Operating Systems Exercise 6 THREADS

1. Generate Armstrong number generation within a range.
Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>


void *child(void *param){
   int temporary =*((int*) param);
   int num, originalNum, rem, result = 0;

   originalNum = temporary;
   num = temporary;
   while (originalNum != 0){
       // rem contains the last digit
       rem = originalNum % 10;
       result += rem * rem * rem;
       // removing last digit from the orignal number
       originalNum /= 10;
   }
   if (result == num)
   printf("%d \n", num);
   pthread_exit(NULL);
}

int main(){
   int start, end ;
   int range;
   printf("Enter the range : ");
   scanf("%d",&end);
   range = end + 1;
```

```
    pthread_t tid[range] ;
    for (int i = 0; i <= end; i++){
        pthread_create(&tid[i],NULL,child,&i);
        pthread_join(tid[i], NULL);
    }
    return 0;
}
```

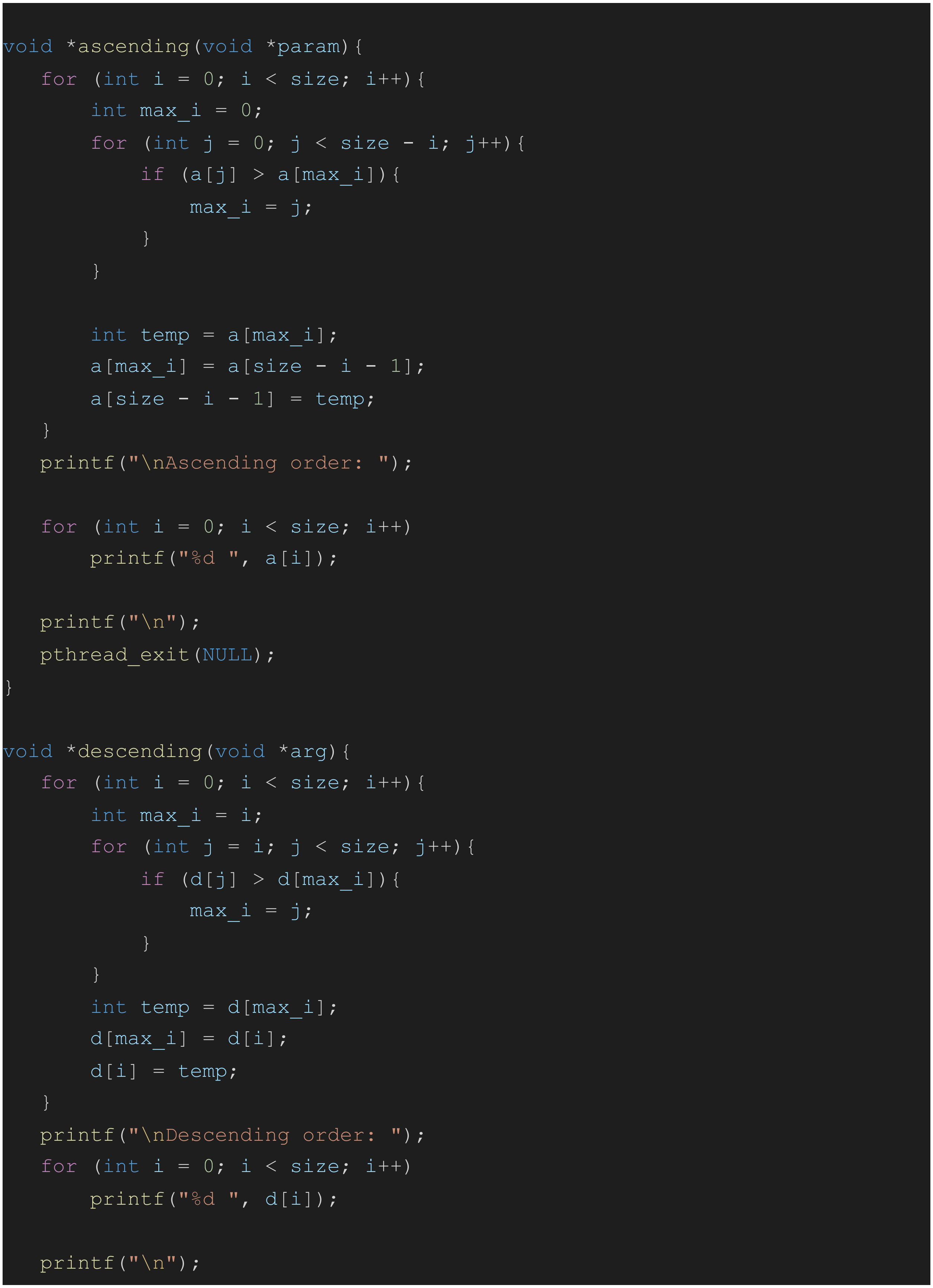
Output:

```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ gcc -o armStrongThreads Armstrong_threads.c -lpthread
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./armStrongThreads
Enter the range : 500
0
1
153
370
371
407
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

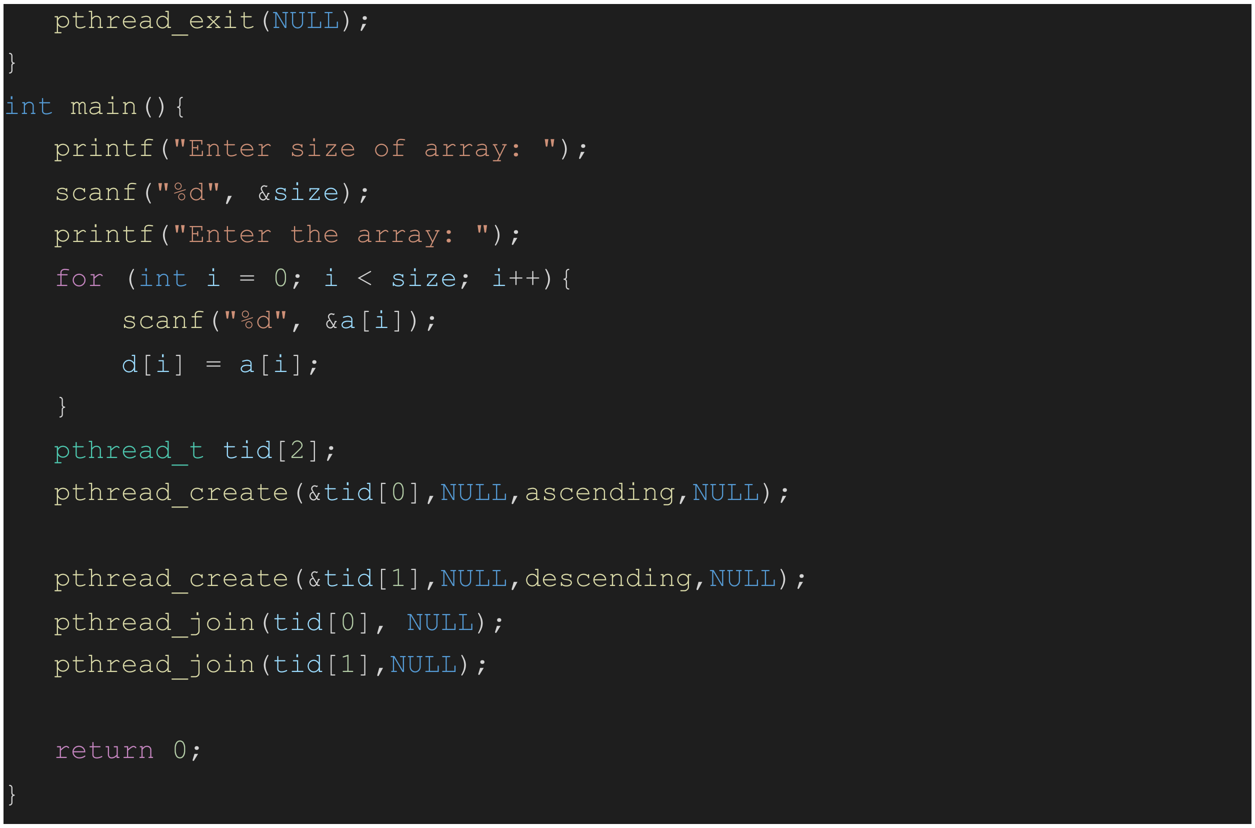
2. Ascending Order sort and Descending order sort.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>

#define MAX 100

int a[MAX],d[MAX];
int size;
```



```
void *ascending(void *param){
    for (int i = 0; i < size; i++){
        int max_i = 0;
        for (int j = 0; j < size - i; j++){
            if (a[j] > a[max_i]){
                max_i = j;
            }
        }

        int temp = a[max_i];
        a[max_i] = a[size - i - 1];
        a[size - i - 1] = temp;
    }
    printf("\nAscending order: ");

    for (int i = 0; i < size; i++)
        printf("%d ", a[i]);

    printf("\n");
    pthread_exit(NULL);
}

void *descending(void *arg){
    for (int i = 0; i < size; i++){
        int max_i = i;
        for (int j = i; j < size; j++){
            if (d[j] > d[max_i]){
                max_i = j;
            }
        }
        int temp = d[max_i];
        d[max_i] = d[i];
        d[i] = temp;
    }
    printf("\nDescending order: ");
    for (int i = 0; i < size; i++)
        printf("%d ", d[i]);

    printf("\n");
```



```
    pthread_exit(NULL);
}
int main(){
    printf("Enter size of array: ");
    scanf("%d", &size);
    printf("Enter the array: ");
    for (int i = 0; i < size; i++){
        scanf("%d", &a[i]);
        d[i] = a[i];
    }
    pthread_t tid[2];
    pthread_create(&tid[0],NULL,ascending,NULL);

    pthread_create(&tid[1],NULL,descending,NULL);
    pthread_join(tid[0], NULL);
    pthread_join(tid[1],NULL);

    return 0;
}
```

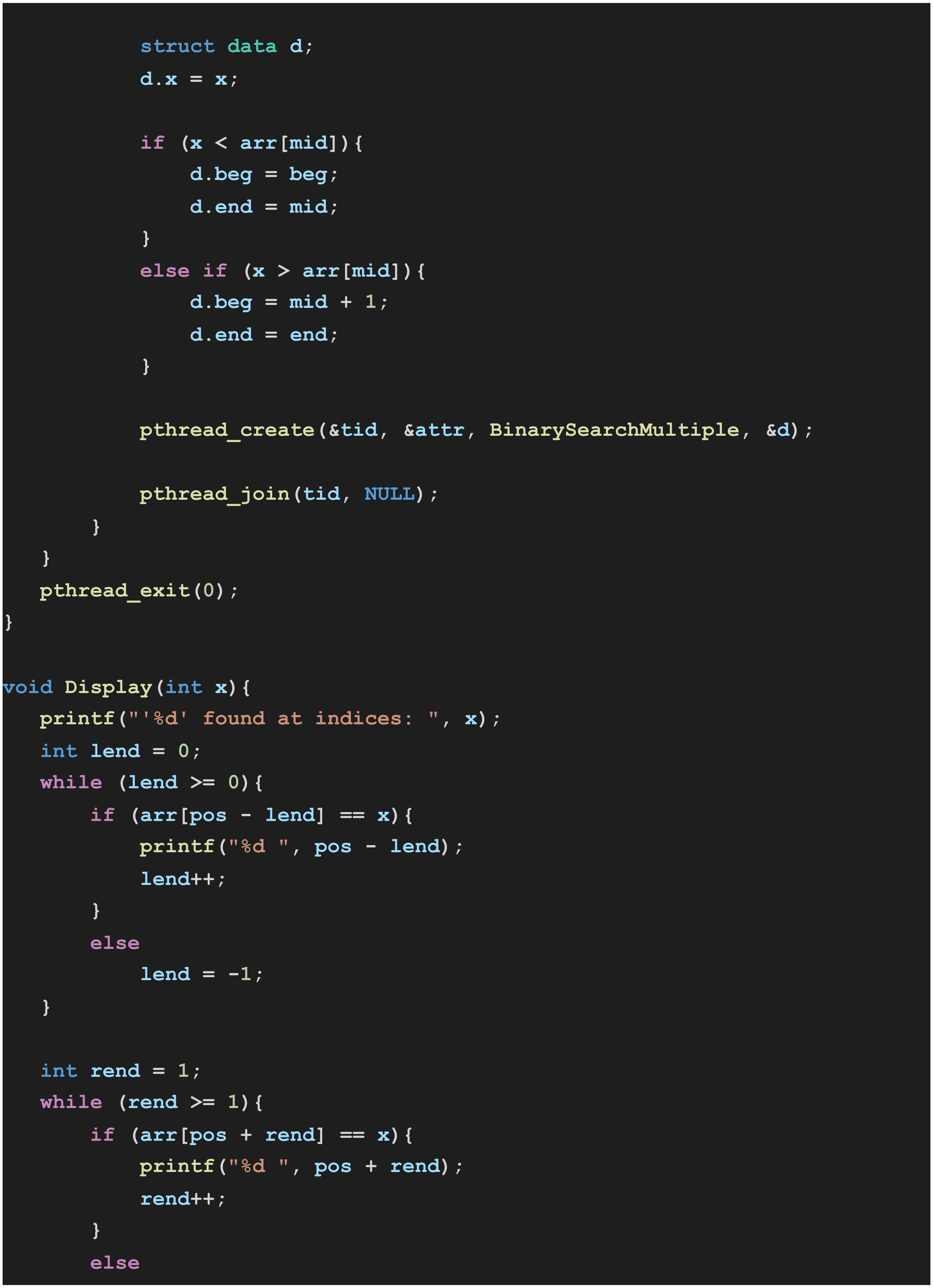
Output:

```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ gcc asc_desc_threads.c
-o ascDecThreads -lpthread
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./ascDecThreads
Enter size of array: 10
Enter the array: 4
5
6
3
9
8
7
2
3
1

Ascending order: 1 2 3 3 4 5 6 7 8 9

Descending order: 9 8 7 6 5 4 3 3 2 1
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

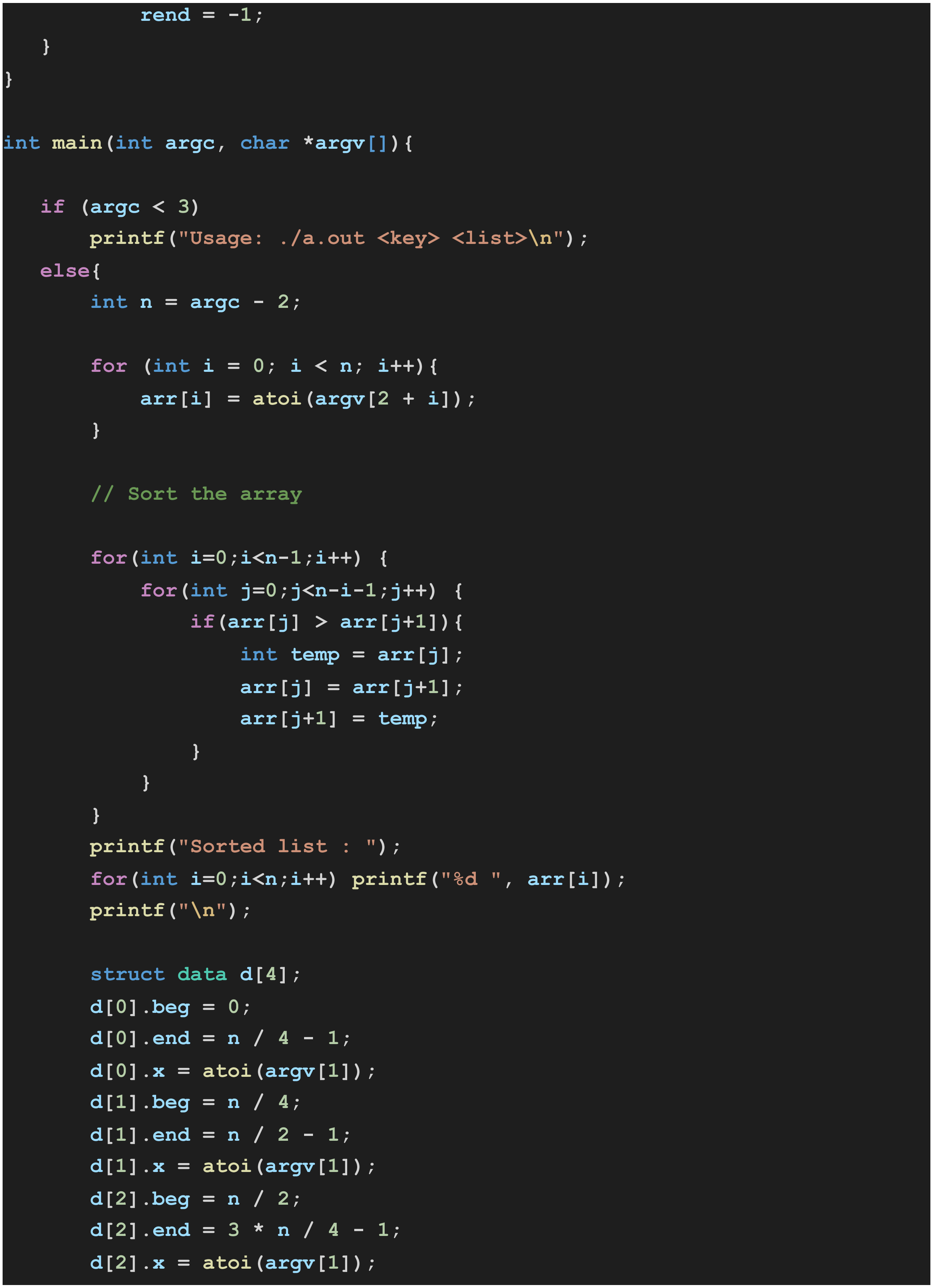
3. Implement a multithreaded version of binary search. By default, you can implement a search
for the first occurrence and later extend to support multiple occurrence (duplicated elements
search as well)

Code:

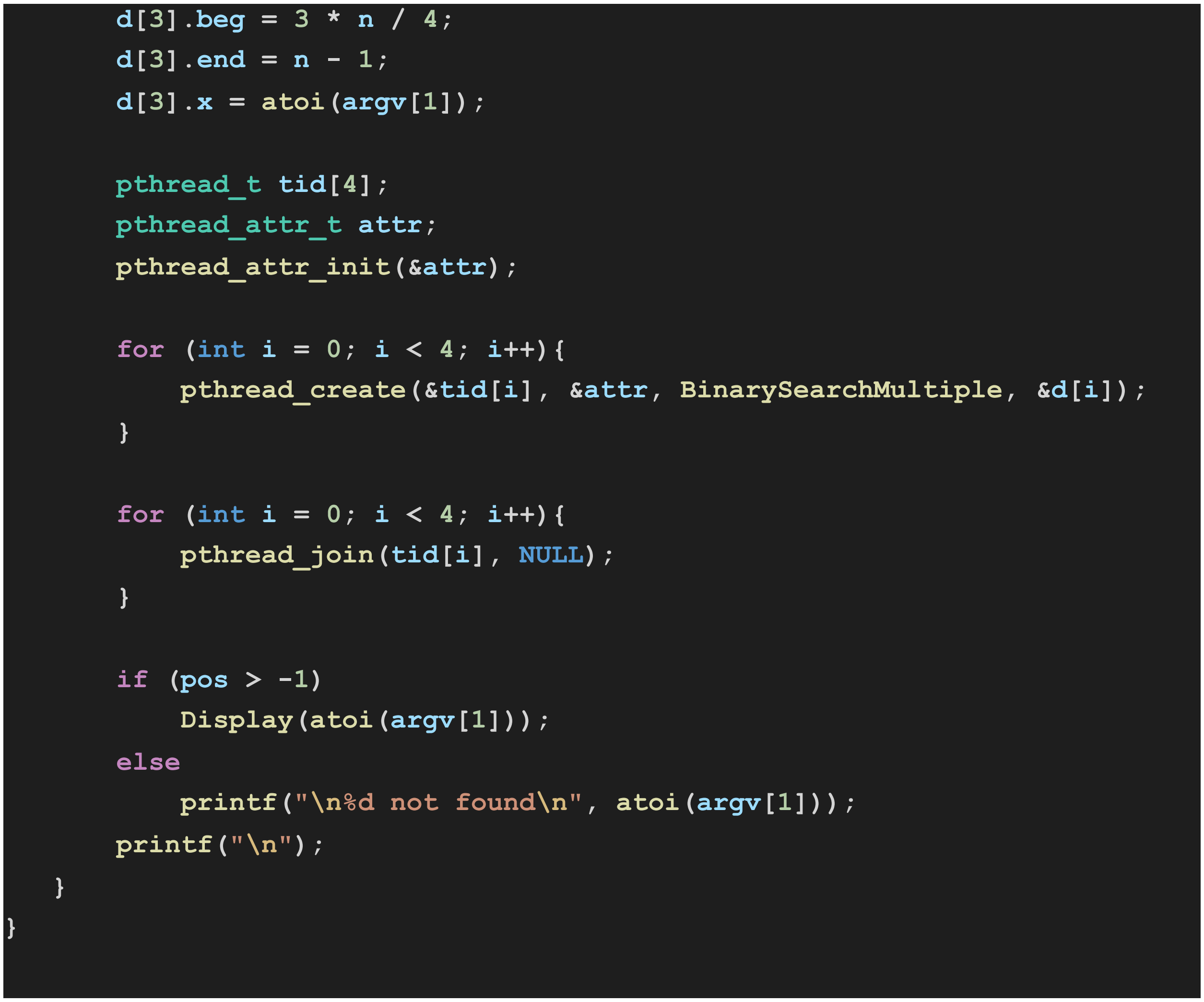
```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>

int arr[100];
int pos = -1;
struct data{
   int beg;
   int end;
   int x;
};
void *BinarySearchMultiple(void *d){
   struct data *dm = d;
   int beg = dm->beg;
   int end = dm->end;
   int x = dm->x;


   if (beg < end){
       int mid = (beg + end) / 2;

       if (arr[mid] == x){
           pos = mid;
       }
       else{
           pthread_t tid;
           pthread_attr_t attr;
           pthread_attr_init(&attr);
```



```
            struct data d;
            d.x = x;

            if (x < arr[mid]){
                d.beg = beg;
                d.end = mid;
            }
            else if (x > arr[mid]){
                d.beg = mid + 1;
                d.end = end;
            }

            pthread_create(&tid, &attr, BinarySearchMultiple, &d);

            pthread_join(tid, NULL);
        }
    }
    pthread_exit(0);
}

void Display(int x){
    printf("'%d' found at indices: ", x);
    int lend = 0;
    while (lend >= 0){
        if (arr[pos - lend] == x){
            printf("%d ", pos - lend);
            lend++;
        }
        else
            lend = -1;
    }

    int rend = 1;
    while (rend >= 1){
        if (arr[pos + rend] == x){
            printf("%d ", pos + rend);
            rend++;
        }
        else
```



```
            rend = -1;
    }
}

int main(int argc, char *argv[]){

    if (argc < 3)
        printf("Usage: ./a.out <key> <list>\n");
    else{
        int n = argc - 2;

        for (int i = 0; i < n; i++){
            arr[i] = atoi(argv[2 + i]);
        }

        // Sort the array

        for(int i=0;i<n-1;i++) {
            for(int j=0;j<n-i-1;j++) {
                if(arr[j] > arr[j+1]){
                    int temp = arr[j];
                    arr[j] = arr[j+1];
                    arr[j+1] = temp;
                }
            }
        }
        printf("Sorted list : ");
        for(int i=0;i<n;i++) printf("%d ", arr[i]);
        printf("\n");

        struct data d[4];
        d[0].beg = 0;
        d[0].end = n / 4 - 1;
        d[0].x = atoi(argv[1]);
        d[1].beg = n / 4;
        d[1].end = n / 2 - 1;
        d[1].x = atoi(argv[1]);
        d[2].beg = n / 2;
        d[2].end = 3 * n / 4 - 1;
        d[2].x = atoi(argv[1]);
```



```
        d[3].beg = 3 * n / 4;
        d[3].end = n - 1;
        d[3].x = atoi(argv[1]);

        pthread_t tid[4];
        pthread_attr_t attr;
        pthread_attr_init(&attr);

        for (int i = 0; i < 4; i++){
            pthread_create(&tid[i], &attr, BinarySearchMultiple, &d[i]);
        }

        for (int i = 0; i < 4; i++){
            pthread_join(tid[i], NULL);
        }

        if (pos > -1)
            Display(atoi(argv[1]));
        else
            printf("\n%d not found\n", atoi(argv[1]));
        printf("\n");
    }
}
```

Output:

```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./binarySearchThreaded
10 4 5 6 8 7 1 5 2 3 9
Sorted list : 1 2 3 4 5 5 6 7 8 9

10 not found

vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./binarySearchThreaded 1
4 5 6 8 7 1 5 2 3 1
Sorted list : 1 1 2 3 4 5 5 6 7 8
'1' found at indices: 0 1
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./binarySearchThreaded 5
1 2 3 4 5 6 7 8 9 4 5
Sorted list : 1 2 3 4 4 5 5 6 7 8 9
'5' found at indices: 6 5
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

4.Generation of Prime Numbers upto a limit supplied as Command Line Parameter.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>

void *primecheck(void *param ){
   int n = *((int *)param);
   int j,flag=1;
   if (n <= 1)
       flag = 0;
   else if (n == 2)
       flag = 1;
   else {
       for(j=2;j<=sqrt(n);j++){
           if(n%j == 0){
               flag=0;
               break;
           }
       }
   }
   if(flag == 1)
   printf("%d\n",n);
}

int main(int argc,const char *argv[]){
   if(argc!=2)
   printf("Usage: ./a.out num(limit of prime numbers to be generated)\n");
   else{
       int count = atoi(argv[1]);
       pthread_t tid[count*2];
       pthread_attr_t attr;
       pthread_attr_init(&attr);
       for (int i=1;i<=count;i++){
           pthread_create(&tid[i],&attr,primecheck,&i);
           pthread_join(tid[i],NULL);
       }
   }
   return 0;
}
```

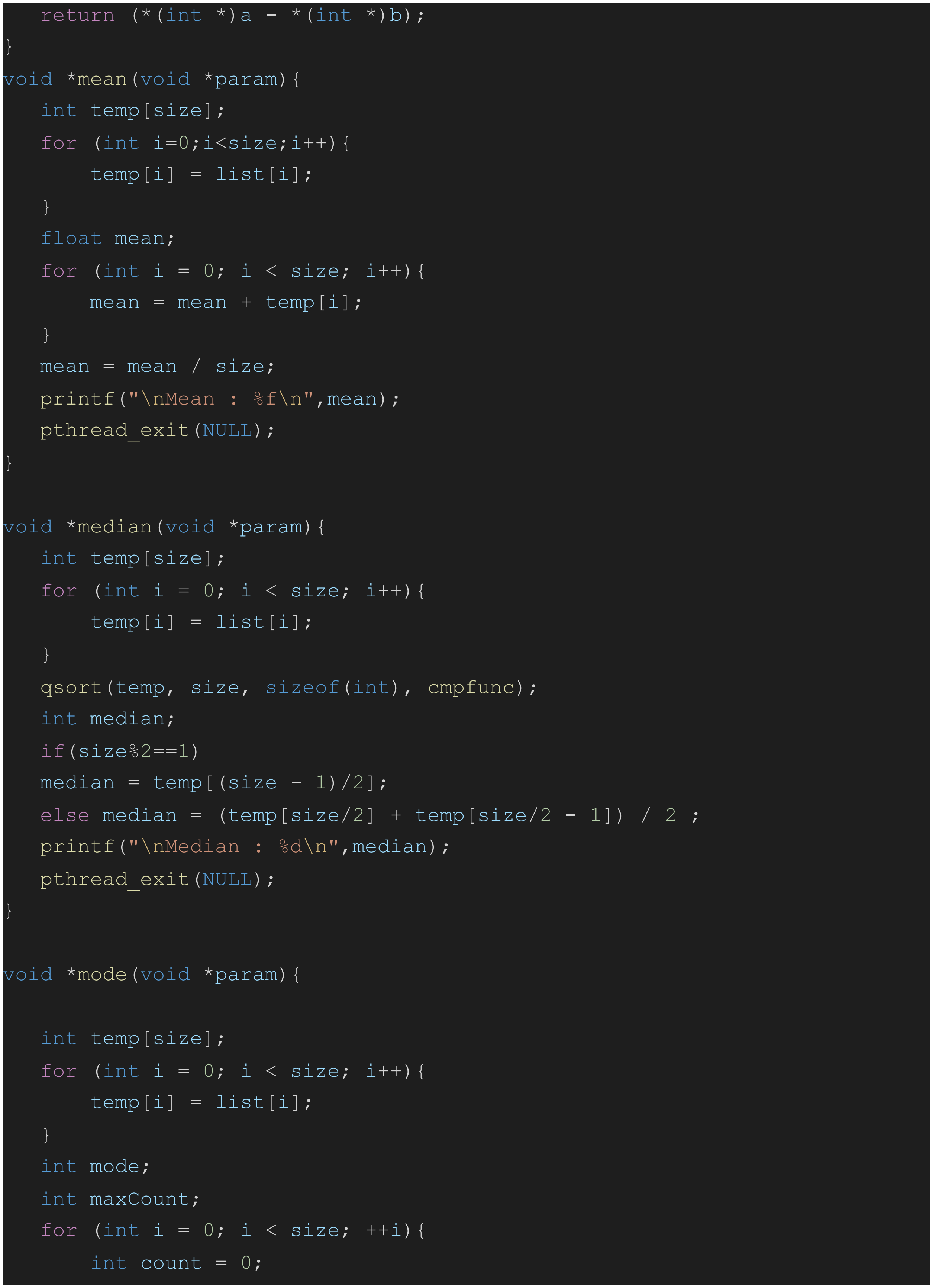
Output:

```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./prime 6
2
3
5
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./prime 25
2
3
5
7
11
13
17
19
23
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

5. Computation of Mean, Median, Mode for an array of integers.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>
#define MAX 100
int list[MAX];
int size;
int cmpfunc(const void *a, const void *b){
```



```
    return (*(int *)a - *(int *)b);
}
void *mean(void *param){
    int temp[size];
    for (int i=0;i<size;i++){
        temp[i] = list[i];
    }
    float mean;
    for (int i = 0; i < size; i++){
        mean = mean + temp[i];
    }
    mean = mean / size;
    printf("\nMean : %f\n",mean);
    pthread_exit(NULL);
}

void *median(void *param){
    int temp[size];
    for (int i = 0; i < size; i++){
        temp[i] = list[i];
    }
    qsort(temp, size, sizeof(int), cmpfunc);
    int median;
    if(size%2==1)
    median = temp[(size - 1)/2];
    else median = (temp[size/2] + temp[size/2 - 1]) / 2 ;
    printf("\nMedian : %d\n",median);
    pthread_exit(NULL);
}

void *mode(void *param){

    int temp[size];
    for (int i = 0; i < size; i++){
        temp[i] = list[i];
    }
    int mode;
    int maxCount;
    for (int i = 0; i < size; ++i){
        int count = 0;
        for (int j = 0; j < size; ++j){
            if (temp[j] == temp[i])
                ++count;
        }

        if (count > mode){
            maxCount = count;
            mode = temp[i];
        }
    }
    printf("\nMode : %d\n",mode);
    pthread_exit(NULL);
}

int main(int argc, char const *argv[]){
    if(argc<2)
    printf("Usage: ./a.out <list of numbers>\n");
    size = argc - 1;
    for (int i = 0; i < size; i++){
        list[i] = atoi(argv[i+1]);
    }
    pthread_t tid[3];
    pthread_attr_t attr;
    pthread_attr_init (&attr);

    pthread_create(&tid[0],&attr,mean,NULL);
    pthread_create(&tid[1], &attr, median, NULL);
    pthread_create(&tid[2], &attr, mode, NULL);
    pthread_join(tid[0], NULL);
    pthread_join(tid[1], NULL);
    pthread_join(tid[2], NULL);
    return 0;
}
```

Output:

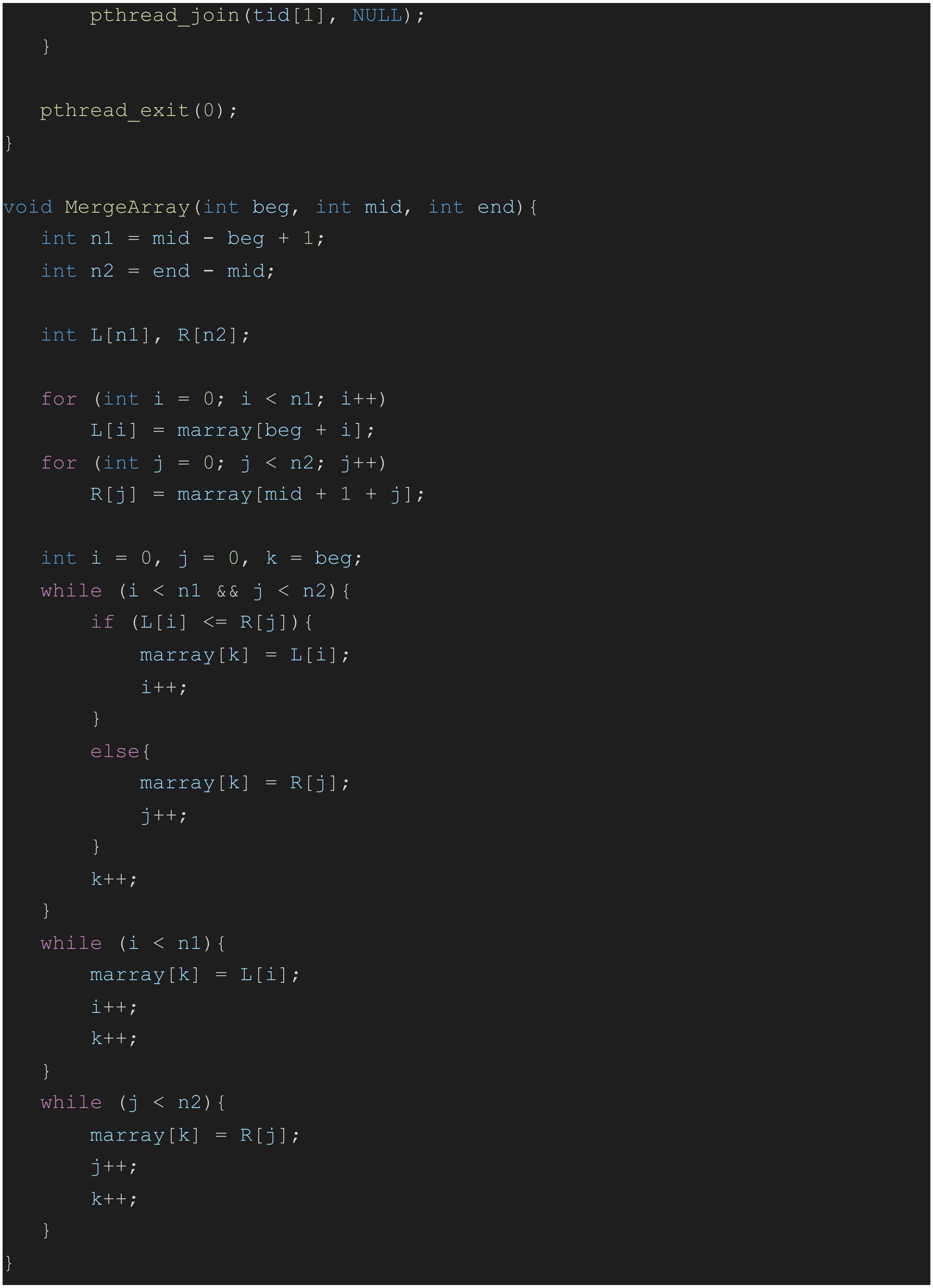
```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./meanMedianMode 1 2 3
4 5 6 7 8 9
```

```
Mean : 5.000000

Median : 5

Mode : 1
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

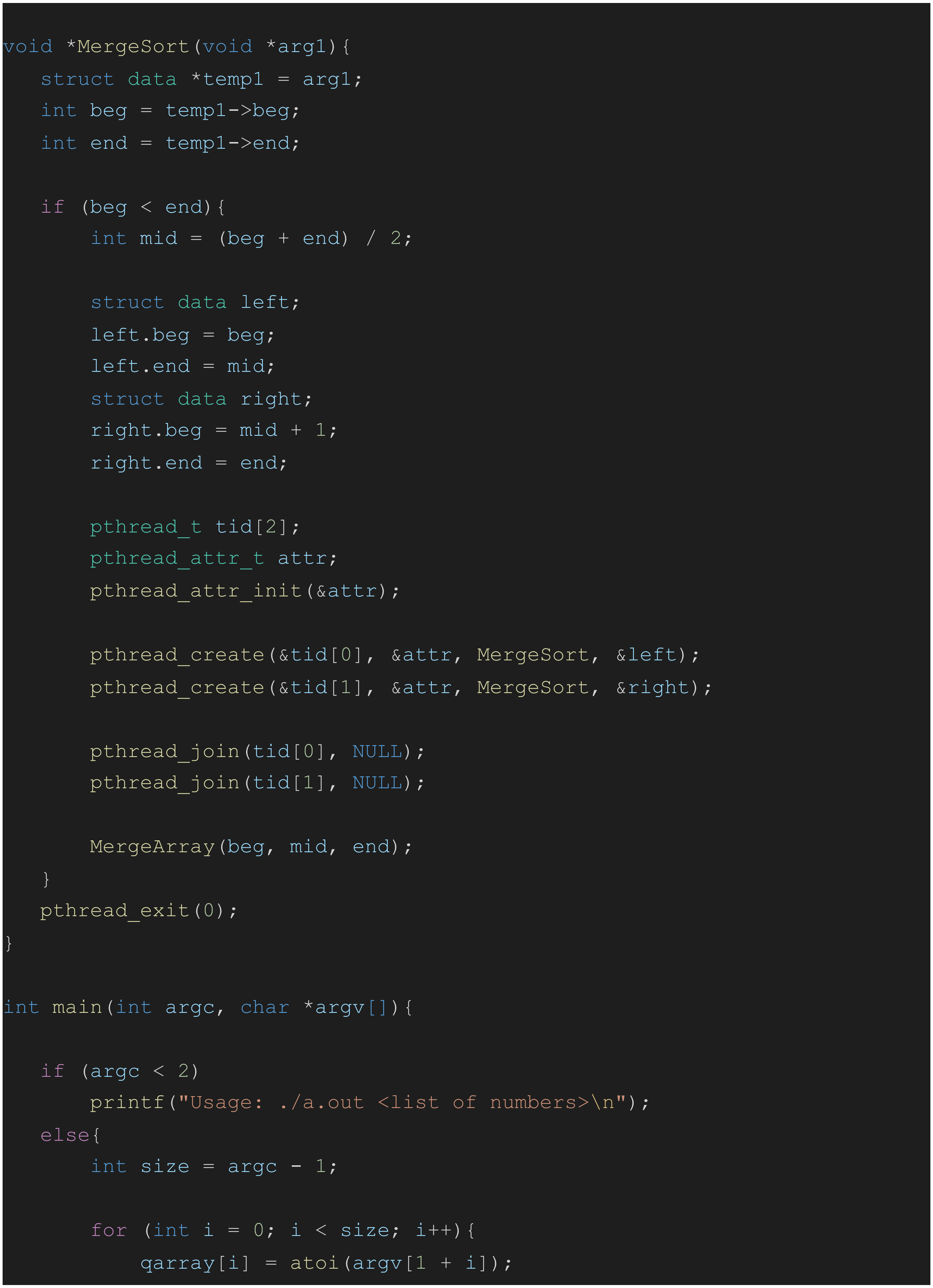
6. Implement Merge Sort and Quick Sort in a multithreaded fashion.
Code:

```c
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>
#define MAX 100
int qarray[MAX];
int marray[MAX];

struct data {
   int beg;
   int end;
};

int Partition(int beg, int end){
   int i = beg, j = end;
   int p;
   p = beg;

   int val = p;
   while (i < j){
       while (qarray[p] >= qarray[i] && i < end){
           i++;
       }
       while (qarray[p] < qarray[j] && j > beg){
           if (j == p + 1 && i <= p)
               j = p - 1;
```

```
            //if(j!=beg)j--;
            else
                j--;
        }
        if (i < j){
            int temp = qarray[i];
            qarray[i] = qarray[j];
            qarray[j] = temp;
        }
    }
    int temp = qarray[p];
    qarray[p] = qarray[j];
    qarray[j] = temp;
    val = j;
    return val;
}

void *QuickSort(void *arg){
    struct data *temp = arg;
    int beg = temp->beg;
    int end = temp->end;

    if (beg < end){
        int j = Partition(beg, end);

        struct data left;
        left.beg = beg;
        left.end = j - 1;
        struct data right;
        right.beg = j + 1;
        right.end = end;

        pthread_t tid[2];
        pthread_attr_t attr;
        pthread_attr_init(&attr);

        pthread_create(&tid[0], &attr, QuickSort, &left);
        pthread_create(&tid[1], &attr, QuickSort, &right);

        pthread_join(tid[0], NULL);
```



```
        pthread_join(tid[1], NULL);
    }

    pthread_exit(0);
}

void MergeArray(int beg, int mid, int end){
    int n1 = mid - beg + 1;
    int n2 = end - mid;

    int L[n1], R[n2];

    for (int i = 0; i < n1; i++)
        L[i] = marray[beg + i];
    for (int j = 0; j < n2; j++)
        R[j] = marray[mid + 1 + j];

    int i = 0, j = 0, k = beg;
    while (i < n1 && j < n2){
        if (L[i] <= R[j]){
            marray[k] = L[i];
            i++;
        }
        else{
            marray[k] = R[j];
            j++;
        }
        k++;
    }
    while (i < n1){
        marray[k] = L[i];
        i++;
        k++;
    }
    while (j < n2){
        marray[k] = R[j];
        j++;
        k++;
    }
}
```



```
void *MergeSort(void *arg1){
   struct data *temp1 = arg1;
   int beg = temp1->beg;
   int end = temp1->end;

   if (beg < end){
       int mid = (beg + end) / 2;

       struct data left;
       left.beg = beg;
       left.end = mid;
       struct data right;
       right.beg = mid + 1;
       right.end = end;

       pthread_t tid[2];
       pthread_attr_t attr;
       pthread_attr_init(&attr);

       pthread_create(&tid[0], &attr, MergeSort, &left);
       pthread_create(&tid[1], &attr, MergeSort, &right);

       pthread_join(tid[0], NULL);
       pthread_join(tid[1], NULL);

       MergeArray(beg, mid, end);
   }
   pthread_exit(0);
}

int main(int argc, char *argv[]){

   if (argc < 2)
       printf("Usage: ./a.out <list of numbers>\n");
   else{
       int size = argc - 1;

       for (int i = 0; i < size; i++){
           qarray[i] = atoi(argv[1 + i]);
```

```
            marray[i] = atoi(argv[1 + i]);
        }

        struct data param;
        param.beg = 0;
        param.end = size - 1;

        pthread_t tid[2];
        pthread_attr_t attr;
        pthread_attr_init(&attr);

        pthread_create(&tid[0], &attr, MergeSort, &param);
        pthread_create(&tid[1], &attr, QuickSort, &param);

        pthread_join(tid[0], NULL);
        pthread_join(tid[1], NULL);

        printf("Merge Sort: ");

        for (int i = 0; i < size; i++)
            printf("%d ", qarray[i]);

        printf("\n");

        printf("Quick Sort: ");

        for (int i = 0; i < size; i++)
            printf("%d ", marray[i]);

        printf("\n");
    }
    return 0;
}
```

Output:

```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./mergeQuick 1 4 8 9 5 6
3 7 5 2 9 7 4 8 6 3 5 4
Merge Sort: 1 2 3 3 4 4 4 5 5 5 6 6 7 7 8 8 9 9
Quick Sort: 1 2 3 3 4 4 4 5 5 5 6 6 7 7 8 8 9 9
```

vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$

7. Estimation of PI Value using Monte carlo simulation technique (refer the internet for the method..) using threads.
Code:[Reference]

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>

int circle_points = 0;
int square_points = 0;
double rand_x,rand_y,origin_dist;

int interval;

void *runner(void *p){
   rand_x  = (double)(rand() % (interval + 1)) / interval;
   rand_y =  (double)(rand() % (interval + 1)) / interval;
   origin_dist = (rand_x * rand_x) + (rand_y * rand_y);
   if(origin_dist <= 1)
       circle_points++;
   square_points++;

   pthread_exit(NULL);
}

int main(int argc,char *argv[]){
   if(argc != 2)
   printf("Usage: ./a.out <interval>\n");
   else{
       interval = atoi(argv[1]);
       pthread_t tid[interval*interval];
       pthread_attr_t attr;
```

```
        pthread_attr_init (&attr);
        srand(time(NULL));

        for(int i = 0;i<(interval*interval);i++)
        pthread_create(&tid[i],&attr,runner,NULL);
        for(int i = 0;i<(interval*interval);i++)
        pthread_join(tid[i],NULL);

        double pi = (double)(4 * circle_points) / square_points;
        printf("\nFinal Estimation of Pi = %f,\n", pi);
    }
    printf("\n");
    return 0;

}
```

Output:

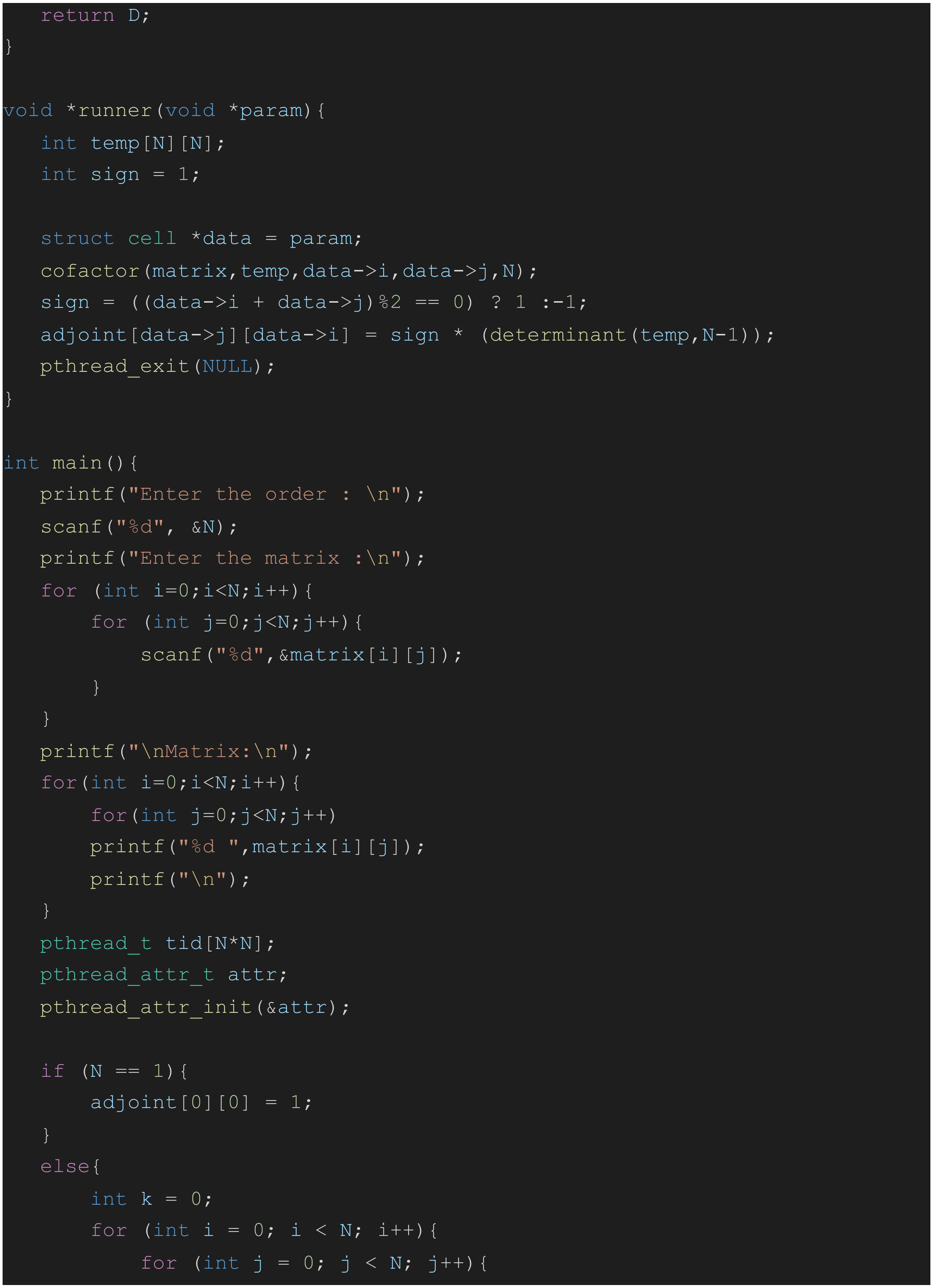
```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./pieExtimation 25

Final Estimation of Pi = 3.174400,

vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./pieExtimation 125

Final Estimation of Pi = 3.145472,

vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

(Optional Questions)

8. Computation of a Matrix Inverse using Determinant, Cofactor threads, etc.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>
#define MAX 100
int N;
int matrix[MAX][MAX];
int adjoint[MAX][MAX];
float inverse[MAX][MAX];

struct cell{
    int i;
    int j;

};
/* Function to get cofactor of matrix[p][q] in temp[][]. N is current
dimension of matrix[][]*/
void cofactor(int mat[MAX][MAX], int temp[MAX][MAX],int p,int q,int n){
    int i=0,j=0;
    for(int row=0 ; row<n ; row++){
        for(int col=0 ; col<n ; col++){
            if(row!=p && col!=q){
                temp[i][j++] = mat[row][col];
                if (j==n-1){
                    j=0;
                    i++;
                }
            }
        }
    }
}

int determinant(int mat[MAX][MAX],int n){
    int D=0;
    if(n==1)
    return mat[0][0];

    int temp[N][N]; // To store cofactors
    int sign = 1;    // To store sign multiplier

    // Iterate for each element of first row
    for(int f=0 ; f<n ; f++){
        cofactor(mat,temp,0,f,n);
        D += sign * mat[0][f] * determinant(temp,n-1);
        sign = -sign;
    }
```



```
    return D;
}

void *runner(void *param){
    int temp[N][N];
    int sign = 1;

    struct cell *data = param;
    cofactor(matrix,temp,data->i,data->j,N);
    sign = ((data->i + data->j)%2 == 0) ? 1 :-1;
    adjoint[data->j][data->i] = sign * (determinant(temp,N-1));
    pthread_exit(NULL);
}

int main(){
    printf("Enter the order : \n");
    scanf("%d", &N);
    printf("Enter the matrix :\n");
    for (int i=0;i<N;i++){
        for (int j=0;j<N;j++){
            scanf("%d",&matrix[i][j]);
        }
    }
    printf("\nMatrix:\n");
    for(int i=0;i<N;i++){
        for(int j=0;j<N;j++)
        printf("%d ",matrix[i][j]);
        printf("\n");
    }
    pthread_t tid[N*N];
    pthread_attr_t attr;
    pthread_attr_init(&attr);

    if (N == 1){
        adjoint[0][0] = 1;
    }
    else{
        int k = 0;
        for (int i = 0; i < N; i++){
            for (int j = 0; j < N; j++){
                struct cell *d = (struct cell *)malloc(sizeof(struct
cell));

                d->i = i;
                d->j = j;

                pthread_create(&tid[k], &attr, runner, d);
                k++;
            }
        }
        for (int i = 0; i < k; i++)
            pthread_join(tid[i], NULL);
    }
    printf("\nAdjoint:\n");
    for (int i = 0; i < N; i++){
        for (int j = 0; j < N; j++)
            printf("%d ", adjoint[i][j]);
        printf("\n");
    }
    int det = determinant(matrix, N);
    if (det == 0){
        printf("Inverse doesn't exist\n");
        return 0;
    }
    for (int i = 0; i < N; i++)
        for (int j = 0; j < N; j++)
            inverse[i][j] = adjoint[i][j] / ((float)det);

    printf("Inverse:\n");
    for (int i = 0; i < N; i++){
        for (int j = 0; j < N; j++)
            printf("%f ", inverse[i][j]);
        printf("\n");
    }
    printf("\n");
    return 0;
}
```

Output:

```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./matInv
```

```
Enter the order :
3
Enter the matrix :
4 5 6 1 5 9 7 2 8

Matrix:
4 5 6
1 5 9
7 2 8

Adjoint:
22 -28 15
55 -10 -30
-33 27 15
Inverse:
0.133333 -0.169697 0.090909
0.333333 -0.060606 -0.181818
-0.200000 0.163636 0.090909

vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

9. Read upon efficient ways of parallelizing the generation of Fibonacci series and apply the logic in a multithreaded fashion to contribute a faster version of fib series generation.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>

struct keyvalue{
   int key;
   int value;
};

int fib(int n){
   if(n==0 || n==1)
   return n;
   else
   return fib(n-1)+fib(n-2);
}

void *runner(void *param){
   struct keyvalue *temporary = (struct keyvalue*)param;
   temporary->value = fib(temporary->key);
   pthread_exit(NULL);
}

int main(){
   int range;
   printf("enter the number of fibonacci numbers to generate : \n");
   scanf("%d", &range);
   struct keyvalue *generate=(struct keyvalue*)malloc(range*sizeof(struct
keyvalue));

   pthread_t tid[range];
   printf("Fibonacci Series of %d terms\n",range);
   for (int i=0;i<range;i++){
       generate[i].key =i;
       pthread_create(&tid[i],NULL,runner,&generate[i]);
       pthread_join(tid[i],NULL);
   }
   for(int i=0;i<range;i++){
       printf("%d\n",generate[i].value);
   }

   return 0;
}
```

Output:

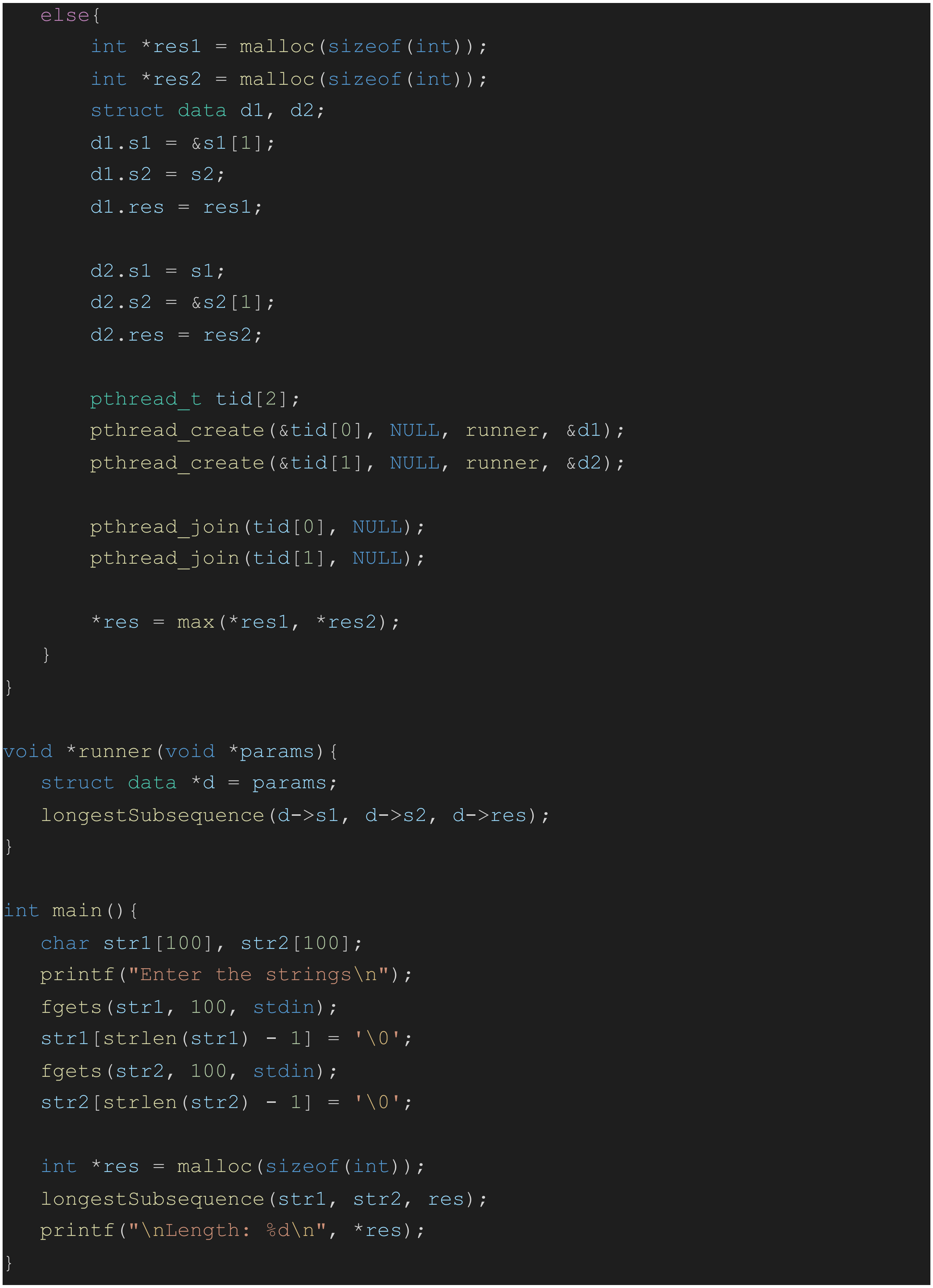
```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./fiboThread
enter the number of fibonacci numbers to generate :
10
Fibonacci Series of 10 terms
0
1
1
```

```
2
3
5
8
13
21
34
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```

10. Longest common subsequence generation problem using threads.

Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <string.h>
#include <time.h>
#include <sys/types.h>
#include <sys/wait.h>
#include <unistd.h>
#include <pthread.h>

int max(int x, int y){
    return (x > y ? x : y);
}

struct data{
    char *s1, *s2;
    int *res;
};

void *runner(void *);

void *longestSubsequence(char *s1, char *s2, int *res){
    if (s1[0] == '\0' || s2[0] == '\0')
        *res = 0;
    else if (s1[0] == s2[0]){
        int *res1 = malloc(sizeof(int));
        longestSubsequence(&s1[1], &s2[1], res1);
        *res = 1 + *res1;
    }
```



```
    else{
        int *res1 = malloc(sizeof(int));
        int *res2 = malloc(sizeof(int));
        struct data d1, d2;
        d1.s1 = &s1[1];
        d1.s2 = s2;
        d1.res = res1;

        d2.s1 = s1;
        d2.s2 = &s2[1];
        d2.res = res2;

        pthread_t tid[2];
        pthread_create(&tid[0], NULL, runner, &d1);
        pthread_create(&tid[1], NULL, runner, &d2);

        pthread_join(tid[0], NULL);
        pthread_join(tid[1], NULL);

        *res = max(*res1, *res2);
    }
}

void *runner(void *params){
    struct data *d = params;
    longestSubsequence(d->s1, d->s2, d->res);
}

int main(){
    char str1[100], str2[100];
    printf("Enter the strings\n");
    fgets(str1, 100, stdin);
    str1[strlen(str1) - 1] = '\0';
    fgets(str2, 100, stdin);
    str2[strlen(str2) - 1] = '\0';

    int *res = malloc(sizeof(int));
    longestSubsequence(str1, str2, res);
    printf("\nLength: %d\n", *res);
}
```

Output:

```
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./lonComSub
Enter the strings
substring
sub

Length: 3
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$ ./lonComSub
Enter the strings
operating System
sys

Length: 2
vijay@vijay-desktop:~/Desktop/Operating_Systems-master/Threads$
```