Pointer Lesson 1 Outline

A Pointer Experiment

1. Take out a sheet of scrap paper.
2. Tear it in half.
3. Tear it in half again.
4. On one of the quarter sheets, write **<u>legibly</u>** either:
   - your full name (first and last), or
   - an integer from 1 to 100.
5. Fold it in half.
6. Fold it in half again.
7. When the hat comes around the first time,
   put your quarter sheet of paper into it.
8. When the hat comes around the second time,
   take a random quarter sheet of paper out of it.
   If you draw your own name, take out another one and
   put your name back in.

Point!

9. Let’s pick someone.
10. Have them stand up and read their piece of paper, then stay standing.
11. If they read a name, that person should also stand up, and the person who read their name should point at them.
12. Let’s do several of those around the room.
13. So the people pointing at other people are “pointers,” and the people who have a number are “values.”

What is a Pointer?

A ***pointer*** is a variable whose value is an address.

```
float* float_pointer;
```

This means:

Grab a bunch of bytes in memory,
name them `float_pointer`, and think of them as storing an **address**, which is a special kind of `int`.

How many bytes?

On most platforms that you can buy today, a pointer is 8 bytes.

`NULL` Pointer

A `NULL` pointer is a pointer that points to nowhere.

```
float* float_pointer = (float*)NULL;
```

This initialization statement means that the `float` pointer named `float_pointer` should initially point to nowhere.

Note that `NULL` is a C named constant. On most platforms, its value is zero, but that doesn't have to be the case.

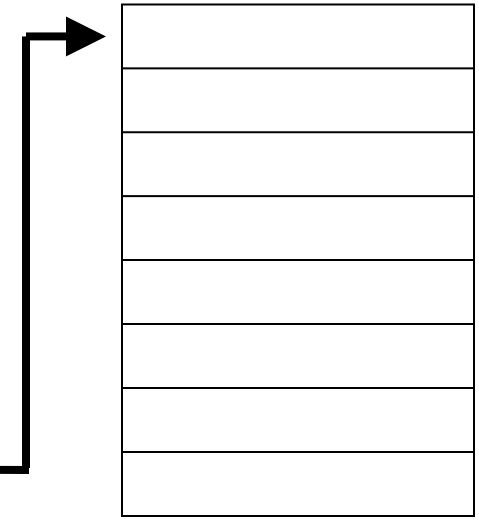
Are Pointers Useful?

We’ve already seen a context where pointers are useful: **dynamic allocation of arrays**.

A dynamically allocated array is really just a pointer to the first byte of the first element of that array:

```
float* list1_input_value =
            (float*)NULL;
          list1_input_value
```

```
list1_input_value =
      (float*)malloc(sizeof(float) *
                      number_of_elements);
          list1_input_value
```



Pointers and Allocation

When you allocate an array

```
list1_input_value =
    (float*)malloc(sizeof(float) *
                   number_of_elements);
```

you're setting a pointer variable's value to:

the address of
the first byte of
the first element of
the array.

What Does `malloc` Do?

The `malloc` function finds a block of memory that is otherwise not being used, claims it, and returns its address (that is, a pointer to the block's first byte).

```
list1_input_value =
    (float*)malloc(sizeof(float) *
                   number_of_elements);
```

In this case, `malloc` finds an unclaimed block of

`sizeof(float) * number_of_elements`

bytes, lays claim to that block, and returns its address to be assigned to `list1_input_value` (which is a pointer, which is to say its value is an address in main memory).

Pointers and Deallocation

When you deallocate an array

```
free(list1_input_value);
```

you're **releasing the block of memory** that contains the array; that is, you're no longer claiming it.

But, that **doesn't change the value of the pointer** variable, because you didn't assign the pointer variable a new value. The pointer's value is still the address of the block of memory – which no longer is the array.

This is **BAD BAD BAD**!

Because, you might accidentally use that pointer later.

So, you have to assign `NULL` to (***nullify***) the pointer **IMMEDIATELY**:

```
list1_input_value = (float*)NULL;
```

Function Arguments

When you call a function in C and you pass it some arguments, those arguments are ***passed by copy***.

This means that the formal arguments in the function definition are actually copies of the actual arguments in the function call. They live at different addresses than the originals.

Pass by copy is also known as:

- pass by value;
- call by copy;
- call by value.

Pass by Copy Example

```
% cat my_bad_increment.c
#include <stdio.h>
int main ()
{ /* main */
    int x = 5;
    void my_increment(int var);

    printf("main: before call, x = %d\n", x);
    my_increment(x);
    printf("main: after  call, x = %d\n", x);
} /* main */

void my_increment (int var)
{ /* my_increment */
    printf("my_increment: before inc, var = %d\n", var);
    var += 1;
    printf("my_increment: after  inc, var = %d\n", var);
} /* my_increment */
% gcc -o my_bad_increment my_bad_increment.c
% my_bad_increment
main: before call, x = 5
my_increment: before inc, var = 5
my_increment: after  inc, var = 6
main: after  call, x = 5
```

Pass by Copy or Pass by Reference

Okay, so ***pass by copy*** means that changing the value of the copy doesn't change the value of the original.

Is there a way to pass an argument so that, in the function, we can change the value of the formal argument, and that'll change the value of the actual argument in the call?

Yes: ***pass by reference***.

Pass by Reference

Pass by reference means that, instead of passing a ~~**copy**~~ of the actual argument, you pass the **address** of the actual argument.

If we can pass the address, then we can modify the value of the variable that lives at that address.

Pass by Reference Example

```
% cat my_good_increment.c
#include <stdio.h>
int main ()
{ /* main */
    int x = 5;
    void my_increment(int* varptr);

    printf("main: before call, x = %d\n", x);
    my_increment(&x);
    printf("main: after  call, x = %d\n", x);
} /* main */

void my_increment (int* varptr)
{ /* my_increment */
    printf("my_increment: before inc, *varptr = %d\n", *varptr);
    *varptr += 1;
    printf("my_increment: after  inc, *varptr = %d\n", *varptr);
} /* my_increment */
% gcc -o my_good_increment my_good_increment.c
% my_good_increment
main: before call, x = 5
my_increment: before inc, *varptr = 5
my_increment: after  inc, *varptr = 6
main: after  call, x = 6
```

The Address Operator `&`

The ***address operator*** `&` is an operator that means "the address of:"

```
% cat addr_op.c
#include <stdio.h>
int main ()
{ /* main */
    int* ip = (int*)NULL;
    int  i;

    ip  = &i;
    i   = 5;
    printf("i=%d, *ip=%d\n", i, *ip);
    *ip = 6;
    printf("i=%d, *ip=%d\n", i, *ip);
} /* main */
% gcc -o addr_op addr_op.c
% addr_op
i=5, *ip=5
i=6, *ip=6
```

Address Operator and `scanf`

We already know a case where we use the address operator: `scanf`.

When we call `scanf`, we want to change the value of the argument(s) at the end of the call; for example:

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

We want to modify the value of `number_of_elements`.

So we have to pass the **address** of this variable, so that `scanf` can change its value.

Pass by Copy vs Pass by Reference #1

In C, when an argument is passed to a function,
the program grabs a new location in memory and
copies the value of the actual argument into this new location,
which is then used as the formal argument.

This approach is known by several names:

- ***pass by value***
- ***call by value***
- ***pass by copy***
- ***call by copy***

By contrast, if we use pointers – and possibly
the address operator `&` in the actual argument(s) –
then this accomplishes the equivalent of ***pass by reference***
(even though the pointer itself is passed by copy).

Pass by Copy vs Pass by Reference #2

We can visualize ***pass by reference***
by imagining Henry's house, which has the address
123 Any Street
We can ***refer*** to Henry's house this way:
Henry's house
But we can also ***refer*** to Henry's house this way:
Dr. Neeman's house
So, "Henry's house" and "Dr. Neeman's house"
are two different names for the same location;
they are ***aliases***.

Pass by Copy vs Pass by Reference #3

We can ***refer*** to Henry’s house this way:

Henry’s house

But we can also ***refer*** to Henry’s house this way:

Dr. Neeman’s house

So, “Henry’s house” and “Dr. Neeman’s house” are ***aliases***: two different names for the same location.

With **pass by reference**, when we call a function, each actual argument and its corresponding formal argument are **aliases** of the same location in memory.

Pass by Reference Bad Example

```
% cat henrys_house_bad.c
#include <stdio.h>
int main ()
{ /* main */
    int henrys_house;
    void who(int  dr_neemans_house);

    who( henrys_house);
    printf("%d people live in Henry’s house.\n",
        henrys_house);
} /* main */

void who (int  dr_neemans_house)
{ /* who */
    printf("How many people live in Dr Neeman’s house?\n");
    scanf("%d", &dr_neemans_house);
} /* who */
% gcc -o henrys_house_bad henrys_house_bad.c
% henrys_house_bad
How many people live in Dr Neeman's house?
4
134513624 people live in Henry's house.
```

Pass by Reference Good Example

```
% cat henrys_house_good.c
#include <stdio.h>
int main ()
{ /* main */
    int henrys_house;
    void who(int* dr_neemans_house);

    who(&henrys_house);
    printf("%d people live in Henry’s house.\n",
        henrys_house);
} /* main */

void who (int* dr_neemans_house)
{ /* who */
    printf("How many people live in Dr Neeman’s house?\n");
    scanf("%d", dr_neemans_house);
} /* who */
% gcc -o henrys_house_good henrys_house_good.c
% henrys_house_good
How many people live in Dr Neeman's house?
4
4 people live in Henry's house.
```

Is Pass by Reference Really by Reference?

In C, the **only** passing option is **pass by copy**.

To pass by reference, we have to
piggyback on top of pass by copy –
because in C, **everything** is **pass by copy**.

So, the **value** that we have to pass by copy is
the **address** of the argument we want to be able to change,
which we achieve using the **address operator** `&`.

In other words, in C, pass by reference is actually pass by copy:
you pass a copy of the address of
the variable that you want the function to be able to change.