Session Outcome

After completion of this session, you will be able to

- implement Linear data structures (Apply)
  - implement Array data structure (Apply)

Array

Need: Storing marks of 20 students need 20 variables

Definition: *An array is a*

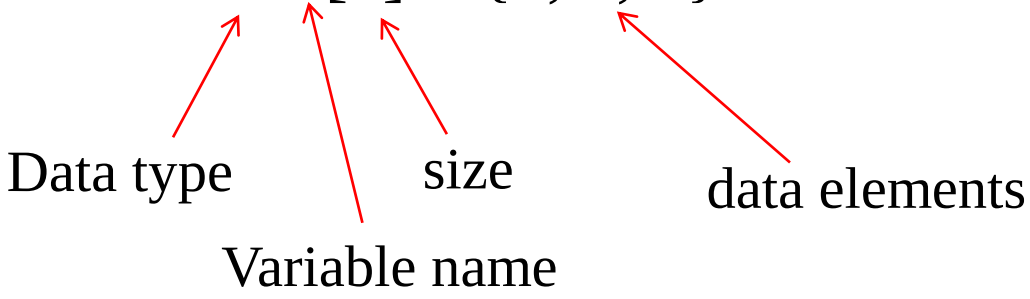
fixed size,

sequence collection of elements

of same data type.

Declaration and storing Array Elements

1. `int a[3] = {1, 2, 5}` [Compile Time]



2. [Run time]

```
int i, a[3];
 for (i=0 ;  i < 3; i++)
      a[i] = i;
```

3. [Run time]

```
int  i, a[3];
for (i=0 ; i < 3 ; i++)
     scanf("%d",&a[i]);
```

Address of Array Elements

a[k] = BaseAddress [a] + w (k – lowerbound)

Where *k*, is the index of element

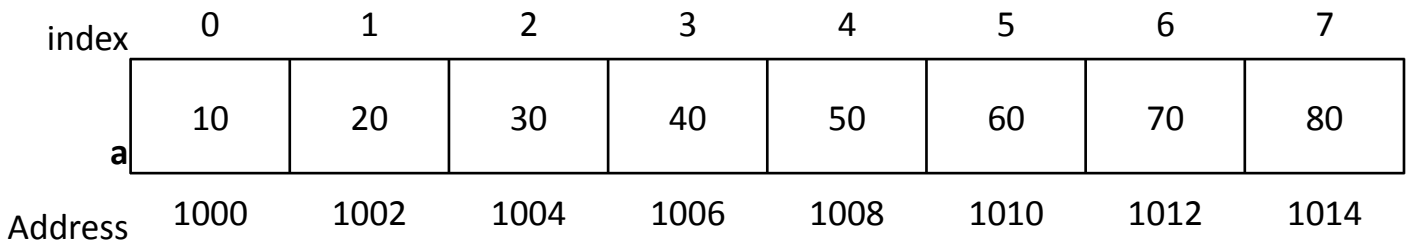
a, is the array variable name

w, is the number of words per memory location

lowerbound, is starting index

BaseAddress, is the starting address of array or address of first element of array

e.g.



a [3] = 1000 + 2 (3 – 0)

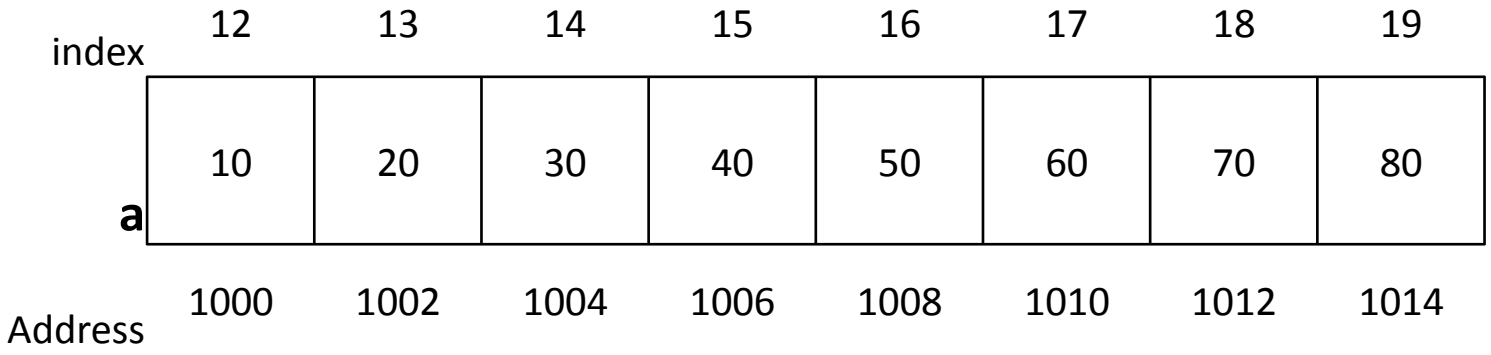
= 1006.

Length of Array

Length = upperbound – lowerbound + 1

Where, upperbound is the last index of array
lowerbound is the first index of array

e.g.



Length = 19 – 12 + 1 = 8.

Operations of Array { **traversal**, insertion, deletion, merging, searching }

1. **Traversal**

   A is the array

   lowerbound is starting index

   upperbound is last index

step 1: set i = lowerbound

step 2: Repeat step 2 to step 4 while i <= upperbound

step 3: print (A[i])

step 4: set i = i + 1

step 5: Exit.

Operations of Array
{ traversal, **insertion**, deletion, merging, searching }

2. Insertion

I) at the end of Array

II) middle of Array

(I) Insertion at the end of Array

Simply add new element at end of array

step 1: upperbound = upperbound + 1

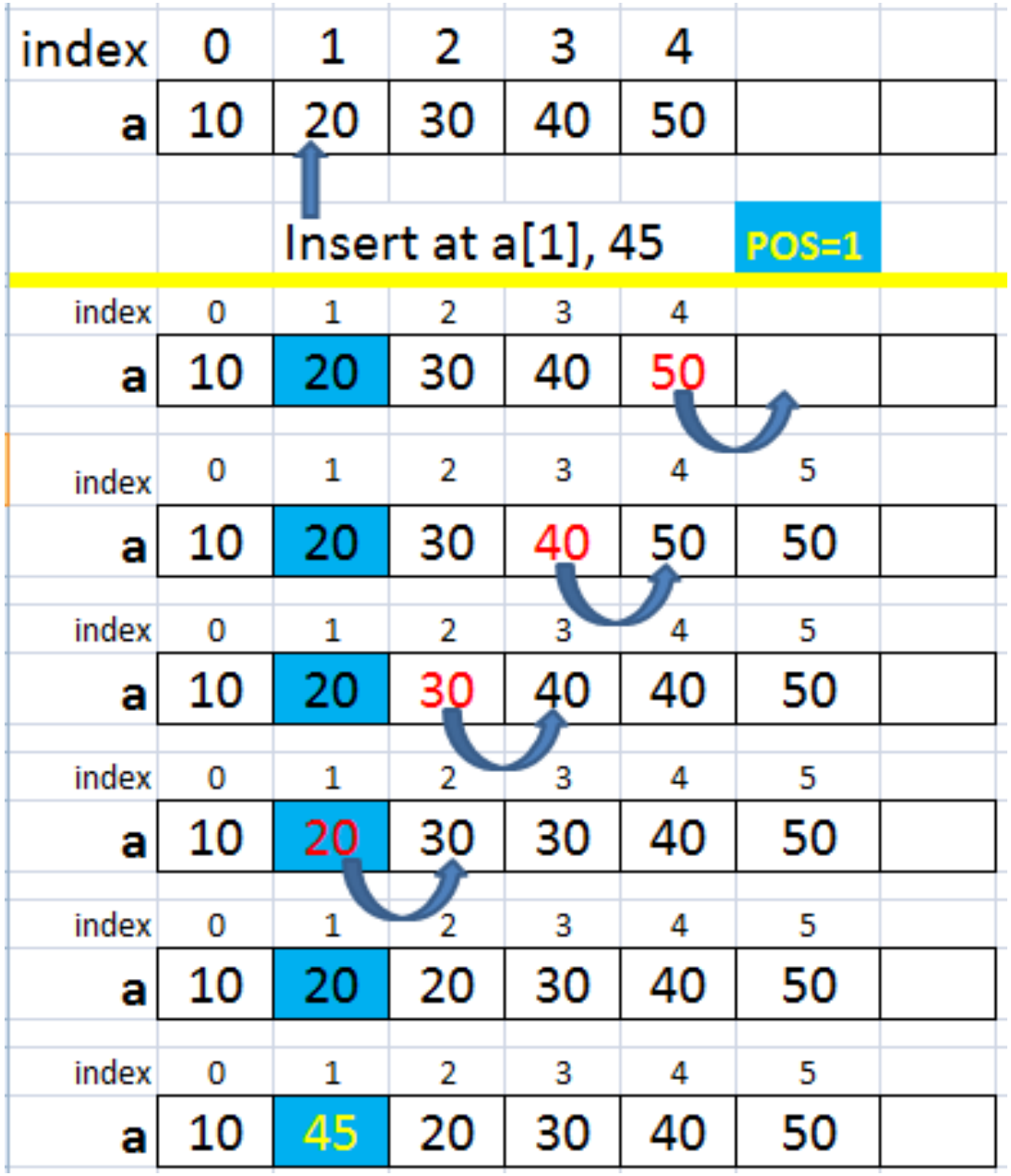
step 2: a[upperbound] = new_value

step 3: Exit.

(II) Insertion at Middle of Array

Operations of Array
{ traversal, **insertion**, deletion, merging, searching }

(II) Insertion at Middle of Array



Operations of Array { traversal, **insertion**, deletion, merging, searching }

2. Insertion → I) at the end of Array
→ II) middle of Array

(II) Insertion at Middle of Array

insert (A, N, POS, new_value)

A, the array in which the element has to be inserted

N, number of elements in the array

POS, the position at which the element has to be inserted, and

new_value, the value has to be inserted

step 1: set i = N-1

step 2: Repeat step 2 to step 4 while i >= POS

step 3: set a[i+1] = a[i]

step 4: set i = i – 1

step 5: set N = N + 1

step 6: set a[POS] = new_value

step 7: Exit.

Operations of Array
{ traversal, insertion, **deletion**, merging, searching }

3. Deletion → I) Last element
→ II) middle element

(I) Delete last element

Simply delete last

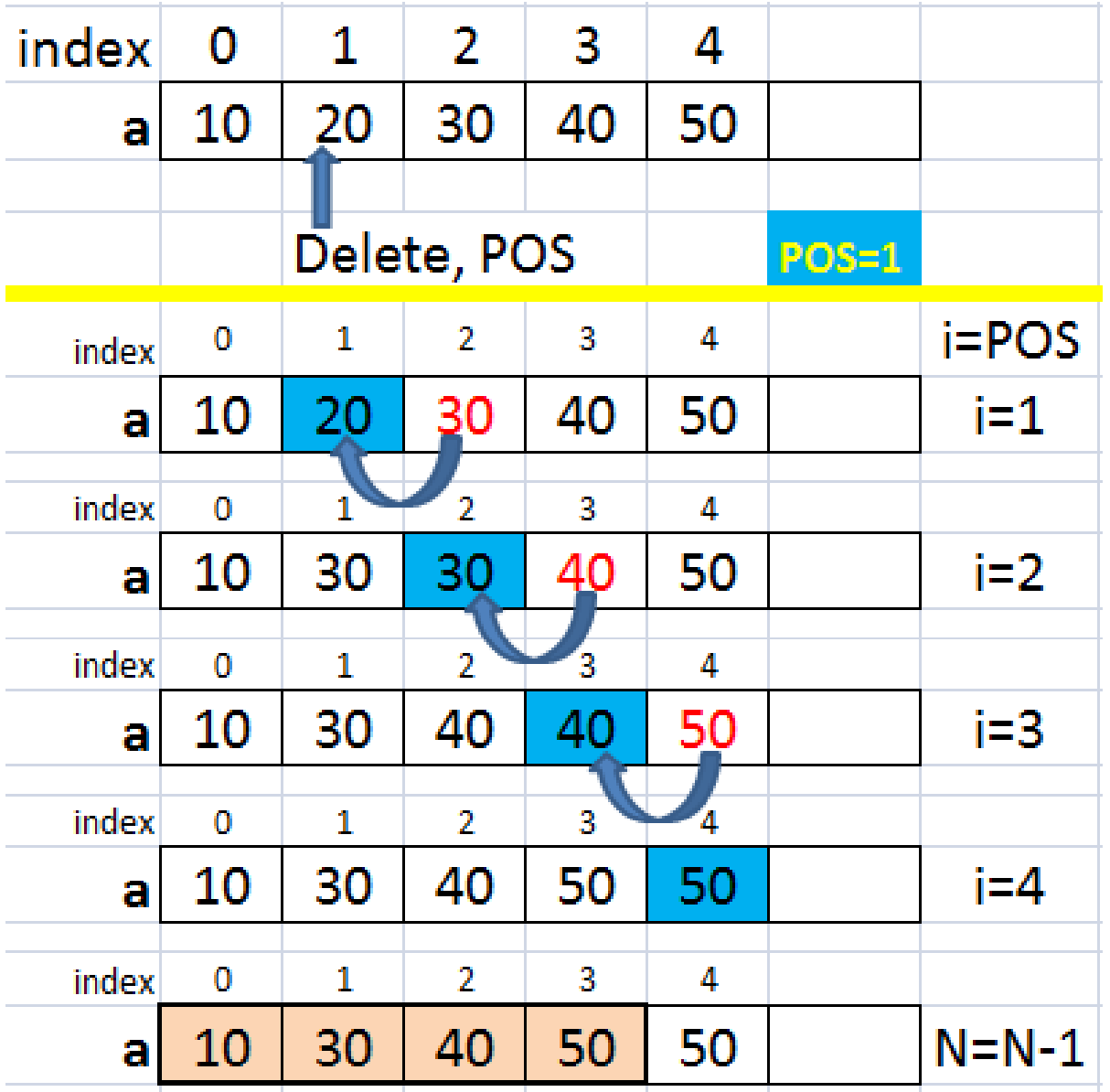
step 1: upperbound = upperbound - 1

step 2: Exit.

(II) Delete middle element

Operations of Array { traversal, insertion, **deletion**, merging, searching }

(II) Delete middle element



Operations of Array { traversal, insertion, **deletion**, merging, searching }

3. Deletion → I) Last Element
→ II) Middle Element

(II) Delete Middle Element

delete (A, N, POS)

A, the array in which the element has to be inserted

N, number of elements in the array

POS, the position at which the element has to be deleted

step 1: set i = POS

step 2: Repeat step 2 to step 4 while i < N-1

step 3: set a[i] = a[i+1]

step 4: set i = i + 1

step 5: set N = N – 1

step 6: Exit.

Operations of Array { traversal, insertion, deletion, **merging**, searching }

4. Merging

two unsorted array

A

10	50	20	40

B

30	5	15	9

C = A B

10	50	20	40	30	5	15	9

two sorted array

A

10	20	40	50

B

5	9	15	30

C = if A < B, then A else B; for all elements

5	9	10	15	20	30	40	50

Operations of Array { traversal, insertion, deletion, merging, **searching** }

- **5. Searching** → **(I) Linear Search**
  → **(II) Binary Search**

(I) Linear Search

linear_search (A, N, Value, POS)

A, is the array
N, number of elements in the array
Value, is the data which we want to search
POS, is the index of searched data

step 1: set POS = -1 , i = 0

step 2: Repeat steps 3 while i < N

step 3: if A[i] = Value then
set POS = i
print POS
goto step 5

step 4: print “Value is not present in Array”

step 5: Exit.

Operations of Array
{ traversal, insertion, deletion, merging, **searching** }

(II) Binary Search

binary_search (A, lb, ub, Value, POS)

A, is the array
lb, is the starting index of array
ub, is the last index of array
Value, is the data which we want to search
POS, is the index of searched data

step 1: set POS = -1, beg = lb, end = ub
step 2: Repeat steps 2 to step 4 while beg <= end
step 3: set mid = (beg+end) / 2
step 4: if A[mid] = Value
POS = mid
print POS
goto step 6
if Value < A[mid]
end = mid – 1
else beg = mid + 1
step 5: if POS = -1, then
print “Value is not present in Array”
step 6: Exit.

1D Array for Inter-Function Communication

1. Passing Individual Element
   (i) Passing Data Value
   (ii) Passing Address

2. Passing the Entire Array

1D Array for Inter-Function Communication

1. Passing Individual Element

(i) Passing Data Value

```
void fun(int);
void main( )
{
      int a[5] = {1,2,3,4,5};
      fun(a[3]);
}
```

Function declaration

Calling function

```
void fun(int num)
{
      printf("%d",num);
}
```

Called function

****

(ii) Passing Address

```
void fun(int*);
void main( )
{
      int a[5] = {1,2,3,4,5};
      fun(&a[3]);
}
```

Function declaration

Calling function

```
void fun(int *num)
{
      printf("%d", *num);
}
```

Called function

1D Array for Inter-Function Communication

2. Passing the entire Array

Function declaration

```
void fun(int [ ]);
void main( )
{
      int a[5] = {1,2,3,4,5};
      fun(a);
}
```

Calling function

Called function

```
void fun(int b[ ])
{
      int i;
      for(i=0;i<5;i++)
            printf("%d,",b[i]);
}
```

Pointers and Arrays

```
int a[5] = {1,2,3,4,5};
int *ptr;
ptr = &a[0];
ptr = &a[2];
ptr = a;
```

Note that a[i] = *(a+i)

Pointers of Arrays

```
int *ptr[3];
int a=5, b=7, c=10;
ptr [0]= &a;
ptr [1]= &b;
ptr [2]= &c;
printf("%d", *ptr[1]);
```

2D Arrays

- **Declaration of 2D Array:**

data_type array_name [rowsize] [colsize];

int marks[3][3];

marks			
	00	01	02
	10	11	12
	20	21	22

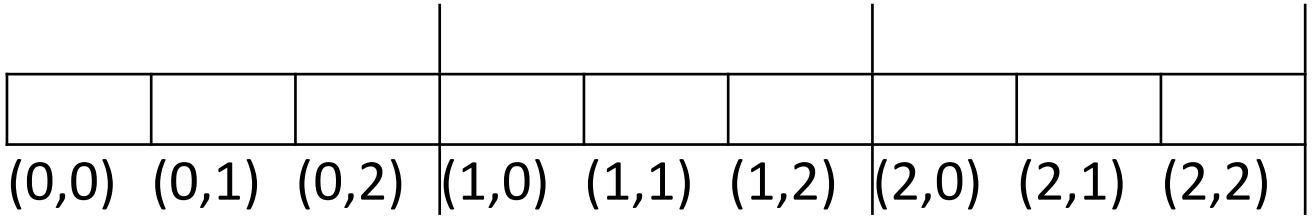
These elements are stored sequentialy; Two ways:

(i) Row Major Order (RMO)

(ii) Column Major Order (CMO)

2D Arrays

(i) Row Major Order (RMO)



A[M][N];

Address A[i, j] = BaseAddress + w*{ N(i-1) + (j-1)}

Where, w is the # of words stored per memory location

N is the number of elements in one Row (num of Columns)

i and j are the subscripts of array element

Example 1: A[20][5], Base Address=1000, number of words per memory location = 2, Compute the address of element, A[18,4]. Assume, the elements are stored in RMO.

2D Arrays

(I) Row Major Order (RMO)

Example 1: A[20][5], Base Address=1000, number of words per memory location = 2, Compute the address of element, A[18,4]. Assume, the elements are stored in RMO.

Solution:

Address of A[i, j] = BaseAddress + w * [N*(i-1) + (j-1)]

Address of A[18,4] = 1000 + 2 * [5 * (18-1) + (4-1)]

= 1000 + 2 * [85 + 3]

= 1176

Example 2: A[10][5], Base Address=2000, number of words per memory location = 2, Compute the address of element, A[8,5]. Assume, the elements are stored in RMO.

Ans:

Address of A[8,5] = 2078.

Example 3: A[10][10], Base Address=1000, number of words per memory location = 2, Compute the address of element, A[8,5]. Assume, the elements are stored in RMO.

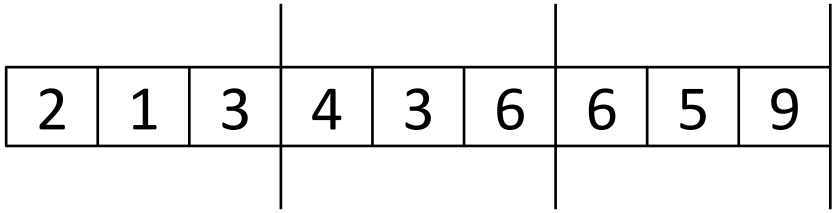
Ans:

Address of A[8,5] = 1148.

2D Arrays

(II) Column Major Order (CMO)

2	4	6
1	3	5
3	6	9



For MxN Matrix,

Address of A[i, j] = BaseAddress + w * [M*(j-1) + (i-1)]

Example 1: A[10][10], Base Address=1000, number of words per memory location = 2, Compute the address of element, A[8,5]. Assume, the elements are stored in CMO.

Solution:

Address of A[i, j] = BaseAddress + w * [M *(j-1) + (i-1)]

Address of A[8,5] = 1000 + 2 * [10 * (5-1) + (8-1)]

= 1000 + 2 * [40 + 7]

= 1094

2D Arrays

- **Initialization of 2D Array**

  int A[2][3] = {1,2,3,4,5,6};

  int A[2][3] = { {1,2,3}, {4,5,6}};

  Only the size of first dimension can be omitted.

  int A[ ] [3] = { {1,2,3}, {4,5,6}};

  int A[2][3] = {0};

- **Accessing the Elements**
  - Using two FOR loops

2D Arrays

- **Operations on 2D Array**

1) Transpose: A is MxN then B is NxM where, $B_{i,j} = A_{j,i}$

2) Sum: $C_{i,j} = A_{i,j} + B_{i,j}$

3) Difference: $C_{i,j} = A_{i,j} - B_{i,j}$

4) Product: A is M x N

   B is P x Q

   if N = P then $C_{i,j} = \sum A_{i,k} B_{k,j}$, for k = 1 to N

Quiz

Which of the following C expressions access the $(i, j)^{th}$ entry of an (m × n) matrix stored in column major order both row and column starting index is 1?

a). $n \times (i - 1) + j$
b). $m \times (j - 1) + i$
c). $m \times (n - j) + j$
d). $n \times (m - i) + j$