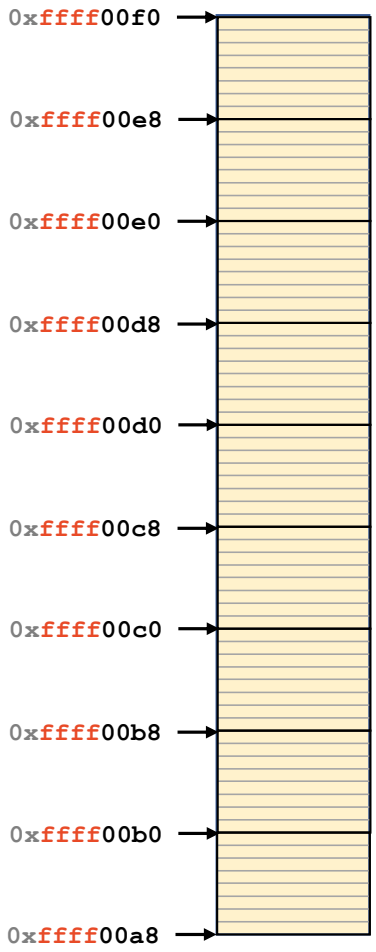
CS 225

Data Structures

January 23 – Heap Memory

Wade Fagen-Ulmschneider, Craig Zilles



puzzle.cpp

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 2 using cs225::Cube;
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 4 Cube *CreateCube() {
 5   Cube c(20);
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 8
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10   Cube *c = CreateCube();
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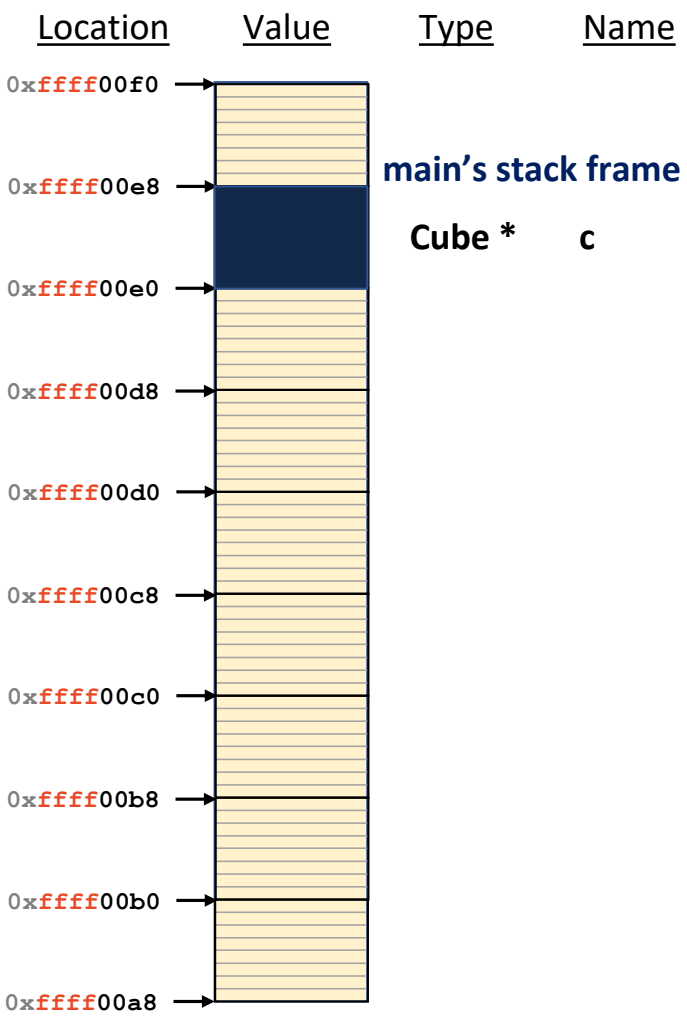

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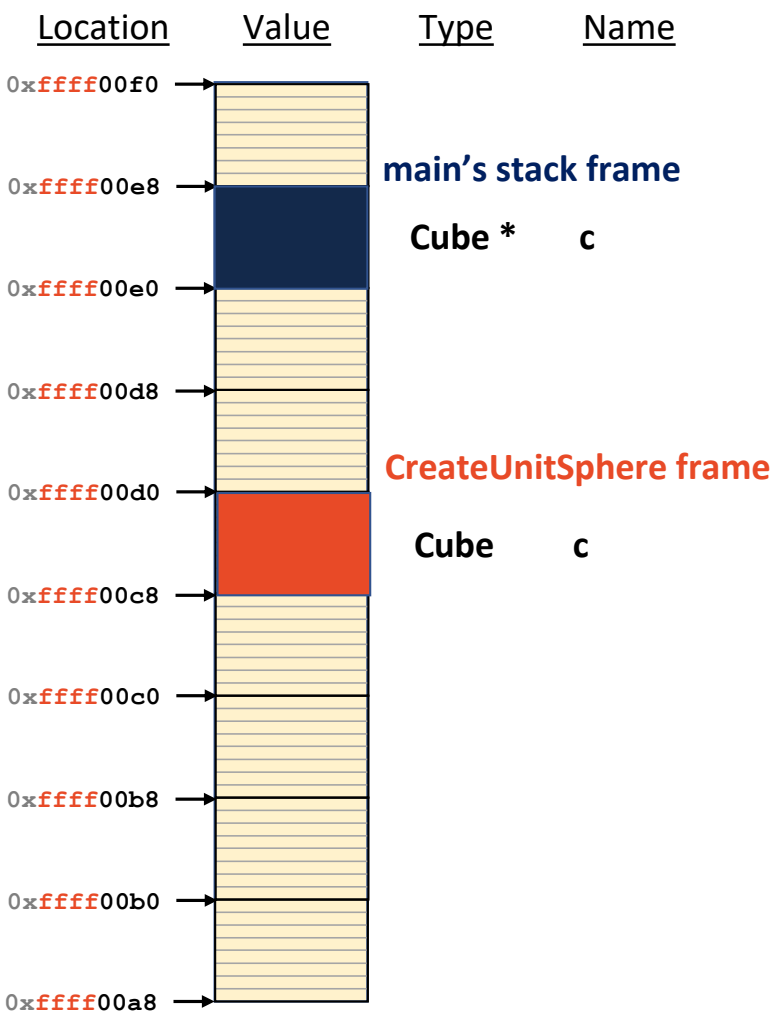

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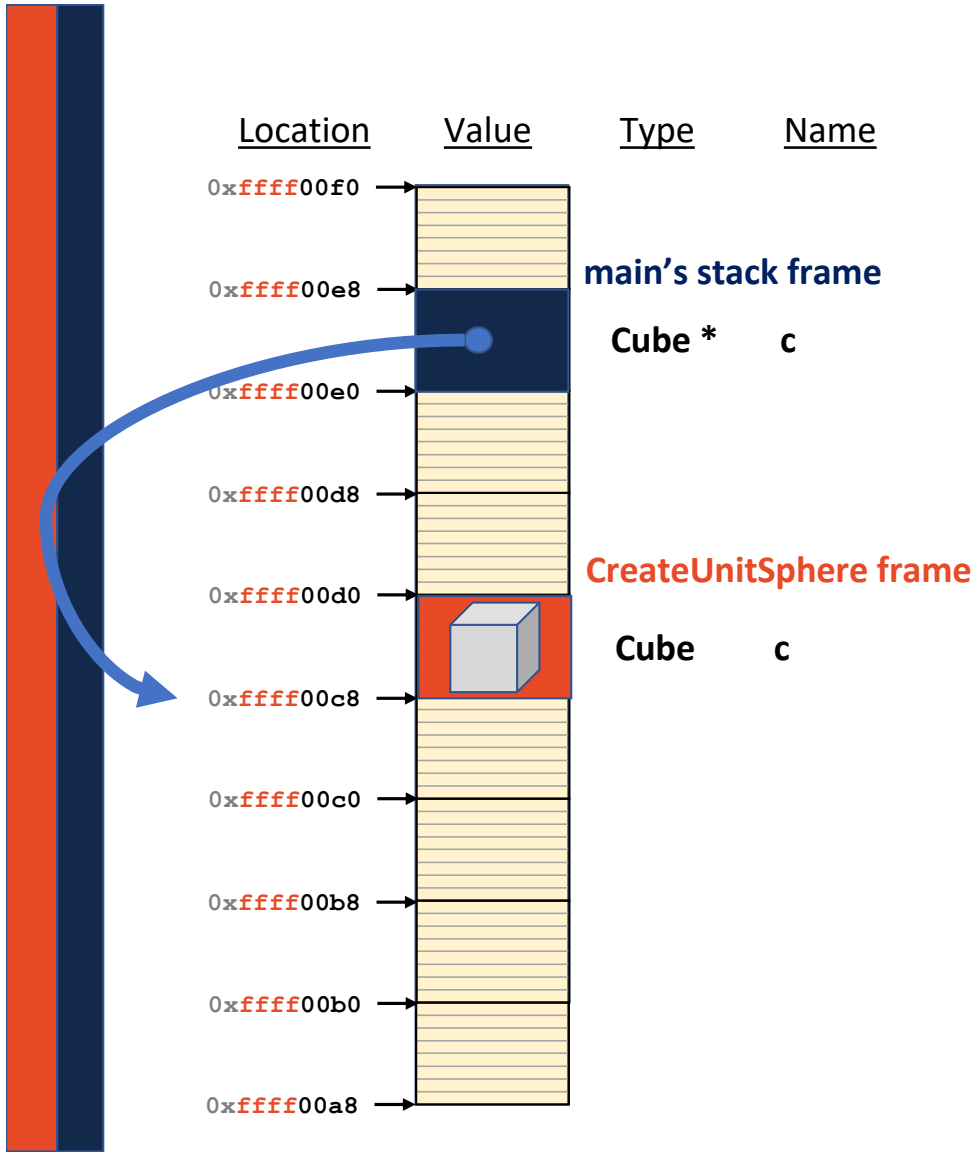

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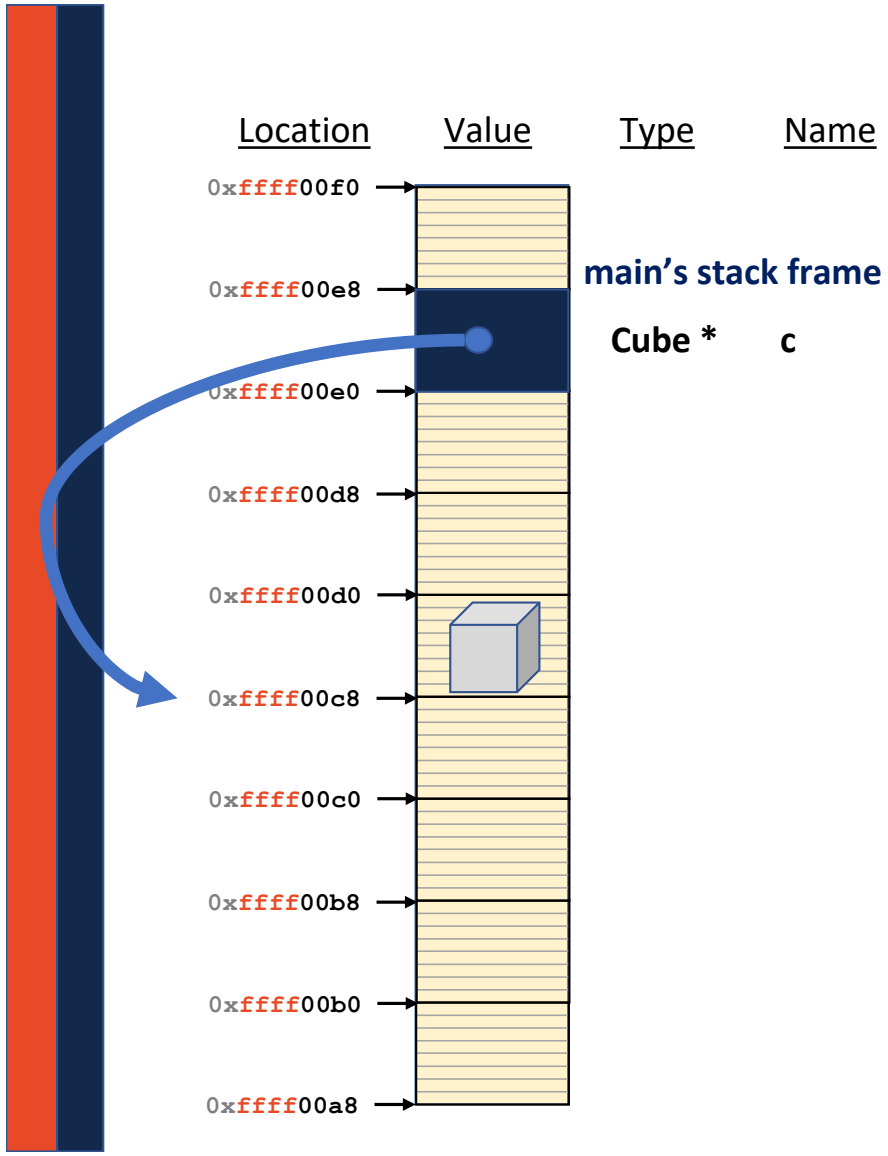

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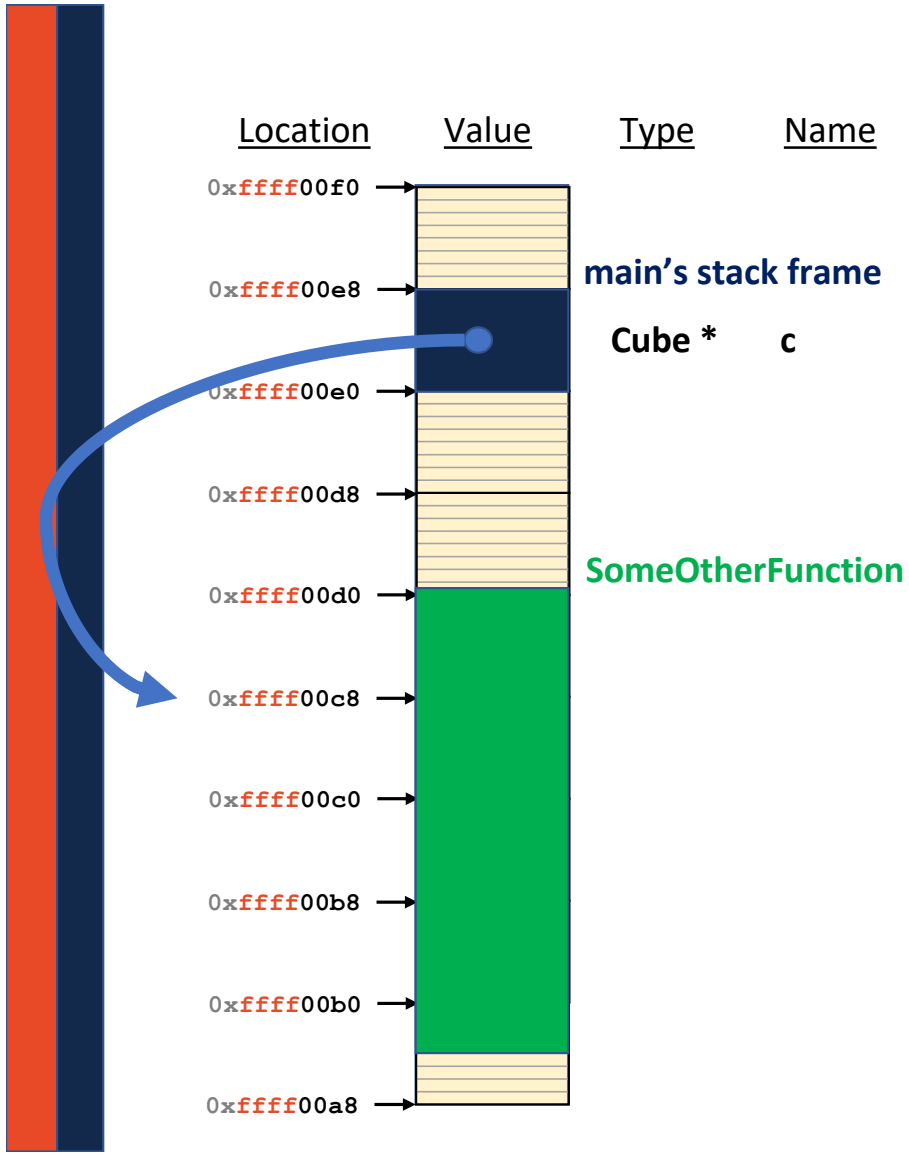

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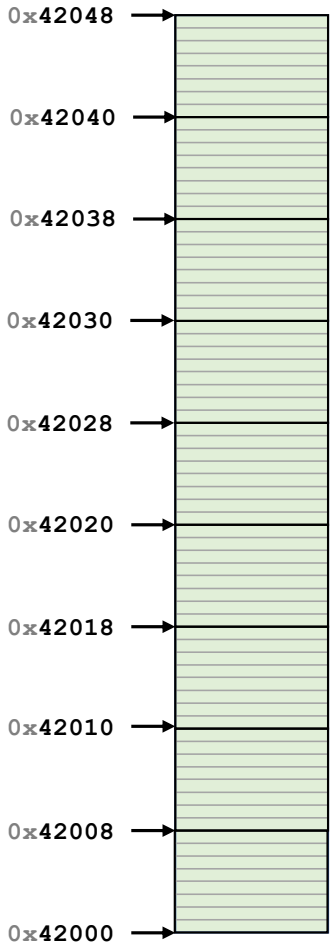
Heap Memory


0x42048
0x42040
0x42038
0x42030
0x42028
0x42020
0x42018
0x42010
0x42008
0x42000

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.

1.

1.

Heap Memory - delete

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

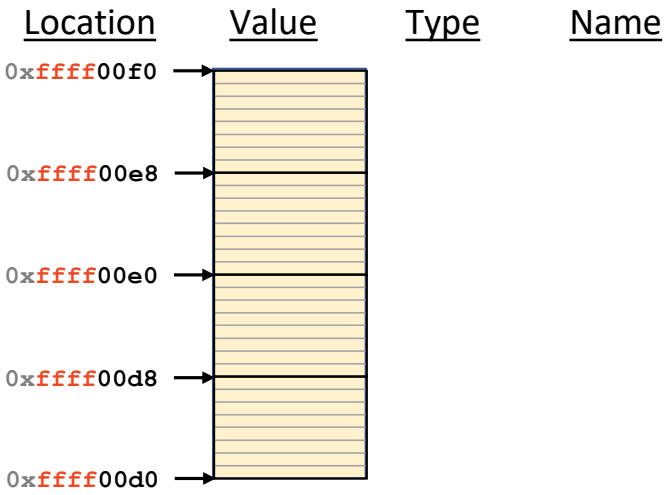
-
-

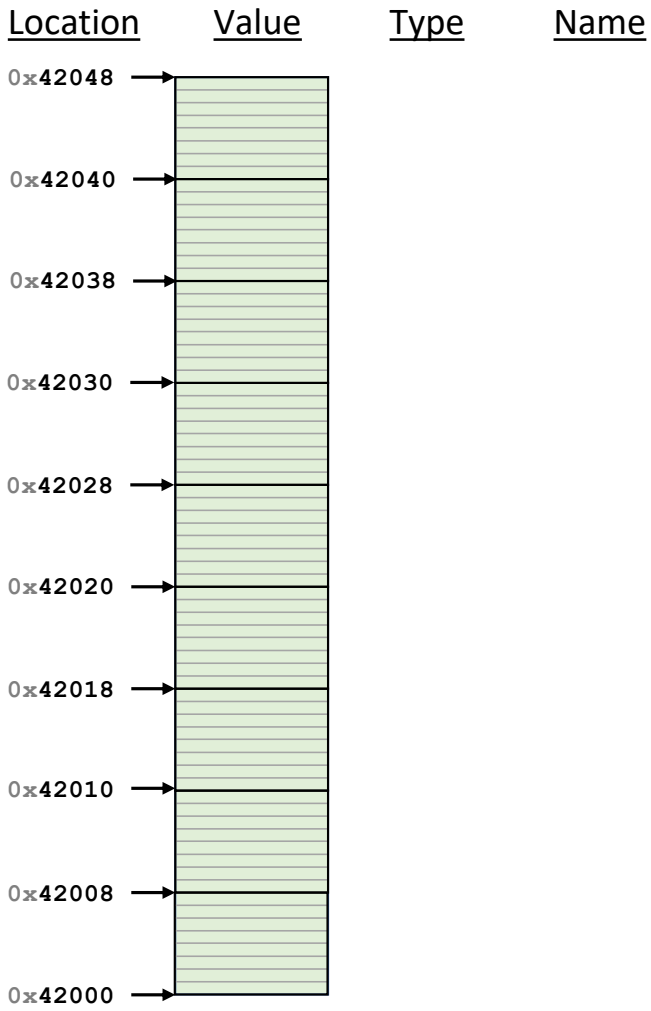
3. Memory is never automatically reclaimed, even if it goes out of scope. Any memory lost, but not freed, is considered to be “leaked memory”.

Heap Memory vs. Stack Memory Lifecycle

heap1.cpp

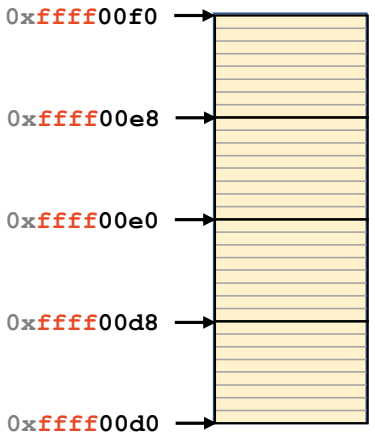
```
 8 int main() {
 9   int *p = new int;
10   cs225::Cube *c = new cs225::Cube(10);
11
12   return 0;
13 }
```



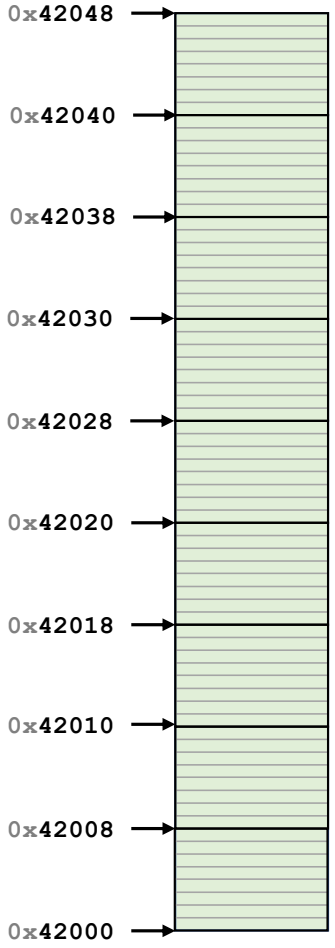


heap2.cpp

```
1  int main() {
2    Cube *c1 = new Cube();
3    Cube *c2 = c1;
4    c2->setRadius( 10 );
5    delete c2;
6    delete c1;
7    return 0;
8  }
9
10
11
```

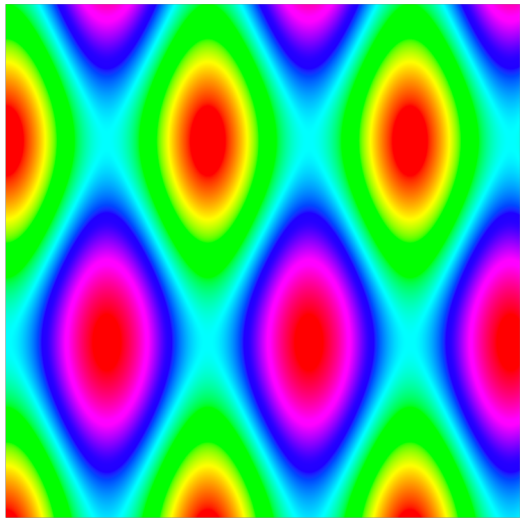


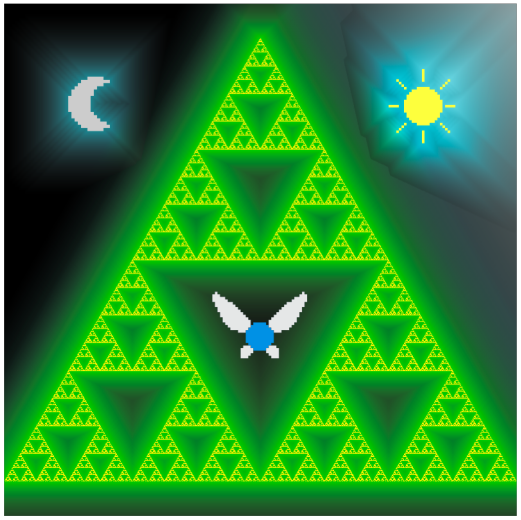
Location Value Type Name

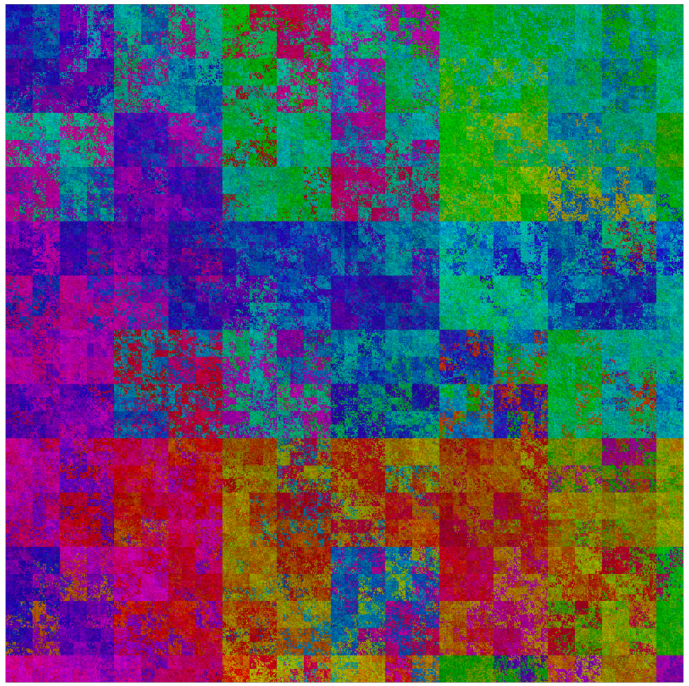


Exam 0 – Starts Tomorrow

MP1







copy.cpp

```
 1 #include <iostream>
 2 using std::cout;
 3 using std::endl;
 4
 5 int main() {
 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;
17 }
```

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. Never creates new memory

2. Must be initialized when created

3. Can never be modified (or redeclared in same scope)

Reference Variable

A reference variable is an alias to an existing variable.

```
 1 #include <iostream>
 2
 3 int main() {
 4   int i = 7;
 5   int & j = i;   // j is an alias of i
 6
 7   j = 4;
 8   std::cout << i << " " << j << std::endl;
 9
10   i = 2;
11   std::cout << i << " " << j << std::endl;
12   return 0;
13 }
```

heap-puzzle1.cpp

```
 1 #include <iostream>
 2 using namespace std;
 3
 4 int main() {
 5   int *x = new int;
 6   int &y = *x;
 7
 8   y = 4;
 9
10   cout << &x << endl;
11   cout << x << endl;
12   cout << *x << endl;
13
14   cout << &y << endl;
15   cout << y << endl;
16   cout << *y << endl;
17 }
```

heap-puzzle2.cpp

```
 1 #include <iostream>
 2 using namespace std;
 3
 4 int main() {
 5   int *p, *q;
 6   p = new int;
 7   q = p;
 8   *q = 8;
 9   cout << *p << endl;
10
11   q = new int;
12   *q = 9;
13   cout << *p << endl;
14   cout << *q << endl;
15
16   return 0;
17 }
```

heap-puzzle3.cpp

```
 1 #include <iostream>
 2 using namespace std;
 3
 4 int main() {
 5   int *x;
 6   int size = 3;
 7
 8   x = new int[size];
 9
10   for (int i = 0; i < size; i++) {
11     x[i] = i + 3;
12   }
13
14   delete[] x;
15 }
16
17
```