CSc 120
Introduction to Computer Programming II

13: Exceptions

EXERCISE

Given the following code:

```
def foo():
    n = int(input("Enter a number:"))
    print("n = ", n)
    print("reciprocal = ", str(1/n))
```

What happens when n is 2?

What happens when n is 0?

Errors and exceptions in Python

A Python program can have two kinds of errors:*

Syntax errors:

- the code is not legal Python syntax
- detected before the program is run

Exceptions:

- the code is legal Python syntax
- but something goes wrong when the program is run

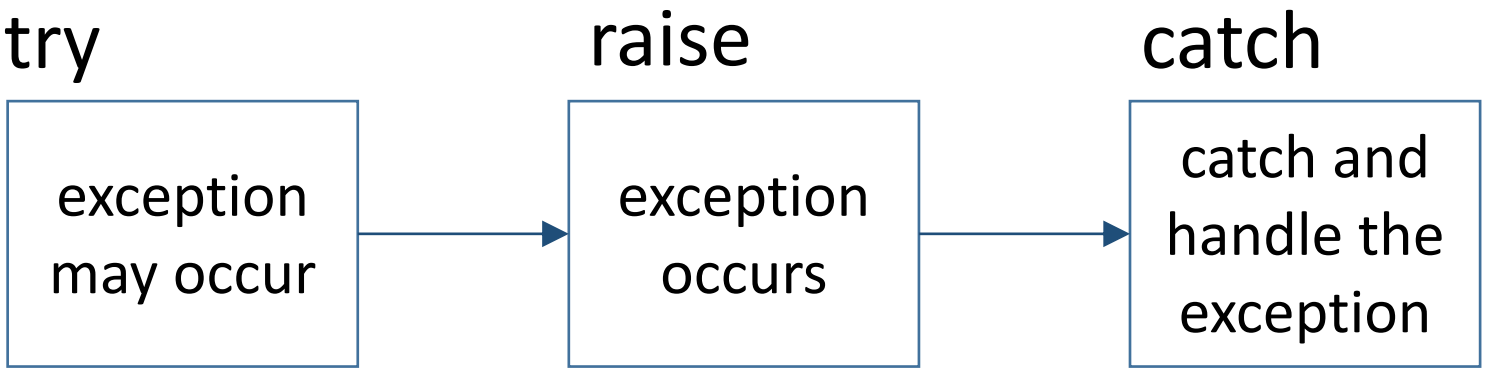
An *exception* is an error that is only detected at run time.

* This does not count logic errors, which the Python system cannot detect

Some common exceptions

- FileNotFoundError
  - file name or directory cannot be found
- IndexError
  - an index into a string or list is out of bounds
- KeyError
  - a non-existent key used to access a dictionary
- TypeError
  - arguments to an operation are of the wrong type
- ValueError
  - type is OK but the value is not. E.g.: int("abc")
- ZeroDivisionError
  - divide by 0 error

Handling exceptions



Handling exceptions

Example:

try:

code that might raise an exception

except:

code to handle the exception

Handling exceptions

Example:

```
try:
    infile = open(filename)
except:
    print("could not open file: " + filename)
```

Handling exceptions

Example:

```
>>> f = open("notthere.txt")
Traceback (most recent call last):
  File "<pyshell#6>", line 1, in <module>
    f = open("notthere.txt")
FileNotFoundError: [Errno 2] No such file or directory:
'notthere.txt'
>>>
```

Handling exceptions

Example:

```
>>> f = open("notthere.txt")
Traceback (most recent call last):
  File "<pyshell#6>", line 1, in <module>
    f = open("notthere.txt")
FileNotFoundError: [Errno 2] No such file or directory: 'notthere.txt'
>>>
>>> try:
        f = open("notthere.txt")
except:
        print("Error: file not found")
Error: file not found
>>>
```

EXERCISE - Whiteboard

Add try and except statements to handle an exception that may occur.

try:
    code that might raise an exception
except:
    code to handle the exception

```
def foo():
    n = int(input("Enter a number:"))
    print("n = ", n)
    print("reciprocal = ", str(1/n))
```

EXERCISE-sol

```
def foo():
    try:
        n = int(input("Enter a number:"))
        print("n = ", n)
        print("reciprocal = ", str(1/n))
    except:
        print("Divide-by-zero error")
```

EXERCISE-sol?

If you run the code and enter a non-digit value, what happens?

What's the problem?

```
def foo():
    try:
        n = int(input("Enter a number:"))
        print("n = ", n)
        print("reciprocal = ", str(1/n))
    except:
        print("Divide-by-zero error")
```

Handling exceptions

Example:

- This will catch any exception raised in the **try** block
- This may not always be desirable

try:

code that might raise an exception

except:

code to handle the exception

Handling exceptions

```
>>> def foo(filename):
...     try:
...         infile = open(filename)
...         n = int(infile.read())
...         print("n = " + str(n))
...         print("reciprocal = " + str(1/n))
...     except:
...         print("ERROR: could not read file: " + filename)
```

Handling exceptions

```
>>> def foo(filename):
...     try:
...         infile = open(filename)
...         n = int(infile.read())
...         print("n = " + str(n))
...         print("reciprocal = " + str(1/n))
...     except:
...         print("ERROR: could not read file: " + filename)
...
>>> foo('file_3')
n = 3
reciprocal = 0.3333333333333333
>>>
```

Handling exceptions

```
>>> def foo(filename):
...     try:
...         infile = open(filename)
...         n = int(infile.read())
...         print("n = " + str(n))
...         print("reciprocal = " + str(1/n))
...     except:
...         print("ERROR: could not read file: " + filename)
...
>>> foo('file_3')
n = 3
reciprocal = 0.3333333333333333
>>>
>>> foo('nonexistent_file')
ERROR: could not read file: nonexistent_file
>>>
```

Handling exceptions

```
>>> def foo(filename):
...     try:
...         infile = open(filename)
...         n = int(infile.read())
...         print("n = " + str(n))
...         print("reciprocal = " + str(1/n))
...     except:
...         print("ERROR: could not read file: " + filename)
...
>>> foo('file_3')
n = 3
reciprocal = 0.3333333333333333
>>>
>>> foo('nonexistent_file')
ERROR: could not read file: nonexistent_file
>>>
>>> foo('file_0')
n = 0
ERROR: could not read file: file_0
```

CULPRIT: Catching all exceptions (BAD STYLE)

The file was read!

The error message doesn't make sense

Handling exceptions

```
>>> def reciprocal(filename):
...     try:
...         infile = open(filename)
...         n = int(infile.read())
...         print("n = " + str(n))
...         print("1/n = " + str(1/n))
...     except IOError:
...         print("ERROR: could not read file: " + filename)
...
>>> reciprocal('file_3')
n = 3
1/n = 0.3333333333333333
>>> reciprocal('nonexistent')
ERROR: could not read file: nonexistent
>>>
>>> reciprocal('file_0')
n = 0
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "<stdin>", line 6, in reciprocal
ZeroDivisionError: division by zero
```

Deals with a specific exception

Does not mislead on other exceptions

EXERCISE-Whiteboard

Modify the code to catch a ZeroDivisionError.

```
def foo():
    try:
        n = int(input("Enter a number:"))
        print("n = ", n)
        print("reciprocal = ", str(1/n))
    except:
        print("ERROR: Divide-by-zero error")
```

EXERCISE-Sol

Modify the code to catch a ZeroDivisionError.

```
def foo():
    try:
        n = int(input("Enter a number:"))
        print("n = ", n)
        print("reciprocal = ", str(1/n))
    except ZeroDivisionError:
        print("ERROR: Divide-by-zero error")
```

Handling multiple exceptions 1

```
>>> def reciprocal(filename):
        try:
            infile = open(filename)
            n = int(infile.read())
            print("n = " + str(n))
            print("1/n = " + str(1/n))
        except (IOError,ArithmeticError):
            print("Something broke! :-(")
```

Handle multiple exceptions in the same way

```
>>> reciprocal("file_3")
n = 3
1/n = 0.3333333333333333
>>> reciprocal("nonexistent_file")
Something broke! :-(
>>> reciprocal("file_0")
n = 0
Something broke! :-(
>>>
```

Behavior for both exceptions is the same

Handling multiple exceptions 2

```
>>> def reciprocal(filename):
        try:
            infile = open(filename)
            n = int(infile.read())
            print("n = " + str(n))
            print("1/n = " + str(1/n))
        except IOError:
            print("ERROR: could not read file: " + filename)
        except ZeroDivisionError:
            print("ERROR: divide by zero :-(")
```

Handle multiple exceptions in different ways

```
>>> reciprocal("file_3")
n = 3
1/n = 0.3333333333333333
>>> reciprocal("nonexistent_file")
ERROR: could not read file: nonexistent_file
>>> reciprocal("file_0")
n = 0
ERROR: divide by zero :-(
>>>
```

Handling multiple exceptions 2

```
>>> def reciprocal(filename):
        try:
            infile = open(filename)
            n = int(infile.read())
            print("n = " + str(n))
            print("1/n = " + str(1/n))
        except IOError:
            print("ERROR: could not read file: " + filename)
        except ZeroDivisionError:
            print("ERROR: divide by zero :-(")


>>> reciprocal("file_3")
n = 3
1/n = 0.3333333333333333
>>> reciprocal("nonexistent_file")
ERROR: could not read file: nonexistent_file
>>> reciprocal("file_0")
n = 0
ERROR: divide by zero :-(
>>>
```

Exception propagation

```
>>> def fun1(x):
        return 1/x

>>> def fun2(x):
        return 1 + fun1(x)

>>> def fun3(x):
        try:
            return 2 * fun2(x)
        except ZeroDivisionError:
            print("caught divide-by-0 in fun3")
```

an unhandled exception is passed along from a function to its caller until (a) it is handled; or (b) it reaches the top level of execution

```
>>> fun3(2)
3.0
>>> fun3(0)
caught divide-by-0 in fun3
>>>
```

Dealing with exceptions

- If possible and appropriate, try to recover from the exception
  - depends on the problem spec, nature of the exception
- If recovery is not possible, exit the program

```
import sys
...
sys.exit(1)
```

exits the program with error code 1
(this indicates that an error occurred to any other program that may be using this program)

Example

```
import sys

def read_input(filename):
    try:
        fileobj = open(filename)
    except IOError:
        print("ERROR: could not open file " + filename)
        sys.exit(1)

    for line in fileobj:
        ...process contents of file...
```

Else clause (optional)

Executed if no exceptions are raised.

```
...
for fname in names_list:
    try:
        f = open(fname)
    except IOError:
        print("cannot open ", fname)
    else:
        print("length of", fname, "is", len(f.readlines()))
        f.close()
```

Exceptions: summary

- Avoid naked **except** if at all possible
  - catch and handle specific exceptions by name
  - other exceptions will propagate up to the caller
- Keep the **try** … **except** separation as small as possible
  - makes the code easier to understand
  - avoids inadvertent masking of exceptions
- Recover from the exception if possible; otherwise exit with error code 1

EXERCISE-ICA39

Do all problems.