CSC 211: Object Oriented Programming

Dynamic Memory Allocation, Destructors

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Dynamic Memory Allocation

The `new` and `delete` operators

- Used to create and destroy variables, objects, or arrays while the program is running
- Memory allocated with the `new` operator does **NOT** use the **call stack**
  - new allocations go into the **heap** (area of memory reserved for dynamic memory allocation)
- Programmer **must** destroy all variables, objects, and arrays created dynamically
  - using the `delete` operator


```
#include <iostream>

int main( ) {
    int *p1, *p2;

    p1 = new int;
    *p1 = 10;
    p2 = p1;
    *p2 = 20;
    p1 = new int;
    *p1 = 30;

    std::cout << *p1 << ' ' << *p2 << '\n';

    delete p1;
    delete p2;

    return 0;
}
```

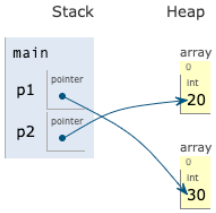
Tracing the code

C++ (gcc 4.8, C++11)
EXPERIMENTAL! known limitations

```
1  #include <iostream>
2
3  int main( ) {
4      int *p1, *p2;
5
6      p1 = new int;
7      *p1 = 10;
8      p2 = p1;
9      *p2 = 20;
10     p1 = new int;
11     *p1 = 30;
12
13     std::cout << *p1 << ' ' << *p2 << '\n';
14
15     delete p1;
16     delete p2;
17
18     return 0;
19 }
```

Print output (drag lower right corner to resize)

```
30 20
```



http://pythontutor.com/cpp.html#mode=edit

Syntax for `new` and `delete`

```
#include "date.h"
#include <iostream>

int main( ) {
    // creating a single variable
    int *p = new int;
    *p = 5;

    // creating an array
    int *array = new int[20];
    for (int i = 0 ; i < 20 ; i ++) {
        array[i] = 0;
    }

    // creating an object
    Date *today = new Date(11, 18, 2019);
    (*today).print();

    // delete all allocated objects
    delete p;
    delete [] array;
    delete today;

    return 0;
}
```

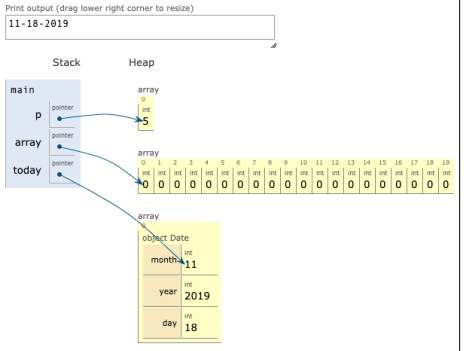

Tracing the code

C++ (gcc 4.8, C++11)
EXPERIMENTAL! known limitations

```
31 int main( ) {
32     // creating a single variable
33     int *p = new int;
34     *p = 5;
35
36     // creating an array
37     int *array = new int[20];
38     for (int i = 0 ; i < 20 ; i ++) {
39         array[i] = 0;
40     }
41
42     // creating an object
43     Date *today = new Date(11, 18, 2019);
44     (*today).print();
45
46     // delete all allocated objects
47     delete p;
48     delete [] array;
49     delete today;
50
51     return 0;
52 }
```

Print output (drag lower right corner to resize)

```
11-18-2019
```



http://pythontutor.com/cpp.html#mode=edit

Pointers and objects

- Data members and methods of an object can be accessed by dereferencing a pointer

```
Date *today = new Date(11, 18, 2019);
(*today).print();
```

- Or … can use the **–> operator**

```
Date *today = new Date(11, 18, 2019);
today->print();
```

Destructors

Destructor

- Special `method` automatically called when objects are destroyed
  - it is used to delete any memory created dynamically
- Objects are destroyed when …
  - … they exist in the stack and go out of scope
  - … they exist in the heap and the delete operator is used
- A destructor …
  - … is a member function (usually `public`)
  - … must have the same name as its class preceded by a ~
  - … is automatically called when an object is destroyed
  - … does not have a return type (not even `void`)
  - … takes no arguments

Live Example (dynamic array)

```
#ifndef _DYNARRAY_H_
#define _DYNARRAY_H_

class DynArray {
    private:
        unsigned int size;
        unsigned int capacity;
        int *array;

    public:
        // allocates an array with default capacity
        // default: 25
        DynArray();
        // allocates an array with capacity
        DynArray(int capacity);

        // frees memory allocated by one of the
        // constructors
        ~DynArray();

        // appends a value to the end of the array
        // automatically doubles the capacity when
        // array is full
        // throws exception if memory cannot be
        // allocated anymore
        void append(int value);

        // gets the value at index idx
        // throws exception if idx is invalid
        int get(unsigned int idx);
```

```
        // sets the value at index idx
        // throws exception if idx is invalid
        void set(int value, unsigned int idx);

        // returns the current number of elements
        // in the array
        unsigned int size();

        // returns T if key is in the array and F
        // otherwise. it also changes idx to the
        // index of the first occurrrence of key
        // in the array
        bool find_first(int key, int& idx);

        // returns a string representation of the
        // array
        string to_string();

        // sets size to 0 (basically)
        void clear();

        // removes element at index idx
        // needs to shift all subsequente elements
        // 1 position back to the left and
        // decrement size
        // throws exception if idx is invalid
        void remove(unsigned int idx);
}

#endif
```