a....skip a....pop a   ACCEPTED

7 votes -- Rohan Mundhey (4.2k points)

5.11.9 Pushdown Automata: GATE2005-IT-38 top http://gateoverflow.in/3785

Selected Answer

Answer is (D)

In NPDA we may have a dead configuration. This mean we may not give any transition to any alphabet from this state.

we say that a string is accepted if PDA is in final state after reading the final symbol in the string or after it has read **'$'** symbol denoting end of the string and **it is in final state.**

Now coming to options:

Question never says that we have transitions defined for all the alphabet symbols in the PDA. Although it is ALREADY in the FINAL state we may not have **ANY transition for any input symol. In this case string will be rejected as it will never finish reading the string.**

To sum up: A string is rejected in following two ways:

1. If no transition is defined for any configuration(this includes the final state as well because to accept the string we need the transition (f,$,_)---> (f,_) in final state or accepting state where blank('_') denotes arbitrary stack symbol that does not matter because we are not accepting by EMPTY stack

2. If string enters a configuration for which no transition is defined, STRING **is rejected.**

So option (D) is correct. Because the same way it may not empty the stack when it finishes reading the string.

16 votes -- Sandeep_Uniyal (7.3k points)

5.11.10 Pushdown Automata: GATE2006-IT-31 top

http://gateoverflow.in/3570

Selected Answer

option B is correct

$$L = \{a^l b^m c^n \mid l \neq m \text{ or } m \neq n\}$$

(q0,a,Z0)
$\rightarrow$(q0,aZ0)

(q0,a,a)
$\rightarrow$(q0,aa)

(q0,b,a)
$\rightarrow$ (q1,∈), (q2,ba)

[here it is NPDA where we have to check $l \neq m$ or $m \neq n$; for $l \neq m$ we need to pop a for b; for $m \neq n$ we need to keep b in stack so that we can pop b for c]

(q1,b,a)
$\rightarrow$(q1,∈)

(q1,c,a)
$\rightarrow$ (qf,∈)

(q1,b,Z0)
$\rightarrow$ (qf,∈)

(q2,b,b)
$\rightarrow$q2,bb)

(q2,c,b)
$\rightarrow$(q3,∈)

(q3,c,b)
$\rightarrow$(q3,∈)

(q3,c,a)
$\rightarrow$(qf,∈)

(q3,∈,b)
$\rightarrow$(qf,∈)

A is wrong as it is not context free

D a*b* is regular, so must have DFA , and so an equivalent DPDA

C can be accepted using DPDA

12 votes -- Praveen Saini (53.6k points)

5.11.11 Pushdown Automata: GATE2006-IT-33 top

http://gateoverflow.in/3572

Selected Answer

for every a we put two X in stack [at state s]

after that for every b we pop out one X [reach to state t (getting b after a)]

after that for every c we pop out one X [reach to state u (getting c after b)]

if all X are popped out then reached to final state f , mean for every b there is a, for every c there is a .

a was followed by b and b was followed by c [state s to t , t to u , u to f, final]

means sum of no of b's and no of c's = twice of no of a's [one a for one b , one a for one c]

i.e. $\{a^l b^m c^n \mid 2l = m + n\}$

14 votes -- Praveen Saini (53.6k points)

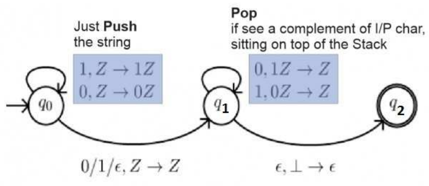
5.11.12 Pushdown Automata: GATE2015-1-51 top

http://gateoverflow.in/8357

Selected Answer

Here, Z is used to represent the entire stack content except the top
Z is the string in Stack read from top to bottom. $1, Z \rightarrow 1Z$ means, on input symbol 1, the stack content changes from Z to $1Z$

In q_0 state, for '1', a '1' is pushed and for a '0' a '0' is pushed. In q1 state, for a '0' a '1' is popped and for a '1' a '0' is popped. So, the given PDA is accepting all strings of of the form $x0x_r'$ or $x1x_r'$ or xx_r', where x_r' is the reverse of the 1's complement of x. i.e.:



The given string 101100 has 6 letters and we are given 5 letter strings. So, $x0$ is done, with $x = 10110$. So, $x_r' = (01001)_r = 10010$.

answer = **option B**

34 votes -- Arjun Suresh (294k points)

5.11.13 Pushdown Automata: ISI 2015 PCB C4 A top

http://gateoverflow.in/121031

Selected Answer

Now, this is what we called a problem.

Here is the grammar,

$S \rightarrow E|U|\epsilon$

$E \rightarrow AB|BA$

$A \rightarrow ZAZ|a$

$B \rightarrow ZBZ|b$

$U \rightarrow ZUZ|Z$

$Z \rightarrow a|b$

For more Explore this.

5 votes -- Muktinath Vishwakarma (34.1k points)

5.12 Recursive And Recursively Enumerable Languages(13) top

5.12.1 Recursive And Recursively Enumerable Languages: GATE 2016-1-44 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 s recursively enumerable.
C. W is not recursively enumerable and Z is recursive.
D. W is not recursively enumerable and Z is not recursive.

gate2016-1 theory-of-computation easy recursive-and-recursively-enumerable-languages

Answer

5.12.2 Recursive And Recursively Enumerable Languages: GATE1990-3-vi top

Choose the correct alternatives (More than one may be correct).

Recursive languages are:

A. A proper superset of context free languages.
B. Always recognizable by pushdown automata.
C. Also called type $\emptyset$ languages.
D. Recognizable by Turing machines.

gate1990 normal theory-of-computation turing-machine recursive-and-recursively-enumerable-languages

Answer

5.12.3 Recursive And Recursively Enumerable Languages: GATE2003-13 http://gateoverflow.in/904 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 $P = NP$

gate2003 theory-of-computation normal recursive-and-recursively-enumerable-languages

Answer

5.12.4 Recursive And Recursively Enumerable Languages: GATE2003-15 http://gateoverflow.in/120 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 gate2003 normal recursive-and-recursively-enumerable-languages

Answer

5.12.5 Recursive And Recursively Enumerable Languages: GATE2005-56 http://gateoverflow.in/1379 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

gate2005 theory-of-computation recursive-and-recursively-enumerable-languages easy

Answer

5.12.6 Recursive And Recursively Enumerable Languages: GATE2008-13, ISRO2016-36 top http://gateoverflow.in/411

If L and $\bar{L}$ are recursively enumerable then L is

A. regular
B. context-free
C. context-sensitive
D. recursive

gate2008 theory-of-computation easy isro2016 recursive-and-recursively-enumerable-languages

Answer

5.12.7 Recursive And Recursively Enumerable Languages: GATE2008-48 http://gateoverflow.in/461 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

gate2008 theory-of-computation easy recursive-and-recursively-enumerable-languages

Answer

5.12.8 Recursive And Recursively Enumerable Languages: GATE2010-17 http://gateoverflow.in/2190 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.

gate2010 theory-of-computation recursive-and-recursively-enumerable-languages decidability normal

Answer

5.12.9 Recursive And Recursively Enumerable Languages: GATE2014-1-35 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.

gate2014-1 theory-of-computation easy recursive-and-recursively-enumerable-languages

Answer

5.12.10 Recursive And Recursively Enumerable Languages: GATE2014-2-16 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.

gate2014-2 theory-of-computation recursive-and-recursively-enumerable-languages normal

Answer

5.12.11 Recursive And Recursively Enumerable Languages: GATE2015-1_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. $\bar{L}_1$ (Compliment of L_1) is recursive
II. $\bar{L}_2$ (Compliment of L_2) is recursive
III. $\bar{L}_1$ is context-free
IV. $\bar{L}_1$ ∪ L_2 is recursively enumerable

A. I only
B. III only
C. III and IV only
D. I and IV only

gate2015-1 theory-of-computation recursive-and-recursively-enumerable-languages normal

Answer

5.12.12 Recursive And Recursively Enumerable Languages: TIFR2010-B-40 top

Which of the following statement is FALSE?

a. All recursive sets are recursively enumerable.
b. The complement of every recursively enumerable sets is recursively enumerable.
c. Every Non-empty recursively enumerable set is the range of some totally recursive function.
d. All finite sets are recursive.
e. The complement of every recursive set is recursive.

tifr2010 theory-of-computation recursive-and-recursively-enumerable-languages

Answer

5.12.13 Recursive And Recursively Enumerable Languages: TIFR2012-B-19 top

Which of the following statements is TRUE?

a. Every turning machine recognizable language is recursive.
b. The complement of every recursively enumerable language is recursively enumerable.
c. The complement of a recursive language is recursively enumerable.
d. The complement of a context-free language is context-free.
e. The set of turning machines which do not halt on empty input forms a recursively enumerable set.

tifr2012 theory-of-computation recursive-and-recursively-enumerable-languages

Answer

Answers: Recursive And Recursively Enumerable Languages

5.12.1 Recursive And Recursively Enumerable Languages: GATE 2016-1-44 top

http://gateoverflow.in/39721

Selected Answer

X is recursive language, so
$\overline{X}$ is also recursive.

Y is recursively enumerable,but not recursive so
$\overline{Y}$ is not recursively enumerable language.

$A \leq B$, (A is reducible to B) , i. e,solving A cannot be "harder" than solving B.

1. if A is reducible to B, and B is decidable, then A is decidable.

i) if A is reducible to B, and B is recursive, then A is recursive.

2. if A is undecidable, and reducible to B, then B is undecidable.

i) if B is recursively enumerable, and A is reducible to B, then A is recursively enumerable.

ii) if A is not recursively enumerable, and reducible to B, then B is not recursively enumerable.

Now Back to question.

$\overline{Y}$ is not recursively enumerable, and reducible to
W, then
W is not recursively enumerable (using 2(ii)).

Z is reducible to
$\overline{X}$ and
$\overline{X}$ is recursive, then
Z is recursive (using 1(i)).

Option C is correct

29 votes -- Praveen Saini (53.6k points)

5.12.2 Recursive And Recursively Enumerable Languages: GATE1990-3-vi top

http://gateoverflow.in/84833

Selected Answer

A.A proper superset of context free languages.**TRUE,**Since there are languages which are not CFL still Recursive

B.Always recognizable by pushdown automata.**FALSE**

C.Also called type 0 languages.**FALSE,** R.E languages are actually type-0 languages

D.Recognizable by Turing machines,**TRUE**

5 votes -- Prajwal Bhat (11.9k points)

5.12.3 Recursive And Recursively Enumerable Languages: GATE2003-13 http://gateoverflow.in/904 top

Selected Answer

(A) L is recursive. If $P = NP$, L is Σ^* which is recursive (in fact regular). If not, $L = \phi$ which is again recursive. So, in both cases L is recursive.

17 votes -- Arjun Suresh (294k points)

5.12.4 Recursive And Recursively Enumerable Languages: GATE2003-15 http://gateoverflow.in/120 top

Selected Answer

Answer is (D)- L is recursive but not necessarily Regular or not even context-free.

Since, the strings of L can be enumerated it means L is recursively enumerable. That is we have a TM which accepts all strings in L. Now, to be recursive the TM should reject all strings not in L. Since, the strings of the language can be enumerated in lexicographic order, it's easy to do this. For any word w, if we see a word in the enumeration which is lexicographically higher than w but no w, it means w is not in the language. This makes L '''recursive'''.

Now, why L need not be context free or regular? Consider

$L = \{a^n b^n c^n$ |

The strings of this language can be enumerated in lexicographic order. But we know L is not context free as no PDA can accept L.

35 votes -- Arjun Suresh (294k points)

5.12.5 Recursive And Recursively Enumerable Languages: GATE2005-56 http://gateoverflow.in/1379 top

Selected Answer

L_1 being recursive, we have a TM M for L_1 which accepts all words in L_1 and rejects all words in L_1'. So, this TM also works for L_1' by changing the accept and reject states. Thus L_1' is recursive.

L_2 being recursively enumerable but not recursive means TM for L_2 can accept all words in L_2 but cannot reject all words not in L_2 => TM for L_2' cannot exist (as otherwise TM for L_2 could simulate the moves of that TM to reject words in L_2')=> L_2' is not recursively enumerable. So, (B).

13 votes -- Arjun Suresh (294k points)

5.12.6 Recursive And Recursively Enumerable Languages: GATE2008-13, ISRO2016-36 top

http://gateoverflow.in/411

Selected Answer

(D) recursive

L is recursively enumerable means a TM accepts all strings in L. $\bar{L}$ is recursively enumerable means a TM accepts all strings in $\bar{L}$. So, we can always decide if a string is in L or not, making L recursive.

If a language L and its complement $\overline{L}$ are both recursively enumerable, then both languages are recursive. If L is recursive, then $\overline{L}$ is also recursive, and consequently both are recursively enumerable.

Proof: If L and $\overline{L}$ are both recursively enumerable, then there exist Turing machines M and $\widehat{M}$ that serve as enumeration procedures for L and $\overline{L}$, respectively. The first will produce $w_1, w_2, \ldots$ in L, the second $\widehat{w}_1, \widehat{w}_2, \ldots$ in $\overline{L}$. Suppose now we are given any $w \in \Sigma^+$. We first let M generate w_1 and compare it with w. If they are not the same, we let $\widehat{M}$ generate $\widehat{w}_1$ and compare again. If we need to continue, we next let M generate w_2, then $\widehat{M}$ generate $\widehat{w}_2$, and so on. Any $w \in \Sigma^+$ will be generated by either M or $\widehat{M}$, so eventually we will get a match. If the matching string is produced by M, w belongs to L, otherwise it is in $\overline{L}$. The process is a membership algorithm for both L and $\overline{L}$, so they are both recursive.

For the converse, assume that L is recursive. Then there exists a membership algorithm for it. But this becomes a membership algorithm for $\overline{L}$ by simply complementing its conclusion. Therefore, $\overline{L}$ is recursive. Since any recursive language is recursively enumerable, the proof is completed. ■

http://goo.gl/RtV8MO

15 votes -- Keith Kr (6.3k points)

5.12.7 Recursive And Recursively Enumerable Languages: GATE2008-48 top

http://gateoverflow.in/461

Selected Answer

there exists a set of languages which is RE but not REC(i.e. Recursively Enumerable but not Recursive), this set is a subset of RE but is Not Recursive

option D tells us that every subset of RE is REC this is false,
Hence, **option D** is chosen

12 votes -- Amar Vashishth (28.7k points)

5.12.8 Recursive And Recursively Enumerable Languages: GATE2010-17 top

http://gateoverflow.in/2190

Selected Answer

Recursively enumerable languages are closed under union and intersection. So, lets consider each option
(A) $L_2 - L_1 = L_2 \cap \overline{L_1}$
Recursive languages are closed under complement, and so $\overline{L_1}$ is recursive and hence recursively enumerable also. So, $L_2 \cap \overline{L_1}$ is recursively enumerable is always TRUE.

(B) $L_1 - L_3 = L_1 \cap \overline{L_3}$

Recursively enumerable languages are not closed under complement. So, $\overline{L_3}$ may or may not be recursively enumerable and hence we can't say anything if $L_1 \cap \overline{L_3}$ is recursively enumerable or not.

(C) Intersection of two recursively enumerable languages is always recursively enumerable(RE closed under intersection).

(D) Union of two recursively enumerable languages is always recursively enumerable(RE closed under union).

For verifying closure properties:
http://gatecse.in/wiki/Closure_Property_of_Language_Families

34 votes -- Arjun Suresh (294k points)

5.12.9 Recursive And Recursively Enumerable Languages: GATE2014-1-35 top

Selected Answer

(C) is not possible. If L is re we have a TM that accepts string in L. If L' is re, we have a TM that accepts strings in L'. So, using both these TMs we can make a new TM M which accepts strings in L and rejects strings in L' - that is M decides L, making L recursive.

15 votes -- Arjun Suresh (294k points)

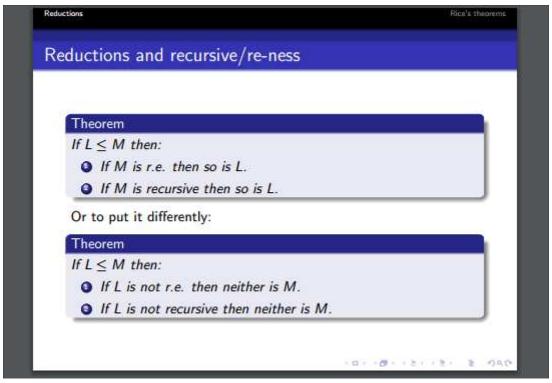
5.12.10 Recursive And Recursively Enumerable Languages: GATE2014-2-16 top

Selected Answer

A $\leq_m$ B means A cannot be harder than B. (Since A can be reduced to B, instead of deciding A, we can now decide B)

So, the first 3 options are correct. Option (D) is false, as B is not recursively enumerable doesn't guarantee A is not recursively enumerable.

14 votes -- Arjun Suresh (294k points)



This slide explains everything

11 votes -- resilientknight (2.3k points)

5.12.11 Recursive And Recursively Enumerable Languages: GATE2015-1_3 top

Selected Answer

D.

L1 is context-free and hence recursive also. Recursive set being closed under complement, L1' will be recursive.

L1' being recursive it is also recursively enumerable and Recursively Enumerable set is closed under Union. So, L1' U L2 is recursively enumerable.

Context free languages are not closed under complement- so III is false

Recursive set is closed under complement. So, if L2' is recursive, (L2')' = L2 is also recursive which is not the case here.

So, II is also false.

17 votes -- Arjun Suresh (294k points)

5.12.12 Recursive And Recursively Enumerable Languages: TIFR2010-B-40 top

http://gateoverflow.in/19048

Selected Answer

B) The complement of every recursively enumerable sets is recursively enumerable.

because RE language are not closed under complement.

8 votes -- Umang Raman (15.2k points)

5.12.13 Recursive And Recursively Enumerable Languages: TIFR2012-B-19 top

http://gateoverflow.in/25218

Selected Answer

a.False. Turing recognizable language are recursive enumerable and recursive set is a **proper subset** of it.

b. False, Complement of r.e. **need not** be r.e.

c. True. Complement of recursive language is recursive and every recursive language is recursive enumerable.

d. False. Complement of CFL **need not** be CFL (but is guaranteed to be a CSL).

e. False. **NOT halt** on empty, yes ans not possible. Only no ans is there. So it will be non r.e. while its complement is r.e. but not recursive.

10 votes -- srestha (58.4k points)

5.13 Regular Expressions(27) top

5.13.1 Regular Expressions: GATE 1992-2 (xii) Which of the following regular expression identities are true? top

http://gateoverflow.in/83956

(A) r(*) = r*

(B) (r*S*)* = (r + s)*

(C) (r + s)* = r* + s*

(D) r*s* = r* + s*

gate1992 theory-of-computation regular-expressions

Answer

5.13.2 Regular Expressions: GATE 2016-1-18 top

http://gateoverflow.in/39647

Which one of the following regular expressions represents the language: *the set of all binary strings having two consecutive 0's and two consecutive 1's*?

A. $(0+1)^*0011(0+1)^* + (0+1)^*1100(0+1)^*$
B. $(0+1)^*(00(0+1)^*11 + 11(0+1)^*00)(0+1)^*$
C. $(0+1)^*00(0+1)^* + (0+1)^*11(0+1)^*$
D. $00(0+1)^*11 + 11(0+1)^*00$

gate2016-1 theory-of-computation regular-expressions normal

Answer

5.13.3 Regular Expressions: GATE1987-10d top

http://gateoverflow.in/82455

Give a regular expression over the alphabet $\{0, 1\}$ to denote the set of proper non-null substrings of the string 0110.

gate1987 theory-of-computation regular-expressions

Answer

5.13.4 Regular Expressions: GATE1991_03,xiii top http://gateoverflow.in/527

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only.

Let $r = 1(1+0)^*, s = 11^*0 \text{ and } t = 1^*0$ 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-expressions normal

Answer

5.13.5 Regular Expressions: GATE1992_02,xvii top http://gateoverflow.in/575

02. Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

Which of the following regular expression identities is/are TRUE?

(a) $r^{(*)} = r^*$

(b) $(r^*s^*) = (r+s)^*$

(c) $(r+s)^* = r^* + s^*$

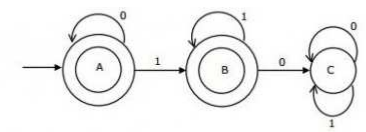
(d) $r^*s^* = r^* + s^*$

gate1992 theory-of-computation regular-expressions easy

Answer

5.13.6 Regular Expressions: GATE1994_2.10 top http://gateoverflow.in/2477

The regular expression for the language recognized by the finite state automaton of figure is _______



gate1994 theory-of-computation finite-automata regular-expressions easy

Answer

5.13.7 Regular Expressions: GATE1995-1.9 , ISRO2017-13 top http://gateoverflow.in/2596

In some programming language, an identifier is permitted to be a letter followed by any number of letters or digits. If L and D denote the sets of letters and digits respectively, which of the following expressions defines an identifier?

A. $(L+D)^+$
B. $(L.D)^*$
C. $L(L+D)^*$
D. $L(L.D)^*$

gate1995 theory-of-computation regular-expressions easy isro2017

Answer

5.13.8 Regular Expressions: GATE1996_1.8 top http://gateoverflow.in/2712

Which two of the following four regular expressions are equivalent? (ε is the empty string).

i. $(00)^*(\varepsilon + 0)$
ii. $(00)^*$
iii. 0^*
iv. $0(00)^*$

A. (i) and (ii)
B. (ii) and (iii)
C. (i) and (iii)
D. (iii) and (iv)

gate1996 theory-of-computation regular-expressions easy

Answer

5.13.9 Regular Expressions: GATE1997_6.4 top http://gateoverflow.in/2260

Which one of the following regular expressions over $\{0,1\}$ denotes the set of all strings not containing 100 as substring?

(a) $0^*(1+0)^*$

(b) 0^*1010^*

(c) $0^*1^*01^*$

(d) $0^*(10+1)^*$

gate1997 theory-of-computation regular-expressions normal

Answer

5.13.10 Regular Expressions: GATE1998_1.12 top http://gateoverflow.in/1649

The string 1101 does not belong to the set represented by

(a) 110*(0 + 1)
(b) 1(0 + 1)*101
(c) (10)*(01)*(00 + 11)*
(d) (00 + (11)*0)*

gate1998 theory-of-computation regular-expressions easy

Answer

5.13.11 Regular Expressions: GATE1998_1.9 top http://gateoverflow.in/1646

If the regular set A is represented by $A = (01+1)^*$ and the regular set B is represented by $B = ((01)^*1^*)^*$, which of the following is true?

(a) $A \subset B$

(b) $B \subset A$

(c) A and B are incomparable

(d) $A = B$

gate1998 theory-of-computation regular-expressions normal

Answer

5.13.12 Regular Expressions: GATE1998_3b top http://gateoverflow.in/2941

Give a regular expression for the set of binary strings where every 0 is immediately followed by exactly k 1's and preceded by at least k 1's (k is a fixed integer)

gate1998 theory-of-computation regular-expressions easy

Answer

5.13.13 Regular Expressions: GATE2000-1.4 top http://gateoverflow.in/627

Let S and T be languages over $\Sigma = \{a.b\}$ represented by the regular expressions $(a+b^*)^*$ and $(a+b)^*$, respectively. Which of the following is true?

A. $S \subset T$
B. $T \subset S$
C. $S = T$
D. $S \cap T = \phi$

gate2000 theory-of-computation regular-expressions easy

Answer

5.13.14 Regular Expressions: GATE2003-14 top http://gateoverflow.in/905

The regular expression $0^*(10^*)^*$ denotes the same set as

A. $(1^*0)^*1^*$
B. $0+(0+10)^*$
C. $(0+1)^*10(0+1)^*$
D. None of the above

gate2003 theory-of-computation regular-expressions easy

Answer

5.13.15 Regular Expressions: GATE2004-IT-7 top http://gateoverflow.in/3648

Which one of the following regular expressions is NOT equivalent to the regular expression (a + b + c)*?

A. (a* + b* + c*)*
B. (a*b*c*)*
C. ((ab)* + c*)*
D. (a*b* + c*)*

gate2004-it theory-of-computation regular-expressions normal

Answer

5.13.16 Regular Expressions: GATE2005-IT-5 top http://gateoverflow.in/3749

Which of the following statements is TRUE about the regular expression 01*0?

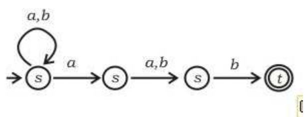
A. It represents a finite set of finite strings.
B. It represents an infinite set of finite strings.
C. It represents a finite set of infinite strings.
D. It represents an infinite set of infinite strings.

gate2005-it theory-of-computation regular-expressions easy

Answer

5.13.17 Regular Expressions: GATE2006-IT-5 top http://gateoverflow.in/3544

Which regular expression best describes the language accepted by the non-deterministic automaton below?



A. (a + b)* a(a + b)b
B. (abb)*
C. (a + b)* a(a + b)* b(a + b)*
D. (a + b)*

gate2006-it theory-of-computation regular-expressions normal

Answer

5.13.18 Regular Expressions: GATE2007-IT-73 top

http://gateoverflow.in/3525

Consider the regular expression R = (a + b)* (aa + bb) (a + b)*

Which one of the regular expressions given below defines the same language as defined by the regular expression R?

A. (a(ba)* + b(ab)*)(a + b)$^+$
B. (a(ba)* + b(ab)*)*(a + b)*
C. (a(ba)* (a + bb) + b(ab)*(b + aa))(a + b)*
D. (a(ba)* (a + bb) + b(ab)*(b + aa))(a + b)$^+$

gate2007-it theory-of-computation regular-expressions normal

Answer

5.13.19 Regular Expressions: GATE2008-IT-5 top

http://gateoverflow.in/3265

Which of the following regular expressions describes the language over{0, 1} consisting of strings that contain exactly two 1's?

A. (0 + 1) * 11(0 + 1) *
B. 0 * 110 *
C. 0 * 10 * 10 *
D. (0 + 1) * 1(0 + 1) * 1 (0 + 1) *

gate2008-it theory-of-computation regular-expressions easy

Answer

5.13.20 Regular Expressions: GATE2009-15 top

http://gateoverflow.in/1307

Which one of the following languages over the alphabet $\{0,1\}$ is described by the regular expression: $(0+1)^*0(0+1)^*0(0+1)^*$?

A. The set of all strings containing the substring 00
B. The set of all strings containing at most two 0's
C. The set of all strings containing at least two 0's
D. The set of all strings that begin and end with either 0 or 1

gate2009 theory-of-computation regular-expressions easy

Answer

5.13.21 Regular Expressions: GATE2010-39 top

http://gateoverflow.in/2340

Let $L = \{w \in \ (0+1)^* \mid w \text{ has even number of } 1s\}$. i.e., L is the set of all the bit strings with even numbers of 1s. Which one of the regular expressions below represents L?

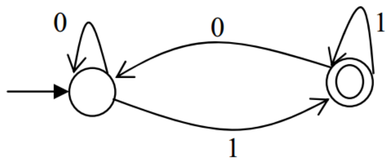
A. $(0^*10^*1)^*$
B. $0^*(10^*10^*)^*$
C. $0^*(10^*1)^*0^*$
D. $0^*1(10^*1)^*10^*$

gate2010 theory-of-computation regular-expressions normal

Answer

5.13.22 Regular Expressions: GATE2014-1-36 top http://gateoverflow.in/1914

Which of the regular expressions given below represent the following DFA?



I. $0^*1(1+00^*1)^*$
II. $0^*1^*1+11^*0^*1$
III. $(0+1)^*1$

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

gate2014-1 theory-of-computation regular-expressions finite-automata easy

Answer

5.13.23 Regular Expressions: GATE2014-3-15 top http://gateoverflow.in/2049

The length of the shortest string NOT in the language (over $\Sigma = \{a, b\}$) of the following regular expression is ________.

$$a^*b^*(ba)^*a^*$$

gate2014-3 theory-of-computation regular-expressions numerical-answers easy

Answer

5.13.24 Regular Expressions: ISI2013-CS-4b top http://gateoverflow.in/47638

Write a regular expression for all strings of 0's and 1's in which the total number of 0's to the right of each 1 is even. Justify your answer.

descriptive isi2013 theory-of-computation regular-expressions

Answer

5.13.25 Regular Expressions: TIFR2010-B-34 top http://gateoverflow.in/19047

Let r, s, t be regular expressions. Which of the following identities is correct?

a. $(r+s)^* = r^*s^*$
b. $r(s+t) = rs+t$
c. $(r+s)^* = r^*+s^*$
d. $(rs+r)^*r = r(sr+r)^*$
e. $(r^*s)^* = (rs)^*$

tifr2010 theory-of-computation regular-expressions

Answer

5.13.26 Regular Expressions: TIFR2015-B-7 top http://gateoverflow.in/29861

Let a, b, c be regular expressions. Which of the following identities is correct?

a. $(a+b)^* = a^*b^*$
b. $a(b+c) = ab+c$

c. $(a+b)^* = a^* + b^*$
d. $(ab+a)^*a = a(ba+a)^*$
e. None of the above.

tifr2015 theory-of-computation regular-expressions

Answer

5.13.27 Regular Expressions: TIFR2017-B-9 top

http://gateoverflow.in/95705

Which of the following regular expressions correctly accepts the set of all 0/1-strings with an even (poossibly zero) numbe of 1s?

A. $(10^*10^*)^*$
B. $(0^*10^*1)^*$
C. $0^*1(10^*1)^*10^*$
D. $0^*1(0^*10^*10^*)^*10^*$
E. $(0^*10^*1)^*0^*$

tifr2017 theory-of-computation regular-expressions

Answer

Answers: Regular Expressions

5.13.1 Regular Expressions: GATE 1992-2 (xii) Which of the following regular expression identities are true? top

http://gateoverflow.in/83956

Selected Answer

B is only correct

why not A?

A's RHS can accept null strings, LHS can't.
if r=ab then r*=abababa.....
r(*)=ab(*)=ab

4 votes -- Amitabh Tiwari (2.5k points)

5.13.2 Regular Expressions: GATE 2016-1-18 top

http://gateoverflow.in/39647

Selected Answer

Set of all binary strings having two consecutive 0s and two consecutive 1s

Anything 00 *Anything* 11*Anything* + *Anything* 11 *Anything* 00 *Anything*

$(0+1)^*00(0+1)^*11(0+1)^* + (0+1)^*11(0+1)^*00(0+1)^*$

And it is same after taking common.

$(0+1)^*(00(0+1)^*11 + 11(0+1)^*00)(0+1)^*$

So **Option B** is Ans

Neither they said Both are immediate nor they give a predefined order, so it should be as above

32 votes -- Praveen Saini (53.6k points)

5.13.3 Regular Expressions: GATE1987-10d top

http://gateoverflow.in/82455

$\varepsilon^* 0110 \varepsilon^*$

2 votes -- billy (535 points)

5.13.4 Regular Expressions: GATE1991_03,xiii top

http://gateoverflow.in/527

Selected Answer

ans is A and C

to know the ans let us check all the options.

a) $L(s) \subseteq L(r)$: strings generated by s are any numbers of 1's followed by one 0, i.e., $10, 110, 1110, 1110, \ldots$. Strings generated by r are is 1 followed by any combination of 0 or 1, i.e., $1, 10, 11, 1110, 101, 110 \ldots$. This shows that all the strings that can be generated by s, can also be generated by r it means $L(s) \subseteq L(r)$ is true.
$L(s) \subseteq L(t)$: here strings generated by t are any numbers of 1 (here 1* means we have strings as $\epsilon, 1, 11, 111, \ldots$) followed by only one 0, i.e., $0, 10, 110, 1110, \ldots$. So we can see that all the strings that are present in s can also be generated by t, hence $L(s) \subseteq L(t)$ which shows that option A is true.

b) $L(r) \subseteq L(s)$: this is false because string 1 which can be generated by r, cannot be generated by s.

c) Same as option A.

d) $L(t) \subseteq L(s)$: this is false because string 0 which can be generated by t,cannot be generated by s.

16 votes -- neha pawar (4.4k points)

5.13.5 Regular Expressions: GATE1992_02,xvii top

http://gateoverflow.in/575

Selected Answer

(a) is the answer

(b) RHS generates Σ^* while LHS can't generate strings where r comes after s like sr, srr etc. LHS $\subset$ RHS.

(c) LHS generates Σ^* while RHS can't generate strings where r comes after an s. RHS $\subset$ LHS.

(d) LHS contains all strings where after an s, no r comes. RHS contains all strings of either r or s but no combination of them. So, RHS $\subset$ LHS.

17 votes -- Arjun Suresh (294k points)

5.13.6 Regular Expressions: GATE1994_2.10 top

http://gateoverflow.in/2477

Selected Answer

$L = 0^* 1^*$

L contains all binary strings where a 1 is not followed by a 0.

16 votes -- Manu Thakur (6k points)

5.13.7 Regular Expressions: GATE1995-1.9 , ISRO2017-13 top

http://gateoverflow.in/2596

Selected Answer

It is C

It has to be started by a letter followed by any number of letters and digits.

18 votes -- Gate Keeda (19.1k points)

5.13.8 Regular Expressions: GATE1996_1.8 top

http://gateoverflow.in/2712

Selected Answer

C.

you can have any no. of 0's as well as null.

A is false because you cannot have single 0 in ii). same for option B. In D you are forced to have single 0 in iv) whereas not in iii).

14 votes -- Gate Keeda (19.1k points)

5.13.9 Regular Expressions: GATE1997_6.4 top http://gateoverflow.in/2260

Selected Answer

> "A regular expression denoting a language (set of strings) means it should generate all string in L and not generate any string not in L"

(a) - generates 100

(b) doesn't generate 0 (start trying strings in lexicographic order- 0, 1, 00, 01, 10,...)

(c) doesn't generate 1

(d) is the answer

12 votes -- Arjun Suresh (294k points)

5.13.10 Regular Expressions: GATE1998_1.12 top http://gateoverflow.in/1649

Selected Answer

Only (a) and (b) can generate 1101.

In (c) after 11, we can not have 01 and so 1101 cannot be generated.

In (d) Every 11 followed by some 0. So it cannot generate 1101 or 11011.

21 votes -- Arjun Suresh (294k points)

5.13.11 Regular Expressions: GATE1998_1.9 top http://gateoverflow.in/1646

Selected Answer

(d) $A = B$. Both generates all strings over $\{0, 1\}$ where a 0 is immediately followed by a 1.

10 votes -- Arjun Suresh (294k points)

5.13.12 Regular Expressions: GATE1998_3b top http://gateoverflow.in/2941

Selected Answer

1*1^k(01^k)* + 1*

This is correct expression, this considering chance of not having any 0's (In that case string can also be empty string).

11 votes -- Akash (43.8k points)

5.13.13 Regular Expressions: GATE2000-1.4 top http://gateoverflow.in/627

Selected Answer

(c) $S = T$. Both generates all strings over Σ.

13 votes -- Arjun Suresh (294k points)

5.13.14 Regular Expressions: GATE2003-14 top http://gateoverflow.in/905

Selected Answer

(A) is the answer. Both (A) and the given expression generates all strings over Σ.

(B) doesn't generate 11

(C) doesn't generate 11

19 votes -- Arjun Suresh (294k points)

5.13.15 Regular Expressions: GATE2004-IT-7 top http://gateoverflow.in/3648

Selected Answer

A) (a* + b* + c*)* = (^ + a+aa+.. ..+b+bb+...+c+cc...)* = (a+b+c+ aa+..+bb+..+cc+..)*= (a+b+c)*
[any combination of rest of aa ,bb,cc, etc already come in (a+b+c)*]

B) (a*b*c*)* = (a*+b*+c* +a*b*+b*c*+a*c*+..)*= (a+b+c+....)* = (a+b+c)*

C) ((ab)* + c*)* =(ab+c+^+abab+...)* = (ab+c)*

D) (a*b* + c*)* = (a*+b*+c*+...)* =(a+b+c+..)* = (a+b+c)*

14 votes -- Praveen Saini (53.6k points)

5.13.16 Regular Expressions: GATE2005-IT-5 top http://gateoverflow.in/3749

Selected Answer

(B). Infinite set (because of *) of finite strings. A string is defined as a **FINITE sequence** of characters and hence can never be infinite.

15 votes -- Arjun Suresh (294k points)

5.13.17 Regular Expressions: GATE2006-IT-5 top http://gateoverflow.in/3544

Selected Answer

Well A is answer

Say s1, s2 , s3 and t are states (in sequence)

s1 is start state

s1= ^ + s1a + s1b = ^+s1(a+b) = (a+b)* [using arden's theorem R= Q+RP , then R= QP*][^ bcoz of start state]

s2 = s1a = (a+b)*a

s3= s2a+s2b = s2(a+b) = (a+b)*a(a+b)

t= s3b= (a+b)*a(a+b)b

t is final state so regular expression is (a+b)*a(a+b)b

11 votes

-- Praveen Saini (53.6k points)

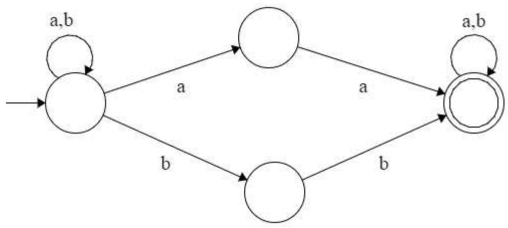
5.13.18 Regular Expressions: GATE2007-IT-73 top

http://gateoverflow.in/3525

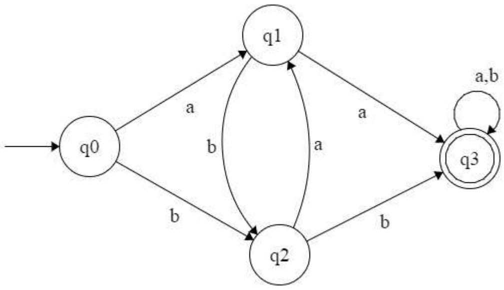
Selected Answer

R = (a+b)*(aa+bb)(a+b)*

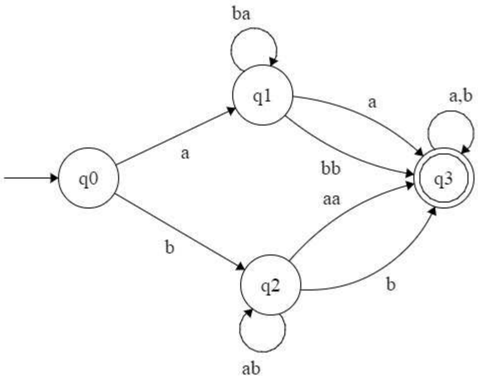
having NFA



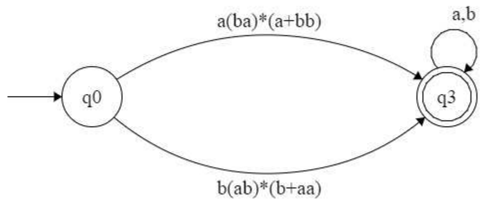
Equivalent DFA :



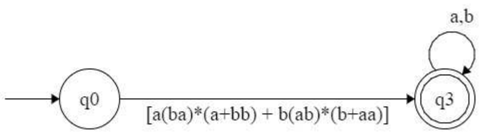
which is equivalent Transition graph [by removing transition from q1 to q2 and q2 to q1 but does not effect on language ..be careful]



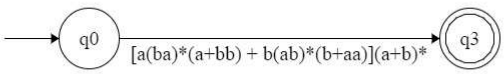
That is equivalent to



which is equivalent to



which is equivalent to



so equivalent regular expression is [a(ba)*(a+bb) + b(ab)*(b+aa)](a+b)*

so option C is answer.

16 votes -- Praveen Saini (53.6k points)

Another quick approach of solving this question for keen observer :-

Observe that aa or bb is minimal string that is possible in first Regular Expression (a + b)* (aa + bb) (a + b)*.

A) We can have ba or ab as minimal strings which are not possible in (a + b)* (aa + bb) (a + b)*

B) We can empty string , which is not possible in (a + b)* (aa + bb) (a + b)*

D) Minimum string length is 3, aa or bb is not possible in this RE.

This rules out option A,B, & D. So option C is answer.

10 votes -- Akash (43.8k points)

5.13.19 Regular Expressions: GATE2008-IT-5 top

http://gateoverflow.in/3265

Selected Answer

A) with at least 2 consecutive 1's, any no of 0's and any no of 1's
B) exactly two consecutive 1's
C)exactly two 1's but need not be consecutive
D) any no of 1's and 0's with at least two 1's

Hence C) is the correct option.

17 votes -- Manu Thakur (6k points)

5.13.20 Regular Expressions: GATE2009-15 top

http://gateoverflow.in/1307

Selected Answer

(C) is the answer.

Counter example for other choices:

(A) 1010 is accepted which doesn't contain 00
(B) 000 is accepted
(D) 01 is not accepted

12 votes -- Arjun Suresh (294k points)

5.13.21 Regular Expressions: GATE2010-39 top http://gateoverflow.in/2340

Selected Answer

(A) - If the string contains a 1, it must end in a 1 hence cannot generate all bit strings with even number of 1's (eg, 1010)

(B) - is the answer

(C) - between the second and third 1's a 0 is not allowed (eg, 011011)

(D) - 00 is not allowed, zero is an even number.

26 votes -- Arjun Suresh (294k points)

5.13.22 Regular Expressions: GATE2014-1-36 top http://gateoverflow.in/1914

Selected Answer

(B) is the answer. (II) doesn't generate 11011 which is accepted by the given DFA

25 votes -- Arjun Suresh (294k points)

5.13.23 Regular Expressions: GATE2014-3-15 top http://gateoverflow.in/2049

Selected Answer

R = a*b*(ba)*a*

for finding shortest string that is not in language it is better to look strings of length 0, then of length 1 and so on

length0 { ϵ} is in L

length1 {a, b} all belong to L

length2 {aa, ab, ba, bb} all belong to L

length 3 {aaa, aab, aba, abb, baa, bab, bba, bbb} ***bab does not belong to L***

30 votes -- Praveen Saini (53.6k points)

5.13.24 Regular Expressions: ISI2013-CS-4b top http://gateoverflow.in/47638

Selected Answer

Here Total no. of 0's to the right of each 1's should be even.So,to the left side of every 1's no. of 0's can be anything.

L={ϵ,0,00,000,01,011,0111,1,11,111,1111,100,10000,100100,10010000..................}

Hence,

R.E.=$0^*(1+00)^*$= 0*(1(00)*)* = 0*(1+(00)*)* =0*(1*+(00))* = 0*(1*+(00)*)*

5 votes -- Leen Sharma (32.3k points)

5.13.25 Regular Expressions: TIFR2010-B-34 top

http://gateoverflow.in/19047

Selected Answer

a. (r + s)* = r*s*   LHS can generate 'sr' but RHS not
b. r(s + t) = rs + t   LHS can generate 'rt' but RHS not
c. (r + s)* = r* + s*   LHS can generate 'sr' but RHS not
d. (rs + r)* r = r (sr + r)*   They are equivalent
e. (r*s)* = (rs)*   LHS can generate 'rrrs' but RHS not

So option D is correct answer.

11 votes -- Umang Raman (15.2k points)

5.13.26 Regular Expressions: TIFR2015-B-7 top

http://gateoverflow.in/29861

Selected Answer

a)
$(a+b)^*$ = { any strings of over {a,b} }

a^*b^* = { any number of a's followed by any number of b's }

False, as strings, ba , aba, bab, etc are not present in
a^*b^*

b)
$a(b+c) = \{ab, ac\}$

$ab + c = \{ab, c\}$

False

c)
$(a+b)^*$ = { any strings of over {a,b} }
$a^* + b^*$ = { any numbers of a's or any numbers of b's }

False , as strings , ab, ba, aba, bab etc are not present in
$a^* + b^*$

d)
$(ab+a)^*a = a(ba+a)^*$, **True**
$p(qp)^* = p\{\epsilon, qp, qpqp, qpqpqp, \dots\} = \{p, pqp, pqpqp, pqpqpqp, \dots\} = \{\epsilon, pq, pqpq, pqpqpq, \dots\}p = (pq)^*p$

$(ab+a)^*a = (a(b+\epsilon))^*a = a((b+\epsilon)a)^* = a(ba+a)^*$

16 votes -- Praveen Saini (53.6k points)

5.13.27 Regular Expressions: TIFR2017-B-9 top

http://gateoverflow.in/95705

Selected Answer

As, mentioned in the question, the regular expression must accept all strings of 0 and 1 but with even no of 1s (including no 1s). Hence, 00 must be in the language. Option a, b, c, d do not accept 00. Hence, option e is correct.

5 votes -- tarun_svbk (1k points)

5.14 Regular Grammar(3) top

5.14.1 Regular Grammar: GATE1990-15a top

http://gateoverflow.in/86864

Is the language generated by the grammer G regular? If so, give a regular expression for it, else prove otherwise

G: $S \rightarrow aB$

$B \rightarrow bC$

$C \rightarrow xB$

$C \rightarrow c$

gate1990 descriptive theory-of-computation regular-languages regular-grammar grammar

Answer

5.14.2 Regular Grammar: GATE2006-IT-29 top http://gateoverflow.in/3568

Consider the regular grammar below

S → bS | aA | ϵ
A → aS | bA

The Myhill-Nerode equivalence classes for the language generated by the grammar are

A. {w ∈ (a + b)* | #a(w) is even) and {w ∈ (a + b)* | #a(w) is odd}
B. {w ∈ (a + b)* | #a(w) is even) and {w ∈ (a + b)* | #b(w) is odd}
C. {w ∈ (a + b)* | #a(w) = #b(w) and {w ∈ (a + b)* | #a(w) ≠ #b(w)}
D. {ϵ}, {wa | w ∈ (a + b)* and {wb | w ∈ (a + b)*}

gate2006-it theory-of-computation normal regular-grammar

Answer

5.14.3 Regular Grammar: GATE2015-2_35 top http://gateoverflow.in/8159

Consider the alphabet $\Sigma = \{0, 1\}$, the null/empty string λ and the set of strings $X_0, X_1, \text{ and } X_2$ generated by the corresponding non-terminals of a regular grammar. $X_0, X_1, \text{ and } X_2$ are related as follows.

$X_0 = 1X_1$

$X_1 = 0X_1 + 1X_2$

$X_2 = 0X_1 + \{\lambda\}$

Which one of the following choices precisely represents the strings in X_0?

A. 10(0*+(10)*)1
B. 10(0*+(10)*)*1
C. 1(0+10)*1
D. 10(0+10)*1 +110(0+10)*1

gate2015-2 theory-of-computation regular-grammar normal

Answer

Answers: Regular Grammar

5.14.1 Regular Grammar: GATE1990-15a top http://gateoverflow.in/86864

Selected Answer

First of all this grammar is right linear..And we know :

> Two special types of linear grammars are the following:
>
> - the **left-linear** or left regular grammars, in which **all nonterminals** in right hand sides are **at the left ends**;
> - the **right-linear** or right regular grammars, in which **all nonterminals** in right hand sides are **at the right ends**.

Hence the given grammar is regular and hence the language generated by regular grammar will also be regular..Alternatively we can also write a regular expression for it ..Let us see how to do it :

Given grammar

G: S→aB

B→bC

C→xB | c

So we can reverse substitution from C onwards to S to see what S generates..

Substituting the yield of C in B , we have :

B → bxB | bc

which gives B = (bx)* bc

Now substituting B in S we have :

S → aB

S = a(bx)*bc

Hence the corresponding regular expression is : a(bx)*bc

13 votes -- HABIB MOHAMMAD KHAN (76.8k points)

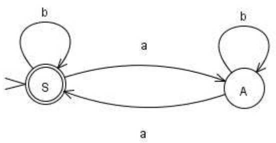
5.14.2 Regular Grammar: GATE2006-IT-29 top http://gateoverflow.in/3568

Selected Answer

Option A is correct.

The given grammar generates all string over the alphabet $\{a, b\}$ which have an even number of a's.

The given right-linear grammar can be converted to the following DFA.



13 votes -- Pragy Agarwal (19.5k points)

Before doing this question we should know following points :-
1. Number of equivalence classes = no. of states in MFA(Minimal FA)
2. In MFA we get some language at each and every stage.These languages are mutually exclusive.These languages are called as equivalence classes.

So, here

First ,Convert the Given Right Linear Regula Grammar into DFA. There are two states named S and A.(As shown in pragy's ans)

The language at state S represent one Equivalence Class. {w ∈ (a + b)* | #a(w) is even)

The language at State A represent another Equivalence Class. {w ∈ (a + b)* | #a(w) is odd}

So option A is Ans.

13 votes -- Rajesh Pradhan (18.6k points)

5.14.3 Regular Grammar: GATE2015-2_35 top http://gateoverflow.in/8159

Selected Answer

Here we have little different version of Arden's Theorem

if we have R= PR + Q then it has a solution R = P*Q

Proof :

R= PR+ Q

= P(PR+Q)+Q (by putting R= PR+Q)

= PPR+PQ+Q

=PP(PR+Q)+PQ+Q (by putting R= PR+Q)

= PPPR+PPQ+PQ+Q

and so on , we get R = {..........+PPPPQ+PPPQ+PPQ+PQ+Q}

= {..........+PPPP+PPP+PP+P+ ^}Q = P*Q

or Another way

R=PR+Q

= P(P*Q) + Q (by putting R = P*Q)

=(PP* + ^)Q = P*Q

So Equation is Proved .

Now for the Above Question

X_1= $0X_1$ + 1 X_2 (Equation 2)

= $0X_1$ +1($0X_1$ + ^) (Put the value of X_2 from Equation 3)

=$0X_1$ +10 X_1+ 1 = (0+10)X_1 +1

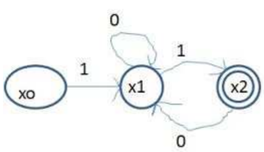
X_1= (0+10)*1 (Apply if R = PR + Q then R = P*Q)

X_0 = 1 X_1 (Equation 1)

X0 = 1(0+10)*1 (Put the value of X1 we calculated).

So 1(0+10)*1 option C is correct.

20 votes -- Praveen Saini (53.6k points)



convert the given transitions to a state diagram

from the given diagram we can write

X_0 =1(0+10)*1 option C

21 votes -- Umang Raman (15.2k points)

5.15 Regular Languages(36) top

5.15.1 Regular Languages: CMI2012-A-01 top http://gateoverflow.in/46529

Let $L \subseteq \{0,1\}^*$. Which of the following is true?

A. If L is regular, all subsets of L are regular.
B. If all proper subsets of L are regular, then L is regular.
C. If all finite subsets of L are regular, then L is regular.
D. If a proper subset of L is not regular, then L is not regular.

cmi2012 theory-of-computation regular-languages

Answer

5.15.2 Regular Languages: CMI2015-A-09 top http://gateoverflow.in/47046

Let L_1 and L_2 be languages over an alphabet Σ such that $L_1 \subseteq L_2$. Which of the following is true:

A. If L_2 is regular, then L_1 must also be regular.
B. If L_1 is regular, then L_2 must also be regular.
C. Either both L_1 and L_2 are regular, or both are not regular.
D. None of the above.

cmi2015 theory-of-computation regular-languages

Answer

5.15.3 Regular Languages: GATE 2016-2-17 top http://gateoverflow.in/39542

Language L_1 is defined by the grammar: $S_1 \rightarrow aS_1b \mid \varepsilon$

Language L_2 is defined by the grammar: $S_2 \rightarrow abS_2 \mid \varepsilon$

Consider the following statements:

- P: L_1 is regular
- Q: L_2 is regular

Which one of the following is **TRUE**?

A. Both P and Q are true.
B. P is true and Q is false.
C. P is false and Q is true.
D. Both P and Q are false.

gate2016-2 theory-of-computation normal regular-languages

Answer

5.15.4 Regular Languages: GATE1987-2h top http://gateoverflow.in/80589

State whether the following statements are TRUE or FALSE:

Regularity is preserved under the operation of string reversal.

gate1987 regular-languages theory-of-computation

Answer

5.15.5 Regular Languages: GATE1987-2i top http://gateoverflow.in/80590

State whether the following statements are TRUE or FALSE:

All subsets of regular sets are regular.

gate1987 theory-of-computation regular-languages

Answer

5.15.6 Regular Languages: GATE1990-3-viii top http://gateoverflow.in/84837

Choose the correct alternatives (More than one may be correct).

Let R_1 and R_2 be regular sets defined over the alphabet Σ Then:

A. $R_1 \cap R_2$ is not regular.
B. $R_1 \cup R_2$ is regular.
C. $\Sigma^* - R_1$ is regular.
D. R_1^* is not regular.

gate1990 normal theory-of-computation regular-languages

Answer

5.15.7 Regular Languages: GATE1991-03,xiv top http://gateoverflow.in/528

Choose the correct alternatives (more than one may be correct) and write the corresponding letters only:

Which of the following is the strongest correct statement about a finite language over some finite alphabet Σ ?

(a). It could be undecidable

(b). It is Turing-machine recognizable

(c). It is a context sensitive language.

(d). It is a regular language.

(e). None of the above,

gate1991 theory-of-computation easy regular-languages

Answer

5.15.8 Regular Languages: GATE1995_2.24 top http://gateoverflow.in/2637

Let $\Sigma = \{0,1\}, L = \Sigma^*$ and $R = \{0^n1^n \mid n > 0\}$ then the languages $L \cup R$ and R are respectively

(A) regular, regular

(B) not regular, regular

(C) regular, not regular

(D) not regular, not regular

gate1995 theory-of-computation easy regular-languages

Answer

5.15.9 Regular Languages: GATE1996_1.10 top http://gateoverflow.in/2714

Let $L \subseteq \Sigma^*$ where $\Sigma = \{a,b\}$. Which of the following is true?

(a) $L = \{x \mid x \text{ has an equal number of } a\text{'s and } b\text{'s}\}$ is regular

(b) $L = \{a^nb^n \mid n \geq 1\}$ is regular

(c) $L = \{x \mid x \text{ has more number of } a\text{'s than } b\text{'s}\}$ is regular

(d) $L = \{a^mb^n \mid m \geq 1, n \geq 1\}$ is regular

gate1996 theory-of-computation normal regular-languages

Answer

5.15.10 Regular Languages: GATE1998_2.6 top http://gateoverflow.in/1678

Which of the following statements is false?

(a) Every finite subset of a non-regular set is regular

(b) Every subset of a regular set is regular

(c) Every finite subset of a regular set is regular

(d) The intersection of two regular sets is regular

gate1998 theory-of-computation easy regular-languages

Answer

5.15.11 Regular Languages: GATE1999_6 top http://gateoverflow.in/1505

a. Given that A is regular and $(A \cup B)$ is regular, does it follow that B is necessarily regular? Justify your answer.
b. Given two finite automata $M1, M2$, outline an algorithm to decide if $L(M1) \subset L(M2)$. (note: strict subset)

gate1999 theory-of-computation normal regular-languages

Answer

5.15.12 Regular Languages: GATE2000-2.8 top http://gateoverflow.in/655

What can be said about a regular language L over { a } whose minimal finite state automaton has two states?

A. L must be $\{a^n \mid n \text{ is odd}\}$
B. L must be $\{a^n \mid n \text{ is even}\}$
C. L must be $\{a^n \mid n \geq 0\}$
D. Either L must be $\{a^n \mid n \text{ is odd}\}$, or L must be $\{a^n \mid n \text{ is even}\}$

gate2000 theory-of-computation easy regular-languages

Answer

5.15.13 Regular Languages: GATE2001-1.4 top http://gateoverflow.in/697

Consider the following two statements:

$S1 : \left\{0^{2n} \mid n \geq 1\right\}$ is a regular language

$S2 : \{0^m 1^n 0^{m+n} \mid m \geq 1 \text{ and } n \geq 1\}$ is a regular language

Which of the following statement is correct?

A. Only S1 is correct
B. Only S2 is correct
C. Both S1 and S2 are correct
D. None of S1 and S2 is correct

gate2001 theory-of-computation easy regular-languages

Answer

5.15.14 Regular Languages: GATE2001-2.6 top http://gateoverflow.in/724

Consider the following languages:

- $L1 = \{ww \mid w \in \{a, b\}^*\}$
- $L2 = \left\{ww^R \mid w \in \{a, b\}^*, w^R \text{ is the reverse of w}\right\}$
- $L3 = \left\{0^{2i} \mid \text{i is an integer}\right\}$

- $L4 = \left\{0^{i^2} \mid \text{i is an integer}\right\}$

Which of the languages are regular?

A. Only L1 and L2
B. Only L2, L3 and L4
C. Only L3 and L4
D. Only L3

gate2001 theory-of-computation normal regular-languages

Answer

5.15.15 Regular Languages: GATE2006-29 top http://gateoverflow.in/992

If s is a string over (0+1)* then let $n_0(s)$ denote the number of 0's in s and $n_1(s)$ the number of 1's in s. Which one of the following languages is not regular?

A. $L = \{s \in (0+1)^* \mid n_0(s) \text{ is a 3-digit prime }\}$
B. $L = \{s \in (0+1)^* \mid \text{ for every prefix s' of s, } \mid n_0(s') - n_1(s') \mid \leq 2\}$
C. $L = \{s \in (0+1)^* \mid n_0(s) - n_1(s) \mid \leq 4\}$
D. $L = \{s \in (0+1)^* \mid n_0(s) \mod 7 = n_1(s) \mod 5 = 0\}$

gate2006 theory-of-computation normal regular-languages

Answer

5.15.16 Regular Languages: GATE2006-IT-30 top http://gateoverflow.in/3569

Which of the following statements about regular languages is NOT true ?

A. Every language has a regular superset
B. Every language has a regular subset
C. Every subset of a regular language is regular
D. Every subset of a finite language is regular

gate2006-it theory-of-computation easy regular-languages

Answer

5.15.17 Regular Languages: GATE2006-IT-80 top http://gateoverflow.in/3624

Let L be a regular language. Consider the constructions on L below:

I. repeat (L) = {ww | w ∊ L}
II. prefix (L) = {u | ∃v : uv ∊ L}
III. suffix (L) = {v | ∃u : uv ∊ L}
IV. half (L) = {u | ∃v : | v | = | u | and uv ∊ L}

Which of the constructions could lead to a non-regular language?

A. Both I and IV
B. Only I
C. Only IV
D. Both II and III

gate2006-it theory-of-computation normal regular-languages

Answer

5.15.18 Regular Languages: GATE2006-IT-81 top http://gateoverflow.in/3637

Let L be a regular language. Consider the constructions on L below:

I. repeat (L) = {ww | w ∊ L}
II. prefix (L) = {u | ∃v : uv ∊ L}
III. suffix (L) = {v | ∃u uv ∊ L}
IV. half (L) = {u | ∃v : | v | = | u | and uv ∊ L}

Which of the constructions could lead to a non-regular language?

a. Both I and IV
b. Only 1
c. Only IV
d. Both II and III

Which choice of L is best suited to support your answer above?

A. (a + b)*
B. {ϵ, a, ab, bab}
C. (ab)*
D. $\{a^nb^n \mid n \geq 0\}$

gate2006-it theory-of-computation normal regular-languages

Answer

5.15.19 Regular Languages: GATE2007-31 top http://gateoverflow.in/1229

Which of the following languages is regular?

A. $\{ww^R \mid w \in \{0,1\}^+\}$

B. $\{ww^Rx \mid x, w \in \{0,1\}^+\}$

C. $\{wxw^R \mid x, w \in \{0,1\}^+\}$

D. $\{xww^R \mid x, w \in \{0,1\}^+\}$

gate2007 theory-of-computation normal regular-languages

Answer

5.15.20 Regular Languages: GATE2007-7 top http://gateoverflow.in/1205

Which of the following is TRUE?

A. Every subset of a regular set is regular
B. Every finite subset of a non-regular set is regular
C. The union of two non-regular sets is not regular
D. Infinite union of finite sets is regular

gate2007 theory-of-computation easy regular-languages

Answer

5.15.21 Regular Languages: GATE2008-IT-35 top http://gateoverflow.in/3345

Which of the following languages is (are) non-regular?

- $L_1 = \{0^m1^n \mid 0 \leq m \leq n \leq 10000\}$
- L_2 = {w | w reads the same forward and backward}
- L_3 = {w ∊ {0, 1} * | w contains an even number of 0's and an even number of 1's}

A. L_2 and L_3 only
B. L_1 and L_2 only
C. L_3 only
D. L_2 only

gate2008-it theory-of-computation normal regular-languages

Answer

5.15.22 Regular Languages: GATE2008_53 top http://gateoverflow.in/476

Which of the following are regular sets?

I. $\{a^n b^{2m} \mid n \geq 0, m \geq 0\}$

II. $\{a^n b^m \mid n = 2m\}$

III. $\{a^n b^m \mid n \neq m\}$

IV. $\{xcy \mid x, y, \in \{a, b\}^*\}$

A. I and IV only
B. I and III only
C. I only
D. IV only

gate2008 theory-of-computation normal regular-languages

Answer

5.15.23 Regular Languages: GATE2011-24 top http://gateoverflow.in/3429

Let P be a regular language and Q be a context-free language such that $Q \subseteq P$. (For example, let P be the language represented by the regular expression p^*q^* and Q be $\{p^n q^n \mid n \in N\}$) . Then which of the following is **ALWAYS** regular?

(A) $P \cap Q$

(B) $P - Q$

(C) $\Sigma^* - P$

(D) $\Sigma^* - Q$

gate2011 theory-of-computation easy regular-languages

Answer

5.15.24 Regular Languages: GATE2012-25 top http://gateoverflow.in/1609

Given the language $L = \{ab, aa, baa\}$, which of the following strings are in L^*?

1. $abaabaaabaa$
2. $aaaabaaaa$
3. $baaaaabaaaab$
4. $baaaaabaa$

(A) 1, 2 and 3
(B) 2, 3 and 4
(C) 1, 2 and 4
(D) 1, 3 and 4

gate2012 theory-of-computation easy regular-languages

Answer

5.15.25 Regular Languages: GATE2013-8 top http://gateoverflow.in/1417

Consider the languages $L_1 = \phi$ and $L_2 = \{a\}$. Which one of the following represents $L_1 {L_2}^* \cup {L_1}^*$?

(A) $\{\epsilon\}$

(B) ϕ

(C) a^*

(D) $\{\epsilon, a\}$

gate2013 theory-of-computation normal regular-languages

Answer

5.15.26 Regular Languages: GATE2014-1-15 top

http://gateoverflow.in/1781

Which one of the following is **TRUE**?

A. The language $L = \{a^n b^n \mid n \geq 0\}$ is regular.
B. The language $L = \{a^n \mid n \text{ is prime }\}$ is regular.
C. The language L= $\{w \mid w \text{ has } 3k+1\ b's \text{ for some } k \in N \text{ with } \Sigma = \{a,b\}\}$ is regular.
D. The language $L = \{ww \mid w \in \Sigma^* \text{ with } \Sigma = \{0,1\}\}$ is regular.

gate2014-1 theory-of-computation regular-languages normal

Answer

5.15.27 Regular Languages: GATE2014-2-15 top

http://gateoverflow.in/1971

If $L_1 = \{a^n \mid n \geq 0\}$ and $L_2 = \{b^n \mid n \geq 0\}$, consider

I. $L_1 . L_2$ is a regular language
II. $L_1 . L_2 = \{a^n b^n \mid n \geq 0\}$

Which one of the following is CORRECT?

A. Only I
B. Only II
C. Both I and II
D. Neither I nor II

gate2014-2 theory-of-computation normal regular-languages

Answer

5.15.28 Regular Languages: GATE2014-2-36 top

http://gateoverflow.in/1995

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

gate2014-2 theory-of-computation normal regular-languages

Answer

5.15.29 Regular Languages: GATE2015-2_51 top

http://gateoverflow.in/8254

Which of the following is/are regular languages?

$L_1 : \{wxw^R \mid w, x \in \{a,b\}^* \text{ and } |w|, |x| > 0\}, w^R \text{ is the reverse of string } w$

$L_2 : \{a^n b^m \mid m \neq n \text{ and } m, n \geq 0\}$

$L_3 : \{a^p b^q c^r \mid p, q, r \geq 0\}$

A. L_1 and L_3 only
B. L_2 only
C. L_2 and L_3 only
D. L_3 only

gate2015-2 theory-of-computation normal regular-languages

Answer

5.15.30 Regular Languages: ISI2014-CS-4b top http://gateoverflow.in/47445

Consider the following statement:
For all languages $L \subseteq \{0,1\}^*$, if L^* is regular then L is regular.
Is the above statement true? Justify your answer.

descriptive isi2014 theory-of-computation regular-languages

Answer

5.15.31 Regular Languages: ISI2015-CS-5a top http://gateoverflow.in/47327

Construct two nonregular languages L_1 and L_2 such that $L_1 \cup L_2$ is regular.

Prove that the languages L_1 and L_2 constructed above are nonregular and $L_1 \cup L_2$ is regular.

descriptive isi2015 theory-of-computation regular-languages

Answer

5.15.32 Regular Languages: TIFR2013-B-6 top http://gateoverflow.in/25667

Let L and L' be languages over the alphabet Σ. The left quotient of L by L' is

$$L/L' \overset{def}{=} \{w \in \Sigma^* : wx \in L \text{ for some } x \in L'\}$$

Which of the following is true?

a. If L/L' is regular then L' is regular.
b. If L is regular then L/L' is regular.
c. If L/L' is regular then L is regular.
d. L/L' is a subset of L.
e. If L/L' and L' are regular, then L is regular.

tifr2013 theory-of-computation regular-languages

Answer

5.15.33 Regular Languages: TIFR2013-B-8 top http://gateoverflow.in/25670

Which one of the following languages over the alphabet $0,1$ is regular?

a. The language of balanced parentheses where $0,1$ are thought of as $(,)$ respectively.
b. The language of palindromes, i.e. bit strings x that read the same from left to right as well as right to left.
c. $L = \left\{0^{m^2} : 3 \leq m\right\}$
d. The Kleene closure L^*, where L is the language in (c) above.
e. $\{0^m 1^n | 1 \leq m \leq n\}$

tifr2013 theory-of-computation regular-languages

Answer

5.15.34 Regular Languages: TIFR2014-B-12 top http://gateoverflow.in/27314

Consider the following three statements:

(i) Intersection of infinitely many regular languages must be regular.

(ii) Every subset of a regular language is regular.

(iii) If L is regular and M is not regular then $L \bullet M$ is necessarily not regular.

Which of the following gives the correct true/false evaluation of the above?

a. true, false, true.
b. false, false, true.
c. true, false, true.

d. false, false, false.
e. true, true, true.

tifr2014 theory-of-computation regular-languages

Answer

5.15.35 Regular Languages: TIFR2015-B-10 top

http://gateoverflow.in/30039

Consider the languages

$L_1 = \{a^m b^n c^p \mid (m = n \vee n = p) \wedge m + n + p \geq 10\}$

$L_2 = \{a^m b^n c^p \mid (m = n \vee n = p) \wedge m + n + p \leq 10\}$

State which of the following is true?

A. L_1 and L_2 are both regular.
B. Neither L_1 nor L_2 is regular.
C. L_1 is regular and L_2 is not regular.
D. L_1 is not regular and L_2 is regular.
E. Both L_1 and L_2 are infinite.

tifr2015 regular-languages

Answer

5.15.36 Regular Languages: TIFR2015-B-6 top

http://gateoverflow.in/29860

Let B consist of all binary strings beginning with a 1 whose value when converted to decimal is divisible by 7.

A. B can be recognized by a deterministic finite state automaton.
B. B can be recognized by a non-deterministic finite state automaton but not by a deterministic finite state automaton.
C. B can be recognized by a deterministic push-down automaton but not by a non-deterministic finite state automaton.
D. B can be recognized by a non-deterministic push-down automaton but not by a deterministic push-down automaton.
E. B cannot be recognized by any push down automaton, deterministic or non-deterministic.

tifr2015 theory-of-computation regular-languages

Answer

Answers: Regular Languages

5.15.1 Regular Languages: CMI2012-A-01 top

http://gateoverflow.in/46529

A. If L is regular, all subsets of L are regular.
False.
Counter Ex. L = { a + b }* then its subset { a^n b^n ; n > 0} is not regular.

C. If all finite subsets of L are regular, then L is regular.
False.
Counter Ex: L = { a^n b^n ; n > 0}, L is not regular, it is context free.
Now take any finite subset of L, this will be regular.
Note: Take only, finite subset of L.

D. If a proper subset of L is not regular, then L is not regular.
False
Ex: L = {a + b}* is regular, Its proper subset { a^n b^n ; n > 0} is not regular.

B. If all proper subsets of L are regular, then L is regular.
True.
Proof: Take any proper subset of L says L1, L1 is regular by definition.
L2 = L - L1.
L2 is also regular because it is also a proper subset of L.

And we now that Union of two regular set is also regular.
L1 U L2 = L. Hence L is also regular.

I have a strong feeling that L is finite that's why all its proper subset is regular.

4 votes -- Hemant Parihar (5.7k points)

5.15.2 Regular Languages: CMI2015-A-09 top http://gateoverflow.in/47046

Selected Answer

Ans should be option D.

Contradiction for A. Let L2 = {a,b}* ... which is regular.

And L1 = $a^n b^n$ which is CFL but not regular.

And here L1 is subset of L2.

Contradiction for B. Let L1 = ab ,

which is regular. And L2 = $a^n b^n$ which is CFL but not regular.

And here L1 is subset of L2.

C- > False , (reason A and B).

7 votes -- Dhananjay Kumar Sharma (25.2k points)

5.15.3 Regular Languages: GATE 2016-2-17 top http://gateoverflow.in/39542

Selected Answer

Answer is C

$S_1 \to aS_1b|\epsilon$

$L_1 = \{a^n b^n \mid n \geq 0\}$ is CFL

$S_2 \to abS_2|\epsilon$

$L_2 = \{(ab)^n \mid n \geq 0\}$ is Regular having regular expression $(ab)^*$

20 votes -- Praveen Saini (53.6k points)

5.15.4 Regular Languages: GATE1987-2h top http://gateoverflow.in/80589

Selected Answer

true!
reverse all the edges and interchange final and initial states in DFA

2 votes -- Motamarri Anusha (11.6k points)

5.15.5 Regular Languages: GATE1987-2i top http://gateoverflow.in/80590

Selected Answer

false!
a*b* is regular but its subset a^nb^n isnt regular

6 votes -- Motamarri Anusha (11.6k points)

5.15.6 Regular Languages: GATE1990-3-viii top http://gateoverflow.in/84837

Selected Answer

Regular Languages are closed under

1. Intersection
2. Union
3. Complement
4. Kleen-Closure

$\Sigma * - R1$ is the complement of $R1$

B,C are true

6 votes -- pC (21.4k points)

5.15.7 Regular Languages: GATE1991-03,xiv top http://gateoverflow.in/528

Selected Answer

(b), (c) and (d) are true. But the strongest answer would be (d) a regular language. It is trivial to say that a finite set of strings (finite language) can be accepted using a finite set of states. And regular language $\subset$ context-free $\subset$ context-sensitive $\subset$ Turing recognizable, would imply that regular language is the strongest answer.

13 votes -- gatecse (13.4k points)

5.15.8 Regular Languages: GATE1995_2.24 top http://gateoverflow.in/2637

Selected Answer

Answer is (C). $L \cup R$ is nothing but L as R is a subset of L and hence regular. R is deterministic context-free but not regular as we require a stack to keep the count of 0's to match that of 1's.

12 votes -- Arjun Suresh (294k points)

5.15.9 Regular Languages: GATE1996_1.10 top http://gateoverflow.in/2714

Selected Answer

Only D. because n and m are independent and thus no memory element required.

a and b are same and are DCFL's.

c is L = { a^n b^m | n > m }. which is not regular.

Correction:I think c should be that x has more a's than b's.

5 votes -- Gate Keeda (19.1k points)

5.15.10 Regular Languages: GATE1998_2.6 top http://gateoverflow.in/1678

Selected Answer

(b) is False. Any language is a subset of Σ^* which is a regular set. So, if we take any non-regular language, it is a subset of a regular language.

(a) and (c) are regular as any finite language is regular.

(d) is regular as regular set is closed under intersection.

13 votes -- Arjun Suresh (294k points)

5.15.11 Regular Languages: GATE1999_6 top

http://gateoverflow.in/1505

Selected Answer

a) A is regular , A U B is regular , then B is not necessary regular

example :- A = (a+b)* B = $a^n b^n$ n>=0 A U B is (a+b)* while B is not regular.

b) we have two machine M 1 and M 2

draw a DFA using M1 and M2 where start state is, say, p0q0 (where p0 is start state in M1 and q0 is start state in M2)

∂(p0q0, 0) = ∂(p0, 0) U ∂(q0, 0)

if L(M1) ⊆ L (M2)

Then final state of M1 will come together with final state of M2, while Final state of M2 can come alone.

i.e All inputs of M1 is also in machine M2 , and there may be different inputs in M2.

13 votes

-- Praveen Saini (53.6k points)

5.15.12 Regular Languages: GATE2000-2.8 top

http://gateoverflow.in/655

Selected Answer

Ans 4) Either L must be {a^n | n is odd}, or L must be {a^n | n is even}

Because if we draw the minimal dfa for each of them, we will get two states each.
Whereas, {a^n| n>=0} requires only one state.

14 votes

-- Keith Kr (6.3k points)

5.15.13 Regular Languages: GATE2001-1.4 top

http://gateoverflow.in/697

Selected Answer

Only s1 is correct a dfa with 2 states where one of the states is both the initial and final state..

8 votes

-- Bhagirathi Nayak (13.3k points)

5.15.14 Regular Languages: GATE2001-2.6 top

http://gateoverflow.in/724

Selected Answer

L1={ww|w∈{a,b}∗} CSL

L2={ww^R|w∈{a,b}∗,wR is the reverse of w} Palindrome so CFL

L3={0^{2i}| i is an integer} Linear Power and regular expression can be stated as $(00)^*$

L4={0^{i^2}| i is an integer} non linear power So CSL

Therefore answer is option D

8 votes

-- Umang Raman (15.2k points)

5.15.15 Regular Languages: GATE2006-29 top

http://gateoverflow.in/992

Selected Answer

A. There are only finite 3 digit primes. And any finite set is regular

B. Here we need just 6 states to recognise L.

1. #0 - #1 = 0
2. #0 - #1 = 1
3. #0 - #1 = 2
4. #0 - #1 = -1
5. #0 - #1 = -2

If the difference goes above 2 or below -2, we go to a dead state. All other states are accepting. This transition to dead state is possible because of the words "for every prefix s' of s" in L and that is what makes this language regular.

C. L is not regular

#0 - #1 = 1
#0 - #1 = 2
#0 - #1 = 3
#0 - #1 = 4
#0 - #1 = 5
.....
#0 - #1 = 1000
......

All these form distinct equivalent classes under Myhill-Nerode theorem meaning from the strings in each of these sets, we can append a string which will take the new string to L, while the same string appended to string in any other set won't reach L.

For example, for 000000, we append 11, for 0000000, we append 111 etc. So, in short we need to maintain the count of 1's and 0's and the count here is not finite.

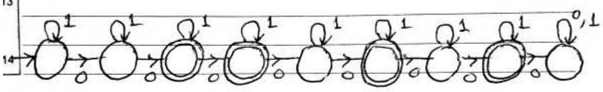
D. This is regular. We need a finite automata with 5 * 7 = 35 states for maintaining the counts of 0's mod 7 and 1's mod 5 and there cannot be more than 35 possibilities for this. With each input symbol, the transition must be going to one among these.

13 votes -- Arjun Suresh (294k points)

Sorry for bad handwriting... :P

A. $n_0(S)$ is a 3 digit prime.
It means no. of 0's are in range (set) {101, 103, ... 997} which is finite.
So, L will be regular.
For simplicity lets consider $n_0(S)$ is a 1 digit prime.
So, set will be {2, 3, 5, 7}

DFA will look like -

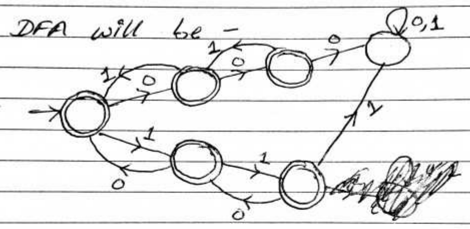


B. Prefix - For a string S, its prefix S' is a substring from the beginning of S.
e.g. S = 10110
S' = 1, 10, 101, 1011, 10110

$L = \{S \in (0+1)^* \mid$ for every prefix S' of S, $|n_0(S') - n_1(S')| \le 2\}$.
So, here we have to ensure that nowhere in our string the difference between 1's and 0's is greater than 2.

If anywhere the above restriction fails we will enter the dead state as we got a substring (prefix) that violates the restriction.

DFA will be -



So, here once the difference between 0's and 1's crosses two we will be in dead state.

e.g. S = 10110 S' = {1, 10, 101, 1011, 10110}
This string will be accepted as nowhere in S' the difference exceeds 2.

S = 011110 S' = {0, 01, 011, 0111, 01111
difference = 3.
This string is not accepted.

C. The difference between number of 0's and 1's should not exceed 4.
Here, once we exceed the limit there is possibility that we might cover up the difference in further string.
e.g. 0111111000
Here just by seeing upto last '1' we can't move to dead state.
So, it needs counting. Hence, not regular.

D. This language can be stated as the language containing strings where no. of 0's are divisible by 7 and no. of 1's are divisible by 5.
So, make DFA by cross product method.
It is regular.

24 votes

-- Rajendra Dangwal (685 points)

5.15.16 Regular Languages: GATE2006-IT-30 top

http://gateoverflow.in/3569

Selected Answer

Option C is not True.

A) Every language has a regular superset: True. Σ^* is such a superset.

B) Every language has a regular subset: True. $\emptyset$ is such a subset.

C) Every subset of a regular language is regular: False. $a^nb^n \subset \Sigma^*$, but a^nb^n is not Regular.

D) Every subset of a finite language is regular: True. Every subset of a finite set must be finite by definition. Every finite set is regular. Hence, every subset of a finite language is regular.

21 votes -- Pragy Agarwal (19.5k points)

5.15.17 Regular Languages: GATE2006-IT-80 top

http://gateoverflow.in/3624

Selected Answer

correct answer is B. only I .

repeat (L) = {ww | w ∊ L} is non regular language

half(L),suffix(L), and prefix(L) are regular languages

refer

http://gateoverflow.in/3637/gate2006-it_81

5 votes -- Praveen Saini (53.6k points)

5.15.18 Regular Languages: GATE2006-IT-81 top

http://gateoverflow.in/3637

Selected Answer

i) repeat(L) is non regular

http://www.cs.odu.edu/~toida/nerzic/390teched/regular/reg-lang/non-regularity.html [example 2]

ii) prefix(L) is regular

http://www.public.asu.edu/~ccolbou/src/355hw2sols09.pdf [2(a)]

iii) suffix(L) is regular

http://www.public.asu.edu/~ccolbou/src/355hw2sols09.pdf [2(b)]

(iv) Half(L) is regular

https://www.complang.tuwien.ac.at/lkovacs/ATCSHW/hw4-sol.pdf [4.2(a)]

so in first part of question . option B is correct only i.

[Need someone to explain these language with more clear explanation @Arjun . that can be understandable by an average student]

for second part of question

A is answer.

Explanation is in comment given below by Arjun (for option A,C and D)

note : for option B L = {ϵ, a, ab, bab} , Repeat(L) = {ϵ, aa,abab, babbab} is regular

9 votes -- Praveen Saini (53.6k points)

5.15.19 Regular Languages: GATE2007-31 top

http://gateoverflow.in/1229

Selected Answer

A. CFL

B. CFL

C. Regular, language is string starting and ending with the same symbol and having length at least 3. e.g. 0x0 or 1x1

D. CFL

http://gatecse.in/wiki/Identify_the_class_of_the_language

13 votes

-- Vikrant Singh (13.4k points)

5.15.20 Regular Languages: GATE2007-7 top

http://gateoverflow.in/1205

Selected Answer

(B) Every finite subset of a non-regular set is regular.

Any finite set is always regular.

Σ^* being regular any non regular language is a subset of this, and hence (A) is false.

If we take a CFL which is not regular, and takes union with its complement (complement of a CFL which is not regular won't be regular as regular is closed under complement), we get Σ^* which is regular. So, (C) is false.

Regular set is not closed under infinite union. Example:
Let $L_i = \{0^i 1^i\}$, $i \in N$

Now, if we take infinite union over all i, we get

$L = \{0^i 1^i \mid i \in N\}$, which is not regular.

So, D is false.

13 votes

-- Omesh Pandita (2.7k points)

5.15.21 Regular Languages: GATE2008-IT-35 top

http://gateoverflow.in/3345

Selected Answer

L1 is regular.. since 10000 is finite.. so finite states are required..

L3 is also regular.. we can make DFA for L3.. states will represent mod 2 for 0 and mod 2 for 1, which is finite

L2 is non. regular.. it is CFG S->aSa | ... | zSz | epsilon | [a-z]

so option (d)

14 votes

-- Vicky Bajoria (4.9k points)

5.15.22 Regular Languages: GATE2008_53 top

http://gateoverflow.in/476

Selected Answer

Answer is A.

Since in option 2 and 3, n is dependent on m, therefore a comparison has to be done to evaluate those and hence are not regular.

I and IV are clearly regular sets.

11 votes -- Gate Keeda (19.1k points)

5.15.23 Regular Languages: GATE2011-24 top http://gateoverflow.in/3429

Selected Answer

c)complement of regular Language is regular

19 votes -- VOOTLA SRINIVAS (303 points)

5.15.24 Regular Languages: GATE2012-25 top http://gateoverflow.in/1609

Selected Answer

L = {ab,aa,baa}

1. abaabaaabaa = ab aa baa ab aa belong to L* (combinations of strings in L)
2. aaaabaaaa = aa aa baa aa belong to L*
3. baaaaabaaaab = baa aa ab aa aa **b** does not belong to L*
4. baaaabaa = baa aa ab aa belong to L*

10 votes -- Praveen Saini (53.6k points)

5.15.25 Regular Languages: GATE2013-8 top http://gateoverflow.in/1417

Selected Answer

Concatenation of empty language with any language will give the empty language and $L_1{}^* = \phi^* = \epsilon$.

Therefore,

$$L_1 L_2^* \cup L_1^*$$
$$= \phi.(L_2)^* \cup \phi^*$$
$$= \phi \cup \{\epsilon\} \, (\because \phi \text{ concatenated with anything is } \phi \text{ and } \phi^* = \{\epsilon\})$$
$$= \{\epsilon\}.$$

Hence option (a) is True.

PS: $\phi^* = \epsilon$*, where* ϵ *is the regular expression and the language it generates is* $\{\epsilon\}$.

21 votes -- Praveen Saini (53.6k points)

5.15.26 Regular Languages: GATE2014-1-15 top http://gateoverflow.in/1781

Selected Answer

(A) is CFL and (B) and (D) are CSL. (C) is regular and regular expression for (C) would be

$$a^*b(a^*ba^*ba^*b)^+a^*$$

10 votes -- Arjun Suresh (294k points)

5.15.27 Regular Languages: GATE2014-2-15 top http://gateoverflow.in/1971

Selected Answer

Option A.

$L_1 = \{\varepsilon, a, aa, aaa, aaaa, \ldots\}$

$L_2 = \{\varepsilon, b, bb, bbb, bbbb, \ldots\}$

$$L_1 \cdot L_2 = \left\{ \begin{array}{cccccc} \varepsilon, & & & & & \\ a, & b, & & & & \\ aa, & ab, & bb & & & \\ aaa, & aab, & abb, & bbb, & & \\ aaaa, & aaab, & aabb, & abbb, & bbbb, & \ldots \end{array} \right\}$$

$$L_1 \cdot L_2 \quad = a^* b^*$$

Thus, $L_1 \cdot L_2$ is Regular.

(Also, since both L_1 and L_2 are Regular, their concatenation has to be Regular since Regular languages are closed under concatenation)

However, $L_1 \cdot L_2 \neq a^n b^n$. This is because in $a^* b^*$, the number of a's and b's can be different whereas in $a^n b^n$ they have to be the same.

22 votes -- Viral Kapoor (2k points)

5.15.28 Regular Languages: GATE2014-2-36 top

http://gateoverflow.in/1995

Selected Answer

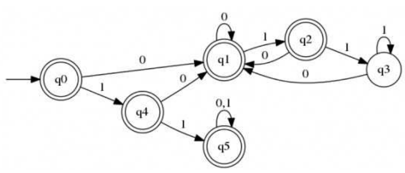
(A) is True. Though at first look both L1 and L2 looks non-regular, L1 is in fact regular. The reason is the relation between 110 and 011.

We cannot have two 110's in a string without a 011 or vice verse. And this would mean that we only need a finite number of states to check for acceptance of any word in this language.

That was just an intuitive explanation. Now I say that L contains all binary strings starting with 11. Yes, if a binary string starts with 11, it can never have more no. of 011 than 110.

Lets take an example:
11 011 011 -There are two 011's. But there are also two 110's. Similarly for any binary string starting with 11.

Using this property, DFA for L1 can be constructed as follows:



40 votes -- gatecse (13.4k points)

5.15.29 Regular Languages: GATE2015-2_51 top

http://gateoverflow.in/8254

Selected Answer

Ans A.

L1: all strings of length 3 or more with same start and end letter- because everything in middle can be consumed by x as per the definition of L.

L2: We need to compare number of a's and b's and these are not bounded. So, we need at least a DPDA.

L3: Any number of a's followed by any number of b's followed by any number of c's. Hence regular.

20 votes -- Vikrant Singh (13.4k points)

5.15.30 Regular Languages: ISI2014-CS-4b top http://gateoverflow.in/47445

Selected Answer

If **L*** is regular, then **L** is not necessarily regular.

Let's take one possible example.

Let **Σ = {a}** and consider the language **L = {** a^{2^n} **| n ∈ N }.**

This language is not regular

and the language **L*** is the language **a***, which is regular. To see this, notice that since **L** contains the string a, the language **L*** contains all strings of the form a^n for any natural number **n**.

Hence,**Option(2)Need not Regular** is the correct choice.

6 votes -- Leen Sharma (32.3k points)

5.15.31 Regular Languages: ISI2015-CS-5a top http://gateoverflow.in/47327

Selected Answer

Consider a language $L1 = \{a^n b^n | n \geq 0\}$ is a non regular language .

And take another language $L2 = L1^c$ which is also non regular .(Since regular set is closed under complementation.)

As we know **the union of any language and its complement is** $\sum$*.

So **L1UL2=** $\sum$***.**

Which is regular.

4 votes -- Manoj Kumar (37.5k points)

5.15.32 Regular Languages: TIFR2013-B-6 top http://gateoverflow.in/25667

Selected Answer

A) False because - L = a*b*, L' = a^nb^n Here L/L' = a*. L/L' is regular, but L' is not.

B) True. If L is regular, L/L' is prefix of language. Regular languages are closed under Qoutient/Prefix. So this is correct.

C) False L' = Empty set. Then L/L' is Empty set whatever L is. Here L can be say a^nb^n. See defination of L/L' to see why L/L' should be empty set.

D) False because L/L' can accept prefixes of string of Language L, which may or may not be accepted by L itself. So L/L' is not subset. (It is not Superset either , because L' can be empty set)

E) False. Same explanation as C.

Answer :- B.

6 votes -- Akash (43.8k points)

5.15.33 Regular Languages: TIFR2013-B-8 top http://gateoverflow.in/25670

Selected Answer 2

Here , **OPTION D** is **regular,** reason is as follows :

L = { 0^ m^2 : m>= 3}

Now, **in L*** if we can **generate 9 continuous powers of zero,** then further every power can be generated by **concatenating** 0^9**.**

Here , L = {0^9 ,0^{16}, 0^{25} , ...}

So, here are **9 continuous powers:**

0^{120} : $0^{16}\,0^{16}\,0^{16}\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9$

0^{121} : $0^{16}\,0^{16}\,0^{16}0^{16}0^{16}0^{16}0^{25}$

0^{122} : $0^{16}\,0^{16}\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9$

0^{123} : $0^{16}\,0^{16}\,0^{16}\,0^{25}\,0^{25}\,0^{25}$

0^{124} : $0^{16}\,0^{18}\,0^{18}\,0^{18}\,0^{18}\,0^{18}\,0^{18}$

0^{125} :$0^{25}\,0^{25}\,0^{25}0^{25}\,0^{25}$

0^{126} : $0^{18}0^{18}0^{18}0^{18}0^{18}0^{18}0^{18}$ {0^{18} can be generated as $0^9\,0^9$ }

0^{127} : $0^{16}\,0^{16}\,0^{16}\,0^{16}\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9\,0^9$

0^{128} : $0^{16}\,0^{16}\,0^{16}\,0^{16}\,0^{16}\,0^{16}\,0^{16}\,0^{16}$

Now, 0^{129} can be given as $0^{120}\,0^9$ and so on..

Every Further powers can be generated by concatenating 0^9.

8 votes -- Himanshu Agarwal (16.2k points)

5.15.34 Regular Languages: TIFR2014-B-12 top http://gateoverflow.in/27314

Selected Answer

i) False

Regular Languages are not closed under Infinite Union and Intersection

$$L1 \cup L2 \cup L3 \cup L4 \cup \ldots$$

For example :
$ab \cup aabb \cup aaabbb \cup aaaabbbb \cup \ldots$

$= \{a^n b^n, n \geq 1\}$
So Infinite Union is not closed

$$L1 \cap L2 \cap L3 \cap L4 \cap \ldots$$

$$= (L1' \cup L2' \cup L3' \cup L4' \cup \ldots)'$$

As Infinite Union is not closed , So Infinite Intersection is also not closed

ii) False.

a^*b^* is regular

its subset $a^n b^n, n \geq 1$ is not regular

a^* is regular

a^p, p is prime, is not regular

iii) False

$L = \{\}$ is regular

M be non-regular like $\{0^n 1^n \mid n > 0\}$.

$L.M = \{\}$, is regular

14 votes -- Praveen Saini (53.6k points)

5.15.35 Regular Languages: TIFR2015-B-10 top http://gateoverflow.in/30039

Selected Answer

L_2 is finite , so regular.

L_1 is non-regular.

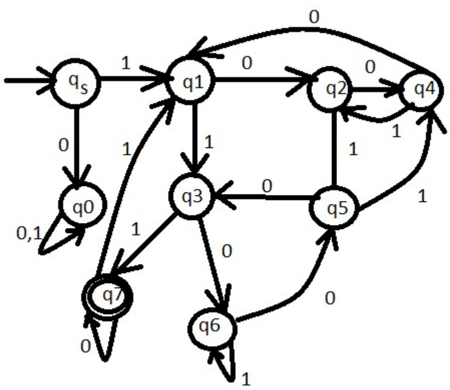
(It seems CFL to me as I think it can be implement with the help of PDA , as stack can ensure
$(m = n \vee n = p)$ and we can also ensure
$(m + n + p \geq 10)$ with minimum states changes along with transitions.)

L_2 is actually {
c^p |
$p \leq 10$}
∪ {
abc^p |
$p \leq 8$}
∪ {
$a^2b^2c^p$ |
$p \leq 6$}
∪ {
$a^3b^3c^p$ |
$p \leq 4$}
∪{
$a^4b^4c^p$ |
$p \leq 2$}
∪{
a^5b^5}
∪ {
a^p |
$p \leq 10$}
∪ {
a^pbc |
$p \leq 8$}
∪ {
$a^pb^2c^2$ |
$p \leq 6$}
∪ {
$a^pb^3c^3$ |
$p \leq 4$}
∪ {
$a^pb^4c^4$ |
$p \leq 2$}
∪ {
b^5c^5 |
$p \leq 10$}

13 votes -- Praveen Saini (53.6k points)

5.15.36 Regular Languages: TIFR2015-B-6 top http://gateoverflow.in/29860

Selected Answer



Answer will be (A)

if it start with 1 it goes to final state

if start with 0 it will go to the reject state

9 votes -- srestha (58.4k points)

5.16 Turing Machine(8) top

5.16.1 Turing Machine: GATE1987-2m top http://gateoverflow.in/80606

State whether the following statements are TRUE or FALSE:

The problem as to whether a Turing machine M accepts input w is undecidable.

gate1987 theory-of-computation turing-machine decidability

Answer

5.16.2 Turing Machine: GATE2001-7 top http://gateoverflow.in/748

Let a decision problem X be defined as follows:

X: Given a Turing machine M over Σ and any word $w \in \Sigma$, does M loop forever on w?

You may assume that the halting problem of Turing machine is undecidable but partially decidable.

a. Show that X is undecidable
b. Show that X is not even partially decidable

gate2001 theory-of-computation decidability turing-machine easy descriptive

Answer

5.16.3 Turing Machine: GATE2002-14 top http://gateoverflow.in/867

The aim of the following question is to prove that the language {M | M is the code of the Turing Machine which, irrespective of the input, halts and outputs a 1}, is undecidable. This is to be done by reducing from the language {M', x | M' halts on x}, which is known to be undecidable. In parts (a) and (b) describe the 2 main steps in the construction of M. In part (c) describe the key property which relates the behaviour of M on its input w to the behaviour of M' on x.

a. On input w, what is the first step that M must make?
b. On input w, based on the outcome of the first step, what is the second step M must make?
c. What key property relates the behaviour of M on w to the behaviour of M' on x?

gate2002 theory-of-computation decidability normal turing-machine descriptive difficult

Answer

5.16.4 Turing Machine: GATE2003-53 top http://gateoverflow.in/941

A single tape Turing Machine M has two states q0 and q1, of which q0 is the starting state. The tape alphabet of M is {0, 1, B} and its input alphabet is {0, 1}. The symbol B is the blank symbol used to indicate end of an input string. The transition function of M is described in the following table.

	0	1	B
q0	q1, 1, R	q1, 1, R	Halt
q1	q1, 1, R	q0, 1, L	q0, B, L

The table is interpreted as illustrated below.

The entry (q1, 1, R) in row q0 and column 1 signifies that if M is in state q0 and reads 1 on the current page square, then it writes 1 on the same tape square, moves its tape head one position to the right and transitions to state q1.

Which of the following statements is true about M?

A. M does not halt on any string in $(0+1)^+$
B. M does not halt on any string in $(00+1)^*$
C. M halts on all strings ending in a 0
D. M halts on all strings ending in a 1

gate2003 theory-of-computation turing-machine normal

Answer

5.16.5 Turing Machine: GATE2003-54 top http://gateoverflow.in/355

Define languages L_0 and L_1 as follows :

$L_0 = \{\langle M, w, 0 \rangle \mid M \text{ halts on } w\}$

$L_1 = \{\langle M, w, 1 \rangle \mid M \text{ does not halts on } w\}$

Here $\langle M, w, i \rangle$ is a triplet, whose first component M is an encoding of a Turing Machine, second component w is a string, and third component i is a bit.

Let $L = L_0 \cup L_1$. Which of the following is true?

A. L is recursively enumerable, but L' is not
B. L' is recursively enumerable, but L is not
C. Both L and L' are recursive
D. Neither L nor L' is recursively enumerable

theory-of-computation turing-machine gate2003 difficult

Answer

5.16.6 Turing Machine: GATE2004-89 top http://gateoverflow.in/1083

L_1 is a recursively enumerable language over Σ. An algorithm A effectively enumerates its words as $\omega_1, \omega_2, \omega_3, \dots .$ Define another language L_2 over $\Sigma \cup \{\#\}$ as $\{w_i \# w_j \mid w_i, w_j \in L_1, i < j\}$. Here # is new symbol. Consider the following assertions.

- $S_1 : L_1$ is recursive implies L_2 is recursive
- $S_2 : L_2$ is recursive implies L_1 is recursive

Which of the following statements is true?

A. Both S_1 and S_2 are true

B. S_1 is true but S_2 is not necessarily true

C. S_2 is true but S_1 is not necessarily true

D. Neither is necessarily true

gate2004 theory-of-computation turing-machine difficult

Answer

5.16.7 Turing Machine: GATE2014-2-35 top http://gateoverflow.in/1994

Let $\langle M \rangle$ be the encoding of a Turing machine as a string over $\Sigma = \{0, 1\}$. Let

$$L = \{\langle M \rangle \mid M \text{ is a Turing machine that accepts a string of length } 2014\}.$$

Then L is

A. decidable and recursively enumerable
B. undecidable but recursively enumerable
C. undecidable and not recursively enumerable
D. decidable but not recursively enumerable

gate2014-2 theory-of-computation turing-machine normal

Answer

5.16.8 Turing Machine: GATE2016-2-44 top

http://gateoverflow.in/39596

Consider the following languages.

- $L_1 = \{\langle M \rangle \mid M \text{ takes at least 2016 steps on some input}\}$,
- $L_2 = \{\langle M \rangle \mid M \text{ takes at least 2016 steps on all inputs}\}$ and
- $L_3 = \{\langle M \rangle \mid M \text{ accepts } \epsilon\}$,

where for each Turing machine M, $\langle M \rangle$ denotes a specific encoding of M. Which one of the following is TRUE?

A. L_1 is recursive and L_2, L_3 are not recursive
B. L_2 is recursive and L_1, L_3 are not recursive
C. L_1, L_2 are recursive and L_3 is not recursive
D. L_1, L_2, L_3 are recursive

gate2016-2 theory-of-computation turing-machine

Answer

Answers: Turing Machine

5.16.1 Turing Machine: GATE1987-2m top

http://gateoverflow.in/80606

Selected Answer

Yes The problem as to whether a Turing machine M accepts input w is undecidable which is the well known Halting Problem.

If string w is going to loop then we can not detemine if it will be eventually accepted by TM or not.

4 votes -- Prashant Singh (49.2k points)

5.16.2 Turing Machine: GATE2001-7 top

http://gateoverflow.in/748

Selected Answer

The question asks if M loop forever on w. If M loop forever on w, M wouldn't halt on w. And if M doesn't halt on w, M should loop forever. So, this problem is exactly same as asking if "M doesn't halt on w", which is the complement of halting problem and is not even partially decidable. So, X is not even partially decidable.

13 votes -- Arjun Suresh (294k points)

5.16.3 Turing Machine: GATE2002-14 top

http://gateoverflow.in/867

Selected Answer

(a) M erases its input w and simulate the moves of M' on x. Thus if M' halts on x, M accepts any input (Σ^*) and if M' doesn't halt on x, M accepts no string (ϕ)

(b) Give the description of M - <M> to the TM that decides L. If TM accepts <M>, M halts on all inputs -> M' accept x. If TM rejects <M>, M doesn't halt on some input -> M' doesn't halt on x, due to our construction of M in 1st step. Thus we decide halting problem

(c) M halting on all inputs w is the key property relating to M' which is halting on a given input x

2 votes -- Arjun Suresh (294k points)

5.16.4 Turing Machine: GATE2003-53 top

http://gateoverflow.in/941

Selected Answer

option A. or epsilon is only accepted i.e tape contain B as the first character

10 votes -- Supromit Roy (727 points)

5.16.5 Turing Machine: GATE2003-54 top

http://gateoverflow.in/355

Selected Answer

Both L and L' are undecidable and not even semi-decidable (not recursively-enumerable). Because halting problem can be solved with both L and L' .

Halting problem can be stated as follows: A machine M and a word w are given. You have to tell, if M halts on w.

So, to solve halting problem $\langle M,w \rangle$ using L, just give $\langle M,w,0 \rangle$ and $\langle M,w,1 \rangle$ to two instances of T which is the assumed Turing machine for L. If T accepts the triplet $\langle M,w,0 \rangle$, it means M halts on w => we have solved halting problem. If T accepts the triplet $\langle M,w,1 \rangle$, it means M doesn't halt on w => we have solved halting problem. We know that either $\langle M,w,0 \rangle$ or $\langle M,w,1 \rangle$ is in L. So, if L is recursively enumerable, T is bound to stop on at least one of these inputs (TM for a recursively enumerable language stops and accepts, when provided with a word in its language).

Hence, if L is recursively enumerable we can solve halting problem => L is not recursively enumerable.
Similarly, we can also show that halting problem can be solved with L'. (shown at end)

Hence, neither L nor L' is recursively enumerable.

To solve halting problem $\langle M,w \rangle$ using L', just give $\langle M,w,0 \rangle$ and $\langle M,w,1 \rangle$ to two instances of T' which is the assumed Turing machine for L'. If T' accepts the triplet $\langle M,w,0 \rangle$, it means M does not halt on w => we have solved halting problem. If T accepts the triplet $\langle M,w,1 \rangle$, it means M halt on w => we have solved halting problem. We know that either $\langle M,w,0 \rangle$ or $\langle M,w,1 \rangle$ is in L'. So, if L' is recursively enumerable, T' is bound to stop on at least one of these inputs (TM for a recursively enumerable language stops and accepts, when provided with a word in its language).

Hence, if L' is recursively enumerable we can solve halting problem => L' is not recursively enumerable.

PS: If the bit part of the triplet is absent then L_0 is halting problem and L_1 is its complement and $L_0 \cup L_1 = \Sigma^*$, which is regular. Lets see how it happens.

Let the alphabet set be $\{0,1\}$. Now for any string like 0010101 there are only two options- belong to L or belong to L' as this is what complement says. Now, lets take the case for L_0 and a string $001\ldots10-01-1$, ("-" shown for notation purpose only) where the first component describes a TM M followed by input "$w=01$" and last bit "1". Now suppose M halts on "01". Still the given input is not in L_0 as the last bit is "1" and not "0" as required by L_0. So, this input must be in L_0'. But since M halts on w, this input is not in L_1 either. Similarly, we can get an infinite set of strings which does not belong to both L_0 and L_1 and this makes their union not Σ^* but an irregular (not r.e. as proved earlier) set. If the last bit is removed from the definition of L_0 and L_1, then any string should be present in either L_0 or L_1 and their union would be Σ^*.

29 votes -- gatecse (13.4k points)

5.16.6 Turing Machine: GATE2004-89 top

http://gateoverflow.in/1083

Selected Answer

S_1 is TRUE.

If L_1 is recursive L_2 must also be recursive. Because to check if a word $w = w_i\#w_j$ belong to L_2, we can give w_i and w_j to the decider for L_1 and if both are accepted then w belong to L_1 and not otherwise.

S_2 is TRUE.

With a decider for L_2 we can make a decider for L_1 as follows. Let w_1 be the first string enumerated by algorithm A for L_1. Now, to check if a word w belongs to L_1, make a string $w' = w_1\#w$ and give it to the decider for L_2 and if accepted, then w belongs to L_1 and not otherwise.

So, answer must be A.

14 votes -- Arjun Suresh (294k points)

5.16.7 Turing Machine: GATE2014-2-35 top http://gateoverflow.in/1994

Selected Answer

There are only a finite number of strings of length 2014. So, we can give all those strings to TM simulating each string for 1 step, then 2 step and so on (dovetailing), and if the TM accepts any of them ("yes" case of TM), we can say "yes". So, L is recursively enumerable.

(If the TM doesn't accept any string of length 2014, it can go to an infinite loop ("no" case of TM), and hence we can't say the method is decidable).

Now, to prove whether the problem is decidable or not we can make use of Rice's theorem. Rice's theorem (I) states that any non-trivial property of L(TM) is undecidable. L(TM) has a string of length 2014 is a non-trivial property as there are TMs whose language contains such a string and there are TMs whose language doesn't have such a string. So, the given problem is undecidable.

http://gatecse.in/wiki/Rice%27s_Theorem_with_Examples

32 votes -- Arjun Suresh (294k points)

5.16.8 Turing Machine: GATE2016-2-44 top http://gateoverflow.in/39596

Selected Answer

L_3 is not recursive as it asks if $L(M)$ contains ϵ which is a non-trivial property of r.e. languages and hence undecidable as per Rice's theorem.

L_1 and L_2 are slightly trickier as these are not describing properties of recursively enumerable languages, but rather of Turing machines. So, we can see if there is some procedure for deciding these.

For L_1 we can give the TM an input of length 2016. Now, it should at least make 2016 steps or reach the halt state before completing the input processing. The second case is possible only if the TM reaches a halt state before reaching the end of string (blank) of input, for all possible inputs of length at least 2016 and can be decided. So, we can be sure that otherwise TM will have at least 2016 steps making L_1 recursive.

L_2 is recursive and it is more easier to prove. For the complement of L_2 we need M to make less than 2016 steps for some input and we can just give it all possible inputs of length less than 2016 and see if it reaches a halt state within 2016 steps. Thus complement of L_2 is recursive $\implies L_2$ is recursive.

So, answer here is C.

36 votes -- Arjun Suresh (294k points)

One more possible approch:

L3 is not recursive (Can be proved using Rice theorm).

Lets talk about L1 and L2, and let me take L2 first

L2= {⟨M⟩|M takes at least 2016 steps on all inputs}, I want to check if for all strings in Σ* M takes more than or equal to 2016 steps or not.

First of all i will restrict number of steps in M to 2016, and i will never run M more than 2016 steps. Because for any string, if M halts (accepts then halts or rejects then halts, does not matter) in less than 2016 steps then that string is not in L2. And if M does not halts within 2016 steps (after 2016 steps, I am not interested whether M is in infinite loop or will halt eventually) then string is in L2

$\implies$ Number of steps to be run in M is not more than 2016.

Since we bound the number of steps that M runs on an input, then there is no point on looking at any strings that are longer
than that number, since if a TM is allowed to run for at most c steps, it is not possible for that TM to "process" any input symbol beyond the cth symbol!

$\implies$ Length of input string is less than 2016. (If i can decide for these strings then L2 is Recursive otherwise not Recursive) And there are finite strings having length less than 2016.

Now my task reduces to : "Take each string in this finite set and run M for finite number of steps"

The number of possible inputs is finite, and the number of steps M runs on each input is finite, therefore M is guaranteed to halt and decide the language. Hence L2 is recursive.

(If we can decide for all inputs then we can also decide for some inputs therefore L1 is also recursive (Reduction), but we can think of L1 as an independent problem)

L1={⟨M⟩|M takes at least 2016 steps on some input}, I want to check if there exist any string in Σ* for which M takes more than or equal to 2016 steps.

With same reasoning i can say that we will run M for finite number of steps and input string set is also finite. The only difference is, we can stop giving input once we find any string taking atleast 2016 steps, whereas in L2 we have to check for all set of input strings length less than 2016.

Therefore L1 is also recursive.

L1, L2 Recursive

L3: Not Recursive.

C is answer.

Ref: Problem number one in this pdf: https://www.cs.rice.edu/~nakhleh/COMP481/final_review_sp06_sol.pdf .

28 votes -- Sachin Mittal (7.1k points)

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