* Hash tables

1) Hash table:-

- Hash tables is a data structure used for storing and retrieving data quickly.
- Every entry in hash table is made using Hash function.

2) Hash function:-

- Hash function is a function used to place data in a hash table.
- Similarly hash function is used to retrieve data from hash table.

1. Linear Probing

- when collision occurs i.e. when two records demand for the same location in the hash table, then the collision can be solved by placing second record linearly down wherever the empty location is found.

eg; m=10 keys = {131, 4, 5, 7, 8, 21, 31, 61}

	Index	data
	0	
131 %10 = 1	1	131
21%10 = 1	2	21
31%10 = 1	3	31
4%10 = 4	4	4
5%10 = 5	5	5
61%10 = 1	6	61
7%10 = 7	7	7
8%10 = 8	8	8
	9	

2. Double hashing

- Double hashing is a technique in which a second hash function is applied to the key when a collision occurs.
- By applying the second hash function we will get the number of positions from the point of collision to insert.

Q. Insert following keys into hash table using quadratic probing where table size $m=7$ and $h1(x) = x \bmod m$, $h2(x) = 5 - (x \bmod 5)$, key $= \{76, 93, 40, 48, 5, 55\}$

insert 76

$76\%7=6$

0	
1	
2	
3	
4	
5	
6	76

probes: 1

insert 93

$93\%7=2$

0	
1	
2	93
3	
4	
5	
6	76

probes: 1

insert 40

$40\%7=5$

0	
1	
2	93
3	
4	
5	40
6	76

probes: 1

insert 47

$47\%7=5$

$5-(47\%7)=3$

0	
1	47
2	93
3	
4	
5	40
6	76

probes: 2

insert 10

$10\%7=3$

0	
1	47
2	93
3	10
4	
5	40
6	76

probes: 1

insert 55

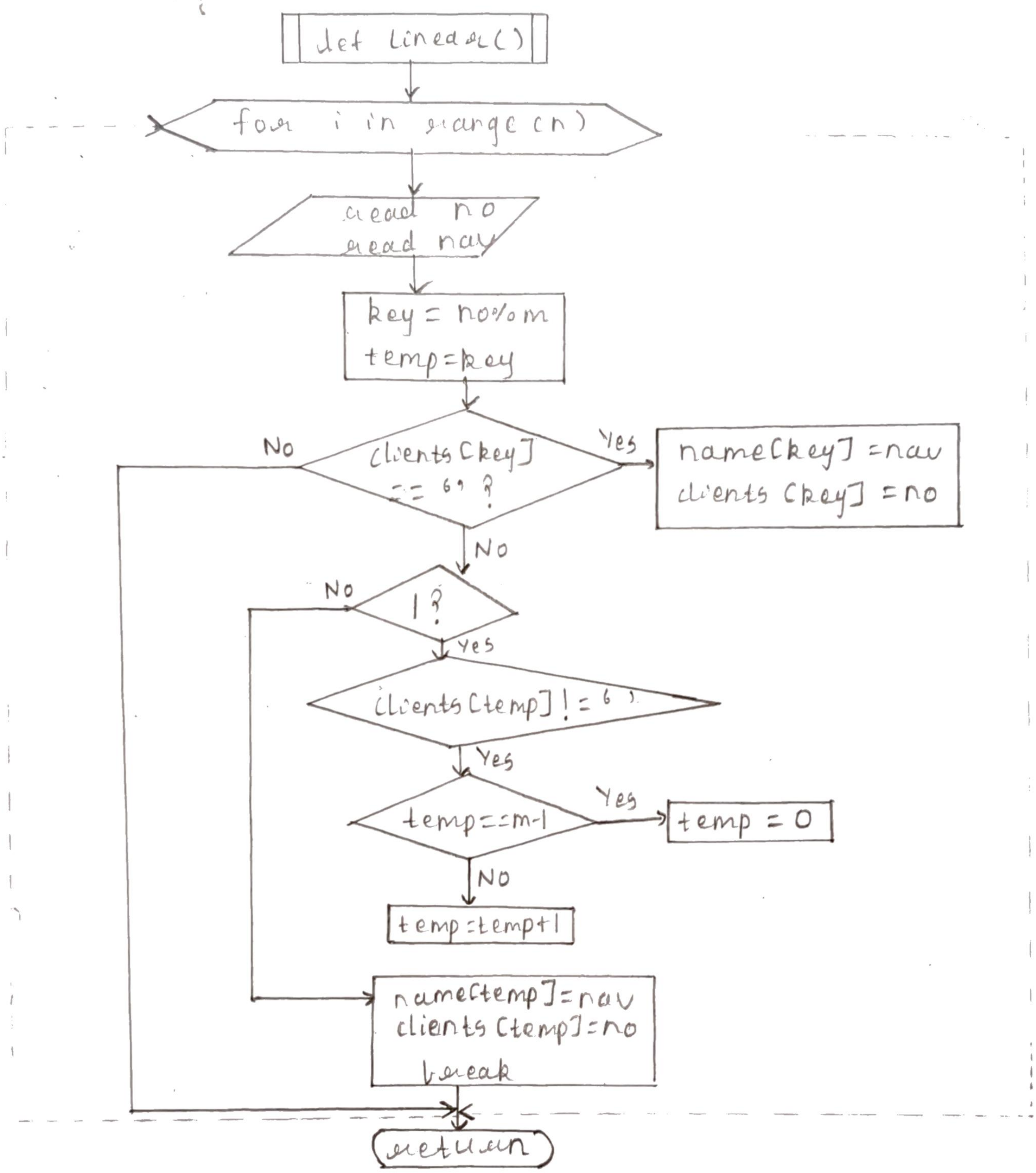
$55\%7=6$

$5-(55\%5)=5$

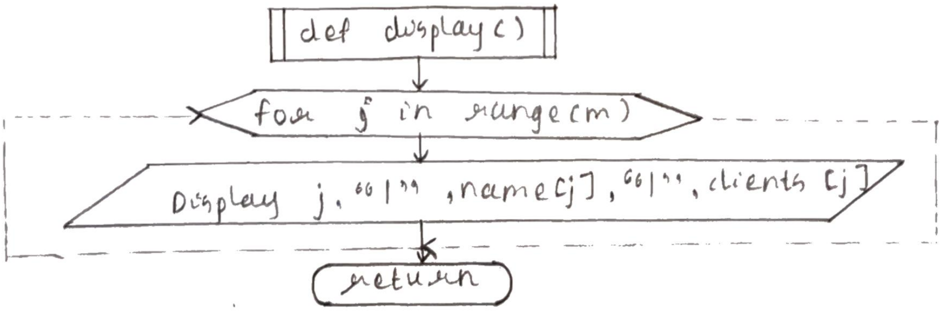
0	
1	47
2	93
3	10
4	55
5	40
6	76

probes: 2

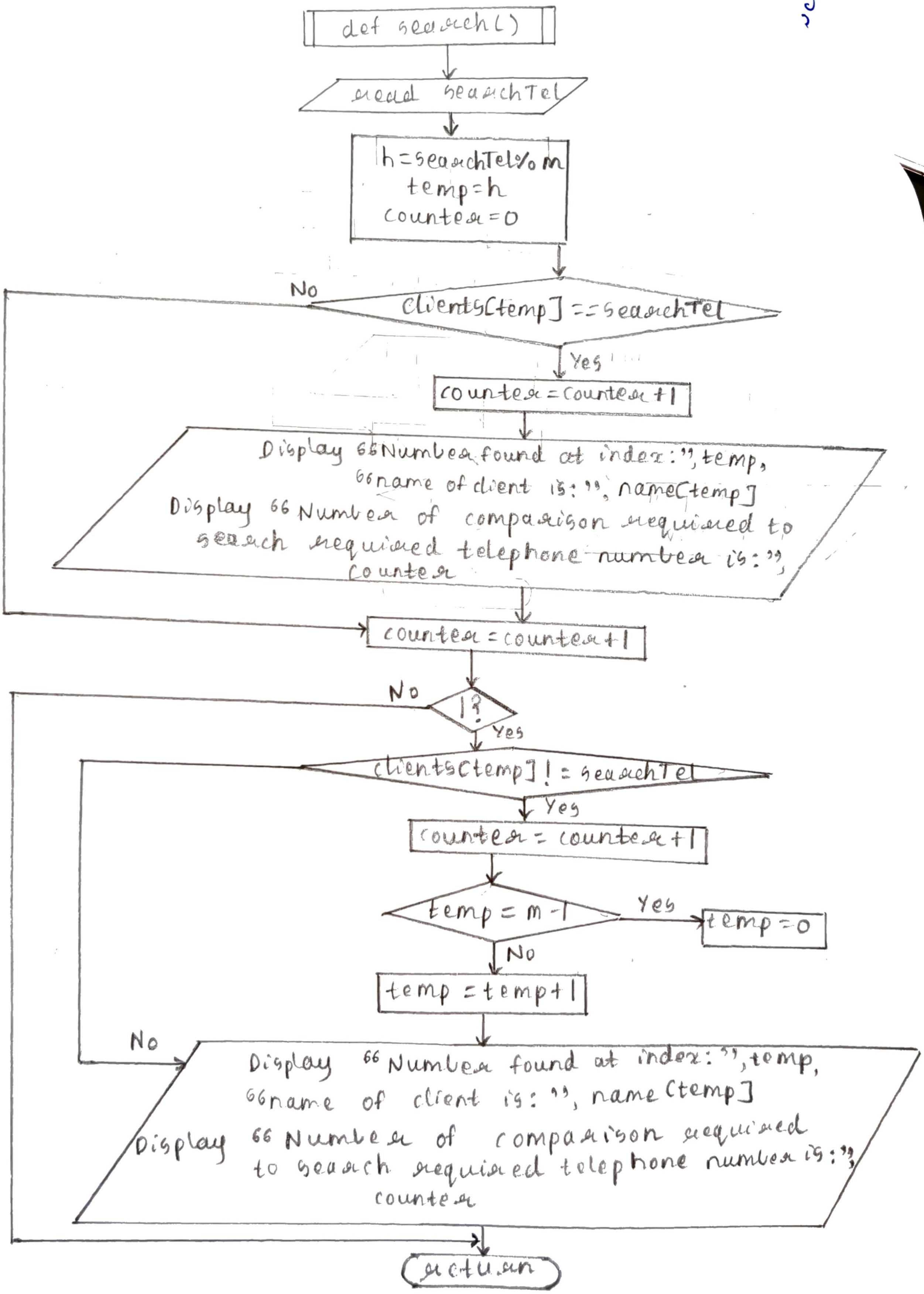
owchart for linear().



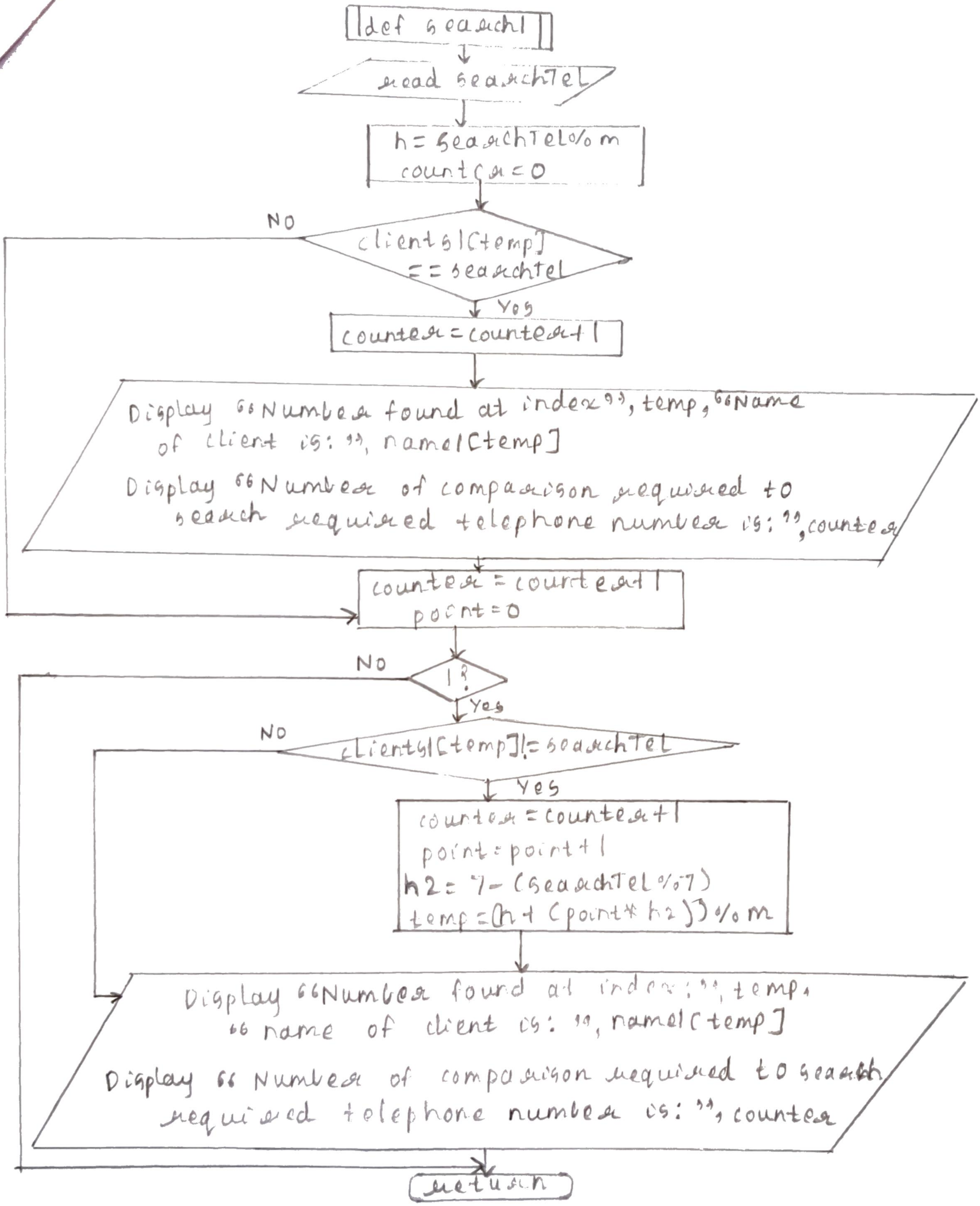
→ Flowchart for display()



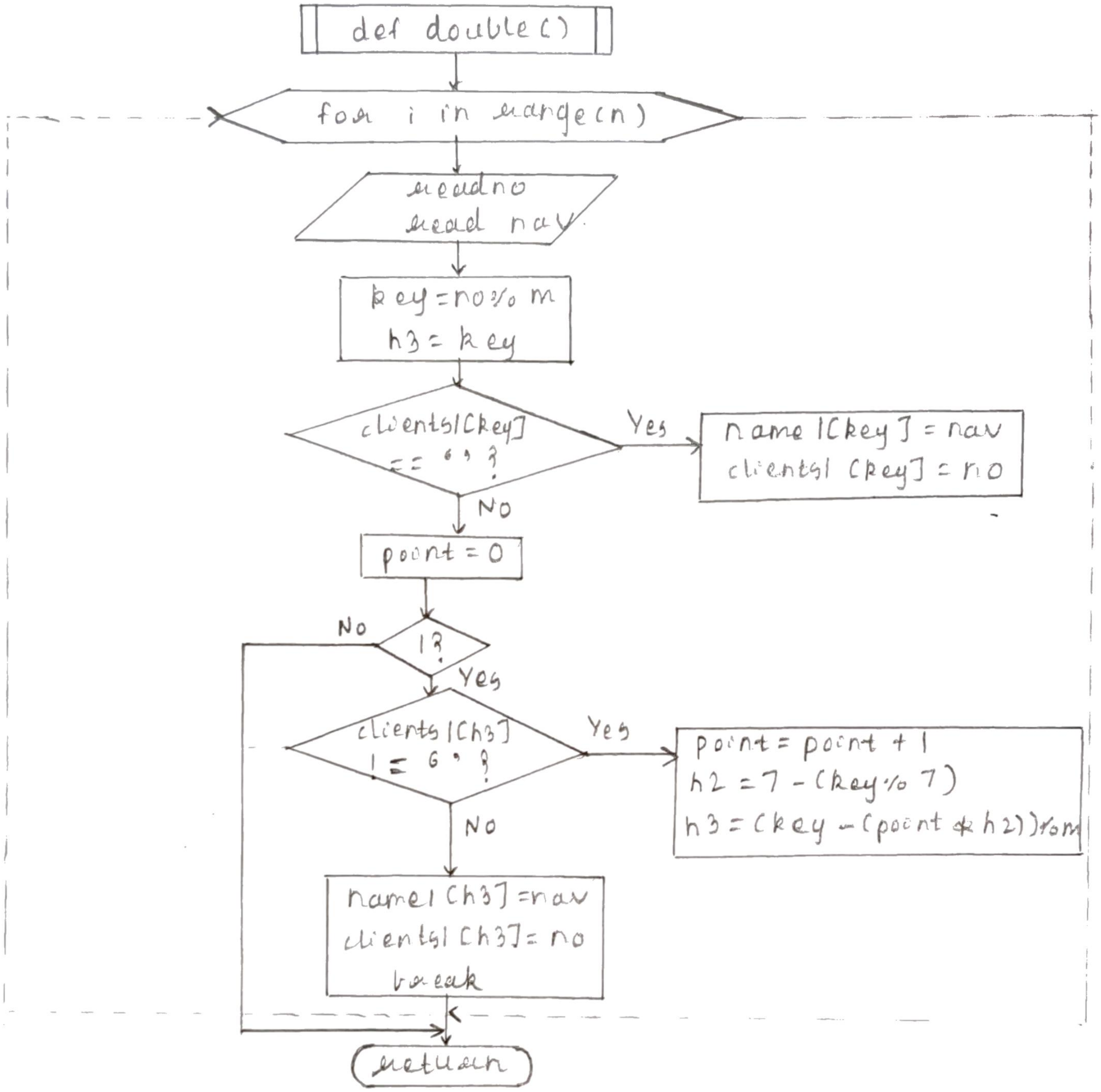
→ Flowchart for search()


def search()
read searchTel
h=searchTel%m
temp=h
counter=0
No
clients[temp]==searchTel
Yes
counter=counter+1
Display "Number found at index:", temp, "name of client is:", name[temp]
Display "Number of comparison required to search required telephone number is:", counter
counter=counter+1
No
1?
Yes
clients[temp]!=searchTel
Yes
counter=counter+1
temp=m-1
Yes
temp=0
No
temp=temp+1
No
Display "Number found at index:", temp, "name of client is:", name[temp]
Display "Number of comparison required to search required telephone number is:", counter
return

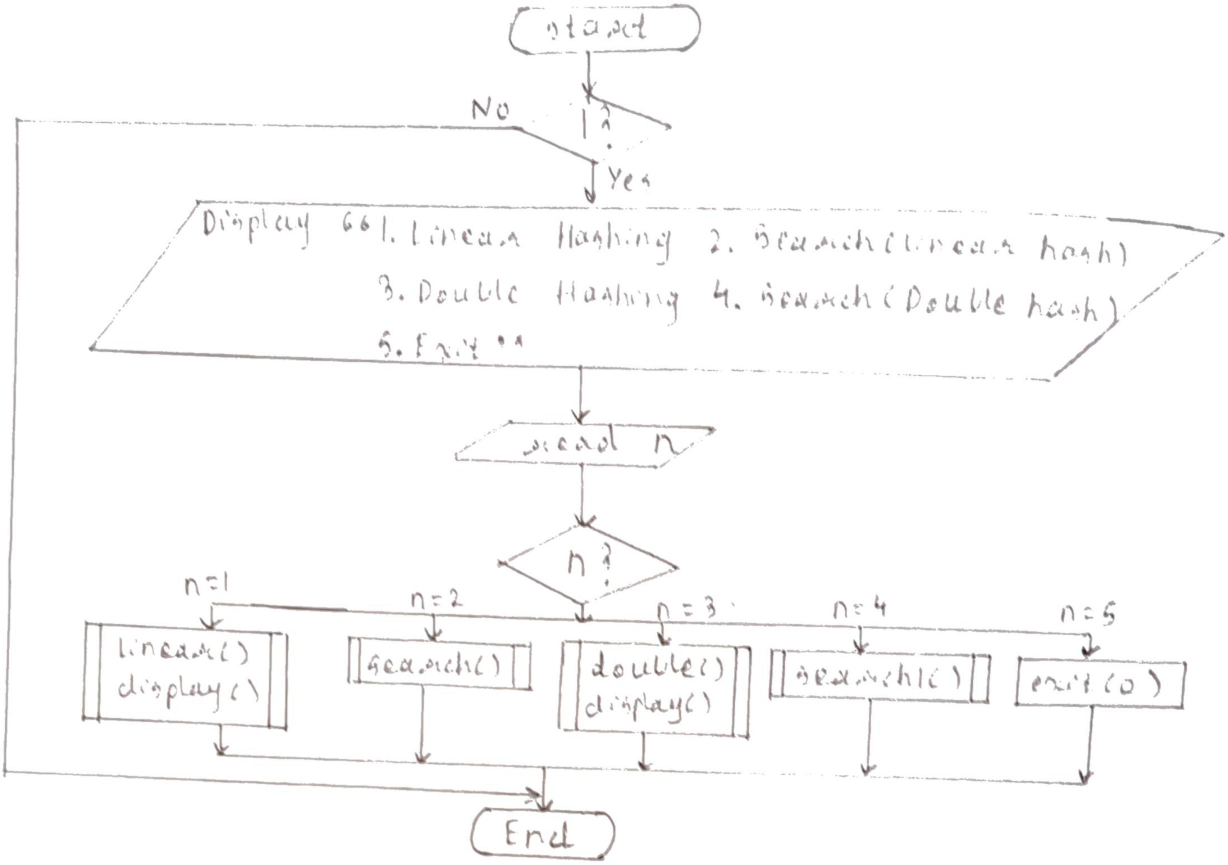
wchart for def search()


def search1
read searchTel
h=searchTel%m
counter=0
NO
clients1[temp]
==searchtel
Yes
counter=counter+1
Display "Number found at index", temp, "Name of client is:", name1[temp]
Display "Number of comparison required to search required telephone number is:", counter
counter=counter+1
point=0
NO
1?
Yes
NO
clients1[temp]!=searchTel
Yes
counter=counter+1
point=point+1
h2=7-(searchTel%7)
temp=(h+(point*h2))%m
Display "Number found at index:", temp, "name of client is:", name1[temp]
Display "Number of comparison required to search required telephone number is:", counter
return

Flowchart for double()



→ Flowchart for main()



```
→ Pseudocode for linear()
1. for i in range(n) do
   begin
           redd no
           read nav
           store no%m in key
           store key in temp
           if clients[key] == '' then
                   store nav in name[key]
                   store no in clients[key]
         else
                   while(1) do
                   begin
                           if clients[temp] != '' then
                                   if temp == m-1 then
                                           temp = 0
                                   else
                                           increment temp
                           else
                                   store nav in name[temp]
                                   store ~~clients~~ no in clients[temp]
                                   break
   end
2. return

→ Pseudocode for display()
1. for j in range(m) do
   begin
           Display j, "|", name[j], "|", clients[j]
   end
2. return
```

→ ~~Pseudocode for search()~~

```
~~1. read searchTel~~
~~2. initialize check = False~~
~~3. for c in range(m) do~~
~~   begin~~
~~       if name[c] == searchTel then~~
~~           Display "Telephone number: ", clients[c]~~
~~           check = True~~
~~   end~~
~~4. if check == False then~~
~~       Display "Enter valid name!!"~~
~~5. return~~
```

→ Pseudocode for double()

```
1. for i in range(n) do
   begin
       read no
       read nav
       store no%m in key
       store key in h3
       if clients1[key] == "" then
           Declare name1[key] = nav
                   clients1[key] = no
       else
           initialize point = 0
           while (1) do
           begin
               if clients1[h3] != "" then
                   increment point
                   initialize h2 = 7 - (key % 7)
                   initialize h3 = (key + (point * h2)) % m
               else
```

→ Pseudocode for def search

```
1. read searchTel
2. calculate h = searchTel % m
3. store h in temp
4. initialize counter = 0
5. if clients[temp] == searchTel then
           increment counter
           Display "Number found at index: ", temp,
                   "name of client is: ", name[temp]
           Display "Number of comparisons required
                   to search required telephone number
                   is: ", counter
   else:
           increment counter
           while (1) do
           begin
                   if clients[temp] != searchTel then
                           increment counter
                           if temp == m-1 then
                                   initialize temp = 0
                           else:
                                   increment temp
                   else:
                           Display "Number found at index:",
                           temp, "name of client is: ", name[temp]
                           Display "Number of comparisons
                           required to search required
                           telephone number is: ", counter
                           break
           end
6. return
```

```
→ Pseudocode for def search1()
1. read searchTel
2. calculate h= searchTel % m
3. store h in temp
4. initialize counter = 0
5. if clients1[temp]==searchTel then
       increment counter
       ~~pos~~ Display "Number found at index: ", temp, "name
               of client is ", name1[temp]
       Display "Number of comparison required to
               search required telephone number is:"
               counter
   else:
       increment counter
       initialize point=0
       while(1) do
       begin
           if clients1[temp] != searchTel then
               increment counter
               increment point
               calculate h2 =7-(searchTel % 7)
               calculate temp= (h+ (point * h2)) % m
           else:
               Display "Number found at index: ",
               temp, "name of client is : ", name1[temp]
               Display "Number of comparisons
               required to search telephone
               number is: ", counter
               break
       end
6. return
```

```
                    Declare name1[h3]=nav
                    clients1[h3]=no
                    break
            end
end
2. return

→ Pseudocode for main()
1. ~~while(1)~~ Start
2. while (1) do
begin
    Display "1. Linear Hashing 2. Search(Linear hash)
             3. Double Hashing 4. Search (Double hash)
             5. Exit "
    read n
    if (n==1) then
            call function Linear()
            call function display ()
    elif n==2 then
            call function search()
    elif n==3 then
            call function double()
            call function display1()
    elif n==4 then
            call function search1()
    elif n==5
            exit(0)
    elif n<0 and n>5
            Display "Enter valid choice !!!"
end
3. End
```

Q1. Explain different hashing functions with example.

Ans. 1. Division method:-

→ Idea:

- Computes hash value from key using the % operator
- Map a key K into one of the m slots by taking the remainder of k divided by m.

$$h(k) = k \bmod m$$

→ Example:-

- $k = 1276$, $n = 10$

$$h(1276) = 1276 \bmod 10 = 6$$

2. Multiplication method:-

→ Idea:

- Multiply key k by a constant A, where $0 < A < 1$
- Extract the fractional part of KA and multiply the fractional part by m
- Take the floor of the result

$$h(k) = \lfloor m\,(kA \bmod 1) \rfloor$$

→ Example:-

$k = 123$, $m = 100$, $A = 0.618033$

$$h(123) = 100\,(123 \times 0.618033 \bmod 1)$$

$$= 100\,(76.018059 \bmod 1)$$

$$= 100\,(0.018059) = 1$$

3. Digit Extraction method:-

→ Idea:

- Selected digits are extracted from the key and used as address

Address = selected digits from key

→ Examples:-

- If six digit employee number is 379245 then select first digit as the index so 379 is the key address.

4. Folding :-

→ Idea:

- It involves splitting keys into two or more parts and then combining the parts to form the hash addresses.

→ Example:

- To map the key 25936715 to a range between 0 and 9999, we can:

i) split the number into two as 2593 and 6715 and

ii) add these two to obtain 9308 as the hash value.

5. Mid-square method:-

→ Idea:

- The key is squared and the middle part of the result taken as the hash values.

→ Example:

- To map the key 3121 into a hash table of size 1000, we square it $3121^2 = 9740642$ and extract 406 as the hash value.

Q2. Describe extensible hashing for the given input keys: 1, 10, 7, 8, 15, 16

Ans. Elements :- 1, 10, 7, 8, 15, 16

Bucket size :- 2 (Assume)

1 → 00001

10 → 01010

7 → 00111

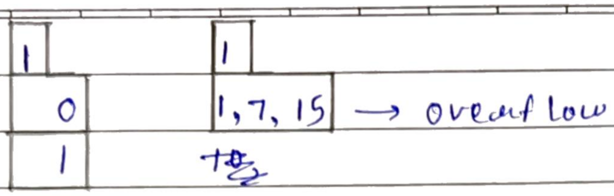
8 → 01000

15 → 01111

16 → 10000

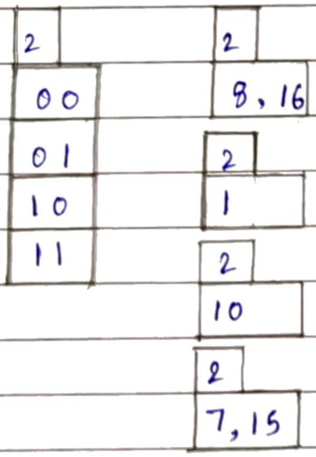
→ For Directory 1,

$2^1 = 2$



→ For Directory 2,

$2^2 = 4$


2
00
01
10
11
2
8, 16
2
1
2
10
2
7, 15