

Tutorial 05 - 07.12./10.12.2020

Group 02/11 - Moritz Makowski - moritz.makowski@tum.de

Multidimensional Arrays, Type Casting, Structs and Enums

Today's Agenda

- Revision: Arrays and Functions
- **Exercise 5.1: Arrays and Functions**
- Multidimensional Arrays
- **Exercise 5.2: Matrix Properties**
- Type Casting
- Struct's
- Union's
- Enum's
- **Exercise 5.3: Using Struct's, Union's and Enum's**

A short revision of **arrays**.

A short revision of **functions**.

Exercises 5.1: Arrays and Functions

- (a) Return the largest element in a list.
- (b) Check whether an element occurs in a list.
- (c) Compute the running total of a list.
- (d) Test whether a string is a palindrome.
- (e) Reverse a list. Assume a fixed length of 10 elements!

You can put all your code inside `main` (in the beginning, while testing your logic) and later divide it into functions. You can also start with separate functions right away.

Multidimensional Arrays

The arrays we know ... `int my_array[10] = ...;` ... are *one-dimensional*. With regular arrays you **"iterate along one dimension"**.

However sometimes you want to have more dimensions than one.

Examples: Matrices/Tensors, Tables.

You cannot only have two-dimensional arrays but as many dimensions as you need. So you will have **one index for each dimension**.

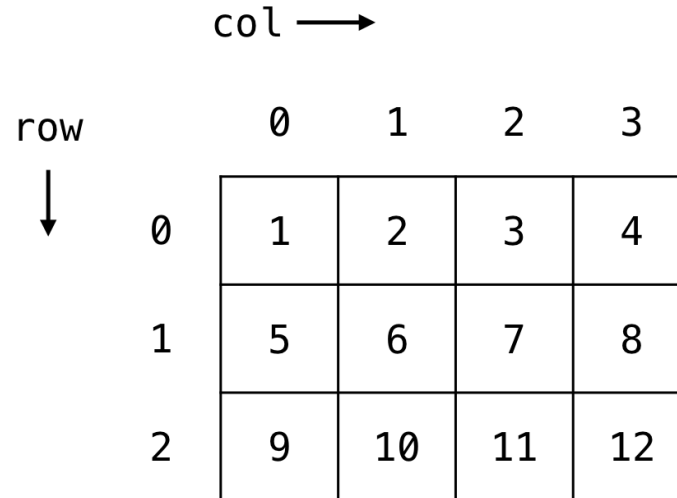
Example Case: Two-Dimensional Arrays

We refer to the row index as i and to the column index as j .

With two dimensions we need to define two sizes: How many rows? How many columns?

The initialization looks a lot like for regular arrays.

```
int my_matrix[3][4] = {  
    {1, 2, 3, 4},  
    {5, 6, 7, 8},  
    {9, 10, 11, 12}  
};
```



A diagram illustrating a 3x4 matrix. To the left of the matrix, the word "row" is written with a downward-pointing arrow. Above the matrix, the word "col" is written with a rightward-pointing arrow. The matrix is a table with 3 rows and 4 columns. The rows are indexed 0, 1, and 2 from top to bottom. The columns are indexed 0, 1, 2, and 3 from left to right. The values in the matrix are: Row 0: 1, 2, 3, 4; Row 1: 5, 6, 7, 8; Row 2: 9, 10, 11, 12.

		col →			
		0	1	2	3
row ↓	0	1	2	3	4
	1	5	6	7	8
	2	9	10	11	12

Image Source: <https://www.dyclassroom.com/>

See `example_5_1_matrix_initialisation.c` on GitHub.

col →

row ↓

	0	1	2	3
0	1	2	3	4
1	5	6	7	8
2	9	10	11	12

Indexing an array is also very similar to regular arrays:

```
int value_at_bottom_left = my_matrix[2][0]; // Will return 9
```


Example Usecase: Matrix properties

See: `example_5_2_diagonal_matrix.c`

Exercise 5.2: Matrix Properties

I have prepared a `main` -file for you called `exercise_5_2_matrix_main.c`.

You are expected to implement two functions (either inside that file or in a separate file).

(a) The function `int is_symmetric(int rows, int columns, int matrix[rows][columns])` returns `1` if the given matrix is symmetric and `0` otherwise.

(b) The function `int is_skew_symmetric(int rows, int columns, int matrix[rows][columns])` returns `1` if the given matrix is skew-symmetric and `0` otherwise.

Revisiting Integer Division

When dividing two integers the result will always be an integer even when stored in a float.

```
int main() {  
    int a = 11;  
    int b = 5;  
  
    float result = a/b; // Will store 2.0000...  
  
    return 0;  
}
```

Enter "Type Casting"

Inside an equation you can convert variables to other data types so that they will be treated as a variable of their newly assigned type (only inside that equation).

```
int main() {  
    int a = 11;  
    int b = 5;  
  
    float result_1 = (float)(a)/b; // Will store 2.2000...  
    float result_2 = a/(float)(b); // Will store 2.2000...  
    float result_3 = (float)(a/b); // WRONG! Will store 2.0000...  
  
    // The variables a and b themselves did  
    // not change -> Both still of type 'int'  
  
    return 0;  
}
```

What if we want to **bundle related information of different data types** together?

Answer: We can use a **struct** !

Example Usecase: Points with 3D Coordinates - Bad

```
int main() {  
  
    float point_1_x = 12;  
    float point_1_y = 8.5;  
    float point_1_z = 0.2;  
  
    float point_2_x = 12.1;  
    float point_2_y = 7.5;  
    float point_2_z = 0.4;  
  
    ...  
  
    return 0;  
}
```

Example Usecase: Points with 3D Coordinates - Good

```
struct point {  
    float x;  
    float y;  
    float z;  
}  
  
int main() {  
  
    struct point point_1;  
    point_1.x = 12;  
    point_1.y = 8.5;  
    point_1.z = 0.2;  
  
    struct point point_2;  
    point_2.x = 12.1;  
    point_2.y = 7.5;  
    point_2.z = 0.4;  
  
    return 0;  
}
```

Example Usecase: Points with 3D Coordinates - Even Better

```
struct point {  
    float x;  
    float y;  
    float z;  
}  
  
int main() {  
    struct point point_1 = {  
        .x = 12,  
        .y = 8.5,  
        .z = 0.2  
    };  
  
    struct point point_2 = {  
        .x = 12.1,  
        .y = 7.5,  
        .z = 0.4  
    };  
  
    return 0;  
}
```


Example Usecase: Points with 3D Coordinates - Perfect

```
struct point {  
    float x;  
    float y;  
    float z;  
}  
  
int main() {  
    struct point point_1 = {12, 8.5, 0.2};  
    struct point point_2 = {12.1, 7.5, 0.4};  
  
    return 0;  
}
```

Why should you use `struct` 's? - #1

1. Cleaner code
2. Less variable names
3. Consistency accross same "object types" is required

Why should you use `struct` 's? - #2

Example usecase: You can loop over an array of structs.

See `example_5_3_struct_array.c` on *GitHub*.

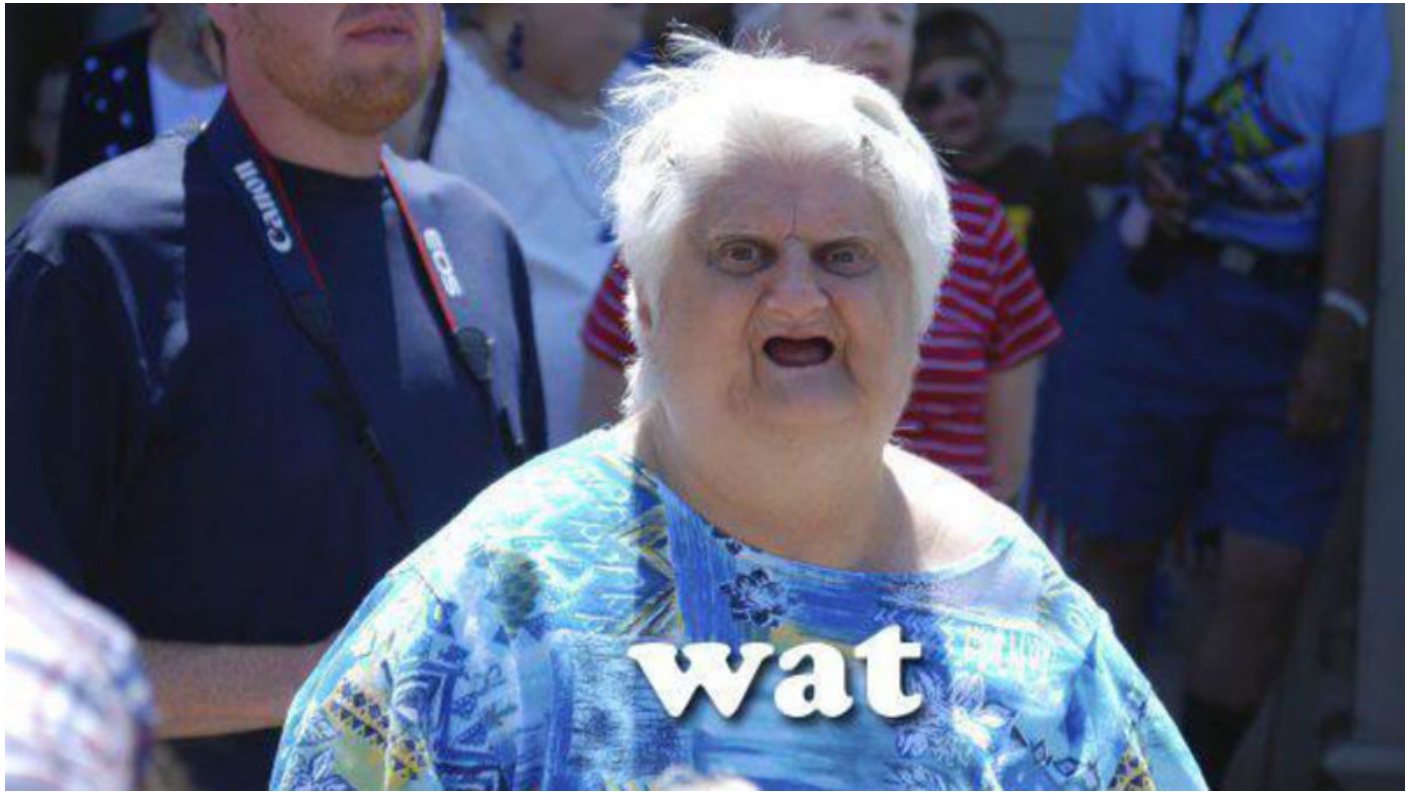
Union's

A `union` can store different data types as well.

BUT: All of them get stored in the same spot of memory.

The size of the `union` is determined by its largest component.

```
union my_union {  
    int number;    // Takes up 4 bytes  
    char letters[2]; // Takes up 2 bytes  
}
```



Shared Memory Space?

```
union mix {  
    int number;           // 4 bytes  
    struct {short lo, hi;} s; // 4 bytes  
    char letters[4];      // 4 bytes  
} m;  
  
// define as integer 'number'  
m.number = 0xFF00F00F; // 1111 1111 0000 0000 11110000 0000 1111  
  
// interpret as struct 's'  
m.s.lo; // 1111 1111 0000 0000  
m.s.hi; // 11110000 0000 1111  
  
// interpret as char array 'letters'  
m.letters[0]; // 1111 1111  
m.letters[1]; // 0000 0000  
m.letters[2]; // 11110000  
m.letters[3]; // 0000 1111
```

Enum's

Example usecase: Using variables that are supposed to store/represent a state, which is encoded in the form of an integer. E.g. the state of a traffic light.

You can now declare the state variable without remembering the encoding for each state:

```
enum color_1 c = BLUE;  
  
if (c == BLUE) {  
    // do something  
}
```

Defining Enum's

```
enum color_1 {  
    RED = 1           // 1  
    YELLOW,           // 2  
    GREEN,            // 3  
}  
  
enum color_2 {  
    RED,              // 0  
    YELLOW,           // 1  
    GREEN = YELLOW + 2, // 3  
    BLUE,             // 4  
    GRAY = 17,        // 17  
    BROWN            // 18  
};
```


See `example_5_4_enums.c` on *GitHub*.

Exercise 5.3: Using Struct's, Union's and Enum's - #1

- (a) Create a `struct rectangle` for a rectangle containing its length and width as `double` values.
- (b) Create a `struct triangle` for a right triangle containing the length of its hypotenuse and its height as `double` values.
- (c) Create a `struct circle` for a circle containing its radius as `double` value.
- (d) For each shape, write a function that receives an appropriate `struct` as a parameter and returns its area as a `double`. You can find a constant named `M_PI` in `math.h`.

Exercise 5.3: Using Struct's, Union's and Enum's - #2

- (e) Create an `enum shape_type` with a value for each of the shapes created above.
- (f) Create a `struct shape` that uses a `union` to hold any of the shapes created above and in addition an `enum` indicating which type of shape is currently in use.
- (g) Create a function `shape_area` that gets a shape as parameter. The function should then print the type and the area of the contained shape. Finally the function should return the area of the shape as a `double`.
- (h) Declare a some shapes and check / use your function.

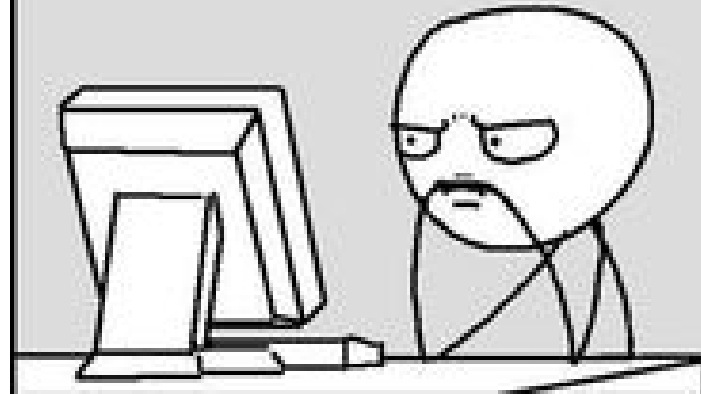
See You Next Week!

All **code examples** and **exercise solutions** on **GitLab** (solutions right after my tutorial):

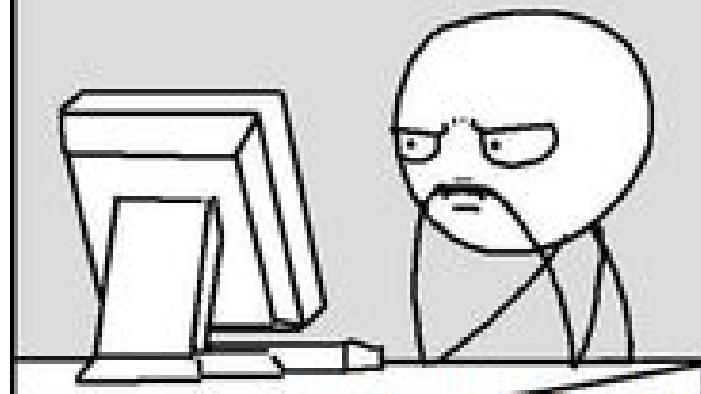
<https://gitlab.lrz.de/dostuffthatmatters/IN8011-WS20>



It doesn't work..... why?



It works..... why?



MemeBlender.com