2-d Arrays

Two Dimensional Arrays

- We have seen that an array variable can store a list of values
- Many applications require us to store a table of values

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
Student 1	75	82	90	65	76
Student 2	68	75	80	70	72
Student 3	88	74	85	76	80
Student 4	50	65	68	40	70

Contd.

- The table contains a total of 20 values, five in each line
  - The table can be regarded as a matrix consisting of four rows and five columns
- C allows us to define such tables of items by using two-dimensional arrays

Declaring 2-D Arrays

- General form:

  type array_name [row_size][column_size];

- Examples:

  int marks[4][5];

  float sales[12][25];

  double matrix[100][100];

Initializing 2-d arrays

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

All of the above will give the 2x3 array

1 2 3
4 5 6

Accessing Elements of a 2-d Array

- Similar to that for 1-d array, but use two indices
  - First indicates row, second indicates column
  - Both the indices should be expressions which evaluate to integer values (within range of the sizes mentioned in the array declaration)
- Examples:

```
x[m][n] = 0;
c[i][k] += a[i][j] * b[j][k];
a = sqrt (a[j*3][k]);
```

Example

int a[3][5];

A two-dimensional array of 15 elements

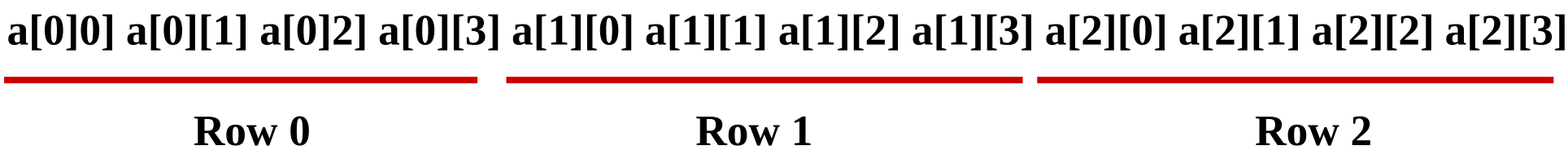
Can be looked upon as a table of 3 rows and 5 columns

	col0	**col1**	**col2**	**col3**	**col4**
row0	a[0][0]	a[0][1]	a[0][2]	a[0][3]	a[0][4]
row1	a[1][0]	a[1][1]	a[1][2]	a[1][3]	a[1][4]
row2	a[2][0]	a[2][1]	a[2][2]	a[2][3]	a[2][4]

How is a 2-d array is stored in memory?

- Starting from a given memory location, the elements are stored row-wise in consecutive memory locations (row-major order)
  - x: starting address of the array in memory
  - c: number of columns
  - k: number of bytes allocated per array element
- a[i][j] ➔ is allocated memory location at

  address x + (i * c + j) * k



Array Addresses

```
int main()
{
 int a[3][5];
 int i,j;

 for (i=0; i<3;i++)
 {
   for (j=0; j<5; j++) printf("%u\n", &a[i][j]);
   printf("\n");
 }
 return 0;
}
```

Output

```
3221224480
3221224484
3221224488
3221224492
3221224496

3221224500
3221224504
3221224508
3221224512
3221224516

3221224520
3221224524
3221224528
3221224532
3221224536
```

How to read the elements of a 2-d array?

- By reading them one element at a time

```
for  (i=0; i<nrow; i++)
    for  (j=0; j<ncol; j++)
        scanf  (“%f”, &a[i][j]);
```

- The ampersand (&) is necessary
- The elements can be entered all in one line or in different lines

How to print the elements of a 2-d array?

- By printing them one element at a time

```
for  (i=0; i<nrow; i++)
    for  (j=0; j<ncol; j++)
        printf  (“\n %f”, a[i][j]);
```

  - The elements are printed one per line

```
for  (i=0; i<nrow; i++)
    for  (j=0; j<ncol; j++)
        printf  (“%f”, a[i][j]);
```

  - The elements are all printed on the same line

Contd.

```
for  (i=0; i<nrow; i++)
{
    printf  (“\n”);
    for  (j=0; j<ncol; j++)
        printf (“%f   ”, a[i][j]);
 }
```

- The elements are printed nicely in matrix form

Example: Matrix Addition

```
int main()
{
   int  a[100][100], b[100][100],
            c[100][100], p, q, m, n;

   scanf ("%d %d", &m, &n);

   for  (p=0; p<m; p++)
      for  (q=0; q<n; q++)
         scanf ("%d", &a[p][q]);

   for  (p=0; p<m; p++)
      for  (q=0; q<n; q++)
         scanf ("%d", &b[p][q]);

   for  (p=0; p<m; p++)
      for  (q=0; q<n; q++)
         c[p][q] = a[p][q] + b[p][q];

   for  (p=0; p<m; p++)
   {
       printf  ("\n");
       for  (q=0; q<n; q++)
            printf ("%d   ", c[p][q]);
    }
   return 0;
}
```

Passing 2-d Arrays as Parameters

- Similar to that for 1-D arrays
  - The array contents are not copied into the function
  - Rather, the address of the first element is passed
- For calculating the address of an element in a 2-d array, we need:
  - The starting address of the array in memory
  - Number of bytes per element
  - Number of columns in the array
- The above three pieces of information must be known to the function

Example Usage

```
int main()
{
   int  a[15][25],  b[15]25];
   :
   :
   add (a, b, 15, 25);
   :
}
```

```
void  add (int x[][25], int
y[][25], int rows, int cols)
{
   :
}
```

We can also write

int x[15][25], y[15][25];

But at least 2nd dimension must be given

Example: Matrix Addition with Functions

```
void ReadMatrix(int A[][100], int x, int y)
{
     int i, j;
     for  (i=0; i<x; i++)
        for  (j=0; j<y; j++)
            scanf (“%d”, &A[i][j]);
}
```

```
void AddMatrix( int A[][100], int B[][100], int C[][100], int x, int y)
{
     int i , j;
     for  (i=0; i<x; i++)
         for  (j=0; j<y; j++)
             C[i][j] = A[i][j] + B[i][j];
}
```

```
void PrintMatrix(int A[][100], int x, int y)
{
    int i, j;
    printf("\n");
    for  (i=0; i<x; i++)
    {
      for  (j=0; j<y; j++)
          printf (" %5d", A[i][j]);
       printf("\n");
    }
}
```

```
int main()
{
    int  a[100][100], b[100][100],
            c[100][100], p, q, m, n;

    scanf ("%d%d", &m, &n);

   ReadMatrix(a, m, n);
   ReadMatrix(b, m, n);

   AddMatrix(a, b, c, m, n);

   PrintMatrix(c, m, n);
   return 0;
}
```

Practice Problems

1. Write a function that takes a n x n square matrix A as parameter (n < 100) and returns 1 if A is an upper-triangular matrix, 0 otherwise.
2. Repeat 1 to check for lower-triangular matrix, diagonal matrix, identity matrix
3. Write a function that takes as parameter an m x n matrix A (m, n < 100) and returns the transpose of A (modifies in A only).
4. Consider a n x n matrix containing only 0 or 1. Write a function that takes such a matrix and returns 1 if the number of 1's in each row are the same and the number of 1's in each column are the same; it returns 0 otherwise
5. Write a function that reads in an m x n matrix A and an n x p matrix B, and returns the product of A and B in another matrix C. Pass appropriate parameters.

For each of the above, also write a main function that reads the matrices, calls the function, and prints the results (a message, the transposed matrix etc.)