CSE216
Foundations of Computer Science

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C crash course (cont.)

Errata:
Indeed, C99 has a bool type

- It is called _Bool
- Aliased to bool in stdbool.h
- But no bool before C99. E.g. No bool in C89 (ANSI C).

In the following

- **C Pointers**
- **Lab questions**

FANG Interview Question 1: const char* vs. char* const

Cannot change *pointer

Cannot change pointer

- What does **const char* s = “hello";** do ?

- **const char*** is a pointer to a "constant character”. This means you're not allowed to change the character that the pointer is referring to

FANG Interview Question 1: const char* vs. char* const

- What does **char* const str = “hello";** do ?

- **char* const** is a “constant pointer” to a character. This means you're not allowed to change the pointer

FANG Interview Question 2: What is void*?

- generic pointer type
- raw address in memory
- can store the address of any object
- can be type-casted to any type of pointer
- Cannot be directly dereferenced. To access the object, you must first cast void * to a correct pointer type.

```c
#include <stdio.h>

void printNumber(void *ptr, char type) {
    if (type == 'i') { // If the type is integer
        int *int_ptr = (int *)ptr;
        printf("The number is %d\n", *int_ptr);
    } else if (type == 'f') { // If the type is float
        float *float_ptr = (float *)ptr;
        printf("The number is %f\n", *float_ptr);
    }
}

int main() {
    int i = 5;
    float f = 9.5;

    // Passing integer pointer
    printNumber(&i, 'i');

    // Passing float pointer
    printNumber(&f, 'f');

    return 0;
}
```

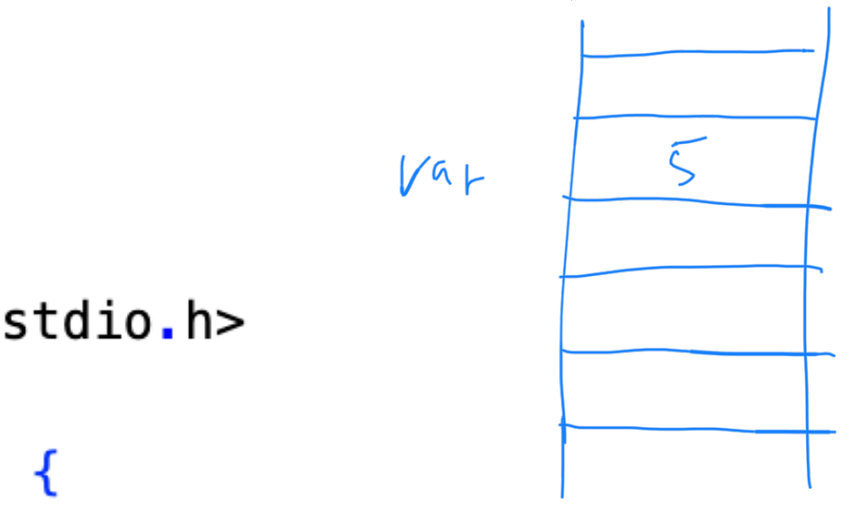
dynamic casting (c++ uses this); occurs at runtim

* Static casting: (double 2); occurs at compile time

* by using a void pointer, we can use a single function that can take in multiple types as arguments.

Address of (&)

- To get the address of a variable, we use the ampersand (&) operator,



var = 5

&var = 0x abcdabcd

address

name | value | type

```c
#include <stdio.h>

int main() {
    int var = 5;
    printf("Address of var: %p\n", (void*)&var);
    return 0;
}
```

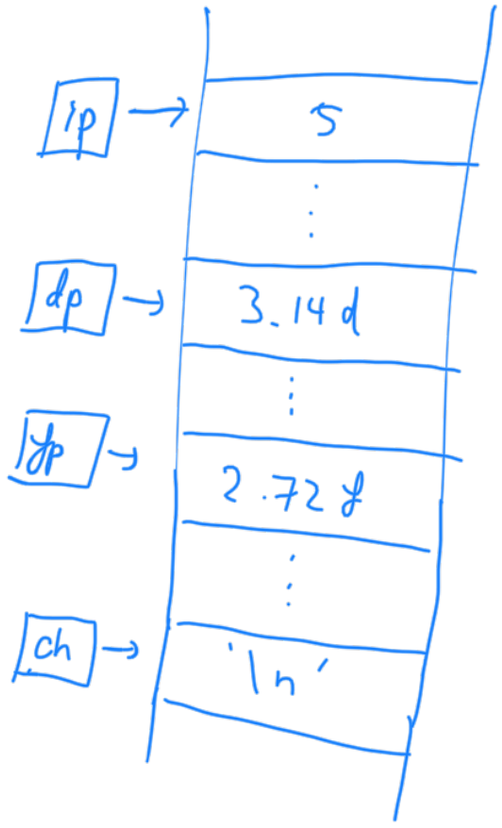
*void is a syntax error;

*p is a concrete pointer. ✓

Cast it to a raw type (for backwards compatibility; older versions require a valid pointer type).

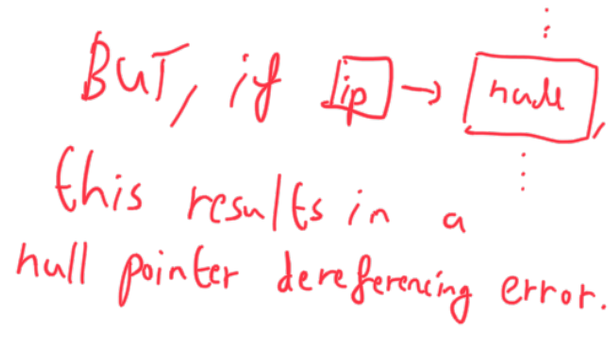
Pointers (*)

- A pointer is a variable whose value is an address
- To define a pointer, use **type *var-name;**



type:
int *
double *
float *
char *

```
int    *ip;    /* pointer to an integer */
double *dp;    /* pointer to a double */
float  *fp;    /* pointer to a float */
char   *ch     /* pointer to a character */
```

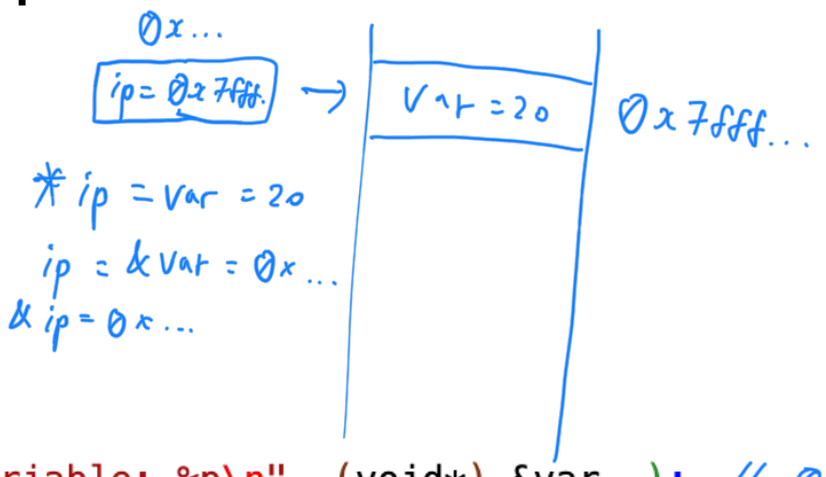


Question

- If the 1st printf gives 0x7fff5c7ea38c, what will be the results of the 2nd and 3rd printf?

★ modern OSs have 64-bit memory addresses;
therefore 16 (16×4=64) hex digits.

0xF = 16(10) = 1111(2)



★ ip = var = 20
ip = &var = 0x...
& ip = 0x...

```c
#include <stdio.h>
int main () {
   int var = 20;
   int *ip = &var;

   printf("Address of var variable: %p\n", (void*) &var  ); // 0x7fff...

   printf("Address stored in ip variable: %p\n", (void *) ip ); // 0x7fff...

   printf("Value of *ip variable: %d\n", *ip ); // 20
   return 0;
}
```

address that ip points to

value denoted by ip

Question

default

popular

- Any difference between int *ptr and int* ptr?

*ptr is an integer

ptr is an int pointer

- The default usage is int *ptr; although many prefer the other

- What is the type of “b” in **int* a, b**?

pointer integer

// Same as int *a, b

// both pointers : int *a, *b

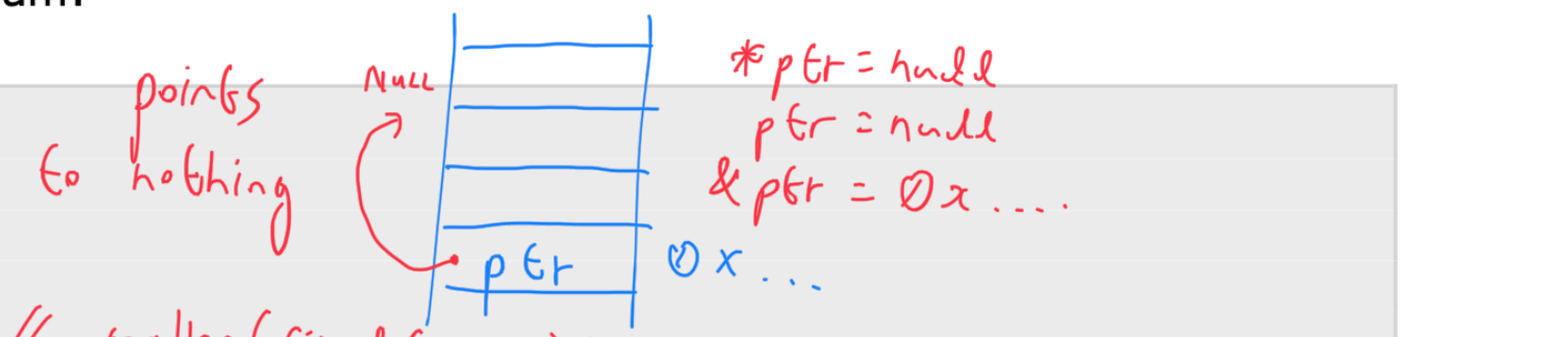
NULL Pointer

- The NULL pointer always points to no objects
- int *ptr = NULL;
- cannot be dereferenced

Non-sense from an online tutorial

The **NULL** pointer is a constant with a value of zero defined in several standard libraries. Consider the following program:

```
#include <stdio.h>

int main ()
{
   int  *ptr = NULL;

   printf("The value of ptr is : %x\n", &ptr  );

   return 0;
}
```



When the above code is compiled and executed, it produces the following result:

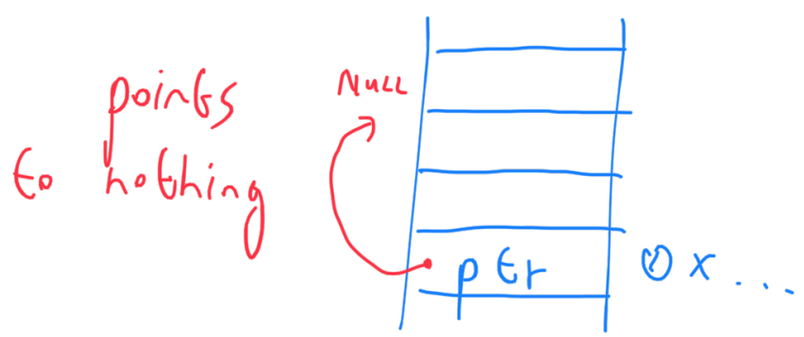
```
The value of ptr is 0
```

WRONG

Some computers, i.e., Macs, denote null pointers as $zero.

Question: What will happen if we run this

```c
#include <stdio.h>
int main () {

  int *ptr = NULL;

  printf("The value of ptr is : %p\n", (void *) &ptr  ); // address of ptr itself

  printf("The value of ptr is : %p\n", (void *) ptr  ); // ptr points to nothing; NULL

  printf("The value of ptr is : %x\n", *ptr  ); // cannot dereference a null pointer.
                                                // Segmentation fault (NPE)

return 0;
}
```



Try: jdoodle.com/ia/IN3

Check if a pointer is Null

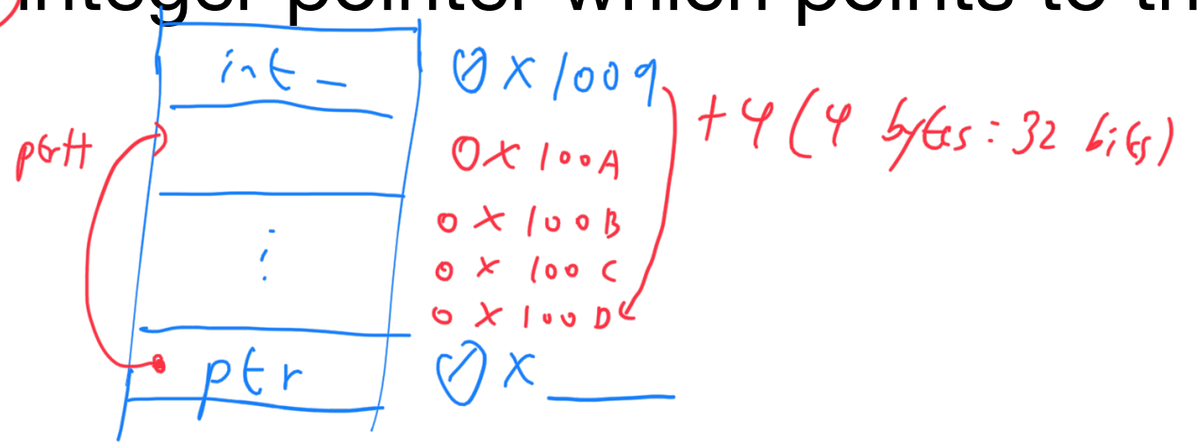

```
if(ptr)     /* succeeds if p is not null */
if(!ptr)    /* succeeds if p is null */
```

// professional way

```
if(ptr) ...
if(!ptr) ...
```

FANG Interview Question 3: Pointer arithmetics

- Assume ptr is an 32-bit integer pointer which points to the address 0x1009.



- ptr++ = ? 0x100D

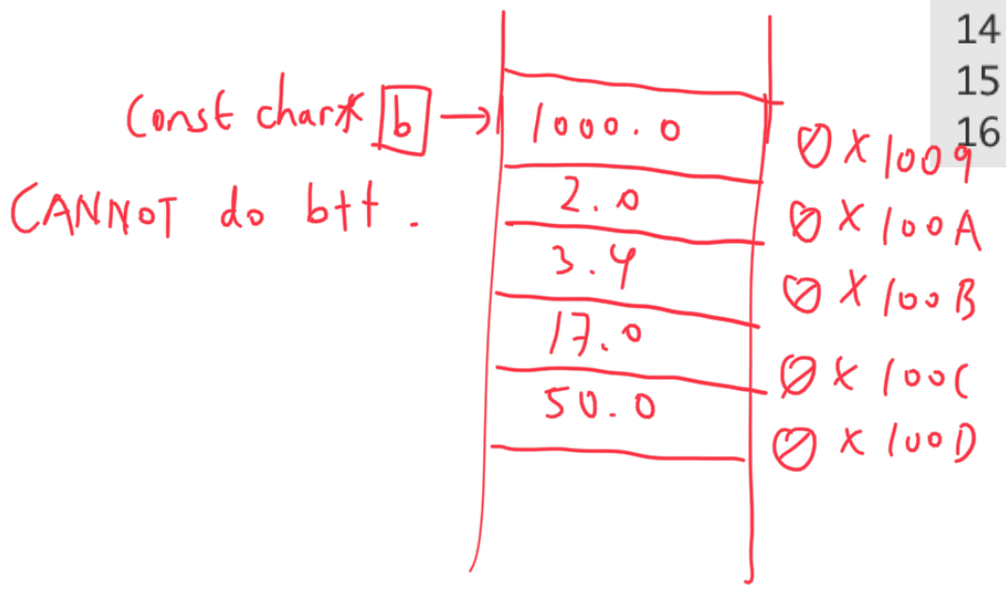
- Assume ptr is a char pointer which points to the address 1009.

1 byte

- ptr++ = ? 0x100A

FANG Interview Question 4: Which one will crash, and why?

```c
#include <stdio.h>

const int MAX = 3;
int main () {

    int var[] = {10, 100, 200};

    double b[5] = {1000.0, 2.0, 3.4, 17.0, 50.0};
    double *ptr=b; // double ptr = &b[0];

    for (int i = 0; i < 5; i++) {
        printf("Value of balance[%d] = %f\n", i, *ptr );
        /* move to the next location */
        ptr++;
    }
    return 0;
}
```




```c
#include <stdio.h>

const int MAX = 3;
int main () {

    int var[] = {10, 100, 200};

    double b[5] = {1000.0, 2.0, 3.4, 17.0, 50.0};

    for (int i = 0; i < 5; i++) {
        printf("Value of b[%d] = %f\n", i, *b );
        /* move to the next location */
        b++;
    }
    return 0;
}
```

b is a const pointer, so it cannot be incremented.

Arrays

- Arrays are constant pointers
- int x[5];
- x++ would not work
- Use int * ptr = x; ptr++;

C Exercises

1

- What will be the output of the following C code?

```
int main() {
    int var = 20;
    int *ptr;
    ptr = &var;
    printf("%d", *ptr);
    return 0;
}
```

int* ptr = var;

// 20

2

- What will be the output of the following C code?

```
int x = 10;

int *p = &x;

*p = 20;   // *(&x) = 10 → 20

printf("%d", x);   // 20
```

3

- What will be the output of the following C code?

```
int main() {

    int arr[] = {10, 20, 30, 40, 50, 60};

    int *ptr = arr;

    printf("%d ", *(ptr++)); // 10 ; different from (*ptr)++.

    printf("%d", *ptr); // 20

    return 0;

}
```

4

- What will be the output of the following C code?

```
int x = 10;
int *p = &x; // 0x ____
*p = 20; // *(&x) = 10 → 20
printf("%d", x); // 20; Same question as 2.
```

Lab exercise 1:
Implementing a Caesar Cipher in C

- In this lab exercise, you will be implementing a simple Caesar cipher in the C programming language. A Caesar cipher is a type of substitution cipher where each character in the plaintext is 'shifted' a certain number of places down the alphabet. For example, with a shift of 3, A would be replaced by D, B would become E, and so on.

Problem Statement

```c
int main() {
    char str[] = "KENNEDY";
    caesarCipher(str);
    printf("%s\n", str); // Should print "NHQQHGB"
    return 0;
}
```

- Write a C function **void caesarCipher(char* str)** that performs a Caesar cipher on an input string. The string will consist of capital letters only, and the cipher should shift each letter 3 places to the right in the alphabet, wrapping around to the beginning of the alphabet if necessary.

- For example, the input string "KENNEDY" should produce the output "NHQQHGB".

FYI

- **Character arrays in C:** In C, strings are typically represented as arrays of characters. For example, the string "HELLO" can be declared as **char str[] = "HELLO";**. Note that all strings in C are null-terminated, which means they end with a special character '\0'.

- **Character pointers in C (char*)**: A character pointer in C can also be used to represent a string. It can point to the first character of a string, and the string is assumed to continue until a null character is encountered. For example, **char* str = "HELLO";**.

- **String manipulation in C**: C provides several functions for manipulating strings, such as **strcpy** for copying strings and **strlen** for finding the length of a string. However, in this exercise, you will be manipulating strings directly.

```c
#include <stdio.h>

void caesarCipher(char* str) {
    int i = 0;
    while(str[i] != '\0') {
        if(str[i] >= 'A' && str[i] <= 'Z') {
            // Shift character by 3 places. If it goes beyond 'Z', take it back
to the start
            str[i] = 'A' + (str[i] - 'A' + 3) % 26;
        }
        i++;
    }
}

int main() {
    char str[] = "KENNEDY";
    caesarCipher(str);
    printf("%s\n", str); // Should print "NHQQHGB"
    return 0;
}
```

Lab exercise 2:
Sentence Title Case Verification in C

- Your task is to write a C function that checks whether a sentence is in 'Title Case'. In other words, the function should return true if each word in the sentence starts with a capital letter and continues with lowercase letters. Here are the specific requirements:

    - The function should take a single argument - a string, representing the sentence to check. This string consists only of letters and blank spaces.

    - The function should return a boolean value (in C, typically represented as an int with 0 for false and non-zero for true).

    - The function should return true if and only if each word in the sentence starts with a capital letter and continues with lowercase letters. Otherwise, it should return false.

- Write the function as described above. Test your function with several test sentences to ensure that it works correctly.

FYI

- In C, strings are represented as arrays of characters. You can use array indexing to access individual characters in a string, similar to how you'd access elements in an array. For example, sentence[0] would give you the first character in the string sentence.

- C provides functions to manipulate and check characters. You might find the following functions from the ctype.h library useful:

  - **isupper(int c)** checks if the given character is uppercase.

  - **islower(int c)** checks if the given character is lowercase.

  - **isspace(int c)** checks if the given character is a whitespace character.

- Reminder: A string in C is null-terminated, meaning it ends with the special null character '\0'. You can use this fact to iterate through the string.

```c
#include <ctype.h>
#include <stdbool.h>
#include <stdio.h>
bool isTitleCase(char* str) {
    int i = 0;
    while (str[i]) {
        // If the character is a space, skip over all spaces and check if next character is uppercase
        if (str[i] == ' ') {
            while (str[i] == ' ') {
                i++;
            }
            if (!str[i] || !isupper(str[i])) {
                return false;
            }
        } else if (i == 0) {
            // The first character of the string should be uppercase
            if (!isupper(str[i])) {
                return false;
            }
        } else if (!islower(str[i])) {
            // All other characters should be lowercase
            return false;
        }
        i++;
    }
    return true;
}
int main(){
    char * s= "Hellon   World";
    char * s2= "Hello world";
    if (isTitleCase(s)) printf ("%s is title case\n", s);
    else     printf ("%s is not title case\n", s);
    if (isTitleCase(s2)) printf ("%s is title case\n", s2);
    else     printf ("%s is not title case\n", s2);
}
```