The 2-dimensional arrays are stored as 1-dimensional arrays in the computer's memory.

There are two ways to achieve this:

Row-major Implementation

In this method, the first row elements are placed first, then the second row elements and so on.

The formula to calculate the address of [I, J]th block is:

Address of $[I, J]^{th}$ element in row-major $= B + W[C(I - L_r) + (J - L_c)]$

Column-major Implementation

In this method, the first column elements are placed first, then the second column elements and so on.

The formula to calculate the address of [I, J]th block is:

Address of $[I, J]^{th}$ element in column-major $= B + W[R(J - L_c) + (I - L_r)]$
Note that:
B is the base address (address of the first block in the array).
W is the width in bytes (size in bytes for each block in the array).
L_r is the index of the first row.
L_c is the index of the first column.
R is the total number of rows.
C is the total number of columns.

Solved Questions based on Array Implementation

ISC Year 2020: A matrix B[10][20] is stored in the memory with each element requiring 2 bytes of storage. If the base address at B[2][1] is 2140, find the address of B[5][4] when the matrix is stored in Column Major Wise.

Address of [I, J]th element in column-major = $B + W[R(J – L_c) + (I – L_r)]$
$= 2140 + 2[10(4 – 1) + (5 – 2)]$
$= 2140 + 2[10 \times 3 + 3]$
$= 2140 + 2[30 + 3]$
$= 2140 + 2[33]$
$= 2140 + 66$
$= 2206$

ISC 2020 Specimen: Each element of an array arr[15][20] requires 'W' bytes of storage. If the address of arr[6][8] is 4440 and the base address at arr[1][1] is 4000, find the width 'W' of each cell in the array arr[][] when the array is stored as Column Major Wise.

Address of [I, J]th element in column-major = $B + W[R(J – L_c) + (I – L_r)]$
$\Rightarrow 4440 = 4000 + W[15(8 – 1) + (6 – 1)]$
$\Rightarrow 4440 = 4000 + W[15(7) + 5]$
$\Rightarrow 4440 = 4000 + W[105 + 5]$
$\Rightarrow 4440 = 4000 + W[110]$
$\Rightarrow W[110] = 440$
$\Rightarrow W = 4.$

ISC Year 2019: A matrix ARR[-4…6, 3…8] is stored in the memory with each element requiring 4 bytes of storage. If the base address is 1430, find the address of ARR[3][6] when the matrix is stored in Row Major Wise.

Number of columns, C = 8 – 3 + 1 = 6.
Address of [I, J]th element in row-major = $B + W[C(I – L_r) + (J – L_c)]$
⇒ Address of ARR[3][6] = $1430 + 4[6(3 – (-4)) + (6 – 3)]$
⇒ Address of ARR[3][6] = $1430 + 4[6(3 + 4) + 3]$
⇒ Address of ARR[3][6] = $1430 + 4[6(7) + 3]$
⇒ Address of ARR[3][6] = $1430 + 4[42 + 3]$
⇒ Address of ARR[3][6] = $1430 + 4[45]$

⇒ Address of ARR[3][6] = 1430 + 180
⇒ Address of ARR[3][6] = 1610.

ISC Year 2018: A matrix A[m][m] is stored in the memory with each element requiring 4 bytes of storage. If the base address at A[1][1] is 1500 and the address of A[4][5] is 1608, determine the order of the matrix when it is stored in Column Major Wise.

Address of [I, J]th element in column-major = $B + W[R(J - L_c) + (I - L_r)]$
⇒ 1608 = 1500 + 4[m(5 – 1) + (4 – 1)]
⇒ 1608 = 1500 + 4[m(4) + 3]
⇒ 1608 = 1500 + 16m + 12
⇒ 1608 = 1512 + 16m
⇒ 16m = 96
⇒ m = 6.

ISC Year 2017: A matrix P[15][10] is stored with each element requiring 8 bytes of storage. If the base address at P[0][0] is 1400, determine the address at P[10][7] when the matrix is stored in Row Major Wise.

Address of [I, J]th element in row-major = $B + W[C(I - L_r) + (J - L_c)]$
⇒ Address at P[10][7] = 1400 + 8[10(10 – 0) + (7 – 0)]
⇒ Address at P[10][7] = 1400 + 8[10(10) + 7]
⇒ Address at P[10][7] = 1400 + 8[100 + 7]
⇒ Address at P[10][7] = 1400 + 8[107]
⇒ Address at P[10][7] = 1400 + 856
⇒ Address at P[10][7] = 2256.

ISC Year 2016: A matrix A[m][n] is stored with each element requiring 4 bytes of storage. If the base address at A[1][1] is 1500 and the address at A[4][5] is 1608, determine the number of rows of the matrix when the matrix is stored in Column Major Wise.

Address of [I, J]th element in column-major = $B + W[R(J – L_c) + (I – L_r)]$
⇒ $1608 = 1500 + 4[R(5 – 1) + (4 – 1)]$
⇒ $1608 = 1500 + 4[4R + 3]$
⇒ $1608 = 1500 + 16R + 12$
⇒ $1608 = 1512 + 16R$
⇒ $16R = 96$
⇒ $R = 6$.

ISC Year 2015: The array D[-2…10][3…8] contains double type elements. If the base address is 4110, find the address of D[4][5], when the array is stored in Column Major Wise.

Number of rows, $R = 10 – (-2) + 1 = 13$.
Address of [I, J]th element in column-major = $B + W[R(J – L_c) + (I – L_r)]$
⇒ Address of D[4][5] = $4110 + 8[13(5 – 3) + (4 – (-2))]$
⇒ Address of D[4][5] = $4110 + 8[13(2) + (4 + 2)]$
⇒ Address of D[4][5] = $4110 + 8[26 + 6]$
⇒ Address of D[4][5] = $4110 + 8[32]$
⇒ Address of D[4][5] = $4110 + 256$
⇒ Address of D[4][5] = 4366.

ISC Year 2014: An array AR[-4 … 6, -2 … 12], stores elements in Row Major Wise, with the address AR[2][3] as 4142. If each element requires 2 bytes of storage, find the Base address.

Number of columns, $C = 12 – (-2) + 1 = 12 + 2 + 1 = 15$.
Address of [I, J]th element in row-major = $B + W[C(I – L_r) + (J – L_c)]$
⇒ $4142 = B + 2[15(2 – (-4)) + (3 – (-2))]$
⇒ $4142 = B + 2[15(2 + 4) + (3 + 2)]$
⇒ $4142 = B + 2[15(6) + 5]$
⇒ $4142 = B + 2[90 + 5]$
⇒ $4142 = B + 2[95]$
⇒ $4142 = B + 190$
⇒ $B = 3952$.

ISC Year 2013: A square matrix M[][] of size 10 is stored in the memory with each element requiring 4 bytes of storage. If the base address at M[0][0] is 1840, determine the address at M[4][8] when the matrix is stored in Row Major Wise.

Address of [I, J]th element in row-major = $B + W[C(I - L_r) + (J - L_c)]$
$\Rightarrow$ Address at M[4][8] = $1840 + 4[10(4 - 0) + (8 - 0)]$
$\Rightarrow$ Address at M[4][8] = $1840 + 4[10(4) + 8]$
$\Rightarrow$ Address at M[4][8] = $1840 + 4[40 + 8]$
$\Rightarrow$ Address at M[4][8] = $1840 + 4[48]$
$\Rightarrow$ Address at M[4][8] = $1840 + 192$
$\Rightarrow$ Address at M[4][8] = 2032.

ISC Year 2012: A matrix B[10][7] is stored in the memory with each element requiring 2 bytes of storage. If the base address at B[x][1] is 1012 and the address at B[7][3] is 1060, determine the value 'x' where the matrix is stored in Column Major Wise.

Address of [I, J]th element in column-major = $B + W[R(J - L_c) + (I - L_r)]$
$\Rightarrow 1060 = 1012 + 2[10(3 - 1) + (7 - x)]$
$\Rightarrow 1060 = 1012 + 2[10(2) + 7 - x]$
$\Rightarrow 1060 = 1012 + 2[20 + 7 - x]$
$\Rightarrow 1060 = 1012 + 2[27 - x]$
$\Rightarrow 1060 = 1012 + 54 - 2x$
$\Rightarrow 1060 = 1066 - 2x$
$\Rightarrow -2x = -6$
$\Rightarrow x = 3.$

ISC Year 2011: A square matrix A [m × m] is stored in the memory with each element requiring 2 bytes of storage. If the base address at A[1][1] is 1098 and the address at A[4][5] is 1144, determine the order of the matrix A[m × m] when the matrix is stored in Column Major Wise.

Address of [I, J]th element in column-major = $B + W[R(J - L_c) + (I - L_r)]$
$\Rightarrow 1144 = 1098 + 2[m(5 - 1) + (4 - 1)]$
$\Rightarrow 1144 = 1098 + 2[m(4) + 3]$
$\Rightarrow 1144 = 1098 + 8m + 6$
$\Rightarrow 1144 = 1104 + 8m$
$\Rightarrow 8m = 40$
$\Rightarrow m = 5.$

ISC Year 2010: A character array B[7][6] has a base address 1046 at 0, 0. Calculate the address at B[2][3] if the array is stored in Column Major Wise. Each character requires 2 bytes of storage.

Address of [I, J]th element in column-major = $B + W[R(J - L_c) + (I - L_r)]$
$\Rightarrow$ Address at B[2][3] = $1046 + 2[7(3 - 0) + (2 - 0)]$
$\Rightarrow$ Address at B[2][3] = $1046 + 2[7(3) + 2]$
$\Rightarrow$ Address at B[2][3] = $1046 + 2[21 + 2]$
$\Rightarrow$ Address at B[2][3] = $1046 + 2[23]$
$\Rightarrow$ Address at B[2][3] = $1046 + 46$
$\Rightarrow$ Address at B[2][3] = 1092.

ISC Year 2009: Each element of an array A[20][10] requires 2 bytes of storage. If the address of A[6][8] is 4000, find the base address at A[0][0] when the array is stored in Row Major Wise.

Address of [I, J]th element in row-major = $B + W[C(I - L_r) + (J - L_c)]$
$\Rightarrow 4000 = B + 2[10(6 - 0) + (8 - 0)]$
$\Rightarrow 4000 = B + 2[10(6) + 8]$
$\Rightarrow 4000 = B + 2[60 + 8]$

$\Rightarrow 4000 = B + 2[68]$
$\Rightarrow 4000 = B + 136$
$\Rightarrow B = 3864.$

ISC Year 2008: A two-dimensional array defined as X[3…6, -2…2] requires 2 bytes of storage space for each element. If the array is stored in Row Major Wise order, determine the address of X[5][1], given the base address as 1200.

Number of columns, $C = 2 - (-2) + 1 = 5$.
Address of $[I, J]^{th}$ element in row-major $= B + W[C(I - L_r) + (J - L_c)]$
$\Rightarrow$ Address of $X[5][1] = 1200 + 2[5(5 - 3) + (1 - (-2))]$
$\Rightarrow$ Address of $X[5][1] = 1200 + 2[5(2) + (3)]$
$\Rightarrow$ Address of $X[5][1] = 1200 + 2[13]$
$\Rightarrow$ Address of $X[5][1] = 1200 + 26$
$\Rightarrow$ Address of $X[5][1] = 1226.$