**Input: keys 12, 44, 13, 88, 23, 94, 11, 39, 20, 16, and 5. Table Size 11**

1. **Perform linear probing on the above Input data with the given Table Size 11.**

**Solution: linear probing**

Table Size(N) = 11

Hash function h(k) = Key % N

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key |  |  |  |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(12):** 12 % 11 🡺1st index

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key |  | 12 |  |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(44):** 44 % 11 🡺0th index

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 |  |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(13):** 13 % 11 🡺2nd index

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(88):** 88 % 11 🡺 0th index, since 0th index is already occupied we are going to move to next index until finds empty. So inserting 88 at 3rd index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(23):** 23 % 11 🡺 1st index, since 1st index is already occupied we are going to keep move to next index until finds empty. So inserting 23 at 4rd index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 | 23 |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(94):** 94 % 11 🡺94-88 = 6st index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 | 23 |  | 94 |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(11):** 11 % 11 🡺 0th index, since 0th index is already occupied we are going to keep move to next index until finds empty. So inserting 11 at 5th index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 | 23 | 11 | 94 |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(39):** 39 % 11 = 39-33 🡺 6th index, since 6th index is already occupied we are going to keep move to next index until finds empty. So inserting 39 at 7th index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 | 23 | 11 | 94 | 39 |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(20):** 20 % 11 = 20-11 🡺 9th index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 | 23 | 11 | 94 | 39 |  | 20 |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(16):** 16 % 11 = 16-11 🡺 5th index. Now inserting 16 at index 8th index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 | 23 | 11 | 94 | 39 | 16 | 20 |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(5):** 5 % 11 =🡺 5th index. Now inserting 16 at index 10th index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 88 | 23 | 11 | 94 | 39 | 16 | 20 | 5 |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

1. **Show the result of Input Keys, assuming collisions are handled by quadratic probing, up to the point where the method fails because no empty slot is found.**

**Solutions: Quadratic probing**

Input: keys 12, 44, 13, 88, 23, 94, 11, 39, 20, 16, and 5

Table Size(N) = 11

Hash function h(k) = Key % N

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key |  |  |  |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(12):** 12 % 11 🡺1st index

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key |  | 12 |  |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(44):** 44 % 11 🡺0th index

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 |  |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(13):** 13 % 11 🡺2nd index

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  |  |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(88):** 88 % 11 🡺 0th index, since 0th index is already occupied collusion occurs and is now solving using quadratic probing as follows,

Secondary hashing A[(i + j^2 ) mod N], j = 1,2,3,….

A[(0 + 1) % 11] = A[1], the slot is occupied at index 1

Now j =2, A[(0 + 4) % 11] = A[4], slot for index 4 is empty then inserted at 4th index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  | 88 |  |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(23):** 23 % 11 🡺 1st index, since 0th index is already occupied collusion occurs and is now solving using quadratic probing as follows,

Secondary hashing A[(i + j^2 ) mod N], j = 1,2,3,…. Where i = 1

A[(1 + 1) % 11] = A[2], the slot is occupied at index 2

Now j =2, A[(1 + 4) % 11] = A[5], slot for index 5 is empty then inserted at 5th index.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  | 88 | 23 |  |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(94):** 94 % 11 🡺 6st index, since 6th index is empty then inserted.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  | 88 | 23 | 94 |  |  |  |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(11):** 11 % 11 🡺 0st index, since 0th index is already occupied collusion occurs and is now solving using quadratic probing as follows,

Secondary hashing A[(i + j^2 ) mod N], j = 1,2,3,…. Where i = 0

A[(0 + 1) % 11] = A[1], the slot is occupied at index 1

Now j =2, A[(0 + 4) % 11] = A[4], slot 4th index is occupied.

Now j =3, A[(0 + 9) % 11] = A[9], slot 9th index is empty then inserted.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  | 88 | 23 | 94 |  |  | 11 |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(39):** 39 % 11 = 39-33 🡺 6st index, since 6th index is already occupied collusion occurs and is now solving using quadratic probing as follows,

Secondary hashing A[(i + j^2 ) mod N], j = 1,2,3,…. Where i = 6

A[(6 + 1) % 11] = A[7], index 7th slot is empty so inserted.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  | 88 | 23 | 94 | 39 |  | 11 |  |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(20):** 20 % 11 = 20-11 🡺 9st index, since 6th index is already occupied collusion occurs and is now solving using quadratic probing as follows,

Secondary hashing A[(i + j^2 ) mod N], j = 1,2,3,…. Where i = 9

A[(9+ 1) % 11] = A[10], index 10th slot is empty so inserted.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 |  | 88 | 23 | 94 | 39 |  | 11 | 20 |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(16):** 16 % 11 = 16 -11 🡺 5st index, since 5th index is already occupied collusion occurs and is now solving using quadratic probing as follows,

Secondary hashing A[(i + j^2 ) mod N], j = 1,2,3,…. Where i = 5

A[(5+ 1) % 11] = A[6], index 6th slot is occupied.

Now j =2, A[(5 + 4) % 11] = A[9], slot 9th index is occupied.

Now j =3, A[(5 + 9) % 11] = 14-11 = 3, A[3], slot 3rd index is empty so inserted.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 16 | 88 | 23 | 94 | 39 |  | 11 | 20 |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

**Insert(5):** 5 % 11 🡺 5st index, since 5th index is already occupied collusion occurs and is now solving using quadratic probing as follows,

Secondary hashing A[(i + j^2 ) mod N], j = 1,2,3,…. Where i = 5

A[(5+ 1) % 11] = A[6], index 6th slot is occupied.

Now j =2, A[(5 + 4) % 11] = A[9], slot 9th index is occupied.

Now j =3, A[(5 + 9) % 11] = A[3], slot 3rd index is occupied.

Now j =4, A[(5 + 16) % 11] = 21-11 = 10, A[10], slot 10th index is occupied.

Now j =5, A[(5 + 25) % 11] = 30-22 = 8, A[8], slot 8th index is empty then inserted.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Key | 44 | 12 | 13 | 16 | 88 | 23 | 94 | 39 | 5 | 11 | 20 |
| Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |