EXPERIMENT 1

20CP209P – Design and Analysis of Algorithm Lab

Aim:

Implement Insertion Sort and Selection Sort and give complexity analysis

Code:

Insertion Sort:

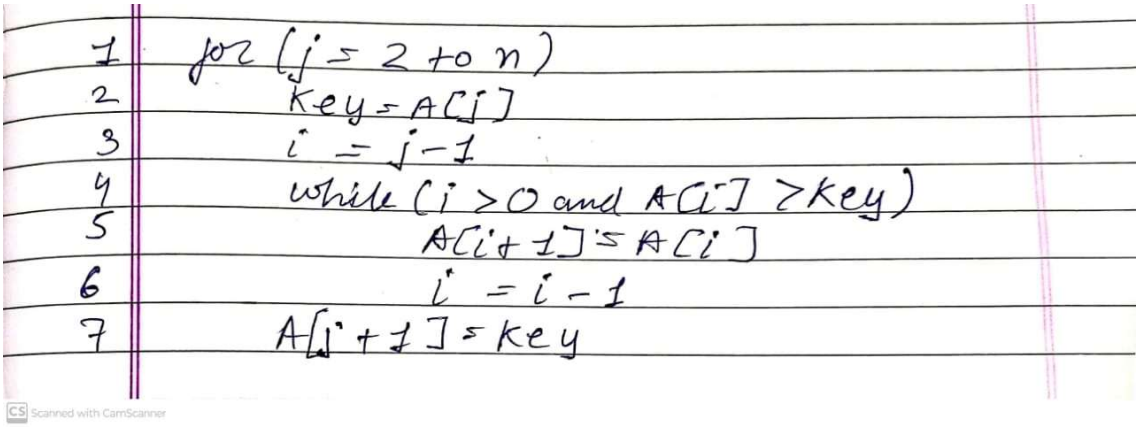
```
#include <stdio.h>
#include <time.h>

void insertion_sort(int arr[], int len);

int main(void)
{
   clock_t start, end;
   int arr[] = {7,4,8,9,0,1,2,5,3,6};

   int len = sizeof(arr) / sizeof(int);

   start = clock();
   insertion_sort(arr, len);
   end = clock();

   for (int i = 0; i < len; i++)
   {
      printf("%d ", i);
   }
   printf("\n");

   printf("time taken for execution: ", (double) (end - start));

   return 0;
}

void insertion_sort(int arr[], int len)
{
   for (int i = 1; i < n; i++)
   {
      int key = arr[i];
      int j = i - 1;

      while (j >= 0 && arr[j] > key)
      {
         arr[j + 1] = arr[j];
```

```
            j--;
        }
        arr[j + 1] = key;
    }

    return;
}
```

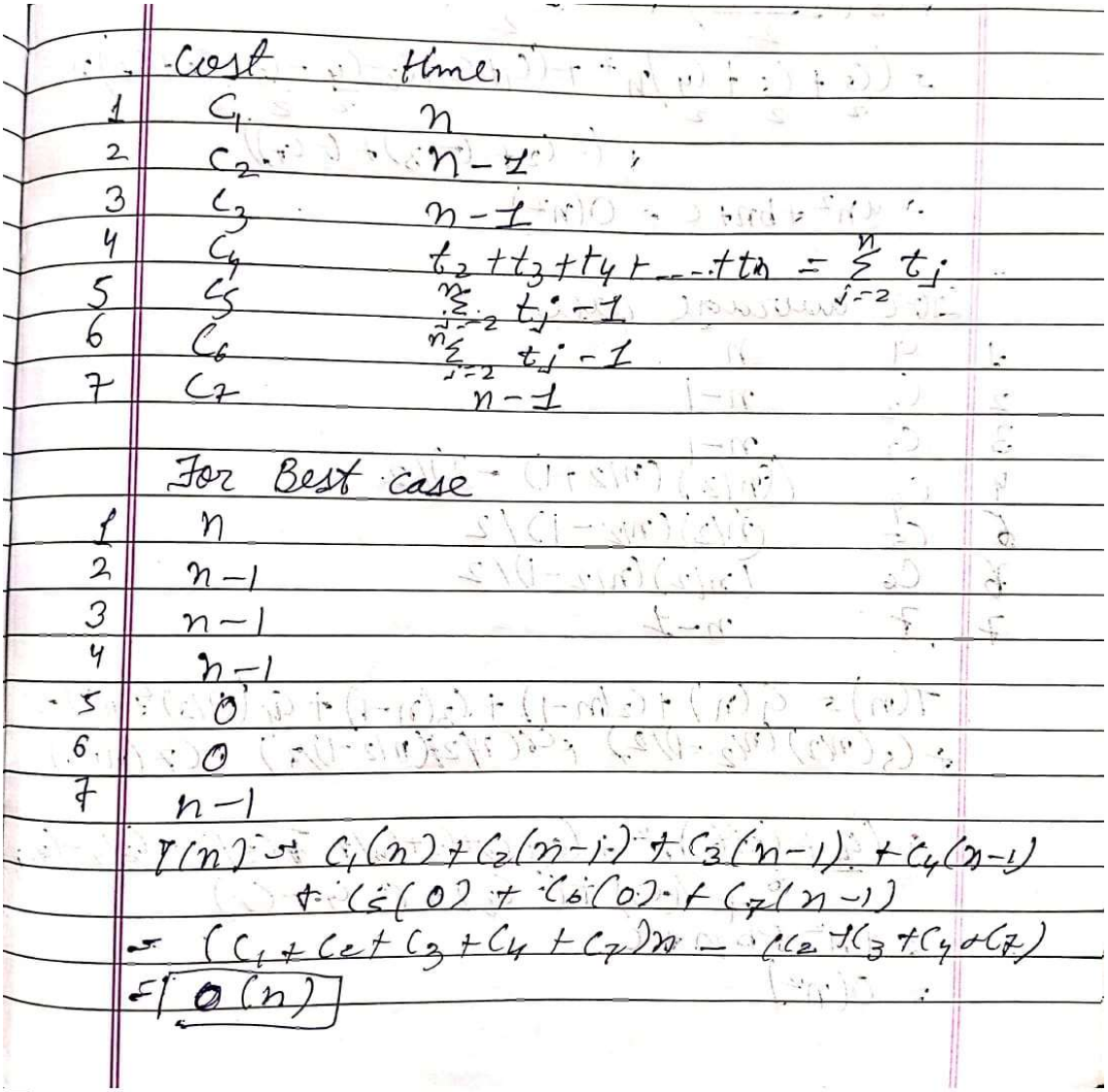
Output:

```
PS B:\sem4\23bcp153_daa\lab1> gcc insertionsort.c -o insertionsort
PS B:\sem4\23bcp153_daa\lab1> ./insertionsort
0 1 2 3 4 5 6 7 8 9
time taken for execution:
PS B:\sem4\23bcp153_daa\lab1>
```

Algorithm:



Complexity Analysis:



	Cost	time
1	C_1	n
2	C_2	$n-1$
3	C_3	$n-1$
4	C_4	$t_2+t_3+t_4+\dots+t_n = \sum_{j=2}^{n} t_j$
5	C_5	$\sum_{j=2}^{n} t_j - 1$
6	C_6	$\sum_{j=2}^{n} t_j - 1$
7	C_7	$n-1$

For Best case

1	n
2	$n-1$
3	$n-1$
4	$n-1$
5	0
6	0
7	$n-1$

$T(n) = C_1(n) + C_2(n-1) + C_3(n-1) + C_4(n-1) + C_5(0) + C_6(0) + C_7(n-1)$

$= (C_1 + C_2 + C_3 + C_4 + C_7)n - (C_2 + C_3 + C_4 + C_7)$

$= \boxed{O(n)}$

For worst case

1	n	
2	$n-1$	
3	$n-1$	
4	$2+3+4+\dots+n$	$= n(n+1)/2 - 1$
5	$n(n-1)/2$	
6	$n(n-1)/2$	
7	$n-1$	

$T(n) = C_1(n) + C_2(n-1) + C_3(n-1) + C_4\left(\frac{n(n-1)}{2}-2\right) + C_5\left(\frac{n(n-1)}{2}\right) + C_6\left(\frac{n(n-1)}{2}\right) + C_7(n-1)$

$= \left(\frac{C_5}{2} + \frac{C_6}{2} + \frac{C_4}{2}\right)n^2 + \left(C_1 + C_2 + C_3 - \frac{C_4}{2} - \frac{C_5}{2} - \frac{C_6}{2} + C_7\right)n + (-C_2 + (-C_3) + 0 - C_7)$

$= an^2 + bn + c = O(n^2)$

For average case

1	C_1	n
2	C_2	$n-1$
3	C_3	$n-1$
4	C_4	$(n/2)(n/2+1) - 2)/2$
5	C_5	$(n/2)(n/2-1)/2$
6	C_6	$(n/2)(n/2-1)/2$
7	7	$n-1$

$T(n) = C_1(n) + C_2(n-1) + C_3(n-1) + C_4\left((n/2)^2 + (n/2) - 2\right) + C_5\left((n/2)(n/2-1)/2\right) + C_6\left((n/2)(n/2-1)/2\right) + C_7(n-1)$

$= \left(\frac{C_4 + C_5 + C_6}{8}\right)n^2 + \left(C_1 + C_2 + C_3 + C_4/4 + C_5/4 - C_6/4 - C_7\right)n + ((-C_2) + (-C_3) + (-C_4) - C_7)$

$= an^2 + bn + c$

$= O(n^2)$

Code:

Selection Sort:

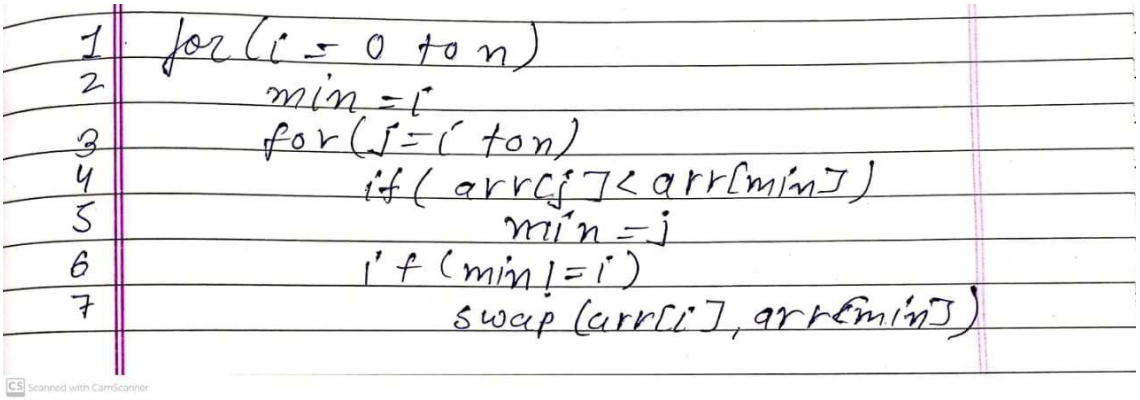
```
#include <stdio.h>
#include <time.h>

void selection_sort(int arr[], int len);

int main(void)
{
   clock_t start, end;
   int arr[] = {7,4,8,9,0,1,2,5,3,6};

   int len = sizeof(arr) / sizeof(int);

   start = clock();
   selection_sort(arr, len);
   end = clock();

   for (int i = 0; i < len; i++)
   {
      printf("%d ", i);
   }
   printf("\n");

   printf("time taken for execution: %f", (double) (end - start));

   return 0;
}

void selection_sort(int arr[], int n)
{
   for (int i = 0; i < n; i++)
   {
      int min = i;
      for (int j = i; j < n; j++)
      {
         if (arr[j] < arr[min])
         {
            min = j;
         }
      }
      if (min != i)
      {
         int temp = arr[i];
         arr[i] = arr[min];
         arr[min] = temp;
      }
   }
```

```
    return;
}
```

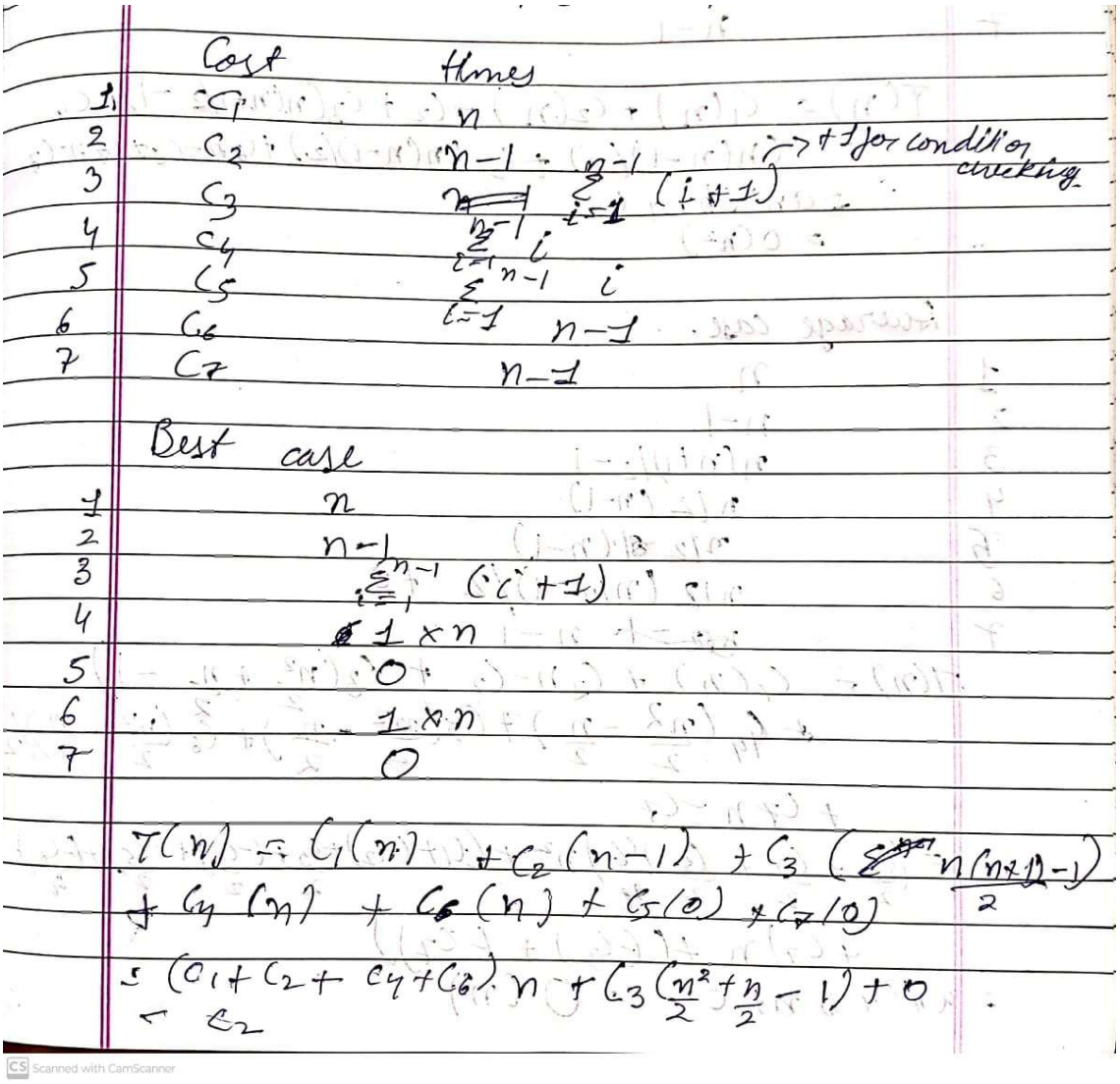
Output:

```
PS B:\sem4\23bcp153_daa\lab1> gcc selectionsort.c -o selectionsort
PS B:\sem4\23bcp153_daa\lab1> ./selectionsort
0 1 2 3 4 5 6 7 8 9
time taken for execution: 0.000000
PS B:\sem4\23bcp153_daa\lab1>
```

Algorithm:



Complexity Analysis:



$= an^2 + bn + c$

$= O(n^2)$

Worst case

1	n
2	$n-1$
3	$(n(n+1)/2) - 1$
4	$n(n-1)/2$
5	$n(n-1)/2$
6	$n-1$
7	$n-1$

$T(n) = C_1(n) + C_2(n) + C_2 + C_3(n(n+1/2 - 1) + C_4 (n(n-1)/2) + C_5 (n(n-1)/2) + C_6 n - C_6 + C_7 n - C_7$

$= an^2 + bn + c$

$= O(n^2)$

Average case.

1	n
2	$n-1$
3	$n(n+1)/2 - 1$
4	$n/2 (n-1)$
5	$n/2 (n-1)$
6	$n/2 (n/2 - 1)/2$
7	$n-1$

$T(n) = C_1(n) + C_2 n - C_2 + C_3\left(\frac{n^2}{2} + \frac{n}{2} - 1\right) + C_4\left(\frac{n^2}{2} - \frac{n}{2}\right) + C_5\left(\frac{n^2}{2} - \frac{n}{2}\right) + C_6\left(\frac{n^2}{2} - \frac{n}{2}\right)/2 + C_7 n - C_7$

$= \left(\frac{C_3}{2} + \frac{C_4}{2} + \frac{C_5}{2} + \frac{C_6}{4}\right) n^2 + \left(C_1 + (-C_2) + \frac{C_3}{2} + \left(-\frac{C_4}{2}\right) + \left(-\frac{C_5}{2}\right) + \left(-\frac{C_6}{4}\right) + C_7\right) n + \left((-C_3) + (-C_7)\right)$

$= an^2 + bn + c = O(n^2)$

EXPERIMENT 2

20CP209P – Design and Analysis of Algorithm Lab

Aim:

Implement Merge Sort and Quick Sort and give complexity analysis

Code:

Merge Sort:

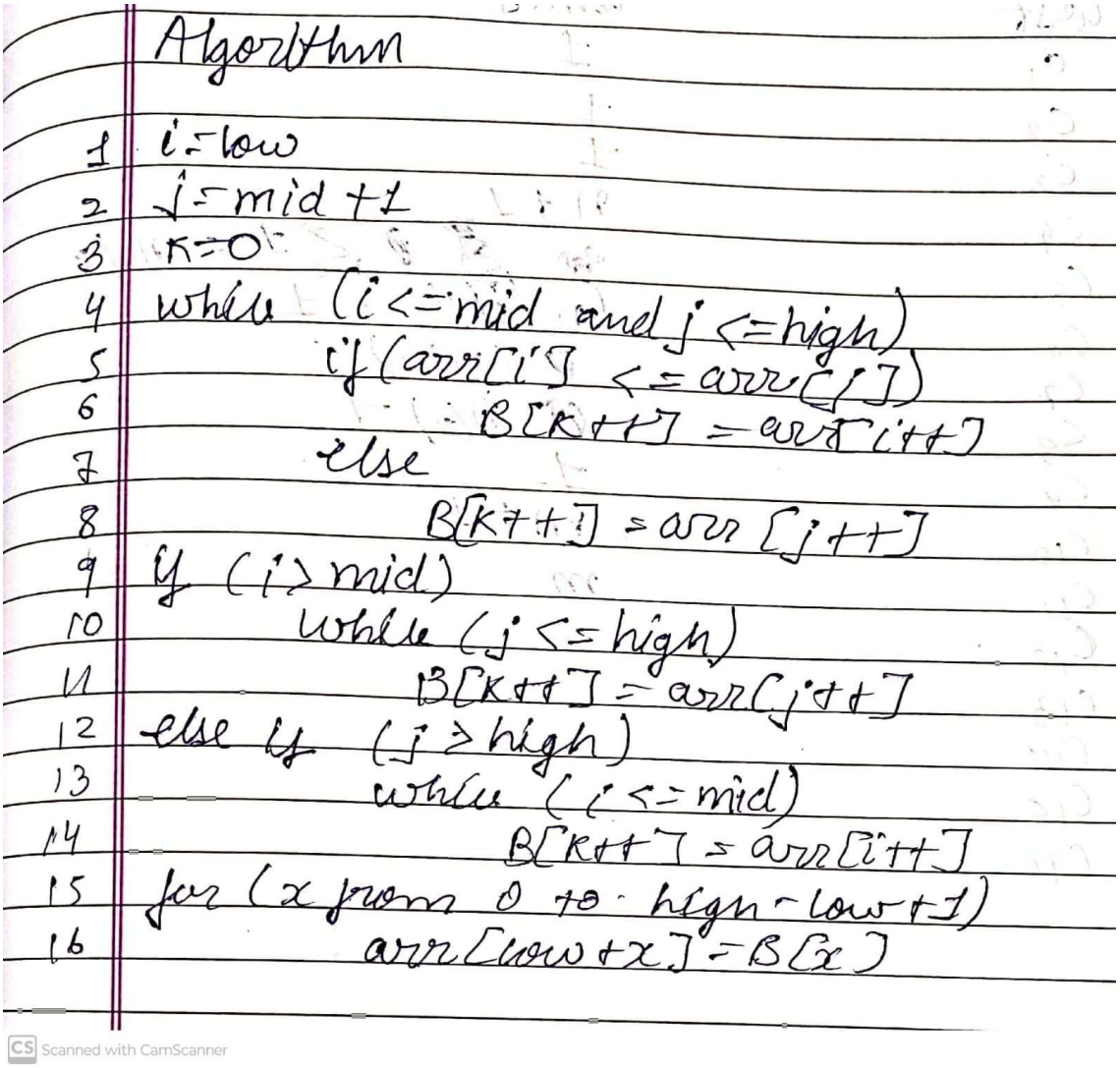
```
#include <stdio.h>
#include <time.h>

void merge_sort(int arr[], int low, int high);
void merge(int arr[], int low, int mid, int high);

int main(void)
{
   clock_t start, end;
   int arr[] = {7, 4, 8, 9, 0, 1, 2, 5, 3, 6};

   int len = sizeof(arr) / sizeof(int);
   int low = 0;
   int high = len - 1;
   start = clock();
   merge_sort(arr, low, high);
   end = clock();

   for (int i = 0; i < len; i++)
   {
      printf("%d ", arr[i]);
   }
   printf("\n");

   printf("Time taken for execution: %f seconds\n", (double)(end - start) / CLOCKS_PER_SEC);

   return 0;
}

void merge_sort(int arr[], int low, int high)
{
   if (low < high)
   {
      int mid = (low + high) / 2;
      merge_sort(arr, low, mid);
      merge_sort(arr, mid + 1, high);
      merge(arr, low, mid, high);
   }
```

```
}

void merge(int arr[], int low, int mid, int high)
{
   int i = low;
   int j = mid + 1;
   int k = 0;

   int arrB[high - low + 1];

   while (i <= mid && j <= high)
   {
      if (arr[i] <= arr[j])
      {
         arrB[k] = arr[i];
         i++; k++;
      }
      else
      {
         arrB[k] = arr[j];
         j++; k++;
      }
   }

   if (i > mid)
   {
      while (j <= high)
      {
         arrB[k] = arr[j];
         j++; k++;
      }
   }

   else if (j > high)
   {
      while (i <= mid)
      {
         arrB[k] = arr[i];
         i++; k++;
      }
   }

   for (int x = 0; x < (high - low + 1); x++)
      arr[low + x] = arrB[x];

   return;
}
```

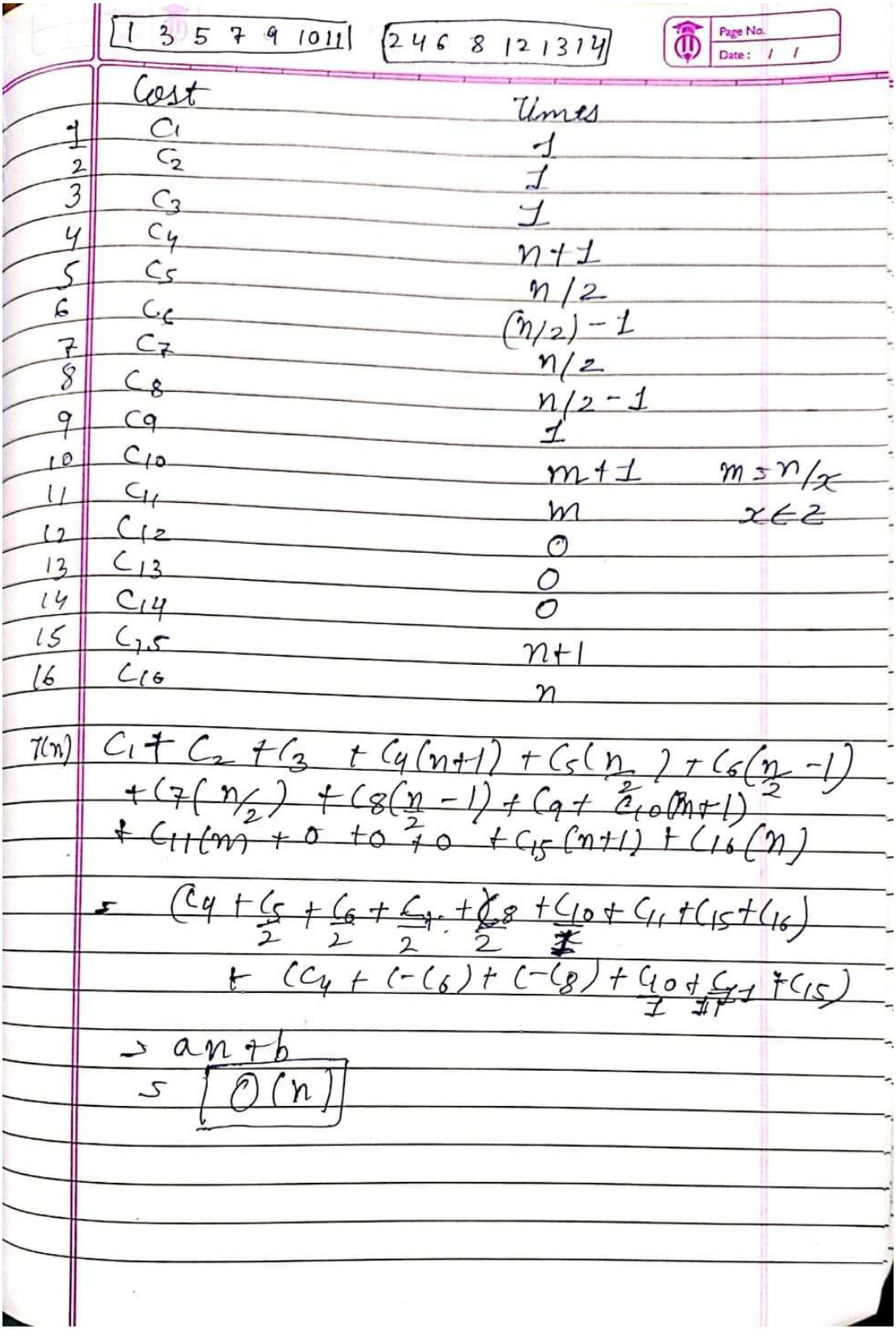
Output:

```
PS B:\sem4\23bcp153_daa\lab2> code mergesort.c
PS B:\sem4\23bcp153_daa\lab2> ./mergesort
0 1 2 3 4 5 6 7 8 9
Time taken for execution: 0.000000 seconds
PS B:\sem4\23bcp153_daa\lab2>
```

Algorithm:



Complexity Analysis:



	Cost	Times	
1	C_1	1	
2	C_2	1	
3	C_3	1	
4	C_4	$n+1$	
5	C_5	$n/2$	
6	C_6	$(n/2)-1$	
7	C_7	$n/2$	
8	C_8	$n/2-1$	
9	C_9	1	
10	C_{10}	$m+1$	$m = n/x$
11	C_{11}	m	$x \in 2$
12	C_{12}	0	
13	C_{13}	0	
14	C_{14}	0	
15	C_{15}	$n+1$	
16	C_{16}	n	

$T(n) = C_1 + C_2 + C_3 + C_4(n+1) + C_5(\frac{n}{2}) + C_6(\frac{n}{2}-1) + C_7(\frac{n}{2}) + C_8(\frac{n}{2}-1) + C_9 + C_{10}(m+1) + C_{11}(m) + 0 + 0 + 0 + C_{15}(n+1) + C_{16}(n)$

$= (C_4 + \frac{C_5}{2} + \frac{C_6}{2} + \frac{C_7}{2} + \frac{C_8}{2} + C_{10} + C_{11} + C_{15} + C_{16}) + (C_4 + (-C_6) + (-C_8) + C_{10} + C_{11} + C_{15})$

$\rightarrow an + b$

$= \boxed{O(n)}$

Code:

Quick Sort:

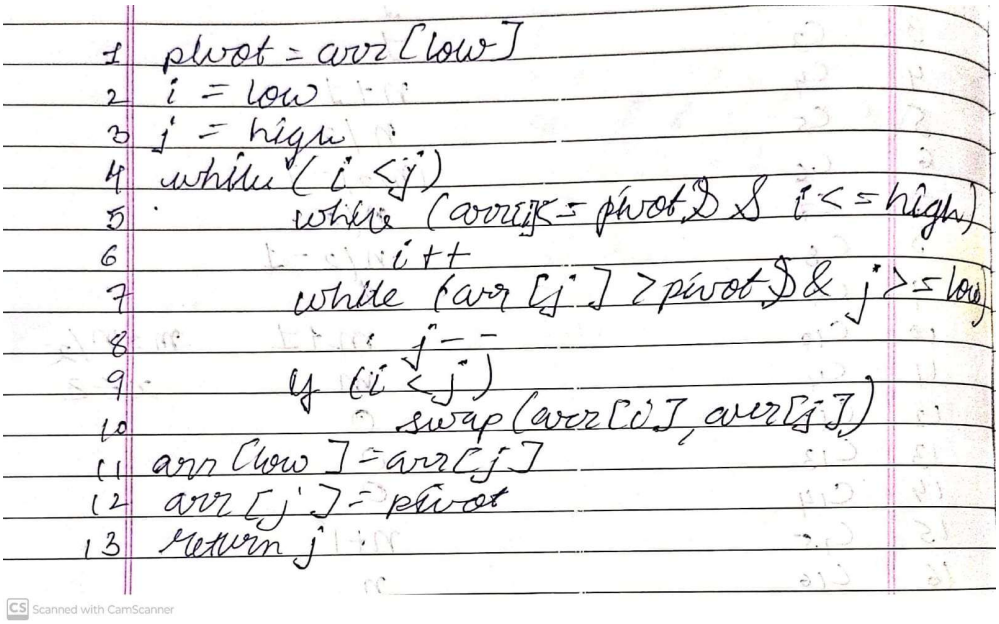
```
#include <stdio.h>
#include <time.h>

void quick_sort(int arr[], int low, int high);
int partition(int arr[], int low, int high);

int main(void)
{
   clock_t start, end;
   // int arr[] = {7, 4, 8, 9, 0, 1, 2, 5, 3, 6};
   int arr[] = {9, 8, 7, 6, 5, 4, 3, 2, 1, 0};

   int len = sizeof(arr) / sizeof(int);
   int low = 0;
   int high = len - 1;
   start = clock();
   quick_sort(arr, low, high);
   end = clock();

   for (int i = 0; i < len; i++)
   {
      printf("%d ", arr[i]);
   }
   printf("\n");

   printf("Time taken for execution: %f seconds\n", (double)(end - start) / CLOCKS_PER_SEC);

   return 0;
}

void quick_sort(int arr[], int low, int high)
{
   if (low < high)
   {
      int location = partition(arr, low, high);
      quick_sort(arr, low, location - 1);
      quick_sort(arr, location + 1, high);
   }
}

int partition(int arr[], int low, int high)
{
   int pivot = arr[low];
   int i = low; // i is start in lab algo
   int j = high; // j is end in lab algo
```

```
    while (i < j)
    {
        while (arr[i] <= pivot && i <= high)
            i++;
        while (arr[j] > pivot && j >= low)
            j--;

        if (i < j)
        {
            int temp = arr[i];
            arr[i] = arr[j];
            arr[j] = temp;
        }
    }

    arr[low] = arr[j];
    arr[j] = pivot;

    return j;
}
```

Output:

```
PS B:\sem4\23bcp153_daa\lab2> code quicksort.c
PS B:\sem4\23bcp153_daa\lab2> ./quicksort
0 1 2 3 4 5 6 7 8 9
Time taken for execution: 0.000000 seconds
PS B:\sem4\23bcp153_daa\lab2>
```

Algorithm:



Complexity Analysis:

Cost	Times
c_1	1
c_2	1
c_3	1
c_4	$n/2 + 1$
c_5	n
c_6	$n/2$
c_7	n
c_8	$n/2$
c_9	$n/2$
c_{10}	$n/2 - 1$
c_{11}	1
c_{12}	1
c_{13}	1

$$T(n) = c_1(1) + c_2 + c_3 + c_4(n/2 + 1) + c_5(n) + c_6(n/2) + c_7(n) + c_8(n/2) + c_9(n/2) + c_{10}(n/2 - 1) + c_{11}(1) + c_{12}(1) + c_{13}(1)$$

$$= \left(\frac{c_4}{2} + c_5 + \frac{c_6}{2} + c_7 + \frac{c_8}{2} + \frac{c_9}{2} + \frac{c_{10}}{2}\right)n + [c_1 + c_2 + c_3 + c_4 + (-c_{10}) + c_{11} + c_{12} + c_{13}]$$

$$= an + b$$

$$= O(n)$$

Time Analysis of all sorting algorithms:

```
PS B:\sem4\23bcp153_daa\lab2> gcc avgtimeall.c mysortlib.c -o avgtimeall
PS B:\sem4\23bcp153_daa\lab2> ./avgtimeall
Average execution time over 100 iterations:
Quick Sort: 0.000750 seconds
Merge Sort: 0.001050 seconds
Selection Sort: 0.042600 seconds
Insertion Sort: 0.026930 seconds
PS B:\sem4\23bcp153_daa\lab2>
```

Selection takes most time

Quick Sort takes least time