

# Basics of C

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# Struct Address

## Objective

- Learn basics of data structures
  - Learn how memory may be padded within data structures
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## Review Basics

Here is the basic use of data structures in C:

```
// Declare data structure in C using typedef
typedef struct {
    int i;
    char c;
    float f;
} my_struct_t;

// Pass data structure as a copy
void struct_as_param(my_struct_t s) {
    s.i = 0;
    s.c = 'c';
}

// Pass data structure as a pointer
void struct_as_pointer(my_struct_t *p) {
    p->i = 0;
    p->c = 'c';
}

// Zero out the struct
void struct_as_pointer(my_struct_t *p) {
    memset(p, 0, sizeof(*p));}
```

---

## Padding

1. Use the struct below, and try this sample code
  - Note that there may be a compiler error in the snippet below that you are expected to resolve on your own
  - Struct should ideally be placed before the main() and the `printf()` should be placed inside of the `main()`
  - You should use your SJ embedded board because the behavior may be different on a different compiler or the board
2. Now un-comment the `packed` attribute such that the compiler packs the fields together, and print them again.

```
typedef struct {  
    float f1; // 4 bytes  
    char c1;  // 1 byte  
    float f2;  
    char c2;  
} /*__attribute__((packed))*/ my_s;  
// TODO: Instantiate a struct of type my_s with the name of "s"  
printf("Size : %d bytes\n"  
       "floats 0x%p 0x%p\n"  
       "chars  0x%p 0x%p\n",  
       sizeof(s), &s.f1, &s.f2, &s.c1, &s.c2);
```

**Note:**

- Important: In your submission (could be comments in your submitted code), provide your summary of the two print-outs. Explain why they are different, and try to draw conclusions based on the behavior.

# Design a code module

This article demonstrates how to design a new code module.

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## Header File

A header file:

- Shall have `#pragma` once attribute (google it for the reason)
- Shall NEVER have variables defined

```
// - Note: Remove all lines from your code that start with //-  
//- Put this line as the very first line in your header module  
#pragma once  
//- #include all header files that THIS header needs  
//- Do not include headers here that are not needed  
//- For example, we do not need gpio.h file here, but maybe you can move this to switch_led.c  
#include "gpio.h"  
  
//- DO NOT put any variables here, like so:  
static int do_not_do_this;  
int definitely_do_not_do_this;  
//- All functions without paramters should be marked as (void)  
void switch_led_logic__initialize(void);  
void switch_led_logic__run_once(void);
```

`#pragma` once is a replacement of

```
#ifndef YOUR_FILE_NAME__  
#define YOUR_FILE_NAME__
```

```
void your_api(void);  
#endif
```

Intent of `#pragma` once and `#ifndef`

- When other code modules `#include` your header file, you only want functions to be declared once
- The name of `#ifndef` can be anything unique, but must not conflict with other files
- `#include` literally copies and pastes the contents of the file in the file wherever you have the

```
#include
```

---

## Source File

A source file:

- Shall have all variables defined as static; this will keep their visibility private to their file

```
// - Note: Remove all lines from your code that start with //-  
// - Include the header file for which this code modules belongs to  
#include "switch_led_logic.h"  
// - Declare all variables as STATIC  
static gpio_s my_led;  
// - Define your public functions (part of this module's header file)  
void switch_led_logic__initialize(void) {  
    my_led = gpio__construct_as_output(GPIO__PORT_2, 0);  
}  
void switch_led_logic__run_once(void) {  
    gpio__set(my_led);  
}
```

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## Unit Test file

A unit-test file:

- Shall `#include` the headers that you want (those that should not be "mocked")
- Shall `#include` Mock headers to generate stubs (rather than the full implementation)

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## Useful stuff

Clang auto-formatter will format the source code for you. It will also sort the `#includes`, so it is recommended to put an empty line such that it sorts the `#includes` more elegantly. For example, you can separate the FreeRTOS includes, system includes, and other includes.

```
// - Note: Remove all lines from your code that start with //-  
// - Include system includes first  
#include <stdio.h>  
// - FreeRTOS requires this header file inclusion before any of its source code  
// - This only applies to code included from FreeRTOS  
#include "FreeRTOS.h"  
#include "semphr.h"  
#include "task.h"  
// - Clang will sort these  
#include "abc.h"#include "def.h"
```

---

## Try the following

- Have two code modules, such as `main.c` and `periodic_callbacks.c` include a header file that does not have `#pragma once` and observe what happens when you compile

# Function Pointer

## Pointers

Pointers are the data types that can be used to store the address of some data stored in a computer's memory. Pointers are mostly used as a data type that would store the address of other variables.

Pointers can point to data/functions where data could be stored as a constant or a variable. We can also use pointers to dereference and get the value at whatever address the pointer is pointing at.

```
// <variable_type> *<name>
// example:
int data;int *pointer_to_integer = &data;
```

---

## Function Pointers

Function pointers are used to store the address of functions. We need function pointers to make "callbacks", but let us understand the basic syntax first.

### Function Pointer Syntax

1. If the function return type is void

```
void (*func_pointer)(void);
```

Let us re-read the syntax, `*func_pointer` is the pointer to a function. `void` is the return type of that function, and finally `void` is the argument type of that function. The parenthesis around the function pointer is a must otherwise it will change the meaning of the function pointer declarations.

2. If a function returns an `int` and has a `char*` as an input parameter, then the code looks like this:

---

```
int (*func_pointer)(char *)
```

In this example:

1. `*func_pointer` is the function pointer
  2. `int` is the return type of that function
  3. `char*` is the type of argument.
- 

## Examples

**Code Example 1:** Function pointers with an int as an argument

```
#include <stdio.h>

void function(int arg) {
    printf("Function being called and arg is: %d\n", arg);
}

int main(void) {
    void (*func_pointer)(int);

    // assign function to the function pointer
    func_pointer = &function;

    // call the function pointer
    (*func_pointer)(6);

    // Or call it like this:
    func_pointer(6);}
```

**Code Example 2:** Function pointer returns and taking argument as void data type.

```
// Let us "typedef" the function pointer: void void_function(void);
typedef void (*void_function_t)(void);
void foo(void) {
    puts("Hello");
}
```



```

int main(void) {
    // assign function to the function pointer
    void_function_t func_pointer = foo;

    // call the function pointer
    func_pointer();}

```

**Code Example 3:** How to use an array of functions using function pointers.

```

/* Example 1 */
void foo(void) { puts("foo"); }
void bar(void) { puts("bar"); }
// Typedef a function with void argument, returning nothing (void)
typedef void (*void_function_t)(void);
int main(void) {
    // assign array of functions to the function pointer
    void_function_t func_pointers[] = {foo, bar};

    // call the function pointers
    func_pointers[0]();
    func_pointers[1]();
}

/* Example 2 */
/* For simplicity considering number_one > number_two */
int add(int number_one, int number_two) { return number_one+number_two; }
int sub(int number_one, int number_two) { return number_one-number_two; }
int multiply(int number_one, int number_two) { return number_one*number_two; }
int divide(int number_one, int number_two) { if(number_two !=0) return (number_one/number_two); else r
int main(void) {
    int x = 10, y = 2;
    int choice,result;

    // assign array of functions to the function pointer
    int (*function_pointer[4])(int,int) = {add, sub, multiply, divide};

    printf("Enter 0: For Addition, 1 for subtraction, 2 for multiplication, and 3 for division: ");

```

```
scanf("%d", &choice);

// call the required function pointer
result = function_pointer[choice](x, y);

printf("Result: %d\r\n", result);
return 0;}
```