DPST1091 / CPTG1391

Introduction to Programming

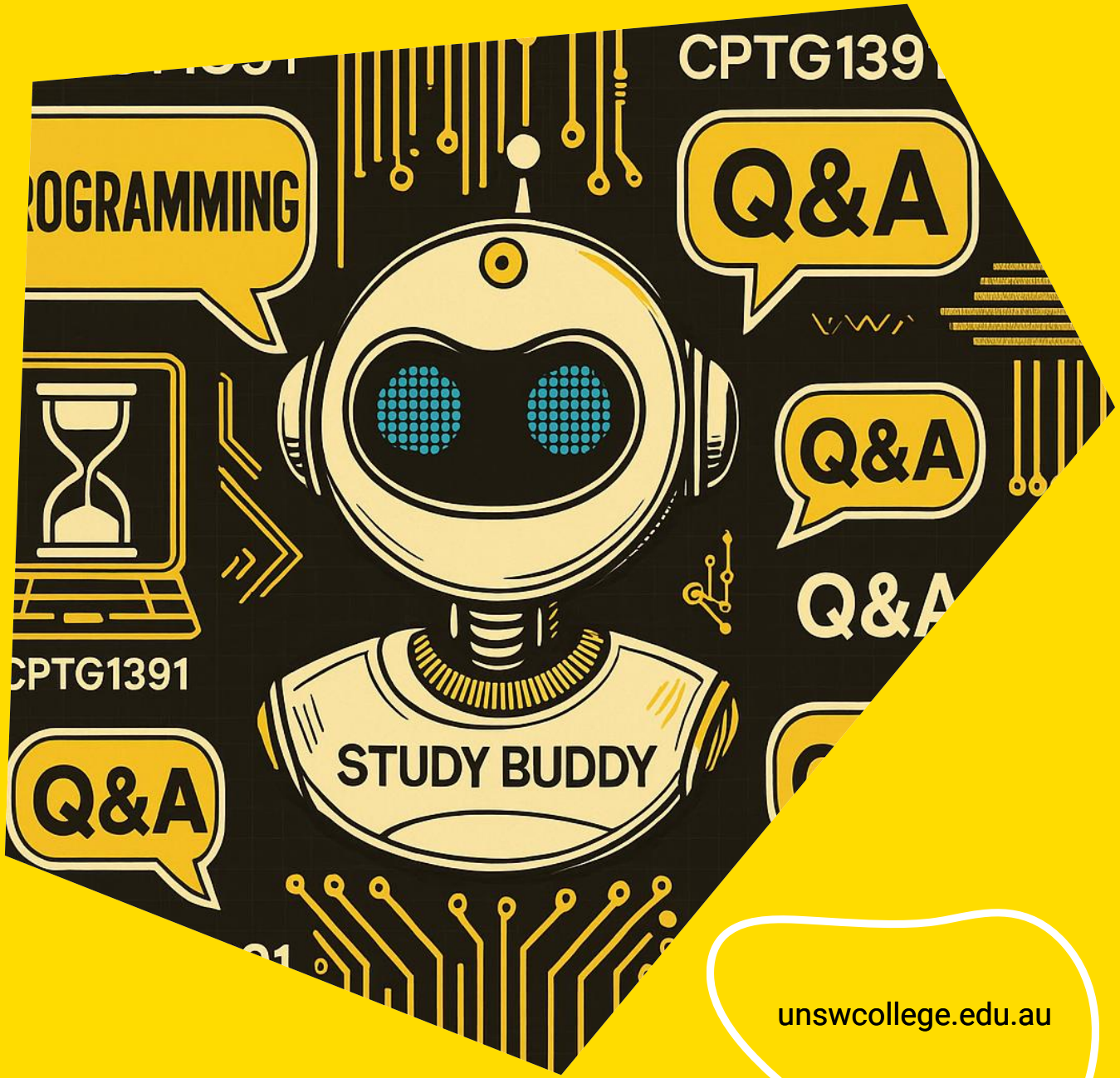
Week 6 – Lecture 2

Lecturer and Course Convener:

Dr Pantea Aria

UNSW College

Pointers and Functions



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Next Week Flexibility Week

No Lecture/Tutorial/labs

We will run **consultations** for everyone

Assignment is due on **Friday Week 8**

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Agenda

- **Last lecture**
  - **Pointers**
  - **Memory, stack**

- **Today**
  - **Pointers and Functions (Call by Reference)**

Memory and Addresses Recap

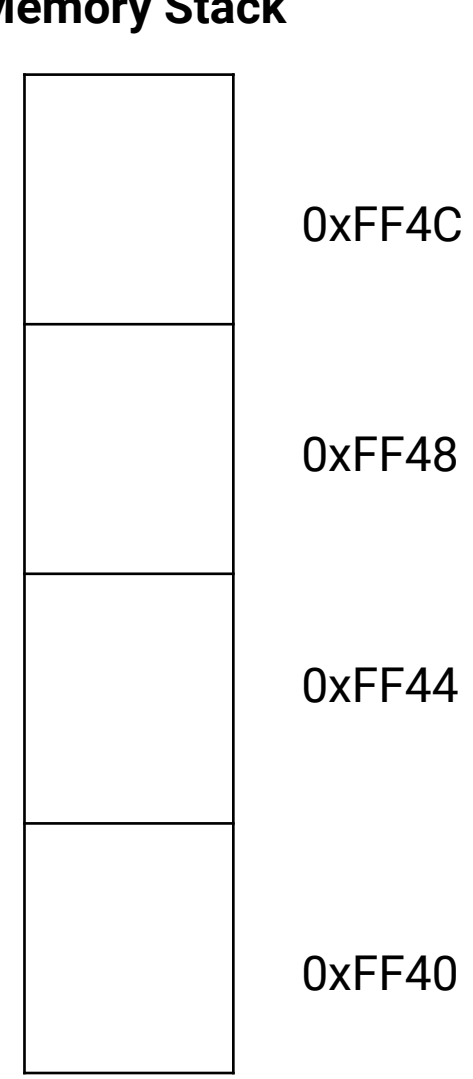
Memory can be thought of as one very **large array made up of bytes**.

Each **memory address** acts like an **index** that refers to a **specific byte** in that array.

Memory addresses are typically written in **hexadecimal**.

The **prefix 0x** indicates that the value is in hexadecimal.

On modern systems, memory addresses are usually **8 bytes** long and may look like:
`0x7ffcaa98655c`

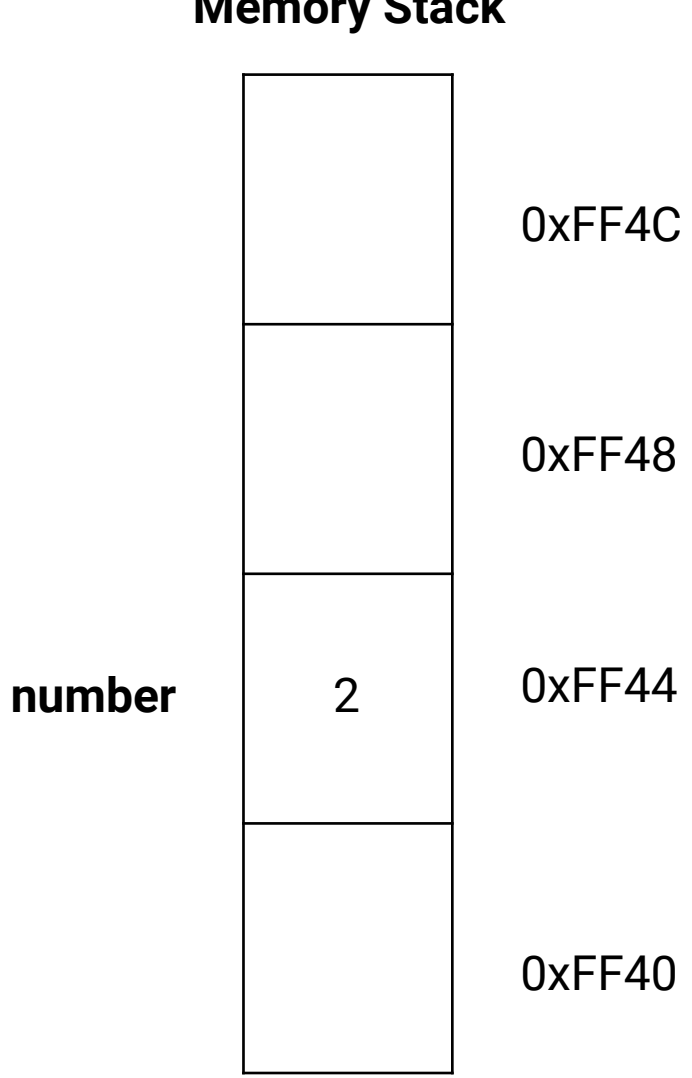


Memory and Variables

```c
// Declare a variable of type int
// Assign the value 2 to it
int number = 2;
```

During program execution, variables are stored in memory, with each variable located at a specific **memory address**.

number is stored at address 0xFF44

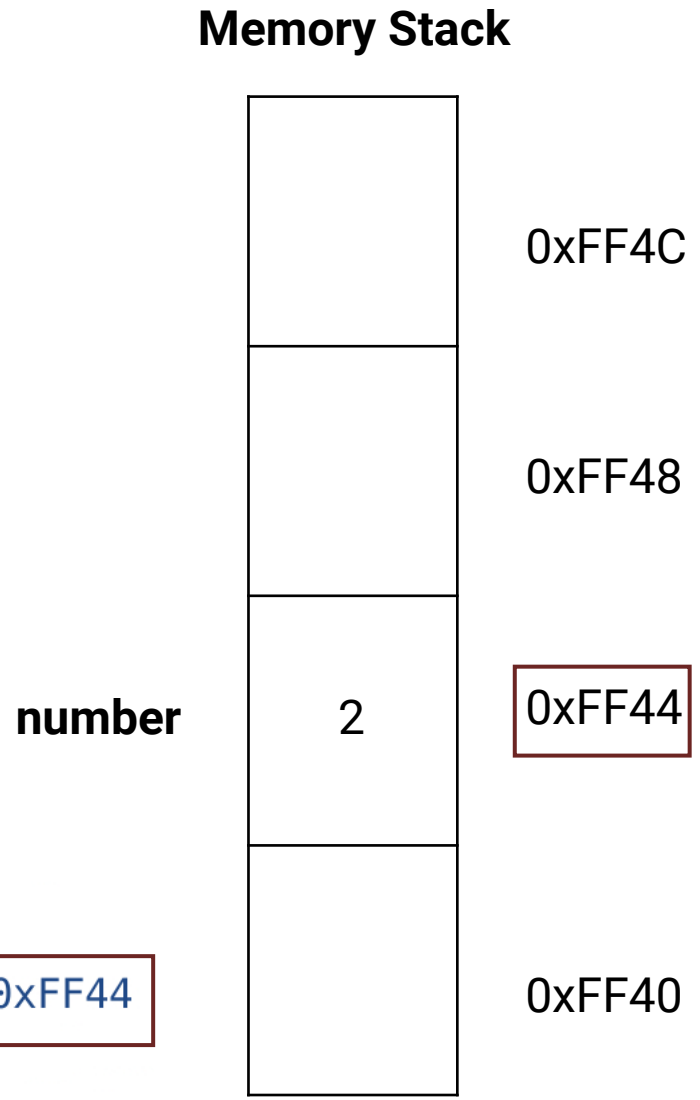


The Address of Operator

&

We can get the address of a variable using the **address of** operator **&**

```c
int number = 2;
// Print the address of x
// In this scenario it would print 0xFF44
printf("%p", &number);
```



Pointers Recap

Pointers are **variables** that **store the addresses** of other variables in memory.

When **declaring a pointer**, you **specify the data type it points** to and use an asterisk (*) to indicate that it is a pointer.

type_pointing_to *name_of_ variable;

```
int *number_ptr;
double *real_ptr;
char *my_ptr;
struct person *student_ptr;
```

Initialising a Pointer

```c
int number = 2;

// number_ptr is declared
// and initialised and
// contains the address
// of int variable number
int *number_ptr = &number;
```

```c
double value = 3.14;

// real_ptr declared
double *real_ptr;

// real_ptr is initialised
// and contains the
// address of double
// variable value
real_ptr = &value;
```

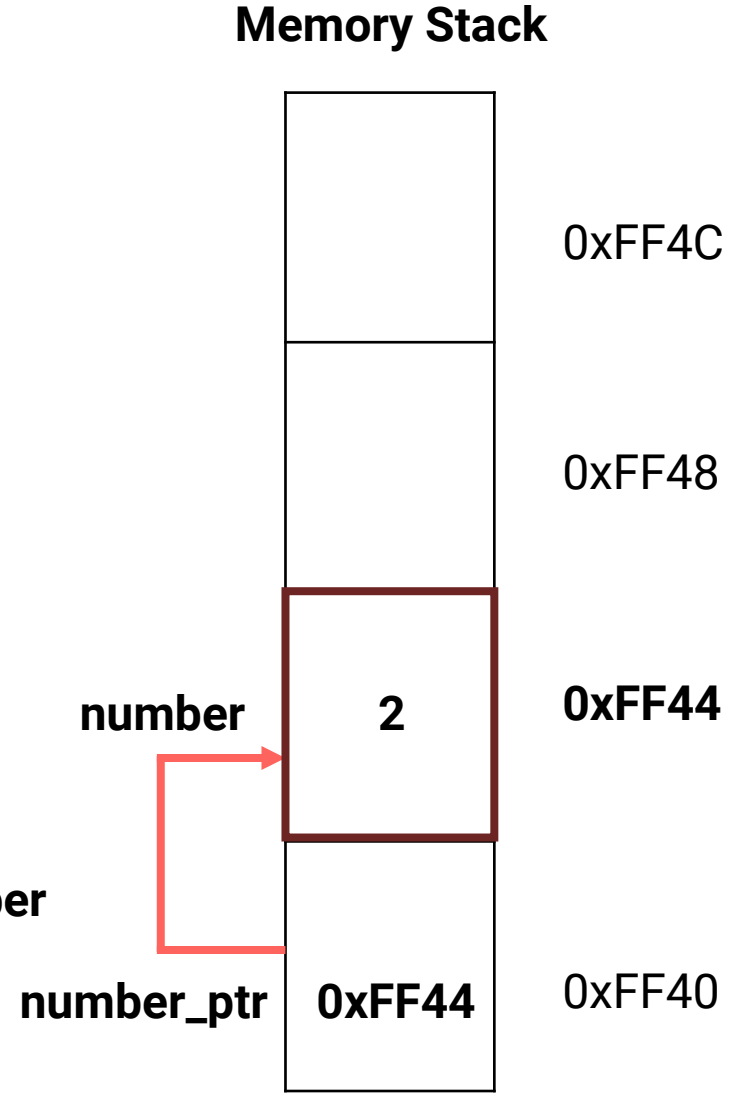
Visualise it in the memory

Referencing

```
int number = 2;

// number_ptr is declared
// and initialised and
// contains the address
// of int variable number
int *number_ptr = &number;
```

So now: **number is 2**
AND
number_ptr is 0xFF44

We can say number_ptr references number
or
number_ptr points to number



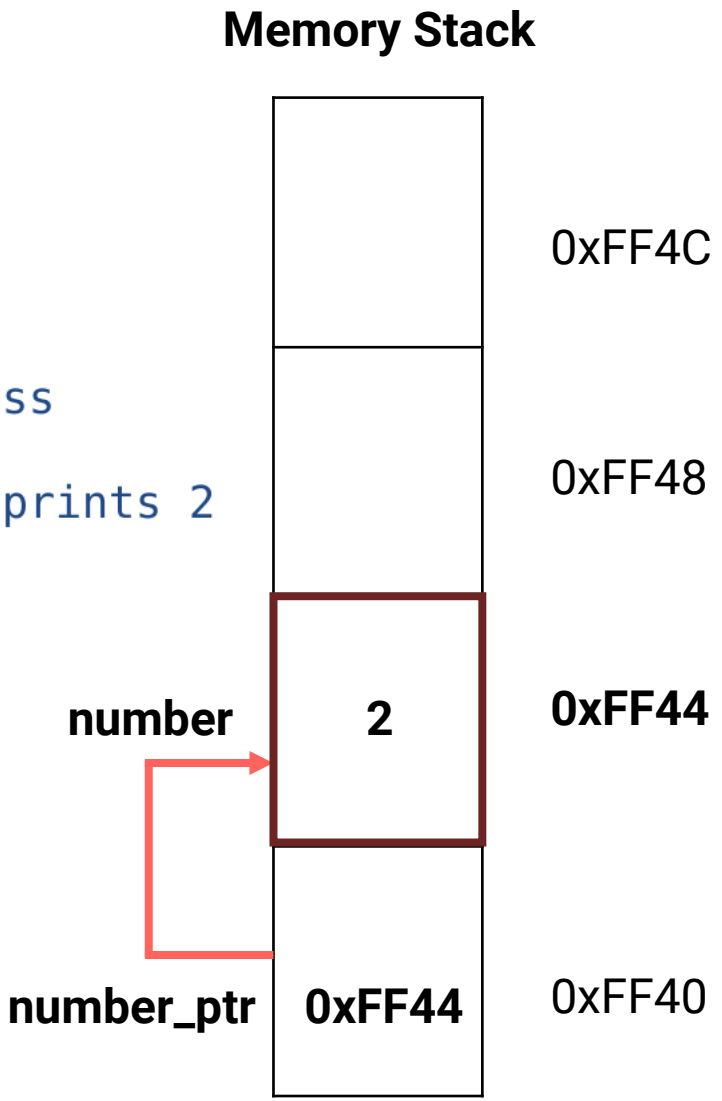
Dereferencing

```c
int number = 2;
int *number_ptr = &number;

// *number_ptr will go to address
// 0xFF44 and get the value 2
printf("%d\n", *number_ptr); //prints 2
```

Dereferencing is simply accessing **the value** at the address of a pointer

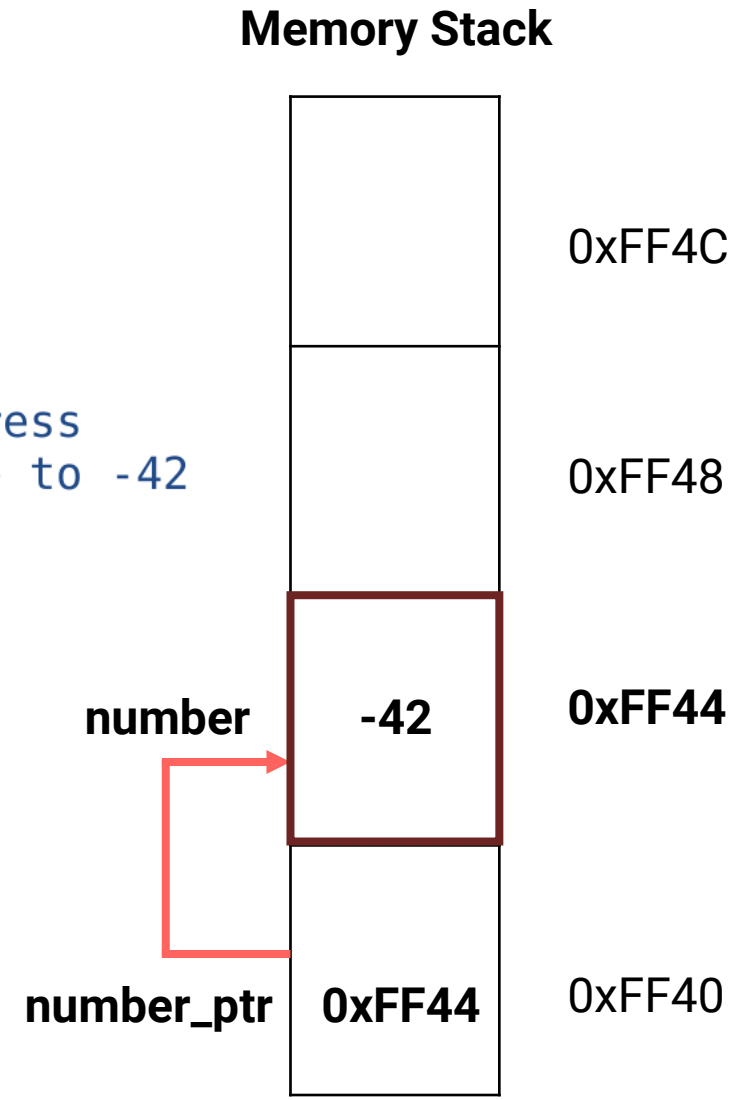
It uses the * symbol again (which causes confusion)

*number_ptr will get the integer at the address 0xFF44



Indirectly modify a variable using pointers

```c
int number = 2;
int *number_ptr = &number;

// *number_ptr will go to address
// 0xFF44 and change the value to -42
// number is now -42
*number_ptr = -42;
```



What was pointer again??

Step	Description	Example
Declare a pointer	Use * to declare a pointer and specify the type of value it will point to	int *number_ptr;
Initialise the pointer	Assign the address of a variable to the pointer using the & operator	number_ptr = &x;
Declare and initialise	Declare the pointer and assign it an address in a single statement	int *number_ptr = &x;
Dereference the pointer	Use * to access the value stored at the address the pointer points to	*number_ptr

```c
int score = 42;

// Declare a pointer
int *score_ptr;

// Initialise pointer
score_ptr = &score;

// Dereference pointer to get
// 42, then add 1 so result is 43
int next_score = *score_ptr + 1;
```

So, what is the point of pointers???

What is the output of this program?

```c
#include <stdio.h>

void increment(int x, int y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(x, y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int x, int y) {
    x = x + 1;
    y = y + 1;

    printf("Inside increment: %d %d\n", x, y);
}
```

And what is the output of this program?

```c
#include <stdio.h>

void swap(int x, int y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before swap: %d %d\n", x, y);

    swap(x, y);

    printf("After swap:  %d %d\n", x, y);

    return 0;
}

void swap(int x, int y) {
    int temp = x;
    x = y;
    y = temp;

    printf("Inside swap: %d %d\n", x, y);
}
```

Stack Memory

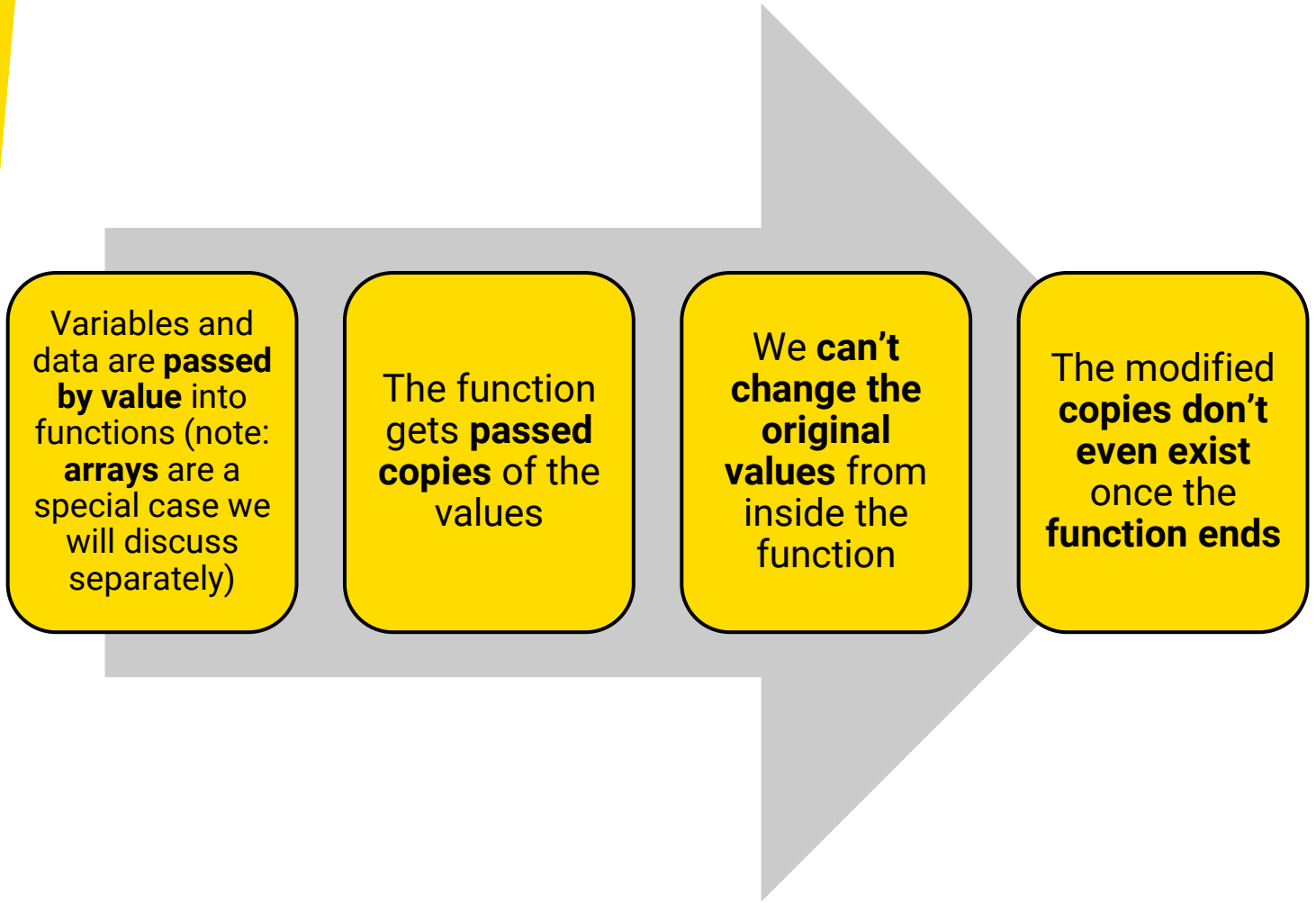
Stack memory stores information needed for your program to run, particularly details about **function calls**.

Each time a function is called, a new block of data is **pushed onto the stack**, including: the **function's local variables** and information about **where the program should return** once the function finishes

When the function (or code block { }) finishes executing, its data, including variables, is **automatically removed from the stack**.

Stack memory is allocated **at run time**, not at run time, and is managed **automatically by the program**, not directly by the developer.

Functions And call by value




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!
BRB
CHIPS
Relax... We'll be back soon!

Call by Reference

We can pass the **addresses of variables** into functions, just like we do with `scanf`, allowing functions **to modify their values.**

When a function **receives an address**, it can access the corresponding memory location and **directly update the original variable.**

Although the function receives a **copy of the address**, that address still refers to the **same memory location**.

This gives us a way for functions to **modify local variables from the calling function**, even when those variables are **not arrays**.

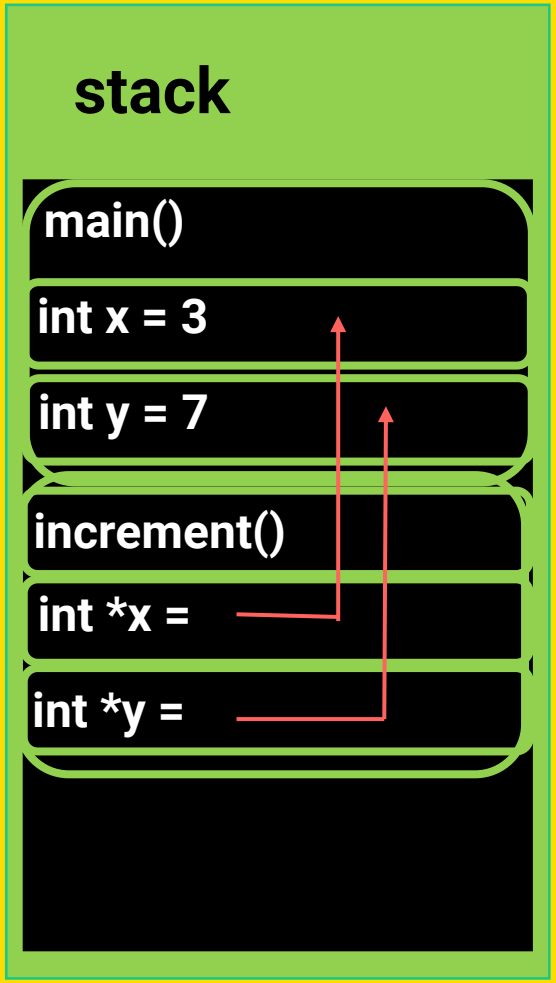
Example

Making function increment work using pointers

```c
#include <stdio.h>

void increment(int *x, int *y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(&x, &y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int *x, int *y) {
    *x = *x + 1;
    *y = *y + 1;

    printf("Inside increment: %d %d\n", *x, *y);
}
```

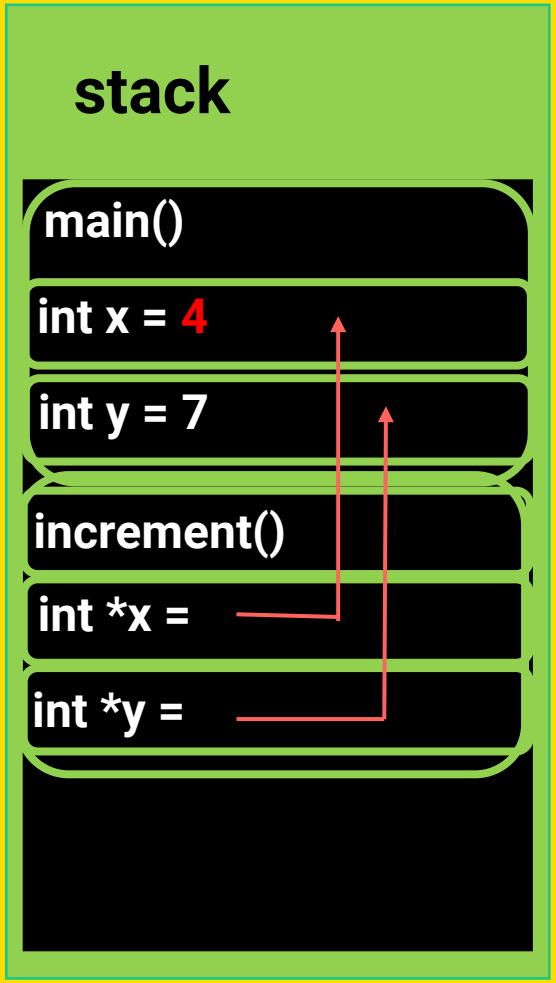
The **`main`** function must pass the **addresses** of `x` and `y` to the function.

The function must be defined with **pointer parameters**, because pointers are used to store memory addresses.




```c
#include <stdio.h>

void increment(int *x, int *y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(&x, &y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int *x, int *y) {
    *x = *x + 1;
    *y = *y + 1;

    printf("Inside increment: %d %d\n", *x, *y);
}
```

Output: Before increment: 3 7




```c
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void increment(int *x, int *y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(&x, &y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int *x, int *y) {
    *x = *x + 1;
    *y = *y + 1;

    printf("Inside increment: %d %d\n", *x, *y);
}
```
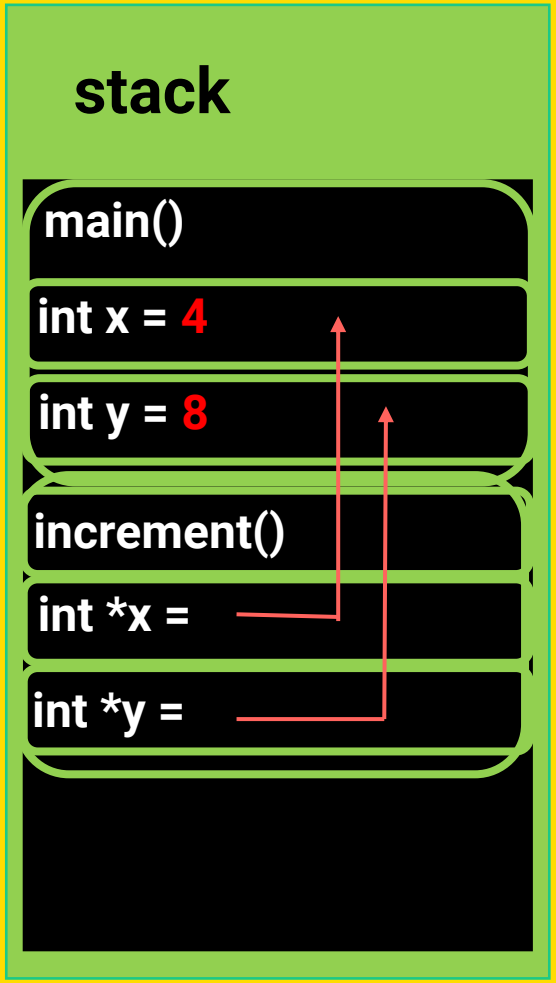
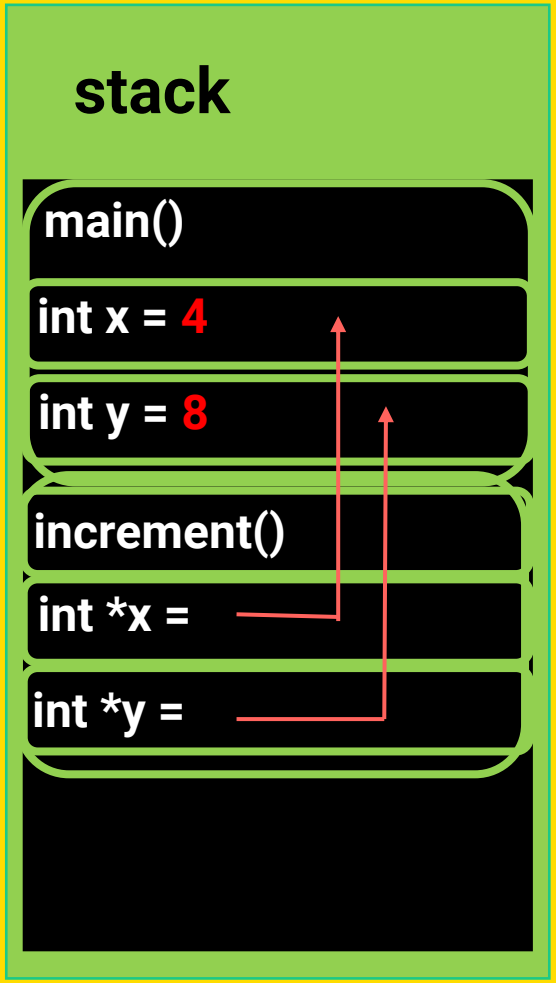

Output: Before increment: 3 7




```c
#include <stdio.h>

void increment(int *x, int *y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(&x, &y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int *x, int *y) {
    *x = *x + 1;
    *y = *y + 1;

    printf("Inside increment: %d %d\n", *x, *y);
}
```

Output: Before increment: 3 7




```c
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int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(&x, &y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int *x, int *y) {
    *x = *x + 1;
    *y = *y + 1;

    printf("Inside increment: %d %d\n", *x, *y);
}
```
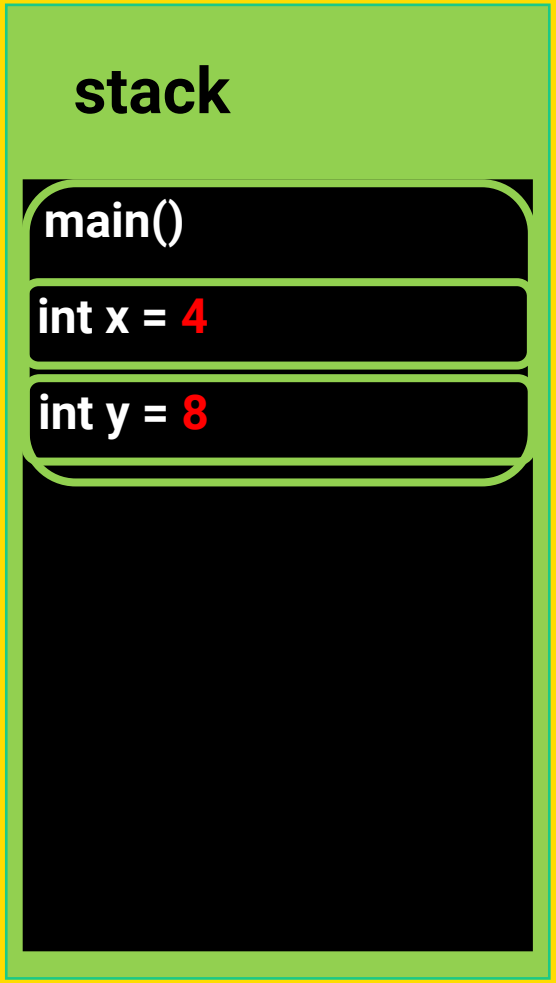

Output: Before increment: 3 7
Output: Inside increment: 4 8




```c
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void increment(int *x, int *y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(&x, &y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int *x, int *y) {
    *x = *x + 1;
    *y = *y + 1;

    printf("Inside increment: %d %d\n", *x, *y);
}
```
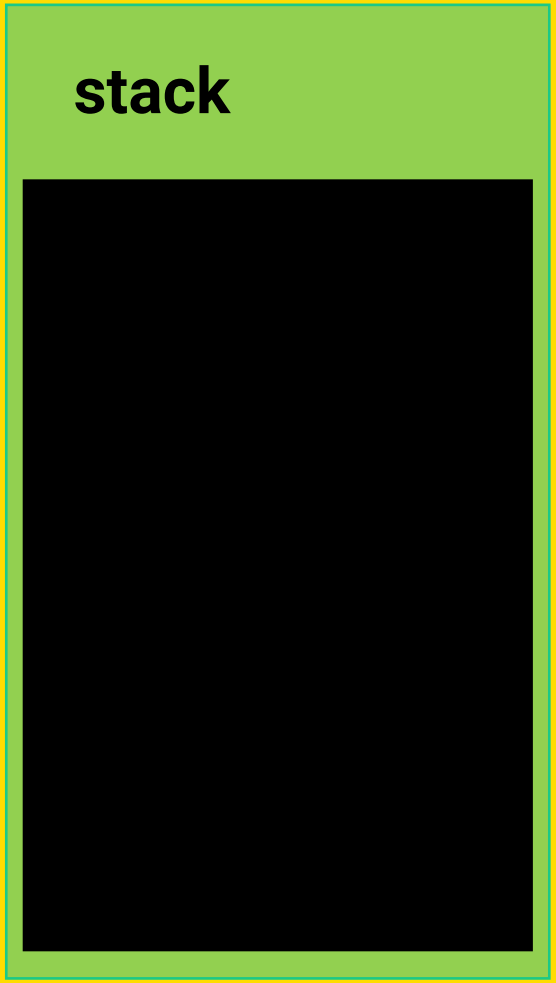

Output: Before increment: 3 7
Output: Inside increment: 4 8
Output: After increment: 4 8




```c
#include <stdio.h>

void increment(int *x, int *y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before increment: %d %d\n", x, y);

    increment(&x, &y);

    printf("After increment:  %d %d\n", x, y);

    return 0;
}

void increment(int *x, int *y) {
    *x = *x + 1;
    *y = *y + 1;

    printf("Inside increment: %d %d\n", *x, *y);
}
```

Output: Before increment: 3 7
Output: Inside increment: 4 8
Output: After increment: 4 8

Example: Let's modify function swap together

```c
#include <stdio.h>

void swap(int x, int y);

int main(void) {
    int x = 3;
    int y = 7;

    printf("Before swap: %d %d\n", x, y);

    swap(x, y);

    printf("After swap:  %d %d\n", x, y);

    return 0;
}

void swap(int x, int y) {
    int temp = x;
    x = y;
    y = temp;

    printf("Inside swap: %d %d\n", x, y);
}
```

Demo

⟶pointer_add.c
⟶Pointer_add_product.c

Live lecture code is written for teaching, not perfection.
It may include extra comments and may not always follow ideal coding style

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Pointers to structs

When working with a **structure variable**, we use the **dot operator (.)** to access its members.

```c
#include <stdio.h>

struct point {
    int x;
    int y;
};

int main(void) {
    struct point location;

    location.x = 5;
    location.y = 12;

    printf("Point coordinates: (%d, %d)\n", location.x, location.y);

    return 0;
}
```

When using a pointer to a struct, accessing members with the dot operator requires extra parentheses

```c
#include <stdio.h>

struct point {
    int x;
    int y;
};

int main(void) {
    struct point location;
    struct point *location_ptr = &location;

    (*location_ptr).x = 10;
    (*location_ptr).y = 9;

    printf("Location: (%d, %d)\n",
           (*location_ptr).x, (*location_ptr).y);

    return 0;
}
```

which can make the code harder to read

Use -> when accessing struct members through a pointer instead of dot operator

```c
#include <stdio.h>

struct point {
    int x;
    int y;
};

int main(void) {
    struct point location;
    struct point *location_ptr = &location;

    location_ptr->x = 10;
    location_ptr->y = 9;

    printf("Location: (%d, %d)\n",
           location_ptr->x, location_ptr->y);

    return 0;
}
```

Example: What is the result of this program??

How can we fix it?

```c
#include <stdio.h>

struct point {
    int x;
    int y;
};
void increment(struct point location);

int main(void) {
    struct point location;

    location.x = 10;
    location.y = 9;

    printf("Before increment: (%d, %d)\n", location.x, location.y);

    increment(location);

    // These will stay the same
    printf("After increment:  (%d, %d)\n", location.x, location.y);

    return 0;
}
void increment(struct point location) {
    location.x = location.x + 1;
    location.y = location.y + 1;

    printf("Inside increment: (%d, %d)\n", location.x, location.y);
}
```

Can I not use a pointer??

In this case Yes!

You can return the updated location

```c
#include <stdio.h>

struct point {
    int x;
    int y;
};

struct point increment(struct point location);
int main(void) {
    struct point location;

    location.x = 10;
    location.y = 9;

    printf("Before increment: (%d, %d)\n", location.x, location.y);

    location = increment(location);

    printf("After increment:  (%d, %d)\n", location.x, location.y);

    return 0;
}
struct point increment(struct point location) {
    location.x = location.x + 1;
    location.y = location.y + 1;

    return location;
}
```

Or pass the address of location to the function

Passing the address of a struct allows a function to modify the original struct without returning it.

```c
#include <stdio.h>

struct point {
    int x;
    int y;
};

void increment(struct point *location);

int main(void) {
    struct point location;

    location.x = 10;
    location.y = 9;

    printf("Before increment: (%d, %d)\n", location.x, location.y);

    increment(&location);

    printf("After increment:  (%d, %d)\n", location.x, location.y);

    return 0;
}

void increment(struct point *location) {
    location->x = location->x + 1;
    location->y = location->y + 1;
}
```

Functions and Arrays

- When an array is passed to a function, the function receives the **address of the first element** of the array.
- The entire array is **not copied** into the function.
- Instead, only a **copy of the array's starting address** is passed.
- Because both the function and the caller refer to the same memory, the function can **modify the original array values**.

Example:

What is the output of this program?

```c
#include <stdio.h>

void double_values(int values[], int size);

int main(void) {
    int scores[] = {3, 5, 7, 9};
    int i = 0;

    double_values(scores, 4);

    while (i < 4) {
        printf("%d ", scores[i]);
        i++;
    }

    return 0;
}

void double_values(int values[], int size) {
    int i = 0;

    while (i < size) {
        values[i] = values[i] * 2;
        i++;
    }
}
```

Demo

→pointer_array_function.c

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

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Pointers and strings (array of char)

```c
#include <stdio.h>

int main(void) {
    char word[] = "Computer";
    char *ptr = &word[3];

    printf("%c\n", *ptr);
    printf("%c\n", ptr[0]);
    printf("%c\n", ptr[1]);
    printf("%s\n", ptr);

    return 0;
}
```

What is happening?

- `word` is a **character array** storing the string `"Computer"`
- `ptr` is a **pointer to a character**
- `&word[3]` points to the **fourth character** of the string (`'p'`)

Understanding the output

- `*ptr`
  → prints `'p'`
- `ptr[0]`
  → same as `*ptr`, prints `'p'`
- `ptr[1]`
  → moves one character forward, prints `'u'`
- `printf("%s", ptr);`
  → prints the string starting from `'p'`:

```
puter
```

Demo

→pointer_string.c
→Pointer_string_function.c

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Voice of the Student

Anonymous ongoing feedback
Anything you wanted to share with me

26T1 Voice of the Student – Fill out form

See you soon …

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