Exceptions
Announcements
Exceptions
Today's Topic: Handling Errors
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Sometimes, computer programs behave in non-standard ways
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- A function receives an argument value of an improper type
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• A function receives an argument value of an improper type
• Some resource (such as a file) is not available
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• A network connection is lost in the middle of data transmission
Today's Topic: Handling Errors

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- A function receives an argument value of an improper type
- Some resource (such as a file) is not available
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Grace Hopper's Notebook, 1947, Moth found in a Mark II Computer
Exceptions
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A built-in mechanism in a programming language to declare and respond to exceptional conditions
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Python raises an exception whenever an error occurs
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Exceptions can be handled by the program, preventing the interpreter from halting
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Unhandled exceptions will cause Python to halt execution and print a stack trace.
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Mastering exceptions:
Exceptions

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Mastering exceptions:

Exceptions are objects! They have classes with constructors.
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Exceptions are objects! They have classes with constructors.

They enable non-local continuation of control
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Mastering exceptions:

Exceptions are objects! They have classes with constructors.

They enable non-local continuation of control

If `f` calls `g` and `g` calls `h`, exceptions can shift control from `h` to `f` without waiting for `g` to return.
Exceptions

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Mastering exceptions:

Exceptions are objects! They have classes with constructors.

They enable non-local continuation of control

If \( f \) calls \( g \) and \( g \) calls \( h \), exceptions can shift control from \( h \) to \( f \) without waiting for \( g \) to return.

(Exception handling tends to be slow.)
Raising Exceptions
Assert Statements

Assert statements raise an exception of type AssertionError
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```
assert <expression>, <string>
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Assertions are designed to be used liberally. They can be ignored to increase efficiency by running Python with the "-O" flag; "O" stands for optimized
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Assertions are designed to be used liberally. They can be ignored to increase efficiency by running Python with the "-O" flag; "O" stands for optimized

```bash
python3 -O
```
Assert Statements

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Whether assertions are enabled is governed by a bool `__debug__`
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Assertions are designed to be used liberally. They can be ignored to increase efficiency by running Python with the "-O" flag; "0" stands for optimized

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Whether assertions are enabled is governed by a bool `__debug__`

(Demo)
Raise Statements
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Exceptions are raised with a raise statement
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raise <expression>
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Raise Statements

Exceptions are raised with a raise statement

    raise <expression>

<expression> must evaluate to a subclass of BaseException or an instance of one
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Exceptions are constructed like any other object. E.g., `TypeError('Bad argument!')`
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`TypeError` -- A function was passed the wrong number/type of argument
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Exceptions are constructed like any other object. E.g., `TypeError('Bad argument!')`

- **TypeError** — A function was passed the wrong number/type of argument
- **NameError** — A name wasn't found
Raise Statements

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Exceptions are constructed like any other object. E.g., `TypeError('Bad argument!')`

`TypeError` -- A function was passed the wrong number/type of argument

`NameError` -- A name wasn't found

`KeyError` -- A key wasn't found in a dictionary
Raise Statements

Exceptions are raised with a raise statement

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Exceptions are constructed like any other object. E.g., `TypeError('Bad argument!')`

- **TypeError** -- A function was passed the wrong number/type of argument
- **NameError** -- A name wasn't found
- **KeyError** -- A key wasn't found in a dictionary
- **RecursionError** -- Too many recursive calls
Raise Statements

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\[ \text{raise} \ <\text{expression}> \]

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Exceptions are constructed like any other object. E.g., \texttt{TypeError}('Bad argument!')

\texttt{TypeError} -- A function was passed the wrong number/type of argument
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(Demo)
Try Statements
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Try statements handle exceptions
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```python
try:
    <try suite>
except <exception class> as <name>:
    <except suite>
...
```
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Execution rule:
Try Statements

Try statements handle exceptions

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    <try suite>
    except <exception class> as <name>:
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Execution rule:

The `<try suite>` is executed first
Try Statements

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try:
    <try suite>
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    <except suite>
...
```

Execution rule:

The `<try suite>` is executed first

If, during the course of executing the `<try suite>`, an exception is raised that is not handled otherwise, and
Try Statements

Try statements handle exceptions

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try:
    <try suite>
    except <exception class> as <name>:
        <except suite>
...
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**Execution rule:**

The `<try suite>` is executed first

If, during the course of executing the `<try suite>`, an exception is raised that is not handled otherwise, and

If the class of the exception inherits from `<exception class>`, then
Try Statements

Try statements handle exceptions

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try:
    <try suite>
except <exception class> as <name>:
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**Execution rule:**

The `<try suite>` is executed first

If, during the course of executing the `<try suite>`, an exception is raised that is not handled otherwise, and

If the class of the exception inherits from `<exception class>`, then

The `<except suite>` is executed, with `<name>` bound to the exception
Handling Exceptions
Handling Exceptions

Exception handling can prevent a program from terminating.
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    >>> try:
Handling Exceptions

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```python
>>> try:
    x = 1/0
```
Handling Exceptions

Exception handling can prevent a program from terminating

```python
>>> try:
    x = 1/0
  except ZeroDivisionError as e:
```
Handling Exceptions

Exception handling can prevent a program from terminating

```python
>>> try:
    x = 1/0
    except ZeroDivisionError as e:
        print('handling a', type(e))
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Handling Exceptions

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handling a <class 'ZeroDivisionError'>
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Handling Exceptions

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handling a <class 'ZeroDivisionError'>
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Handling Exceptions

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handling a <class 'ZeroDivisionError'>
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```

**Multiple try statements:** Control jumps to the except suite of the most recent try statement that handles that type of exception
Handling Exceptions

Exception handling can prevent a program from terminating

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>>> try:
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    except ZeroDivisionError as e:
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handling a <class 'ZeroDivisionError'>
>>> x
0
```

**Multiple try statements:** Control jumps to the except suite of the most recent try statement that handles that type of exception.

(Demo)
WWPD: What Would Python Display?

How will the Python interpreter respond?
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**WWPD: What Would Python Display?**

How will the Python interpreter respond?

```python
def invert(x):
    inverse = 1/x  # Raises a ZeroDivisionError if x is 0
    print('Never printed if x is 0')
    return inverse

def invert_safe(x):
    try:
        return invert(x)
    except ZeroDivisionError as e:
        return str(e)
```
WWPD: What Would Python Display?

How will the Python interpreter respond?

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>>> invert_safe(1/0)
```
**WWPD: What Would Python Display?**

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```
**WWPD: What Would Python Display?**

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12
How will the Python interpreter respond?

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>>> invert_safe(1/0)
>>> try:
...     invert_safe(0)
... except ZeroDivisionError as e:
...     print('Hello!')
```

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WWPD: What Would Python Display?

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...    invert_safe(0)
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>>> inverrrrt_safe(1/0)
```
Example: Reduce
Reducing a Sequence to a Value
Reducing a Sequence to a Value

```python
def reduce(f, s, initial):
    """Combine elements of s pairwise using f, starting with initial.

    E.g., reduce(mul, [2, 4, 8], 1) is equivalent to mul(mul(mul(1, 2), 4), 8).
    
    >>> reduce(mul, [2, 4, 8], 1)
    64
    """
```
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f is ...

*a two-argument function*
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f is ...

a two-argument function

s is ...

a sequence of values that can be the second argument
Reducing a Sequence to a Value

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- f is ... a two-argument function
- s is ... a sequence of values that can be the second argument
- initial is ... a value that can be the first argument

```python
reduce(pow, [1, 2, 3, 4], 2)
```
Reducing a Sequence to a Value

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