POINTERS AND REFERENCES DYNAMIC MEMORY

Problem Solving with Computers-I

```
#include <iostream>
using namespace std;

int main(){
    cout<<"Hola Facebook\n";
    return 0;
}
```

Learning Goals

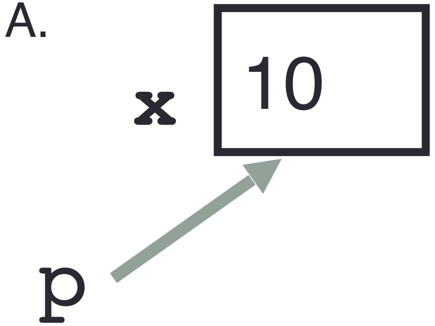
- Understand pointer mechanics and how they are used to pass parameters to functions
- Creating data on the heap with new and delete
- Difference between data on the heap vs. data on the stack
- Functions returning pointers

Tracing code involving pointers

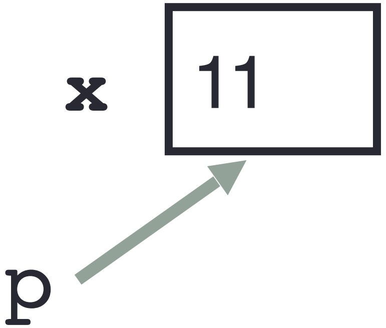
```
int* p;
int x = 10;
p = &x;
*p = *p + 1;
```

Q: Which of the following pointer diagrams best represents the outcome of the above code?

A.



B.



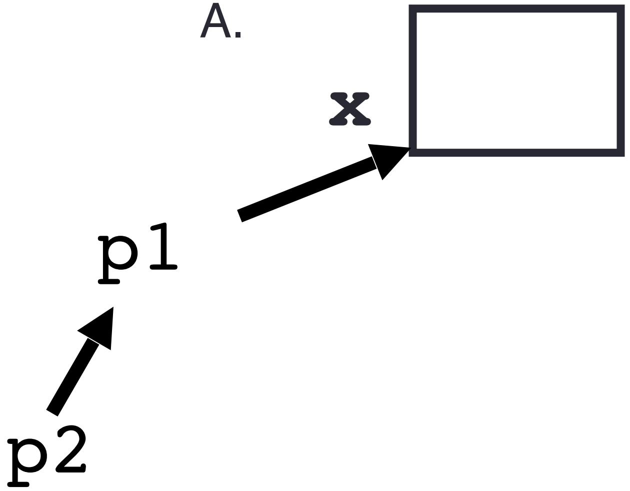
C. Neither, the code is incorrect

Pointer assignment

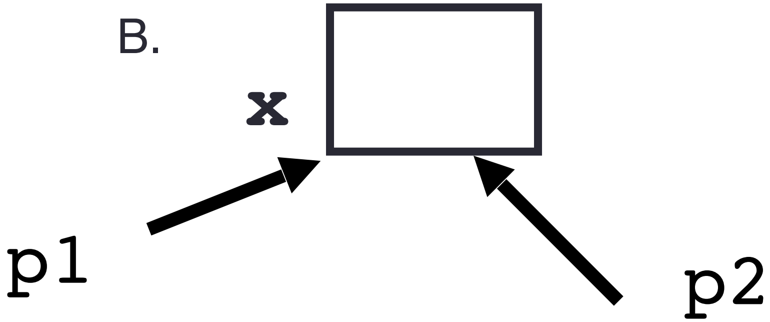
```
int* p1, *p2, x;
p1 = &x;
p2 = p1;
```

Q: Which of the following pointer diagrams best represents the outcome of the above code?

A.

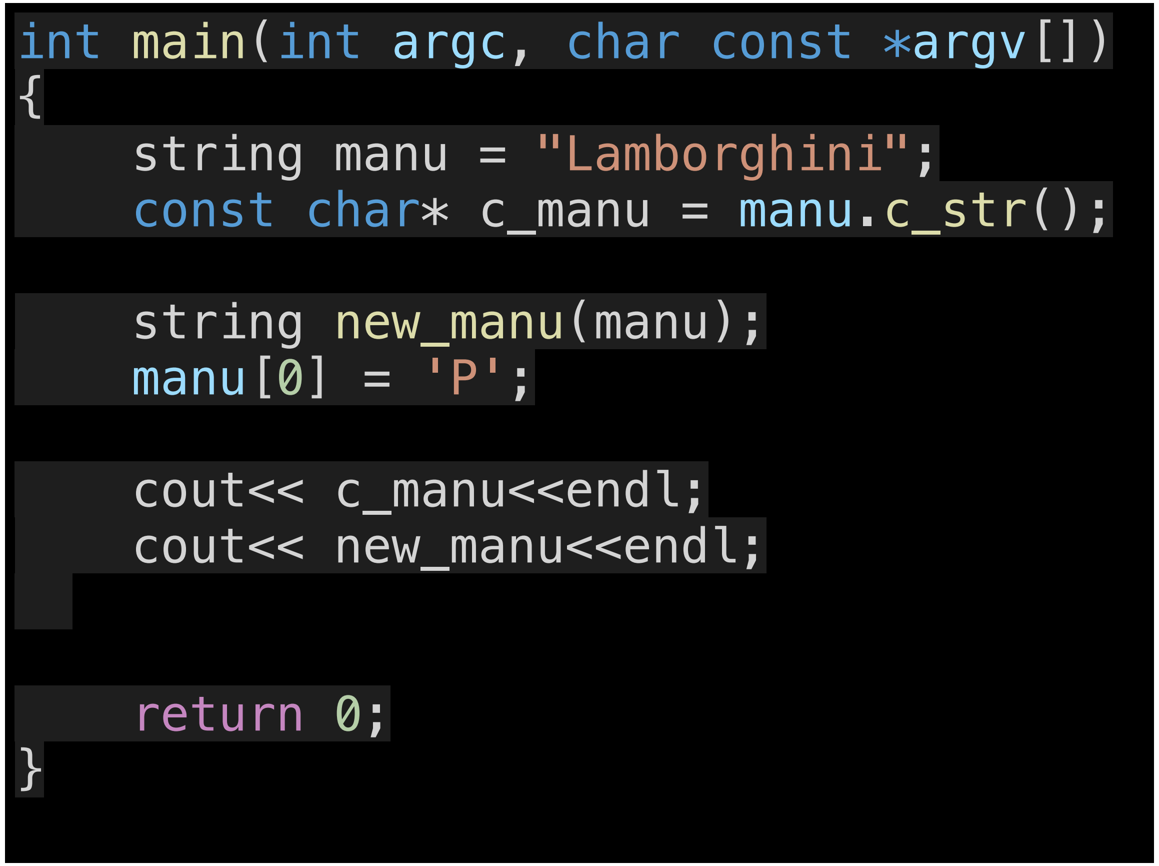


B.



C. Neither, the code is incorrect

strings and c-strings: What is the output?



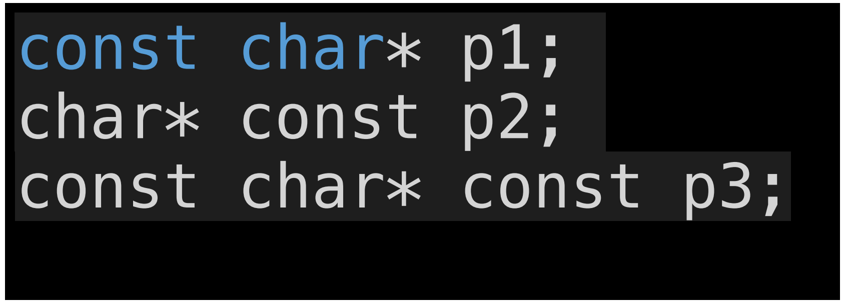
```
int main(int argc, char const *argv[])
{
    string manu = "Lamborghini";
    const char* c_manu = manu.c_str();

    string new_manu(manu);
    manu[0] = 'P';

    cout<< c_manu<<endl;
    cout<< new_manu<<endl;


    return 0;
}
```

Constant pointers and pointers to constants

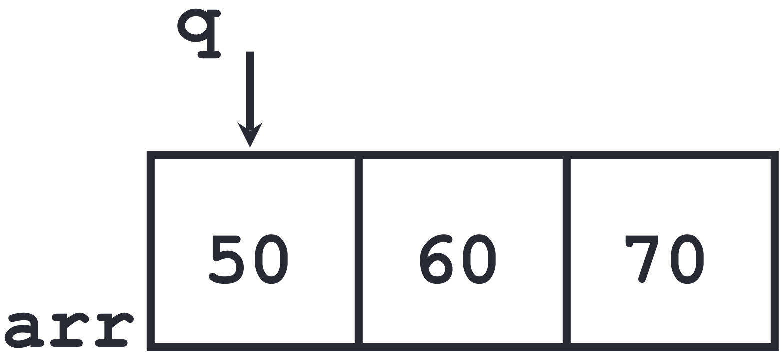


```
const char* p1;
char* const p2;
const char* const p3;
```

What is the difference between these declarations?

```
void IncrementPtr(int* p){
    p++;
}

int arr[3] = {50, 60, 70};
int* q = arr;
IncrementPtr(q);
```



Which of the following is true after **`IncrementPtr(q)`** is called in the above code:

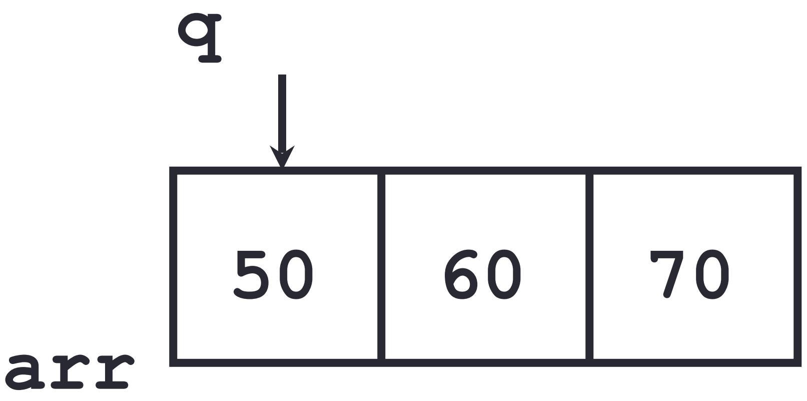
A. **'q'** points to the next element in the array with value 60

B. **'q'** points to the first element in the array with value 50

How should we implement `IncrementPtr()`, so that ‘q’ points to 60 when the following code executes?

```
void IncrementPtr(int** p){
    p++;
}

int arr[3] = {50, 60, 70};
int* q = arr;
IncrementPtr(&q);
```



```
A. p =  p + 1;
B. &p = &p + 1;
C. *p= *p + 1;
D. p= &p+1;
```

Pointer pitfalls

- Dereferencing a pointer that does not point to anything results in undefined behavior.
- On most occasions your program will crash
- Segmentation faults: Program crashes because code tried to access memory location that either doesn’t exist or you don’t have access to

Two important facts about Pointers

1) A pointer can only point to one type –(basic or derived) such as `int`, `char`, a `struct`, another pointer, etc

2) After declaring a pointer: `int *ptr;`

   `ptr` doesn't actually point to anything yet.

   We can either:

   ➢ make it point to something that already exists, OR

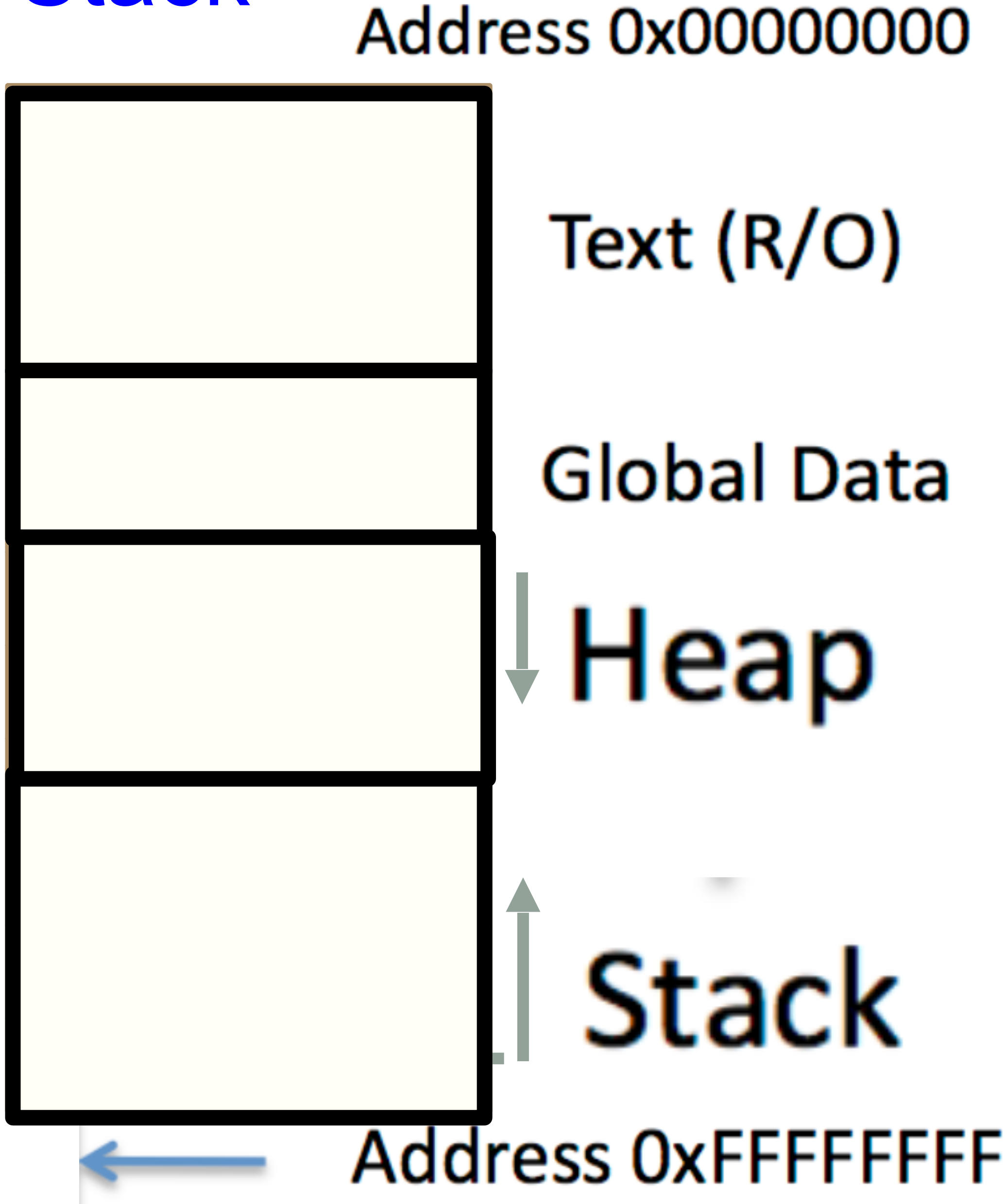
   ➢ allocate room in memory for something new that it will point to

Pointer Arithmetic

- What if we have an array of large structs (objects)?
  - C++ takes care of it: In reality, `ptr+1` doesn't add `1` to the memory address, but rather adds the size of the array element.
  - C++ knows the size of the thing a pointer points to – every addition or subtraction moves that many bytes: 1 byte for a char, 4 bytes for an int, etc.

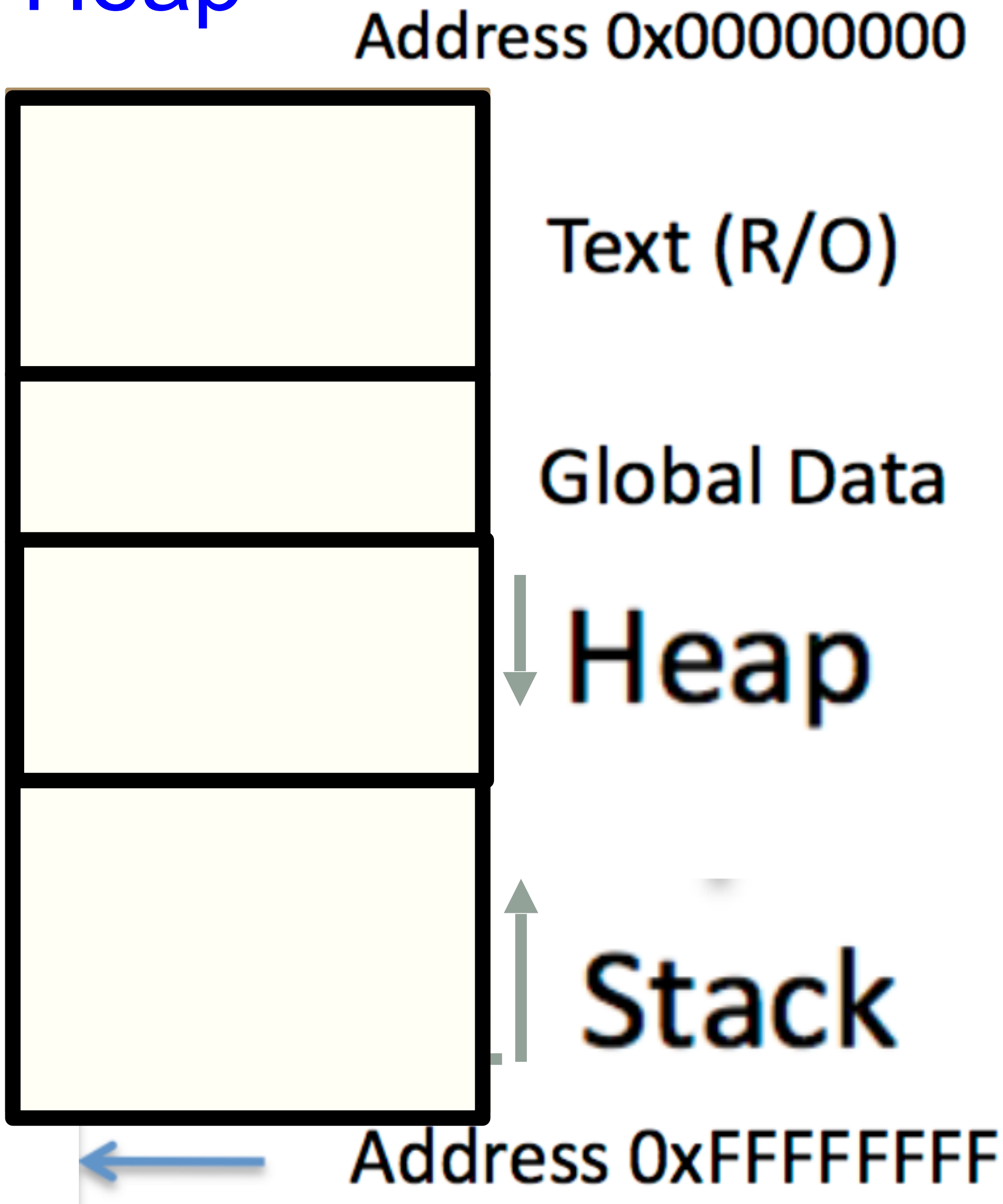
C++ Memory Model: Stack

- Stack: Segment of memory managed automatically using a Last in First Out (LIFO) principle
- Think of it like a stack of books!



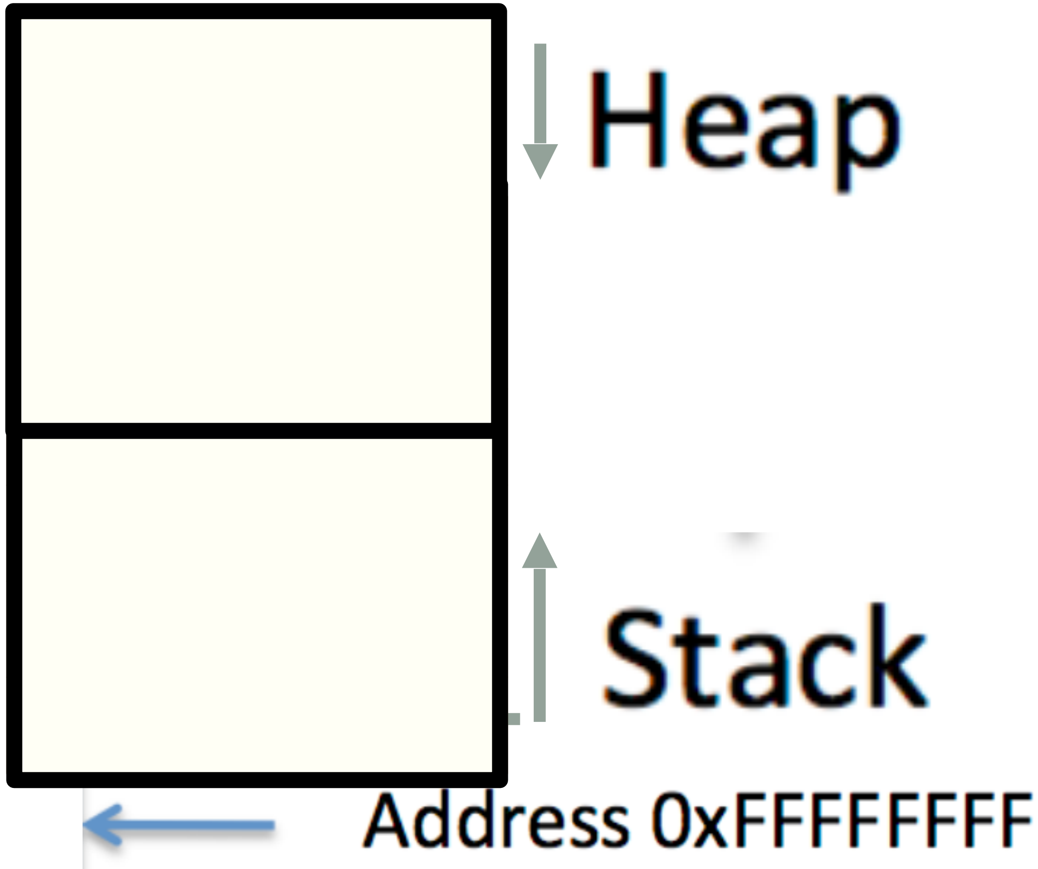
C++ Memory Model: Heap

- Heap: Segment of memory managed by the programmer
- Data created on the heap stays there
  - FOREVER or
  - until the programmer explicitly deletes it



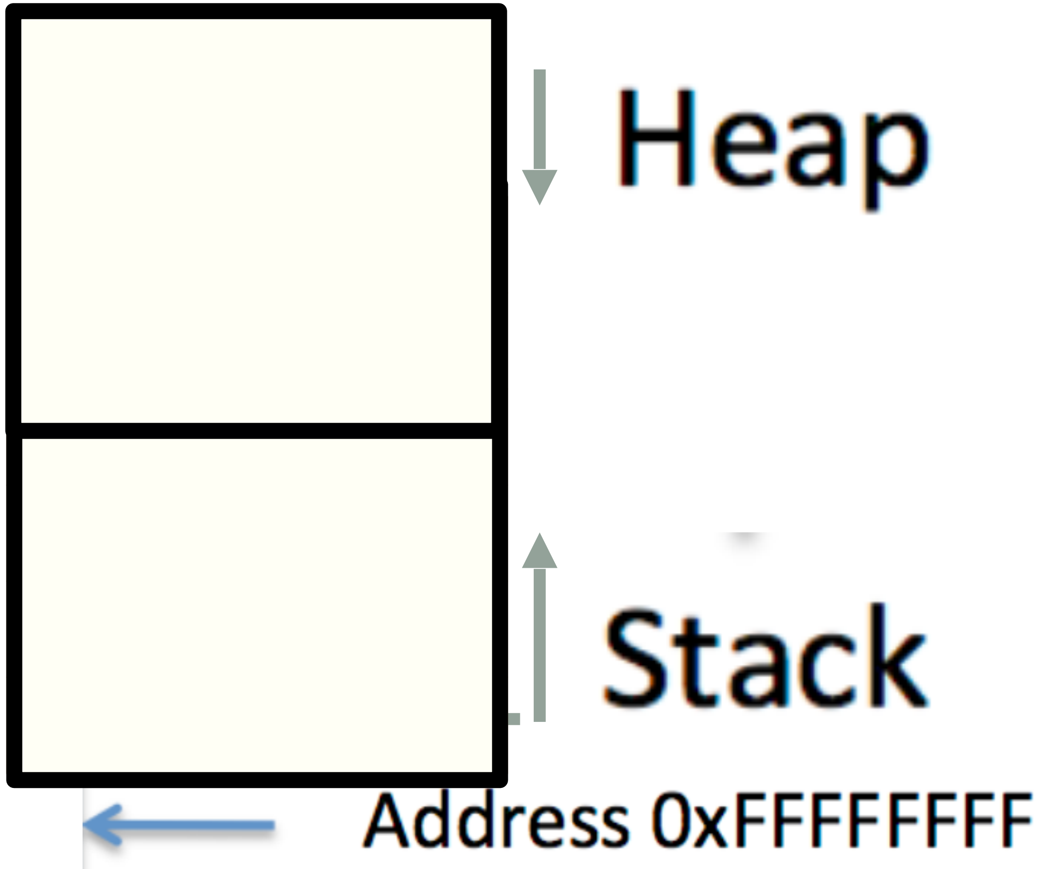
Creating data on the Heap: new

To **allocate** memory on the heap use the **new** operator



Deleting data on the Heap: delete

To **free** memory on the heap use the **delete** operator



Dynamic memory management = Managing data on the heap

```
int* p= new int; //creates a new integer on the
heap

SuperHero* n = new SuperHero;

                //creates a new Student on the
heap

delete p; //Frees the integer

delete n; //Frees the Student
```

The case of the disappearing data!

```
int getInt(){
     int x=5;
     return x;
}
int* getAddressOfInt(){
     int x=10;
     return &x;
}
int main(){
     int y=0, *p=nullptr, z=0;
     y = getInt();
     p = getAddressOfInt();
     z = *p;
    cout<<y<<", "<<z<<", "<<*p<<endl;
}
```

What is the output?

A. 5, 0, 10

B. 5, 10, 10

C. Something else

Heap vs. stack

```
#include <iostream>
using namespace std;

int* createAnIntArray(int len){

    int arr[len];
    return arr;

}
```

Does the above function correctly return an array of integers?

A. Yes

B. No

Next time

- Rule of three and Linked Lists