LIS - Longest increasing subsequence

Array's member	29	6	14	31	39	78	63	50	13	65	61	62	19	64	20	70	43	84	35	98
Index	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

LIS = {6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98}

$$A_{i+1} > A_i$$

Problem: Given sequence $X = \langle x_1, x_2, \ldots, x_n \rangle$, find the **longest subsequence** $Z = \langle z_1, z_2, \ldots, z_k \rangle$ that is $z_{i+1} > z_i$.

A subsequence is a subset of elements from the sequence with **strictly increasing** order (**not necessarily contiguous**).

1. Dynamic Programming תכנון דינמי

LIS dynamic programming (length of subsequence).

29	6	14	31	39	78	63	50	13	65	61	62	19	64	20	70	43	84	35	98

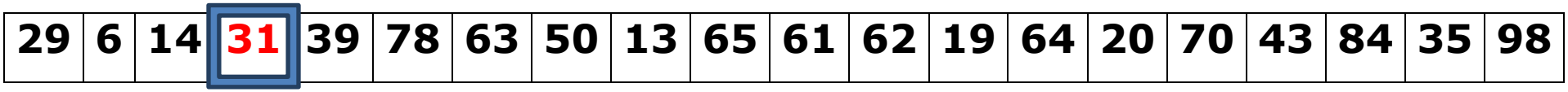
29 index 0

29	6	14	31	39	78	63	50	13	65	61	62	19	64	20	70	43	84	35	98

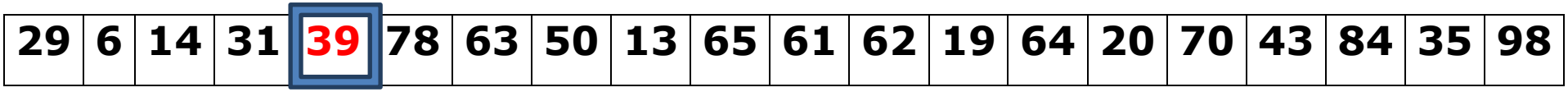
6 index 0

29	6	14	31	39	78	63	50	13	65	61	62	19	64	20	70	43	84	35	98

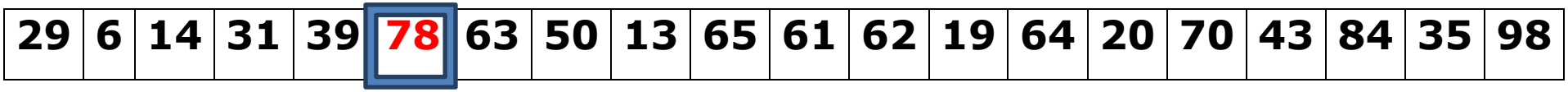
6 14 index 1



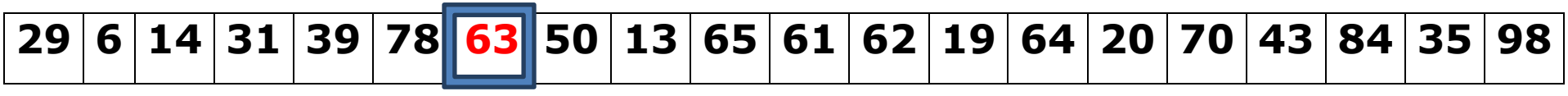
6 14 31 index 2



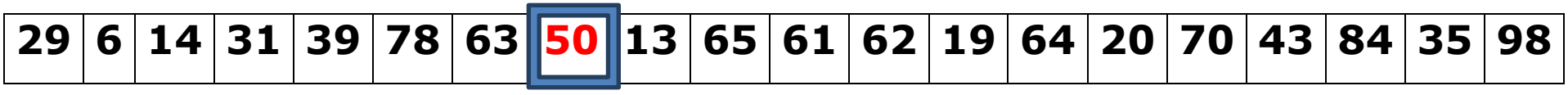
6 14 31 39 index 3



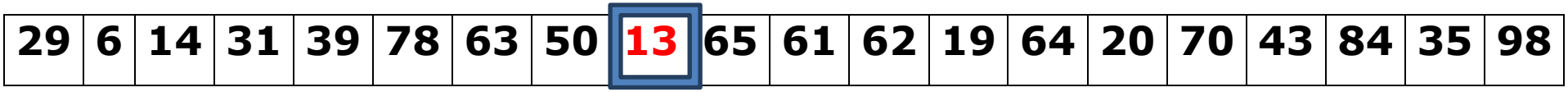
6 14 31 39 78 index 4



6 14 31 39 63 index 4 39 < 63 < 78

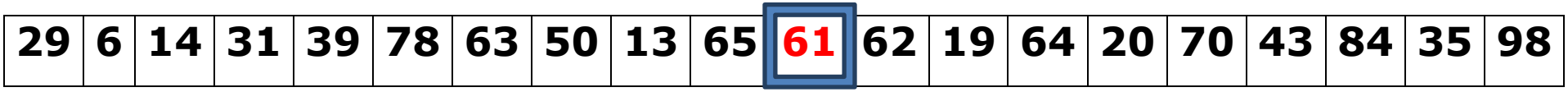


6 14 31 39 **50** index 4 **39 < 50 < 63**

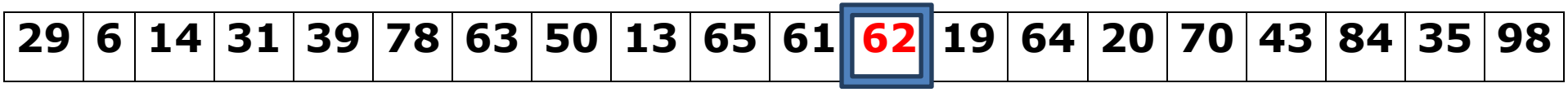


6 **13** 31 39 50 index 1

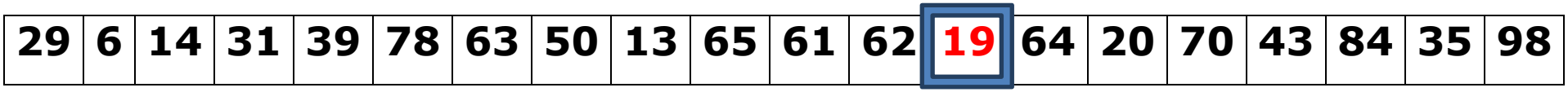
6 13 31 39 50 **65** index 5



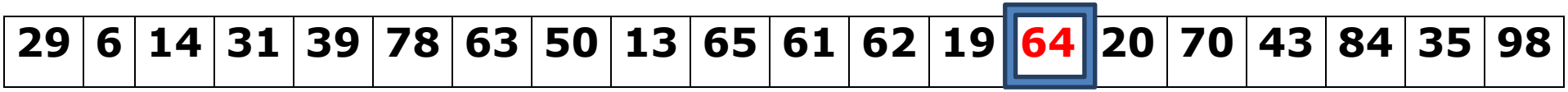
6 13 31 39 50 **61** index 5 **50 < 61 < 65**



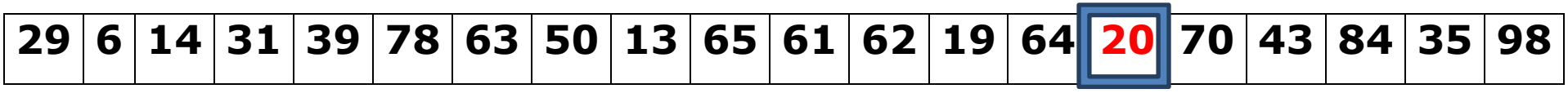
6 13 31 39 50 61 **62** index 6



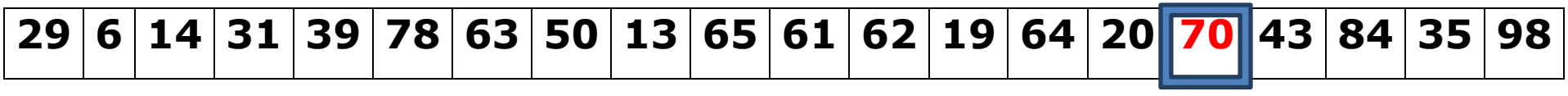
6 13 19 39 50 61 62 index 2



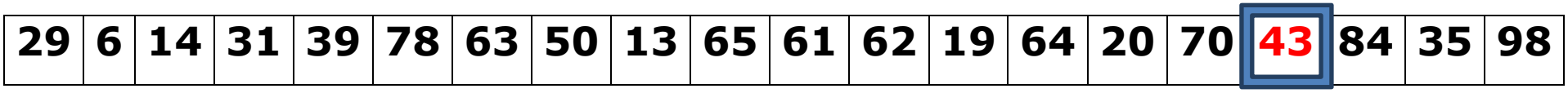
6 13 19 39 50 61 62 64 index 7



6 13 19 20 50 61 62 64 index 3



6 13 19 20 50 61 62 64 70 index 8



6 13 19 20 **43** 61 62 64 70 index 4

29	6	14	31	39	78	63	50	13	65	61	62	19	64	20	70	43	**84**	35	98

6 13 19 20 43 61 62 64 70 **84** index 9

29	6	14	31	39	78	63	50	13	65	61	62	19	64	20	70	43	84	**35**	98

6 13 19 20 **35** 61 62 64 70 84 index 4

29	6	14	31	39	78	63	50	13	65	61	62	19	64	20	70	43	84	35	**98**

6 13 19 20 35 61 62 64 70 84 **98** index 10

6 13 19 20 35 61 62 64 70 84 98

6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98

LIS dynamic programming

6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 35, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98, 0, 0, 0, 0, 0, 0, 0, 0, 0,

6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98

```
int binarySearchBetweenArr(int []arr, int end, int value)
```

Pseudeocode:

```
low = 0
high = end
if (value < arr[0])          return  0
if (value > arr[end])        return  end+1

Loop ( low <= high )
    loop begin
    middle = (low + high)/2
    if (low == high)
            return  low
    else
        if ( arr[middle] == value)
            return middle
        if ( arr[middle] < value)
            high = middle
        else
            low = middle+1
    loop end
return -1
```

int binarySearchBetweenMat(**int** [][]arr, **int** end, **int** value)

Pseudeocode:

```
low = 0
high = end
if (value < arr[0][0])              return  0
if (value > arr[end][end])          return  end+1

Loop ( low <= high )
    loop begin
    middle = (low + high)/2
    if (low == high)
            return  low
    else
        if ( arr[middle][middle] == value)
            return middle
        if ( arr[middle][middle] > value)
                        high = middle
        else
            low = middle+1
```

```
    loop end
return -1
```

int LISLength(**int** [] arr)

Pseudeocode:

```
size = length of arr
array d[size]
d[0] = arr[0]
end = 0
Loop ( i from 1 to size step 1 )
    loop begin
    index = binarySearchBetweenArr(d, end, arr[i])
    d[index] = arr[i]
    if (index > end)
        end = end + 1
    loop end
return  end+1
```

int[] LIS2(**int** [] arr)

Pseudeocode:

```
size = length of arr
array mat[size][size]
mat[0][0] = arr[0]
end = 0
Loop ( i from 1 to size step 1 )
    loop begin
    index = binarySearchBetweenMat(d, end, arr[i])
    mat[index][index] = arr[i]
    Loop ( j from 0 to index step 1 )
        loop begin
        mat[index][j] = mat[index-1][j]
        loop end
    mat[index][index] = arr[i]
    if (index>end)
```

```
            end = end + 1

        loop end
array ans[end+1]
Loop ( j from 0 to index step 1 )

        loop begin
        ans[j] = mat[end][j]
return ans
```

[6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98]

[29, 6, 14, 31, 39, 78, 63, 50, 13, 65, 61, 62, 19, 64, 20, 70, 43, 84, 35, 98]

```
public static int[] LIS2(int [] arr)
```

pseudocode :

```
size = arr.length
mat [size][ size]
end = 0

Loop  ( i from 1 to size -1 step 1)
    index = binarySearchBetweenMat(mat, end, arr[i])
    mat[index][index] = arr[i];
    Loop  ( j from 0 to index  step 1)
        mat[index][j]=mat[index-1][j]
    loop end
```

```
    if (index > end )
        end = end + 1
loop end
```

ans[end+1]

Build ans

```
index = 0       mat[0][0]   =  6
index = 1       mat[1][1]   = 14
index = 2       mat[2][2]   = 31
index = 3       mat[3][3]   = 39
index = 4       mat[4][4]   = 78
index = 4       mat[4][4]   = 63
index = 4       mat[4][4]   = 50
index = 1       mat[1][1]   = 13
index = 5       mat[5][5]   = 65
index = 5       mat[5][5]   = 61
index = 6       mat[6][6]   = 62
index = 2       mat[2][2]   = 19
index = 7       mat[7][7]   = 64
index = 3       mat[3][3]   = 20
index = 8       mat[8][8]   = 70
index = 4       mat[4][4]   = 43
index = 9       mat[9][9]   = 84
index = 4       mat[4][4]   = 35
index = 10     mat[10][10] = 98
```

index = 0   mat[0][0] = 29
mat.length = 20
end = 0
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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index = 1   mat[1][1] = 14
end = 1
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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index = 2   mat[2][2] = 31
end = 2
mat.length = 20
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6, 14, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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index = 3   mat[3][3] = 39
end = 3
mat.length = 20
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index = 4   mat[4][4] = 78
end = 4
mat.length = 20
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6, 14, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 4 mat[4][4] = 63
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 63, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 4   mat[4][4] = 50
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 1 mat[1][1] = 13
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 5   mat[5][5] = 65
end = 5
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 65, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 5   mat[5][5] = 61
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 6   mat[6][6] = 62
end = 6
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 2   mat[2][2] = 19
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 7   mat[7][7] = 64
end = 7
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 3   mat[3][3] = 20
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 8   mat[8][8] = 70
end = 8
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 4   mat[4][4] = 43
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 43, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 9   mat[9][9] = 84
end = 9
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 43, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

6, 14, 31, 39, 50, 61, 62, 64, 70, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 4   mat[4][4] = 35
mat.length = 20
6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 35, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

6, 14, 31, 39, 50, 61, 62, 64, 70, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

index = 10   mat[10][10] = 98

end = 10

mat.length = 20

6, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 13, 19, 20, 35, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,

RESULT :
6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98,
[6, 14, 31, 39, 50, 61, 62, 64, 70, 84, 98]