Prepared by Julian García, based on material by
David Albrecht and María García de la Banda

Lecture 12
Assertions, Exceptions, Testing

FIT 1008
Introduction to Computer Science

Dealing with errors

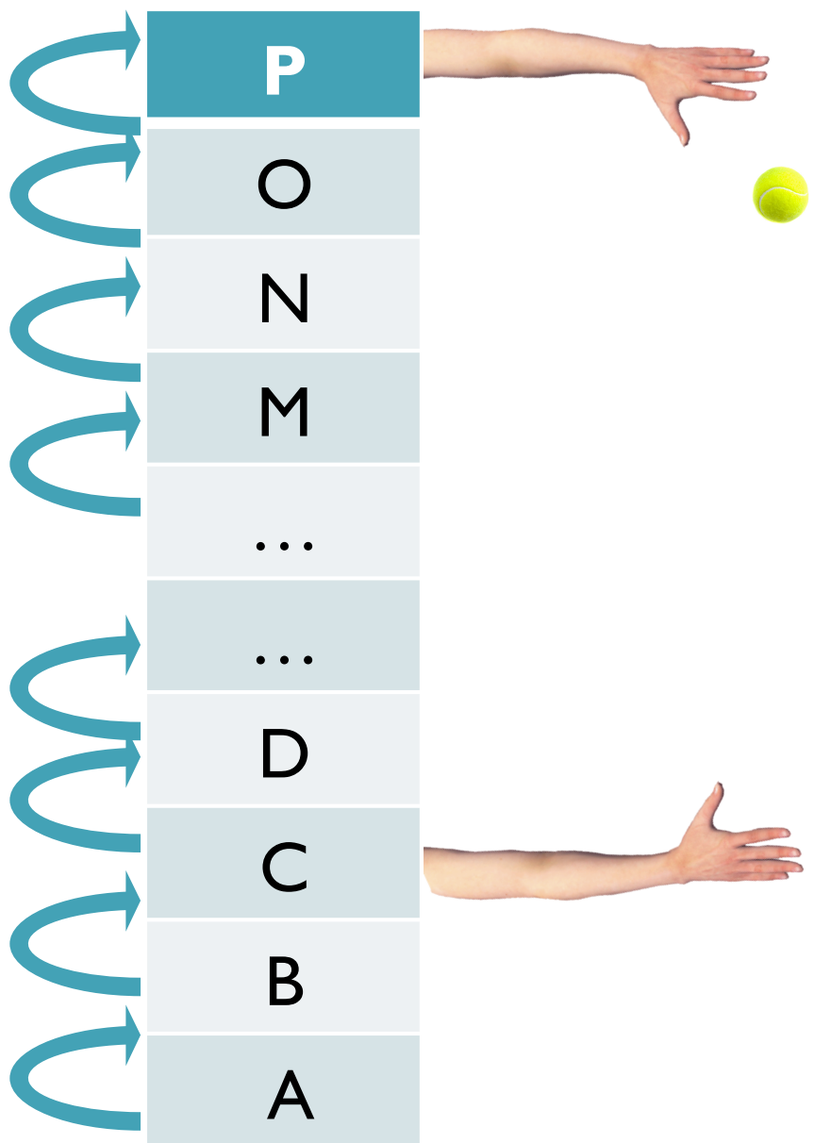
- There are two main situations where we need to deal with errors:
  - When a **precondition** is **not met.** Called “defensive programming” (a MUST in the real world)
  - When **reading** from **input** (i.e., from a file, the screen, etc)

- What do we do if an error is detected?
  - In **FIT1040**: you have **printed error messages**
  - This *might be* OK when interacting with a human.
  - BUT, **what about** the **code** that called the function? How does it get to know something went wrong?

- Modern languages use **exception-handling**.

Exception Handling

- **Exception**: run-time event that breaks the normal flow of execution
- **Exception handler**: block of code that can recover from the event
- **Exception handling**: mechanism to transfer control to a handler



Blocks of code.

Block A calls Block B.
Block B calls Block C.
Block C calls Block D….

P detects an error

P throws (raises) an exception

O might want to catch it.

If O doesn't, then N might, if not M …

Assume C catches the error…

Exception handling

- **Function C** might be able to resolve the issue and continue

- Or, it might try and not be able:
  - It will **raise** (throw) an **exception** itself
  - B or A might be able to "**catch it**"

- If not, execution will be aborted

Example Exception

```
>>> x = [1,2,3]
>>> x[7]=0
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: list assignment index out of range
>>>
```

An **Exception** that no-one has handled.

name

message

Exception handling in Python

- Consider a loop to read an integer provided by the user:

Try clause

Except clause

```
def read_a_number():
    try:
        x = int(input("Please enter a number: "))
        print("Thanks! ")
    except ValueError:
        print("Not a valid number.")
```

try and **except** are keywords

Exception handling in Python (cont)

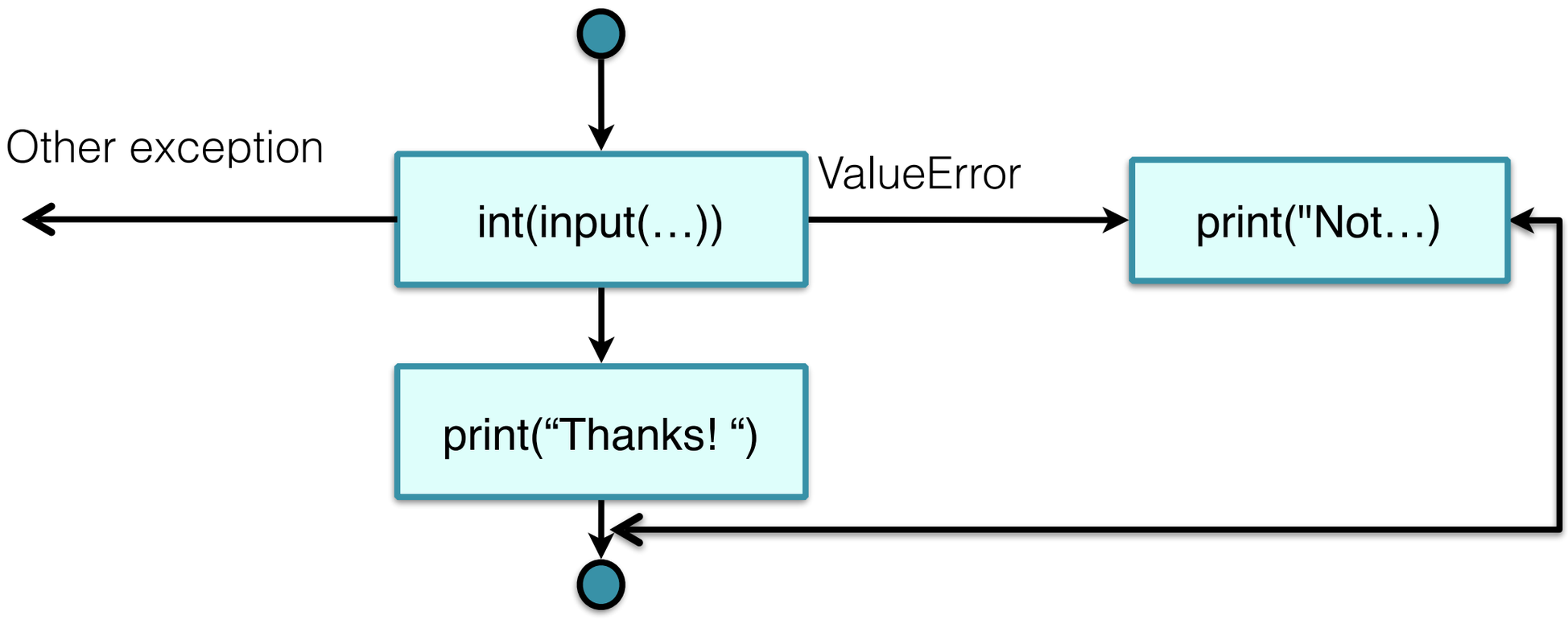
- How does this work in terms of control flow?
- First, execute the **`try`** clause
- If **no exception** inside the try: **skip the `except`** clause and continue

```
def read_a_number():
    try:
        x = int(input("Please enter a number: "))
        print("Thanks! ")
    except ValueError:
        print("Not a valid number.")
```

- If **exception**, **skip the rest of the `try`** clause and:
  - If its **type matches the exception named** after the except
    - The `except` clause is executed
    - **Execution continues after the `try` statemen**t.
  - If its **type does not match**:
    - The next `except` clause is checked.
    - Or if none remain, jump to outer `try` statements
    - If **no handler is found**, it is an unhandled exception and execution stops with a message

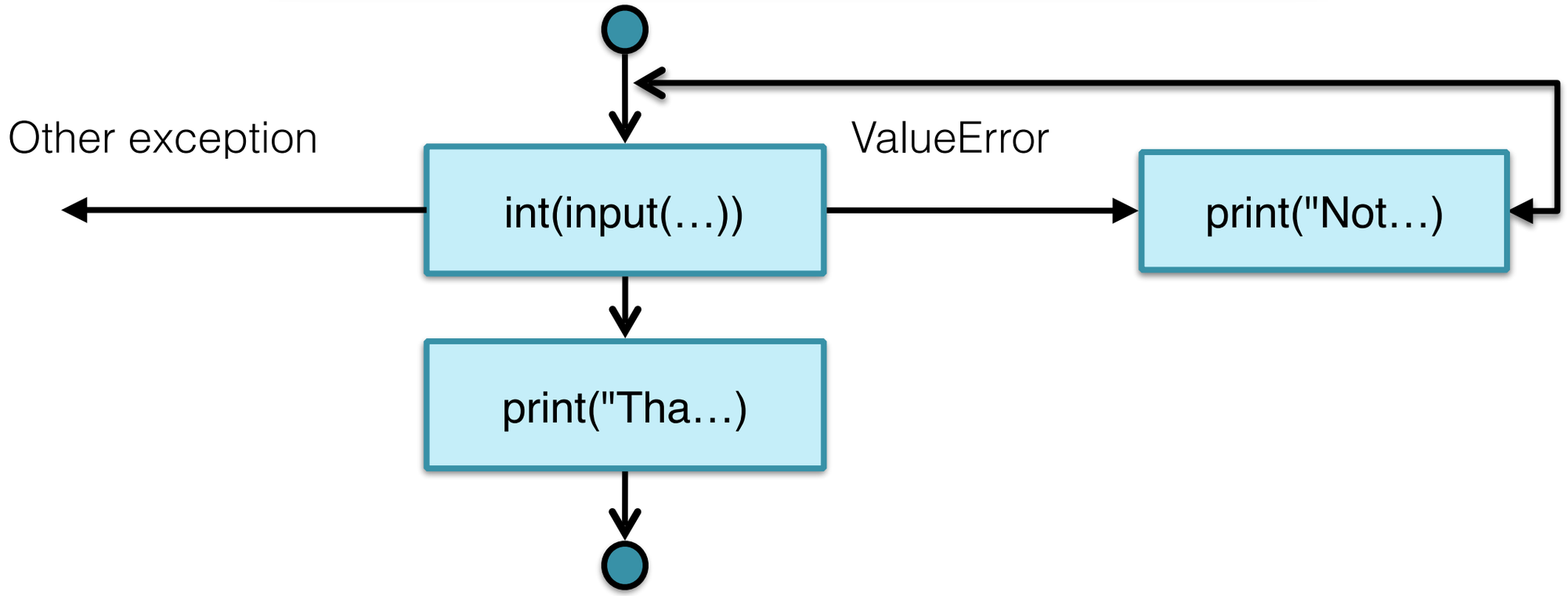
Exception handling in Python (cont)

```
def read_a_number():
    try:
        x = int(input("Please enter a number: "))
        print("Thanks! ")
    except ValueError:
        print("Not a valid number.")
```



Another example

```
while True:
    try:
        x = int(input("Please enter a number: "))
        print("Thanks! ")
        break
    except ValueError:
        print("Not a valid number. Try again...")
```



Raising exceptions

- We can **raise our own exceptions**:

```
def get_height():
    h = int(input("Please enter your height(cms): "))
    if x < 0:
      my_error = ValueError("User gave invalid height")
      raise my_error
    return h
```

- The **`raise`** keyword gets us out of normal execution. Caller takes control, and so on, until it finds a handler for **`ValueError`**.
- ValueError is a built-in exception type. There are many others.
- You can also create your own.

Common Exception Types

Exception	Explanation
`KeyboardInterrupt`	Raised when Ctrl-C is hit
`OverflowError`	Raised when floating point gets too large
`ZeroDivisor`	Raised when there is a divide by 0
`IOError`	Raised when I/O operation fails
`IndexError`	Raised when index is outside the valid range
`NameError`	Raised when attempting to evaluate an unassigned variable
`TypeError`	Raised when an operation is applied to an object of the wrong type
`ValueError`	Raised when operation or function has an argument with an incorrect value.

User defined Exception

```
class MyError(Exception):
    pass
```

```
>>> raise MyError('test message')
Traceback (most recent call last):
   File ``<pyshell#247>'', line 1 in <module>
     raise MyError('test message')
MyError: test message
```

what can go wrong?

```
def power(x, n):
    value = 1
    if n > 0:
        value = power(x, n//2)
        if n % 2 == 0:
            value = value*value
        else:
            value = value*value*x
    return value
```

Assert statement

Useful for checking preconditions.

```
def power(x, n):
    assert n > 0, "n should be a positive Integer"
    value = 1
if n > 0:
    value = power(x, n//2)
    if n % 2 == 0:
        value = value*value
    else:
        value = value*value*x
return value
```

Assert statement

Useful for checking preconditions.

asserts can be turned off

Useful message

```
def power(x, n):
    assert n > 0, "n should be a positive Integer"
    value = 1
    if n > 0:
        value = power(x, n//2)
```

Assert is a keyword.

Logical expression that should be **True**

If the logical expression evaluates to **False**
an exception is Raised

```
AssertionError: Size should be positive
```

assert | əˈsəːt |

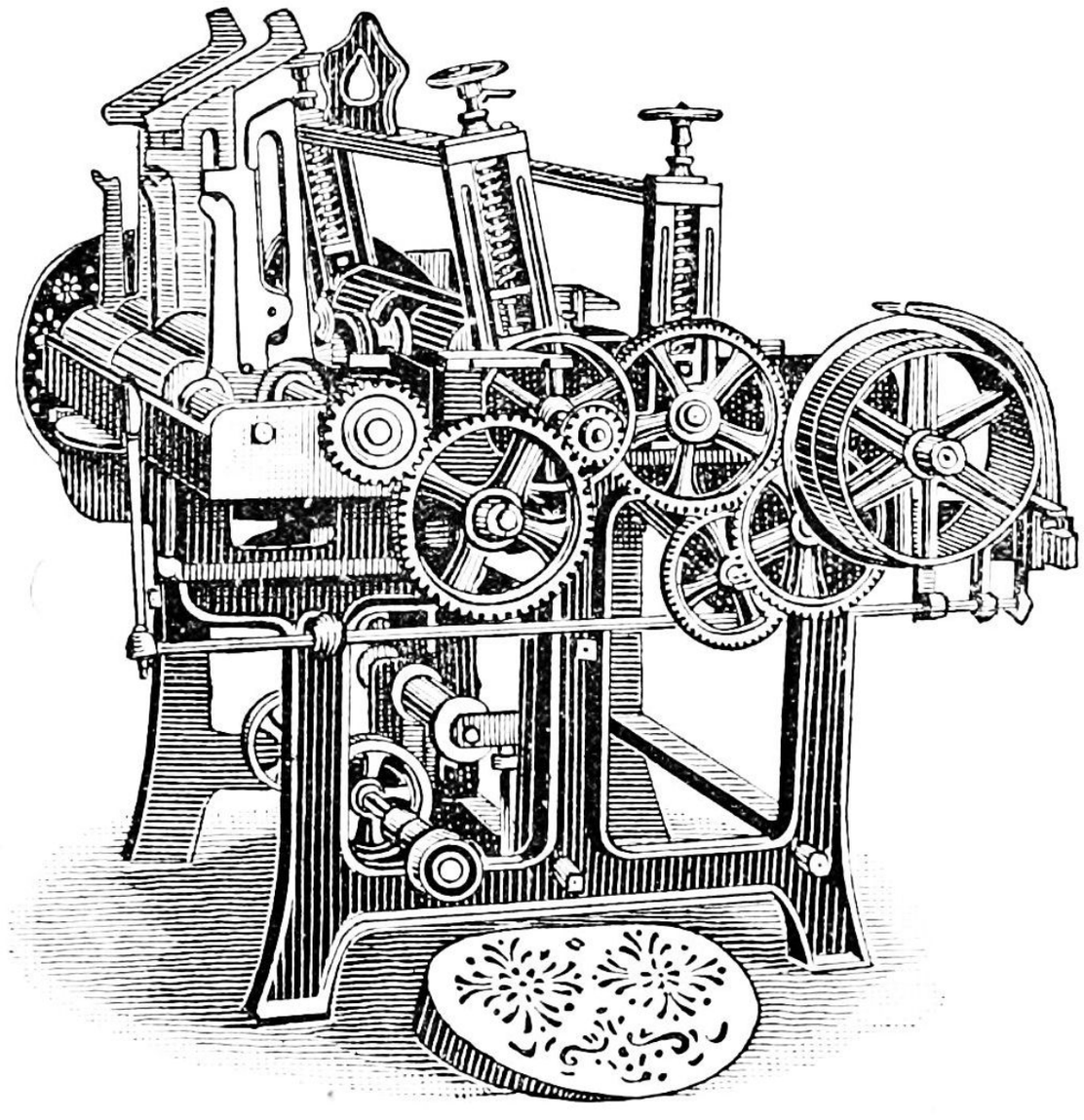
verb [reporting verb]
state a fact or belief confidently and forcefully: [with clause] *: the company asserts that the cuts will not affect development* | [with obj.] *: he asserted his innocence.*

Precondition: condition or predicate that must always be true just prior to the execution of some section of code.

the effect of the code becomes undefined if the precondition does not hold… it may or may not carry out its intended work.

From now on… we will require assertions to handle all declared preconditions in lab.

A systematic approach to “revealing” errors….



Testing the machine

Testing each component

A systematic approach to “revealing” errors….

Unit Testing

Test each **unit of code** separately. (typically: 1 unit = 1 function)

Why

- Increase confidence in code working as expected
- Make “refactoring” easier… coding is an ongoing process
- Found a bug? write a unit test for it… it will never appear again

How? (In FIT1008)

1. For each module, create a separate file: *test_power.py*
2. For each unit to be tested, create a function: def *test_power()*
   - i) Set up testing conditions
   - ii) Call method
   - iii) Verify output (assert)
   - iv) Clean up (if necessary)

```python
def power(x, n):
    assert n >= 0, "n should be a positive Integer"
    value = 1
    if n > 0:
        value = power(x, n//2)
        if n % 2 == 0:
            value = value*value
        else:
            value = value*value*x
    return value
```

power.py

3 Test cases

```python
def test_power():
    assert power(1, 0) == 1**0, "Test failed: 1^0 != 1^0"
    assert power(2, 2) == 4, "Test failed: 2^2 != 4"
    assert power(2.5, 4) == 2.5**4, "Test failed: 2.5^4 != 4"


if __name__ == '__main__':
    test_power()
    print("All tests passing...")
```

test_power.py

From now on… we will require all functionality to be tested.

Disclaimer

- This is a simple way to do testing…
- This is a large topic in itself… you will learn more about it in other units
- Python has a unit testing framework…
  you are not required to use it, but you are welcome to if you want to…

Summary

- Exceptions
- Assertions - Preconditions
- Tests