DPST1091 / CPTG1391
Introduction to Programming
Week 4 – Lecture 2

Lecturer and Course Convener:

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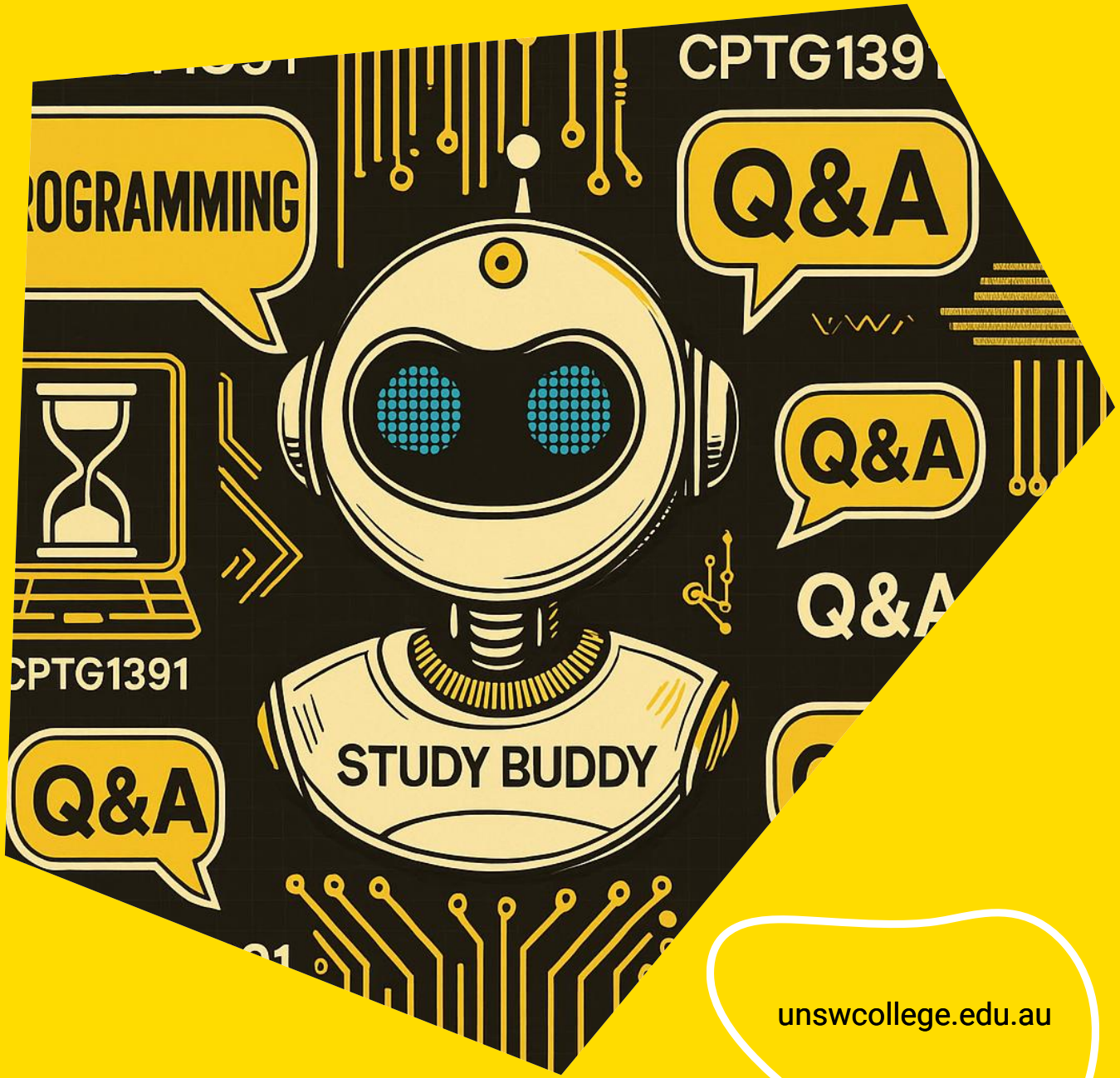
Strings



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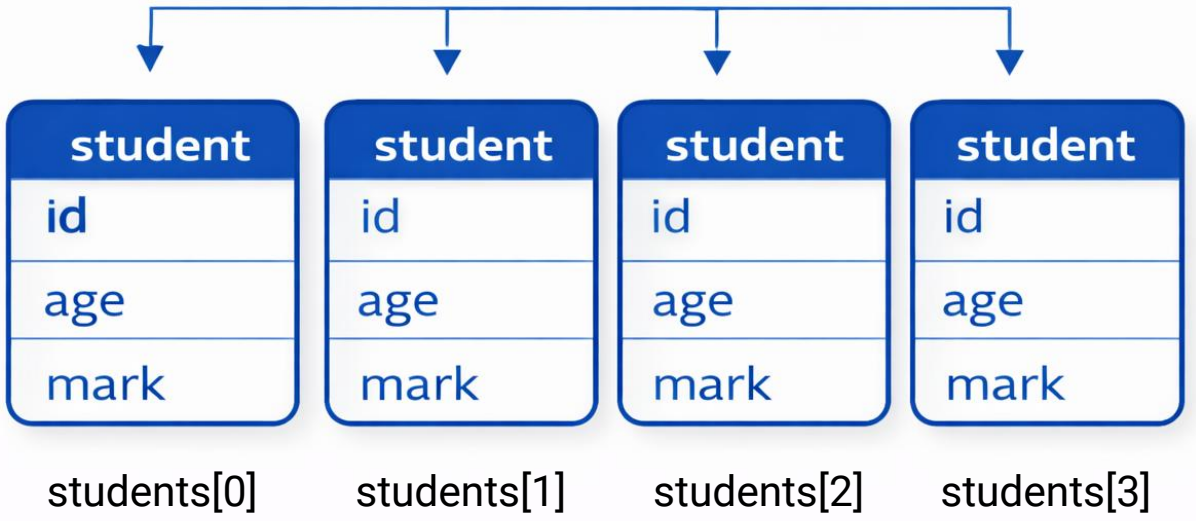
Agenda

- **Last lecture**
  - ⟶arrays of structs
  - ⟶2D arrays

- **Today**
- **strings**

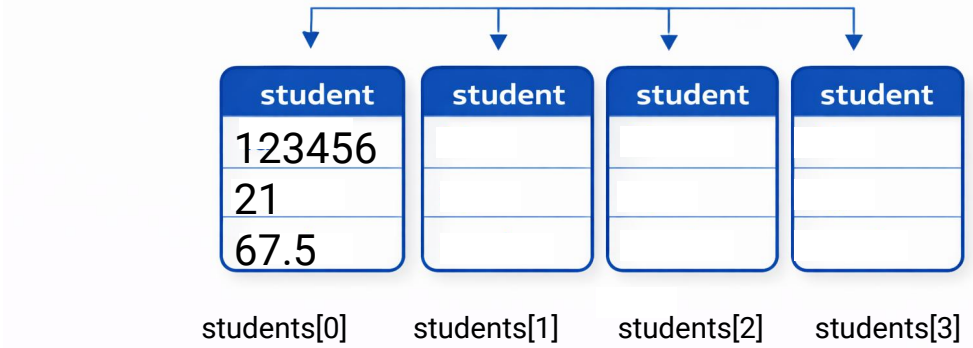
Array of Struct recap

```
struct student {
    int id,
    int age,
    double mark;
};

struct student students[4];
```



Accessing the elements of an array of structures

```
struct student {
   int id,
   int age,
   double mark;
};

struct student students[3];
```




```
students[0].id = 123456;
students[0].age = 21;
students[0].mark = 67.5;
```

2 Dimentional Arrays

arrays of arrays

It stores data in **rows and columns**, like a **table or grid**.
How to declare?

```
<type>  <identifier>[<rows>][<cols>];
```

```
// Declaring a 2D array
int marks[3][4];
```

This means:

3 rows
4 columns

Total elements = 3 × 4 = 12

You can picture it like this:

```
[][][][]
[][][][]
[][][][]
```

Initialising a two-dimensional array

```
// Initialising a 2D array
int marks[3][4] = {
                    {10, 12, 14, 16},
                    {11, 13, 15, 17},
                    {18, 19, 20, 21}
                  };
```

Each inner {} is one row.

	col 0	col 1	col 2	col 3
row 0	10	12	14	16
row 1	11	13	15	17
row 2	18	19	20	21

marks

How to traverse the array

A **2D array has two dimensions**:

- **rows**
- **columns**

So, we need:

- one loop to move through the **rows**
- one loop to move through the **columns**

```
int row = 0;
// outer loop for rows
while (row < 3) {
    int col = 0;
    // inner loop for columns
    while (col < 4) {
        printf("%d ", marks[row][col]);
        col++;
    }
    printf("\n");
    row++;
}
```

Demo

→2Darrays_recap

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It may include extra comments and may not always follow ideal coding style

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IT'S BREAK TIME!
#include <stdio.h>
#define ON_BREAK 1
int main(){
// Time for a 10 minute break! Switch to PARTY_MODE
#define PARTY_MODE ON_BREAK
if (PARTY_MODE == ON_BREAK) ;
print("Program will resume in 10 minutes...");
sleep(600,); // Take a break
exit(0);
}
10 MINUTES BREAK!
print_table(sum);
BRB
CHIPS
Relax... We'll be back soon!

Strings

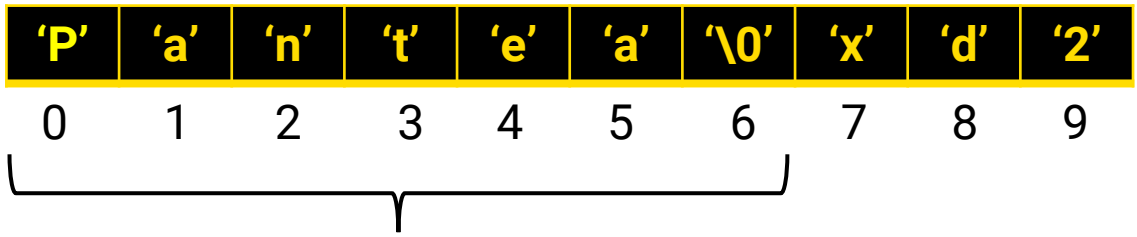
Strings represent **sequences of characters**

In C, a string is defined as: an **array** of characters (**char**)

terminated by the **null character '\0'** stored in consecutive memory locations

Null Terminator '\0'

- Every string in C **must** end with the **null terminator '\0'**
- **Without** it, the data is **not a string**, only an array of char
- The **character array** must be **large enough** to include the '\0'
- The null terminator is **not printed or visible** when the string is displayed
- It tells the program where the **string ends**, especially when **looping** through characters
- Any data stored **after '\0'** is **ignored** and not considered part of the string



How to initialise strings

- A string is stored as a **sequence of characters** in a `char` array
- Each character occupies one position in the array
- The final element is always the **null terminator** `'\0'`

```
Index:   0    1    2    3    4    5    6
Value:  'p'  'a'  'n'  't'  'e'  'a'  '\0'
```

```c
// The long (manual) way
char word[] = {'p', 'a', 'n', 't', 'e', 'a', '\0'};


// The simpler and preferred way
char word[] = "pantea";
```

Both declarations create **exactly the same** string in memory

The **string literal** version **automatically adds the '\0'**

Use **double quotes** " to wrap the string literal

Printing a string

```c
// Printing a string character by character
char name[] = "pantea";

int i = 0;
while (name[i] != '\0') {
    printf("%c", name[i]);
    i++;
}
printf("\n");
```

The loop stops at '\0'

Characters are accessed one at a time using an index

```c
// The easier way
// Using printf with %s
char name[] = "pantea";
printf("%s", name);
```

%s automatically prints characters until it reaches '\0'

Demo

→strings_intro.c

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reading a string

`scanf("%s", ...)` **must not be used** to read strings.

It does **not check the size of the array**

- Input that is too long can cause a **buffer overflow**
- This may **overwrite other memory** and **crash** the program

Buffer overflows are a **serious security vulnerability**

- They can be exploited by attackers
- You will learn more about this in **DPST1092**

`%s` often behaves **differently from what is expected**

- It **stops reading when** it encounters **whitespace** (spaces, tabs, newlines)

For these reasons, `scanf("%s", ...)` is **forbidden in the style guide**

So, how do we read strings?

fgets

Strings should be read using **`fgets`**:

```
fgets(array, size, stream);
```

`fgets` parameters

•**`array`**

The character array where the string will be stored

•**`size`**

The total size of the array

- **`fgets`** reads **at most `size - 1` characters**
- This leaves space for the null terminator `'\0'`

•**`stream`**

The source of the input

- In this course, this will always be **`stdin`**
- (**`stdin`** refers to standard input from the keyboard)

How `fgets` reads input

A single call to `fgets` reads characters until **one of the following occurs**:

- `size - 1` **characters** have been read
  - This leaves room for the null terminator `'\0'`
- A **newline character** (`'\n'`) is encountered
  - The newline **is stored** in the array
- **end of file** (**eof**) is reached
  - For terminal input, this is `Ctrl + D` on a line by itself

Example

```
  char name[MAX_LENGTH];

// Read a string of up to MAX_LENGTH characters
// from standard input (the terminal)
//
fgets(name, MAX_LENGTH, stdin);
```

If `MAX_LENGTH` is **10** and the user types: Pantea
Then the name array will contain:

‘P’	‘a’	‘n’	‘t’	‘e’	‘a’	‘\n’	‘0’	?	?
0	1	2	3	4	5	6	7	8	9

Reading strings in a loop

```c
#include <stdio.h>

// The name will be at most 14 characters (+1 for '\0')
#define MAX_LENGTH 15

int main(void) {
    char name[MAX_LENGTH];

    printf("Please enter your name: ");

    // Read a line of input safely using fgets
    // This stores the input (including '\n' if present)
    while (fgets(name, MAX_LENGTH, stdin) != NULL) {
        // Each successful read replaces the contents of name
    }

    return 0;
}
```

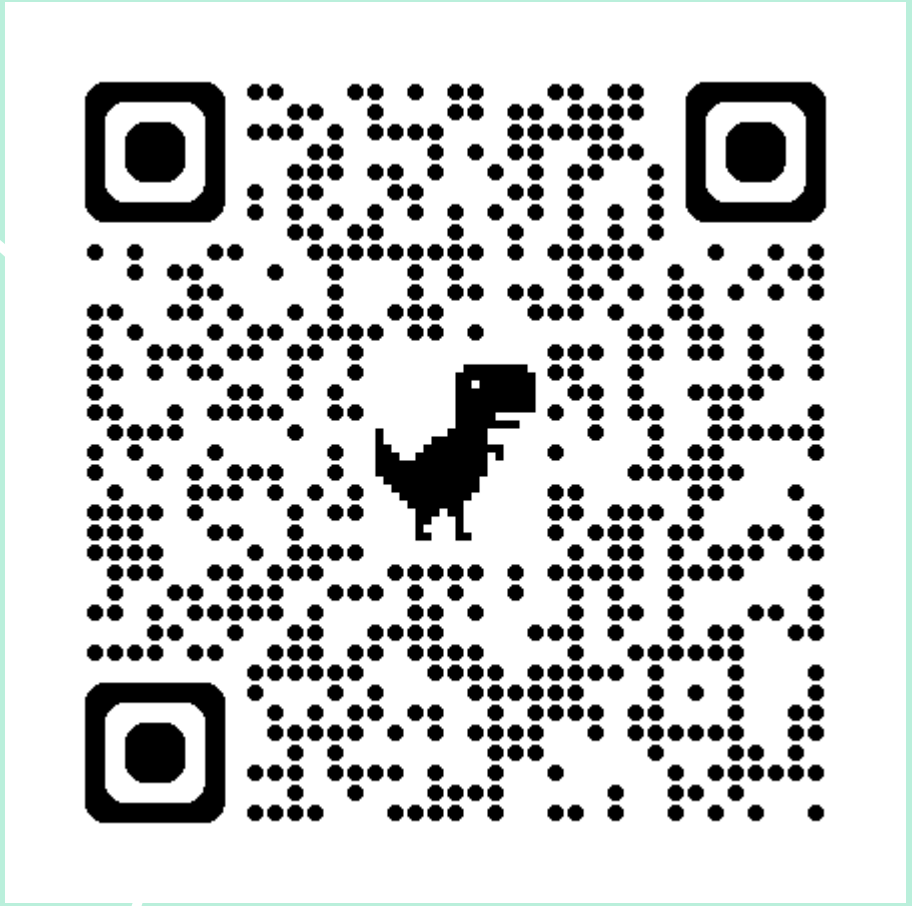
Useful library functions for chars

```
#include <ctype.h>
```

Function	What it does	Example
`toupper()`	Converts a character to uppercase	`toupper('p') → 'P'`
`tolower()`	Converts a character to lowercase	`tolower('A') → 'a'`
`isupper()`	Checks if a character is uppercase	`isupper('P') → 1`
`islower()`	Checks if a character is lowercase	`islower('p') → 1`

Demo

→strings_reading.c



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Useful library functions for strings

```
#include <string.h>
```

Function	What it does	Example
`strlen()`	Returns the number of characters in a string (excluding '\0')	`strlen("pantea")`
`strcpy()`	Copies one string into another	`strcpy(dest, "pantea");`
`strcat()`	Appends one string to the end of another	`strcat(name, "123");`
`strcmp()`	Compares two strings	`strcmp("pantea", "pantea")`
`strchr()`	Finds the first occurrence of a character	`strchr("pantea", 't')`

Example

```c
 // Declare an array to store a string
char pet[MAX_LENGTH] = "Oreo";

// Copy a new string into the array
// Make sure the array is large enough to avoid overflow
strcpy(pet, "Buddy");

printf("%s\n", pet);

// Find the length of the string (does NOT count '\0')
int length = strlen(pet);
printf("%s has length %d\n", pet, length);
```

Example

```c
#include <stdio.h>
#include <string.h>

int main(void) {
    char name1[] = "pantea";
    char name2[] = "Pantea";
    char name3[] = "sara";

    // Case 1: strings are equal
    if (strcmp(name1, "pantea") == 0) {
        printf("name1 is equal to \"pantea\"\n");
    }

    // Case 2: first string comes before second (negative result)
    if (strcmp(name1, name3) < 0) {
        printf("\"%s\" comes before \"%s\"\n", name1, name3);
    }

    // Case 3: first string comes after second (positive result)
    if (strcmp(name1, name2) > 0) {
        printf("\"%s\" comes after \"%s\"\n", name1, name2);
    }

    return 0;
}
```

Demo

→strings_functions.c

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Voice of the Student

Anonymous ongoing feedback
Anything you wanted to share with me

Voice of the Student

26T1 Voice of the Student – Fill out form

See you soon …

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