

Exception Handling

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Exceptions

- *RAISING AN EXCEPTION* interrupts the flow of the program
- *HANDLING AN EXCEPTION* puts the program flow back on track or deals with an error situation
 - Such as out of memory, file cannot be found, CPU illegal instruction error, division by zero, overflow, ...

Python Philosophy



Philosopher's Football

- Handle the common case.
 - And deal with the uncommon with exceptions.

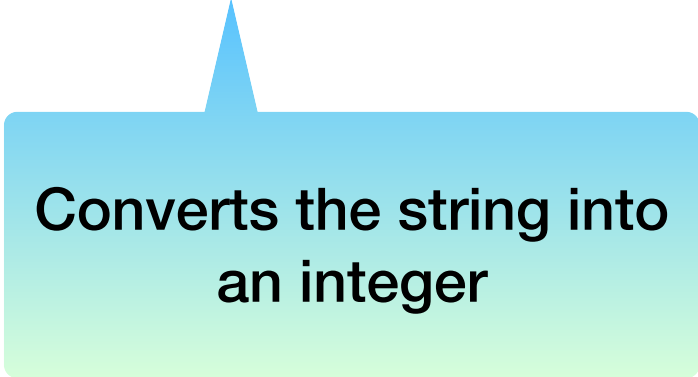
C, Java, C++ Philosophy

- C: check before you assume
- Java, C++: Use exceptions to handle bad situations
- Python: Use exceptions for the not so ordinary

Python

- If an instruction or block of instruction can cause an error, put it in a *try block*.

```
try:  
    int(string)
```



Converts the string into
an integer

Notice that we are not using the result of the conversion, we just attempt the conversion

Python Exceptions

- Then afterwards, *handle the exception*.
- You *should*, but are not required to specify the possible offending exception

```
try:  
    int(string)  
except ValueError:  
    print("Conversion error")
```

If the conversion fails, a
ValueError is thrown

This block handles the
exception

Python Exceptions

- How do you find which error is thrown:
 - You can cause the error and see what type of error it is
 - You can look it up

```
>>> 5/0
Traceback (most recent call last):
  File "<pyshell#5>", line 1, in <module>
    5/0
ZeroDivisionError: division by zero
```

Division by zero creates a
ZeroDivisionError

Python Exceptions

- Putting things together: Testing whether a string represents an integer

Try out the conversion

```
def is_int(string):  
    try:  
        int(string)  
        return True  
    except:  
        return False
```


Python Exceptions

- Putting things together: Testing whether a string represents an integer

```
def is_int(string):  
    try:  
        int(string)  
        return True  
    except:  
        return False
```

Try out the conversion

It worked:
We return True

Python Exceptions

- Putting things together: Testing whether a string represents an integer

Try out the conversion

```
def is_int(string):  
    try:  
        int(string)  
        return True  
    except:  
        return False
```

It did NOT work:
An exception is thrown
We return FALSE

Python Exceptions

- As you can see from this example, the moment an exception is thrown, we jump to the exception handler.

Python Exceptions

- When to use exceptions and when to use if
 - Recall: Using `if` is defensive programming
 - Recall: Using exceptions amounts to the same degree of safety, but is offensive programming
- Rule of thumb:
 - If exceptions are raised infrequently, then use them

Python Exceptions

- Let's make some timing experiments
- Define two functions that square all elements in a list, if the elements are integers.

```
def square_list(lista):  
    result = []  
    for element in lista:  
        if element.isdigit():  
            result.append(int(element)**2)
```

```
def square_list2(lista):  
    result = []  
    for element in lista:  
        try:  
            result.append(int(element)**2)  
        except:  
            pass
```

Python Exceptions

- The pass instruction:
 - When Python expects a statement, but we don't have one:
 - Just use `pass`
 - The No-Operation instruction

Python Exceptions

- Recall how to use the time-module to obtain the CPU (wall-clock) time
- We use this to measure execution time
 - First a list that only contains integers

```
def timeit(function, trials):
    lista = [str(i) for i in range(1000000)]
    count = 0
    for _ in range(trials):
        start = time.time()
        lista2 = function(lista)
        count += time.time() - start
    return count/trials
```

Python Exceptions

- Result: Exceptions are somewhat faster

```
>>> timeit(square_list,5)
0.3025518894195557
>>> timeit(square_list2,5)
0.2796015739440918
```


Python Exceptions

- What if none of the list elements are integers:

```
def timeit(function, trials):  
    lista = ["a"+str(i) for i in range(1000000)]  
    count = 0  
    for _ in range(trials):  
        start = time.time()  
        lista2 = function(lista)  
        count += time.time()-start  
    return count/trials
```

```
>>> timeit(square_list,5)  
0.025159788131713868  
>>> timeit(square_list2,5)  
0.41803536415100095
```

Exceptions are
much slower

Python Exceptions

- What about if the letter is at the end

```
def timeit(function, trials):  
    lista = [str(i)+"a" for i in range(1000000)]  
    count = 0  
    for _ in range(trials):  
        start = time.time()  
        lista2 = function(lista)  
        count += time.time()-start  
    return count/trials
```

```
>>> timeit(square_list,5)  
0.030397653579711914  
>>> timeit(square_list2,5)  
0.40491724014282227
```

Exceptions are
still much slower

Self Test

- Define a function that calculates the geometric mean of two numbers.
- Use an exception to deal with a `ValueError`, arisen by taking the square-root of a negative number
- Here is the if-version. We return `None` if there is no mean.

```
def geo(x, y):  
    if x*y > 0:  
        return math.sqrt(x*y)  
    return None
```

Self Test Solution

```
def geoe(x, y):  
    try:  
        return math.sqrt(x*y)  
    except ValueError:  
        return None
```

Multiple Exceptions

- We can write an exception handler that handles all the exceptions
 - This is discouraged since there are just too many exceptions that can occur
 - such as out-of-memory, system-error, keyboard-interrupt ...
- In this case, the except clause specifies no exception

```
try:  
    accum += 1/n  
except:  
    print("something bad happened")
```

No exception specified
Handler handles
everything

Multiple Exceptions

- Normally, you want to specify which exceptions you are handling
- You can specify several exception handles by repeating the exception clause
- Or you can handle a list of exceptions

```
def test():  
    try:  
        f = open("none.txt")  
        block = f.read(256)  
    except IOError:  
        print("something happened when reading the file")  
    except EOFError:  
        print("ran out of file")  
    except (KeyboardInterrupt, ValueError):  
        print("something strange happened")
```

The parentheses are necessary

Cleaning Up

- Sometimes you need to make sure that failure-prone code cleans up
- Use the `finally` clause
 - Guaranteed to be executed
 - Even with return statements
 - Even when exceptions are raised

Example for `finally` clause

- If we open a file without the if-clause, we are morally obliged to close it
 - Let's say, if you have a long-running process that only needs a file for a little time, you should not hog the file and prevent others from accessing it.

Example for `finally` clause

```
def harmonic(filename):  
    """  
    Assumes that the elements in the file are numbers.  
    We return the harmonic mean of the numbers.  
    """  
    count = 0  
    accumulator = 0  
    try:  
        infile = open(filename, encoding="utf-8")  
        for line in infile:  
            for words in line.split():  
                accumulator += 1/int(words)  
                count += 1  
        return count/accumulator  
    except ZeroDivisionError:  
        print("saw a zero")  
        return 10000000000  
    except ValueError:  
        print("saw a non-integer")  
        return 0  
    finally:  
        print("I am done and closing the file")  
        infile.close()
```

Return in the try block

Return in the handler

**But finally is
guaranteed to run
before any of the
returns**

Raising exceptions

- You can also raise your own exception
 - You can even define your own exceptions when you have understood classes
 - Just say: `raise ValueError`
 - or whatever the exception is that you want to raise.

Self Test

- Recall that the finally clause is always executed.
- What is the output of the following code

```
def raising():  
    try:  
        raise ValueError  
    except ValueError:  
        return 0  
    finally:  
        return 1
```

Answer

- The function returns 1
 - The exception is raised and control passes to the exception handler
 - Before the exception handler can return, the finally clause is executed
 - And that one returns 1