Multi-Dimensional Arrays

Last updated 10/29/20

Multi-Dimensional Arrays

- These slides introduce multi-dimensional arrays
- Upon completion: You should be able to interpret and code using arrays

Multi-Dimensional Arrays

- 2 Dimensional Arrays

  Consider a table

1	2	3	4	5
6	5	4	3	2
12	11	13	14	15
19	17	16	3	1

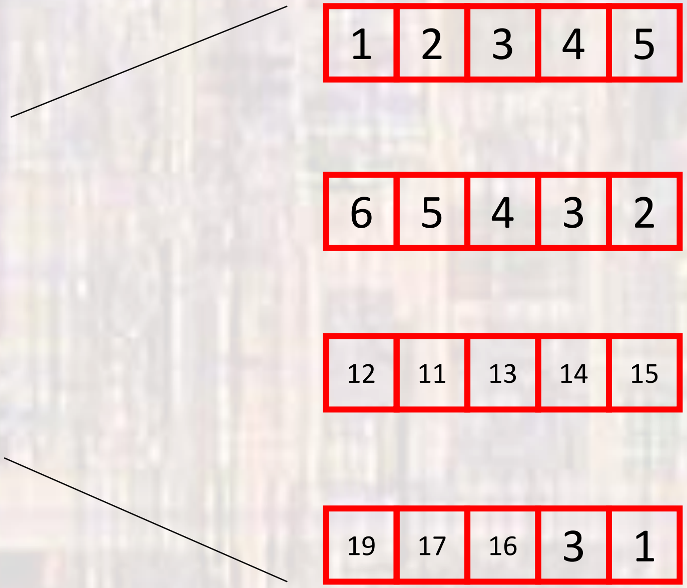
  4 rows x 5 columns

Multi-Dimensional Arrays

- 2 Dimensional Arrays

  Consider a table

1	2	3	4	5
6	5	4	3	2
12	11	13	14	15
19	17	16	3	1



1	2	3	4	5

6	5	4	3	2

12	11	13	14	15

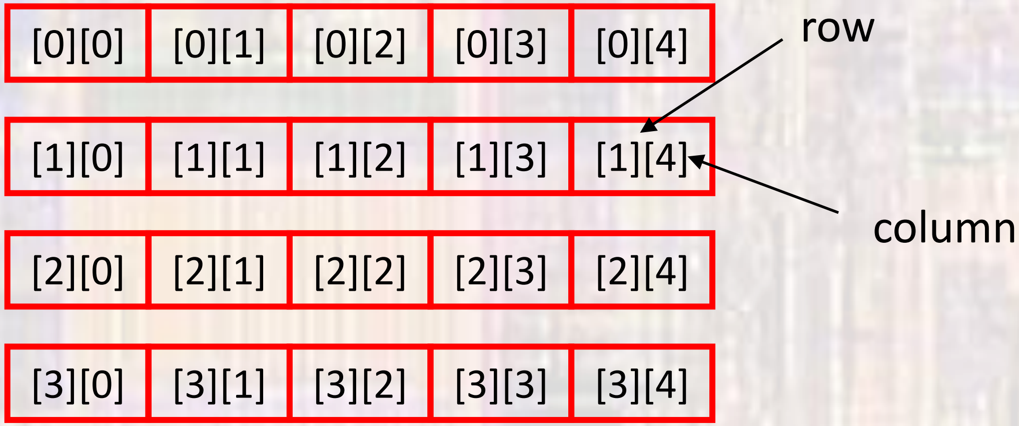
19	17	16	3	1

4 – 1 Dimensional Arrays

Multi-Dimensional Arrays

- 2 Dimensional Arrays

Consider a table



[0][0]	[0][1]	[0][2]	[0][3]	[0][4]
[1][0]	[1][1]	[1][2]	[1][3]	[1][4]
[2][0]	[2][1]	[2][2]	[2][3]	[2][4]
[3][0]	[3][1]	[3][2]	[3][3]	[3][4]

row

column

Array of Arrays – 4x5

Indices are ROW-COL format

Multi-Dimensional Arrays

- 2 Dimensional Arrays

Declaration

```
type arrayName[#rows][#cols];
```

Fixed size array – size known during compilation

```
int scores[4][5];
char first_name[15][20];
```

Variable size array – size only known during execution

```
float testAve[classSize][numTests];
int numAs[gradesGE90][numClasses];
```

where classSize,gradesGE90, numTests, numClasses are integral variables

these are complex – and we will not use them in EE1910

Multi-Dimensional Arrays

- 2 Dimensional Arrays

Initialization

```
type arrayName[#rows][#cols] = {comma separated list};

int myArray[3][4] = {1,2,3,4,1,2,3,4,1,2,3,4};        // basic

int myArray[3][4] = {
                    {1,2,3,4},
                    {1,2,3,4},
                    {1,2,3,4}
                   };                          // preferred

int myArray[3][4] = {0};                       // all zeros
```

Multi-Dimensional Arrays

- 2 Dimensional Arrays

  Accessing elements

```
foo = myArray[1][2];         // foo = 4
foo = myArray[2][foo];       // foo = 15
```

myArray

1	2	3	4	5
6	5	4	3	2
12	11	13	14	15
19	17	16	3	1

```
myArray[0][0] = 0;

foo = 1;
myArray[foo + 1][foo + 2] = 6;
```

0	2	3	4	5
6	5	4	3	2
12	11	13	6	15
19	17	16	3	1

Multi-Dimensional Arrays

- 2 Dimensional Arrays
  - Keyboard example
    - Read the 8 scores for 10 students from the keyboard and store them in a 2 dimensional array

```
int scores[10][8];
int row;
int col;
for(row = 0; row < 10; row++)
    for(col=0; col < 8; col++)
        scanf("%d", &scores[row][col]);
```

notes:

no {} since one line for each for

inner loop – columns (grades)
outer loop – rows (students)
reads all 8 scores for a student
then goes to the next student

&scores[row][col] refers to a single element (address)

Multi-Dimensional Arrays

- 2 Dimensional Arrays
  - Display example
    - Print the scores for 10 students from a 2 dimensional array to the console

```
int row;
int col;
for(row = 0; row < 10; row++){
    for(col=0; col < 8; col++)
        printf("%d", scores[row][col]);
    printf("\n");
}
```

notes:

inner loop – columns (grades)
outer loop – rows (students)
prints all 8 scores for a student
then goes to the next student

Multi-Dimensional Arrays

- 2 Dimensional Arrays
  - Assignment
    - Arrays must be copied element by element

```
int array1[10][8];
int array2[10][8];
…
int row;
int col;
for(row = 0; row < 10; row++)
    for(col=0; col < 8; col++)
        array2[row][col] = array1[row][col];
```

notes:
    order does not matter
    rows or col in outer loop

Multi-Dimensional Arrays

- Arrays in C
  - Example
    - Convert a 2D array to a 1D array

```
int array2D[10][8];
int array1D[80];
```

Multi-Dimensional Arrays

- Arrays in C
  - Example
    - Convert a 2D array to a 1D array

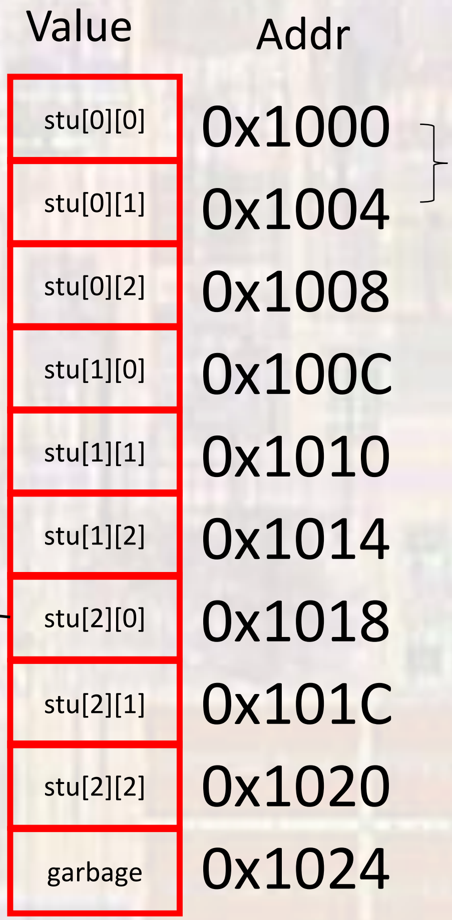
```
int array2D[10][8];
int array1D[80];
…
int row;
int col;
for(row = 0; row < 10; row++)
    for(col=0; col < 8; col++)
        array1D[row*8 + col] = array2D[ row][col];
```

notes:
    order does matter
    row must be in outer loop

Multi-Dimensional Arrays

- 2Dimensional Arrays – Memory View
  - 3x3 array → linear in memory
  - C does NOT check array index ranges

```
int stu[3][3];

foo = stu[1][3];
    sets foo = stu[2][0] wrong

stu[3][2] = 12;
    overwrites critical data value
```



Value	Addr
stu[0][0]	0x1000
stu[0][1]	0x1004
stu[0][2]	0x1008
stu[1][0]	0x100C
stu[1][1]	0x1010
stu[1][2]	0x1014
stu[2][0]	0x1018
stu[2][1]	0x101C
stu[2][2]	0x1020
garbage	0x1024

Multi-Dimensional Arrays

- Passing array values
  - Passing array values works just like any other value

```
fun1(myArray[3][7]);      // passes the value of myArray[3][7]
                          // to function fun1

fun2(&myArray[3][3]);     // passes a pointer to myArray
                          // element 3,3 (the address) to
                          // function fun2
```

Multi-Dimensional Arrays

- Passing array values
  - Passing the whole array
    - If we pass all the elements of a large array to multiple functions we use up a lot of data memory
    - Instead we pass the address of the array (by reference)
  - Remember – the name of the array is already an address to the beginning of the array
  - Must provide the 2nd dimension to compile

```
void fun3(int ary[ ][ val]);   // the array notation name[][#]
                               // tells the compiler it is expecting an
                               // address
…
fun3(myArray);                 // the array name is already an
                               // address
```

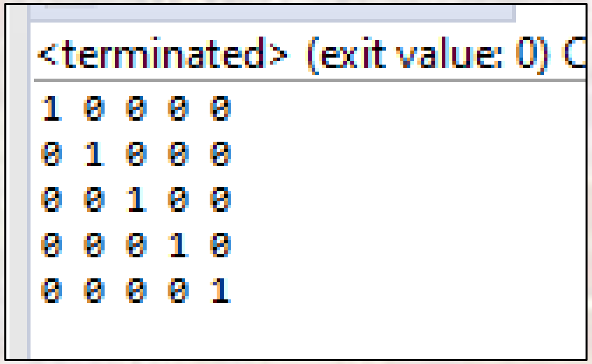
Multi-Dimensional Arrays

- Passing array values
  - Passing a ROW
    - We can pass just 1 row of 2-dimensional array to a function

```
int valArray[10][10];
fun1d(valArray[5]);             // passes only the row with index 5

void fun1d(int myArray[ ]);     // the array notation name[]
                                // tells the compiler it is expecting an
                                // address

                                // only references a 1d array
```

Multi-Dimensional Arrays

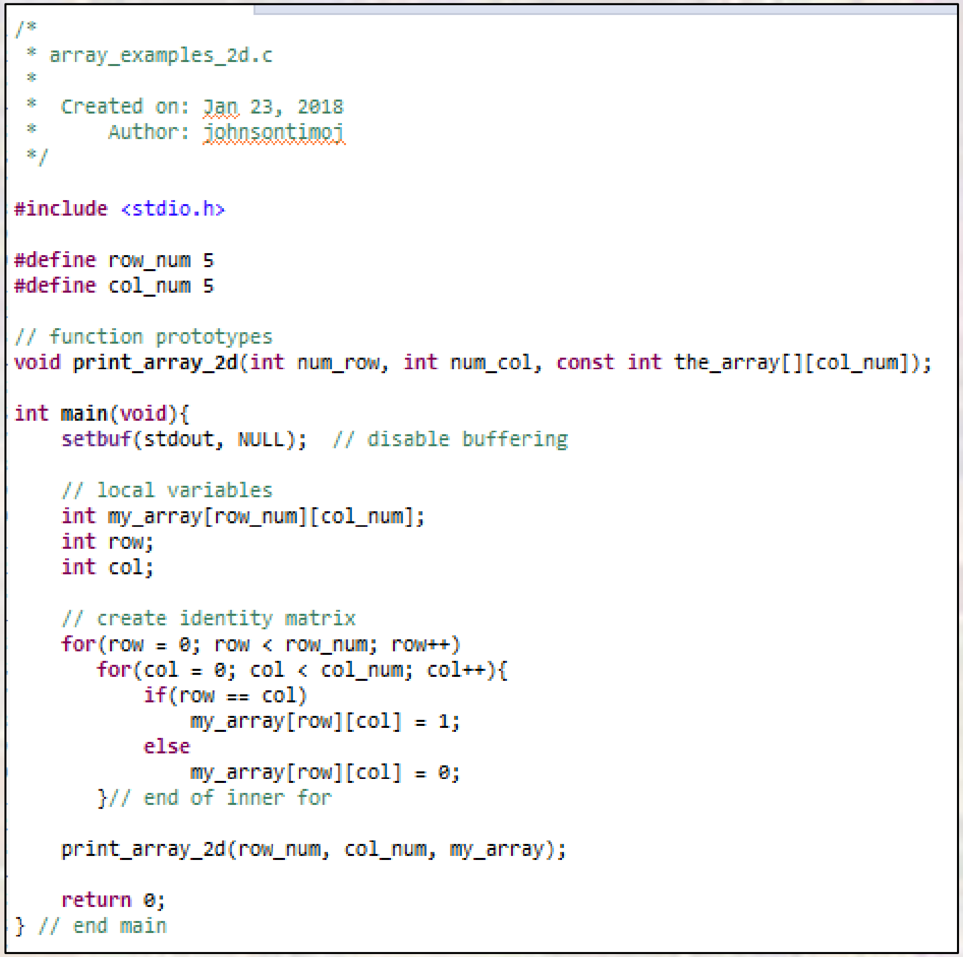
- 2-Dimensional Array example
  - Create an identity matrix
  - 1s on the diagonal, 0 everywhere else



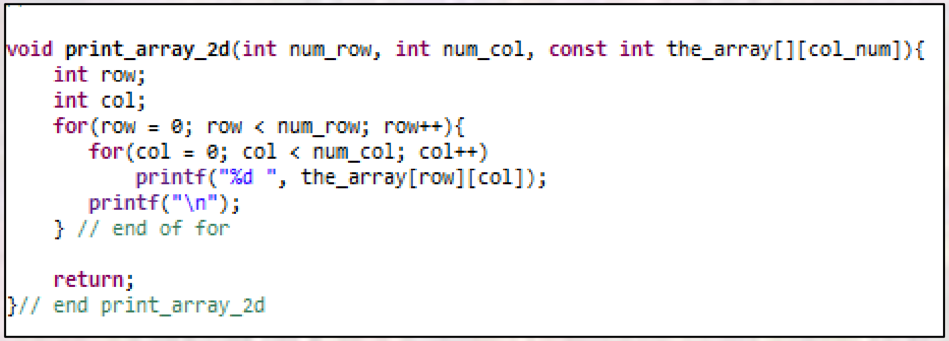
```
<terminated> (exit value: 0) C
1 0 0 0 0
0 1 0 0 0
0 0 1 0 0
0 0 0 1 0
0 0 0 0 1
```

Multi-Dimensional Arrays

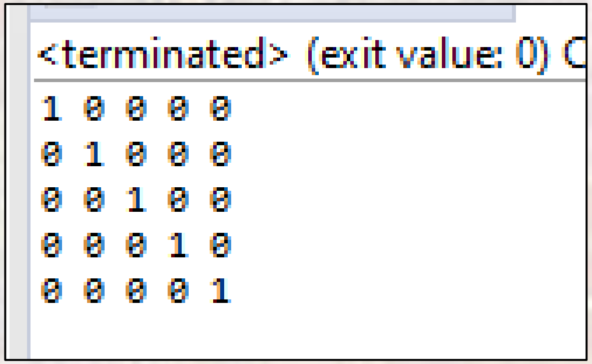
- 2-Dimensional Array example
    - Create an identity matrix



```
/*
 * array_examples_2d.c
 *
 *  Created on: Jan 23, 2018
 *      Author: johnsontimoj
 */

#include <stdio.h>

#define row_num 5
#define col_num 5

// function prototypes
void print_array_2d(int num_row, int num_col, const int the_array[][col_num]);

int main(void){
    setbuf(stdout, NULL);  // disable buffering

    // local variables
    int my_array[row_num][col_num];
    int row;
    int col;

    // create identity matrix
    for(row = 0; row < row_num; row++)
       for(col = 0; col < col_num; col++){
           if(row == col)
               my_array[row][col] = 1;
           else
               my_array[row][col] = 0;
       }// end of inner for

    print_array_2d(row_num, col_num, my_array);

    return 0;
} // end main
```



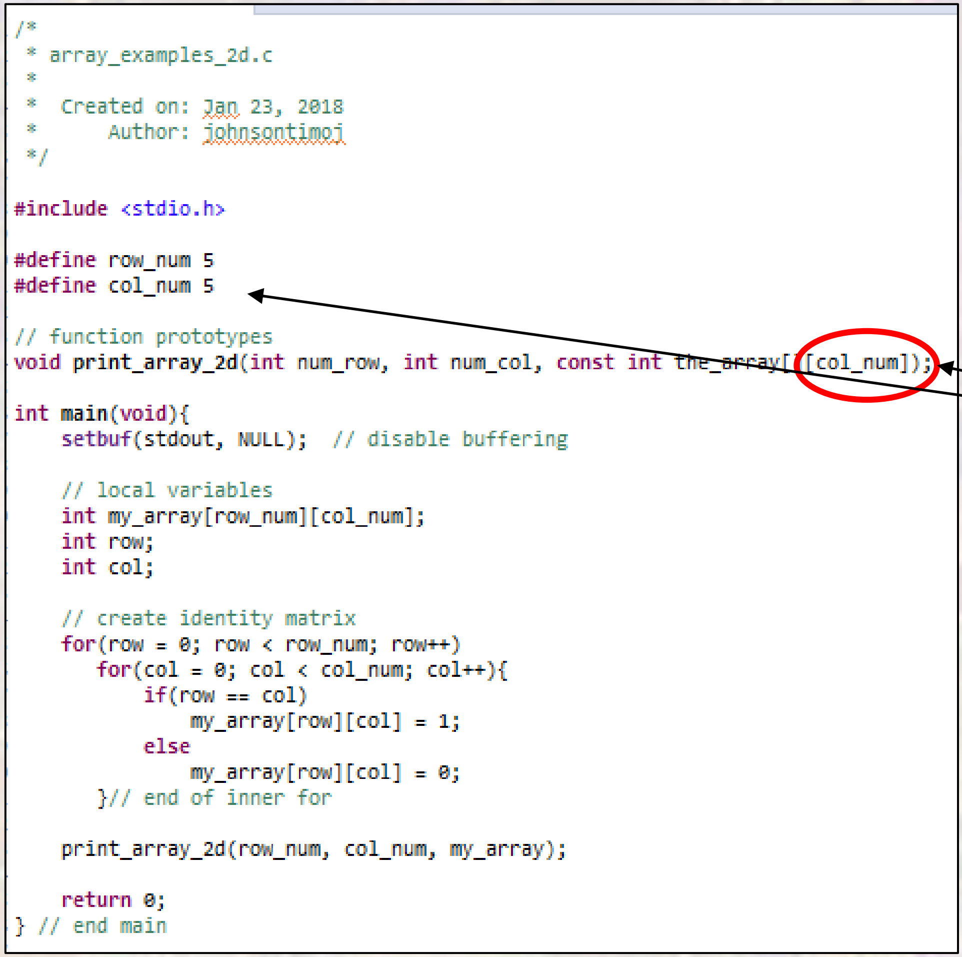
```
void print_array_2d(int num_row, int num_col, const int the_array[][col_num]){
    int row;
    int col;
    for(row = 0; row < num_row; row++){
       for(col = 0; col < num_col; col++)
           printf("%d ", the_array[row][col]);
       printf("\n");
    } // end of for

    return;
}// end print_array_2d
```



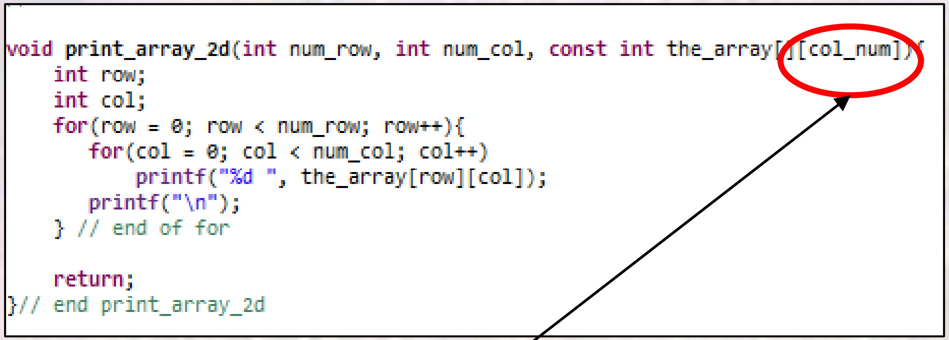
```
<terminated> (exit value: 0) C
1 0 0 0 0
0 1 0 0 0
0 0 1 0 0
0 0 0 1 0
0 0 0 0 1
```

Multi-Dimensional Arrays

- 2-Dimensional Array example
  - Create an identity matrix

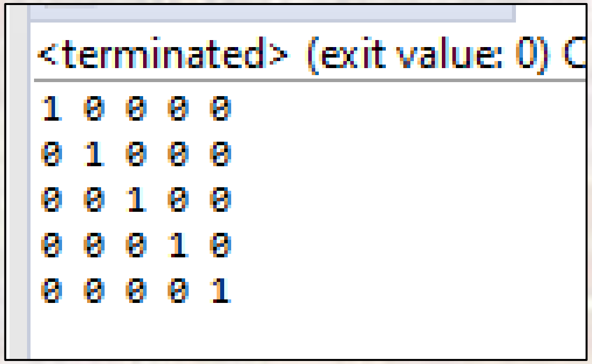


```c
/*
 * array_examples_2d.c
 *
 *  Created on: Jan 23, 2018
 *      Author: johnsontimoj
 */

#include <stdio.h>

#define row_num 5
#define col_num 5

// function prototypes
void print_array_2d(int num_row, int num_col, const int the_array[][col_num]);

int main(void){
    setbuf(stdout, NULL);  // disable buffering

    // local variables
    int my_array[row_num][col_num];
    int row;
    int col;

    // create identity matrix
    for(row = 0; row < row_num; row++)
       for(col = 0; col < col_num; col++){
           if(row == col)
               my_array[row][col] = 1;
           else
               my_array[row][col] = 0;
       }// end of inner for

    print_array_2d(row_num, col_num, my_array);

    return 0;
} // end main
```



```c
void print_array_2d(int num_row, int num_col, const int the_array[][col_num]){
    int row;
    int col;
    for(row = 0; row < num_row; row++){
       for(col = 0; col < num_col; col++)
           printf("%d ", the_array[row][col]);
       printf("\n");
    } // end of for

    return;
}// end print_array_2d
```

Note: Constant 2nd dimension



```
<terminated> (exit value: 0) C
1 0 0 0 0
0 1 0 0 0
0 0 1 0 0
0 0 0 1 0
0 0 0 0 1
```

Multi-Dimensional Arrays

- N Dimensional Arrays
  - No limit to how many dimensions our array can be
  - Syntax follows 2-D approach
  - must provide value for all dimensions beyond the 1st

```
int myArray[3][3][3];        // Rubiks Cube


float myArray[12][3][7][2][100];


fun1(myArray[6][2][3]);
…
int fun1(float theArray[ ][valy][valz]){
…
```

Constant valy, valz

Multi-Dimensional Arrays

- N Dimensional Arrays
  - Can provide the additional dimensions in the call

```
float myArray[6][2][3];
…
fun1(2, 3, myArray);
…
int fun1(int y, int z, float theArray[ ][y][z]){
…
```

Not in EE 1910