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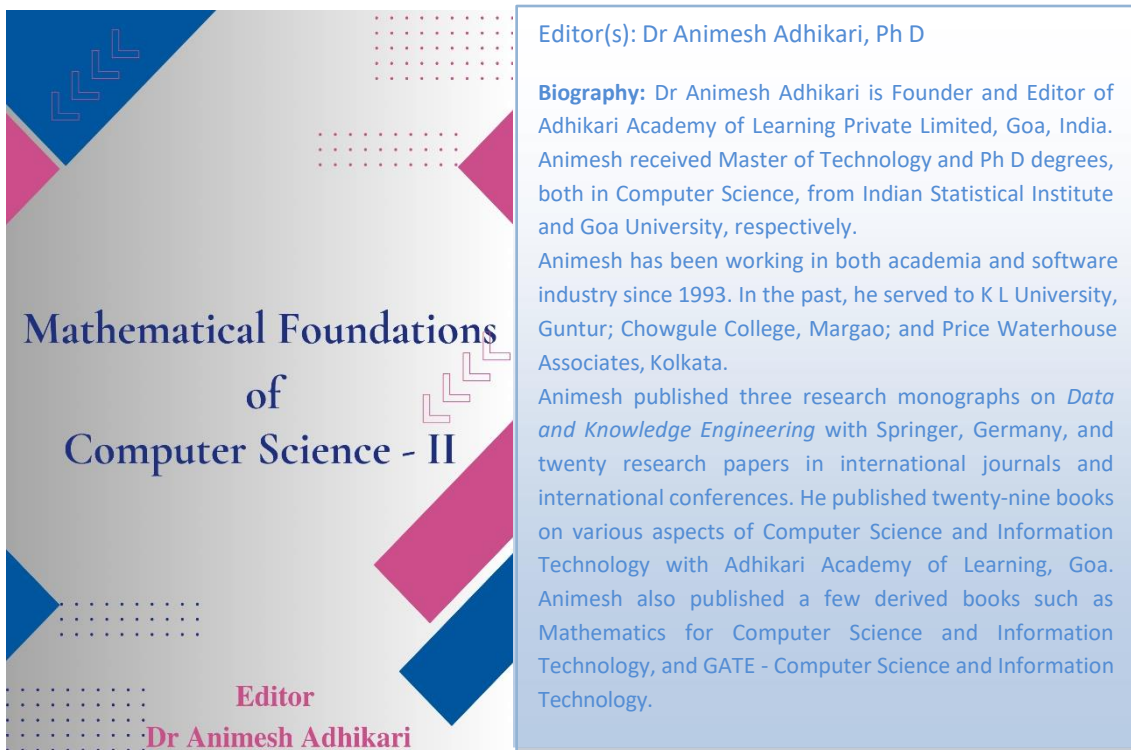
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News

We published the book *Mathematical Foundations of Computer Science - II* (Second Edition) recently. Details of the book are given as follows.

The book includes interesting problems / solutions on combinatorics, mathematical induction, recurrence relation, matrix algebra, determinant, and system of linear equations. The selection of questions / problems is aimed at providing different skills to learners. This book is also effective for students other than Computer Science, who have taken discrete mathematics as a paper of their studies. The second edition of the book contains 310 questions / solutions.



For more details about the book, please visit [book webpage](#).

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Q1. (a) Prove that grammars G_1 and G_2 produce the same language, where,

G_1 contains the following production rules: $S \rightarrow Sa \mid b$

G_2 contains the following production rules: $S \rightarrow bB, B \rightarrow aB \mid \varepsilon$

(b) Apply the result to remove left recursion from the following grammar.

$E \rightarrow E + T \mid T$

$T \rightarrow F$

$F \rightarrow d \mid (E)$, where d is a digit, or, constant, or, identifier

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Answer: Let L_1 be the language generated by grammar G_1 . Note that string $b \in L_1$, since $S \rightarrow b$. If we apply production rule $S \rightarrow Sa$ for n times, the resultant sentential form is Sa^n . Then the string ba^n can be obtained by applying production rule $S \rightarrow b$. Thus, $L_1 = \{ba^n \mid n \geq 0\}$.

Let L_2 be the language generated by grammar G_2 . In this case, we need to apply production rule $S \rightarrow bB$ at the beginning.

■ If we apply rule $B \rightarrow \varepsilon$ at the beginning, string b is generated. Thus, $b \in L_2$.

■ If we apply rule $B \rightarrow aB$ for n times, we get the sentential form ba^nB . Then the string ba^n can be obtained by applying production rule $B \rightarrow \varepsilon$.

Thus, $L_2 = \{ba^n \mid n \geq 0\}$, and hence, grammars G_1 and G_2 produce the same language.

Note: This result helps in removing *left recursion* from grammar having left recursion.

(b) We shall remove left recursion from production rule $E \rightarrow E + T$. The revised production rules without left recursion are given below.

$E \rightarrow TN$

$N \rightarrow +TN \mid \varepsilon$

$T \rightarrow F$

$F \rightarrow d \mid (E)$, where d is a digit, or, constant, or, identifier

Q2. Graph G is obtained by adding vertex s to $K_{3,4}$ and making s adjacent to every vertex of $K_{3,4}$. The minimum of colours required to edge-colour G is -----.

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Answer: Complete bipartite graph $K_{3,4}$ is given in Fig. 1. A proper edge colouring of a graph is an assignments of colours to the edges of the graph so that no two incident edges have the same colour. For edge colouring problem, the minimum required number of colours for edges of a graph is called the *chromatic index*.

Note that chromatic index of $K_{3,4} = \text{maximum}\{3,4\} = 4$. Now, consider the case that vertex s is added to $K_{3,4}$ and made adjacent to every vertex of $K_{3,4}$. Graph G is the resultant graph. Note that each pf the 7 vertices of $K_{3,4}$ is now adjacent to s in G . Thus, we need 7 colours for edge colouring of graph G .

Q3. What is the probability that divisor of 10^{99} is a multiple of 10^{96} ? Choose the correct option.

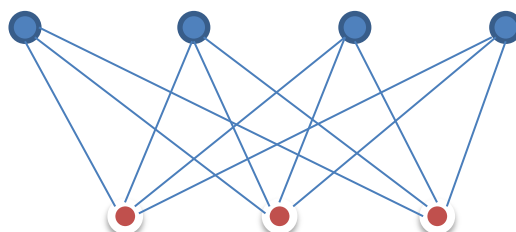


Figure 1: Graph $K_{3,4}$

- (A) $1/625$ (B) $4/625$ (C) $12/625$ (D) $16/625$

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Answer: $10^{99} = (2 \times 5)^{99} = 2^{99} \times 5^{99}$

Then, every factor of 10^{99} is of the form $2^p \times 5^q$, where $p, q = 0, 1, 2, \dots, 99$.

$$\begin{aligned} \text{Number of factors of } 10^{99} &= (\text{Number of choices of } p) \times (\text{Number of choices of } q) \\ &= 100 \times 100 = 10000 \end{aligned} \quad (1)$$

Now, we need to identify the number of positive integers of the form $2^p \times 5^q$ which are multiples of 10^{96} . In this case, p and q take values as 96, 97, 98, 99.

$$\begin{aligned} \text{Number of such multiples of } 10^{96} &= (\text{Number of choices of } p) / (\text{Number of choices of } q) \\ &= 4 \times 40 = 16 \end{aligned} \quad (2)$$

Required probability = (Number of favourable cases) $\times$ (Number of total cases)

$$\begin{aligned} &= 16/10000 \text{ [Using (1), (2)]} \\ &= 1/625 \end{aligned}$$

So, option (A) is correct.

Q4. State the purpose of the code.

```
j = 0;
k = 0;
for (i = 0; i <= strlen (s); i++)
    if (s[i] == ' ' || s[i] == '\0') {
        table[k][j] = '\0';
        k++;
        j = 0;
    }
    else {
        table[k][j] = s[i];
        j++;
    }
```

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Answer: Variable `s` is a given string. Variable `table` holds each word in the given string `s` in a row. In the string `s`, whenever there is a space or null character, it recognizes a word, and control goes to

the next row of `table` array for storing the next word. In this case, `s` is considered as a collection of words, and the variable `table` stores each word in a row.

Q5. Which of the following is NOT a valid deadlock prevention scheme ?

- (a) Release all resources before requesting a new resource.
- (b) Number the resources uniquely and never request a lower numbered resource than the last one requested.
- (c) Never request a resource after releasing any resource.
- (d) Request and all required resources be allocated before execution.

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Answer: The following conditions remain true, if there is a deadlock situation.

- Mutual exclusion of at least one resource (3)
- Hold and wait of a process (4)
- No preemption of resources (5)
- Circular wait of waiting processes (6)

Option (c) does not guarantee conditions (3) to (6). So, it is not a valid deadlock prevention scheme. Thus, option (c) is correct choice.

Q6. Consider the array representation of binary min-heap containing 1023 elements. The minimum number of comparisons required to find the maximum in the heap is -----.

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Answer: Let n be the number of elements in binary min-heap (T). In tree T , there are $\left\lceil \frac{n}{2} \right\rceil$ elements at the leaf level, where $\lceil x \rceil$ represents the minimum integer $\geq x$. In this case, $n = 1023$. There are $\left\lceil \frac{1023}{2} \right\rceil = 512$ elements available at the leaf level. Note that the maximum element is available at the leaf level. We need to search elements at the leaf level to find the maximum element. The start index of the leaf node is $\left\lceil \frac{n}{2} \right\rceil$, where the first element has index 0. The elements at the leaf level are not sorted. So, $(512 - 1) = 511$ element comparisons required using linear search method to find the maximum element. The minimum number of comparisons required is 511.

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