

**Puzzle:**

```

puzzle.cpp
4 Cube *CreateCube() {
5   Cube c(20);
6   return &c;
7 }
8
9 int main() {
10  Cube *c = CreateCube();
11  SomeOtherFunction();
12  double v = c->getVolume();
13  double a = c->getSurfaceArea();
14  return 0;
15 }

```

**Takeaway:**

**Heap Memory:**

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

- Memory is never automatically reclaimed, even if it goes out of scope. Any memory lost, but not freed, is considered to be “leaked memory”.

```

heap1.cpp
8 int main() {
9   int *p = new int;
10  cs225::Cube *c = new cs225::Cube(10);
11
12  return 0;
13 }

```

Stack	Value	Heap	Value
0xffff00f0 →		0x42020 →	
0xffff00e8 →		0x42018 →	
0xffff00e0 →		0x42010 →	
0xffff00d8 →		0x42008 →	
0xffff00d0 →		0x42000 →	

```

heap2.cpp
4 int main() {
5   Cube *c1 = new Cube();
6   Cube *c2 = c1;
7   c2->setLength( 10 );
8   delete c2;
9   delete c1;
10  return 0;
11 }

```

Stack	Value	Heap	Value
0xffff00f0 →		0x42020 →	
0xffff00e8 →		0x42018 →	
0xffff00e0 →		0x42010 →	
0xffff00d8 →		0x42008 →	
0xffff00d0 →		0x42000 →	

## Copying Memory – Deep Copy vs. Shallow Copy

```

copy.cpp
6 int i = 2, j = 4, k = 8;
7 int *p = &i, *q = &j, *r = &k;
8
9 k = i;
10 cout << i << j << k << *p << *q << *r << endl;
11
12 p = q;
13 cout << i << j << k << *p << *q << *r << endl;
14
15 *q = *r;
16 cout << i << j << k << *p << *q << *r << endl;
    
```

Consider how each assignment operator changes the data:

	Type of LHS	Type of RHS	Data Changed?
Line 8-9			
	i =	j =	k =
	p =	q =	r =
Line 11-12			
	i =	j =	k =
	p =	q =	r =
Line 14-15			
	i =	j =	k =
	p =	q =	r =

### Reference Variable

A reference variable is an alias to an existing variable. Modifying the reference variable modifies the variable being aliased. Internally, a reference variable maps to the same memory as the variable being aliased. Three key ideas:

- 1.
- 2.
- 3.

```

reference.cpp
3 int main() {
4     int i = 7;
5     int &j = i; // j is an alias of i
6
7     j = 4; // j and i are both 4.
8     std::cout << i << " " << j << std::endl;
9
10    i = 2; // j and i are both 2.
11    std::cout << i << " " << j << std::endl;
12    return 0;
13 }
    
```

```

heap-puzzle1.cpp
6 int *x = new int;
7 int &y = *x;
8
9 y = 4;
10
11 cout << &x << endl;
12 cout << x << endl;
13 cout << *x << endl;
14
15 cout << &y << endl;
16 cout << y << endl;
17 cout << *y << endl;
    
```

```

heap-puzzle2.cpp
6 int *p, *q;
7 p = new int;
8 q = p;
9 *q = 8;
10 cout << *p << endl;
11
12 q = new int;
13 *q = 9;
14 cout << *p << endl;
15 cout << *q << endl;
    
```

### CS 225 – Things To Be Doing:

1. Finish up mp\_intro – Due Monday, Sep. 7 at 11:59pm
2. Complete lab\_intro new lab this week in lab sections