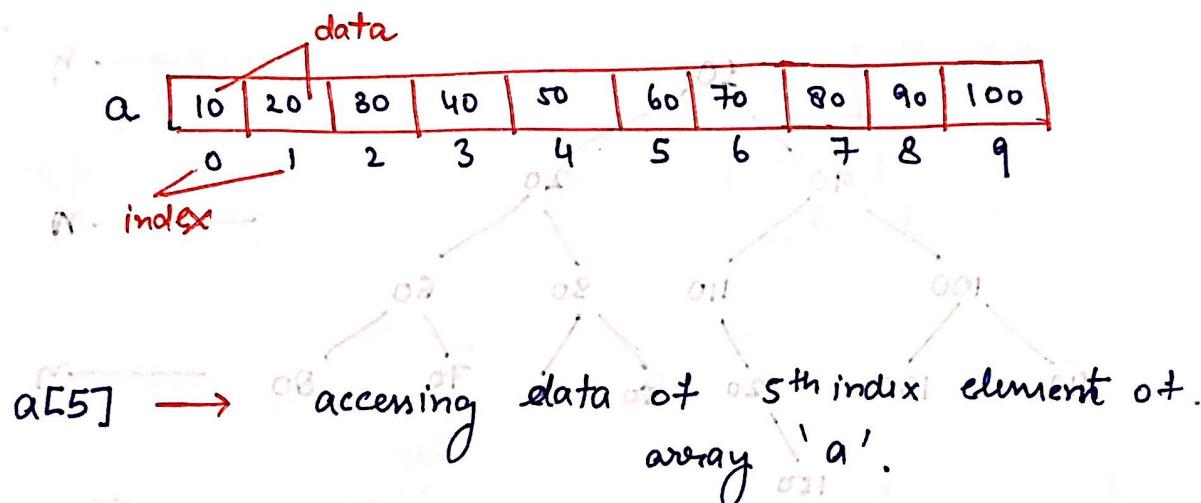
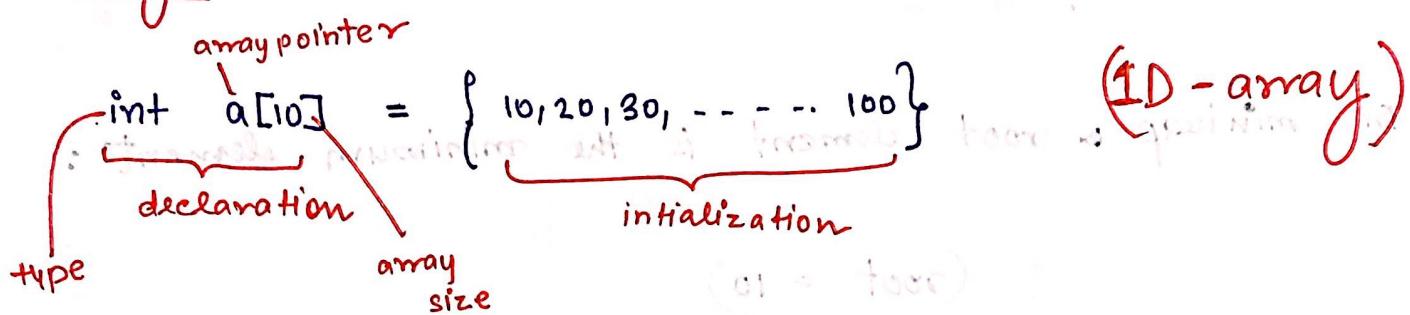


# DATA STRUCTURE (Programming)

= Array :-



`& a[5] → return address of that element`  
*return operator*

`*(& a[5]) → return data of returned address`

Q:  $a = \{ 55, \dots, 125 \}$  ; Base Add: 1000  
 index  
 size of an element = 10  
 Find Loc( $a[119]$ ) ?

$$n = 125 - 55 + 1 = 71$$

$$\text{LOC} = 1000 + \cancel{1000} (119 - 55) 10 \\ = \underline{\underline{1640}}$$

Q.  $a = [-125, -124, \dots, -1, 0, \dots, +125] - BA = 0, S = 1$

Find LOC( $a[-3]$ )

$$\text{LOC} = 0 + (-3 + 125) \times 1 = \underline{\underline{122}}$$

NOTE:-

$\text{Loc}(a[i]) = \text{LB} + (i - \text{LB}) * \text{S}$

Lower Bound      upper Bound      Base Add      size of each element

$$\left( \text{Loc}(a[i]) = \text{LB} + (i - \text{LB}) * \text{S} \right)$$

By default, array index start from zero, not from one  
there is ~~no i~~  
because no need to calculate offset value.

$$(2 \times [(-5 + 0)(1 - 0)]) + 4800 = (\text{EndMem}) \text{ loc}$$

$i - LB$       when  $LB = 0$

$$i - 0 = i \quad (\text{no need to perform SUB opn})$$

## (2-D Array):-

`int a[4][3];`

no. of rows  
8 - 4

no. of columns  
{1 - 3}

a	1	2	3
1	a <sub>11</sub>	a <sub>12</sub>	a <sub>13</sub>
2	a <sub>21</sub>	a <sub>22</sub>	a <sub>23</sub>
3	a <sub>31</sub>	a <sub>32</sub>	a <sub>33</sub>
4	a <sub>41</sub>	a <sub>42</sub>	a <sub>43</sub>

matrix representation

$$\text{Total memory slots} = m \times n \\ = 4 \times 3 = 12$$

a	1000	00	02	04	06	08	10	12	14	16	18	20	22
		0	1	2	3	4	5	6	7	8	9	10	11
a <sub>11</sub>	a <sub>12</sub>	a <sub>13</sub>	a <sub>21</sub>	a <sub>22</sub>	a <sub>23</sub>	a <sub>31</sub>	a <sub>32</sub>	a <sub>33</sub>	a <sub>41</sub>	a <sub>42</sub>	a <sub>43</sub>		

Memory representation (Row major order)

$$\text{LOC}(a[4][3]) = 1000 + [(4-1)(3) + (3-1)] \times 2 \\ = 1022$$

NOTE:- (row-major order)  
In row-major order, memory is stored in row-wise fashion.

$$\text{LOC}(a[m][n]) = BA + [(m-1)c + n-1] \times s$$

BA → Base Address  
m → no. of rows  
n → no. of columns  
s → size of each element  
(int = 2)

$$Q: A = \{ 25, \dots, 500, 125, \dots, 300 \}; BA = 1500 \\ S = 10 B$$

$$\text{Find } \text{Loc}(A[350][200])$$

$$\text{Loc}_{(r,s)} = (B_A)(c_s) + \left[ (m - LB_r)(c_c) + (n - LB_c) \right] S$$

$$\begin{aligned} \text{Loc}_{(350, 200)} &= 500 + \left[ (350 - 25)(176) + (200 - 125) \right] 10 \\ &= 500 + [57200 + 75] 10 \\ &= \underline{\underline{(573250)}} \end{aligned}$$

$$Q: A = \{ -75, \dots, -25, -575, \dots, -100 \}; BA = 0$$

$$\text{Find } \text{Loc}(A[-30][-175])$$

$$\text{Loc} = 0 + \left[ (-30 + 75)(376) + (-175 + 575) \right] \times 1$$

$$= 0 + [16920 + 400] \times 1$$

$$= \underline{\underline{(17320)}}$$

(3-D Array) :-

$$A [ \underbrace{9 \dots 15}_{\text{no. of } n_a \text{ array}}, \underbrace{3 \dots 20}_{\text{no. of row}} , \underbrace{7 \dots 17}_{\text{no. of column}} ] ; BA = 1000 ; S = 10$$

$\downarrow \quad \quad \quad \downarrow \quad \quad \quad \downarrow$   
7      18      11

$$\text{LOC}_{A[i][j][k]} = BA + [(i-LB_1)(n_r \times n_c) + (j-LB_2)(n_c) + (k-LB_3)] \times S$$

row major

$$\begin{aligned} \text{LOC}_{[A[13][15][12]]} &= 1000 + [(13-9)(18 \times 11) + (15-3)(11) + (12-7)] \times 10 \\ &= 1000 + [792 + 132 + 5] \times 10 \\ &= 10290 \end{aligned}$$

$$\text{LOC}_{A[i][j][k]} = BA + [(i-LB_1)(n_r \times n_c) + (k-LB_3)(n_r) + (j-LB_2)] \times S$$

column major

$$\begin{aligned} \text{so, LOC}_{[A[13][15][12]]} &= 1000 + [(13-9)(18 \times 11) + (15-3) + (12-7)(18)] \times 10 \\ &= 1000 + [792 + 12 + 90] \times 10 \\ &= \underline{\underline{9940}} \end{aligned}$$

## (Lower Triangular Matrix) :-

$$A[1 \dots 4, 1 \dots 4] \Rightarrow$$

	1	2	3	4
1	$a_{11}$	0	0	0
2	$a_{21}$	$a_{22}$	0	0
3	$a_{31}$	$a_{32}$	$a_{33}$	0
4	$a_{41}$	$a_{42}$	$a_{43}$	$a_{44}$

non zeros

zeros

$$\text{No. of non-zeros} = a_{11} + \dots + a_{21} + a_{22} + \dots$$

$$a_{31} + a_{32} + a_{33} + \dots = 2$$

$$a_{41} + a_{42} + a_{43} + a_{44} = 3$$

$$= 1 + 2 + 3 + \dots + n$$

$$= \frac{n(n+1)}{2}$$

To store these type of array efficiently, store only non-zero elements.

$$\text{for } n=4, \text{ no. of slots} = \frac{4(4+1)}{2} = 2 \times 5 = 10$$

$a_{11}$	$a_{21}$	$a_{22}$	$a_{31}$	$a_{32}$	$a_{33}$	$a_{41}$	$a_{42}$	$a_{43}$	$a_{44}$
0	1	2	3	4	5	6	7	8	9

$$01(21+0231) + 0001 =$$

$$0001 + 02081 = 02082$$

$$\text{LOC}(A[i][j]) = \begin{cases} 0 & \text{if } i < j \\ BA + \left( \frac{i(i-1)}{2} + (j-1) \right) \times S & \text{row major} \end{cases}$$

Sum of  $(i-1)$  rows

so,

$$\begin{aligned} \text{LOC}(A[4][3]) &= 1000 + \left( \frac{4(3)}{2} + (3-1) \right) \times 2 \\ &= 1000 + (6+2)(2) \\ &= \boxed{1016} \end{aligned}$$

Q. Consider a Lower triangular matrix: (row major order)

$$A [25 \dots 95, \quad 25 \dots 95] \quad BA = 1000, \quad S = 10 \quad B$$

$n_r = 71 \quad n_c = 71$

Find  $\text{LOC}(A[85][70])$

$$i = 85 - 25 + 1 = 61$$

$$j = 70 - 25 + 1 = 16$$

$$\begin{aligned} \text{LOC}(A[85][70]) &= 1000 + \left( \frac{60(61)}{2} + 15 \right) 10 \\ &= 1000 + (1830 + 15) 10 \\ &= 18450 + 1000 \\ &= \boxed{19450} \end{aligned}$$

$$\text{Loc}[i][j] = \begin{cases} 0 & \text{if } i < j \\ BA + \left[ \frac{(i-1) + j(j-1)}{2} \right] \times s \\ BA + \left[ \frac{n(n+1)}{2} - \frac{(n-j+1)(n-j+2)}{2} + \frac{(i-j)}{2} \right] \times s \end{cases}$$

column major order

Q.  $A [25 \dots 95, 25, \dots, 95]$ ;  $BA = 0$  ( $i, j = 5$ )

Find  $\text{Loc}(A[85][50])$

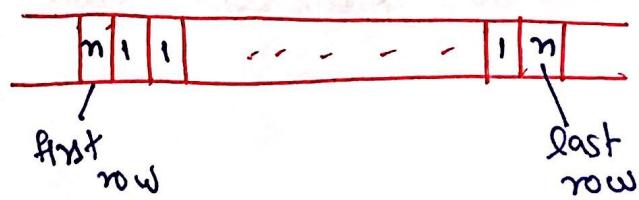
$$\begin{aligned} \text{Loc}(A[85][50]) &= 0 + \left[ \frac{71 \times 72}{2} - \frac{(25 \times 25)}{2} + 15 \right] \times 5 \\ &= [2556 - 351 + 15] \times 5 \end{aligned}$$

(Z-matrix) :-

	1	2	3	4
1	$a_{11}$	$a_{12}$	$a_{13}$	$a_{14}$
2	0	0	$a_{23}$	0
3	0	$a_{32}$	0	0
4	$a_{41}$	$a_{42}$	$a_{43}$	$a_{44}$

$$\text{no. of non-zero elements} = n + n + n - 2$$

$$= (3n - 2)$$



~~row-major :-~~

~~50x50~~

$$\text{Loc}(A[50][23]) = BA + (m + (50-1))$$

First - row

Last - row

Diagonal



$$\text{Loc}(a[i][j])$$

(i) if  $i = 1$  row

$$(\text{Loc} = BA + j - LB)$$

(ii)  $\left[ \begin{array}{l} \text{if } i == \text{Last - row} \\ \text{Loc} = BA + n + j - LB \end{array} \right] + 0 \Rightarrow (\text{Loc}(26)A) \text{ sol.}$

$$2 \times [ \text{if } i == \text{Last - row} ] + 0 \Rightarrow (\text{Loc}(26)A) \text{ sol.}$$

(iii)  $(\text{Loc} = BA + 2n + \text{Column work})$

+ m + n = outer-loop

loop + 1 iteration

inner loop

if  $i < m$  then  
row work

