CSc 110, Autumn 2017

Lecture 10: return values and `math`

Python's `Math` class

Method name	Description
`math.ceil(`*value*`)`	rounds up
`math.floor(`*value*`)`	rounds down
`math.log(`*value, base*`)`	logarithm
`math.sqrt(`*value*`)`	square root

`math.sinh(`*value*`)`
`math.cosh(`*value*`)`
`math.tanh(`*value*`)`
	sine/cosine/tangent of an angle in radians

`math.degrees(`*value*`)` `math.radians(`*value*`)`	convert degrees to radians and back

Constant	Description
`e`	2.7182818...
`pi`	3.1415926...

`import math` necessary to use the above functions

Other math functions:

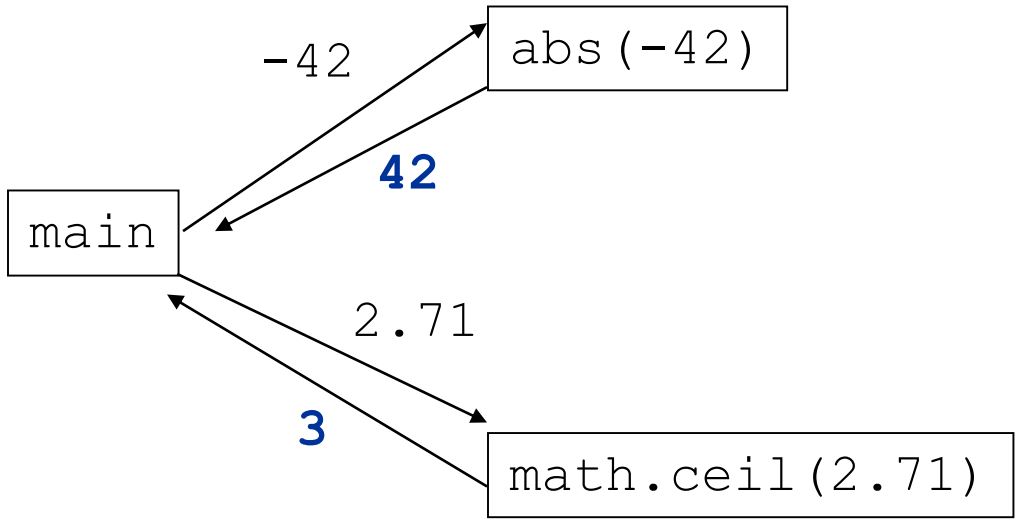
Function name	Description
`abs(`*value*`)`	absolute value
`min(`*value1, value2*`)`	smaller of two values
`max(`*value1, value2*`)`	larger of two values
`round(`*value*`)`	nearest whole number

No output?

- Simply calling these functions produces no visible result.
  - `math.sqrt(81)  # no output`
- Math function calls use a Python feature called *return values* that cause them to be treated as expressions.
- The program runs the function, computes the answer, and then "replaces" the call with its computed result value.
  - `math.sqrt(81)  # no output`
    `9.0  # no output`
- To see the result, we must print it or store it in a variable.
  - `result = math.sqrt(81)`
  - `print(result)  # 9.0`

Return

- **return**: To send out a value as the result of a function.
  - Return values send information *out* from a function to its caller.
    - A call to the function can be used as part of an expression.
  - (Compare to parameters which send values *into* a function)



`Math` questions

- Evaluate the following expressions:
  - `abs(-1.23)`
  - `math.sqrt(121.0) - math.sqrt(256.0)`
  - `round(pi) + round(e)`
  - `math.ceil(6.022) + math.floor(15.9994)`
  - `abs(min(-3, -5))`

- `math.max` and math.`min` can be used to bound numbers.

  Consider a variable named `age`.
  - What statement would replace negative ages with 0?
  - What statement would cap the maximum age to 40?

Why return and not print?

- It might seem more useful for the `math` functions to print their results rather than returning them. Why don't they?

- Answer: Returning is more flexible than printing.
  - We can compute several things before printing:

```
sqrt1 = math.sqrt(100)
sqrt2 = math.sqrt(81)
print("Powers are", sqrt1, "and", sqrt2)
```

  - We can combine the results of many computations:

```
k = 13 * math.sqrt(49) + 5 - math.ceil(17.8)
```

Returning a value

```
def name(parameters):
    statements
    ...
    return expression
```

- When Python reaches a return statement:
  - it evaluates the expression
  - it substitutes the return value in place of the call
  - it goes back to the caller and continues after the method call

Return examples

```
# Converts degrees Fahrenheit to Celsius.
def f_to_c(degrees_f):
    degrees_c = 5.0 / 9.0 * (degrees_f - 32)
    return degrees_c

# Computes triangle hypotenuse length given its side lengths.
def hypotenuse(a, b):
    c = math.sqrt(a * a + b * b)
    return c
```

- You can shorten the examples by returning an expression:

```
def f_to_c(degrees_f):
    return 5.0 / 9.0 * (degrees_f - 32)
```

Common error: Not storing

- Many students incorrectly think that a `return` statement sends a variable's name back to the calling method.

```
def main():
    slope(0, 0, 6, 3)
    print("The slope is", result);  # ERROR: cannot find symbol: result

def slope(x1, x2, y1, y2):
    dy = y2 - y1
    dx = x2 - x1
    result = dy / dx
    return result
```

Fixing the common error

- Returning sends the variable's *value* back. Store the returned value into a variable or use it in an expression.

```
def main():
    s = slope(0, 0, 6, 3)
    print("The slope is", s)

def slope(x1, x2, y1, y2):
    dy = y2 - y1
    dx = x2 - x1
    result = dy / dx
    return result
```

Exercise

- In physics, the *displacement* of a moving body represents its change in position over time while accelerating.
  - Given initial velocity v_0 in m/s, acceleration a in m/s^2, and elapsed time t in s, the displacement of the body is:
  - Displacement = $v_0 t + \frac{1}{2} a t^2$

- Write a method `displacement` that accepts v_0, a, and t and computes and returns the change in position.
  - example: `displacement(3.0, 4.0, 5.0)` returns `65.0`

Exercise solution

```
def displacement(v0, a, t):
    d = v0 * t + 0.5 * a * (t ** 2)
    return d
```

Exercise

- If you drop two balls, which will hit the ground first?
  - Ball 1: height of 600m, initial velocity = 25 m/sec downward
  - Ball 2: height of 500m, initial velocity = 15 m/sec downward

- Write a program that determines how long each ball takes to hit the ground (and draws each ball falling).

- Total time is based on the force of gravity on each ball.
  - Acceleration due to gravity $\cong$ 9.81 m/s^2, downward
  - Displacement = $v_0\, t + \frac{1}{2}\, a\, t^2$

Ball solution

```
# Simulates the dropping of two balls from various heights.
def main():
    panel = DrawingPanel(600, 600)

    ball1x = 100
    ball1y =   0
    v01 = 25
    ball2x = 200
    ball2y = 100
    v02 = 15

 # draw the balls at each time increment
    for time in range(60):
        disp1 = displacement(v01, time/10, 9.81)
        panel.fill_oval(ball1x, ball1y + disp1, ball1x + 10, ball1y + 10 + disp1)
        disp2 = displacement(v02, time/10, 9.81)
        panel.fill_oval(ball2x, ball2y + disp2, ball2x + 10, ball2y + 10 + disp2)

        panel.sleep(50)    # pause for 50 ms
        panel.fill_rect(0, 0, 600, 600, "white")
...
```