Data Structures

Housekeeping
functions
Stacks (intro)
Last C++ odds + ends

Today:

- HW due Thursday
- Lab tomorrow
- Check repo file for grade

Pointers in a class

Pointers are especially useful in classes.

Often, we don't know the details of private variables at time of object creation.

Example: using an array

At time of declaration, need:

- type
- var name
- size

An example: A simple vector class

vector in $\mathbb{R}^2$: $\langle 2,5 \rangle$

vector in $\mathbb{R}^4$: $\langle 0,1,0,5 \rangle$

So size is not fixed!

How to make a class?

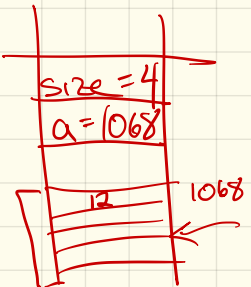
.h file

```
class MyFloatVec {
private:
    int size;
    float * a; //pointer to an array

public:
    MyFloatVec (int s=10) {
        size = s;
        a = new float [size];
        a[0]=12;
    }
};
```

in main

```
MyFloatVec v(4);
```



Accessing an array:

Pointers to arrays are special

↳ any array in fact *is* just a pointer to the 1st spot in the array

(no * or → needed)

Ex: Write a function to allow [] notation, so x[i] gives i^{th} element in the vector:

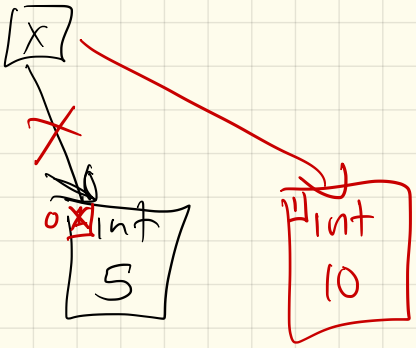
```
pubic:
    //constructor
    ;

float& operator[] (int i){
    if (i<size)
        return a[i];
    else
        <error>
}
```

Garbage Collection:

In python, data that is longer in use are automatically destroyed.

Ex:



x=5

x=10

Pros: - easy
- no user overhead

Cons: - slows language down

C++:

- Value & reference variables are destroyed at the end of their scope

Standard variables are just a label attached to data

↳ data is deallocated, so those spaces are now free again.

Problem: Pointers

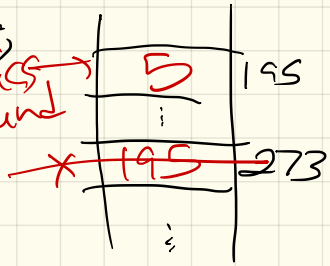
The pointer is destroyed

↳ not underlying data

```
int main() {
    int * x = new int(5);
}
```

memory leak

stuff around



// x is deallocated

Rule: If you use new you must explicitly destroy that data.

So: Housekeeping functions

Basically, need to deal w/ these pointer issues.

① Copy Constructor

Say I call:

MyFloatVec c;

//add data to c

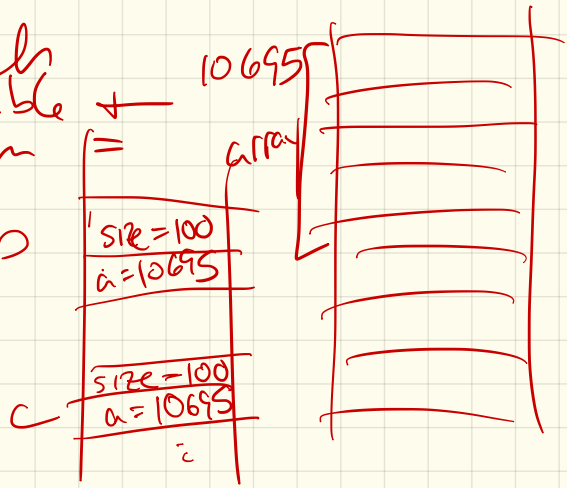
MyFloatVec b(c); ← constructor

Default result?

Copy constructor:

takes each private variable + sets them =

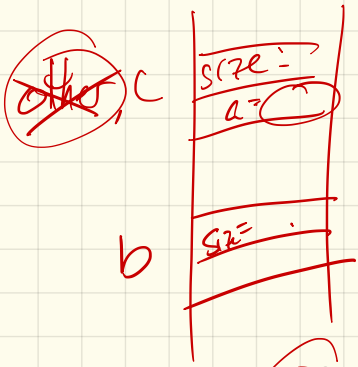
```
b.size = c.size;
b.a = c.a;
```



So - overriding this:

```
class MyFloatVec {
    //other things...

public:
    MyFloatVec(const MyFloatVec &other)
    {
        size = other.size;
        a = new float[size];
        for (int i=0; i<size; i++)
            a[i] = other.a[i];
    } // local "other" is gone
```



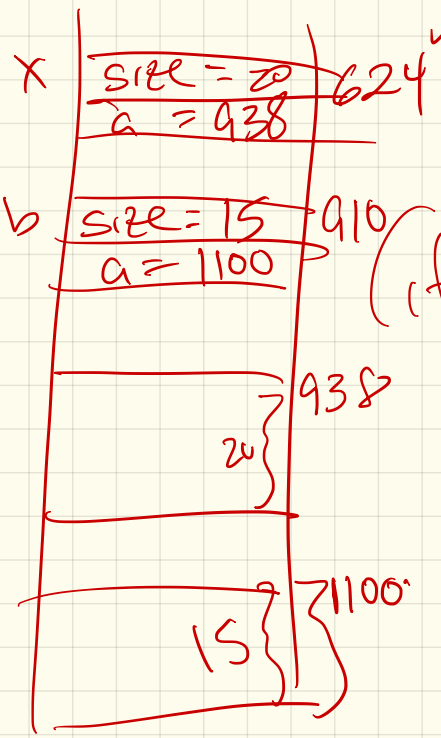
reference variable

→ result: deep copies

② The = operator

Same issue:

```
MyFloatVec x, b;
//put data in
x = b;
```



by default, does shallow copy.

(if private data includes a pointer)

y = x = x;

don't do this

So:

in the class

```
myFloatVec& operator=(const myFloatVec& other)
{
    if (this != &other) {
        delete [] a;
        size = other.size;
        a = new float[size];
        for (int i=0; i<size; i++)
            a[i] = other.a[i];
    }
    return *this;
}
```

(this is like self in python)

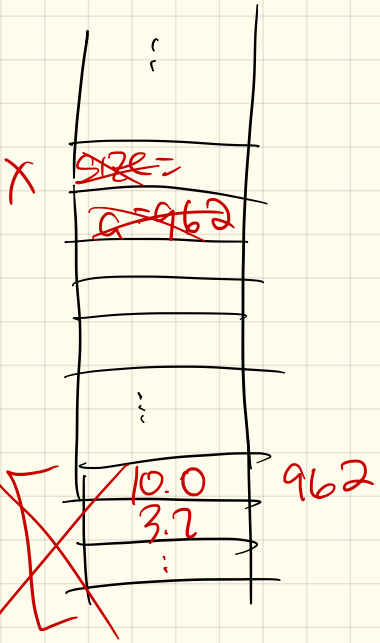
(3) The destructor

Finally: when you create an object

```
int main() {
    myFloatVec x;
    :
```

} // x is destroyed ← what happens

Memory



need to deallocate whatever ptr is going to

So:

in class:

```
~MyFloatVec() {
    delete[] a;
}
```

"opposite" of new:
tells compiler to follow a pointer & deallocate what variable points to

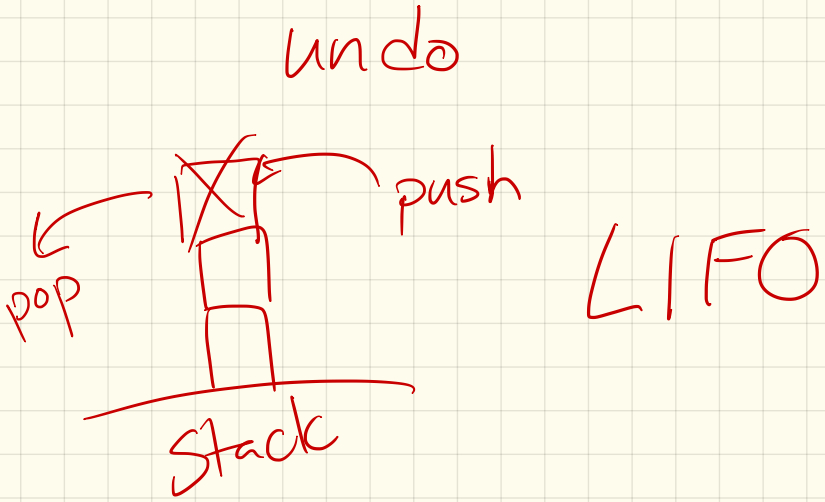
Housekeeping fcns:
Any class w/ a new needs all of them

A note on our first data structure

Stacks: a way to store a list

Ex: Previously visited web pages

Ex: Previous changes to a word document



The stack ADT:

- push(e) : adds e to top
- pop() : removes top

Also:

- size()
- empty()
- top() → returns top w/out removing

see cplusplus.com

Example:

```
int main() {
    stack<int> mystack;
    for (int i=10; i<20; i+=2)
        mystack.push(i);
    mystack.pop();
    mystack.push(100);
    cout << mystack.top() << endl;
}
```

See cplusplus.com for lab tomorrow on stacks.

This week, we'll code our own!

Meanwhile:

A few more C++ odds + ends

Enum:

```
enum Color {RED, BLUE, GREEN};

Color sky = BLUE;
Color grass = GREEN;
if (sky == BLUE)
    cout << "It's a nice day!";
```

Reason:

Structs : useful for simple collections of data

```
enum MealPref {NORMAL, VEG, KOSHER};
struct Passenger {
    string name;
    MealPref foodpref;
    bool isFrequentFlyer;
    int freqFlyerNum;
};
int main() {
    Passenger pass;
    pass.name = "Erin Chambers";
    Passenger pass2 = {"John Smith",
        VEG, true, 12345};

    :
}
```

Templates

If we want a function to work for multiple data types, like ints & floats, use templates.

Ex:

```
template <typename T>
T min (T a, T b) {
    if (a < b)
        return a;
    else
        return b;
}
```

Then:

Templates in classes

These are important in data structures.

Why?

Actually, you'll use these in the stack lab:

Error Handling

In C++, we handle errors by throwing exceptions.

(Exceptions are actually their own classes also.)

Recall: What were the ones in Python?

I'll base mine of C++'s default ones:

```
#include <stdexcept>
```

↳ see cplusplus for details

Some examples

In Python:

```
def sqrt(number):
  if number < 0:
    raise ValueError('number is negative')
```

In C++:

```
double sqrt(double number) {
  if (number < 0)
    throw domain_error("number is negative");
```

In general, to avoid crashing:

```
try {
  // any sequence of commands, possibly nested
} catch (domain_error& e) {
  // what should be done in case of this error
} catch (out_of_range& e) {
  // what should be done in case of this error
} catch (exception& e) {
  // catch other types of errors derived from exception class
} catch (...) {
  // catch any other objects that are thrown
}
```

Reading input example:

```
void openFileReadRobust(ifstream& source) {
  source.close( );                                  // disregard any previous usage of the stream
  while (!source.is_open( )) {
    string filename;
    cout << "What is the filename? ";
    getline(cin, filename);
    source.open(filename.c_str( ));
    if (!source.is_open( ))
       cout << "Sorry. Unable to open file " << filename << endl;
  }
}
```