Lecture 16: Assertions & Exceptions

Comp 102

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Recap

So far...

- Variables, strings, I/O
- Conditions, loops, functions
- Lists, tuples, 2D lists
- Searching, approximation

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- Conditions, loops, functions
- Lists, tuples, 2D lists
- Searching, approximation

You can write programs that **work**.

But can they handle the **unexpected**?

Real-World Hook

Your phone's **Contacts** app lets you search for a name.

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- What if the contact list is **empty**?

Real-World Hook

Your phone's **Contacts** app lets you search for a name.

- What if you search for a name that **doesn't exist**?
- What if you type a **number** where a name should go?
- What if the contact list is **empty**?

The app **doesn't crash** — it handles the problem!

Programs Crash!

Try each of these in Thonny's Shell:

```
>>> contacts = ['Ali', 'Fatima', 'Zain']
>>> contacts[10]

>>> int('hello')

>>> 10 / 0

>>> 'a' / 4
```

Programs Crash!

Try each of these in Thonny's Shell:

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>>> int('hello')          # ValueError

>>> 10 / 0                # ZeroDivisionError

>>> 'a' / 4               # TypeError
```

Exceptions

Big Idea

An **exception** is Python's way of saying

"something went wrong, and I can't continue"

If uncaught, the program **crashes**.

Common Exception Types

Exception	When it Happens	Example
`IndexError`	Bad list index	`L[100]`
`ValueError`	Wrong value for conversion	`int('abc')`
`TypeError`	Wrong type in operation	`'a' / 4`
`ZeroDivisionError`	Division by zero	`10 / 0`
`NameError`	Undefined variable	`print(x)`

try/except: The Safety Net

Think of it like if/else:

```
if condition:
    # runs if True
else:
    # runs if False
```

```
try:
    # risky code
except:
    # runs if error
```

try/except: The Safety Net

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```
try:
    # risky code
except:
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```

Exception **raised** by try block is **caught** by except block.
Program **does not crash**.

Example: sum_digits

Sum all digit characters in a string:

```
1 def sum_digits(s):
2     total = 0
3     for ch in s:
4         total += int(ch)
5     return total
```

Example: sum_digits

Sum all digit characters in a string:

```
1 def sum_digits(s):
2     total = 0
3     for ch in s:
4         total += int(ch)
5     return total

sum_digits('1234')  # returns 10
sum_digits('12E4')  # ValueError!  CRASH
```

Example: sum_digits (fixed)

Wrap the risky line in try/except:

```
1 def sum_digits(s):
2     total = 0
3     for ch in s:
4         try:
5             total += int(ch)
6         except:
7             pass  # skip non-digits
8     return total
```

Example: sum_digits (fixed)

Wrap the risky line in try/except:

```
1  def sum_digits(s):
2      total = 0
3      for ch in s:
4          try:
5              total += int(ch)
6          except:
7              pass  # skip non-digits
8      return total

   sum_digits('12E4')  # returns 7, no crash!
```

You Try!

Write code that keeps asking the user for an integer until they enter a valid one.

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Solution:

```
1 while True:
2     try:
3         n = int(input("Enter an integer: "))
4         break
5     except:
6         print("That's not an integer! Try again.")
```

Handling Specific Exceptions

Bare except catches **everything** — even bugs you want to see!

Better: name the **specific** exception.

```
try:
    n = int(input("Enter a number: "))
    result = 100 / n
except ValueError:
    print("Not a valid number!")
except ZeroDivisionError:
    print("Can't divide by zero!")
```

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Bare except catches **everything** — even bugs you want to see!

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```
try:
    n = int(input("Enter a number: "))
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except ValueError:
    print("Not a valid number!")
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    print("Can't divide by zero!")
```

Demo: enter "abc" → ValueError
enter "0" → ZeroDivisionError
enter "5" → success

The `else` Clause

Code in `else` runs **only if no exception** was raised:

```
1  try:
2      n = int(input("Number: "))
3      result = 100 / n
4  except ValueError:
5      print("Not a number!")
6  else:
7      print(f"Result: {result}")
```

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Why not put it in the `try` block?

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- `try` block should contain **only** the risky code

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- `try` block should contain **only** the risky code
- `else` code won't be accidentally **caught** by `except`

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    n = int(input("Number: "))
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else:
    print(f"Result: {result}")
```

Why not put it in the `try` block?

- `try` block should contain **only** the risky code
- `else` code won't be accidentally **caught** by `except`
- Makes it **clear** which code might fail vs. which runs on success

else: Tracing

```
1 try:
2     n = int(input("Number: "))
3     result = 100 / n
4 except ValueError:
5     print("Not a number!")
6 else:
7     print(f"Result: {result}")
```

Input	Output

else: Tracing

```
1 try:
2     n = int(input("Number: "))
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```

Input	Output
"abc"	Not a number!

else: Tracing

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1 try:
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4 except ValueError:
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```

Input	Output
"abc"	Not a number!
"5"	Result: 20.0

else: Tracing

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1 try:
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Input	Output
"abc"	Not a number!
"5"	Result: 20.0
"0"	ZeroDivisionError — **Crash!**

else: Tracing

```
1 try:
2     n = int(input("Number: "))
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5     print("Not a number!")
6 else:
7     print(f"Result: {result}")
```

Input	Output
"abc"	Not a number!
"5"	Result: 20.0
"0"	ZeroDivisionError — **Crash!**

Key: `else` runs only when the `try` block finishes **without any error**.

The `finally` Clause

Code in `finally` runs **no matter what** — error or not:

```
try:
    n = int(input("Number: "))
    result = 100 / n
except ValueError:
    print("Not a number!")
finally:
    print("Done!")
```

The `finally` Clause

Code in `finally` runs **no matter what** — error or not:

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    result = 100 / n
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When is this useful?

The `finally` Clause

Code in `finally` runs **no matter what** — error or not:

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- **Cleanup** code that **must** run: closing files, freeing resources

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- **Cleanup** code that **must** run: closing files, freeing resources
- Runs even if the exception is **not caught**

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try:
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When is this useful?

- **Cleanup** code that **must** run: closing files, freeing resources
- Runs even if the exception is **not caught**
- Runs even if there is a `return` inside `try`

finally: Tracing

```
1 try:
2     n = int(input("Number: "))
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4 except ValueError:
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Input	Output

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Input	Output
"abc"	Not a number! Done!
"5"	Done!
"0"	Done! then crash

`finally`: Tracing

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7     print("Done!")
```

Input	Output
"abc"	Not a number! Done!
"5"	Done!
"0"	Done! then crash

Key: `finally` **always** runs — even when the program crashes.

Full Pattern

```
try:
    n = int(input("Number: "))
    result = 100 / n
except ValueError:
    print("Not a number!")
except ZeroDivisionError:
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try: risky code

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try: risky code

except: runs if error

else: runs if **no** error

finally: **always** runs

You Try!

Write a function `safe_divide(a, b)` that returns a/b, or `None` if division fails.

```
1 def safe_divide(a, b):
2     """Return a/b, or None if
3     division fails."""
4     pass
```

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Solution:

```
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    except ZeroDivisionError:
        return None
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    pass
```

Solution:

```
def safe_divide(a, b):
    try:
        return a / b
    except ZeroDivisionError:
        return None
```

Think: What does `safe_divide(10, 'a')` do?

Raising Exceptions & Assertions

Raising Your Own Exceptions

So far, *Python* raises exceptions automatically.

You can raise them yourself using `raise`:

```
1 def withdraw(balance, amount):
2     if amount > balance:
3         raise ValueError("Insufficient funds!")
4     return balance - amount
```

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1 def withdraw(balance, amount):
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  withdraw(100, 50)    # returns 50
  withdraw(100, 200)   # ValueError!
```

Why Raise Exceptions?

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- **Signal** the problem to the **caller**, not just the user
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  - A `print` is easy to miss — an exception **cannot** be ignored
- **Separate** what went wrong from how to handle it
  - The function that *detects* the error may not know the right response
  - Let the *caller* decide: retry? show a message? log it?

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  - A `print` is easy to miss — an exception **cannot** be ignored
- **Separate** what went wrong from how to handle it
  - The function that *detects* the error may not know the right response
  - Let the *caller* decide: retry? show a message? log it?
- **Stop bad data** from spreading through your program
  - Returning `-1` or `None` silently can cause bugs *later*
  - An exception **halts immediately** at the source of the problem

print vs raise

Bad: just print

```
1 def withdraw(balance, amount):
2     if amount > balance:
3         print("Not enough funds")
4         return balance
5     return balance - amount
```

Good: raise

```
1 def withdraw(balance, amount):
2     if amount > balance:
3         raise ValueError(
4             "Not enough funds")
5     return balance - amount
```

print vs raise

Bad: just print

```
1  def withdraw(balance, amount):
2      if amount > balance:
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   b = withdraw(100, 200)
   print(b)  # 100 --- looks fine?!
```

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print vs raise

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   # ValueError --- can't ignore!
```

The `print` version **silently** returns wrong data. The `raise` version **forces** the caller to deal with the problem.

Example: `sum_digits` with `raise`

Instead of silently skipping bad characters, **announce** the problem:

```
1  def sum_digits(s):
2      total = 0
3      for ch in s:
4          if not ch.isdigit():
5              raise ValueError(f"'{ch}' is not a digit!")
6          total += int(ch)
7      return total
```

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3      for ch in s:
4          if not ch.isdigit():
5              raise ValueError(f"'{ch}' is not a digit!")
6          total += int(ch)
7      return total

   sum_digits('12E4')
   # ValueError:  'E' is not a digit!
```

You Try!

Write `pairwise_div(L1, L2)` that returns a new list where element `i` is `L1[i] / L2[i]`.

- `raise ValueError` if lists have different lengths
- `raise ZeroDivisionError` if any element of `L2` is 0

You Try!

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- `raise ValueError` if lists have different lengths
- `raise ZeroDivisionError` if any element of `L2` is 0

Solution:

```
1  def pairwise_div(L1, L2):
2      if len(L1) != len(L2):
3          raise ValueError("Lists must be same length!")
4      result = []
5      for i in range(len(L1)):
6          if L2[i] == 0:
7              raise ZeroDivisionError(f"L2[{i}] is 0!")
8          result.append(L1[i] / L2[i])
9      return result
```

Assertions

Big Idea

An **assertion** is a claim about your program's state.

If the claim is **False**, the program halts immediately.

Assertions

Syntax:

```
assert <condition>, "error message"
```

If `condition` is **False** → raises `AssertionError`

Assertions

Syntax:

```
assert <condition>, "error message"
```

If `condition` is **False** → raises `AssertionError`

Examples:

```
assert len(s) != 0, "String is empty!"
assert b != 0, "Can't divide by zero!"
assert type(n) == int, "Must be an integer!"
```

Assertions: Examples

```
1 def avg(grades):
2     assert len(grades) != 0, "No grades!"
3     return sum(grades) / len(grades)

avg([85, 90, 78])  # returns 84.33
avg([])            # AssertionError: No grades!
```

Assertions: Examples

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1 def avg(grades):
2     assert len(grades) != 0, "No grades!"
3     return sum(grades) / len(grades)

avg([85, 90, 78])  # returns 84.33
avg([])            # AssertionError: No grades!
```

```
1 def divide(a, b):
2     assert b != 0, "b cannot be 0"
3     return a / b

divide(10, 2)  # returns 5.0
divide(5, 0)   # AssertionError: b cannot be 0
```

Assertions vs Exceptions

Assertions

"Am I (the programmer) right?"

- Used during **development**
- Catches **programmer** mistakes
- `assert condition`
- Program **halts** if False

Exceptions

"Did the user/world behave?"

- Used in **production**
- Handles **runtime** problems
- `try/except` or `raise`
- Program can **recover**

You Try!

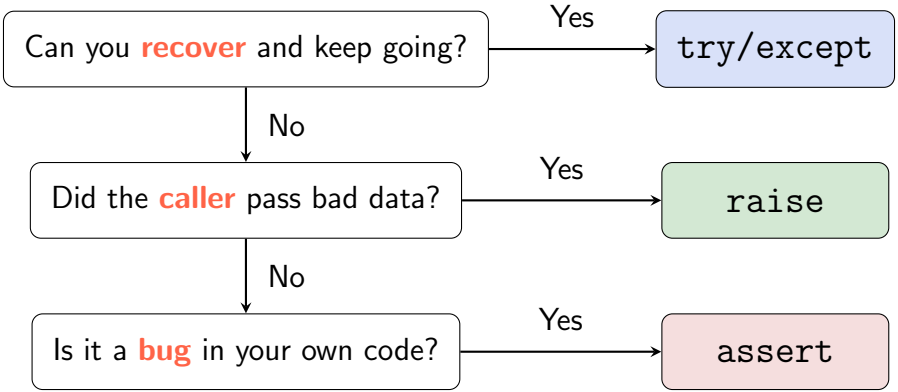
Add assert statements to pairwise_div:

```
1 def pairwise_div(L1, L2):
2     """ L1 and L2 are <non-empty> lists
3         of <equal lengths> containing numbers.
4     Returns pairwise division of L1 by L2.
5     Raise ValueError if L2 contains 0. """
6     # add assert lines here
```

You Try! Solution

```
1  def pairwise_div(L1, L2):
2      assert len(L1) > 0, "L1 is empty!"
3      assert len(L2) > 0, "L2 is empty!"
4      assert len(L1) == len(L2), "Different lengths!"
5      result = []
6      for i in range(len(L1)):
7          if L2[i] == 0:
8              raise ValueError(f"L2[{i}] is 0!")
9          result.append(L1[i] / L2[i])
10     return result
```

When to Use Each?



Putting It All Together

Extended Example: Class Grades

A teacher has a class list. Each entry is a list of two parts:

- A list of first and last name
- A list of grades

```
class_list = [
  [['Ali', 'Khan'],      [85, 90, 78]],
  [['Fatima', 'Noor'],   [92, 88, 95]],
  [['Deadpool'],         []]
]
```

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class_list = [
  [['Ali', 'Khan'],      [85, 90, 78]],
  [['Fatima', 'Noor'],   [92, 88, 95]],
  [['Deadpool'],         []]
]
```

Goal: compute the **average** grade for each student.

The Functions

```
1  def avg(grades):
2      return sum(grades) / len(grades)
3
4  def get_stats(class_list):
5      new_stats = []
6      for stu in class_list:
7          new_stats.append(
8              [stu[0], stu[1], avg(stu[1])])
9      return new_stats
```

The Functions

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1  def avg(grades):
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4  def get_stats(class_list):
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6      for stu in class_list:
7          new_stats.append(
8              [stu[0], stu[1], avg(stu[1])])
9      return new_stats
```

`get_stats(class_list)` → **CRASH!**

`ZeroDivisionError`: Deadpool has **no grades** → `len([])` is 0

Option 1: `try/except`

Display a warning, keep going:

```
1 def avg(grades):
2     try:
3         return sum(grades) / len(grades)
4     except ZeroDivisionError:
5         print('warning: no grades data')
6         return None
```

Option 1: `try/except`

Display a warning, keep going:

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```

`get_stats(class_list)` →

```
[['Ali', 'Khan'],      [85, 90, 78], 84.33]
[['Fatima', 'Noor'],   [92, 88, 95], 91.67]
[['Deadpool'],         [],           None ]
```

Option 2: Guard Clause

Policy decision: no grades = zero average.

```
1 def avg(grades):
2     if len(grades) == 0:
3         return 0.0
4     return sum(grades) / len(grades)
```

Option 2: Guard Clause

Policy decision: no grades = zero average.

```
1  def avg(grades):
2      if len(grades) == 0:
3          return 0.0
4      return sum(grades) / len(grades)
```

`get_stats(class_list)` →

```
[['Ali', 'Khan'],      [85, 90, 78], 84.33]
[['Fatima', 'Noor'],   [92, 88, 95], 91.67]
[['Deadpool'],         [],           0.0  ]
```

Option 3: Assert

Strictest: empty grades means a **bug upstream**.

```
1 def avg(grades):
2     assert len(grades) > 0, "No grades data!"
3     return sum(grades) / len(grades)
```

Option 3: Assert

Strictest: empty grades means a **bug upstream**.

```
1  def avg(grades):
2      assert len(grades) > 0, "No grades data!"
3      return sum(grades) / len(grades)
```

`get_stats(class_list)` →

```
AssertionError: No grades data!
```

Program **halts** — having no grades **should never happen**.

Comparing the Three Approaches

Approach	Behavior	Use When
`try/except`	Skip problem, continue	User-facing app; show friendly message
Guard clause	Return default value	Missing data has a sensible default
`assert`	Halt program	Bug in the code; should never happen

Comparing the Three Approaches

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Which one is best? *It depends on the context!*

Summary

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- **Exceptions** — Python's error reporting mechanism
  - Common: `ValueError`, `TypeError`, `IndexError`, `ZeroDivisionError`
  - `try/except` to catch; `raise` to throw
  - `else` for success; `finally` for cleanup
- **Assertions** — programmer's sanity check
  - `assert condition, "message"`
  - Halts on failure; for development-time checks
- **Rule of thumb:**
  - Exceptions for **runtime** problems
  - Assertions for **logic** bugs

Big Idea

Good programs don't just **work** —

they fail **gracefully**.

Exceptions handle the unexpected.
Assertions verify the expected.

Questions?

Exit Ticket

Today's question *(2 minutes)*

Name the exception Python raises:

(a) `int('abc')`

(b) `10 / 0`

COMP 102 — Exit Ticket #16

Name: _____

Roll #: _____ Date: _____

Answer:

Hand it to me on your way out.
No name, no attendance.