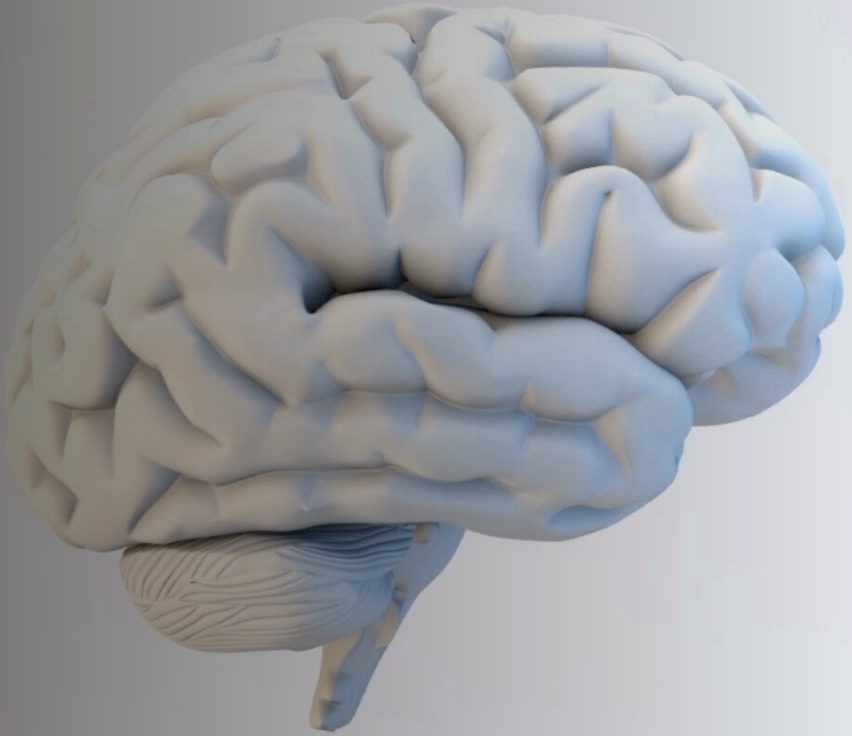
HELP SESSION 1
HW1 and C Review



CS370

COLORADO STATE UNIVERSITY

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Outline

- Overview of the assignment
- Pointers and references
- Dynamic Memory
- Tying it all together/Questions

Overview of Assignment

- Required files:
  - Initiator.c
  - Worker.c
  - Worker.h

Initiator.c

- Takes in one command line argument

  ⇒ Perform argument check

- Set the seed with srand()
  - atoi()
- Invoke functions in worker.c
  - float running_ratio = get_running_ratio();
- *What should be included in initiator.c so that it can call the functions in worker.c?*

Worker.c

- int random_in_range(int lower_bound, int upper_bound)
- float get_running_ratio();
- int get_divisibility_count (int *array, int arraySize, int randomDividend);

You are encouraged to define new functions as you see fit. However, the above three functions must be included.

int random_in_range(int lower_bound, int upper_bound)

- Returns a random number in range [a,b)
- Given to you in write up

int get_divisibility_count (int *array, int arraySize, int randomDividend);

- Returns to get_running_ratio() the number of divisible items in each array.

float get_running_ratio();

- Controls flow of the program

1. Calculate the number of iterations for your loop
2. Allocate an array with the appropriate number of elements on each iteration
3. Populate the array with random integers (updated 9/2/2021)
4. Generate a new divisor per iteration
5. Calls get_divisibility_count()
6. Keep track of the iteration with the largest number of divisible integers.
7. Keep a running sum of the ratio of (divisible/non-divisible)
8. Returns average ratio across all iterations

   => (running sum-from step (6))/number of iterations-from step (1)

C review

- The following slides are based on material gathered from CS370- Spring2021 Help Session 1.
- Materials and images found on the following websites:
  1. https://iq.opengenus.org/pointers-in-c/
  2. https://www.geeksforgeeks.org/difference-between-malloc-and-calloc-with-examples/
  3. https://www.geeksforgeeks.org/difference-between-malloc-and-calloc-with-examples/
  4. https://www.cprogramming.com/tutorial/makefiles.html

C review: Pointers

- A pointer declared datatype *var_name is a reference to a section of memory allocated for some type of object.
- * operator is the de-referencing operator.

 It has dual meaning.

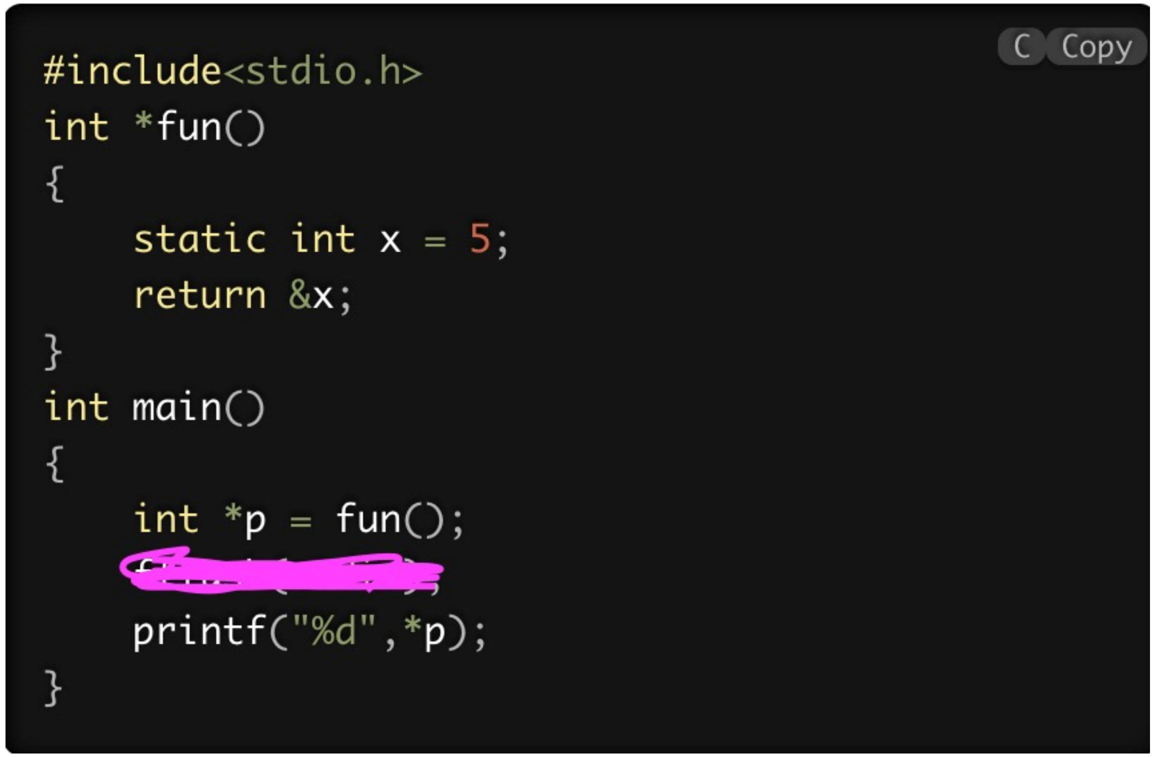
 1) declaring a pointer int *p;

 2) Accessing what the pointer is pointing to printf(“%d”, *p);

Warning regarding dangling pointers!!!!

References

- The & operator is used to obtain the address of an object so that it may be assigned to a pointer.
- Let int *p;
- If int x = 5; and p = &x
- Then return *p equals?



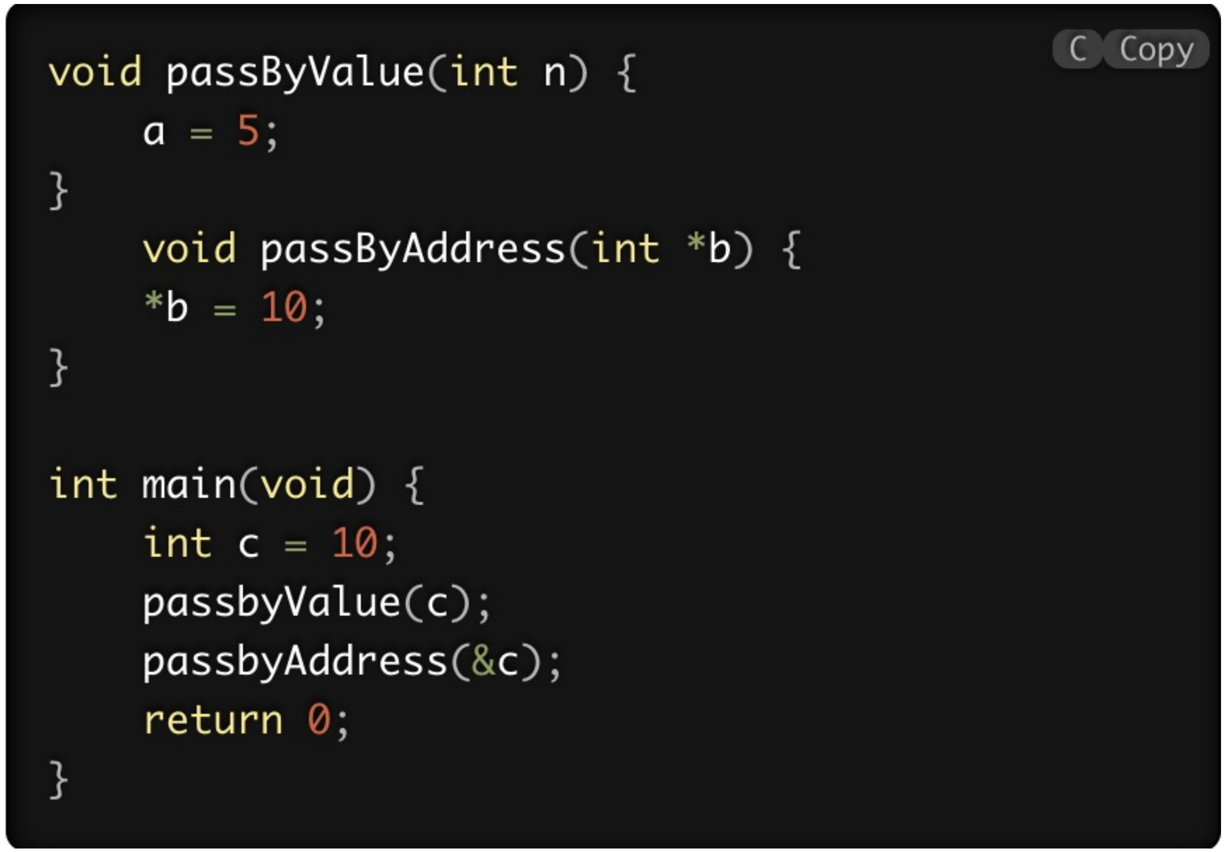
```c
#include<stdio.h>
int *fun()
{
    static int x = 5;
    return &x;
}
int main()
{
    int *p = fun();
    [redacted]
    printf("%d",*p);
}
```

Image taken from:

https://iq.opengenus.org/pointers-in-c/

References continued

- Use the & operator to pass an object by address.
- Why?
- Its less costly than copying the object.



```c
void passByValue(int n) {
    a = 5;
}
    void passByAddress(int *b) {
    *b = 10;
}

int main(void) {
    int c = 10;
    passbyValue(c);
    passbyAddress(&c);
    return 0;
}
```

Image taken from:

https://iq.opengenus.org/pointers-in-c/

Arrays

- Declaring an array

  Data_type array_name [array_size];

  Data_type array_name[n] = {x0,x1,x2,x3, … xn-1} where (x0,..,xn-1) are objects of the data_type and n is the size of the array.

  NOTE: this is how you declare and innitialize an array on the stack. Your assignment requires you to do so on the heap. More on that next!

  NOTE: [n] may be omitted in favor of []. Which implies you do not have to give a size when you declare and initialize in the same step.

- Indexing in arrays –zero based index

  Array_name[0] = 5

  return Array_name[0] -> returns 5

Arrays as pointers

- Int my_array[] = {1,2,3,4,5};
- Int *p = my_array;
- What does p contain? What about *p?
- Int x = *(p+i) equivalent to x = p[i] (updated 9/2/2021)
- p= &my_array[2]
- What does p contain?
- My_array[i] is equivalent to *(my_array+i)

More operations on pointers

- *p++

  Says give me the value at p, then increment p such that it points to the next element.

  By how much is it incremented?

- *++p

  Says increment p and give me the value that p is now pointing to.

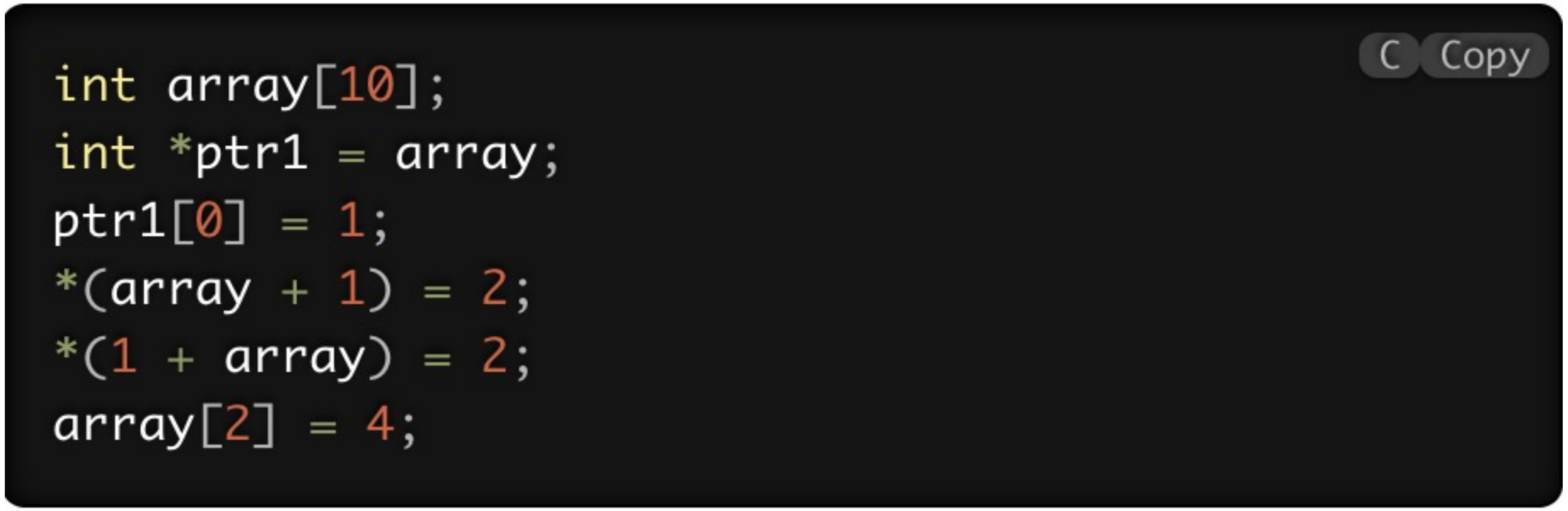
- ++*p

  Says increment the value at p

Pointers and Strings

- A string in C is an array of char types.
- It is terminated by ‘\0’ which is the null character.
- char my_string[] =“Hello World!”
- What is the size of my_string?
- Check it yourself
- printf("%lu\n", (sizeof(my_string)/sizeof(char)));

Arrays as pointers



```c
int array[10];
int *ptr1 = array;
ptr1[0] = 1;
*(array + 1) = 2;
*(1 + array) = 2;
array[2] = 4;
```

Image taken from:

https://iq.opengenus.org/pointers-in-c/

THE HEAP!

- Your assignment requires you to allocate on the heap.
- void* malloc(size_t size);

  “allocates memory block of given size (in bytes) and returns a pointer to the beginning of the block. ”

  malloc() doesn’t initialize the allocated memory.
- void* calloc(size_t num, size_t size);

  Similar to malloc but initiallises the memory to zero

https://www.geeksforgeeks.org/difference-between-malloc-and-calloc-with-examples/

Free() and Valgrind

- You need to free the memory you allocate
- How do you check for memory leaks?

Valgrind: A program for tracking memory leaks and errors.

Command: valgrind -q --leak-check=full ./a.out

To see the line where the memory leak occurred compile with –g flag

gcc –o test –g test.c

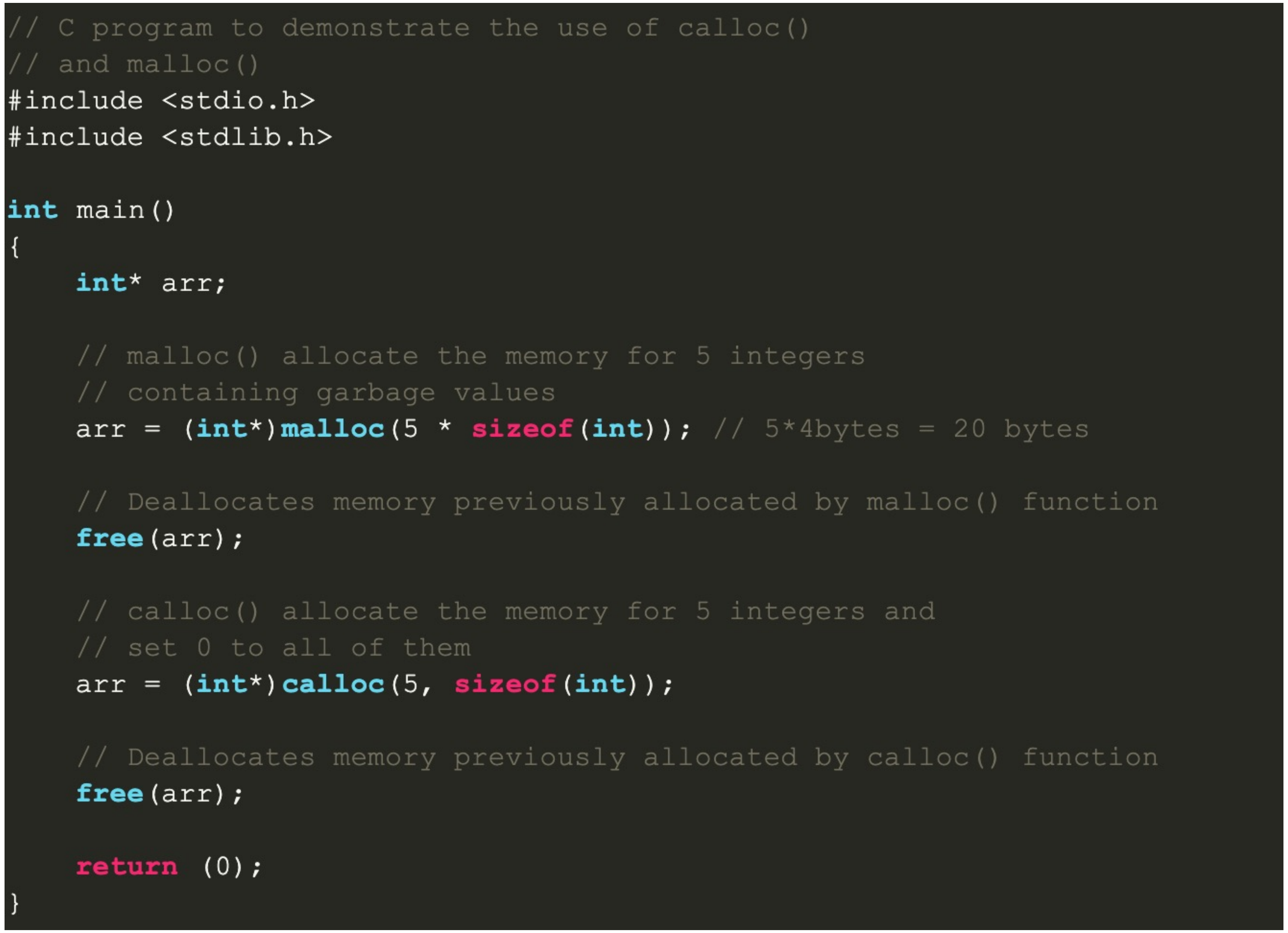
See this helpful lab from CS253 taught by Jack Applin for instructions on how to use valgrind

NOTE: This lab is in c++ but valgrind works all the same.

Please don't use c++ code or compiler.

https://www.cs.colostate.edu/~cs253/Fall21/Lab/Valgrind

Sample array on the heap and using free()



```c
// C program to demonstrate the use of calloc()
// and malloc()
#include <stdio.h>
#include <stdlib.h>

int main()
{
    int* arr;

    // malloc() allocate the memory for 5 integers
    // containing garbage values
    arr = (int*)malloc(5 * sizeof(int)); // 5*4bytes = 20 bytes

    // Deallocates memory previously allocated by malloc() function
    free(arr);

    // calloc() allocate the memory for 5 integers and
    // set 0 to all of them
    arr = (int*)calloc(5, sizeof(int));

    // Deallocates memory previously allocated by calloc() function
    free(arr);

    return (0);
}
```

Image taken from:

https://www.geeksforgeeks.org/difference-between-malloc-and-calloc-with-examples/

Makefile

- A Makefile is simply a way of associating short names, called targets, with a series of commands to execute when the action is requested
    - Default target: make
    - Alternate target: make clean

Makefile continued

- Basic macro: CC=gcc
  - Convert a macro to its value in a target: $(CC)
  - Ex: $(CC) a_source_file.c gets expanded to gcc a_source_file.c
- · To execute: make / make build · To clean: make clean

Makefile Sample

- files=Program1.c Program2.c
- out_exe= Program1
- build: $(out_exe)
- $(out_exe): $(files)
  ```
  $(CC) -o $(out_exe) $(files)
  ```
- package:
  ```
  tar -cvzf John_Doe.tar *.c *.h *.txt Makefile
  ```
- clean:
  ```
  rm -f $(out_exe)
  ```

Any questions?

Acknowledgements

- These slides are based on contributions of current and past CS370 instructors and TAs, including Jack Applin, Abhishek Yeluri, Kevin Bruhwiler, Yashwant Malaiya and Shrideep Pallickara.