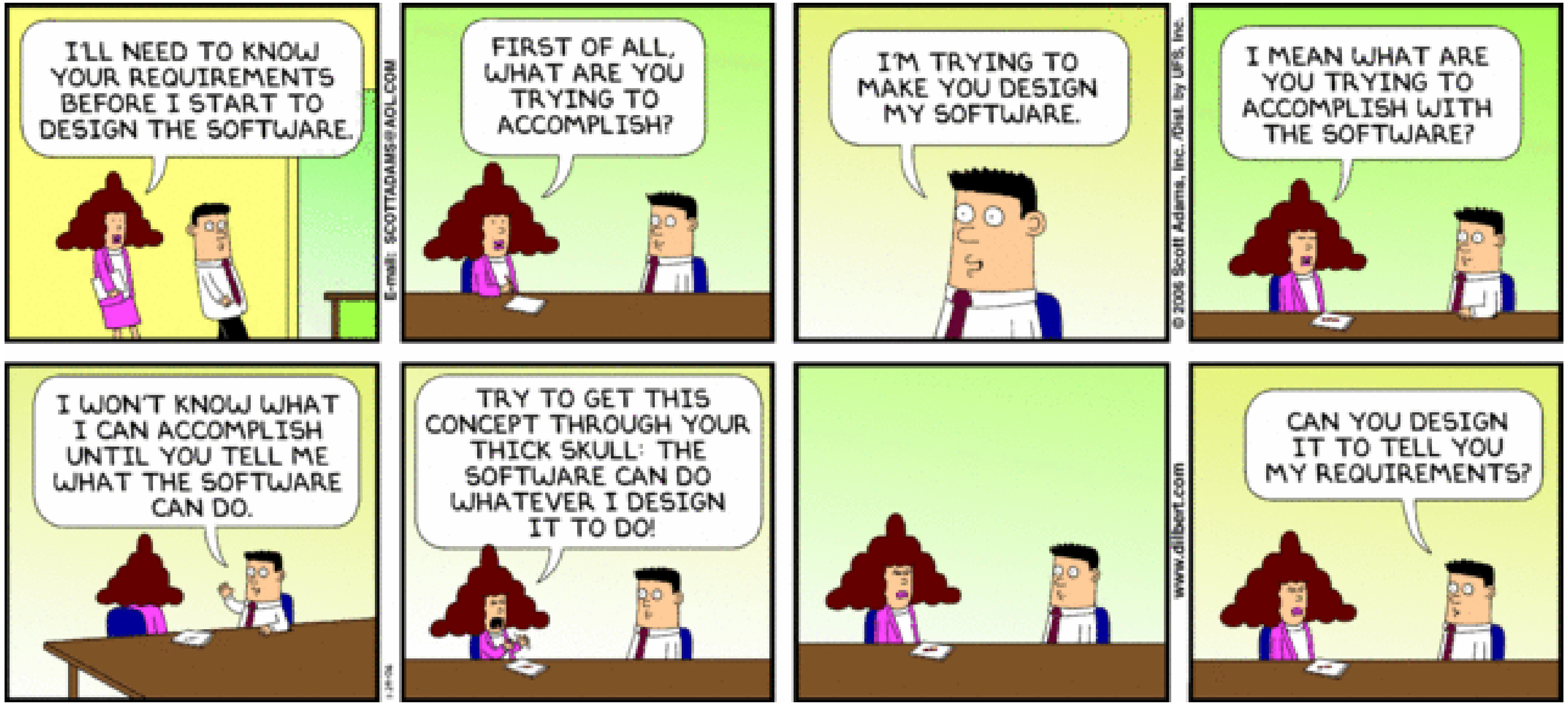
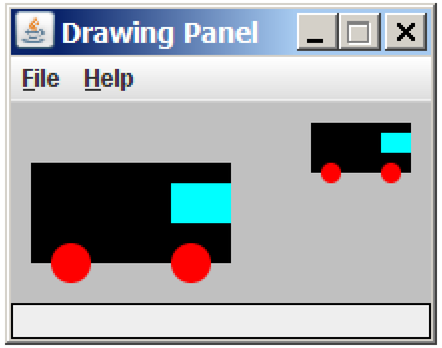
CSc 110, Autumn 2016

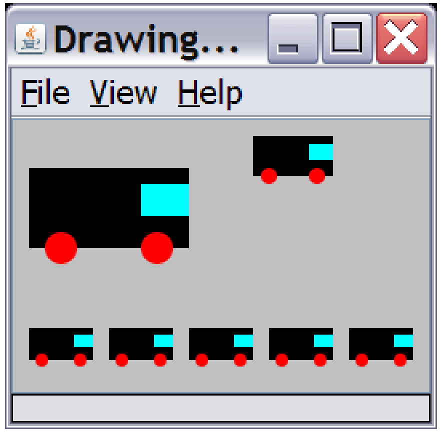
Lecture 8: Return values and `math`



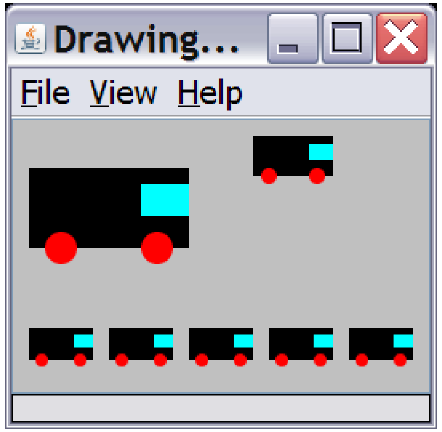
Drawing parameter question

- Modify `draw_car` to allow the car to be drawn at any size.
  - Existing car: size 100. Second car: (150, 10), size 50.
- Once you have this working, use a `for` loop with your function to draw a line of cars, like the picture at right.
  - Start at (10, 130), each size 40, separated by 50px.





Drawing parameter answer




```
def main():
    panel = DrawingPanel(260, 100, background="light gray")
    draw_car(panel, 10, 30, 100)
    draw_car(panel, 150, 10, 50)
    for i in range(0, 5):
        draw_car(panel, 10 + i * 50, 130, 40);

def draw_car(p, x, y, size):
    p.canvas.create_rectangle(x, y, x + size, y + size / 2, fill="black")

    p.canvas.create_oval(x + size / 10, y + size / 10 * 4, x + size / 10 * 3, y +
                         size / 10 * 6, fill="red", width=0)
    p.canvas.create_oval(x + size / 10 * 7, y + size / 10 * 4, x + size / 10 * 9,
                         y + size / 10 * 6, fill="red", width=0)

    p.canvas.create_rectangle(x + size / 10 * 7, y + size / 10, x + size,
                              y + size / 10 * 3, fill="cyan", width=0)
```

Python's `Math` class

Method name	Description
`ceil(`*value*`)`	rounds up
`floor(`*value*`)`	rounds down
`log(`*value, base*`)`	logarithm
`sqrt(`*value*`)`	square root
`sinh(`*value*`)` `cosh(`*value*`)` `tanh(`*value*`)`	sine/cosine/tangent of an angle in radians
`degrees(`*value*`)` `radians(`*value*`)`	convert degrees to radians and back

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

`from math import *` necessary to use the above functions

Other math functions:

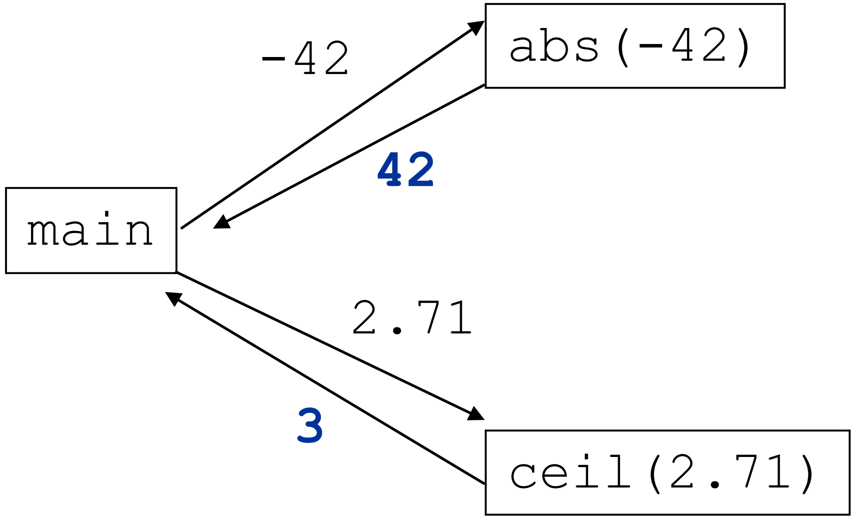
Function name	Description
`abs(`*value*`)`	absolute value
`min(`*value1, value2*`)`	smaller of two values
`max(`*value1, value2*`)`	larger of two values
`round(`*value*`)`	nearest whole number

No output?

- Simply calling these functions produces no visible result.
  - `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.
  - ```
    sqrt(81)         # no output
    9.0              # no output
    ```
- To see the result, we must print it or store it in a variable.
  - `result = 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)`
  - `sqrt(121.0) - sqrt(256.0)`
  - `round(pi) + round(e)`
  - `ceil(6.022) + floor(15.9994)`
  - `abs(min(-3, -5))`

- `max` and `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?

Quirks of real numbers

- Some `float` values print poorly (too many digits).

```
result = 1.0 / 3.0
print(result)          # 0.3333333333333
```

- The computer represents `float`s in an imprecise way.

```
print(0.1 + 0.2)
```

  - Instead of 0.3, the output is `0.30000000000000004`

Type casting

- **type cast**: A conversion from one type to another.
  - To truncate a `double` from a real number to an integer

- Syntax:

  type (expression)

  Examples:

```
result = 19 / 5                 # 3.8
result2 = int(result)           # 3
x = int(sqrt(121))              # 1000
```

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 = 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 " + str(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 = $v_0 t + ½ a t^2$
- 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 ≅ 9.81 m/s^2, downward
  - Displacement = $v_0 t + ½ a t^2$

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(0, 60, 1):
        disp1 = displacement(v01, time/10, 9.81)
        panel.canvas.create_oval(ball1x, ball1y + disp1, ball1x + 10, ball1y + 10 + disp1)
        disp2 = displacement(v02, time/10, 9.81)
        panel.canvas.create_oval(ball2x, ball2y + disp2, ball2x + 10, ball2y + 10 + disp2)

        panel.sleep(50)    # pause for 50 ms
        panel.canvas.create_rectangle(0, 0, 600, 600, fill="white", width=0)
...
```