

# 601.220 Intermediate Programming

## Destructors

# C++ dynamic memory allocation revisited

- `new` and `delete` are essentially the C++ versions of `malloc` and `free`
- Big difference: `new` not only allocates the memory, it also calls the appropriate constructor if needed

# C++ dynamic memory allocation revisited

```
// destructors1.cpp

1  #include <iostream>
2
3  class DefaultSeven {
4  public:
5      DefaultSeven() : i(7) { }
6      int get_i() { return i; }
7  private:
8      int i;
9  };
10
11 int main() {
12     DefaultSeven s;
13     DefaultSeven *sptr = new DefaultSeven(); // using new
14     std::cout << "s.get_i() = " << s.get_i() << std::endl;
15     std::cout << "sptr->get_i() = " << sptr->get_i() << std::endl;
16     delete sptr; // free the memory before exiting
17     return 0;
18 }
```

# C++ dynamic memory allocation revisited

```
$ g++ -o destructors1 destructors1.cpp -std=c++11 -pedantic -Wall -Wextra
$ ./destructors1

s.get_i() = 7
sptr->get_i() = 7
```

- **new** called the default constructor for us in both cases
- **delete** releases the memory, but we should also set `sptr` to **NULL**

## C++ dynamic memory allocation revisited

- `T* fresh = new T[n]` allocates an array of `n` elements of type `T`
- Use `delete[] fresh` to deallocate – always use `delete[]` (not `delete`) to deallocate a pointer returned by `new T[n]`
- If `T` is a class type, then `T`'s default constructor is called for **each** element allocated
- If `T` is a “built-in” type (`int`, `float`, `char`, etc.), then the values are **not initialized**, like with `malloc`

# C++ dynamic memory allocation revisited

```
// destructors2.cpp

1  #include <iostream>
2
3  class DefaultSeven {
4  public:
5      DefaultSeven() : i(7) { }
6      int get_i() { return i; }
7  private:
8      int i;
9  };
10
11 int main() {
12     DefaultSeven *s_array = new DefaultSeven[10];
13     for(int i = 0; i < 10; i++) {
14         std::cout << s_array[i].get_i() << " ";
15     }
16     std::cout << std::endl;
17     delete[] s_array;
18     return 0;
19 }
```

# C++ dynamic memory allocation revisited

```
$ g++ -o destructors2 destructors2.cpp -std=c++11 -pedantic -Wall -Wextra  
$ ./destructors2  
7 7 7 7 7 7 7 7 7 7
```

- Confirming that default constructor was indeed called for all 10 elements

# C++ classes: destructors

- A class *constructor*'s job is to initialize the fields of the object
  - It's common for a constructor to obtain a resource (allocate memory, open a file, etc.) that should be released when the object is destroyed (deallocate memory, close a file, etc.)
- A class *destructor* is a method called by C++ when the object's lifetime ends or it is otherwise deallocated (ie, with `delete`)
- A destructor's name is the class name prepended with `~`, e.g. `~Rectangle()`
- The destructor is **always automatically** called when object's lifetime ends, including when it is deallocated
  - It's a convenient place to clean up



# C++ classes: destructors

```
// sequence.h

1  #ifndef SEQUENCE_H
2  #define SEQUENCE_H
3  #include <cassert>
4  class Sequence { // What does this class do? Anything wrong with it?
5  public:
6      Sequence() : array(NULL), size(0) { }
7      // Note: constructor can have both an initializer
8      // list and statements in its body
9      Sequence(int sz) : array(new int[sz]), size(sz) {
10         for(int i = 0; i < sz; i++) array[i] = i;
11     }
12     int at(int i) {
13         assert(i < size);
14         return array[i];
15     }
16 private:
17     int *array;
18     int size;
19 };
20 #endif // SEQUENCE_H
```

# C++ classes: destructors

```
// destructors3.cpp
```

```
1  #include <iostream>
2  #include "sequence.h"
3
4  int main() {
5      Sequence seq(10);
6      for(int i = 0; i < 10; i++) {
7          std::cout << seq.at(i) << ' ';
8      }
9      std::cout << std::endl;
10     return 0;
11 }
```

```
$ g++ -o destructors3 destructors3.cpp -std=c++11 -pedantic -Wall -Wextra
```

```
$ ./destructors3
```

```
0 1 2 3 4 5 6 7 8 9
```

# C++ classes: destructors

```
$ valgrind --leak-check=full ./destructors3
```

```
==3294== Memcheck, a memory error detector
==3294== Copyright (C) 2002-2015, and GNU GPL'd, by Julian Seward et al.
==3294== Using Valgrind-3.11.0 and LibVEX; rerun with -h for copyright info
==3294== Command: ./destructors3
==3294==
==3294== error calling PR_SET_PTRACER, vgdb might block
==3294==
==3294== HEAP SUMMARY:
==3294==    in use at exit: 72,744 bytes in 2 blocks
==3294==    total heap usage: 3 allocs, 1 frees, 76,840 bytes allocated
==3294==
==3294== 40 bytes in 1 blocks are definitely lost in loss record 1 of 2
==3294==    at 0x4C2E80F: operator new[](unsigned long) (in /usr/lib/valgrind/vgpreload_memcheck-amd64-linux.so)
==3294==    by 0x400AD2: Sequence::Sequence(int) (in /d/Study/PhDCS(JHU)/JHU2020/2020-09-12(Fall) - Intermediate Programming)
==3294==    by 0x4009E9: main (in /d/Study/PhDCS(JHU)/JHU2020/2020-09-12(Fall) - Intermediate Programming)
==3294==
==3294== LEAK SUMMARY:
==3294==    definitely lost: 40 bytes in 1 blocks
==3294==    indirectly lost: 0 bytes in 0 blocks
==3294==    possibly lost: 0 bytes in 0 blocks
==3294==    still reachable: 72,704 bytes in 1 blocks
==3294==    suppressed: 0 bytes in 0 blocks
==3294== Reachable blocks (those to which a pointer was found) are not shown.
==3294== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==3294==
==3294== For counts of detected and suppressed errors, rerun with: -v
==3294== ERROR SUMMARY: 1 errors from 1 contexts (suppressed: 0 from 0)
```

## C++ classes: destructors

- Allocates `new int[sz]` in constructor, but never `delete[]`s it
- It's common for a constructor to obtain a resource (allocate memory, open a file, etc) that should be released when the object is destroyed
- *Destructor* is a function called by C++ when the object's lifetime ends, or is otherwise deallocated (i.e. with `delete`)
- It's common for a destructor to release the resource (deallocate memory, close a file, etc)

# C++ classes: destructors

```
// sequence.h

1  #ifndef SEQUENCE_H
2  #define SEQUENCE_H
3  #include <cassert>
4  class Sequence { // What does this class do? Anything wrong with it?
5  public:
6      Sequence() : array(NULL), size(0) { }
7      Sequence(int sz) : array(new int[sz]), size(sz) {
8          for(int i = 0; i < sz; i++) array[i] = i;
9      }
10     ~Sequence() { delete[] array; }
11     int at(int i) {
12         assert(i < size);
13         return array[i];
14     }
15 private:
16     int *array;
17     int size;
18 };
19 #endif // SEQUENCE_H
```

# C++ classes: destructors

```
// destructors3.cpp
```

```
1  #include <iostream>
2  #include "sequence.h"
3
4  int main() {
5      Sequence seq(10);
6      for(int i = 0; i < 10; i++) {
7          std::cout << seq.at(i) << ' ';
8      }
9      std::cout << std::endl;
10     return 0;
11 }
```

```
$ g++ -o destructors3 destructors3.cpp -std=c++11 -pedantic -Wall -Wextra
```

```
$ ./destructors3
```

```
0 1 2 3 4 5 6 7 8 9
```

# C++ classes: destructors

```
$ valgrind --leak-check=full ./destructors3

==3306== Memcheck, a memory error detector
==3306== Copyright (C) 2002-2015, and GNU GPL'd, by Julian Seward et al.
==3306== Using Valgrind-3.11.0 and LibVEX; rerun with -h for copyright info
==3306== Command: ./destructors3
==3306==
==3306== error calling PR_SET_PTRACER, vgdb might block
==3306==
==3306== HEAP SUMMARY:
==3306==     in use at exit: 72,704 bytes in 1 blocks
==3306==   total heap usage: 3 allocs, 2 frees, 76,840 bytes allocated
==3306==
==3306== LEAK SUMMARY:
==3306==    definitely lost: 0 bytes in 0 blocks
==3306==    indirectly lost: 0 bytes in 0 blocks
==3306==    possibly lost: 0 bytes in 0 blocks
==3306==    still reachable: 72,704 bytes in 1 blocks
==3306==         suppressed: 0 bytes in 0 blocks
==3306== Reachable blocks (those to which a pointer was found) are not shown.
==3306== To see them, rerun with: --leak-check=full --show-leak-kinds=all
==3306==
==3306== For counts of detected and suppressed errors, rerun with: -v
==3306== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
```

## C++ classes: destructors

Destructors are nearly always a better option than creating a special member function for releasing resources; e.g.:

```
#include <cassert>
```

```
class Sequence {  
public:
```

```
    ...
```

```
    // User must call clean_up when finished with Sequence
```

```
    void clean_up() { delete[] array; }
```

```
    ...
```

```
};
```



## C++ classes: destructors

User forgets to call `clean_up`:

```
{  
    Sequence s(40);  
    // ... (no call to s.clean_up())  
} // s lifetime ends and memory is leaked
```

More subtly

```
{  
    Sequence s(40);  
    if (some_condition) {  
        return 0; // memory leaked!  
    }  
    s.clean_up();  
}
```

# C++ classes: destructors

Destructor is **always automatically called** when object's **lifetime ends** or it is **deallocated**

You don't have to go hunting for all the places to put `object.clean_up()`

## Quiz- answers

The destructor of an object is NOT necessarily called if ...

A an object's lifetime is over

B an object is deallocated

C there are no references or pointers to an object

D None of the above