Institute of
Pervasive Computing

PREEXERCISE
DEBUGGING / CODE TESTING

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Algorithms and Data Structures 1
Exercise – 2023S

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MENTAL HEALTH WEEK 23
Montag, 27. März 2023 bis
Freitag, 31. März 2023
Wo: JKU Campus
MO - Fr: ganztägig
Anmeldung &
weitere Infos:
Das wartet kostenlos auf dich:
ca 30 Workshops und Vorträge von externen Workshop-
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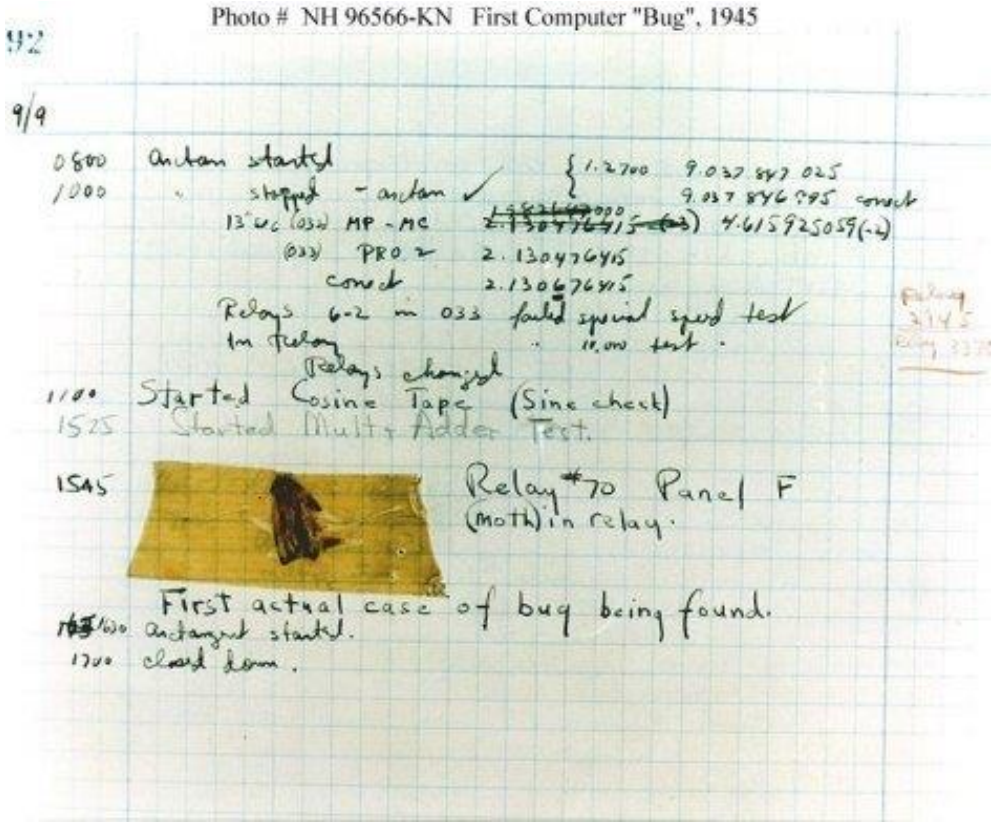
OVERVIEW

Debugging and code testing

- Debugging
- How to test your code - Unit testing
- Live demo of the unit testing framework **unittest** in **PyCharm**
- Brief introduction to **exceptions**

BUGS?

- Bug = Software Error
  - Bug = dt. „Wanze“ / „Käfer“
  - First Bug caused by a Bug: 1945 – Moth in Switch
  - Oldest known Bug: 18. November 1878,
    Letter from Thomas Edison to the Inventor
    of the Switchboard



- Debugging = using a debugger (software for error detection and correction)
  - A very powerful tool in software development and essential help for programmers when creating, optimizing and troubleshooting software
  - Possibility to check program functionality step-by-step

DEBUGGING / CODE TESTING

Code testing is important to make sure your code is doing what you expect it to do.

There are different approaches:

- Using dedicated debug outputs to e.g., print to terminal (--> cross-platform development)
- Execute code (with any parameters) and analyse result using debugger/breakpoints step by step
- If you have a class without `main()`, write a test class around it to execute the methods
- Make use of unit test frameworks
- …

DEBUGGING / CODE TESTING :: EXAMPLE

Task: Write a class `Calculator` with a method `sum_positive()`, that

- takes two arguments `a` and `b` which must be integer numbers
- calculates and returns the sum of two positive integer values `a` and `b` or
- returns -1 if at least one parameter is negative.

Additionally, store the last computed value in a variable

```
class Calculator:
    last_value = 0

    def sum_positive(self, a, b):
        if a >= 0 and b >= 0:
            self.last_value = a + b
            return a + b
        else:
            self.last_value = -1
            return -1
```

DEBUGGING / CODE TESTING :: EXAMPLE

How can we test that code?

```
class Calculator:
    last_value = 0

    def sum_positive(self, a, b):
        if a >= 0 and b >= 0:
            self.last_value = a + b
            return a + b
        else:
            self.last_value = -1
            return -1
```

Make it executable…

```
class Calculator:
    last_value = 0

    def sum_positive(self, a, b):
        if a >= 0 and b >= 0:
            self.last_value = a + b
            return a + b
        else:
            self.last_value = -1
            return -1

calc = Calculator()
print(calc.sum_positive(1, 2))
```

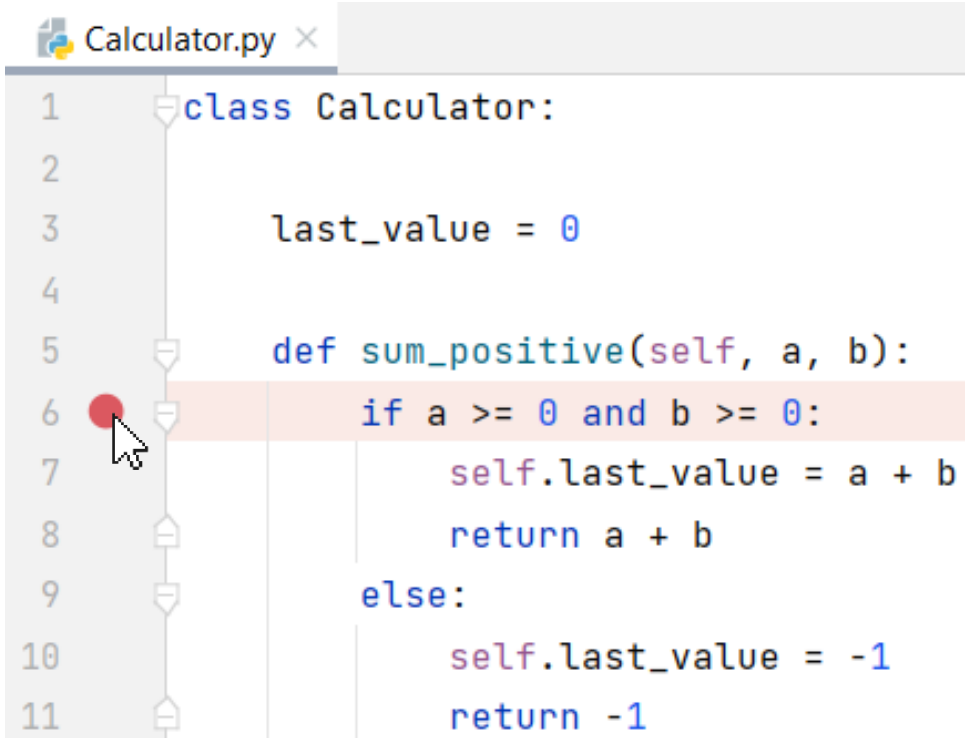
DEBUGGING / CODE TESTING :: EXAMPLE

Create a breakpoint in PyCharm

1. with a left-click next to the code line number
2. using the shortcut *ctrl+8 to* toggle a breakpoint on the selected line
3. In the menu:
   'Run'->'Toggle Breakpoint'->'Line Breakpoint'

A red bullet appears next to the line number

→ Breakpoint set



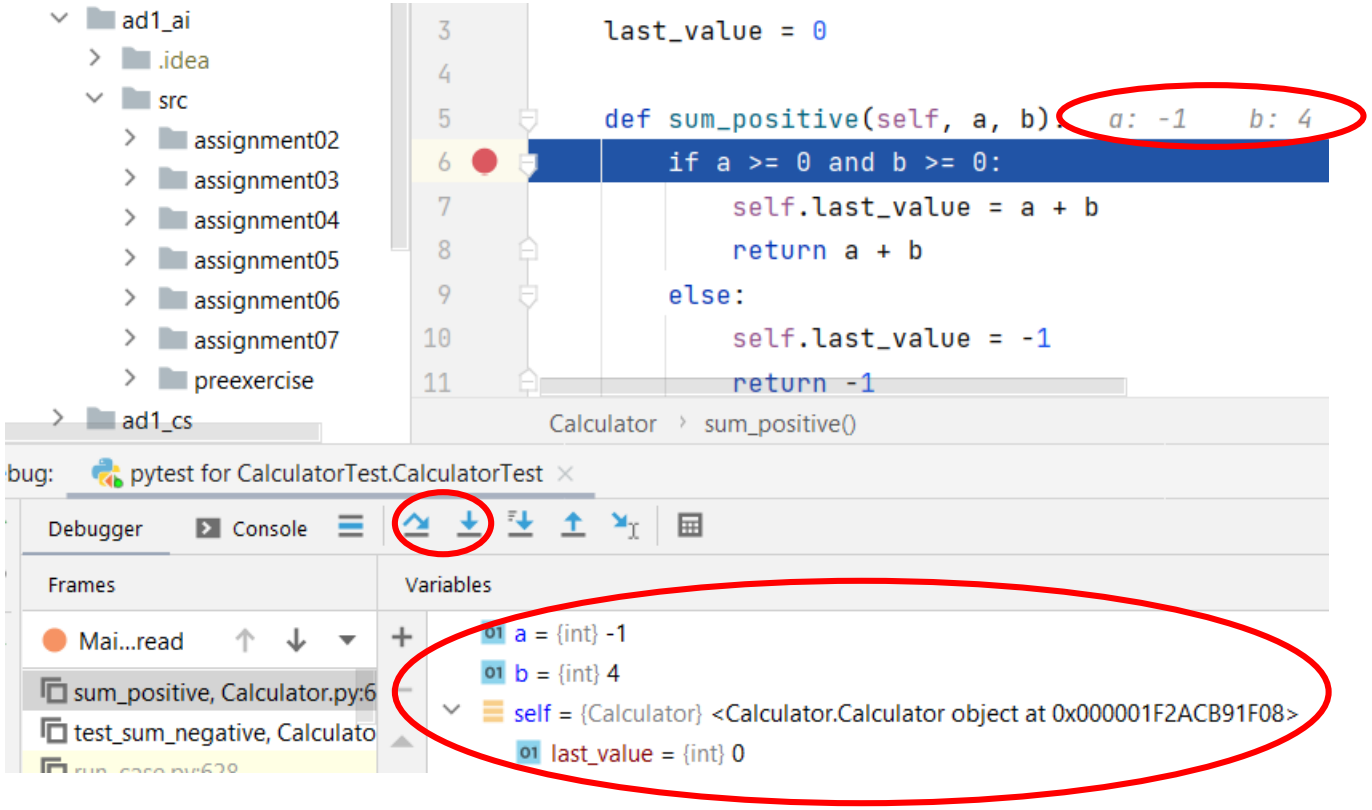
DEBUGGING / CODE TESTING :: EXAMPLE

Click the Debug-Button

or create a specific *Debug Configuration*

Program execution will stop at the first breakpoint:

- Use F7 (Step Into) or F8 (Step Over) to execute the highlighted line
- In the “Variables-Box” at the bottom, you see variables used in the current context including their values



UNIT TESTING

One definition:

A unit test is an automated piece of code that invokes another piece of code (the unit of work being tested) and then checks the correctness of some assumptions about an end result of that code. If the assumptions turn out to be wrong, the unit test failed.

(slightly adapted from Roy Osherove, "The Art of Unit Testing")

Unit tests are used in software projects to automate testing of the **behaviour of software** components, apart from its use in a full (complex) software system.

Do not care about implementation details.

A unit in our understanding can be e.g. an interface/class but also a single method.

UNIT TESTING

Properties of good unit tests:

- Full access/control of the unit under test
- Should run quickly
- Should be consistent in its results
- Should be fully isolated (run independently of other tests)
- Can run automatically and repeatable without need of configuration or other resources.
  (in contrast to integration testing)

Approach

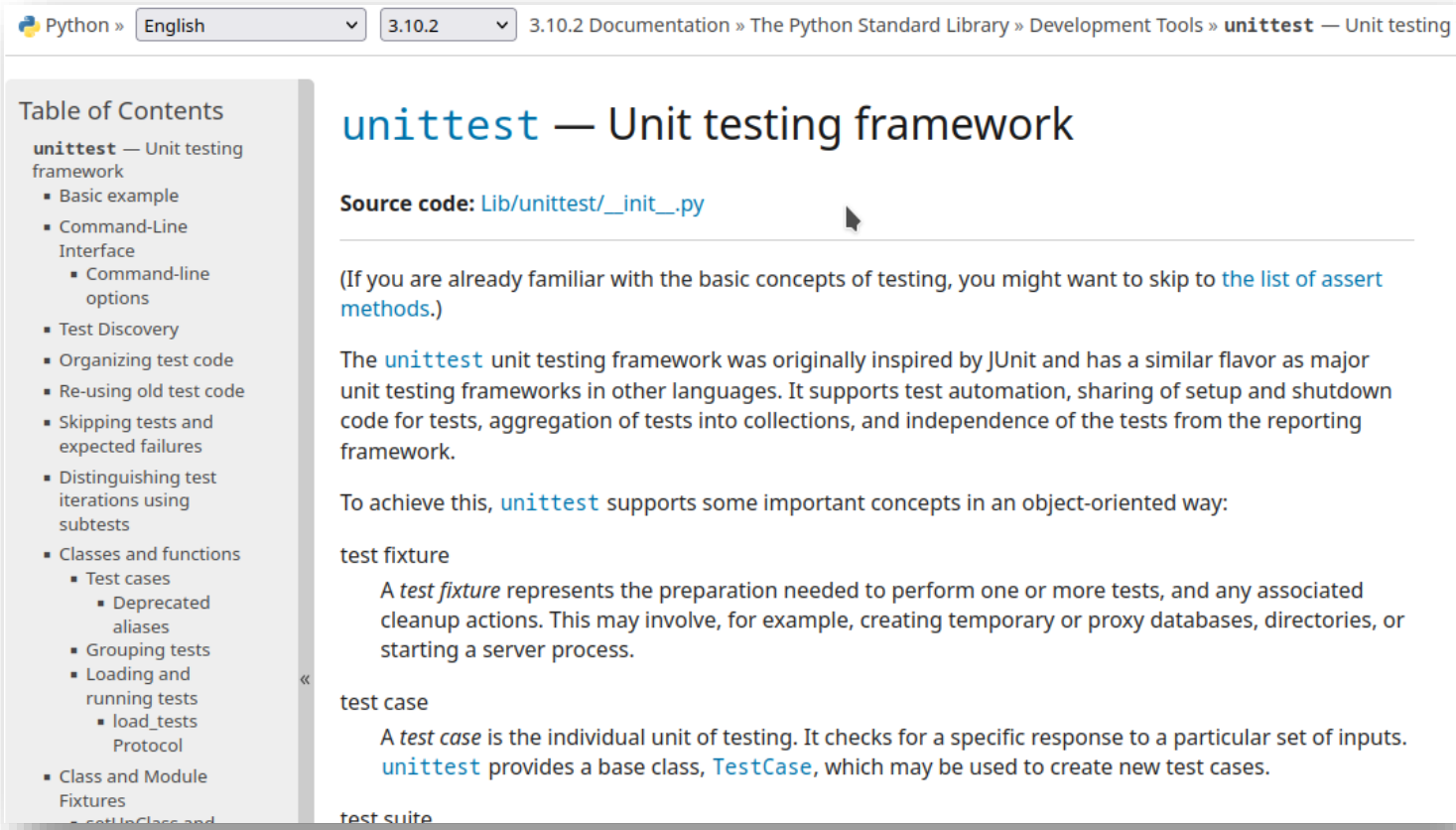
1. Initialisation of the required initial state of the software component to start testing.
2. Execution of the piece of code to be tested on that state.
3. The actual result is compared to the expected result from the specification.

UNIT TESTING :: UNITTEST FRAMEWORK

Unittest

- **framework** for writing small tests
- **scales** for complex functional testing
- **applications** and **libraries**

- https://docs.python.org/3/library/unittest.html



UNIT TESTING :: PRINCIPLE

CalculatorTest.py

```python
import unittest
from Calculator import Calculator


class CalculatorTest(unittest.TestCase):
    def setUp(self):
        print("\n------------ setup ---------------\n")
        self.calculator = Calculator()

    def tearDown(self):
        print("\n------------ teardown ------------\n")
        del self.calculator

    def test_sum_positive(self):
        self.assertTrue(self.calculator.last_value == 0)  # for
        self.assertEqual(7, self.calculator.sum_positive(3, 4))
        self.assertEqual(7, self.calculator.last_value)
        self.assertEqual(6, self.calculator.sum_positive(2, 4))
        self.assertEqual(6, self.calculator.last_value)
```

- **Import** necessary packages and the tested class
- ***setUp()***
  runs before each test method
- ***tearDown()***
  runs after each test method
- ***test_*** **+ name** of method
  define your test cases for this method

UNIT TESTING :: PRINCIPLE

```
14    def test_sum_positive(self):
15        self.assertTrue(self.calculator.last_value == 0)  # for
16        self.assertEqual(7, self.calculator.sum_positive(3, 4))
17        self.assertEqual(7, self.calculator.last_value)
18        self.assertEqual(6, self.calculator.sum_positive(2, 4))
19        self.assertEqual(6, self.calculator.last_value)
```

Unittest uses **assert methods**

- to verify assumptions
- help to find bugs quickly
- systematic way to check if the internal state of a program is as expected

assert (expression)

assertEqual (expected, actual, ["message"])

- compares expected vs. actual value
- print message, if not equal

assertTrue (condition)

assertFalse (condition)

- check boolean condition

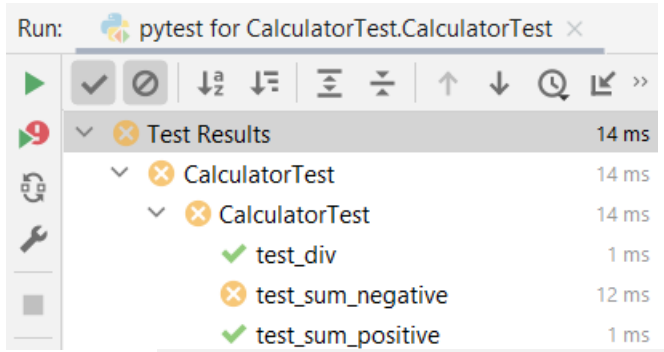
UNIT TESTING :: PRINCIPLE

CalculatorTest.py

```
1  import unittest
2  from Calculator import Calculator
3
4
5  class CalculatorTest(unittest.TestCase):
6      def setUp(self):
7          print("\n------------ setup ------------
8          self.calculator = Calculator()
9
10     def tearDown(self):
11         print("\n------------ teardown ----------
12         del self.calculator
13
14     def test_sum_positive(self):
15         self.assertTrue(self.calculator.last_valu
16         self.assertEqual(7, self.calculator.sum_p
17         self.assertEqual(7, self.calculator.last_
18         self.assertEqual(6, self.calculator.sum_p
19         self.assertEqual(6, self.calculator.last_
```

Run…

The test framework executes all or selected test cases and creates a summary about the results.




```
self = <CalculatorTest.CalculatorTest testMethod=test

    def test_sum_negative(self):
        self.assertEqual(-1, self.calculator.sum_posi
        self.assertEqual(-1, self.calculator.last_val
>       self.assertEqual(-2, self.calculator.sum_posi

CalculatorTest.py:24: AssertionError
```

Summary on executed tests:

- Green OK
- Red/Orange Error/Failure (wrong result)

EXCEPTIONS :: OVERVIEW

Exceptions cannot be ignored --> In worst case there is an uncontrolled program crash.

Basically, exceptions should be handled either

- to repair the situation
- or at least to avoid an uncontrolled program crash.

How to deal with it?

1. When an exception has been thrown, an **exception object** is created (including information such as name, description, call stack).
2. An exception is passed back to calling functions until one finally "*catches*" the exception.
3. In Python an exception is caught using a **try-except** block.

EXCEPTIONS :: TYPES

Class	Description
Exception	A base class for most error types
AttributeError	Raised by syntax obj.foo, if obj has no member named foo
EOFError	Raised if "end of file" reached for console or file input
IOError	Raised upon failure of I/O operation (e.g., opening file)
IndexError	Raised if index to sequence is out of bounds
KeyError	Raised if nonexistent key requested for set or dictionary
KeyboardInterrupt	Raised if user types ctrl-C while program is executing
NameError	Raised if nonexistent identifier used
StopIteration	Raised by next(iterator) if no element; see Section 1.8
TypeError	Raised when wrong type of parameter is sent to a function
ValueError	Raised when parameter has invalid value (e.g., sqrt(−5))
ZeroDivisionError	Raised when any division operator used with 0 as divisor

EXCEPTIONS :: EXCEPTION HANDLING

`try - except`

- place error prone code within a **try block**
- define and catch exceptions in **except blocks**
- consider the exception type **hierarchy**

`print`(e), ***`print`***(e.***`__class__`***)

- gather **information** about the exception
- print a specific **message**

`finally`:

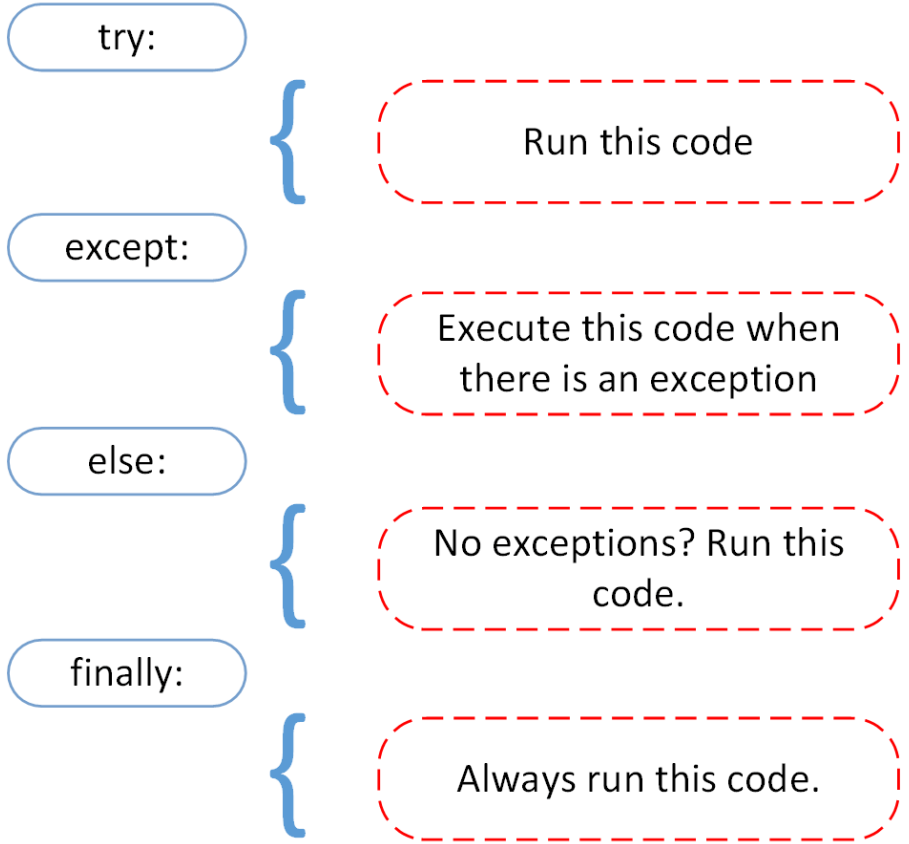
- **always** executed
- **clean-up** resources
- **close** files and database connections

ExceptionDemo.py

```python
class ExceptionDemo:
    try:
        x = 2
        y = 0
        print(x / y)

    except ZeroDivisionError as e:
        print("Cannot divide by zero")
        print(e)
        print("Class: ", e.__class__)
        print("Additional info", e.__traceback__)

    except (IndexError, ZeroDivisionError):
        # handle multiple exceptions
        # a ZeroDivisionError will never execute
        pass

    finally:
        # cleanup resources
        pass
```

EXCEPTIONS :: EXCEPTION HANDLING

```
try:
    result = int(input("Please enter a number: "))
except ValueError:
    print("Invalid number. Try again...")
else:
    print("result is", result)
finally:
    print("executing finally clause")
```



Abort if a runtime error is not handled by any of the above

Raise an exception

- do not abort execution
- force a specified exception to occur
- e.g., **raise AssertionError**
- show which test failed (output vs. expected result)

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