Exception Handling

Exception handling is a mechanism for **stopping "normal" program flow** and **continuing at some surrounding context** or code block.

Exceptions: Key Concepts

Raise an exception to interrupt program flow.

Handle an exception to resume control.

Exceptions: Key Concepts

Raise an exception to interrupt program flow.

Handle an exception to resume control.

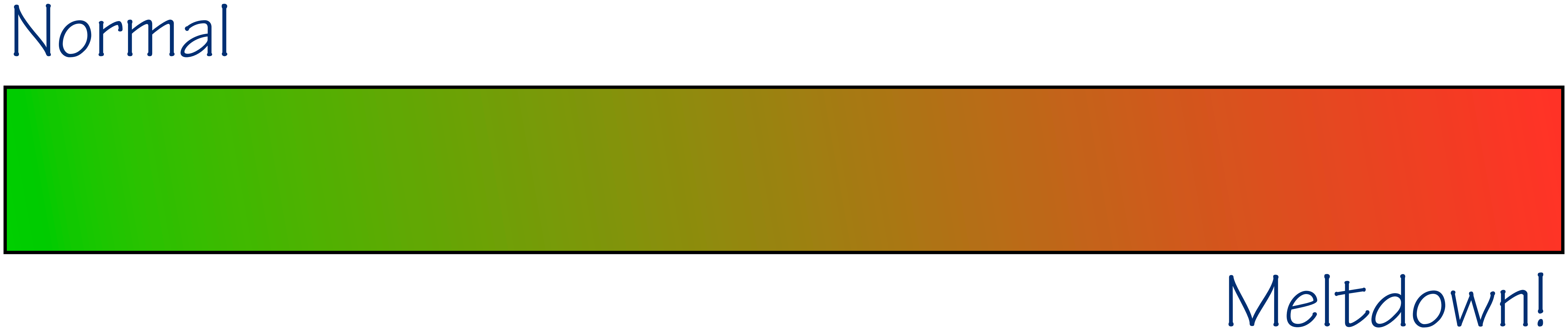
Unhandled exceptions will terminate the program.

Exception objects contain information about the exceptional event.

Similar to other imperative languages

C++

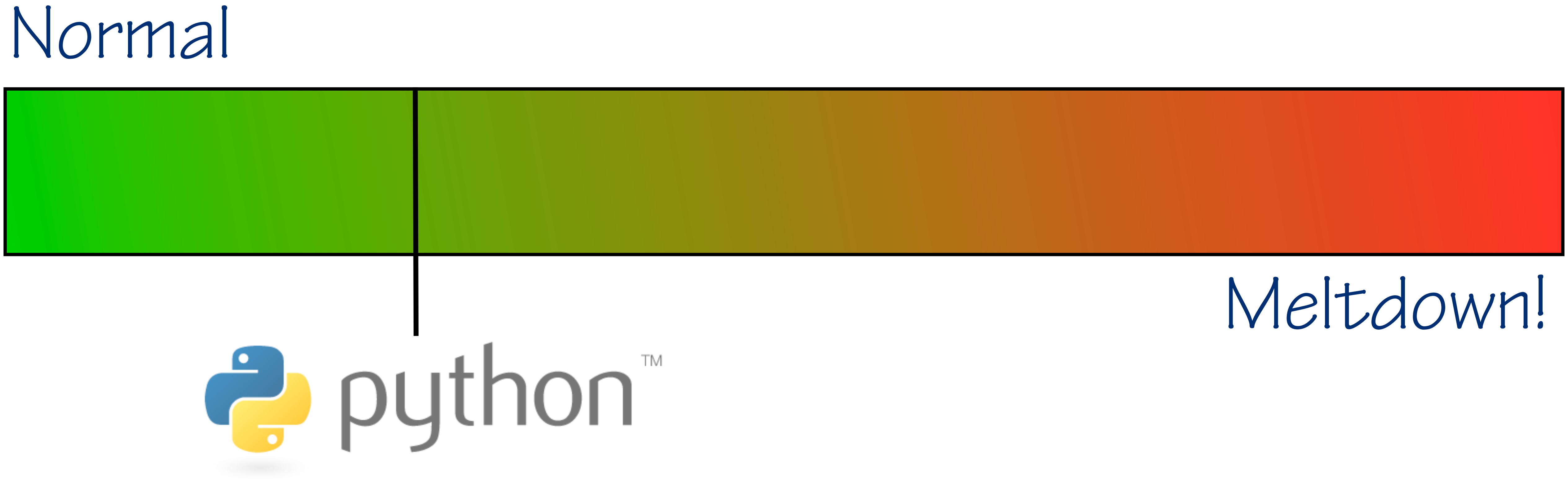
What is exceptional?



Normal

Meltdown!

What is exceptional?

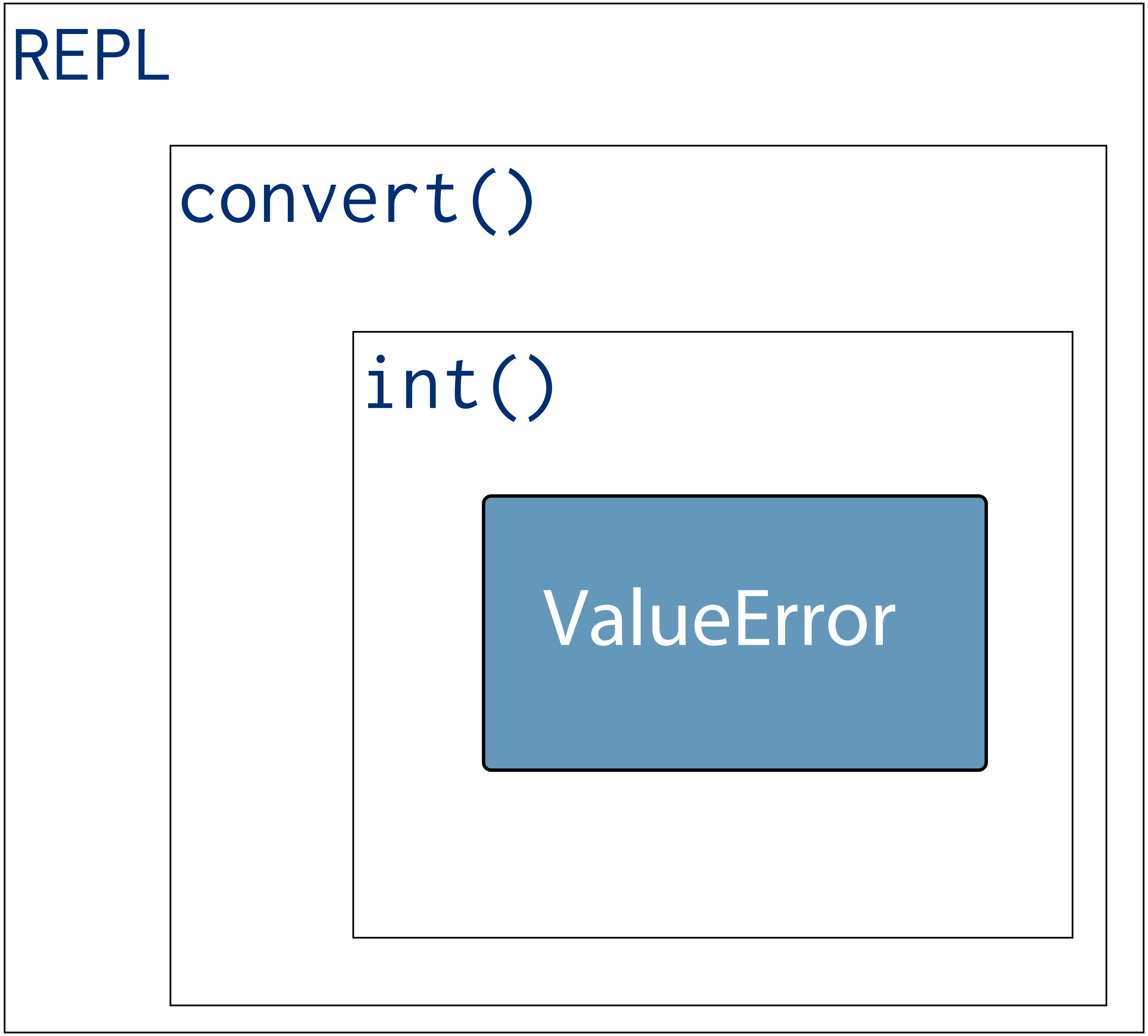


Normal

Meltdown!

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    x = int(s)
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    x = int(s)
    return x
```

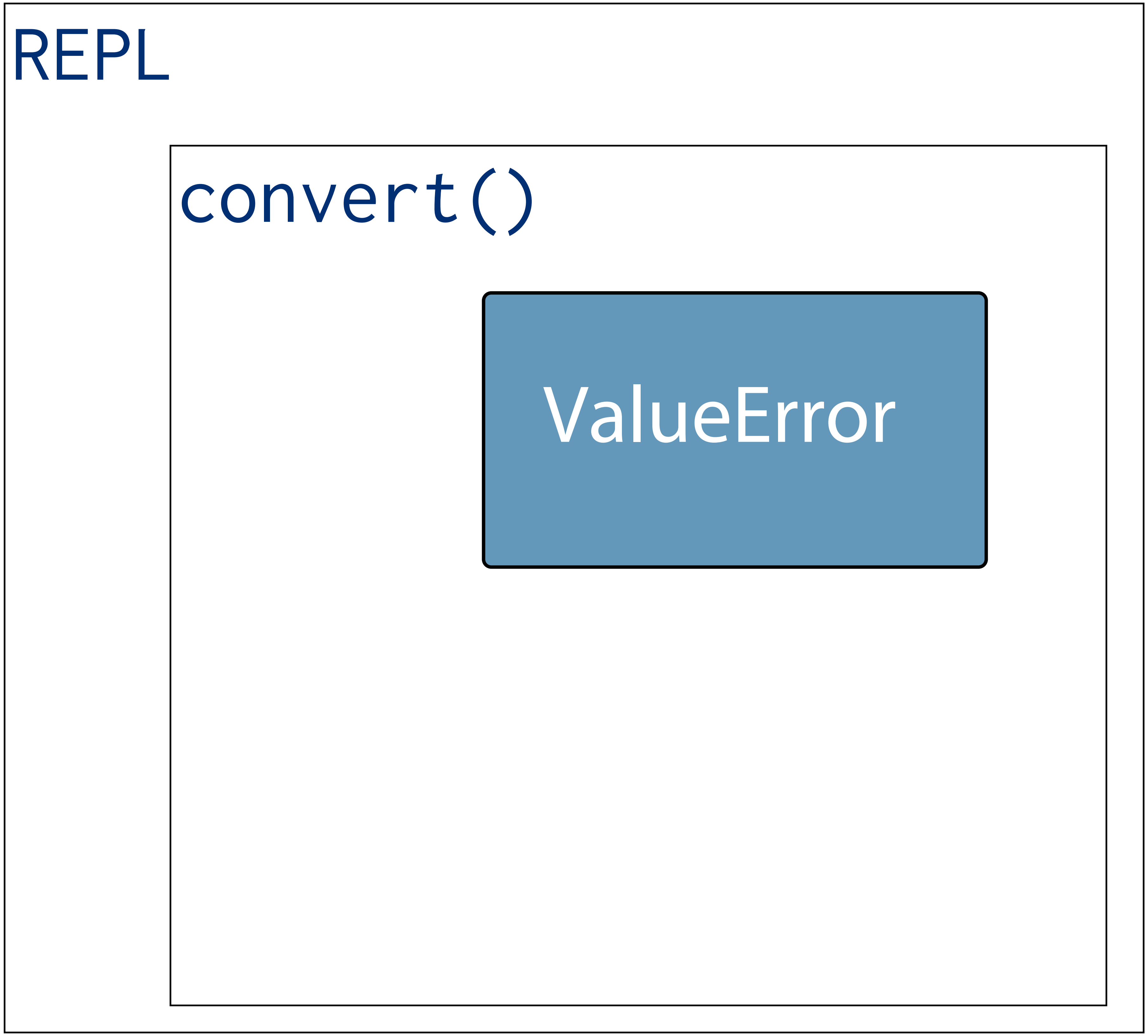


REPL

convert()

int()

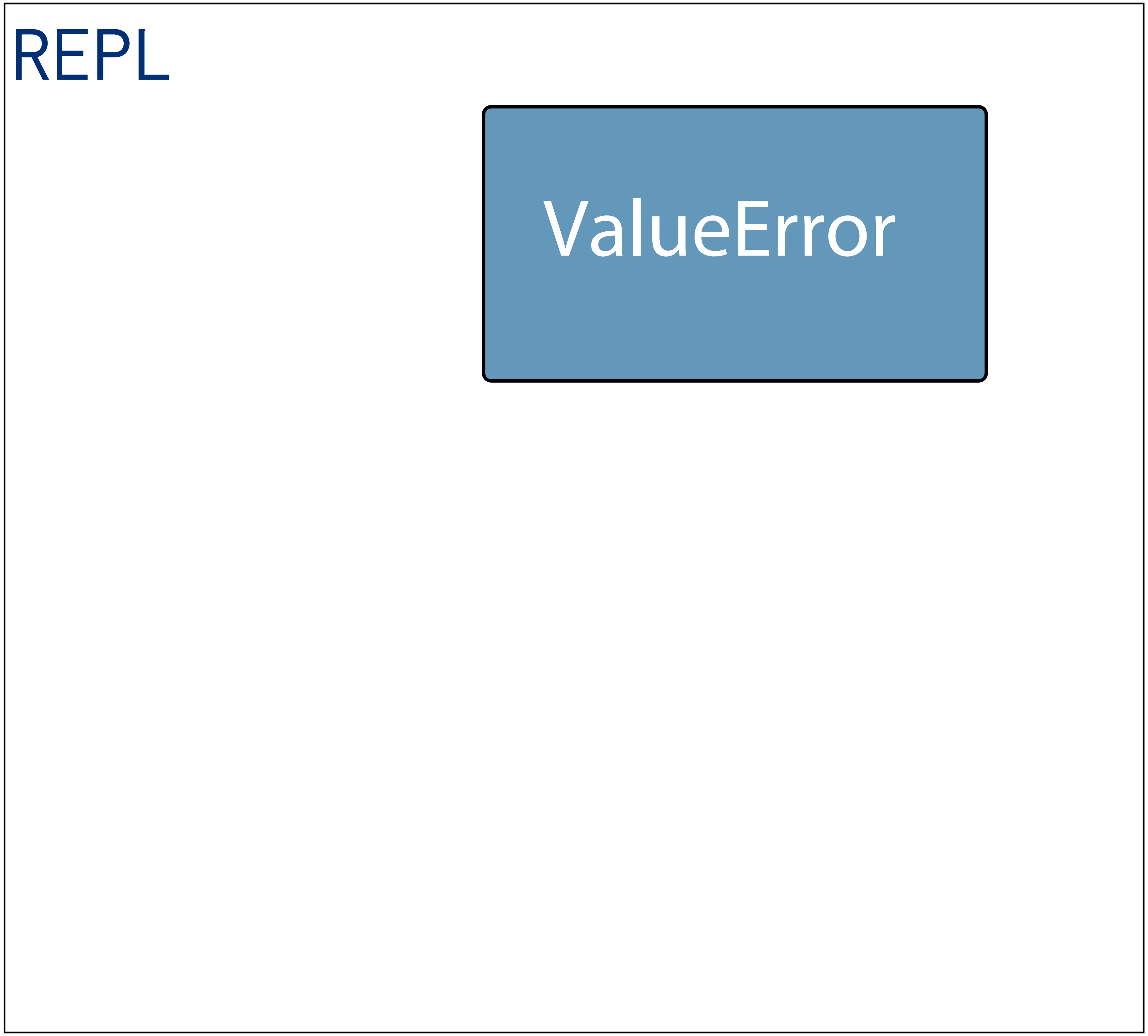
ValueError



REPL

convert()

ValueError



REPL

ValueError

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    try:
        x = int(s)
    except ValueError:
        x = -1
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    try:
        x = int(s)
    except ValueError:
        x = -1
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    try:
        x = int(s)
    except ValueError:
        x = -1
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    try:
        x = int(s)
        print(”Conversion succeeded! x =”, x)
    except ValueError:
        print(”Conversion failed!”)
        x = -1
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    try:
        x = int(s)
        print("Conversion succeeded! x =”, x)
    except ValueError:
        print("Conversion failed!”)
        x = -1
    except TypeError:
        print("Conversion failed!”)
        x = -1
    return x
```

```
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    x = -1
    try:
        x = int(s)
        print("Conversion succeeded! x =”, x)
    except ValueError:
        print("Conversion failed!”)
    except TypeError:
        print("Conversion failed!”)
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    x = -1
    try:
        x = int(s)
        print("Conversion succeeded! x =”, x)
    except (ValueError, TypeError):
        print("Conversion failed!")
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    x = -1
    try:
        x = int(s)
    except (ValueError, TypeError):
    return x
```

Exceptions for programmer errors

`IndentationError`

`SyntaxError`

`NameError`

You should not normally catch these.

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    x = -1
    try:
        x = int(s)
    except (ValueError, TypeError):
        pass
    return x
```

```python
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    try:
        return int(s)
    except (ValueError, TypeError):
        return -1
```

```
'''A module for demonstrating exceptions.'''

def convert(s):
    '''Convert to an integer.'''
    try:
        return int(s)
    except (ValueError, TypeError) as e:
        return -1
```

```python
'''A module for demonstrating exceptions.'''

import sys

def convert(s):
    '''Convert to an integer.'''
    try:
        return int(s)
    except (ValueError, TypeError) as e:
        print("Conversion error: {}"\
              .format(str(e)),
              file=sys.stderr)
        return -1
```

```python
from math import log

def string_log(s):
    v = convert(s)
    return log(v)
```

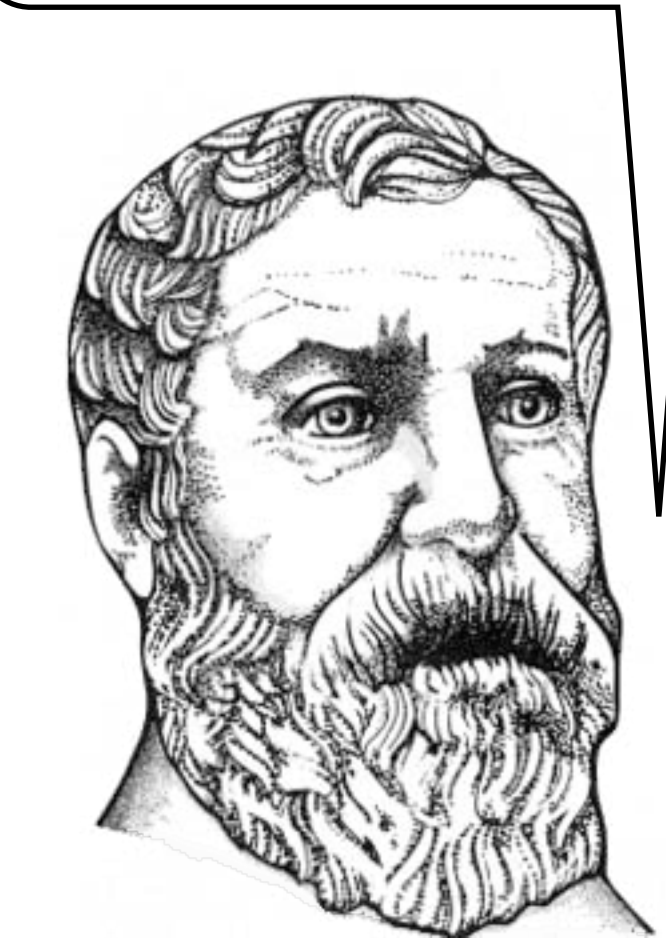
Exceptions can not be ignored.

But error codes can...

```python
def convert(s):
    '''Convert to an integer.'''
    try:
        return int(s)
    except (ValueError, TypeError) as e:
        print("Conversion error: {}".format(str(e)),
              file=sys.stderr)
        raise
```

Exceptions are part of the API

Callers need to know **what exceptions** to expect, and **when.**



```python
def sqrt(x):
    '''Compute square roots using the method of Heron of Alexandria.

    Args:
        x: The number for which the square root is to be computed.

    Returns:
        The square root of x.
    '''
    guess = x
    i = 0
    while guess * guess != x and i < 20:
        guess = (guess + x / guess) / 2.0
        i += 1
    return guess

def main():
    print(sqrt(9))
    print(sqrt(2))

if __name__ == '__main__':
    main()
```

```python
def sqrt(x):
    '''Compute square roots using the method of Heron of Alexandria.

    Args:
        x: The number for which the square root is to be computed.

    Returns:
        The square root of x.
    '''
    guess = x
    i = 0
    while guess * guess != x and i < 20:
        guess = (guess + x / guess) / 2.0
        i += 1
    return guess

def main():
    print(sqrt(9))
    print(sqrt(2))
    print(sqrt(-1))

if __name__ == '__main__':
    main()
```

```python
def sqrt(x):
    '''Compute square roots using the method of Heron of Alexandria.

    Args:
        x: The number for which the square root is to be computed.

    Returns:
        The square root of x.
    '''
    guess = x
    i = 0
    while guess * guess != x and i < 20:
        guess = (guess + x / guess) / 2.0
        i += 1
    return guess

def main():
    print(sqrt(9))
    print(sqrt(2))
    try:
        print(sqrt(-1))
    except ZeroDivisionError:
        print("Cannot compute square root of a negative number.")

    print("Program execution continues normally here.")

if __name__ == '__main__':
    main()
```

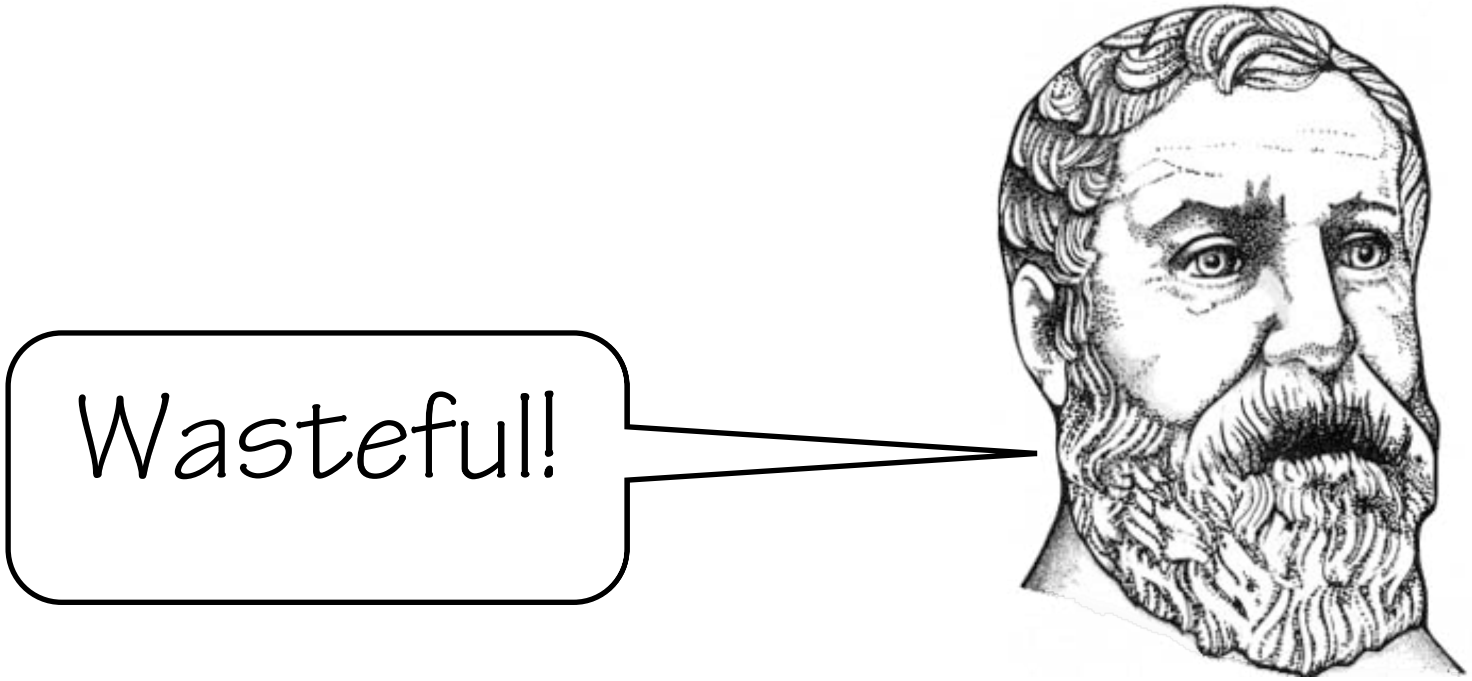
```python
def sqrt(x):
    '''Compute square roots using the method of Heron of Alexandria.

    Args:
        x: The number for which the square root is to be computed.

    Returns:
        The square root of x.
    '''
    guess = x
    i = 0
    while guess * guess != x and i < 20:
        guess = (guess + x / guess) / 2.0
        i += 1
    return guess

def main():
    try:
        print(sqrt(9))
        print(sqrt(2))
        print(sqrt(-1))
        print("This is never printed.")
    except ZeroDivisionError:
        print("Cannot compute square root of a negative number.")

    print("Program execution continues normally here.")

if __name__ == '__main__':
    main()
```

Use exceptions that users will anticipate.

Standard exceptions are often the best choice.

```python
def sqrt(x):
    '''Compute square roots using the method of Heron of Alexandria.

    Args:
        x: The number for which the square root is to be computed.

    Returns:
        The square root of x.
    '''
    guess = x
    i = 0
    try:
        while guess * guess != x and i < 20:
            guess = (guess + x / guess) / 2.0
            i += 1
    except ZeroDivisionError:
        raise ValueError()
    return guess
```

```python
def sqrt(x):
    '''Compute square roots using the method of Heron of Alexandria.

    Args:
        x: The number for which the square root is to be computed.

    Returns:
        The square root of x.
    '''
    guess = x
    i = 0
    try:
        while guess * guess != x and i < 20:
            guess = (guess + x / guess) / 2.0
            i += 1
    except ZeroDivisionError:
        raise ValueError()
    return guess
```



```
def sqrt(x):
    '''Compute square roots using the method of Heron of Alexandria.

    Args:
        x: The number for which the square root is to be computed.

    Returns:
        The square root of x.

    Raises:
        ValueError: If x is negative.
    '''

    if x < 0:
        raise ValueError("Cannot compute square root “
                         “of negative number {}".format(x))

    guess = x
    i = 0
    while guess * guess != x and i < 20:
        guess = (guess + x / guess) / 2.0
        i += 1
    return guess
```

```
import sys

def main():
    try:
        print(sqrt(9))
        print(sqrt(2))
        print(sqrt(-1))
        print("This is never printed.”)
    except ValueError as e:
        print(e, file=sys.stderr)

    print("Program execution continues normally here.”)
```

Exceptions are part of the API

Exceptions are parts of families of related functions referred to at “protocols”.

Use common or existing exception types when possible.

Use common or existing exception types when possible.

```
IndexError
KeyError
ValueError
TypeError
e
```

Follow existing usage patterns.

IndexError

integer index is out of range

ValueError

object is of the right type, but contains an inappropriate value.

KeyError

Look-up in a mapping fails

Avoid protecting against **`TypeErrors`**.

Avoid protecting against **TypeErrors**.

Avoid protecting against `TypeErrors`.

This is **against the grain** in Python

```python
def convert(s):
    '''Convert to an integer.'''
    if not isinstance(s, str):
        raise TypeError(
            "Argument must be a string")

    try:
        return int(s)
    except (ValueError, TypeError) as e:
        print("Conversion error: {}".format(str(e)),
              file=sys.stderr)
        raise
```

```
def convert(s):
    '''Convert to an integer.'''
    if not isinstance(s, str):
        raise TypeError(
            "Argument must be a string")

    try:
        return int(s)
    except (ValueError, TypeError) as e:
        print("Conversion error: {}".format(str(e)),
              file=sys.stderr)
        raise
```

float?

```python
def convert(s):
    '''Convert to an integer.'''
    if not isinstance(s, str):
        raise TypeError(
            "Argument must be a string")

    try:
        return int(s)
    except (ValueError, TypeError) as e:
        print("Conversion error: {}".format(str(e)),
              file=sys.stderr)
        raise
```

float?

Fraction?

```
def convert(s):
    '''Convert to an integer.'''
    if not isinstance(s, str):
        raise TypeError(
            "Argument must be a string")

    try:
        return int(s)
    except (ValueError, TypeError) as e:
        print("Conversion error: {}".format(str(e)),
              file=sys.stderr)
        raise
```

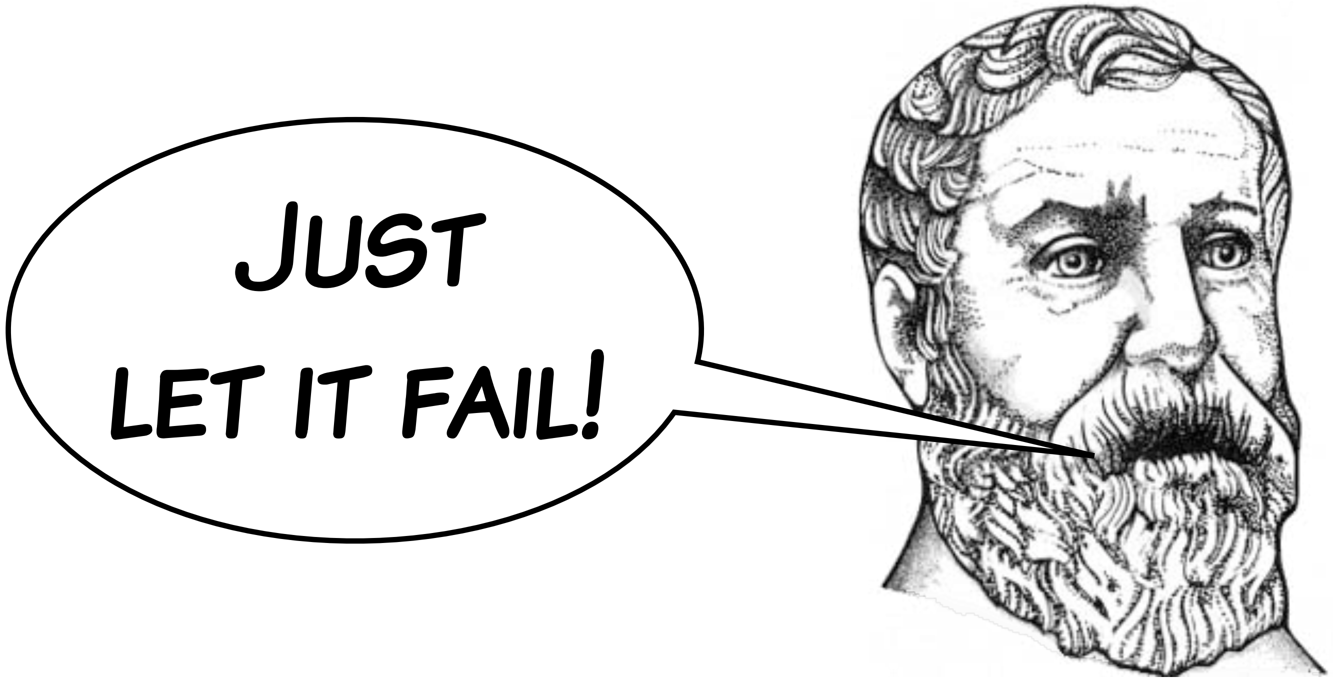
float?

Fraction?

complex?

etc.

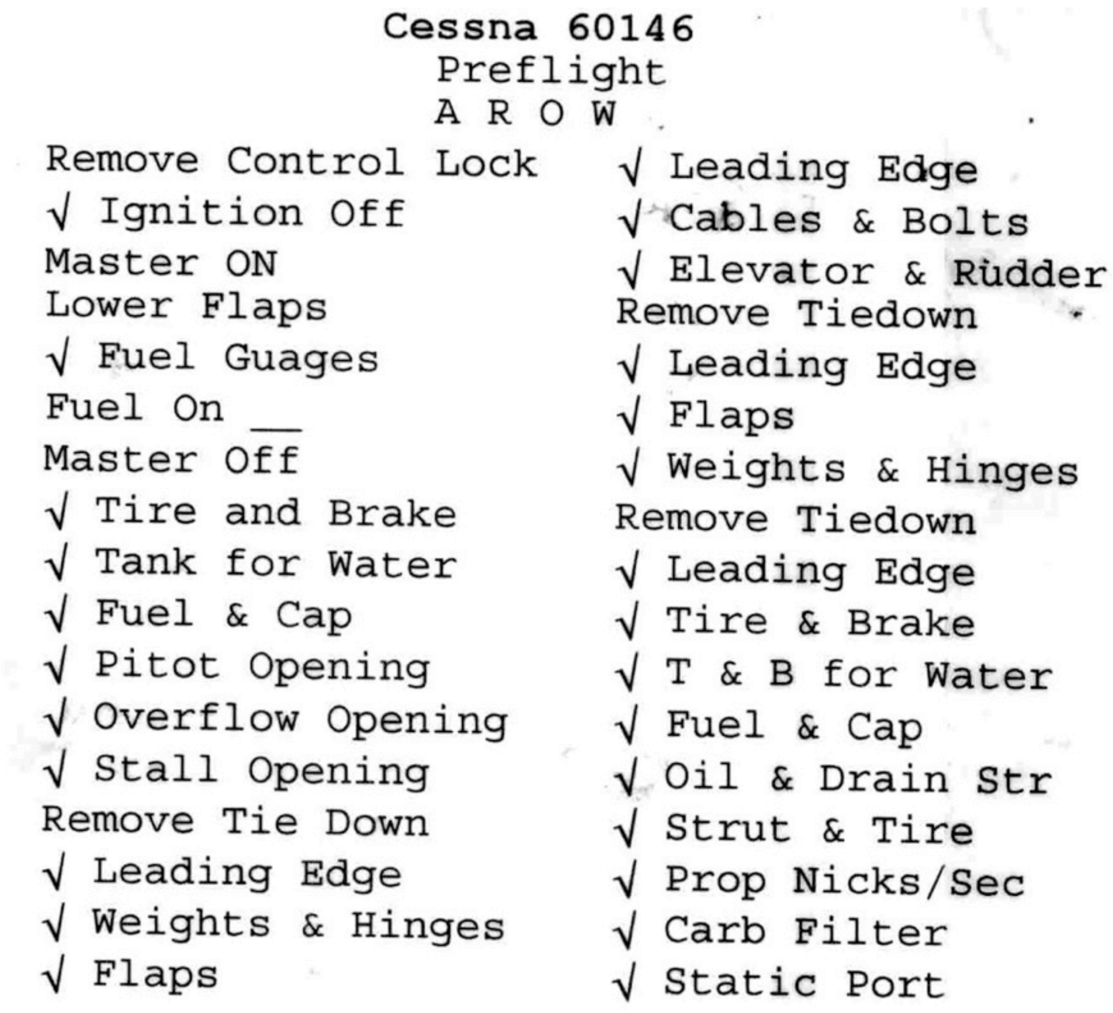
```
def convert(s):
    '''Convert to an integer.'''
    ~~if not isinstance(s, str):~~
        ~~raise TypeError(~~
            ~~"Argument must be a string")~~

    try:
        return int(s)
    except (ValueError, TypeError) as e:
        print("Conversion error: {}".format(str(e)),
              file=sys.stderr)
        raise
```



It’s usually **not worth checking** types.

This can **limit** your functions **unnecessarily.**

Dealing with failures

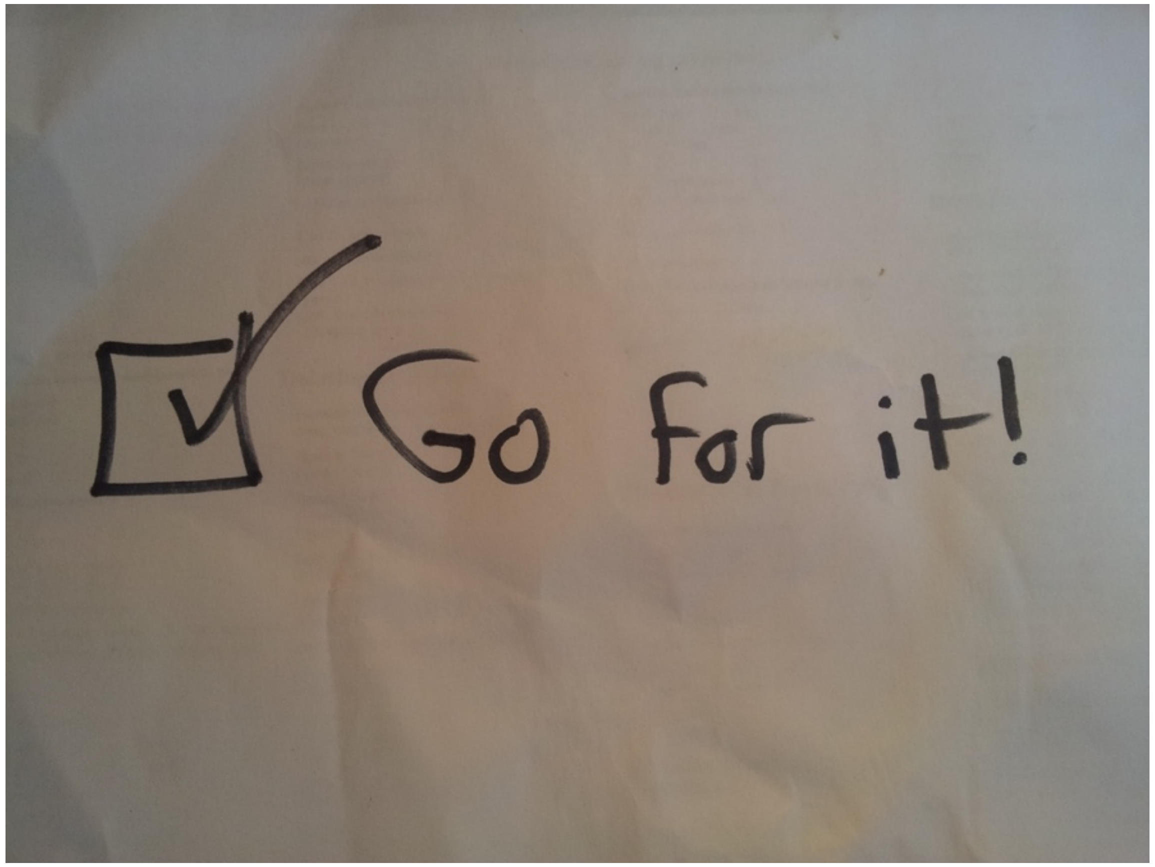


Cessna 60146
Preflight
A R O W

Remove Control Lock
√ Ignition Off
Master ON
Lower Flaps
√ Fuel Guages
Fuel On __
Master Off
√ Tire and Brake
√ Tank for Water
√ Fuel & Cap
√ Pitot Opening
√ Overflow Opening
√ Stall Opening
Remove Tie Down
√ Leading Edge
√ Weights & Hinges
√ Flaps

√ Leading Edge
√ Cables & Bolts
√ Elevator & Rudder
Remove Tiedown
√ Leading Edge
√ Flaps
√ Weights & Hinges
Remove Tiedown
√ Leading Edge
√ Tire & Brake
√ T & B for Water
√ Fuel & Cap
√ Oil & Drain Str
√ Strut & Tire
√ Prop Nicks/Sec
√ Carb Filter
√ Static Port

vs.



Two Philosophies

Look Before You Leap

vs.

It's Easier to Ask Forgiveness than Permission

Two Philosophies

It’s **E**asier to **A**sk **F**orgiveness than **P**ermission

python™

```python
import os

p = '/path/to/datafile.dat'

if os.path.exists(p):
    process_file(p)
else:
    print('No such file as {}'.format(p))
```

```python
import os

p = '/path/to/datafile.dat'

if os.path.exists(p):
    process_file(p)
else:
    print('No such file as {}'.format(p))
```

```
import os

p = '/path/to/datafile.dat'

if os.path.exists(p):
    process_file(p)
else:
    print('No such file as {}'.format(p))
```

Race condition

```python
p = '/path/to/datafile.dat'

try:
    process_file(f)
except OSError as e:
    print('Could not process file because{}'\
          .format(str(e)))
```

Local vs. Non-Local Handling

Error codes require interspersed, **local handling.**

Exceptions allow centralized, **non-local handling.**

EAFP + Exceptions

Exceptions require explicit **handling.**

Error codes are **silent** by default.

EAFP + Exceptions = errors are difficult to ignore!

Resource Cleanup with Finally

`try...finally` lets you clean up whether an **exception occurs or not.**

```
import os

def make_at(path, dir_name):
    original_path = os.getcwd()
    os.chdir(path)
    os.mkdir(dir_name)
    os.chdir(original_path)
```

If this fails...

...then this won't happen!

```python
import os

def make_at(path, dir_name):
    original_path = os.getcwd()
    try:
        os.chdir(path)
        os.mkdir(dir_name)
    finally:
        os.chdir(original_path)
```

```python
import os

def make_at(path, dir_name):
    original_path = os.getcwd()
    try:
        os.chdir(path)
        os.mkdir(dir_name)
    finally:
        os.chdir(original_path)
```

```python
import os

def make_at(path, dir_name):
    original_path = os.getcwd()
    try:
        os.chdir(path)
        os.mkdir(dir_name)
    finally:
        os.chdir(original_path)
```

```
import os

def make_at(path, dir_name):
    original_path = os.getcwd()
    try:
        os.chdir(path)
        os.mkdir(dir_name)
    finally:
        os.chdir(original_path)
```

finally-block is executed no matter how the try-block exits.

```python
import os
import sys

def make_at(path, dir_name):
    original_path = os.getcwd()
    try:
        os.chdir(path)
        os.mkdir(dir_name)
    except OSError as e:
        print(e, file=sys.stderr)
        raise
    finally:
        os.chdir(original_path)
```

```python
import os
import sys

def make_at(path, dir_name):
    original_path = os.getcwd()
    try:
        os.chdir(path)
        os.mkdir(dir_name)
    except OSError as e:
        print(e, file=sys.stderr)
        raise
    finally:
        os.chdir(original_path)
```

Runs even if OSError is thrown and handled.

Moment of Zen

Errors should never pass silently, unless explicitly silenced.

Errors are like bells
And if we make them silent
They are of no use

Platform-Specific Modules

Windows

```
msvcrt
```

Linux OSX

```
sys
tty
termios
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

```python
"""keypress - A module for detecting a single keypress."""

try:
    import msvcrt

    def getkey():
        """Wait for a keypress and return a single character string."""
        return msvcrt.getch()

except ImportError:

    import sys
    import tty
    import termios

    def getkey():
        """Wait for a keypress and return a single character string."""
        fd = sys.stdin.fileno()
        original_attributes = termios.tcgetattr(fd)
        try:
            tty.setraw(sys.stdin.fileno())
            ch = sys.stdin.read(1)
        finally:
            termios.tcsetattr(fd, termios.TCSADRAIN, original_attributes)
        return ch

    # If either of the Unix-specific tty or termios are not found,
    # we allow the ImportError to propagate from here
```

python

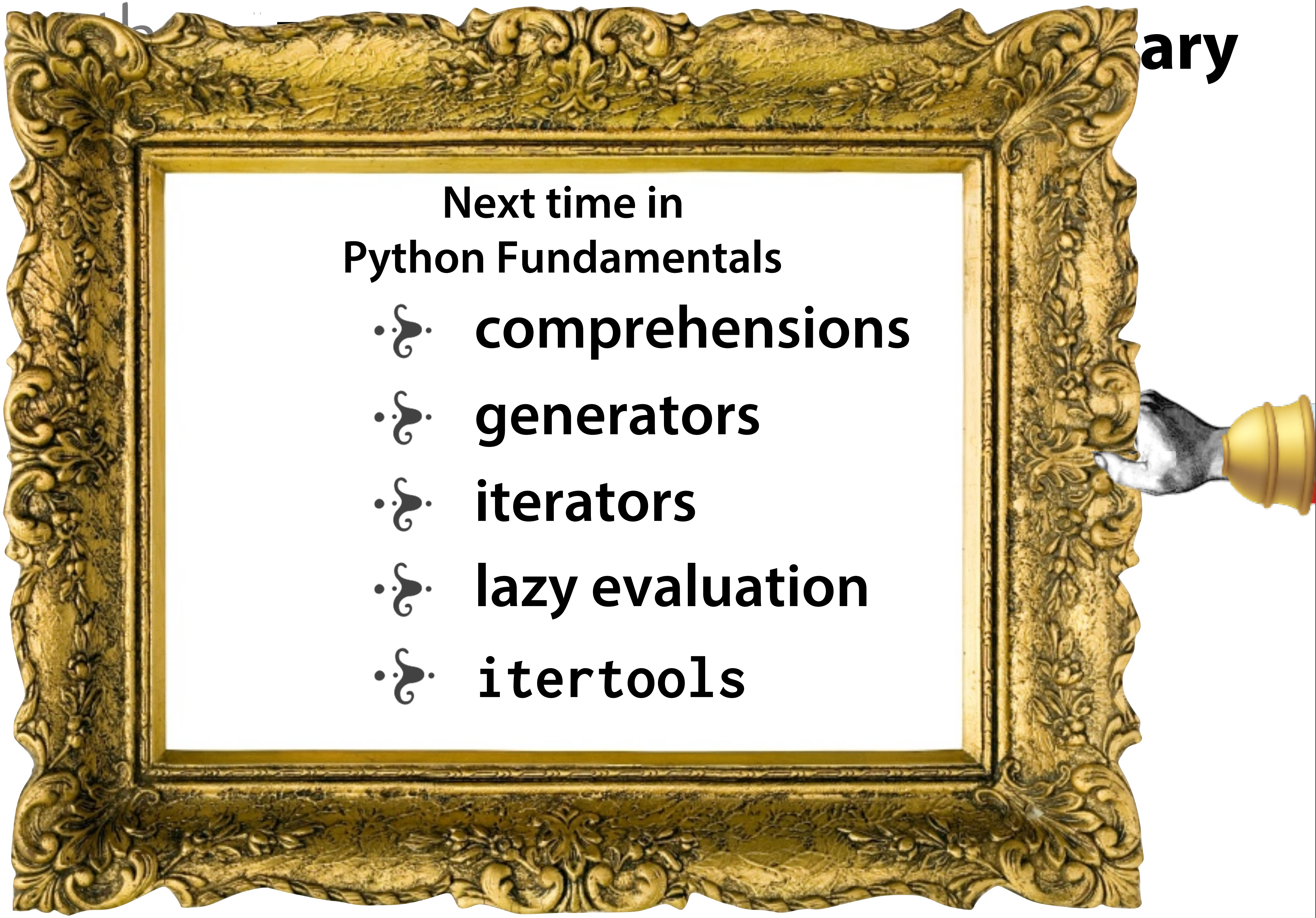
Exception Handling – Summary

- Raising an exception interrupts normal program flow and transfers control to an exception handler.
- Exception handlers defined using the `try...except` construct.
- `try` blocks define a context for detecting exceptions.
- Corresponding `except` blocks handle specific exception types.
- Python uses exceptions pervasively.
    - Many built-in language features depend on them.
- `except` blocks can capture an exception, which are often of a standard type.
- Programmer errors should not normally be handled.
- Exceptional conditions can be signaled using `raise`.
- `raise` without an argument re-raises the current exception.

python Exception Handling – Summary

- Output of `print()` can be redirected using the optional `file` argument.
- Use and and `or` for combining boolean expressions.
- Return codes are too easily ignored.
- Platform-specific actions can be implemented using EAFP along with catching `ImportErrors`.

ary



Next time in
Python Fundamentals

- comprehensions
- generators
- iterators
- lazy evaluation
- `itertools`