# CS 485
# Advanced Object Oriented Design

Enum

Spring 2019

http://www.netobjectives.com/PatternRepository/index.php?title=PatternsByAlphabet

http://www.netobjectives.com/files/books/dpe/design-patterns-matrix.pdf

CS485_Student_Examples/06_EnumClass

## Enumerated Data Types are ADTs

- An enumerated data type is a programmer-defined data type

**General Format**

```
enum TypeName {One or more enumerators};
```

**Example**

```
enum Day {MON, TUE, WED, THU, FRI, SAT, SUN};
Day day;
day = MON;
```

- The enumerators are integer constants the compiler assigns starting with 0 unless otherwise specified

# Enumerated Data Types

```
Day day;
int whatDay, indx;
```

- `day = 3;              // illegal`
- `whatDay = TUE;        // legal`
- `if (day > WED)        // legal`
- `for (indx = MON; indx <= SUN; ++indx)  // legal`
- `day = static_cast<Day> (day + 1);  // legal`

# Enumerated Data Types

```
switch (day)
{
   case MON:          cout << "Monday";
                      break;


   case TUE:          cout << "Tuesday";
                      break;
   …
}
```

- Anonymous Enumerator Data Types

```
enum {FREEZING = 32, BOILING = 212};
```

## The logical conclusion...

```cpp
enum Day { MON, TUE, WED, THU, FRI, SAT, SUN };

int foo (char param);
int bar (bool bParam);

Day today = MON;

if (4.2 > today) // legal
{
  std::cout << foo (MON); // legal
  std::cout << bar (MON); // legal
}
```

Effective Modern C++, Meyers, Item 10

# C++11 Scoped Enum

- Goals
  - better type checking
  - less name pollution

```
enum class Day { MON, TUE, WED, THU, FRI, SAT, SUN };

enum UnscopedDay {mon, tue, wed, thur, fri, sat, sun};

int foo (char param);
int bar (bool bParam);

int main ()
{
  Day today = Day::MON;

  if (4.2 > today) // illegal
  {
    std::cout << foo (today); // illegal
    std::cout << bar (today); // illegal
    today = TUE; // illegal
  }

  UnscopedDay tomorrow = tue;
  if (4.2 > tomorrow) // legal
  {
    std::cout << foo (tomorrow); // legal
    std::cout << bar (tomorrow); // legal
  }

  return EXIT_SUCCESS;
}
```

http://www.stroustrup.com/C++11FAQ.html#enum

## Declaration

```
enum class Day : char { MON, TUE, WED, THU, FRI, SAT, SUN };
```

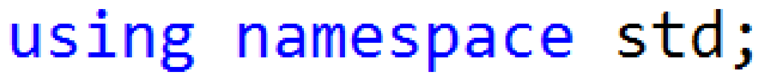
enum class NAME : TYPESPECIFIER { LIST };

Still no easy way to print an enum value :(

http://en.cppreference.com/w/cpp/language/enum

# Namespaces

- Keep your declared names inside a restricted scope



```
using namespace std;
```

- Reduce name collisions
  - what if two libraries both provide the function

```
int *quartiles(int *paData, int size);
```

CS485_Student_Examples/06_NamespaceExample

# Example

```
namespace CS485
{
  const std::string objects = "have data and responsibilities";
}

namespace CS250
{
  const std::string objects = "have data and functionality";
}

void outputDef ()
{
  //std::cout << objects; // illegal!

  std::cout << CS250::objects << std::endl;

  std::cout << CS485::objects << std::endl;
}
```

# using

```
using namespace std;

using CS485::objects;

void outputDef ()
{
  std::cout << objects; // legal!

  std::cout << CS250::objects << std::endl;

  std::cout << CS485::objects << std::endl;
}
```

## Notes

- The same namespace can be spread across many header files

- namespace `std` is defined in:
  - iostream
  - vector
  - memory

- This allows you to only include the piece of the namespace you need.

# Useful to package classes

- *Prefer non-member, non-friend functions to member functions**
- If a non-member, non-friend function can do the work, what does that tell me about the class's interface?

```
namespace Example
{
  class BigResponsibilities  { ... } ;

  void helpfulFunction(BigResponsibilities &)
}
```

*Effective C++, Third Edition, Meyers, Item 23

# Exceptions

CS485_Student_Examples/06_ExceptionExample

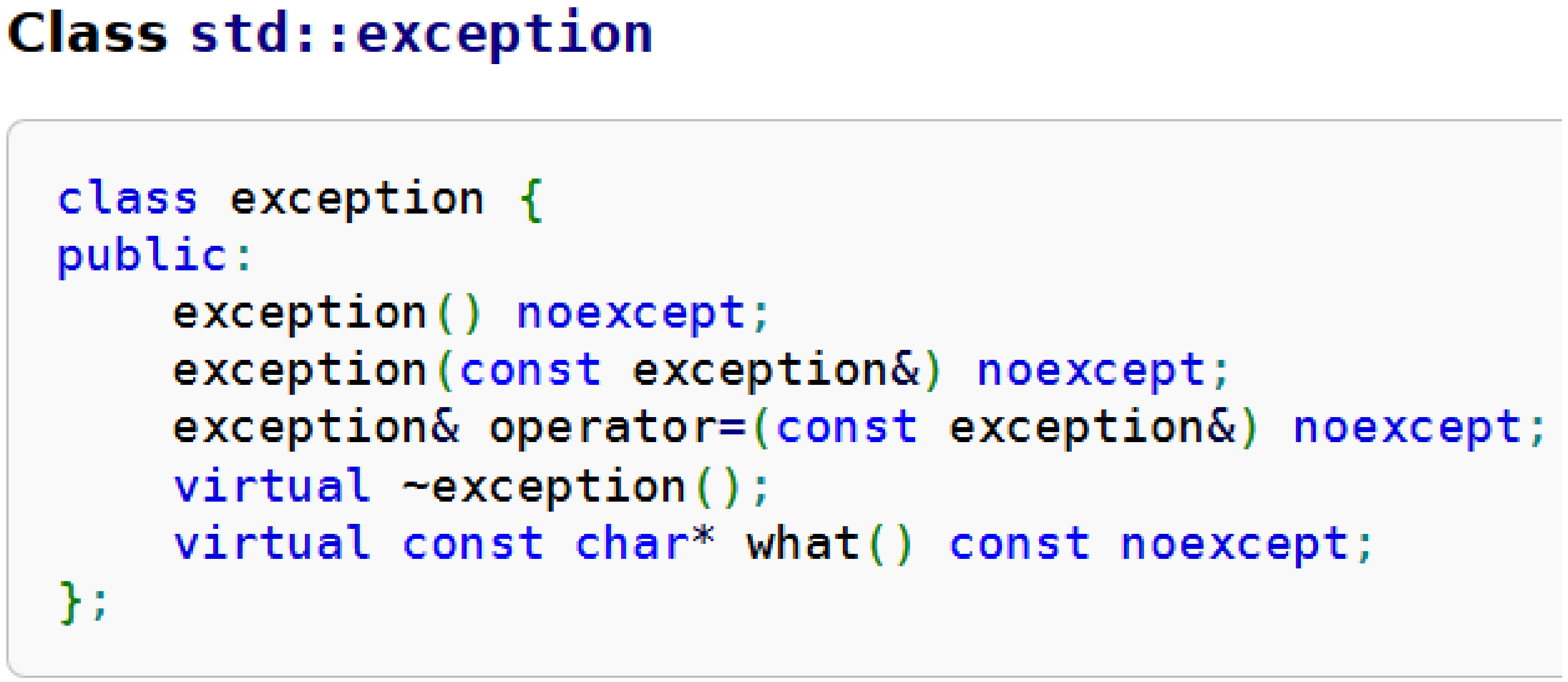
# Exceptions

- Signal an error has occurred

- Predefined exceptions

http://en.cppreference.com/w/cpp/error/exception

http://en.cppreference.com/w/cpp/language/exceptions



## Class std::exception

```
class exception {
public:
    exception() noexcept;
    exception(const exception&) noexcept;
    exception& operator=(const exception&) noexcept;
    virtual ~exception();
    virtual const char* what() const noexcept;
};
```

http://en.cppreference.com/w/cpp/header/exception

## Oh no

- std::terminate

- std::unexpected *(until c++17)*

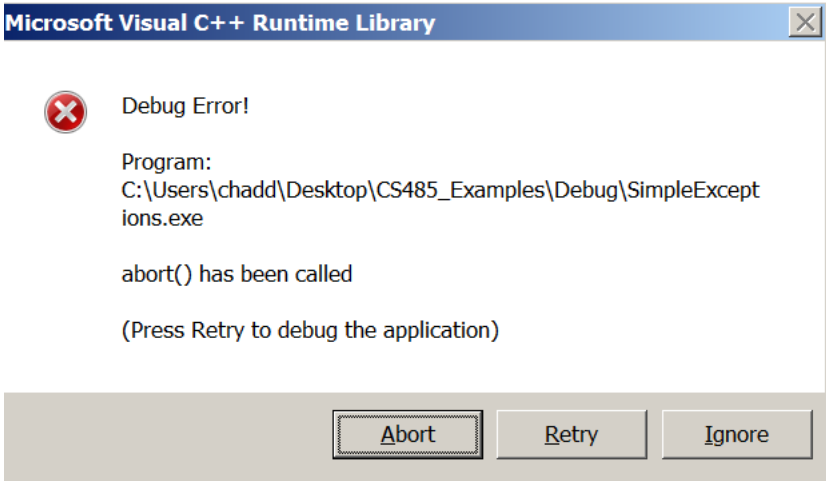
*http://en.cppreference.com/w/cpp/error/terminate

http://en.cppreference.com/w/cpp/error/unexpected

# Example

```cpp
int *paValues;
int size = -1;

try
{
  paValues = new int[size]; // try to allocate array of size -1
}
catch (const std::bad_alloc& e)
{
  std::cout << e.what () << std::endl;
}
catch (...)
{
  std::cout << "Unknown exception" << std::endl;
}
```

Uncaught Exception



Microsoft Visual C++ Runtime Library

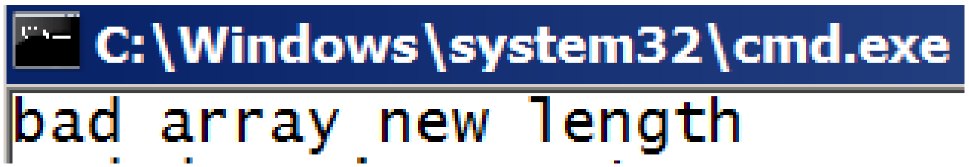
Debug Error!

Program:
C:\Users\chadd\Desktop\CS485_Examples\Debug\SimpleExceptions.exe

abort() has been called

(Press Retry to debug the application)

Caught Exception



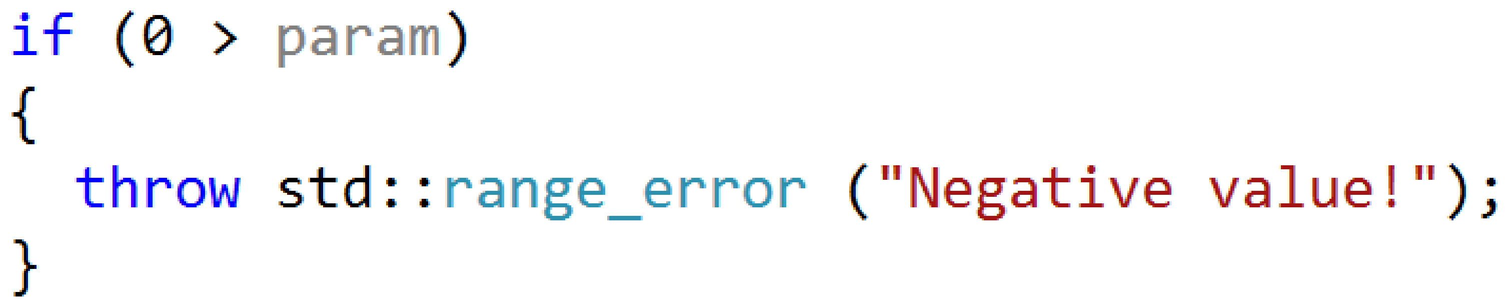
C:\Windows\system32\cmd.exe

```
bad array new length
```

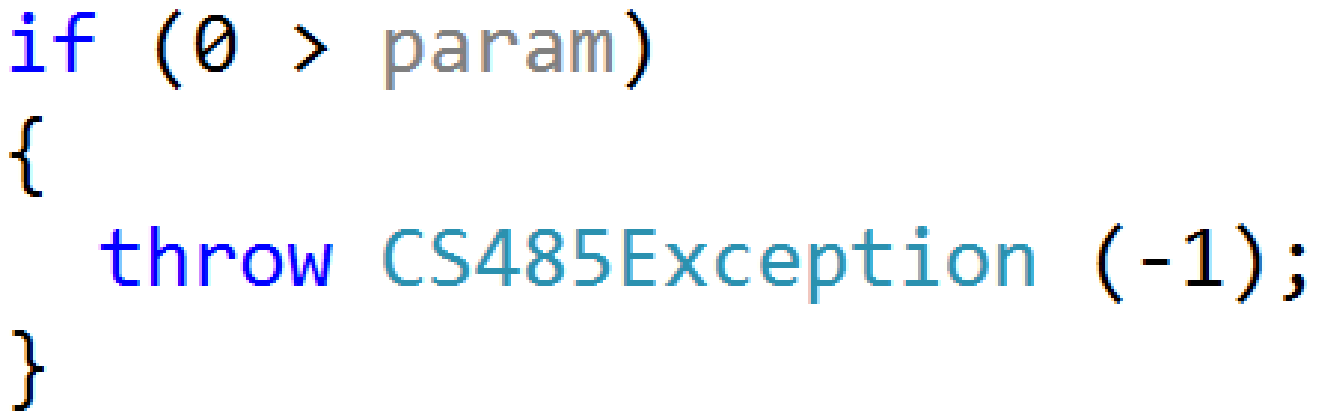
http://en.cppreference.com/w/cpp/language/try_catch

```
class CS485Exception : public std::exception
{
public:

  CS485Exception (int value=0);
  CS485Exception (const CS485Exception & rcOther);

  ~CS485Exception ();

  CS485Exception& operator= (CS485Exception cOther);

  virtual const char* what () const override;

private:
  int mValue;

  char *mpszMessage = nullptr;
};
```

# Throw



```
if (0 > param)
{
  throw std::range_error ("Negative value!");
}
```

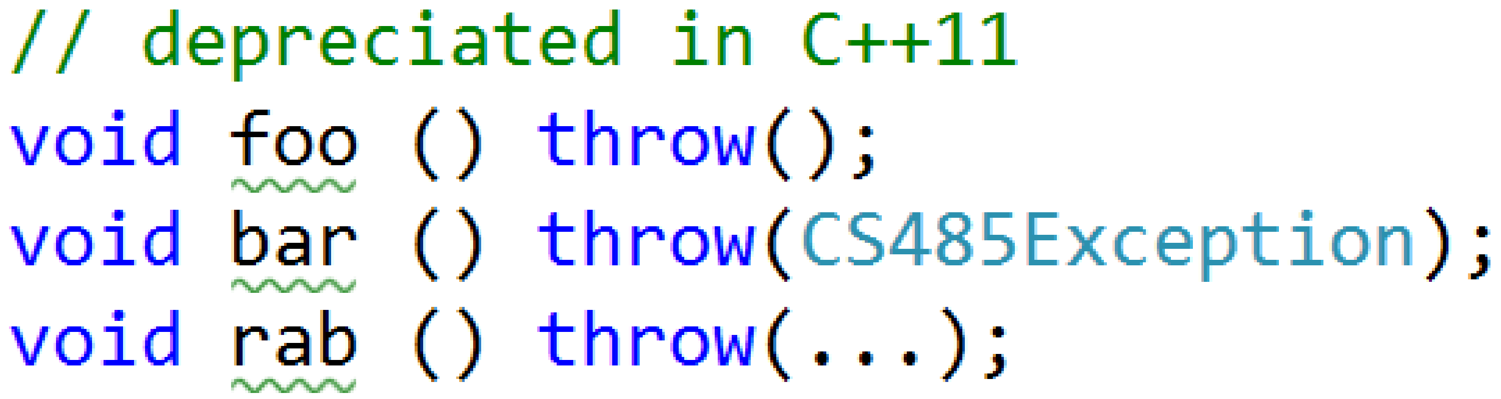


```
if (0 > param)
{
  throw CS485Exception (-1);
}
```

Empty throw; just rethrows the current exception (must be in try/catch block)

http://en.cppreference.com/w/cpp/language/throw

# dynamic runtime check

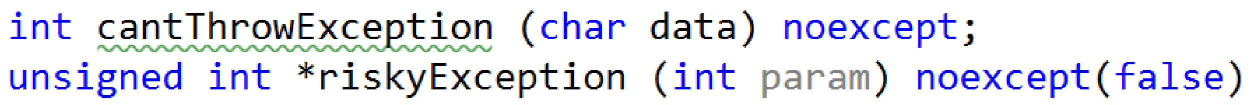


```cpp
// depreciated in C++11
void foo () throw();
void bar () throw(CS485Exception);
void rab () throw(...);
```

# noexcept specifier

- Mark whether or not your function can throw an exception -- *or allow an exception to be propagated from any other function that it invokes either directly or indirectly.*
- Violation of this leads to termination, `std::terminate`

non-throwing functions*



```
int cantThrowException (char data) noexcept;
unsigned int *riskyException (int param) noexcept(false)
```

- marked noexcept
- destructors
- default constructors, copy constructors, move constructors
- copy assignment operators, move assignment operators
- deallocation functions (delete)

→ except that there are many caveats and qualifications

## References for the previous slide

http://en.cppreference.com/w/cpp/error/terminate

http://en.cppreference.com/w/cpp/language/noexcept_spec

https://akrzemi1.wordpress.com/2014/04/24/noexcept-what-for/

http://www.open-std.org/JTC1/SC22/WG21/docs/papers/2009/n2855.html#problem

http://www.stroustrup.com/C++11FAQ.html#noexcept

## Exception Safety guarantees

- No-throw/No-fail
- Strong exception safety
- Basic exception safety
- No exception safety

https://msdn.microsoft.com/en-us/library/hh279653.aspx

## Risks

- Throwing from a destructor

- Options

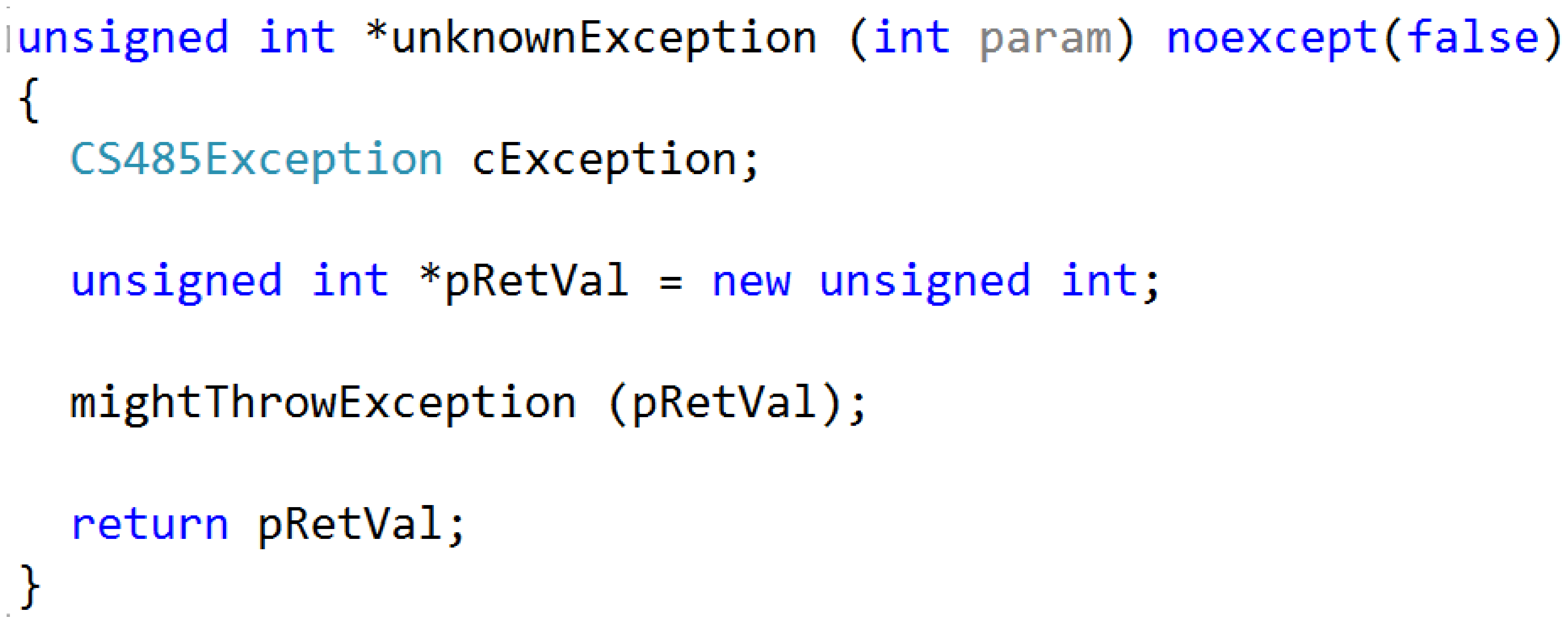
*Effective C++, Third Edition, Meyers, Item 11
More Effective C++, Third Edition, Meyers, p45-80

# Risks

```
unsigned int *riskyException (int param) noexcept(false)
{
  CS485Exception cException;

  unsigned int *pRetVal = new unsigned int;

  if (0 > param)
  {
    throw std::range_error ("Negative value!");
  }

  *pRetVal = param;

  return pRetVal;
}
```

Which destructors are called?

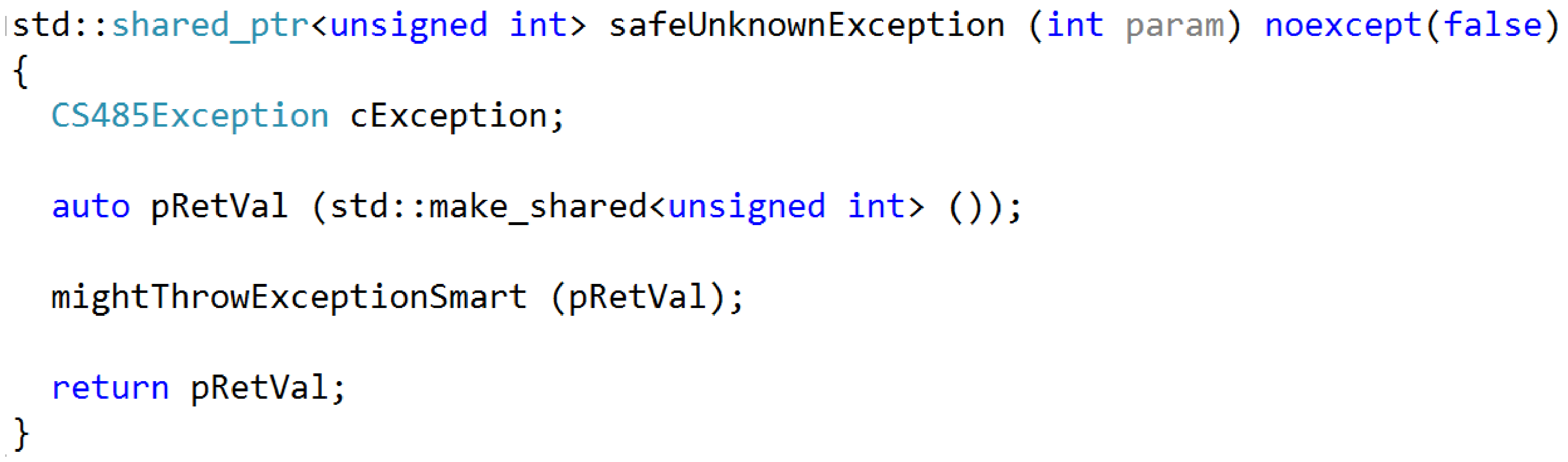
# Risks



```
unsigned int *unknownException (int param) noexcept(false)
{
  CS485Exception cException;

  unsigned int *pRetVal = new unsigned int;

  mightThrowException (pRetVal);

  return pRetVal;
}
```

Which destructors are called?

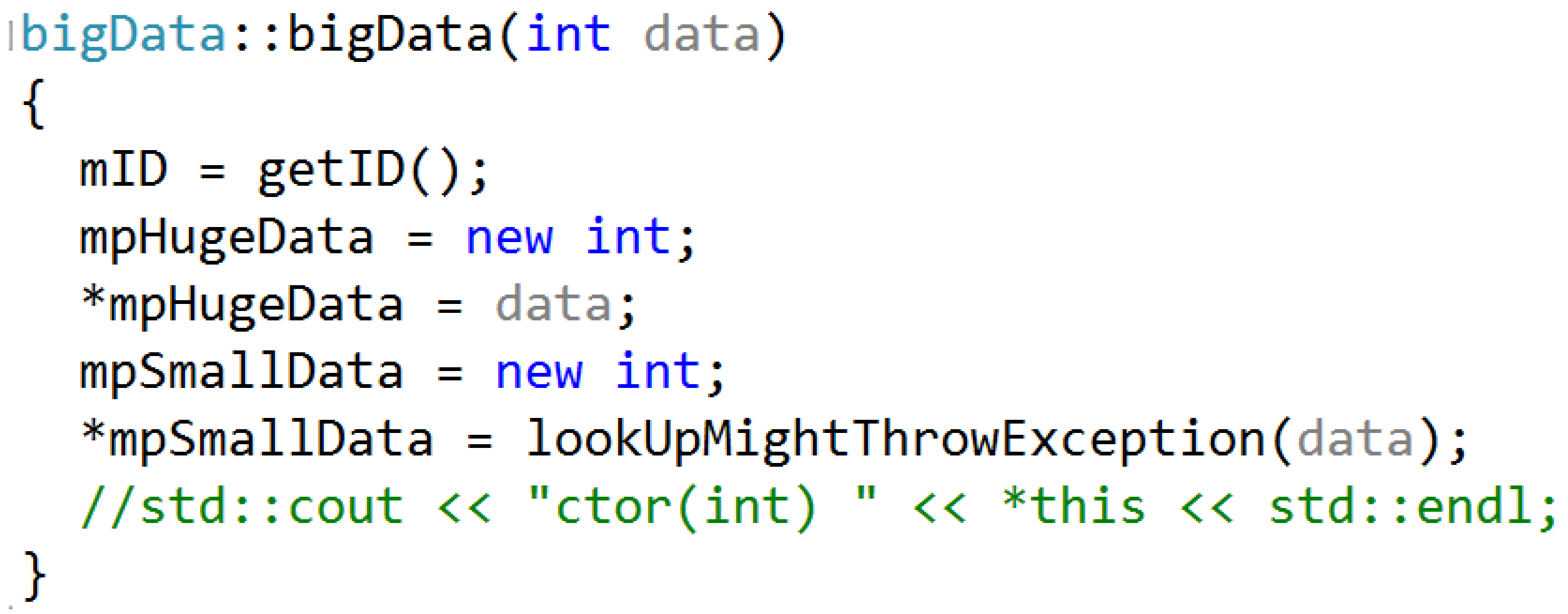
# Mitigation



```
std::shared_ptr<unsigned int> safeUnknownException (int param) noexcept(false)
{
  CS485Exception cException;

  auto pRetVal (std::make_shared<unsigned int> ());

  mightThrowExceptionSmart (pRetVal);

  return pRetVal;
}
```

Which destructors are called?

# Constructors



```
bigData::bigData(int data)
{
  mID = getID();
  mpHugeData = new int;
  *mpHugeData = data;
  mpSmallData = new int;
  *mpSmallData = lookUpMightThrowException(data);
  //std::cout << "ctor(int) " << *this << std::endl;
}
```

Solution?