

[220] Error Handling

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**Fill out exam 2 conflict
form by Friday Oct 30th**

Learning Objectives Today

How to crash more

- turn semantic bugs into runtime bugs with `assert`

How to crash less

- **`assert`** statements
- catch exceptions with **`try/except`**
- **`raise`** custom exceptions



<https://en.wikipedia.org/wiki/Pizza>



https://en.wikipedia.org/wiki/Grace_Hopper

Example: Pizza Analyzer

```
import math

def pizza_size(radius):
    return (radius ** 2) * math.pi

def slice_size(radius, slice_count):
    total_size = pizza_size(radius)
    return total_size * (1 / slice_count)

def main():
    for i in range(10):
        # grab input
        args = input("Enter pizza diameter(inches), slice count: ")
        args = args.split(',')
        radius = float(args[0].strip()) / 2
        slices = int(args[1].strip())

        # pizza analysis
        size = slice_size(radius, slices)
        print('PIZZA: radius={}, slices={}, slice square inches='
              .format(radius, slices, size))

main()
```

Exercise: what are possible bad inputs for

- diameter
- slice count
- other?

Does it cause a runtime error or semantic error?

Assert

Syntax:

```
assert BOOLEAN_EXPRESSION
```

Purpose:

Force program to crash if something is non-sensible, rather than run and produce garbage.

semantic errors
(hard to debug)



runtime errors
(easier to debug)

Assert

Warning: sometimes people disable assertions when running your code to improve performance

Syntax:

`assert` **BOOLEAN_EXPRESSION**

True

nothing happens

False

Crash!

```
Enter pizza diameter(inches), slice count): -10, 8
Traceback (most recent call last):
  File "pizza.py", line 24, in <module>
    main()
  File "pizza.py", line 20, in main
    size = slice_size(radius, slices)
  File "pizza.py", line 8, in slice_size
    total_size = pizza_size(radius)
  File "pizza.py", line 4, in pizza_size
    assert(radius > 0)
AssertionError
```

Assert

Syntax:

```
assert BOOLEAN_EXPRESSION
```

Examples:

```
assert x > 0
```

```
assert items != None
```

```
assert "age" in person
```

```
assert len(nums) % 2 == 1
```

Pizza Example: add asserts to crash upon

- diameter <= 0
- slices <= 0

What if we want to keep running even
if there is an error?

Try/Except

Syntax:

```
flaky_function( )
```


Try/Except

Syntax:

try:

`flaky_function()`

except:

`print("error!") # or some other handling`

Try/Except

Syntax:

try:

```
    flaky_function()
```

except:

```
    print("error!") # or some other handling
```

Description:

try and **except** blocks come in pairs (runtime errors are “exceptions”)

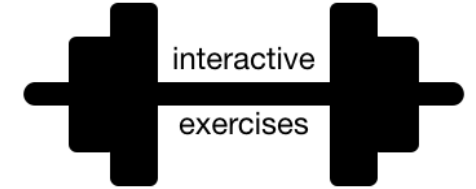
Python tries to run the code in the **try** block. If there’s an exception, it just runs the **except** block (instead of crashing). This is called “**catching**” the exception.

If there is no exception, the **except** block does not run.

Pizza Example: try/except to continue running upon

- parse errors
- analysis errors

Exceptions are Exceptions to Regular Control Flow

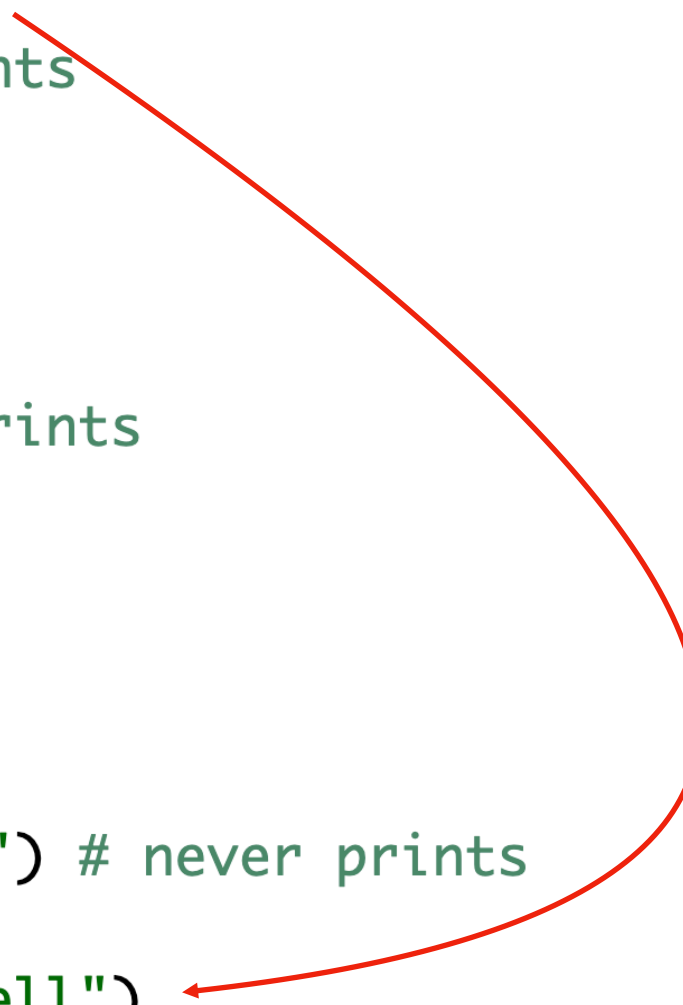


```
try:
    print("2 inverse is", 1/2)
    print("1 inverse is", 1/1)
    print("0 inverse is", 1/0)
    print("-1 inverse is", -1/1)
    print("-2 inverse is", -1/1)
except:
    print("that's all, folks!")
```

never runs

Exceptions are Exceptions to Regular Control Flow

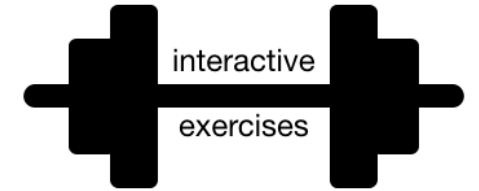
```
def buggy():  
    print("buggy: about to fail")  
    print("buggy: infinity is ", 1/0)  
    print("buggy: oops!") # never prints  
  
def g():  
    print("g: before buggy")  
    buggy()  
    print("g: after buggy") # never prints  
  
def f():  
    try:  
        print("f: let's call g")  
        g()  
        print("f: g returned normally") # never prints  
    except:  
        print("f: that didn't go so well")
```



f()

Try this example in notebook or script format

Exceptions are Exceptions to Regular Control Flow



```
def buggy():  
    print("buggy: about to fail")  
    print("buggy: infinity is ", 1/0)  
    print("buggy: oops!") # never prints
```

```
def g():  
    print("g: before buggy")  
    try:  
        buggy()  
    except:  
        print("g: caught an exception from buggy")  
    print("g: after buggy")
```

```
def f():  
    try:  
        print("f: let's call g")  
        g()  
        print("f: g returned normally")  
    except:  
        print("f: that didn't go so well")
```

*g catches, so f never knows
about the exception*

```
f()
```

Try this example in notebook or script format

What if we want to know
the reason for the exception?

Crash Cause

Pizza Example: print failure reasons

- for parse errors
- for analysis errors

Version 1:

```
try:  
    flaky_function()  
except:  
    print("error!") # or some other handling
```

Version 2:

```
try:  
    flaky_function()  
except Exception as e:  
    print("error because:", str(e))
```

*e is of type Exception (very general)
(there are different types of exceptions)*

*get exception object
describing the problem*

why it failed

What if we only want to catch
certain exceptions?

Narrow Catching

Pizza Example: catch only real parse errors

- strings when want ints
- not enough values
- NOT typos in variable names


Version 2:

```
try:
    flaky_function()
except Exception as e:
    print("error because:", str(e))
```

Version 3:

```
try:
    flaky_function()
except (ValueError, IndexError) as e:
    print("error because:", str(e))
```

only catch these two
(not NameError and others)



General Rule: always catch specific types of exceptions,
and/or make sure the user knows there was an error
(unexpected silent errors are the worst!)

Exception Hierarchy

Documentation:

<https://docs.python.org/3/library/exceptions.html#exception-hierarchy>

```
BaseException
+-- SystemExit
+-- KeyboardInterrupt
+-- GeneratorExit
+-- Exception
    +-- StopIteration
    +-- StopAsyncIteration
    +-- ArithmeticError
        +-- FloatingPointError
        +-- OverflowError
        +-- ZeroDivisionError
    +-- AssertionError
    +-- AttributeError
    +-- BufferError
    +-- EOFError
    +-- ImportError
        +-- ModuleNotFoundError
    +-- LookupError
        +-- IndexError
        +-- KeyError
    +-- MemoryError
    +-- NameError
        +-- UnboundLocalError
    +-- OSError
        +-- BlockingIOError
        +-- ChildProcessError
        +-- ConnectionError
            +-- BrokenPipeError
            +-- ConnectionAbortedError
            +-- ConnectionRefusedError
            +-- ConnectionResetError
        +-- FileExistsError
        +-- FileNotFoundError
        +-- InterruptedError
        +-- IsADirectoryError
        +-- NotADirectoryError
        +-- PermissionError
        +-- ProcessLookupError
        +-- TimeoutError
    +-- ReferenceError
    +-- RuntimeError
        +-- NotImplementedError
        +-- RecursionError
    +-- SyntaxError
        +-- IndentationError
        +-- TabError
    +-- SystemError
    +-- TypeError
    +-- ValueError
        +-- UnicodeError
            +-- UnicodeDecodeError
            +-- UnicodeEncodeError
            +-- UnicodeTranslateError
    +-- Warning
        +-- DeprecationWarning
        +-- PendingDeprecationWarning
        +-- RuntimeWarning
        +-- SyntaxWarning
        +-- UserWarning
        +-- FutureWarning
        +-- ImportWarning
        +-- UnicodeWarning
        +-- BytesWarning
        +-- ResourceWarning
```

**screenshot
of hierarchy**

What if we want to produce a specific kind of error? (not just an assert)

Custom Errors

BaseException

+-- Exception

+-- ArithmeticError

| +-- FloatingPointError

| +-- OverflowError

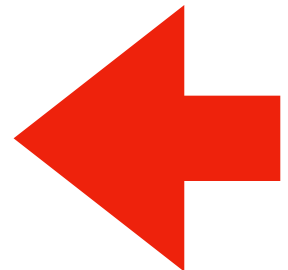
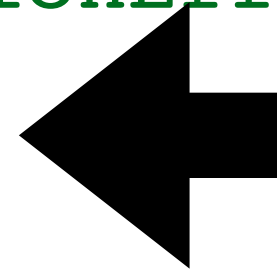
| +-- ZeroDivisionError

+-- AssertionError

+-- AttributeError

+-- TypeError

+-- ValueError



Asserts vs. Raising Exception Objects

Version 1 (quick and dirty):

```
def slice_size(radius, slice_count):  
    assert radius > 0  
    return pizza_size(radius) / slice_count
```

Version 2 (more robust and informative):

```
def slice_size(radius, slice_count):  
    if radius <= 0:  
        raise ArithmeticError("number of slices <= 0")  
    return pizza_size(radius) / slice_count
```

tell Python this exception
occurred here

create TypeError object

with this message

Summary

Asserts

- force a crash/exception
- better to crash in an obvious way than to use corrupt data

Exceptions

- produce them with `raise`
- catch them with `try/except`
- can choose specific types of exceptions

General Rule: always catch specific types of exceptions,
and/or make sure the user knows there was an error
(unexpected silent errors are the worst!)