# COMP1511 - Programming Fundamentals

Week 4 - Lecture 7

# What did we learn last week?

**Code Style and Code Reviews**

- Making our code understandable

**Functions**

- Separating code for reuse

**Arrays**

- Collections of identical variables

# What are we covering today?

**Functions and Libraries**

- A recap of functions
- Using functions from other files

**Arrays and 2D Arrays**

- A recap of arrays
- Arrays inside arrays!

# Recap of Functions

**Code outside of our main that we can use (and reuse)**

- Has a name that we use to call it
- Has an output type and input parameters
- Has a body of code that runs when it is called
- Uses return to exit and give back its output

# Functions in Code

```
// a function declaration
int add (int a, int b);

int main (void) {
    int firstNumber = 4;
    int secondNumber = 6;
    // use the function here
    int total = add(firstNumber, secondNumber);
    return 0;
}

// the function is defined here
int add (int a, int b) {
    return a + b;
}
```

# Why use functions?

**Why do we separate code into functions?**

**Saves us from repeating code**

- Instead of replicating code, we can write it once
- This also makes the code much easier to modify

**Easier to organise code**

- Complex functionality can be hidden inside a function
- The flow of the program can be read easily with clear function names

# C Libraries

**We've already used `stdio.h` several times**

- C has other standard libraries that we can make use of
- The simple C reference in the Weekly Tests has some information
- **`math.h`** is a useful library of common maths functions
- **`stdlib.h`** has some useful functions
- Look through the references (including **`man`** manuals in linux)
- Don't worry if you don't understand the functions yet, some of them have no context in the programming we've done so far

# Using Libraries

```
// include some libraries
#include <math.h>
#include <stdlib.h>
#include <stdio.h>

int main (void) {
    int firstNumber = -4;
    int secondNumber = 6;

    // change a number to its absolute value
    firstNumber = abs(firstNumber);

    // calculate a square root
    int squareRoot = sqrt(firstnumber);
    printf("The final number is: %d", squareRoot);
    return 0;
}
```

# Libraries

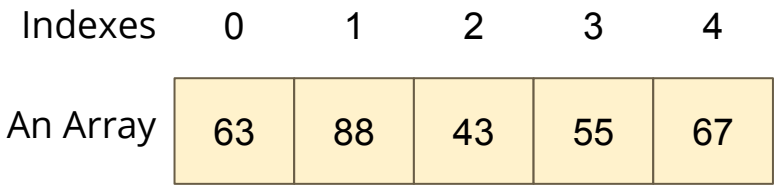
**More complexity means more use of functions**

- We've already seen `printf()` and `scanf()`
- We'll be using libraries with memory management
- And in other upcoming topics . . .

# Recap of Arrays

## A collection of variables

- Contains multiple variables all of the same type
- Declared using a variable type and a size
- Individual variables are accessed using an index



# Using Arrays in C

## Some example code of an array

```
int main (void) {
    // declare an array of doubles, size 4, initially all 0
    double myArray[4] = {0};

    // assign a value
    myArray[1] = 0.95;
    // test a value
    if (myArray[2] < 1) {
        // print out a value
        printf("Third element is: %lf", myArray[2]);
    }
```

# Accessing multiple values at once

## Loops and Arrays go together perfectly

- Accessing all members is a reasonably simple while loop

```
int main (void) {
    // declare an array of doubles, size 4, initially all 0
    double myArray[4] = {0};

    // loop through the array and output the elements
    int i = 0;
    while (i < 4) {
        printf("%lf\n", myArray[i]);
        i++;
    }
```

# Creating Arrays with certain sizes

## Arrays start at an exact size and don't change

- When we create an array, we give it a size and a type
- Both of those are fixed and won't change

```c
int main (void) {
    // declare an array of doubles,
    // size 4
    double myArray[4] = {0};

}
```

```c
int main (void) {
    // This declaration is not
    // possible!
    int arraySize = 4;
    double myArray[arraySize] = {0};

}
```

We can't declare an array with a variable size like this!

# Using Constants for Array Sizes

**If we do want to be able to change the size in code . . .**

- We can use a constant to set the size
- Unlike a variable, this cannot change after it is compiled
- It does make our lives much easier if we need a change mid-project

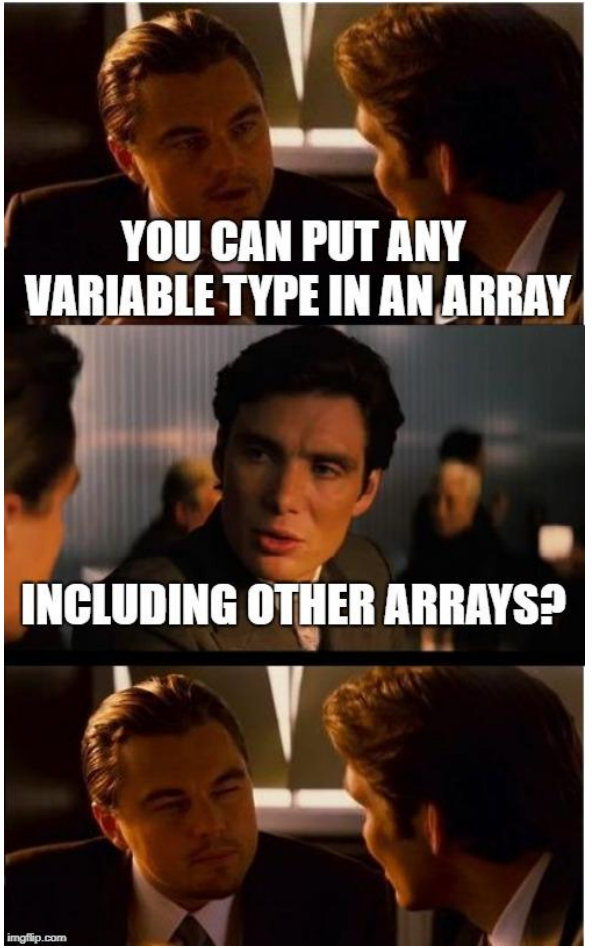
```
#define ARRAY_SIZE 4

int main (void) {
    // This declaration allows us to change the
    // array size while coding
    double myArray[ARRAY_SIZE] = {0};
}
```

# Arrays inside Arrays

**An Array is a type of variable**

**An Array can contain any type of variable**

- Arrays can be put inside other arrays!
- We call these multi-dimensional arrays
- Think of them as a grid, two or more dimensions



# Two Dimensional Arrays

**Arrays inside arrays**

- Can be thought of like a grid
- The outer array contains arrays
- Each array is a row of the grid
- Addressed using a pair of integers like coordinates
- All inner arrays are of the same type

| Indexes | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 0 | 63 | 88 | 43 | 55 | 67 |
| 1 | 54 | 52 | 91 | 21 | 32 |
| 2 | 77 | 58 | 1 | 61 | 79 |

**A 2D Array**

# Two Dimensional Arrays in Code

```
int main (void) {
    // declare a 2D Array
    int grid[4][4] = {0};

    // assign a value
    grid[1][3] = 3;
    // test a value
    if (grid[2][0] < 1) {
        // print out a value
        printf("The bottom left square is: %d", grid[3][0]);
    }
```

# Break Time

**Let’s take five minutes break**

- We're building up to much harder (and maybe frustrating) problems
- Remember that most hard problems are made up of smaller, easier problems
- Look for ways to break things down into parts that you can manage with the coding skills you've learnt!


*Problems by Parallel Studio*

# Let's work with 2D Arrays

**I would like to make a simple game called "The Tourist"**

- The world is a square grid
- The tourist can move up, down, left or right
- Be able to print out the world, including the location of the tourist
- The tourist likes seeing new things . . .
- Track where they've been
- And lose the game if we revisit somewhere we've been

# Starter Code

**Working with code that's already got some functionality**

- We're going to start with some code called tourist.c
- This file already has the ability to print a 2D array
- It's a bit similar to using starting code in the Assignment

# Print Map

## Here's a handy function that we'll be reusing

```
void printMap(int map[N_ROWS][N_COLS], int posR, int posC) {
    int row = 0;
    while (row < N_ROWS) {
        int col = 0;
        while (col < N_COLS) {
            if (posR == row && posC == col) {
                printf("T ");
            } else {
                printf("%d ", map[row][col]);
            }
            col++;
        }
        row++;
        printf("\n");
    }
}
```

# Break the problem down into parts

**What do we need to do?**

- We need to set up our grid and the tourist's position
- The tourist needs to move one step at a time
- Each time the tourist visits a location, we set it to 1
- We also check each location to make sure it's new

# The Square Grid World

## Variables for the grid and the tourist's position

```c
#include <stdio.h>

// The dimensions of the map
#define N_ROWS 10
#define N_COLS 10

int main (void) {
    int map[N_ROWS][N_COLS] = {0};
    int posR = 0, posC = 0;
```

# Controlling the Tourist

**Next Steps**

- Let’s add movement
- Then track where the Tourist has been, using the map
- After that, we'll check for places we've already been

**Looping**

- We can loop repeatedly for “turns” to allow the user to input directions

# Movement - this code will loop

```
printf("Please enter a numpad direction or 0 to exit: ");
int input;
scanf("%d", &input);
if (input == 4) {
    posC--;
} else if (input == 8) {
    posR--;
} else if (input == 6) {
    posC++;
} else if (input == 2) {
    posR++;
} else if (input == 0) {
    exit = 1;
} else {
    printf("Input is not a numpad direction, please use 2,4,6 or 8\n");
}
```

# Tracking the Tourist using the Map

## Set each location we visit to 1

```
// loop and let the user control the Tourist's movement
int exit = 0;
while (!exit) {
    // mark the location as having been visited by incrementing
    map[posR][posC] = 1;

    // show the current status
    printMap(grid, posR, posC);

    printf("Please enter a numpad direction or 0 to exit: ");

    // Movement code from previous slide goes here . . .
```

# Have we been here before?

**We want the game to end if the tourist revisits a location**

- If the location we visit is already 1
- Then we're going to exit the game
- We can add this check after our movement

```
// Check if we've been here before
if (map[posR][posC] == 1) {
    printf("We've already been here! How boring!\n");
    exit = 1;
}
```

# 1 isn't as helpful as "EXPLORED"

**Let's swap out the number for a more readable #define**

```
#include <stdio.h>

// The dimensions of the map
#define N_ROWS 10
#define N_COLS 10

// Has the square been explored before?
#define UNEXPLORED 0
#define EXPLORED 1
```

# The Tourist Game

**This is now roughly complete**

- We can move the tourist
- We can track where we've been
- We can display where we've been as well as current location
- We can exit if we revisit a location

**But how safe is it?**

- Try different inputs
- Try moving around a bit

# What happens if …

**Moving around and seeing what works**

- Use the controls to move around the map
- Try entering some integers that aren’t the movement

**What issues do we find?**

# Walking off the edge of the map

**Our Tourist can walk outside of the bounds of our arrays!**

Let's add some code to check if we're outside the map and stop that movement

```
// Check if we've walked off the map
if (posR < 0) {
    posR = 0;
} else if (posR >= N_ROWS) {
    posR = N_ROWS - 1;
}
if (posC < 0) {
    posC = 0;
} else if (posC >= N_COLS) {
    posC = N_COLS - 1;
}
```

# Where else can we take this code?

**What about scoring?**

- Could we give the player a score based on the number of places they visited?
- How would we calculate that?
- Also . . .
- Some of this code might be useful in understanding the first assignment

# What did we learn today?

**Functions and Libraries**

- We can use functions that we didn't write ourselves
- We can include libraries that have many functions that can help us

**Multi-Dimensional Arrays**

- We can work with arrays in arrays to make things like grids