MINISTRY OF EDUCATION, CULTURE AND RESEARCH

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Report

Laboratory Work No.2

of the "Data Structures and Algorithms" course

Checked:

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Purpose of laboratory work:

Solving problems with 1-D arrays. It aims to strengthen programming skills by working with 1-D arrays, array manipulation, algoritmic thinking and problem-solving.

Task:

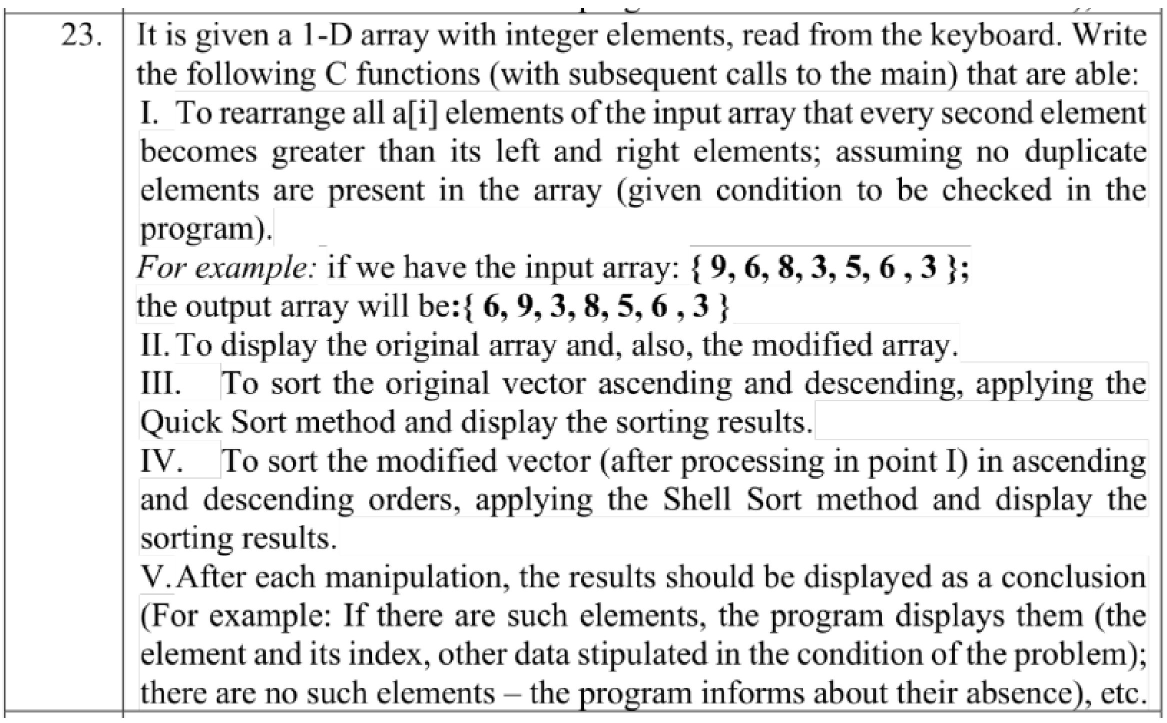
1. Solve the following problems in C, writing your own functions according to the given statements. Write the solution of the problem by procedural approach in two versions:

   a. with the use of the method of transmitting the parametric functions by value;
   b. with the use of the method of passing parameters of functions by address/pointers (the formal parameter will be a pointer to the value of the corresponding object).
   c. To draw the block diagram corresponding to the solved problem.

2. Modify the content of your problems emerging from the possibilities that are missing, but which can be brought as added value in the condition of the existing problem. Formulate and present in writing the modified condition; to solve in C your problem in the modified version, using functions developed by you.

   - Because of the fact that in every problem in version 1, you should use two specified sorting methods, in version 2, of the problem proposed (modified) by you, you should use the sorting methods as Counting Sort & Merge Sort.

Condition of the problem:



23.	It is given a 1-D array with integer elements, read from the keyboard. Write the following C functions (with subsequent calls to the main) that are able: I. To rearrange all a[i] elements of the input array that every second element becomes greater than its left and right elements; assuming no duplicate elements are present in the array (given condition to be checked in the program). *For example:* if we have the input array: **{ 9, 6, 8, 3, 5, 6 , 3 };** the output array will be:**{ 6, 9, 3, 8, 5, 6 , 3 }** II. To display the original array and, also, the modified array. III. To sort the original vector ascending and descending, applying the Quick Sort method and display the sorting results. IV. To sort the modified vector (after processing in point I) in ascending and descending orders, applying the Shell Sort method and display the sorting results. V. After each manipulation, the results should be displayed as a conclusion (For example: If there are such elements, the program displays them (the element and its index, other data stipulated in the condition of the problem); there are no such elements – the program informs about their absence), etc.

Code of the program (having relevant comments in it):

1. Version with the use of the method of transmitting the function parameters by value:

```
      #include <stdio.h>


      //the function which checks whether there are duplicate elements or not
in the array

      int check(int A[], int n){

       int status = 1;

      for(int i=0; i<n-1;i++){

          int check=A[i];

          for(int j=i+1;j<n;j++){

              if (A[j] ==check){

                  status=0;

                  return status;

              }

          }

          }

          return status;
      }

      //the function which rearranges the elements of the array according to
the condition:

      //so that every second element is bigger than its neighbors

      void rearrange(int arr[], int n){

          int small[10], big[10], max,k,j,i, maxind;

          int maxelements=n/2; //calculates the number second-positions in the
array



          //this block of code finds the maximum element of the array

          j = 0;

          max = arr[0];

          for(int i=0;i<n;i++){

            if (arr[i]>max){

              max = arr[i];

              maxind=i;

            }

          }


          //here, in the array "big", the biggest elements of the array are
stored

          //the number of the biggest elements is equal to the maxelements
variable

          big[j]=max; //the first element of the "big" array is the maximum
element of the original array



          //the loop finds the other biggest elements and fills in the "big"
array

          for(j=1;j<maxelements;j++){

            i=0;

            max = arr[0];

            while(max>=big[j-1]){
               i++;
               max=arr[i];
            }
            for(int i=0;i<n;i++){
              if(arr[i]>max && arr[i]<big[j-1]){
                  max = arr[i];
                  maxind=i;
              }
            }
            big[j]=max;
          }



          int jbig=j; //jbig variable represents the number of elements of the
"big" array

          //here the "small" array is initialized, it contains all the other
elements of the
          //array, the ones smaller than the elements in the "big" array
          j=0;
          for(i=0;i<n;i++){
            if(arr[i]<big[jbig-1]){
              small[j]=arr[i];
              j++;
            }
          }
          int jsmall=j; //jsmall variable represents the number of elements of
the "small" array

      //finally, the array is updated: at every second position an element of
the "big" array is inserted
      j=0;
      for(i=1;i<n;i+=2){
        arr[i]=big[j];
        j++;}
```

```
       //at all the other positions left, an element of the "small" array is
inserted
       j=0;
       for(i=0;i<n;i+=2){
         arr[i]=small[j];
         j++;}

       }

       //function which prints the array
       void display(int a[], int n){
         for(int i=0;i<n;i++){
            printf("%d  ", a[i]);
         }
         printf("\n");
       }

       //function which swaps values
       void swap(int *a, int *b){
         int t=*a;
         *a=*b;
         *b=t;
       }

       //function essential for the quick sort method, it specifies the pivot is
at the end and
       //traverses the array, compares values with the pivot and makes necessary
swaps
       int partition(int arr[], int start, int end, int type){
        int pivot = arr[end];
        int i=start-1;
        int j,t;

        if (type==1){ //type = 1 so the sorting will be ascending
```

```
    for(j=start;j<end;j++){
    if(arr[j]<=pivot){
      i++;
      swap(arr+i, arr+j);
    }
   }
   swap(arr+end, arr+i+1);

  return i+1;
   }

   else{ //type = 0 so the sorting will be descending
    for(j=start;j<end;j++){
    if(arr[j]>=pivot){
      i++;
      swap(arr+i, arr+j);
    }
   }
   swap(arr+end, arr+i+1);

  return i+1;
   }



  }
```

//function essential for the quick sort method, partitions the array according to the pivot and

```
  //recursively calls the quicksort function until the array is fully sorted
  void quicksort(int arr[], int start, int end, int type){
     if(start<end){
       int pivot = partition(arr,start, end, type);
       quicksort(arr,start, pivot-1, type);
       quicksort(arr, pivot+1, end, type);
```

```
   }

}

//function which performs shellsort
void shellsort(int arr[], int n, int type){
  int t,i,j;
  for(int interval=n/2;interval>0;interval/=2){
    for( i=interval;i<n;i++){
      t = arr[i];
      if (type==1){ //type = 1 so the sorting will be ascending
        for(j=i;j>=interval && arr[j-interval]>t;j-=interval){
          arr[j]=arr[j-interval];
      }}
      else{ //type = 0 so the sorting will be descending
        for(j=i;j>=interval && arr[j-interval]<t;j-=interval){
          arr[j]=arr[j-interval];
      }
      }
       arr[j]=t;
      }

    }
  }


int main(){
//varianta 23
int A[50], n,i,j, status, copy[50];

status = 0;

//a loop which doesn't allow the user to proceed unless
//the array has distinct elements
```

```
    while(status==0){
       printf("Enter n:"); scanf("%d", &n); //reading the number of elements
of the vector
        for(i=0;i<n;i++){                   //reading the vector elements
           scanf("%d", &A[i]);
    }

       status = check(A,n); //here the condition which guides the iteration
is checked
        if (status == 1){
        printf("There are no duplicate elements.");
       }else{
        printf("There are duplicate elements. Read elements again.");
       }
    }


    for(i=0;i<n;i++){ //creating a copy of the original vector A
        printf("%d  ", A[i]);
        copy[i]=A[i];
    }
    printf("\n");

    //Task 1: the rearranging of the elements of the vector
    rearrange(copy,n);

    //Task 2: displaying the original array and the modified array
    printf("Original array:");
    display(A,n);

    printf("Modified array:");
    display(copy,n);

    //Task 3: sorting (both ascendingly and descendingly) using Quick Sort
and displaying the original vector
```

```
	printf("Ascending sorting of original vector (QuickSort):");
	int type = 1; //this variable indicates whether the sort will be ascending(1) or descending(0)
	quicksort(A,0,n-1, type);
	display(A,n);
	printf("\n");

	printf("Descending sorting of original vector (QuickSort):");
	type = 0; //indicates the descending sort
	quicksort(A,0,n-1, type);
	display(A,n);
	printf("\n");

	//Task 4: sorting (both ascendingly and descendingly) using Shell Sort and displaying the modified vector
	printf("Ascending sorting of modified vector (ShellSort):");
	type = 1;
	shellsort(copy,n, type);
	display(copy,n);
	printf("\n");

	printf("Descending sorting of modified vector (ShellSort):");
	type = 0;
	shellsort(copy,n, type);
	display(copy,n);
	printf("\n");




	return 0;
	}
```

2. Version with the use of the method of passing the function parameters by pointers.

```
    #include <stdio.h>


    //the function which checks whether there are duplicate elements or not
in the array
    int check(int *A, int n){
     int status = 1;
    for(int i=0; i<n-1;i++){
        int check=*(A+i);
        for(int j=i+1;j<n;j++){
            if (*(A+j) ==check){
                status=0;
                return status;
            }
        }
        }
        return status;


    }


    //the function which rearranges the elements of the array according to
the condition:
    //so that every second element is bigger than its neighbors
    void rearrange(int *arr, int n){
        int small[10], big[10], max,k,j,i, maxind;
        int maxelements=n/2; //calculates the number second-positions in the
array


        //this block of code finds the maximum element of the array
        j = 0;
        max = *(arr+0);
        for(int i=0;i<n;i++){
          if (*(arr+i)>max){
            max = *(arr+i);
            maxind=i;
          }
          }


          //here, in the array "big", the biggest elements of the array are
stored

          //the number of the biggest elements is equal to the maxelements
variable

          big[j]=max;  //the first element of the "big" array is the maximum
element of the original array


          //the loop finds the other biggest elements and fills in the "big"
array

          for(j=1;j<maxelements;j++){

            i=0;

            max = *(arr+0);

            while(max>=big[j-1]){

               i++;

               max=*(arr+i);

            }

            for(int i=0;i<n;i++){

              if(*(arr+i)>max && *(arr+i)<big[j-1]){

                  max = *(arr+i);

                  maxind=i;

              }

            }

            big[j]=max;

          }


          int jbig=j; //jbig variable represents the number of elements of the
"big" array


          //here the "small" array is initialized, it contains all the other
elements of the

          //array, the ones smaller than the elements in the "big" array

          j=0;

          for(i=0;i<n;i++){

            if(*(arr+i)<big[jbig-1]){
                small[j]=*(arr+i);
                j++;
              }
            }
            int jsmall=j; //jsmall variable represents the number of elements of
the "small" array

      //finally, the array is updated: at every second position an element of
the "big" array is inserted
      j=0;
      for(i=1;i<n;i+=2){
        *(arr+i)=big[j];
        j++;}

      //at all the other positions left, an element of the "small" array is
inserted
      j=0;
      for(i=0;i<n;i+=2){
        *(arr+i)=small[j];
        j++;}

      }

      //function which prints the array
      void display(int *a, int n){
        for(int i=0;i<n;i++){
           printf("%d  ", *(a+i));
        }
        printf("\n");
      }

      //function which swaps values
      void swap(int *a, int *b){
        int t=*a;
        *a=*b;
```

```
         *b=t;
       }

       //function essential for the quick sort method, it specifies the pivot is
at the end and
       //traverses the array, compares values with the pivot and makes necessary
swaps
       int partition(int *arr, int start, int end, int type){
        int pivot = *(arr+end);
        int i=start-1;
        int j,t;

        if (type==1){ //type = 1 so the sorting will be ascending
         for(j=start;j<end;j++){
         if(*(arr+j)<=pivot){
           i++;
           swap(arr+i, arr+j);
         }
        }
        swap(arr+end, arr+i+1);

       return i+1;
        }

        else{ //type = 0 so the sorting will be descending
         for(j=start;j<end;j++){
         if(*(arr+j)>=pivot){
           i++;
           swap(arr+i, arr+j);
         }
        }
        swap(arr+end, arr+i+1);

       return i+1;
        }
       }


       //function essential for the quick sort method, partitions the array
 according to the pivot and

       //recursively calls the quicksort function until the array is fully sorted

       void quicksort(int *arr, int start, int end, int type){

          if(start<end){

            int pivot = partition(arr,start, end, type);

            quicksort(arr,start, pivot-1, type);

            quicksort(arr, pivot+1, end, type);

          }


       }


       //function which performs shellsort

       void shellsort(int *arr, int n, int type){

         int t,i,j;

         for(int interval=n/2;interval>0;interval/=2){

           for( i=interval;i<n;i++){

             t = *(arr+i);

             if (type==1){

               for(j=i;j>=interval && *(arr+j-interval)>t;j-=interval){

                 *(arr+j)=*(arr+j-interval);

             }}

             else{

               for(j=i;j>=interval && *(arr+j-interval)<t;j-=interval){

                 *(arr+j)=*(arr+j-interval);

             }

             }

              *(arr+j)=t;

             }
           }
         }



       int main(){
       //varianta 23
       int A[50], n,i,j, status, copy[50];

       status = 0;

       //a loop which doesn't allow the user to proceed unless
       //the array has distinct elements
       while(status==0){
          printf("Enter n:"); scanf("%d", &n); //reading the number of elements
 of the vector
           for(i=0;i<n;i++){
              scanf("%d", A+i);        //reading the vector elements
       }

          status = check(A,n);  //here the condition which guides the iteration
 is checked
          if (status == 1){
           printf("There are no duplicate elements.");
          }else{
           printf("There are duplicate elements. Read elements again.");
          }
       }



       for(i=0;i<n;i++){    //creating a copy of the original vector A
           printf("%d  ", A[i]);
           copy[i]=A[i];
       }
       printf("\n");
```

```
	//Task 1: the rearranging of the elements of the vector
	rearrange(copy,n);

	//Task 2: displaying the original array and the modified array
	printf("Original array:");
	display(A,n);

	printf("Modified array:");
	display(copy,n);

	//Task 3: sorting (both ascendingly and descendingly) using Quick Sort
and displaying the original vector
	printf("Ascending sorting of original vector (QuickSort):");
	int type = 1; //this variable indicates whether the sort will be
ascending(1) or descending(0)
	quicksort(A,0,n-1, type);
	display(A,n);
	printf("\n");

	printf("Descending sorting of original vector (QuickSort):");
	type = 0; //indicates the descending sort
	quicksort(A,0,n-1, type);
	display(A,n);
	printf("\n");

	//Task 4: sorting (both ascendingly and descendingly) using Shell Sort
and displaying the modified vector
	printf("Ascending sorting of modified vector:");
	type = 1;
	shellsort(copy,n, type);
	display(copy,n);
	printf("\n");

	printf("Descending sorting of modified vector:");
	type = 0;
```

```
shellsort(copy,n, type);

display(copy,n);

printf("\n");




return 0;

}
```

3. Modified version

The condition for my new version was to check whether every 3 elements of the vector (the first, second and the third; the second, third and fourth, and so on) can represent lengths of a triangle. If the condition was met (if an element and its two neighbors can form a triangle), then the elements takes value 1 (and 0 if it is vice versa). Next I had to sort the original vector both ascendingly and descendingly, using Counting sort and then the results vector (both ascendingly and descendingly) using Merge Sort.

```
#include <stdio.h>

//function which checks whether all the elements of the vector are positive
int checkpositive(int arr[], int n){
    for(int i=0;i<n;i++){
        if(arr[i]<=0){
            return 0;
        }
    }
    return 1;
}

//function which checks the triangle inequality
int condition(int a, int b, int c){
    if (a+b>c && a+c>b && b+c>a){
        return 1;
    }
    else{
        return 0;
    }
}

//function which checks if every 3 consecutive elements of the vector can
represent lengths of a triangle
```

```
//the "condition" function is called here too
void checktriangles(int arr[],int results[], int n){
    for(int i=0;i<n;i++){
        if (i==0 || i==n-1){
            results[i]=0;
        } else if (condition(arr[i-1], arr[i], arr[i+1])==1){
            results[i]=1;
        }
        else{
            results[i]=0;
        }
    }
}

//function which prints the array
void display(int a[], int n){
  for(int i=0;i<n;i++){
     printf("%d  ", a[i]);
  }
  printf("\n");
}

//function which performs the counting sort of an array
void counting(int arr[], int n){
    int i,max,count[50], final[50];

    max=arr[0];
    for(i=0;i<n;i++){
        if(arr[i]>max){
            max=arr[i];
        }
    }

    for(i=0;i<max+1;i++){
        count[i]=0;
    }

    for(i=0;i<n;i++){
        count[arr[i]]++;
    }

    for(i=1;i<max+1;i++){
        count[i]+=count[i-1];
    }

    for(i=n-1;i>=0;i--){
       final[count[arr[i]]-1]=arr[i];
       count[arr[i]]--;
    }

    for(i=0;i<n;i++){
        arr[i] = final[i];
    }
}
```

```
	//function which recursively divides the initial array into smaller
subarrays so that it can be sorted using Merge Sort
	void dividemerge(int arr[], int a, int b, int type){
	    int m;
	    if (a<b){
	      m=(a+b)/2;
	      dividemerge(arr, a, m, type);
	      dividemerge(arr,m+1,b, type);
	      mergesort(arr, a,m,b, type);
	    }
	}

	//function essential for the Merge Sort
	void mergesort(int arr[], int a, int m, int b, int type){
	    int n1,n2,i,j,k;
	    n1=m-a+1;
	    n2=b-m;
	    int L[n1], R[n2];

	    for(i=0;i<n1;i++){
	        L[i]=arr[a+i];
	    }

	    for(j=0;j<n2;j++){
	        R[j]=arr[m+1+j];
	    }

	    i=0;j=0;k=a;
	    while(i<n1 && j<n2){
	        if(L[i]<R[j]){
	            if(type==1){
	                arr[k]=L[i];
	                i++;
	            }
	            else{
	               arr[k]=R[j];
	                j++;
	            }


	        }
	        else{
	             if(type==1){
	                arr[k]=R[j];
	                j++;
	            }
	            else{
	               arr[k]=L[i];
	                i++;
	            }
	        }
	        k++;
	    }
```

```
          while(i<n1){
              arr[k]=L[i];
              k++;
              i++;
          }

          while(j<n2){
              arr[k]=R[j];
              k++;
              j++;
          }


      }

      int main(){
      //varianta 23 - modified version
      int A[50], n,i,j, status, results[50];

      status = 0;

      //a loop which doesn't allow the user to proceed unless
      //the array has positive elements
      while(status==0){
         printf("\nEnter  n:");  scanf("%d",  &n);    //reading  the  number  of
elements of the vector
          for(i=0;i<n;i++){
             scanf("%d", &A[i]);       //reading the vector elements
             results[i]=A[i];          //creating a copy of the original vector
A
      }

         status = checkpositive(A,n);    //here the condition which guides the
iteration is checked
         if (status == 1){
          printf("There are only positive elements.");
         }else{
          printf("There are nonpositive elements. Read elements again.");
         }
      }

      //Task 1: the "checktriangles" function is called and the "results" array
is filled
      checktriangles(A, results,n);

      //Task 2: displaying the original array and the modified array
      printf("Original array:");
      display(A,n);

      printf("Modified array:");
      display(results,n);

      //Task 3: sorting the original vector using Counting Sort in an ascending
manner
```

```
        printf("Ascending sorting of original vector using counting sort:");
        counting(A,n);
        display(A,n);


        //Task 4: Sorting the modified vector using Merge Sort, both ascendingly
and descendingly
        int type=1;
        printf("Ascending sorting of modified vector using merge sort:");
        dividemerge(results,0,n-1, type);
        display(results,n);

        type=0;
        printf("Descending sorting of modified vector using merge sort:");
        dividemerge(results, 0,n-1,type);
        display(results, n);



        }
```

Block diagrams (for the second version):

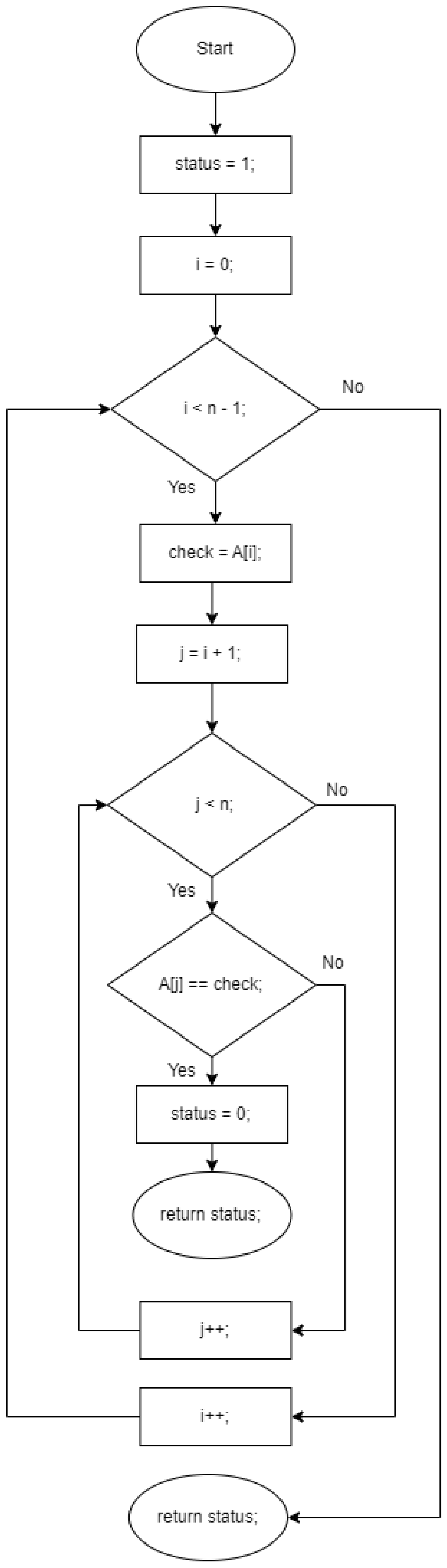


Figure 1.1 - *Function "check()"*

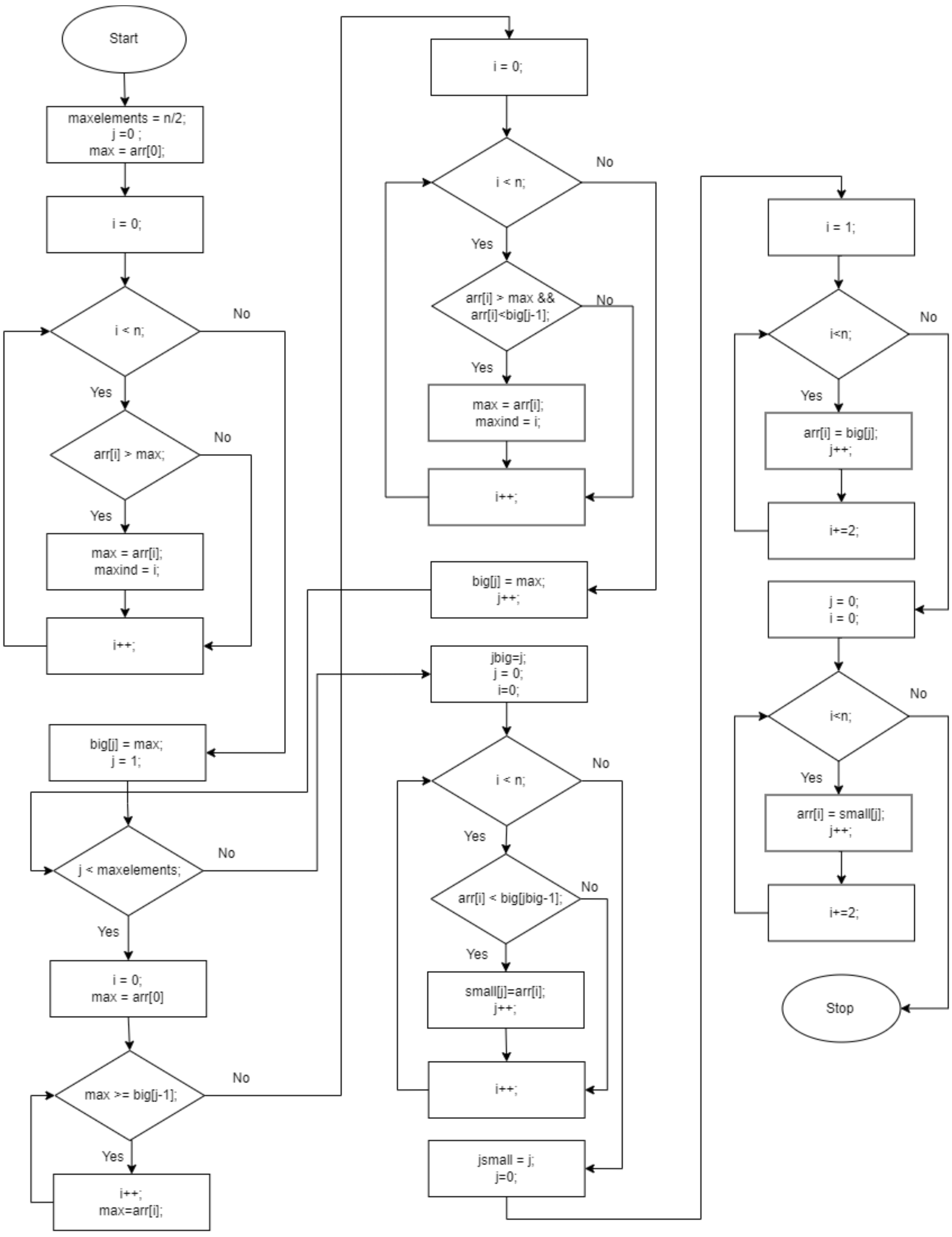


Figure 1.2 - *Function "rearrange()"*

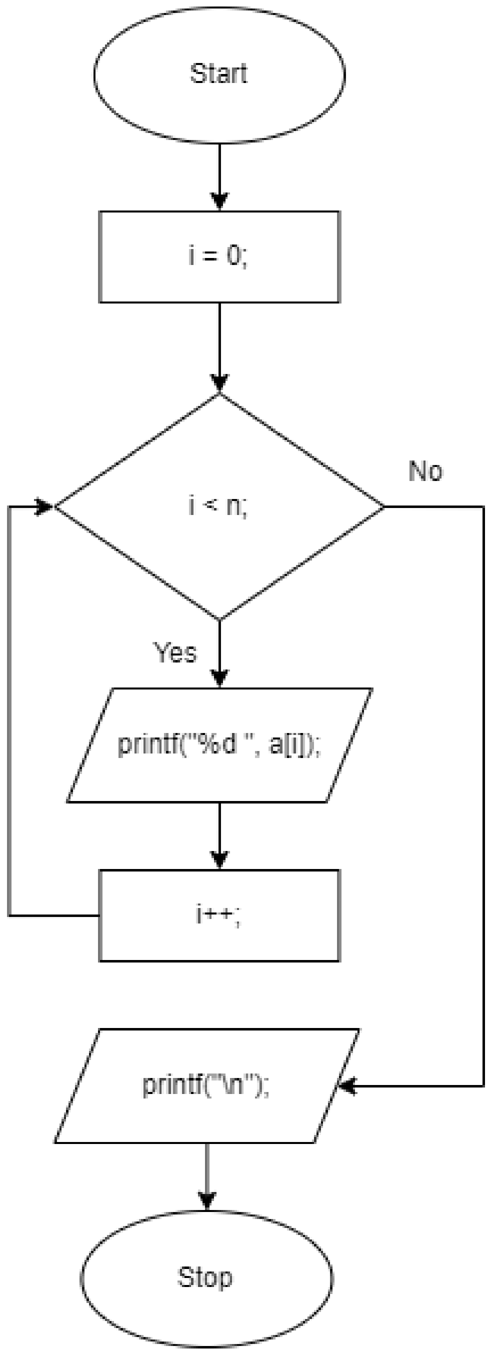


Figure 1.3 - *Function "display()"*

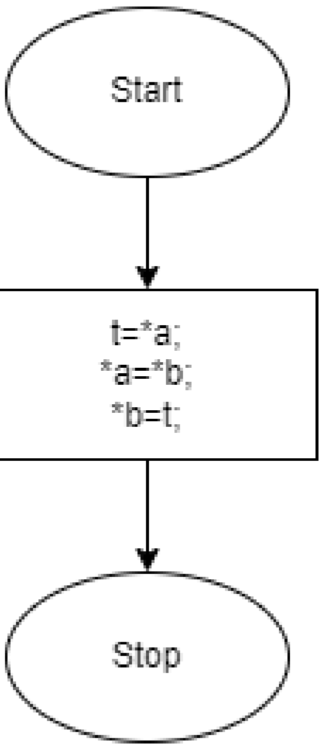


Figure 1.4 - *Function “swap()”*

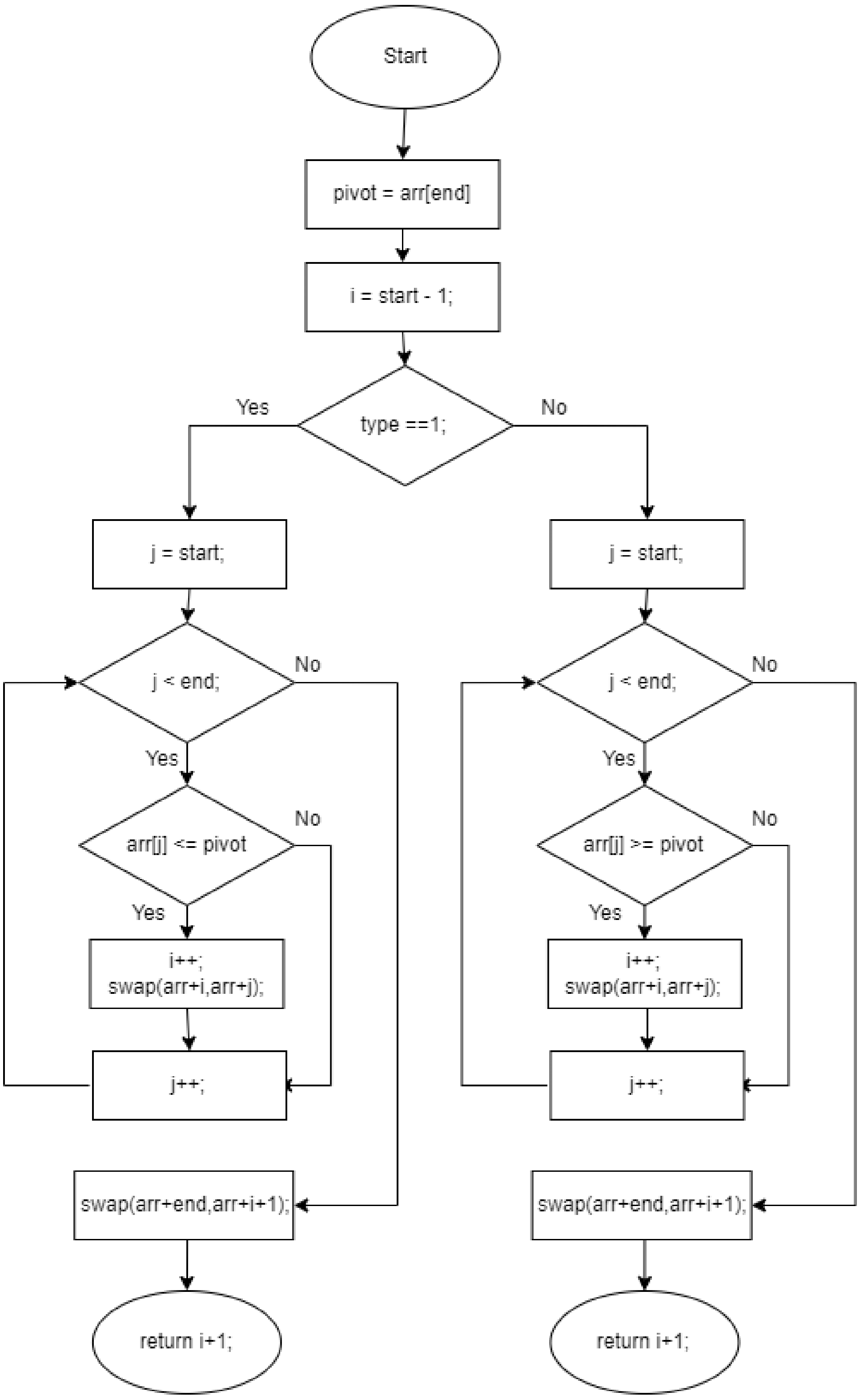


Figure 1.5 - *Function "partition()"*

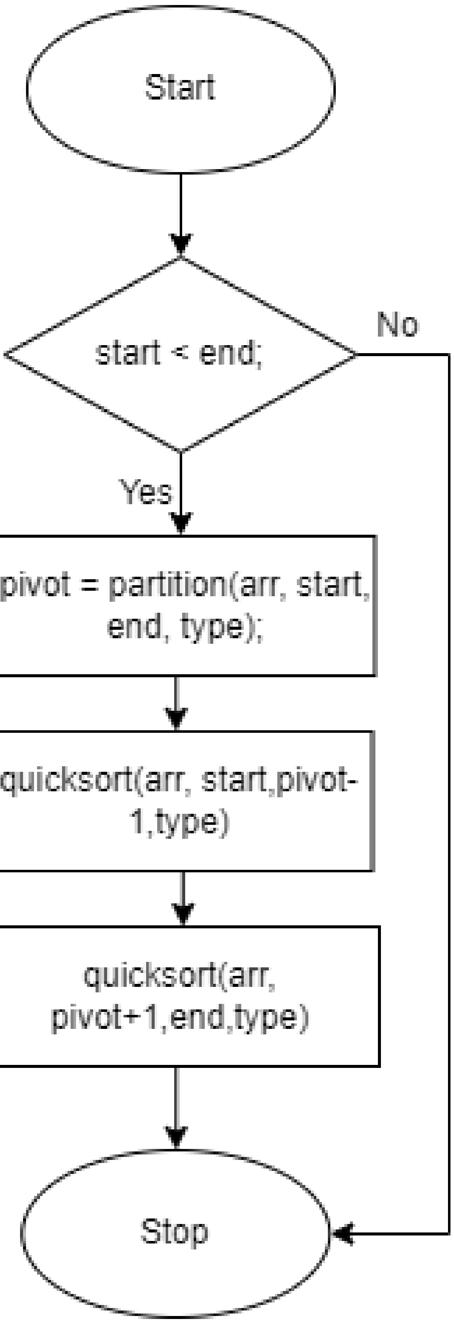
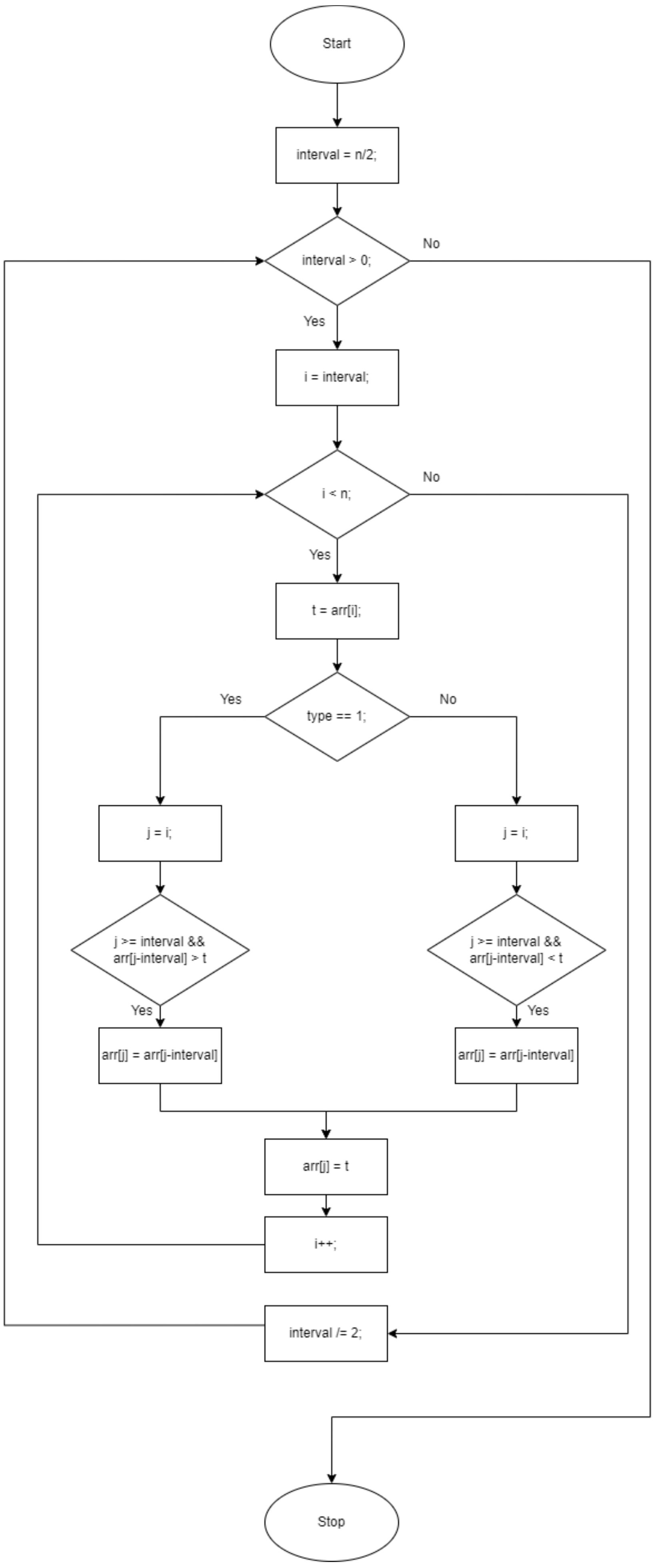

Start
start < end;
No
Yes
pivot = partition(arr, start, end, type);
quicksort(arr, start,pivot-1,type)
quicksort(arr, pivot+1,end,type)
Stop

Figure 1.6 - *Function "quicksort()"*



Start
interval = n/2;
interval > 0;
No
Yes
i = interval;
i < n;
No
Yes
t = arr[i];
type == 1;
Yes
No
j = i;
j = i;
j >= interval && arr[j-interval] > t
j >= interval && arr[j-interval] < t
Yes
Yes
arr[j] = arr[j-interval]
arr[j] = arr[j-interval]
arr[j] = t
i++;
interval /= 2;
Stop

Figure 1.7 - *Function "shellsort()"*

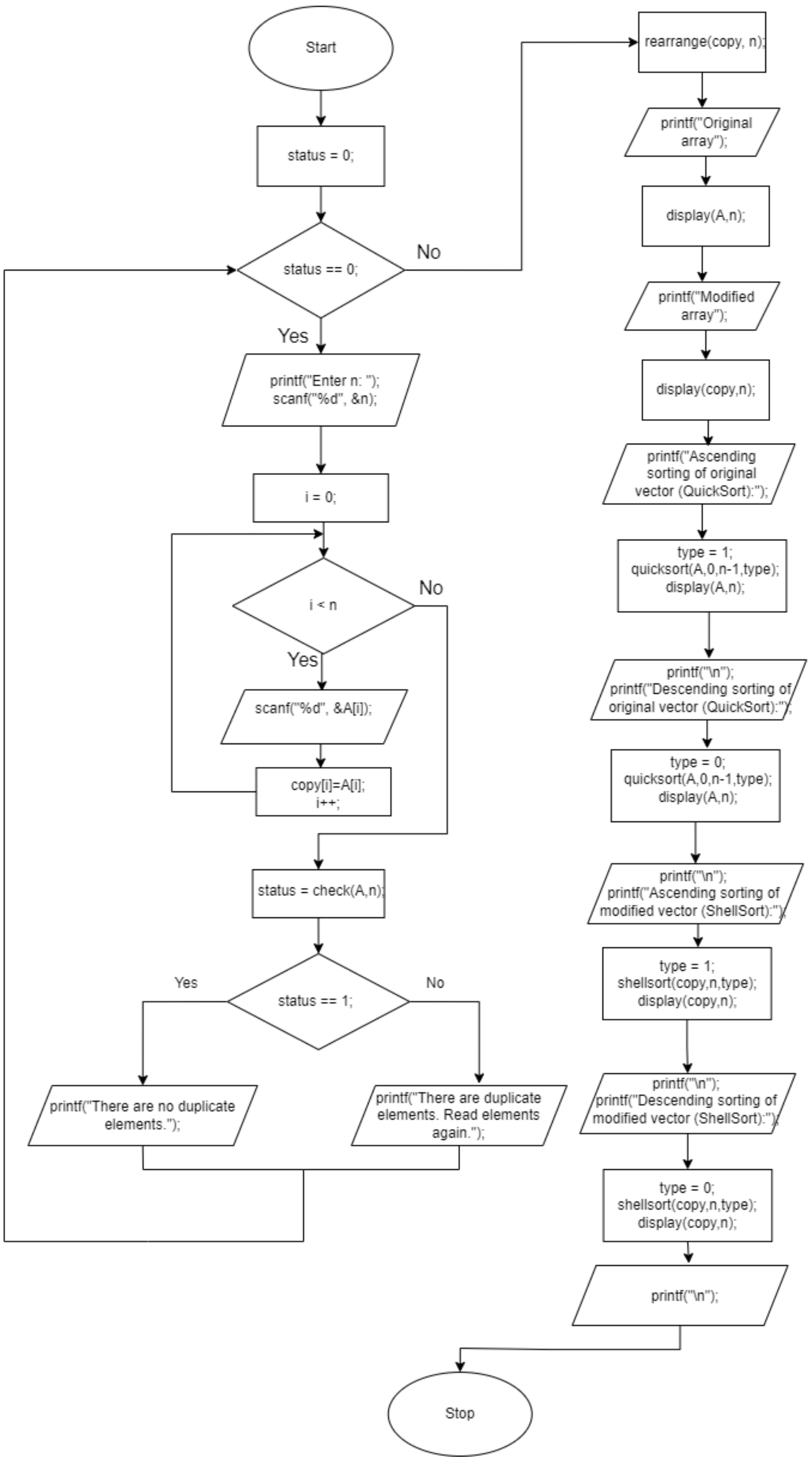


Figure 1.8 - *Function "main()"*

Block diagrams (for the second version):

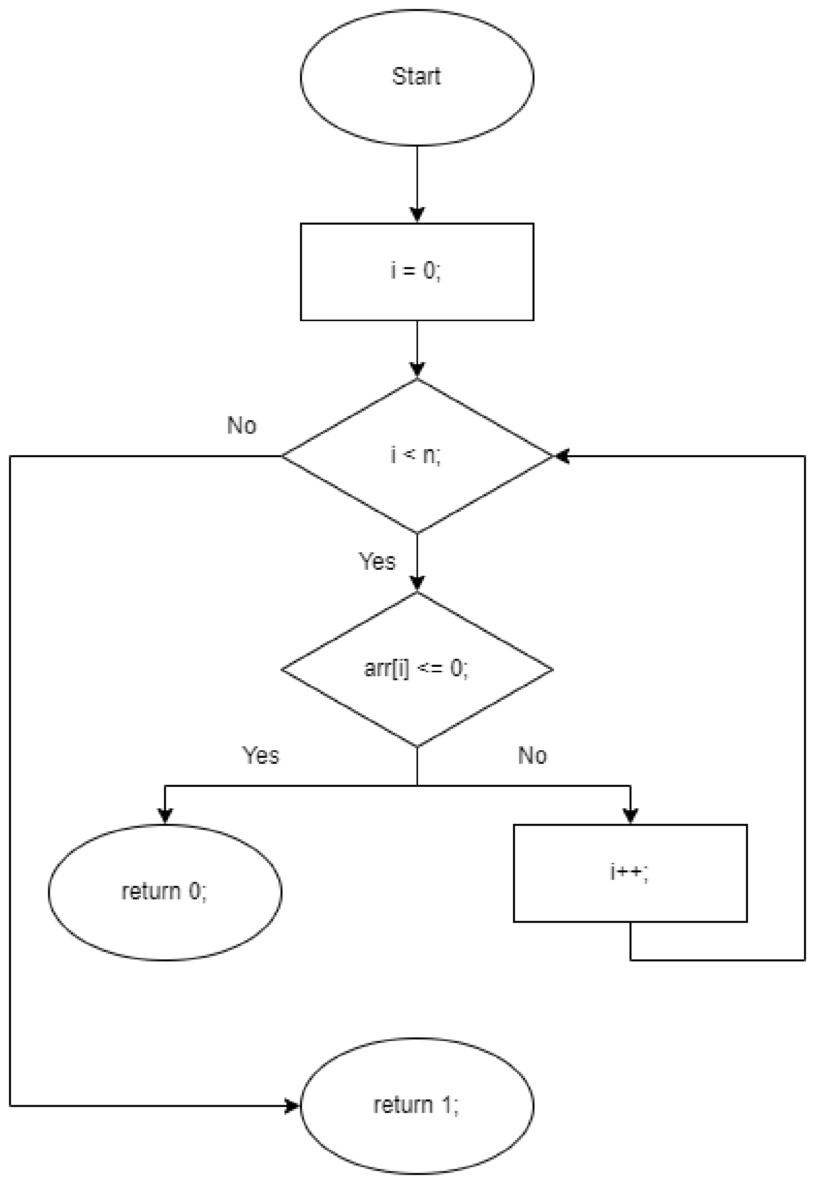


Figure 2.1 - *Function "checkpositive()"*

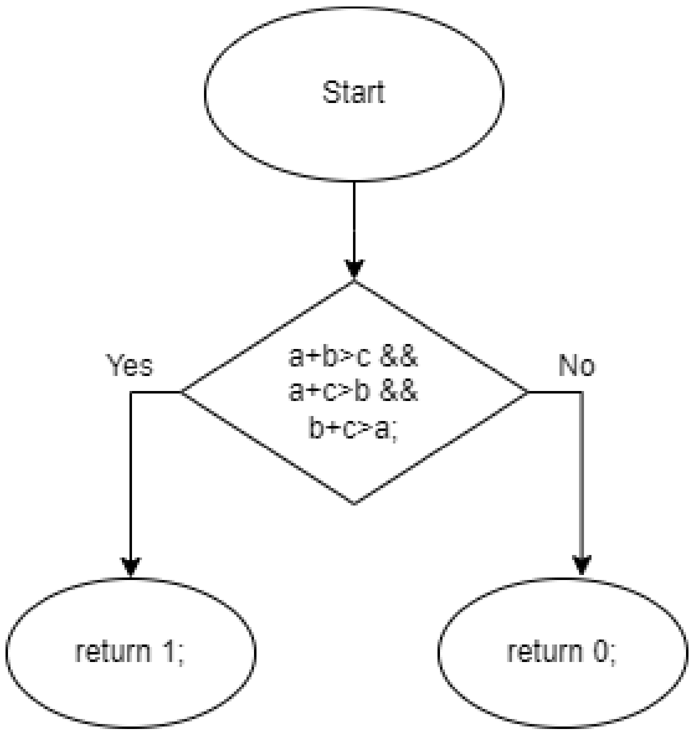


Figure 2.2 - *Function "condition()"*

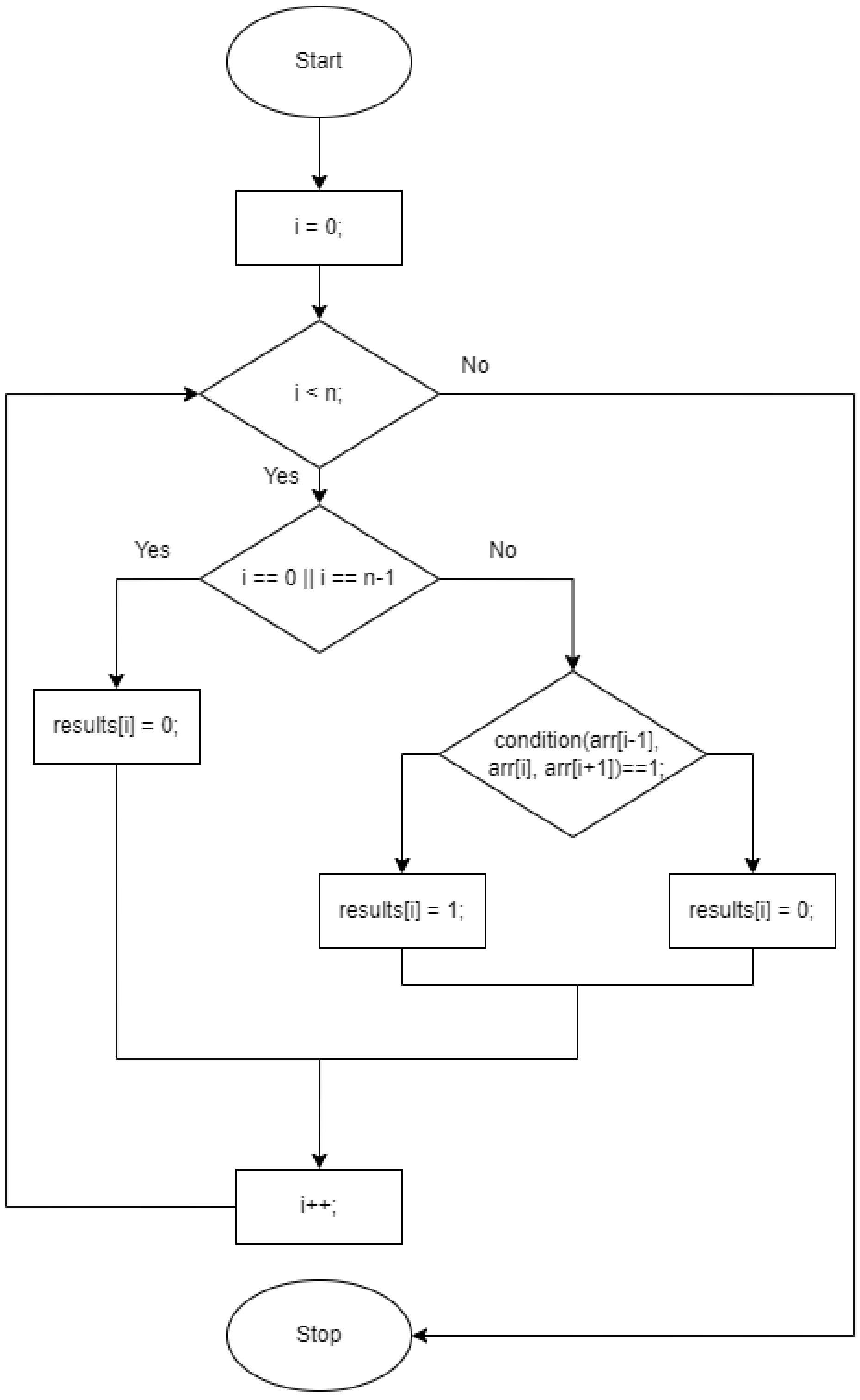


Figure 2.3 - *Function "checktriangles()"*

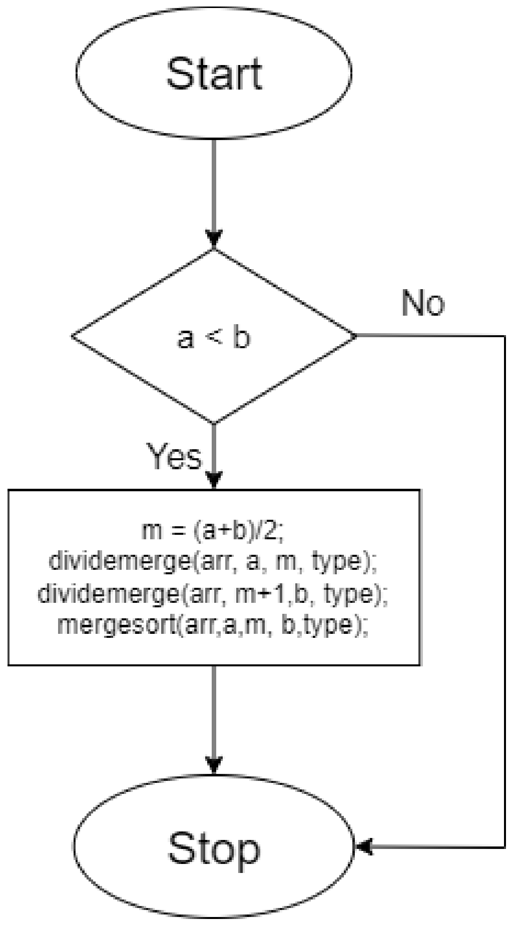

Start
a < b
No
Yes
m = (a+b)/2;
dividemerge(arr, a, m, type);
dividemerge(arr, m+1,b, type);
mergesort(arr,a,m, b,type);
Stop

Figure 2.4 - *Function "dividemerge()"*

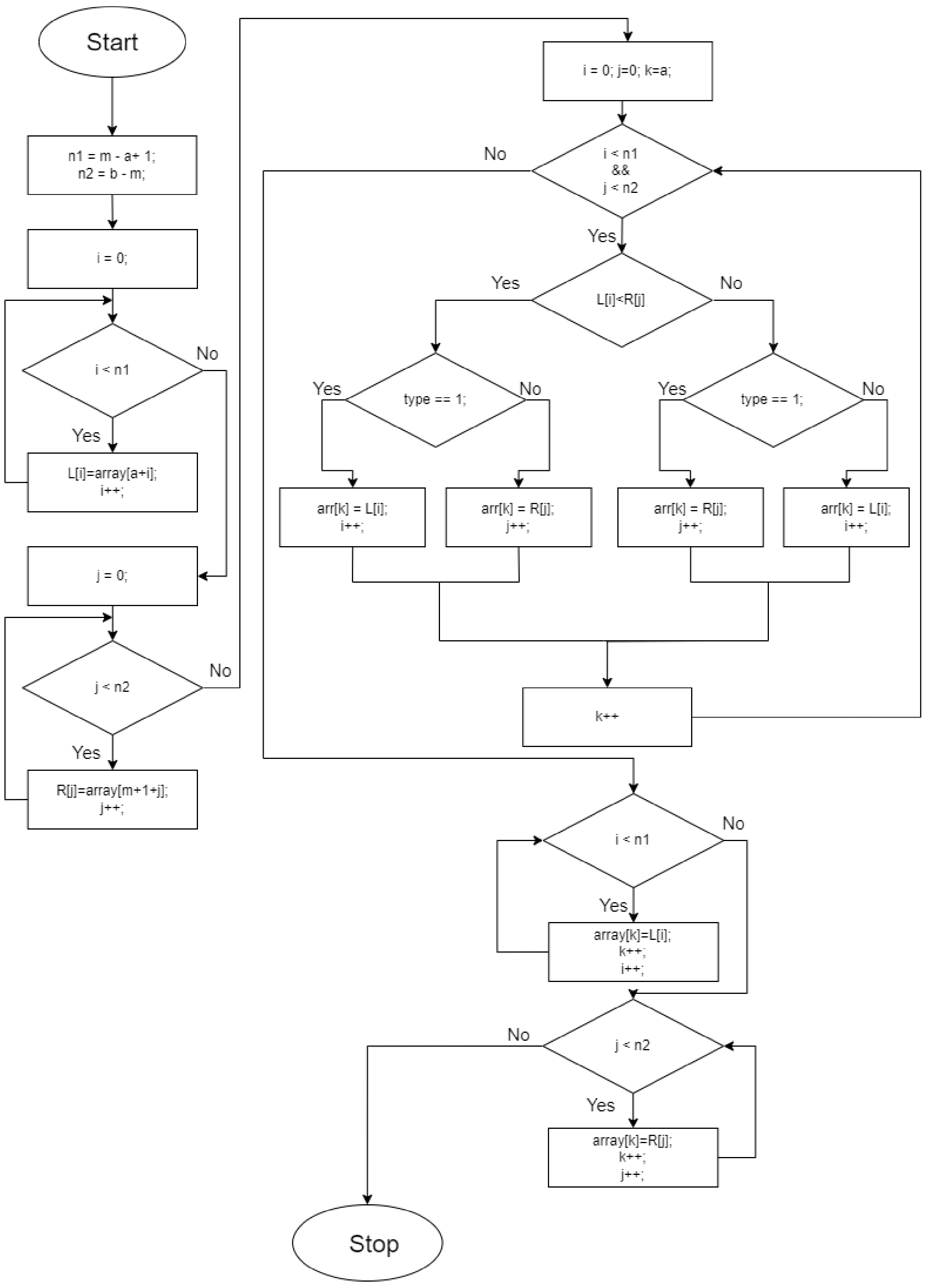


Figure 2.5 - *Function "mergesort()"*

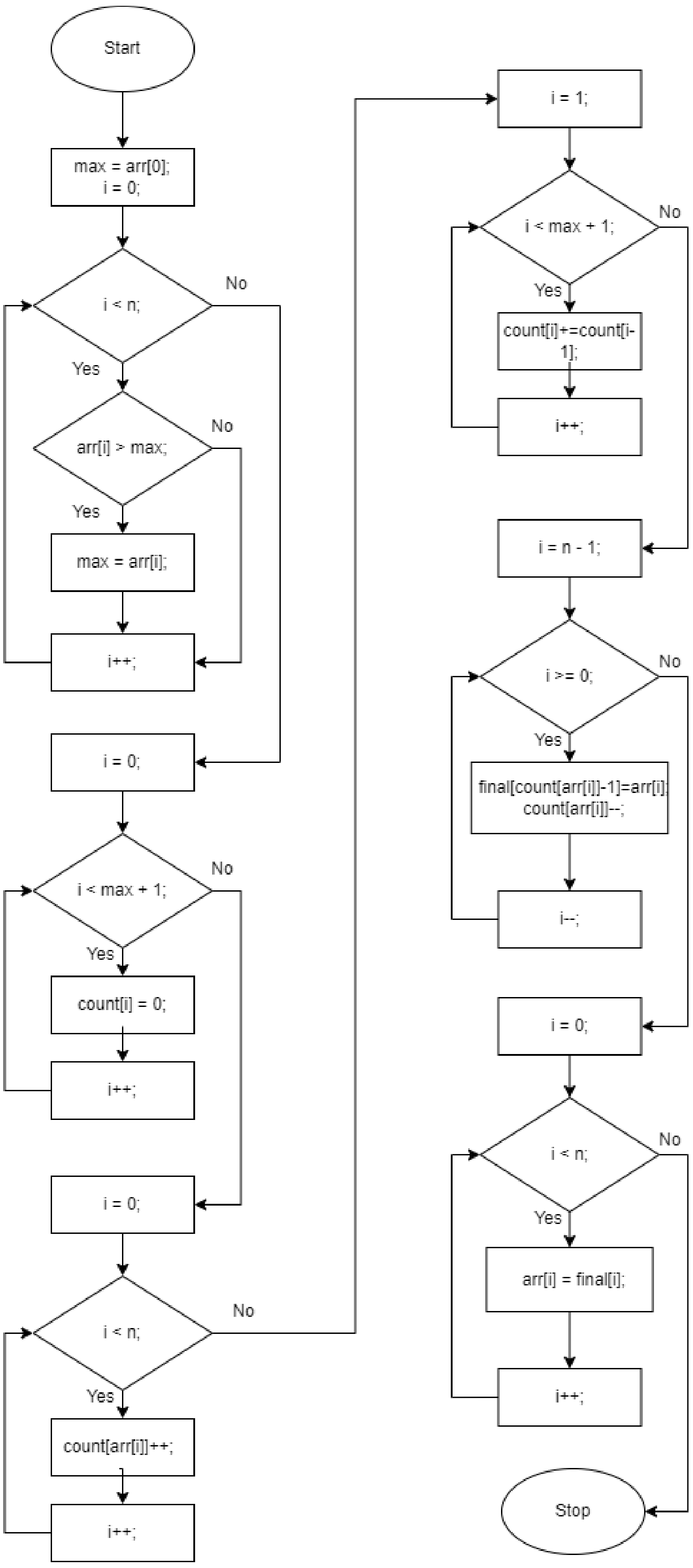
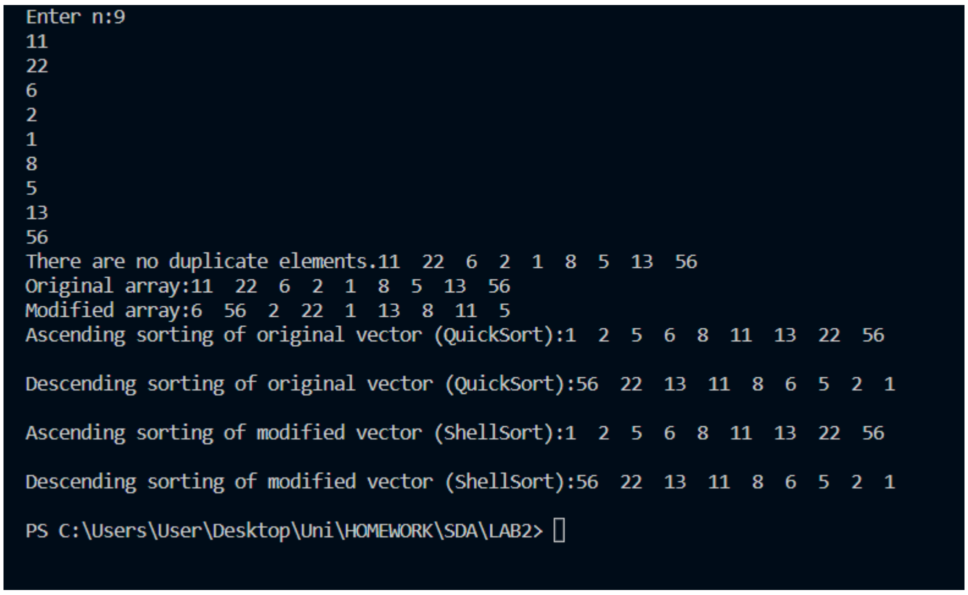


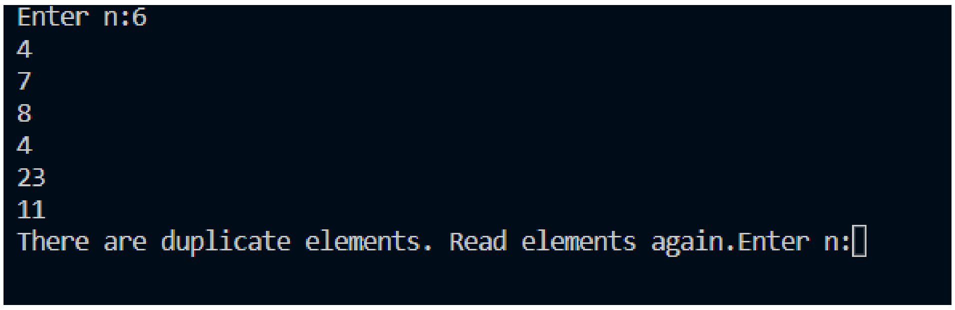
Figure 2.6 - *Function "counting()"*

Output (first version):



```
Enter n:9
11
22
6
2
1
8
5
13
56
There are no duplicate elements.11  22  6  2  1  8  5  13  56
Original array:11  22  6  2  1  8  5  13  56
Modified array:6  56  2  22  1  13  8  11  5
Ascending sorting of original vector (QuickSort):1  2  5  6  8  11  13  22  56

Descending sorting of original vector (QuickSort):56  22  13  11  8  6  5  2  1

Ascending sorting of modified vector (ShellSort):1  2  5  6  8  11  13  22  56

Descending sorting of modified vector (ShellSort):56  22  13  11  8  6  5  2  1

PS C:\Users\User\Desktop\Uni\HOMEWORK\SDA\LAB2> 
```

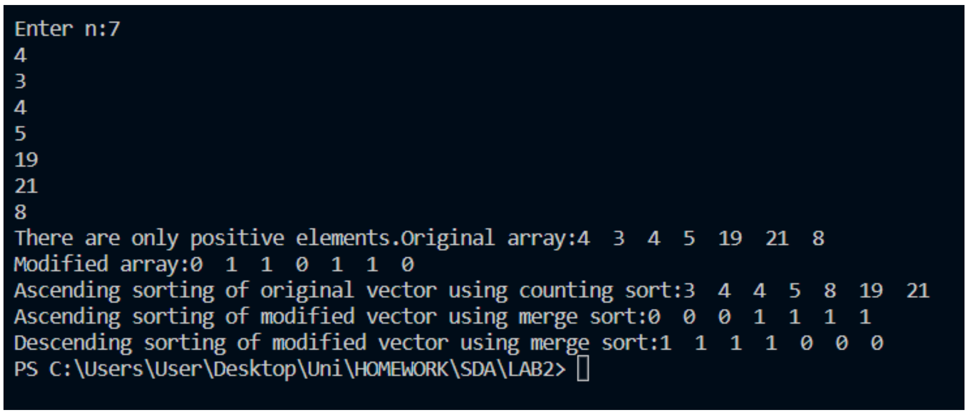
Figure 3.1 - *Output when all elements are distinct.*



```
Enter n:6
4
7
8
4
23
11
There are duplicate elements. Read elements again.Enter n:
```

Figure 3.2 - *Output when not all elements are distinct.*

Output (modified version):



```
Enter n:7
4
3
4
5
19
21
8
There are only positive elements.Original array:4  3  4  5  19  21  8
Modified array:0  1  1  0  1  1  0
Ascending sorting of original vector using counting sort:3  4  4  5  8  19  21
Ascending sorting of modified vector using merge sort:0  0  0  1  1  1  1
Descending sorting of modified vector using merge sort:1  1  1  1  0  0  0
PS C:\Users\User\Desktop\Uni\HOMEWORK\SDA\LAB2> 
```

Figure 3.3 - *Output.*

Conclusion:

In this laboratory work, I dealt with vectors and sorting algorithms. I had to rearrange a vector in a specific way and then use both Quick Sort and Shell Sort (ascendingly and descendingly). My modified version consisted of checking whether every 3 elements of the vector (the first, second and the third; the second, third and fourth, and so on) can represent lengths of a triangle. Then, I performed Counting sort and Merge Sort.

I managed to put to use the knowledge I gained during the lectures and the seminars and I was also provided with insights regarding efficiency of various sorting algorithms.

I took notice of how efficient all these algorithms are but, in spite of this, some are limited as the input size increases. So, I learned the importance of choosing sorting algorithms based on diverse scenarios and also learned to implement them both ascendingly and descendingly.