CS 225
Data Structures

September 5 – Heap Memory
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#include "Cube.h"

using cs225::Cube;

Cube *CreateCube() {
    Cube c(20);
    return &c;
}

int main() {
    Cube *c = CreateCube();
    SomeOtherFunction();
    double v = c->getVolume();
    double a = c->getSurfaceArea();
    return 0;
}
```cpp
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```
Heap Memory

0x42000
0x42008
0x42010
0x42018
0x42020
0x42028
0x42030
0x42038
0x42040
0x42048
Heap Memory - new

As programmers, we can use heap memory in cases where the lifecycle of the variable exceeds the lifecycle of the function.

The only way to create heap memory is with the use of the new keyword. Using new will:

1. 

2. 

3. 
Heap Memory - delete

2. The **only** way to free heap memory is with the use of the `delete` keyword. Using `delete` will:

- 

- 

3. Memory is never automatically reclaimed, even if it goes out of scope. Any memory lost, but not freed, is considered to be “leaked memory”.
Heap Memory vs. Stack Memory Lifecycle
int main() {
  int *p = new int;
  cs225::Cube *c = new cs225::Cube(10);
  return 0;
}

Location | Value | Type | Name
---|---|---|---
0xFFFF00f0 | | | 
0xFFFF00e8 | | | 
0xFFFF00e0 | | | 
0xFFFF00d8 | | | 
0xFFFF00d0 | | | 

Heap viewer for heap1.cpp
```cpp
int main() {
    Cube *c1 = new Cube();
    Cube *c2 = c1;
    c2->setRadius( 10 );
    delete c2;
    delete c1;
    return 0;
}
```
Exam 0 – Starts Tomorrow
```cpp
#include <iostream>
using std::cout;
using std::endl;

int main() {
    int i = 2, j = 4, k = 8;
    int *p = &i, *q = &j, *r = &k;

    k = i;
    cout << i << j << k << *p << *q << *r << endl;

    p = q;
    cout << i << j << k << *p << *q << *r << endl;

    *q = *r;
    cout << i << j << k << *p << *q << *r << endl;
}
```
Pointers and References

A variable containing an instance of an object:
1 Cube s1;

A reference variable of a Cube object:
1 Cube & s1;

A variable containing a pointer to a Cube object:
1 Cube * s1;
Reference Variable

A reference variable is an alias to an existing variable.

Key Idea: Modifying the reference variable modifies the variable being aliased.
Reference Variable

Three facts about reference variables:

1.

2.

3.
Reference Variable

A reference variable is an alias to an existing variable.

```cpp
#include <iostream>

int main() {
    int i = 7;
    int & j = i;  // j is an alias of i

    j = 4;
    std::cout << i << " " << j << std::endl;

    i = 2;
    std::cout << i << " " << j << std::endl;

    return 0;
}
```
```cpp
#include <iostream>
using namespace std;

int main() {
    int *x = new int;
    int &y = *x;

    y = 4;

    cout << &x << endl;
    cout << x << endl;
    cout << *x << endl;
    cout << &y << endl;
    cout << y << endl;
    cout << *y << endl;
}
```
```cpp
#include <iostream>
using namespace std;

int main() {
    int *p, *q;
    p = new int;
    q = p;
    *q = 8;
    cout << *p << endl;

    q = new int;
    *q = 9;
    cout << *p << endl;
    cout << *q << endl;

    return 0;
}
```
```cpp
test::main() {
  int x;
  int size = 3;
  x = new int[size];
  for (int i = 0; i < size; i++) {
    x[i] = i + 3;
  }
  delete[] x;
}
```