



Ramakrishna Mission Vivekananda Educational and Research Institute

Deemed-to-be-University as declared by Government of India under section 3 of UGC Act, 1956

Please read the instructions carefully:

- Use of calculators, electronic devices, mobile phones etc. is strictly prohibited.

Student's Name:

Roll No:

Time: 2 hrs

Section A

[10 questions × 2 marks = 20 marks]

1. What are the key differences between a compiled language and an interpreted language? Provide an example for each and discuss their advantages and disadvantages.
2. Define a bit and a byte. If a computer uses 8-bit bytes, how many unique unsigned integer values can a single byte store? Using a diagram, illustrate how the value 7 would be stored in a byte of memory. Assume `int` consumes 2 bytes.
3. Write down the characteristics of an algorithm.
4. Arrange the functions in ascending order of their time complexity: 2^n , $n!$, $n^{\log n}$
5. What is Big Θ notation? Provide a diagram and an example.
6. Explain the Addition property of Big O notation and provide a proof.
7. Find the time complexity of the following loop:

```
for (i = n; i >= 5; i =  $\sqrt{i}$ )  
    x = x + 1;
```
8. Find the time complexity of the following loop:

```
while n > 1 do  
    for i = 1 to n do  
        x = x + 1;  
    end for  
    n = floor(n / 2);  
end while
```
9. We have an array `int A[-10..10][-20..20]`. Width of `int` = 2 bytes. Base Address = 1000. Find the address of `A[5][6]` in both Row Major Order (RMO) and Column Major Order (CMO).
10. Write the `pop` functionality of a singly linked list.

Section B

[5 questions × 4 marks = 20 marks]

1. Solve the recurrence relation:

$$T(n) = \begin{cases} 1, & \text{if } n = 0, \\ T\left(\frac{n}{2}\right) + T\left(\frac{2n}{5}\right) + 7n, & \text{if } n > 0. \end{cases}$$

2. Consider an array $A = \{3, 8, 2, 5, 7, 6, 12\}$ of length 7.

- A subarray is a sequence of consecutive elements in the original array.
- A subarray of size w contains exactly w consecutive elements.

Let $w = 4$. Valid subarrays: $\{3, 8, 2, 5\}$, $\{8, 2, 5, 7\}$, $\{2, 5, 7, 6\}$, $\{5, 7, 6, 12\}$. Their sums are

$$3 + 8 + 2 + 5 = 18, \quad 8 + 2 + 5 + 7 = 22, \quad 2 + 5 + 7 + 6 = 20, \quad 5 + 7 + 6 + 12 = 30.$$

The maximum sum is 30. Write an optimal algorithm (time complexity $< n^2$) to find the maximum sum of any subarray of size w .

3. Design an algorithm to find the middle node of a singly linked list without using its length. Examples:

10 \rightarrow 20 \rightarrow 30 \rightarrow 40 \rightarrow 50 \rightarrow None (**middle = 30**)

10 \rightarrow 20 \rightarrow 30 \rightarrow 40 \rightarrow 50 \rightarrow 60 \rightarrow None (**middle = 40**)

4. Write an algorithm to reverse a singly linked list.

Original:

10 \rightarrow 20 \rightarrow 30 \rightarrow 40 \rightarrow 50 \rightarrow None

Reversed:

None \leftarrow 10 \leftarrow 20 \leftarrow 30 \leftarrow 40 \leftarrow 50

5. Write a recursive algorithm to compute $\sin(x)$ using the series. Show the recursion tree starting with count = 3.

$$\sin(x) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \dots$$

Assume x in radians; terminate recursion by term count.

Section C

[2 questions \times 10 marks = 20 marks]

1. Illustrate with diagram the Tower of Hanoi problem for $n = 1, 2, 3$ disks, showing the sequence of moves. Write a recursive algorithm to illustrate the Tower of Hanoi problem. Determine its time complexity and why it becomes impractical for large n .
2. Let `int A[15]={0,1,2,...,14}` and `key = 5`.
 - (i) Write both iterative and recursive binary search algorithms; show each step in a table.
 - (ii) Compute average times for successful and unsuccessful search.