INDIAN INSTITUTE OF TECHNOLOGY TIRUPATI
DEPARTMENT OF MATHEMATICS AND STATISTICS

MA635P-Scientific Programming Laboratory

Lab Exercise-2 (150 Marks) Deadline: 13 January 2026, 4:00 PM

Exercise 1: Big O

Suppose an algorithm takes 1 minute to compute 10 operations or to process 10 pieces of data. How many operations/data will be processed in one hour (H), 1 day (D), 1 week (W), 1 year (Y), 1 decade (D), and 1 century (C) by the algorithm if $T(n)$ as in Table **??**? Write a Python program to fill Table 1. [40]

$T(n)$	**Name**	c	**1 m**	**1 H**	**1 D**	**1 W**	**1Y**	**10 Y**	**1 C**
$O(\log(n))$	logarithmic		10						
$O((\log^2(n)))$	poly-logarithmic		10						
$O(n)$	linear		10						
$O(n^2)$	quadratic		10						
$O(n^3)$	cubic		10						
$O(n^{1.5})$	polynomial		10						
$O(2^n)$	exponential		10						

Tab. 1: Big O

Hint: For $O(n)$: $T(n) = cn \implies T(10) = 60 \implies 60 = 10c \implies c = 6 \implies T(n) = 6n$
For 1 Hour:

$$T(n) = 3600 \implies 6n = 3600 \implies n = 600$$

1 Minute: 10, 1 Hour: 600, 1 Day: 14400, 1 Week: 100800, 1 Year: 5.26×10^6, 10 Years: 5.26×10^7

For $O(n^2)$: $T(n) = cn^2 \implies T(10) = 60 \implies 60 = 100c \implies c = 0.6 \implies T(n) = 0.6n^2$

For 1 Hour: $T(n) = 3600 \implies 0.6n^2 = 3600 \implies n = 77$

For 1 Minute: 10, 1 Hour: 77

Exercise 2: File Size and Vector Operations Count

1. Use random library to create a random vector X of size 5 and another vector Y of size 5.
2. Store/Write the vector in a file VectorX.txt and VectorY.txt as given in the format below?

   Vector.txt

   5
   0.1575
   0.7924
   0.9845
   0.2563
   0.4866

3. What is the size of the file VectorX.txt or VectorY.txt?

4. Let $S(n, X)$ denote the size of the file VectorX.txt. What will be the size of the file VectorX.txt if n is as in table 2?

5. Let $T_+(n, X, Y)$ denote the number of additions involved during $X + Y$. Fill the table 2.

6. Let $T_+^*(n, X, Y)$ denote the number of multiplications and additions involved while computing the dot product of two vectors. Fill the following table 2. [30]

n	$S(n, X)$	$T_+(n, X, Y)$	$T_+^*(n, X, Y)$
10			
100			
1000			
10^6			
10^9			

Tab. 2: Vector Storage and Operations Count

Exercise 3: Matrix Operations and Matrix-Vector Product Count

1. Use random library to create a random matrices A and B of size 5×5

2. Store/Write the matrix in a file MatrixA.txt and MatrixB.txt as below

   Matrix.txt
   5,5
   0.8147,0.0975,0.1576,0.1419,0.6557
   0.9058,0.2785,0.9706,0.4218,0.0357
   0.1270,0.5469,0.9572,0.9157,0.8491
   0.9134,0.9575,0.4854,0.7922,0.9340
   0.6324,0.9649,0.8003,0.9595,0.6787

3. What is the size of the file MatrixA.txt or MatrixB.txt?

4. Let $S(n, A)$ denote the size of the file MatrixA.txt. What will be the size of the file MatrixA.txt if n is as given in the table 3?

5. Let $T_+(n, A, B)$ denote the number of additions involved while adding two square matrices. Fill the table 3.

6. Let $T_+^*(n, A, B)$ denote the number of multiplications and additions involved while multiplying two square matrices. Fill the table 3.

7. Let $T_+^*(n, A, X)$ denote the number of multiplications and additions involved for Matrix Vector Multiplications. Fill the table 3. $[7 \times 7 = 49 + 1]$

n	$S(n,A)$	$T_+(n,A,B)$	$T_+^*(n,A,B)$	$T_+^*(n,A,X)$
10				
100				
1000				
10^6				
10^9				

Tab. 3: Matrix Storage and Operations Count

Exercise 4: Strassen algorithm

Let A and B matrices of size $2^n \times 2^n$. To compute the matrix-matrix product $C = AB$, split matrices into equally sized block matrices:

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}, B = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix}, C = \begin{bmatrix} C_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix}$$

where A_{ij}, B_{ij} and C_{ij} are of size $2^{n-1} \times 2^{n-1}$. Compute

- $M_1 = (A_{11} + A_{22})(B_{11} + B_{22})$
- $M_2 = (A_{21} + A_{22})B_{11}$
- $M_3 = A_{11}(B_{12} - B_{22})$
- $M_4 = A_{22}(B_{21} - B_{11})$
- $M_5 = (A_{11} + A_{12})B_{2}2$
- $M_6 = (A_{21} - A_{11})(B_{11} + B_{12})$
- $M_7 = (A_{12} - A_{22})(B_{21} + B_{22})$
- $C_{11} = M_1 + M_4 - M_5 + M_7$
- $C_{12} = M_3 + M_5$
- $C_{21} = M_2 + M_1$
- $C_{22} = M_1 - M_2 + M_3 + M_6$

1. Let $ST_+^*(n,A,B)$ denote the number of multiplications and additions involved while multiplying two square matrices. Fill the table 4 using the Strassen Algorithm. $[6 \times 5 = 30]$

n	$S(n,A)$	$ST_+^*(n,A,B)$
4		
16		
256		
512		
1024		
2048		

Tab. 4: Strassen Algorithm Operations Count