

Lecture 11

Asserts and Error Handling

Announcements for Today

(Optional) Videos

- **Lesson 13, 14** for **today**
- **Videos 15.1-15.7** next time

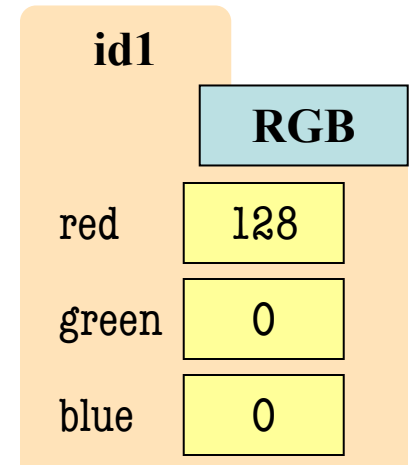
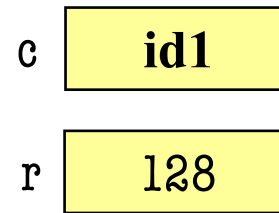
- **Prelim, Oct 12th 7:30-9:00**
 - Material up October 3rd
 - Study guide is now posted
- **Conflict with Prelim time?**
 - Submit to Prelim 1 Conflict assignment on CMS
 - Do not submit if no conflict

Assignments

- A2 graded by Sunday
 - Still taking late submits
 - Also fill out survey
- A3 is now posted
 - Due Friday October 6th
 - Just before Fall Break
 - Graded when get back
 - Material is on exam

Using Color Objects in A3

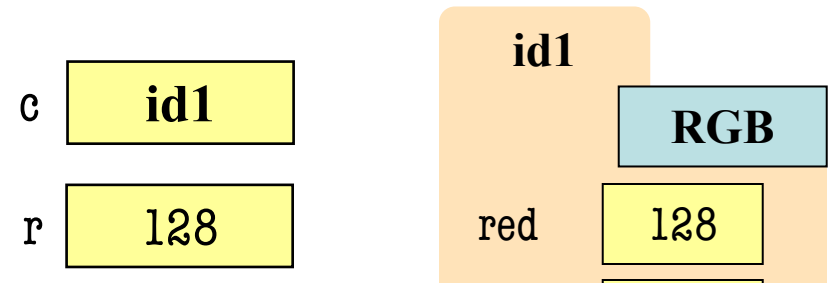
- New classes in introcs
 - RGB, CMYK, and HSL
- Each has its own attributes
 - **RGB**: red, blue, green
 - **CMYK**: cyan, magenta, yellow, black
 - **HSV**: hue, saturation, value
- Attributes have *invariants*
 - Limits the attribute values
 - Example: red is int in 0..255
 - Get an error if you violate



```
>>> import introcs
>>> c = introcs.RGB(128,0,0)
>>> r = c.red
>>> c.red = 500 # out of range
AssertionError: 500 outside [0,255]
```

Using Color Objects in A3

- New classes in introcs
 - RGB, CMYK, and HSL
- Each has its own attributes
 - **RGB**: red, blue, green
 - **CMYK**: cyan, magenta, yellow, black
 - **HSV**: hue, saturation, value
- Attributes have *invariants*
 - Limits the attribute values
 - Example: red is int in 0..255
 - Get an error if you violate



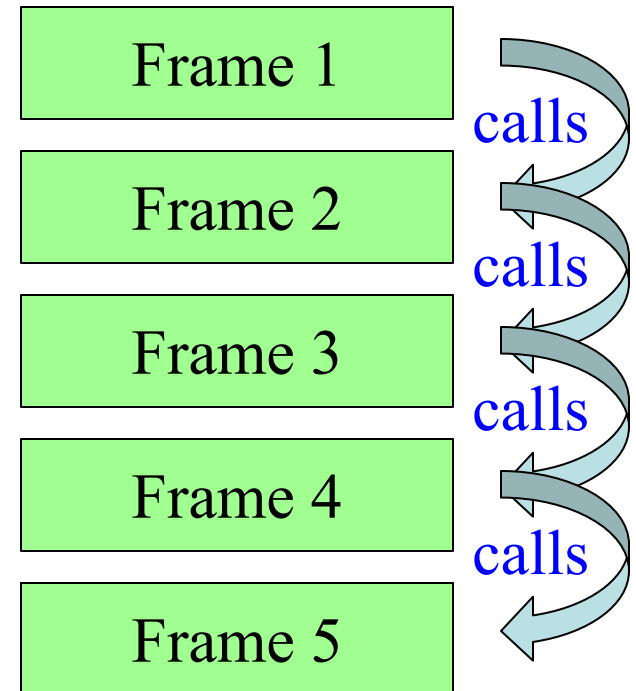
Constructor function.
To make a **new** color.

```
>>> import introcs
>>> c = introcs.RGB(128,0,0)
>>> r = c.red
>>> c.red = 500 # 0
AssertionError: 500
```

Accessing
Attribute

Recall: The Call Stack

- Functions are **stacked**
 - Cannot remove one above w/o removing one below
 - Sometimes draw bottom up (better fits the metaphor)
- Stack represents memory as a ***high water mark***
 - Must have enough to keep the **entire stack in memory**
 - Error if cannot hold stack



Error Messages

Not An Error Message

ZeroDivisionError: division by zero



Everything starting
with the Traceback

An Error Message

Traceback (most recent call last):

File "error.py", line 41, in <module>

print(function_1(1,0))

File "error.py", line 16, in function_1

return function_2(x,y)

File "error.py", line 26, in function_2

return function_3(x,y)

File "error.py", line 36, in function_3

return x/y

ZeroDivisionError: division by zero

Errors and the Call Stack

```
# error.py
```

```
def function_1(x,y):
```

```
    return function_2(x,y)
```

calls

```
def function_2(x,y):
```

```
    return function_3(x,y)
```

calls

```
def function_3(x,y):
```

```
    return x/y # crash here
```

calls

```
if __name__ == '__main__':
```

```
    print(function_1(1,0))
```

Errors and the Call Stack

```
# error.py
```

```
def function_1(x,y):  
    return function_2(x,y)
```

```
def function_2(x,y):  
    return function_3(x,y)
```

```
def function_3(x,y):  
    return x/y # crash here
```

```
if __name__ == '__main__':  
    print(function_1(1,0))
```

Crashes produce the call stack:

Traceback (most recent call last):

File "error.py", line 20, in <module>
 print(function_1(1,0))

File "error.py", line 8, in function_1
 return function_2(x,y)

File "error.py", line 12, in function_2
 return function_3(x,y)

File "error.py", line 16, in function_3
 return x/y

Make sure you can see
line numbers in Pulsar.

Errors and the Call Stack

```
#  
d  
|  
| return function_2(x,y)  
|  
def function_2(x,y):  
|  
| return function_3(x,y)  
|  
def function_3(x,y):  
|  
| return x/y # crash here  
|  
if
```

Script code.
Global space

Where error occurred
(or where was found)

Crashes produce the call stack:

Traceback (most recent call last):

File "error.py", line 20, in <module>
print(function_1(1,0))

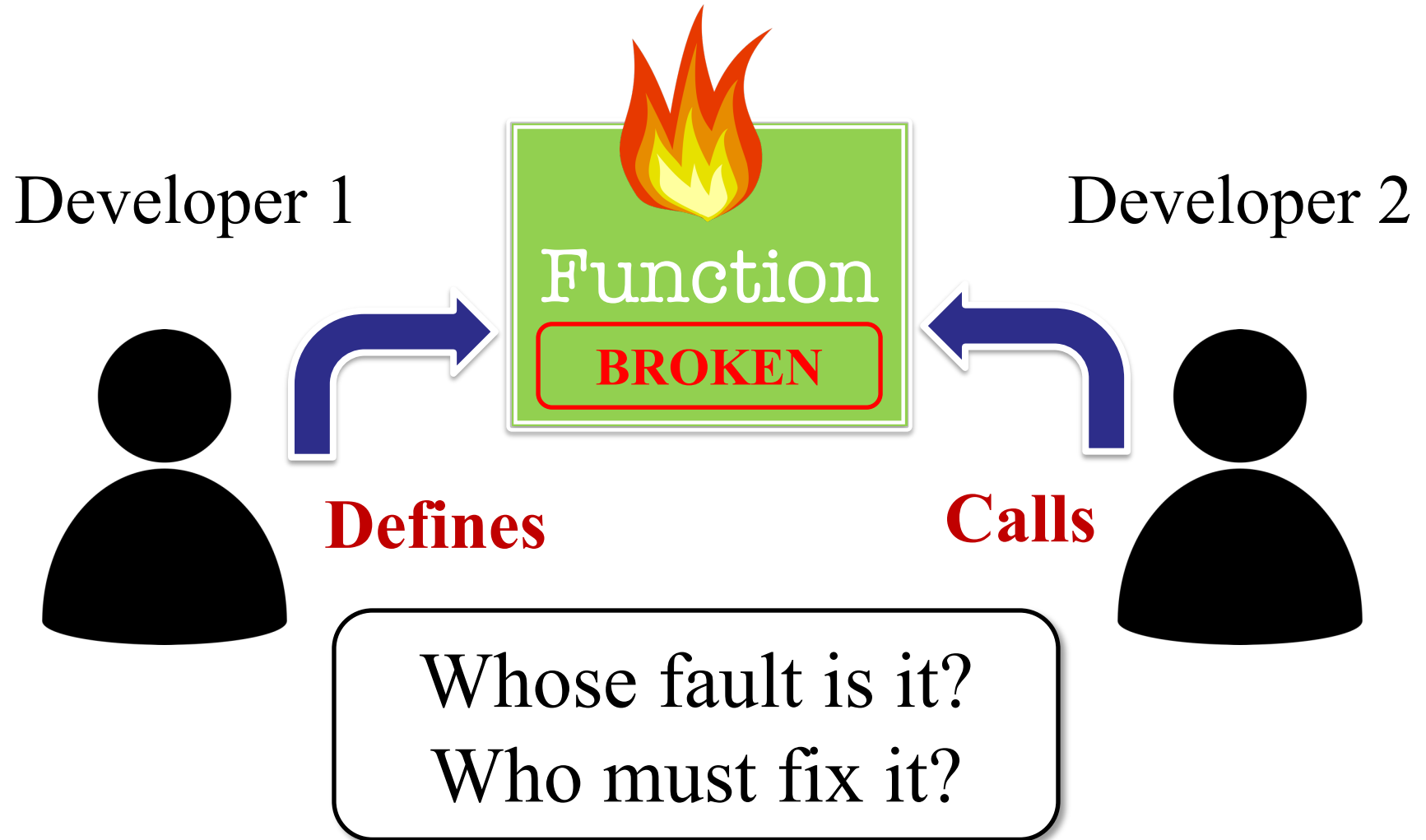
File "error.py", line 8, in function_1
return function_2(x,y)

File "error.py", line 12, in function_2
return function_3(x,y)

File "error.py", line 16, in function_3
return x/y

Make sure you can see
line numbers in Pulsar.

Recall: Assigning Responsibility



Determining Responsibility

```
def function_1(x,y):  
    """Returns: result of function_2  
    Precondition: x, y numbers"""  
    return function_2(x,y)
```

```
def function_2(x,y):  
    """Returns: x divided by y  
    Precondition: x, y numbers"""  
    return x/y
```

```
print(function_1(1,0))
```

Traceback (most recent call last):

File "error1.py", line 32, in <module>
 print(function_1(1,0))

File "error1.py", line 18, in function_1
 return function_2(x,y)

File "error1.py", line 28, in function_2
 return x/y

ZeroDivisionError

Where is the error?

Approaching the Error Message

- Start from the top
- Look at function call
 - Examine arguments
 - (Print if you have to)
 - Verify preconditions
- Violation? Error found
 - Else go to next call
 - Continue until bottom

Traceback (most recent call last):

File "error1.py", line 32, in <module>

```
print(function_1(1,0))
```

File "error1.py", line 18, in function_1

```
return function_2(x,y)
```

File "error1.py", line 28, in function_2

```
return x/y
```

ZeroDivisionError: division by zero

Determining Responsibility

```
def function_1(x,y):  
    """Returns: result of function_2  
    Precondition: x, y numbers"""  
    return function_2(x,y)
```

```
def function_2(x,y):  
    """Returns: x divided by y  
    Precondition: x, y numbers"""  
    return x/y
```

```
print(function_1(1,0))
```

Traceback (most recent call last):

File "error1.py", line 32, in **A** module>
 print(function_1(1,0))

File "error1.py", line 18, in **B** function_1
 return function_2(x,y)

File "error1.py", line 28, in **C** function_2
 return x/y

ZeroDivisionError

Where is the error?

Determining Responsibility

```
def function_1(x,y):  
    """Returns: result of function_2  
    Precondition: x, y numbers"""  
    return function_2(x,y)
```

```
def function_2(x,y):  
    """Returns: x divided by y  
    Precondition: x, y numbers"""  
    return x/y
```

```
print(function_1(1,0))
```

Traceback (most recent call last):

File "error1.py", line 32, in <module>
 print(function_1(1,0))

File "error1.py", line 18, in function_1
 return function_2(x,y)

File "error1.py", line 28, in function_2
 return x/y

Error!

ZeroDivisionError: division by zero

Determining Responsibility

```
def function_1(x,y):  
    """Returns: result of function_2  
    Precondition: x, y numbers"""  
    return function_2(x,y)
```

```
def function_2(x,y):  
    """Returns: x divided by y  
    Precondition: x, y numbs, y > 0"""  
    return x/y
```

```
print(function_1(1,0))
```

Traceback (most recent call last):

File "error1.py", line 32, in **A** module>
 print(function_1(1,0))

File "error1.py", line 18, in **B** function_1
 return function_2(x,y)

File "error1.py", line 28, in **C** function_2
 return x/y

ZeroDivisionError

Where is the error?

Determining Responsibility

```
def function_1(x,y):  
    """Returns: result of function_2  
    Precondition: x, y numbers"""  
    return function_2(x,y)
```

```
def function_2(x,y):  
    """Returns: x divided by y  
    Precondition: x, y numbs, y > 0"""  
    return x/y
```

```
print(function_1(1,0))
```

Traceback (most recent call last):

File "error1.py", line 32, in <module>
 print(function_1(1,0))

File "error1.py", line 18, in function_1
 return function_2(x,y)

Error!

File "error1.py", line 28, in function_2
 return x/y

ZeroDivisionError: division by zero

Determining Responsibility

```
def function_1(x,y):  
    """Returns: result of function_2  
    Precondition: x, y numbs, y > 0"""  
    return function_2(x,y)
```

```
def function_2(x,y):  
    """Returns: x divided by y  
    Precondition: x, y numbs, y > 0"""  
    return x/y
```

```
print(function_1(1,0))
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Traceback (most recent call last):

File "error1.py", line 32, in <module>

print(function_1(1,0))

Error!

File "error1.py", line 18, in function_1

return function_2(x,y)

File "error1.py", line 28, in function_2

return x/y

ZeroDivisionError: division by zero

Aiding the Search Process

- Responsibility is “outside of Python”
 - Have to step through the error message
 - Compare to specification at each step
- How can we make this easier?
 - What if we could control the error messages?
 - Write responsibility directly into error?
 - Then *only need to look at error message*
- We do this with **assert statements**

Assert Statements

- **Form 1:** `assert <boolean>`
 - Does nothing if boolean is True
 - Creates an error if boolean is False
- **Form 2:** `assert <boolean>, <string>`
 - Very much like form 2
 - But error message includes the string
- Statement to **verify a fact is true**
 - Similar to `assert_equals` used in unit tests
 - But more versatile with complete **stack trace**

Why Do This?

- Enforce preconditions!
 - Put precondition as assert.
 - If violate precondition, the program crashes
- Provided code in A3 uses asserts heavily
 - First slide of lecture!

```
def exchange(from_c, to_c, amt)
    """Returns: amt from exchange
       Precondition: amt a float..."""
    assert type(amt) == float
    ...
```

Will do yourself in A4.

`assert <boolean>`

Creates error if <boolean> false

`assert <boolean>, <string>`

As above, but displays <String>

Example: Anglicizing an Integer

```
def anglicize(n):
```

```
    """Returns: the anglicization of int n.
```

```
    Precondition: n an int, 0 < n < 1,000,000"""
```

```
    assert type(n) == int, repr(n)+' is not an int'
```

```
    assert 0 < n and n < 1000000, repr(n)+' is out of range'
```

```
    # Implement method here...
```

Example: Anglicizing an Integer

```
def anglicize(n):
```

```
    """Returns: the anglicization of int n.
```

```
    Precondition: n an int, 0 < n < 1,000,000"""
```

```
    assert type(n) == int, repr(n)+' is not an int'
```

```
    assert 0 < n and n < 1000000, repr(n)+' is out of range'
```

```
    # Implement method here...
```

Check (part of)
the precondition

Error message
when violated

Aside: Using repr Instead of str

```
>>> msg = str(var)+' is invalid'
```

```
>>> print(msg)
```

```
2 is invalid
```

- Looking at this output, what is the type of var?

A: **int**

B: **float**

C: **str**

D: Impossible to tell

Aside: Using repr Instead of str

```
>>> msg = str(var)+' is invalid'
```

```
>>> print(msg)
```

```
2 is invalid
```

- Looking at this output, what is the type of var?

A: int

B: float

C: str

D: Impossible to tell

CORRECT

Aside: Using repr Instead of str

```
>>> msg = str(var)+' is invalid'
```

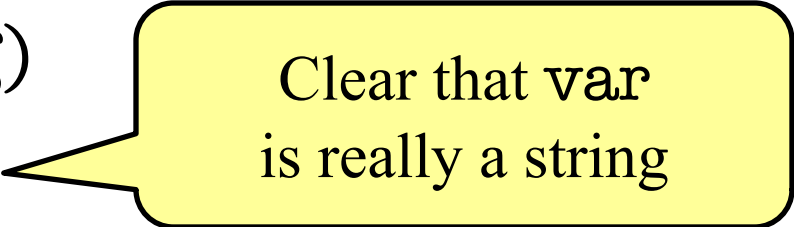
```
>>> print(msg)
```

```
2 is invalid
```

```
>>> msg = repr(var)+' is invalid'
```

```
>>> print(msg)
```

```
'2' is invalid
```



Clear that var
is really a string

Enforcing Preconditions is Tricky!

```
def lookup_netid(nid):
```

```
    """Returns: name of student with netid nid.
```

```
    Precondition: nid is a string, which consists of  
    2 or 3 letters and a number"""
```

```
    assert ?????
```

Assert use expressions only.
Cannot use if-statements.
Each one must fit on one line.

Sometimes we will
only enforce part of
the precondition

Enforcing Preconditions is Tricky!

```
def lookup_netid(nid):
```

```
    """Returns: name of student with netid nid.
```

```
    Precondition: nid is a string, which consists of  
    2 or 3 letters and a number"""
```

```
    assert type(nid) == str, repr(nid) + ' is not a string'
```

```
    assert nid.isalnum(), nid + ' is not just letters/digits'
```

Returns True if s contains
only letters, numbers.

Does this catch
all violations?

Using Functions to Enforce Preconditions

```
def exchange(src, dst, amt):
```

```
    """Returns: amount of src received.
```

```
    Precondition: src is a valid currency code
```

```
    Precondition: dst is a valid currency code
```

```
    Precondition: amt is a float"""
```

```
    assert ??????, repr(src) + ' not valid'
```

```
    assert ??????, repr(dst) + ' not valid'
```

```
    assert type(amt)==float, repr(amt)+' not a float'
```

Using Functions to Enforce Preconditions

```
def exchange(src, dst, amt):
```

```
    """Returns: amount of src received.
```

```
    Precondition: src is a valid currency code
```

```
    Precondition: dst is a valid currency code
```

```
    Precondition: amt is a float"""
```

```
    assert is_currency(src), repr(src) + ' not valid'
```

```
    assert is_currency(dst), repr(dst) + ' not valid'
```

```
    assert type(amt)==float, repr(amt)+' not a float'
```

Recovering from Errors

- Suppose we have this code:

```
result = input('Number: ')    # get number from user
x = float(result)              # convert string to float
print('The next number is '+str(x+1))
```

- What if user mistypes?

Number: 12a

Traceback (most recent call last):

File "prompt.py", line 13, in <module>

```
x = float(result)
```

ValueError: could not convert string to float: '12a'

Ideally Would Handle with Conditional

```
result = input('Number: ')    # get number from user
```

```
if isfloat(result):
```

Does not Exist

```
    x = float(result)          # convert to float
```

```
    print('The next number is '+str(x+1))
```

```
else:
```

```
    print('That is not a number!')
```

Using Try-Except

try:

```
result = input('Number: ')    # get number
x = float(result)              # convert to float
print('The next number is '+str(x+1))
```

except:

```
print('That is not a number!')
```

Similar to if-else

- But always does the try block
- Might not do **all** of the try block

Using Try-Except

try:

```
result = input('Number: ') # get user input
x = float(result)           # convert to float
print('The next number is ' + str(x+1))
```

Conversion
may crash!

except:

```
print('That is not a number!')
```

Execute if crashes

Similar to if-else

- But always does the try block
- Might not do **all** of the try block

Try-Except is Very Versatile

```
def isfloat(s):
```

```
    """Returns: True if string  
    s represents a float"""
```

```
    try:
```

```
        x = float(s)
```

```
        return True
```

```
    except:
```

```
        return False
```

Conversion to a
float might fail

If attempt succeeds,
string s is a float

Otherwise, it is not

Try-Except and the Call Stack

```
# recover.py
```

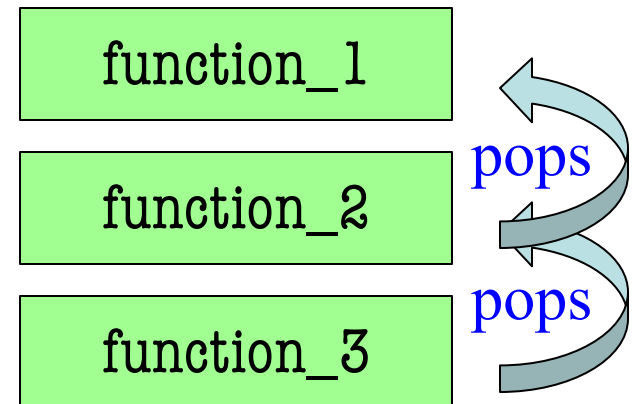
```
def function_1(x,y):  
    try:  
        return function_2(x,y)  
    except:  
        return float('inf')
```

```
def function_2(x,y):  
    return function_3(x,y)
```

```
def function_3(x,y):  
    return x/y # crash here
```

- Error “pops” frames off stack
 - Starts from the stack bottom
 - Continues until it sees that current line is in a try-block
 - Jumps to except, and then proceeds as if no error

line in a try



Try-Except and the Call Stack

```
# recover.py
```

```
def function_1(x,y):
```

```
    try:
```

```
        return function_2(x,y)
```

```
    except:
```

```
        return float('inf')
```

```
def function_2(x,y):
```

```
    return function_3(x,y)
```

```
def function_3(x,y):
```

```
    return x/y # crash here
```

How to return
 ∞ as a float.

- Error “pops” frames off stack

from the stack bottom
until it sees that
current line is in a try-block

- Jumps to except, and then
proceeds as if no error

- **Example:**

```
>>> print function_1(1,0)
```

```
inf
```

```
>>>
```

No traceback!

Tracing Control Flow

```
def first(x):  
    print('Starting first.')  
    try:  
        second(x)  
    except:  
        print('Caught at first')  
    print('Ending first')
```

```
def second(x):  
    print('Starting second.')  
    try:  
        third(x)  
    except:  
        print('Caught at second')  
    print('Ending second')
```

```
def third(x):  
    print('Starting third.')  
    assert x < 1  
    print('Ending third.')
```

What is the output of first(2)?

Tracing Control Flow

```
def first(x):  
    print('Starting first.')  
    try:  
        second(x)  
    except:  
        print('Caught at first')  
    print('Ending first')
```

```
def second(x):  
    print('Starting second.')  
    try:  
        third(x)  
    except:  
        print('Caught at second')  
    print('Ending second')
```

```
def third(x):  
    print('Starting third.')  
    assert x < 1  
    print('Ending third.')
```

What is the output of first(2)?

'Starting first.'
'Starting second.'
'Starting third.'
'Caught at second'
'Ending second'
'Ending first'

Tracing Control Flow

```
def first(x):  
    print('Starting first.')  
    try:  
        second(x)  
    except:  
        print('Caught at first')  
    print('Ending first')
```

```
def second(x):  
    print('Starting second.')  
    try:  
        third(x)  
    except:  
        print('Caught at second')  
    print('Ending second')
```

```
def third(x):  
    print('Starting third.')  
    assert x < 1  
    print('Ending third.')
```

What is the output of first(0)?

Tracing Control Flow

```
def first(x):  
    print('Starting first.')  
    try:  
        second(x)  
    except:  
        print('Caught at first')  
    print('Ending first')
```

```
def second(x):  
    print('Starting second.')  
    try:  
        third(x)  
    except:  
        print('Caught at second')  
    print('Ending second')
```

```
def third(x):  
    print('Starting third.')  
    assert x < 1  
    print('Ending third.')
```

What is the output of first(0)?

'Starting first.'
'Starting second.'
'Starting third.'
'Ending third'
'Ending second'
'Ending first'