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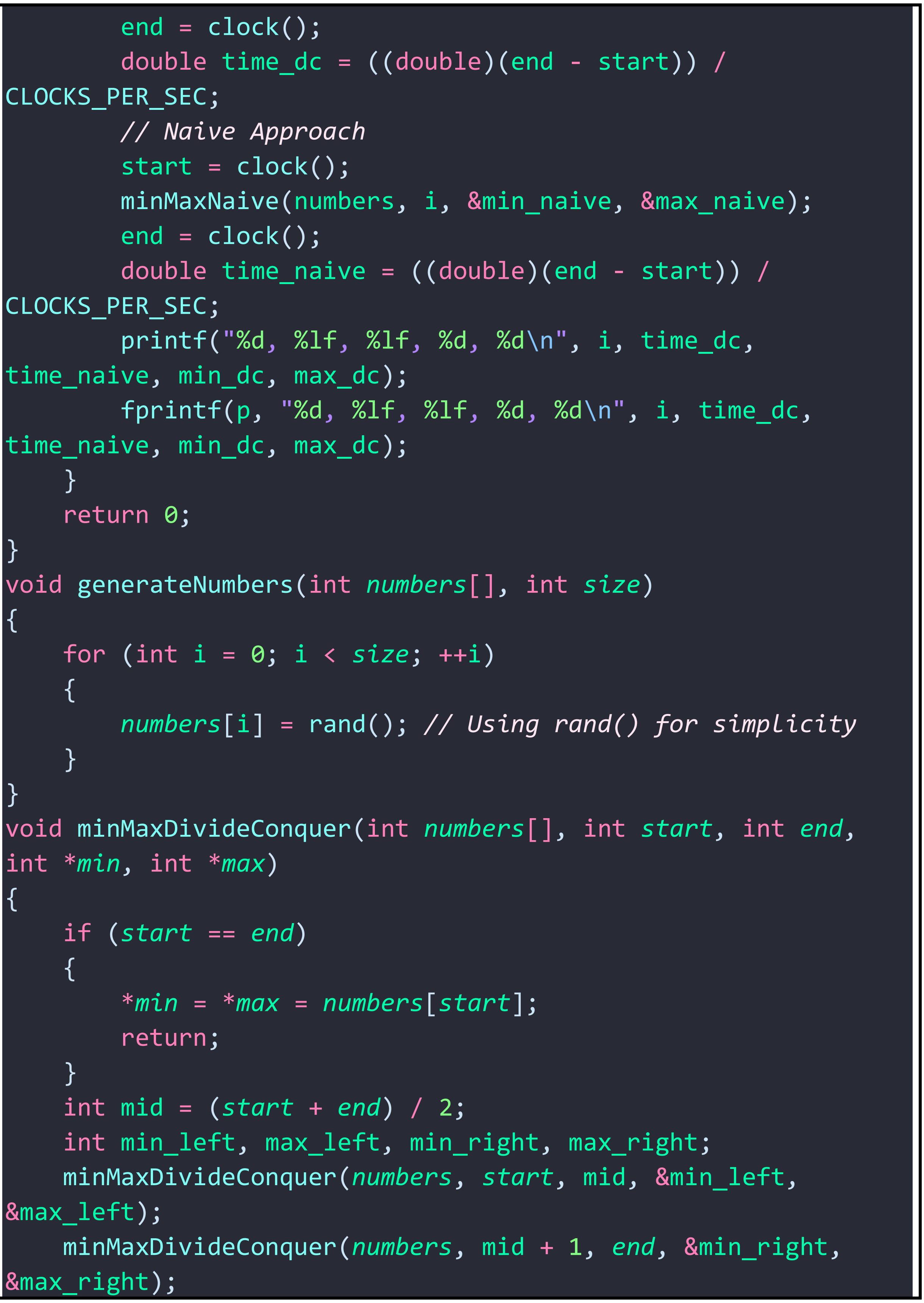
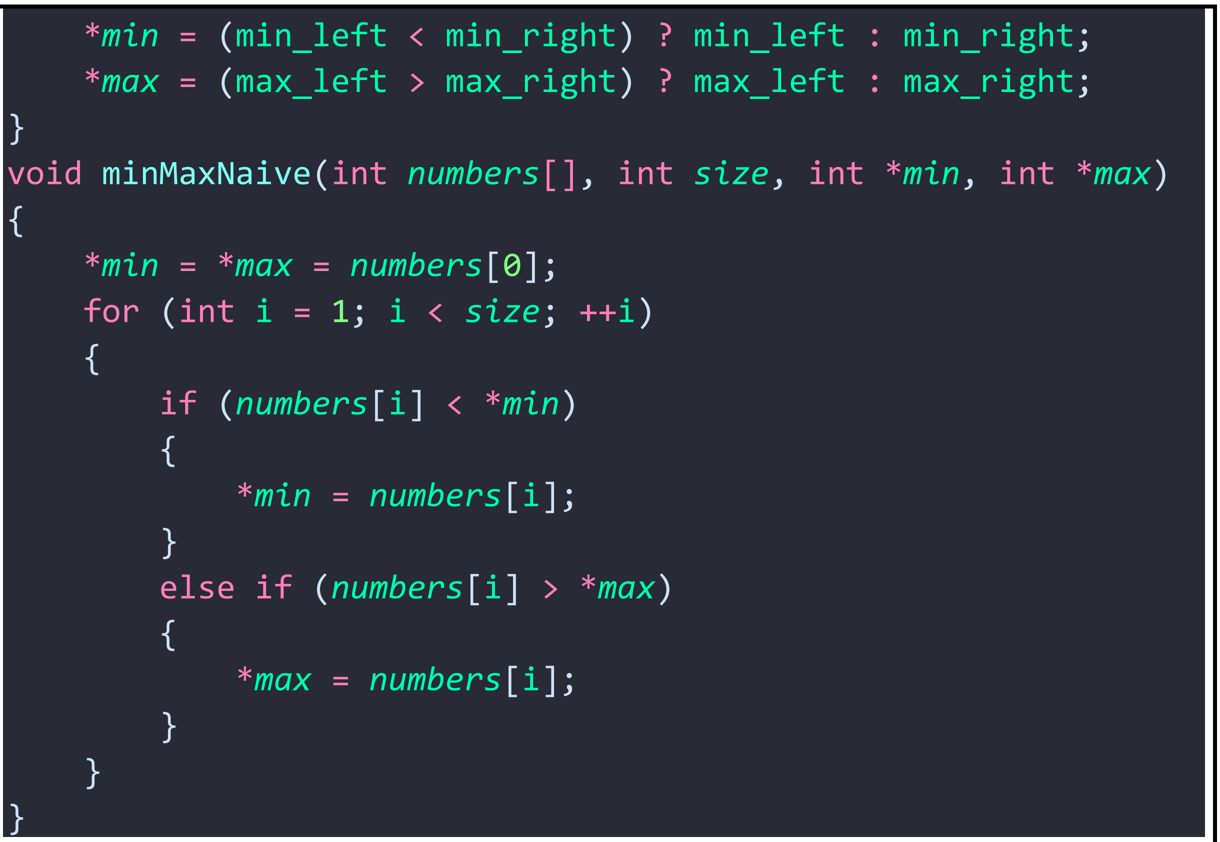
Subject	Design and Analysis of Algorithms (DAA)
Experiment No.	3
Aim	Experiment based on divide and conquer (MIN-MAX and Strassen’s Multiplication.
Min-Max	

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#define ARRAY_SIZE 100000
// Function prototypes
void generateNumbers(int numbers[], int size);
void minMaxDivideConquer(int numbers[], int start, int end,
int *min, int *max);
void minMaxNaive(int numbers[], int size, int *min, int *max);
int main()
{
    FILE *p = fopen("minmax.csv", "w");
    fprintf(p, "Number, Time (Divide & Conquer), Time (Naive),
Min, Max\n");
    int numbers[ARRAY_SIZE];
    int min_dc, max_dc, min_naive, max_naive;
    // Generate 100,000 random integer numbers using rand()
    generateNumbers(numbers, ARRAY_SIZE);
    printf("Number, Time (Divide & Conquer), Time (Naive),
Min, Max\n");
    for (int i = 100; i <= ARRAY_SIZE; i += 100)
    {
        clock_t start, end;

        // Divide and Conquer
        start = clock();
        minMaxDivideConquer(numbers, 0, i - 1, &min_dc,
&max_dc);
```

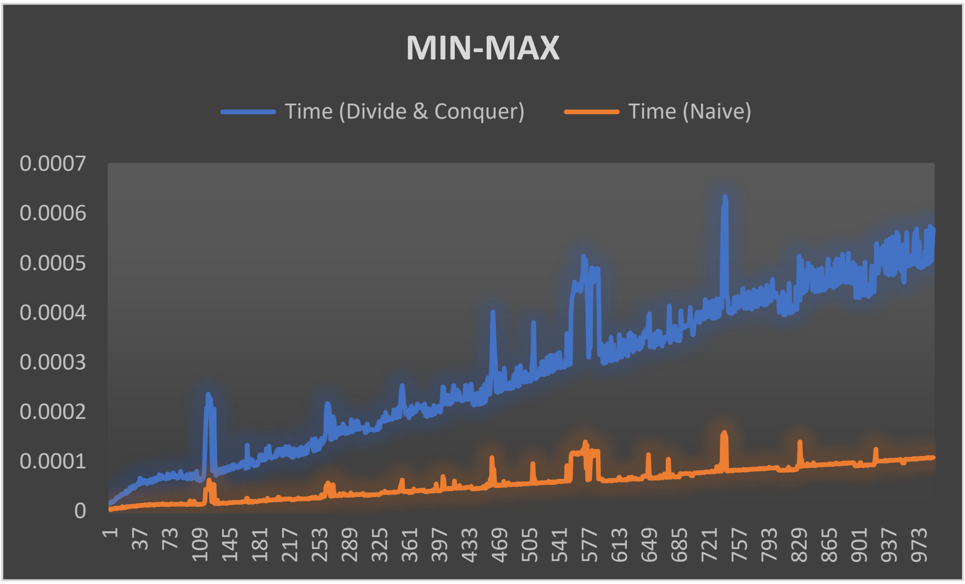


```
        end = clock();
        double time_dc = ((double)(end - start)) /
CLOCKS_PER_SEC;
        // Naive Approach
        start = clock();
        minMaxNaive(numbers, i, &min_naive, &max_naive);
        end = clock();
        double time_naive = ((double)(end - start)) /
CLOCKS_PER_SEC;
        printf("%d, %lf, %lf, %d, %d\n", i, time_dc,
time_naive, min_dc, max_dc);
        fprintf(p, "%d, %lf, %lf, %d, %d\n", i, time_dc,
time_naive, min_dc, max_dc);
    }
    return 0;
}
void generateNumbers(int numbers[], int size)
{
    for (int i = 0; i < size; ++i)
    {
        numbers[i] = rand(); // Using rand() for simplicity
    }
}
void minMaxDivideConquer(int numbers[], int start, int end,
int *min, int *max)
{
    if (start == end)
    {
        *min = *max = numbers[start];
        return;
    }
    int mid = (start + end) / 2;
    int min_left, max_left, min_right, max_right;
    minMaxDivideConquer(numbers, start, mid, &min_left,
&max_left);
    minMaxDivideConquer(numbers, mid + 1, end, &min_right,
&max_right);
```

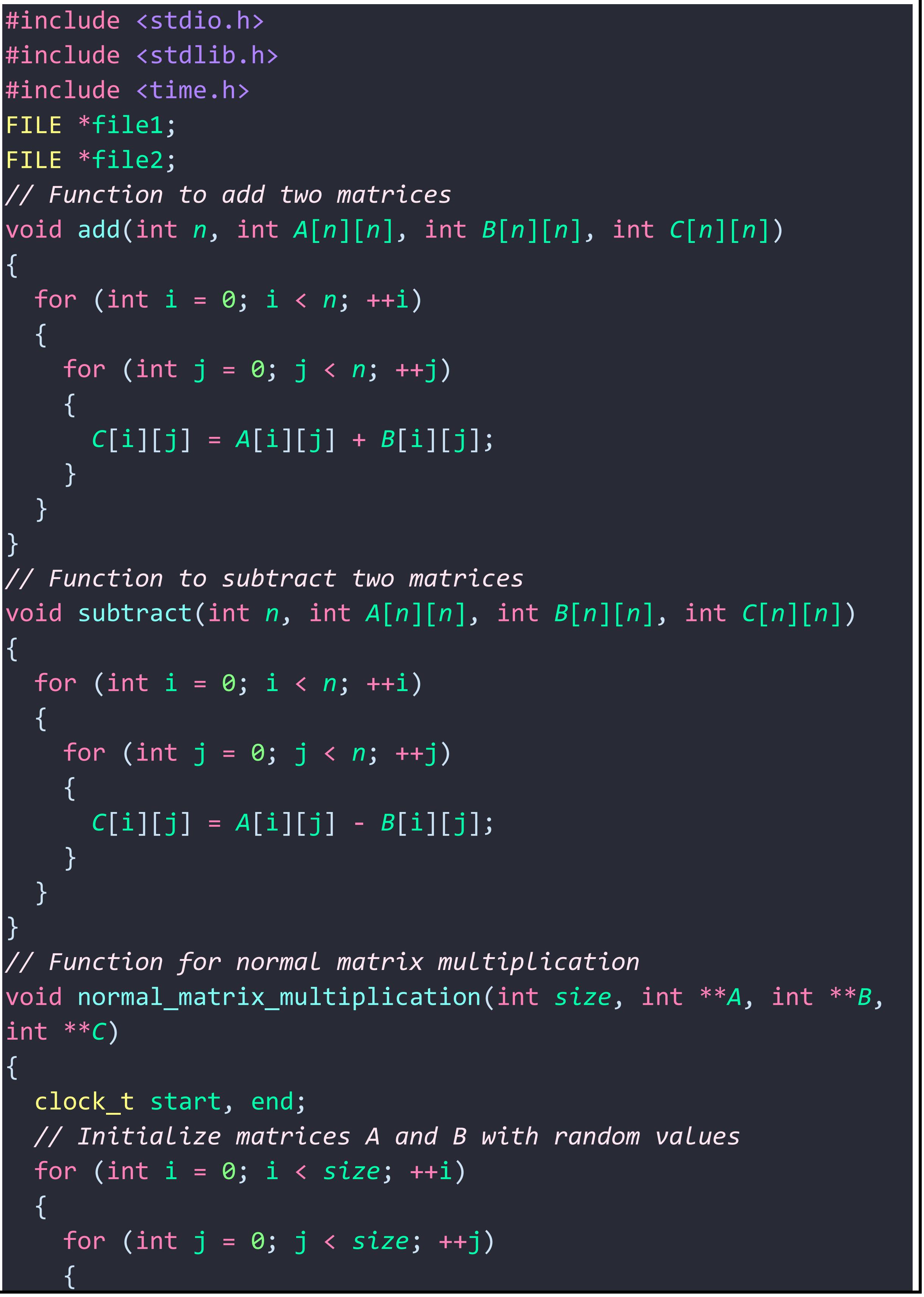


```
    *min = (min_left < min_right) ? min_left : min_right;
    *max = (max_left > max_right) ? max_left : max_right;
}
void minMaxNaive(int numbers[], int size, int *min, int *max)
{
    *min = *max = numbers[0];
    for (int i = 1; i < size; ++i)
    {
        if (numbers[i] < *min)
        {
            *min = numbers[i];
        }
        else if (numbers[i] > *max)
        {
            *max = numbers[i];
        }
    }
}
```

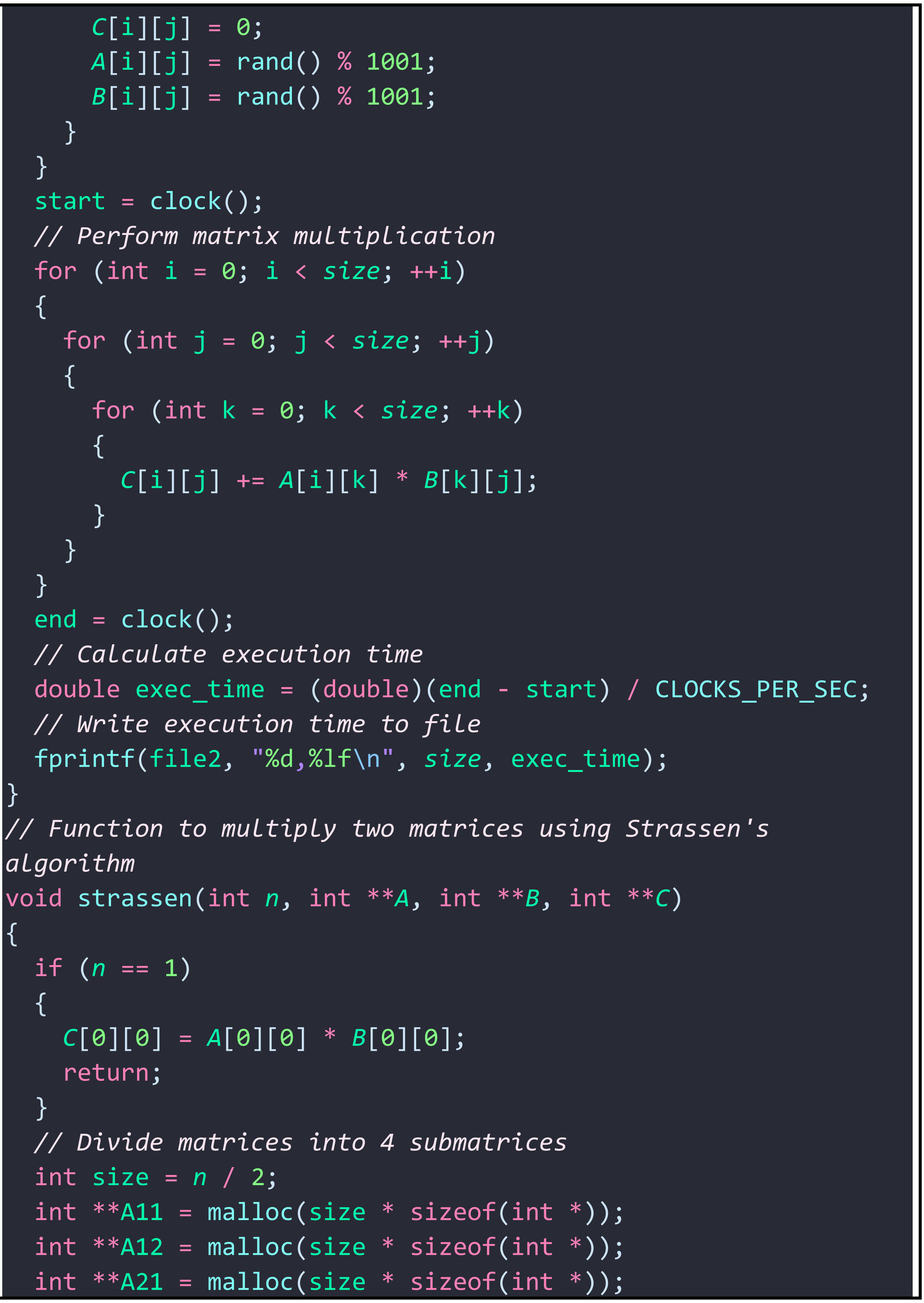
Graphs



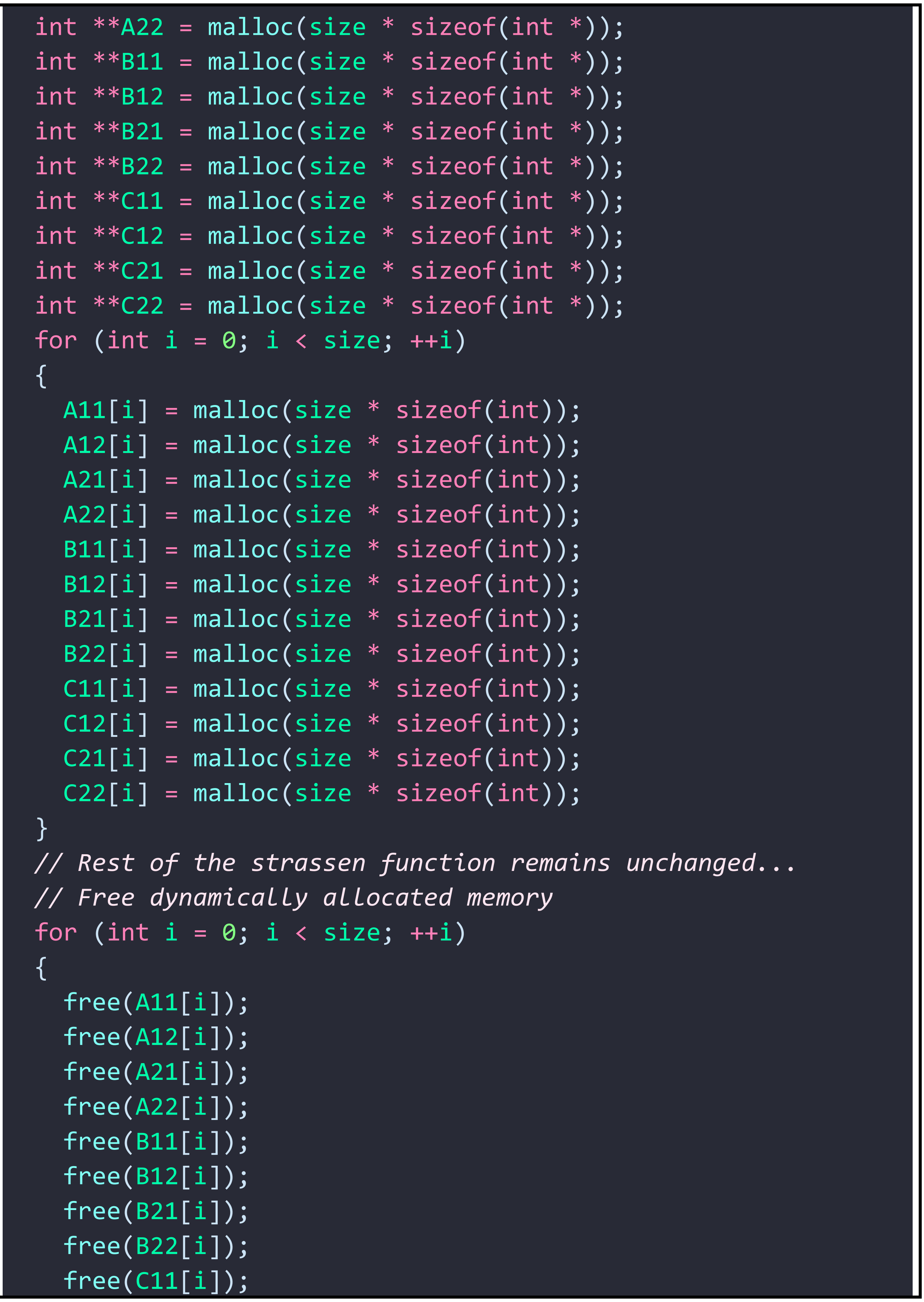
Strassens:



```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
FILE *file1;
FILE *file2;
// Function to add two matrices
void add(int n, int A[n][n], int B[n][n], int C[n][n])
{
  for (int i = 0; i < n; ++i)
  {
    for (int j = 0; j < n; ++j)
    {
      C[i][j] = A[i][j] + B[i][j];
    }
  }
}
// Function to subtract two matrices
void subtract(int n, int A[n][n], int B[n][n], int C[n][n])
{
  for (int i = 0; i < n; ++i)
  {
    for (int j = 0; j < n; ++j)
    {
      C[i][j] = A[i][j] - B[i][j];
    }
  }
}
// Function for normal matrix multiplication
void normal_matrix_multiplication(int size, int **A, int **B,
int **C)
{
  clock_t start, end;
  // Initialize matrices A and B with random values
  for (int i = 0; i < size; ++i)
  {
    for (int j = 0; j < size; ++j)
    {
```

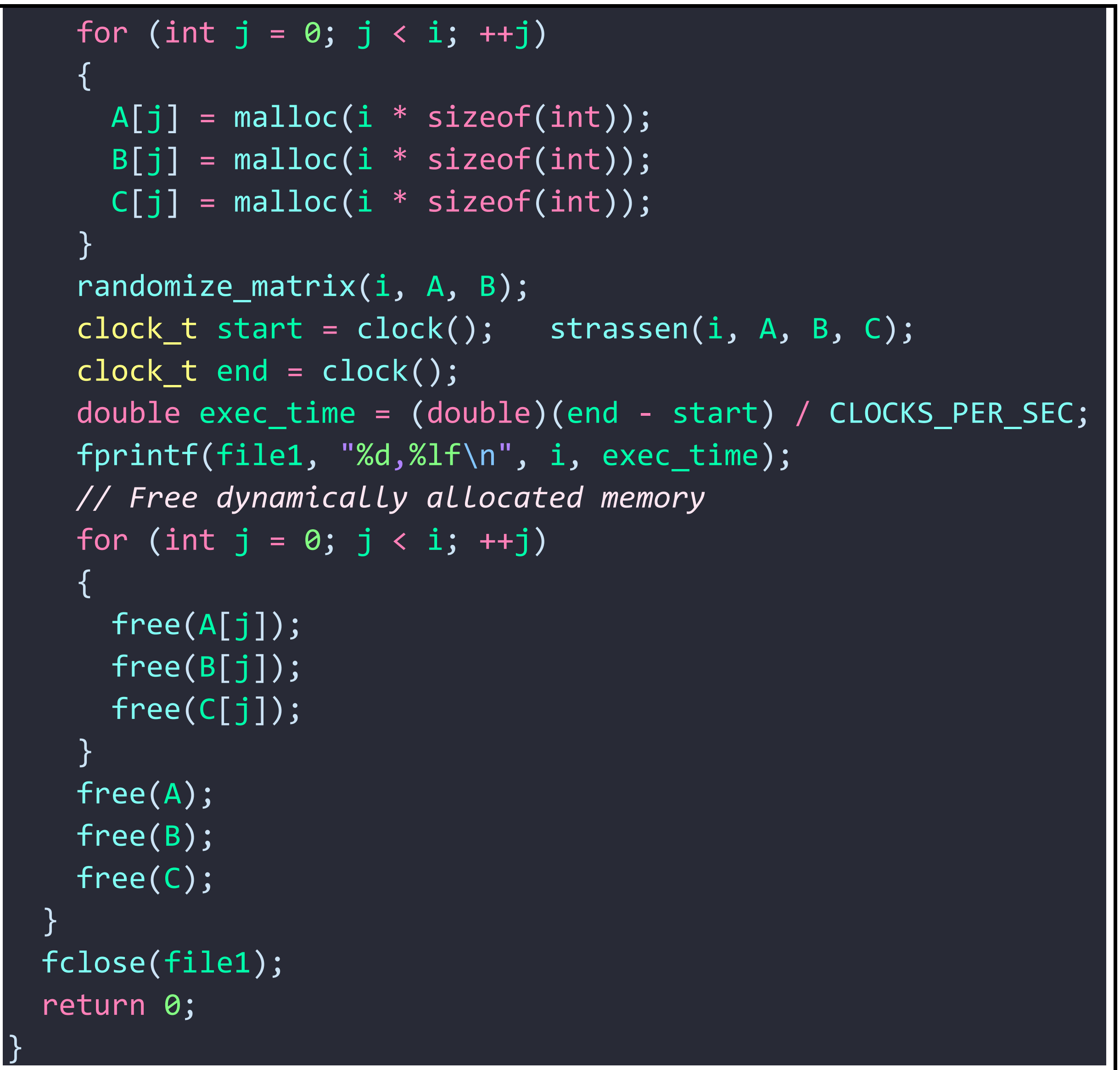


```
      C[i][j] = 0;
      A[i][j] = rand() % 1001;
      B[i][j] = rand() % 1001;
    }
  }
  start = clock();
  // Perform matrix multiplication
  for (int i = 0; i < size; ++i)
  {
    for (int j = 0; j < size; ++j)
    {
      for (int k = 0; k < size; ++k)
      {
        C[i][j] += A[i][k] * B[k][j];
      }
    }
  }
  end = clock();
  // Calculate execution time
  double exec_time = (double)(end - start) / CLOCKS_PER_SEC;
  // Write execution time to file
  fprintf(file2, "%d,%lf\n", size, exec_time);
}
// Function to multiply two matrices using Strassen's
algorithm
void strassen(int n, int **A, int **B, int **C)
{
  if (n == 1)
  {
    C[0][0] = A[0][0] * B[0][0];
    return;
  }
  // Divide matrices into 4 submatrices
  int size = n / 2;
  int **A11 = malloc(size * sizeof(int *));
  int **A12 = malloc(size * sizeof(int *));
  int **A21 = malloc(size * sizeof(int *));
```

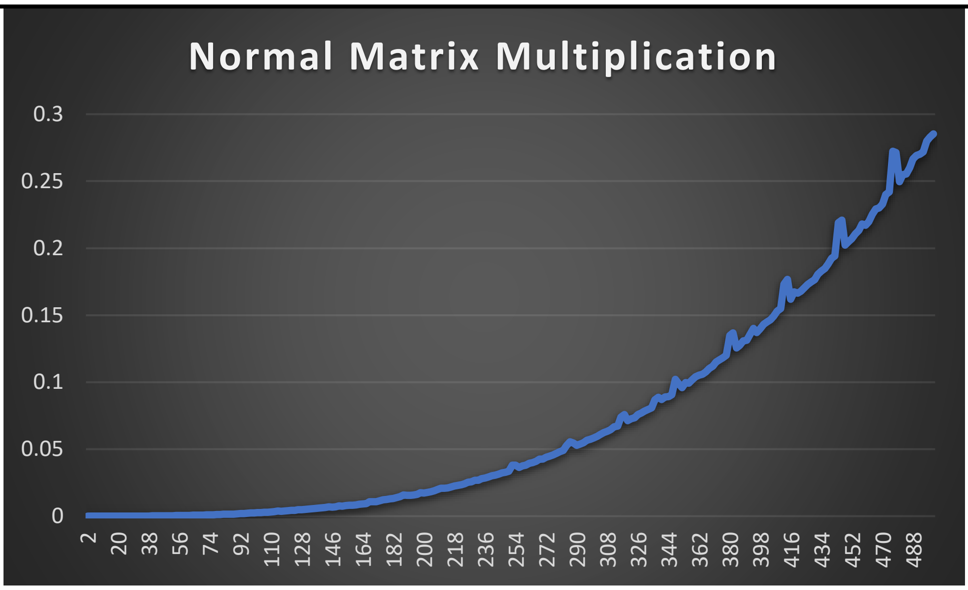


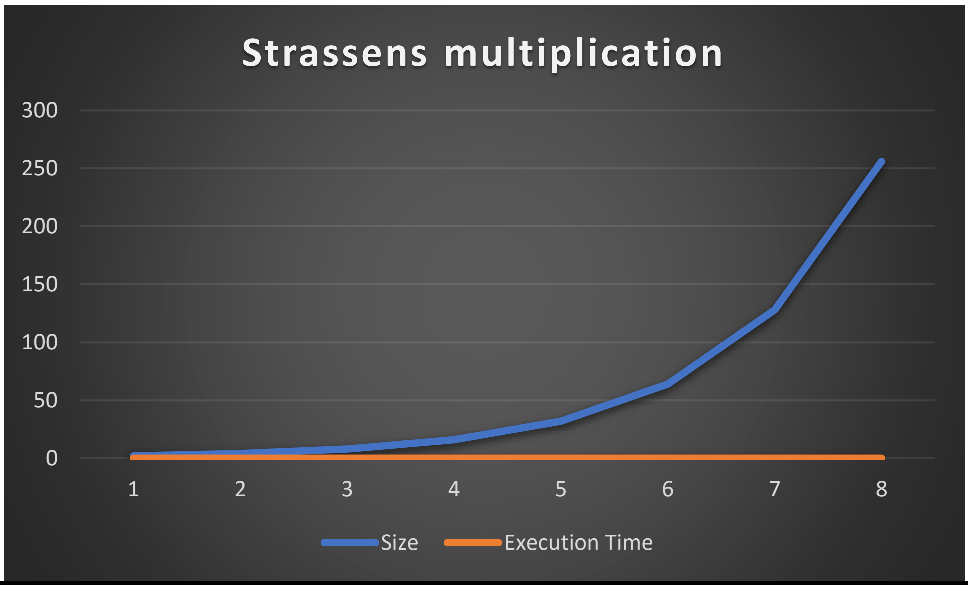
```
int **A22 = malloc(size * sizeof(int *));
int **B11 = malloc(size * sizeof(int *));
int **B12 = malloc(size * sizeof(int *));
int **B21 = malloc(size * sizeof(int *));
int **B22 = malloc(size * sizeof(int *));
int **C11 = malloc(size * sizeof(int *));
int **C12 = malloc(size * sizeof(int *));
int **C21 = malloc(size * sizeof(int *));
int **C22 = malloc(size * sizeof(int *));
for (int i = 0; i < size; ++i)
{
  A11[i] = malloc(size * sizeof(int));
  A12[i] = malloc(size * sizeof(int));
  A21[i] = malloc(size * sizeof(int));
  A22[i] = malloc(size * sizeof(int));
  B11[i] = malloc(size * sizeof(int));
  B12[i] = malloc(size * sizeof(int));
  B21[i] = malloc(size * sizeof(int));
  B22[i] = malloc(size * sizeof(int));
  C11[i] = malloc(size * sizeof(int));
  C12[i] = malloc(size * sizeof(int));
  C21[i] = malloc(size * sizeof(int));
  C22[i] = malloc(size * sizeof(int));
}
// Rest of the strassen function remains unchanged...
// Free dynamically allocated memory
for (int i = 0; i < size; ++i)
{
  free(A11[i]);
  free(A12[i]);
  free(A21[i]);
  free(A22[i]);
  free(B11[i]);
  free(B12[i]);
  free(B21[i]);
  free(B22[i]);
  free(C11[i]);
```

```c
    free(C12[i]);
    free(C21[i]);
    free(C22[i]);
  }
  free(A11);
  free(A12);
  free(A21);
  free(A22);
  free(B11);
  free(B12);
  free(B21);
  free(B22);
  free(C11);
  free(C12);
  free(C21);
  free(C22);
}
// Function to randomly initialize matrices A and B
void randomize_matrix(int n, int **A, int **B)
{
  for (int i = 0; i < n; ++i)
  {
    for (int j = 0; j < n; ++j)
    {
      A[i][j] = rand() % 1025;
      B[i][j] = rand() % 1025;
    }
  }
}
int main()
{
  // Seed for random number generation
  srand(time(NULL));
  // File to store Normal Matrix Multiplication results
  file2 = fopen("Normal_Matrix_Multiplication_File.csv", "w");
  fprintf(file2, "Size,Execution Time\n");
  // Perform Normal Matrix Multiplication for various matrix
sizes
  for (int i = 2; i <= 500; i += 2)
  {
    int **A = malloc(i * sizeof(int *));
    int **B = malloc(i * sizeof(int *));
    int **C = malloc(i * sizeof(int *));
    for (int j = 0; j < i; ++j)
    {
      A[j] = malloc(i * sizeof(int));
      B[j] = malloc(i * sizeof(int));
      C[j] = malloc(i * sizeof(int));
    }
    normal_matrix_multiplication(i, A, B, C);
    // Free dynamically allocated memory
    for (int j = 0; j < i; ++j)
    {
      free(A[j]);
      free(B[j]);
      free(C[j]);
    }
    free(A);
    free(B);
    free(C);
  }
  fclose(file2);
  // File to store Strassen's Matrix Multiplication results
  file1 = fopen("Strassens_Matrix_Multiplication_File.csv",
"w");
  fprintf(file1, "Size,Execution Time\n");
  // Perform Strassen's Matrix Multiplication for various
matrix sizes
  for (int i = 2; i <= 256; i *= 2)
  {
    int **A = malloc(i * sizeof(int *));
    int **B = malloc(i * sizeof(int *));
    int **C = malloc(i * sizeof(int *));
```



```
    for (int j = 0; j < i; ++j)
    {
      A[j] = malloc(i * sizeof(int));
      B[j] = malloc(i * sizeof(int));
      C[j] = malloc(i * sizeof(int));
    }
    randomize_matrix(i, A, B);
    clock_t start = clock();   strassen(i, A, B, C);
    clock_t end = clock();
    double exec_time = (double)(end - start) / CLOCKS_PER_SEC;
    fprintf(file1, "%d,%lf\n", i, exec_time);
    // Free dynamically allocated memory
    for (int j = 0; j < i; ++j)
    {
      free(A[j]);
      free(B[j]);
      free(C[j]);
    }
    free(A);
    free(B);
    free(C);
  }
  fclose(file1);
  return 0;
}
```

<table>
<tr><td><b>Graphs</b></td><td>




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<tr><td><b>Pseudo Code & Example</b></td><td></td></tr>
<tr><td><b>Conclusion</b></td><td>Hence, by completing this experiment I came to know about divide and conquer approach.</td></tr>
</table>