CSc 120
Introduction to Computer Programming II

Exceptions

EXERCISE

Type in the following code:

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

Run the code

Call foo() and enter a number

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

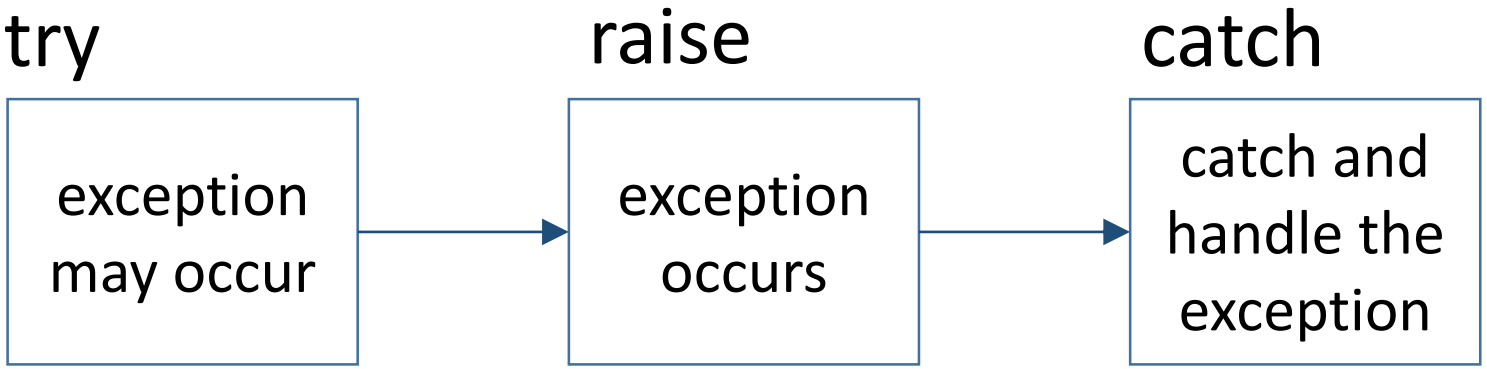
An *exception* is an error that is only detected at run time.

* 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")

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

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

Run the code and enter a non-digit value.
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 <u>any</u> 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

CULPRIT: Catching all exceptions (BAD STYLE)

```
>>> 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
```

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

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")
```

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
>>>
```

EXERCISE

Download:
http://www2.cs.arizona.edu/classes/cs120/spring19/NOTES/propagate.py

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

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

def main():
    z = fun2(3)
    print(z)
    z = fun2(0)
    print(z)
main()
```

Make 2 copies of the program.

1- Modify the code to catch the exception in fun2().

EXERCISE-(cont.)

In which function does the error occur?

Which function catches the error?

EXERCISE

Download:
http://www2.cs.arizona.edu/classes/cs120/spring19/NOTES/propagate.py

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

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

def main():
    z = fun2(3)
    print(z)
    z = fun2(0)
    print(z)
main()
```

2- Modify the code to catch the exception in main().

EXERCISE-(cont.)

Call order:

main() → calls fun2() → calls fun1()

In which function does the error occur?

Which function catches the error?

The error occurs in fun1(). When it's not "handled" there, Python goes to the caller of fun1(), which is fun2().

If not handled there, Python goes to the caller of fun2(), which is main().

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