Readings for Unit 5

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The questions below are due on Sunday July 20, 2025; 10:00:00 PM.

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Portions of these readings were modified or copied verbatim from the very nice book *Think Python 2e* by Allen Downey.

PDF of these readings also available to download: 6s090_reading5.pdf

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1) Introduction

As we have learned throughout the course, functions allow us to abstract away the details of a particular computation so that it can be computed multiple times on different inputs. This week's readings will, first, revisit the details of how Python interprets functions. In particular, we'll focus on the issue of *scoping* (deciding how and where Python looks up variable names). Then, we'll discuss the "first-class" nature of Python functions and other useful features. We'll also discuss some new ways to test our code and how to use external packages.

2) More Functions

To begin, we will step through a complex function example with an environment diagram. This builds upon the things we learned in unit 3's reading, so you may wish to review those now.

2.1) Environment Diagram Review

First, let's walk through the following piece of (admittedly silly) code:

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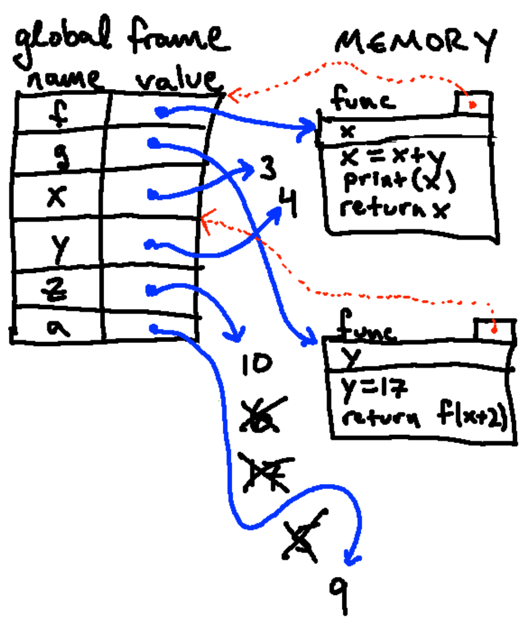
```
def f(x):
    x = x + y
    print(x)
    return x

def g(y):
    y = 17
    return f(x+2)

x = 3
y = 4
z = f(6)

a = g(y)

print(z)
print(a)
print(x)
print(y)
```

Try to use an environment diagram to predict what values will be printed to the screen as this program runs. You can step through our explanation of how this code runs using the buttons below:



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STEP 13

This is our final diagram, where the return value from the call to g is associated with the name a in the global frame.

After executing all of the previous steps, we enter a sequence of print statements. By now, we have printed `10` and `9` already. Now we print `z`, `a`, `x`, and `y`, which have values `10`, `9`, `3`, and `4`, respectively. So all-in-all, we will have printed the following:

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```
10
9
10
9
3
4
```

2.2) A Mystery Program

If you find these diagrams tedious, we get it... In the end, there's a reason we want computers to be the one doing this, after all; they're much better at these operations than we are, and much faster! So, in the short term, this *is* tedious. But the long-term benefits are really great! This kind of practice is helpful in building up a mental model of Python's behavior, which is important so that when you encounter unexpected behavior, you can come back to the model. With practice, this kind of thinking will become second nature, and you won't have to draw these diagrams out in such detail.

To motivate why environment diagrams might be useful, let's look at another example of a *mystery* Python program:

Show/Hide Line Numbers

```
functions = []
for i in range(5):
    def func(x):
        return x + i
    functions.append(func)

for f in functions:
    print(f(12))
```

Without running this code, take a few moments to predict what is going to happen when it is run. Which of the following do you think is going to happen?

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- It prints `12`, then `13`, then ..., then `16`
- It prints `13`, then `14`, then ..., then `17`
- It prints `16`, then `15`, then ..., then `12`
- It prints `17`, then `16`, then ..., then `13`
- A Python error occurs
- Something else

Save Submit View Explanation Clear Answer **100.00%**

As staff, you are always allowed to submit. If you were a student, you would see the following:
You have infinitely many submissions remaining.

Solution: Something else

Now, only once you have made an educated guess above, type this code into your favorite text editor or IDE and run it. Does the result match your expectation?

2.3) Functions Are First-Class Objects

We now shift gears to learn about a powerful feature of Python: that it treats functions as first-class objects, which means that functions in Python can be manipulated in many of the same ways that other objects can be (specifically, they can be passed as arguments to other functions, defined inside of other functions, returned from other functions, and assigned to variables). In this section, we will explore how we can make use of this feature in our programs.

2.3.1) Function Names are Variable Names

In a previous unit, we encountered the `round` function that can round a number to a given number of decimal places. For example:

```
x = int(4.999)  # int always rounds down
y = round(4.5)  # round will round up or down
print(x, y) # 4 5
```

But what would happen if we took away the parentheses and didn't call the function?

```
r = round
print(r) # <built-in function round>
print(r(2.4))  # 2
```

It turns out that we can assign multiple variable names to the same function object in memory. The code above makes `r` and `round` aliases to the same built-in function object. This allows us to call `r` just like `round`. This is also the idea behind passing functions in as arguments to function calls, as we will see in the next section.

2.3.2) Functions as Arguments

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Imagine that you wanted to make plots of several different functions. To do that, you would need to figure out which "y" values correspond to each of a number of "x" values. The following code computes these "y" values for different functions:

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```
import math

def sine_response(lo, hi, step):
    y_vals = []
    x = lo
    while x <= hi:
        y_vals.append(math.sin(x))
        x += step
    return y_vals

def cosine_response(lo, hi, step):
    y_vals = []
    x = lo
    while x <= hi:
        y_vals.append(math.cos(x))
        x += step
    return y_vals

def double_response(lo, hi, step):
    y_vals = []
    x = lo
    while x <= hi:
        y_vals.append(x * 2)
        x += step
    return y_vals

def square_response(lo, hi, step):
    y_vals = []
    x = lo
    while x <= hi:
        y_vals.append(x**2)
        x += step
    return y_vals

if __name__ == "__main__":
    print(sine_response(0, math.pi/2, math.pi/8))
    # [0.0, 0.3826834323650898, 0.7071067811865476, 0.9238795325112867, 1.0]
    print(cosine_response(0, math.pi/2, math.pi/8))
    # [1.0, 0.9238795325112867, 0.7071067811865476, 0.38268343236508984, 6.123233995736766e-17]
    print(double_response(0, 2, .5))
    # [0, 1.0, 2.0, 3.0, 4.0]
    print(square_response(0, 2, .5))
```

```
    # [0, 0.25, 1.0, 2.25, 4.0]
```

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Now imagine that instead of just wanting a list of y-values, you wanted these functions to return two lists, one to represent the x-values, and one to represent the y-values. Making this change or changing anything at all about this program would be a pain because you would have to manually change *each* of the above functions.

One way to make changing a program easier is to write it in a way that avoids repetition. After all, `sine_response`, `cosine_response`, `double_response`, and `square_response` are almost exactly the same, except for how the y-values get calculated. It would be nice if instead of four functions we could write a single function that could use different equations.

It turns out, we can cut down on a lot of this repetition by creating a more general function called `response`, which takes in a function `f` in addition to the other inputs.

```
def response(f, lo, hi, step):
    y_vals = []
    x = lo
    while x <= hi:
        y_vals.append(f(x))
        x += step
    return y_vals
```

Notice that, inside of the definition of `response`, we call `f`, the function that was passed in as an argument. Using `response`, we could compute the same y-values as the `sine_response` function as follows:

```
# These two compute the same response!
y1 = sine_response(0, math.pi/2, math.pi/8)
print(y1) # [0.0, 0.3826834323650898, 0.7071067811865476, 0.9238795325112867, 1.0]
y2 = response(math.sin, 0, math.pi/2, math.pi/8)
print(y2) # [0.0, 0.3826834323650898, 0.7071067811865476, 0.9238795325112867, 1.0]
```

When we pass in `math.sin` as an argument, we do not put parentheses after it. This is because we want to refer to the function itself (which is called `math.sin`), and not to any particular output of the function (which we'd get by calling it, such as in `math.sin(7)`).

Try Now:

Would the following code output the same values for `y1` and `y2`?

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```
y1 = double_response(0, 2, 0.5)
print(y1)
y2 = response(2 * x, 0, 2, 0.5)
print(y2)
```

Show/Hide

Running the program results in the following output:

```
y1 = double_response(0, 2, 0.5)
print(y1)  # [0, 1.0, 2.0, 3.0, 4.0]
y2 = response(2 * x, 0, 2, 0.5)
print(y2)  # NameError: name 'x' is not defined
```

While this was a valiant attempt, it results in a `NameError` because `x` is not defined. Furthermore, `2 * x` is an expression (not a function!), so even if `x` was a variable, we would get a different error:

```
x = 5
y2 = response(2 * x, 0, 2, 0.5)  # TypeError: 'int' object is not callable
print(y2)  # The program does not execute this line because of the error
```

This runtime error is caused because passing in `2 * x` evaluates to `10`, which is then the value associated with `f` in the frame where the call to `response` is running. When `f(x)` is called as part of the line `y_vals.append(f(x))`, a `TypeError` is raised because the value of `f` is `10` which cannot be called!

The program below shows the same error:

```
x = 5
f = x * 2
print(f(x))  # equivalent to print(10(x))
# TypeError: 'int' object is not callable
```

We can recreate the behavior of `double_response` with `response` by creating a *function* to double individual values:

```
def double(x):
    return 2 * x
```

```
y1 = double_response(0, 2, 0.5)
print(y1)  # [0, 0.5, 1.0, 1.5, 2.0]
y2 = response(double, 0, 2, 0.5)   # note double is passed in without using ()!
print(y2)  # [0, 0.5, 1.0, 1.5, 2.0]
```

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Try Now:

How could we re-write the entire original program in terms of the `response` function?

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Rewriting the program in terms of `response` allows us to go from 43 to 25 lines of code. Also, if we want to change the output we only have to modify one function instead of four.

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```
import math

def response(f, lo, hi, step):
    y_vals = []
    x = lo
    while x <= hi:
        y_vals.append(f(x))
        x += step
    return y_vals

def double(x):
    return 2 * x

def square(x):
    return x ** 2

if __name__ == "__main__":
    print(response(math.sin, 0, math.pi/2, math.pi/8))
    # [0.0, 0.3826834323650898, 0.7071067811865476, 0.9238795325112867, 1.0]
    print(response(math.cos, 0, math.pi/2, math.pi/8))
    # [1.0, 0.9238795325112867, 0.7071067811865476, 0.38268343236508984, 6.123233995736766e-17]
    print(response(double, 0, 2, .5))
    # [0, 1.0, 2.0, 3.0, 4.0]
    print(response(square, 0, 2, .5))
    # [0, 0.25, 1.0, 2.25, 4.0]
```

2.4) Understanding the Mystery Program

Earlier, we looked at the following piece of code as an example of code that is difficult to understand:

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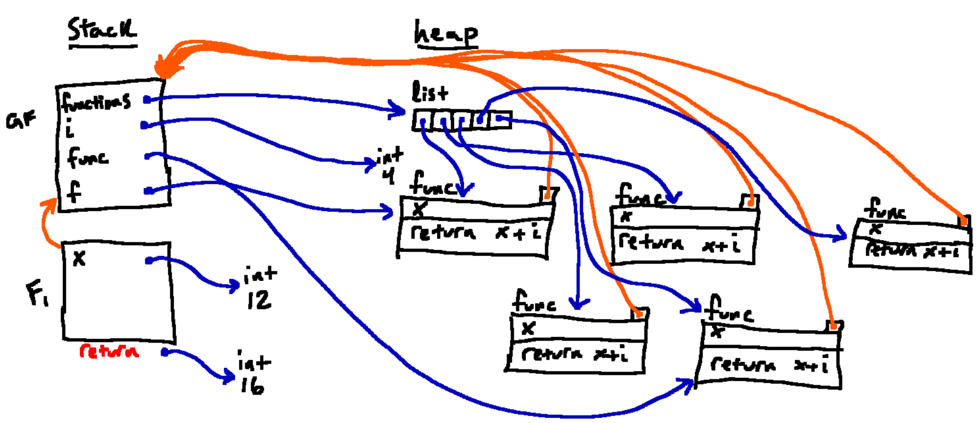
```
1 functions = []
2 for i in range(5):
3     def func(x):
4         return x + i
5     functions.append(func)
6
7 for f in functions:
8     print(f(12))
```

It is somewhat surprising that, despite the looping structure here, when we run this code, we see five `16`'s printed to the screen! Despite the surprising nature of this example, though, we now have all of the tools we need in order to make sense of this example and to understand *why* it behaves the way it does. We'll walk through an environment diagram to explain this behavior, and you're strongly encouraged to follow along (and to reach out for help if any of the steps are unclear!).

We'll start by drawing the diagram just for the first segment of the code (lines 1-5, where we are building up the `functions` list). Again, we encourage you to try to stay one step ahead of the drawings below (that is, try to draw out how things will change during each step, then click ahead and compare your work against our diagram).



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Looking up `x` inside of **F1**, we find the `12` that is bound locally. But `i` is *not* bound locally. So what do we do? We follow the parent pointer, and we *do* find the name `i` in the global frame. It references a value of `4` for `i`, so that's what we'll use.

Then we add those two values together to get a new `int` object representing `16`, which we return.

We'll stop here with the diagram, but note that this result would have been the same regardless of which of these function objects we called. None of them remembers the value that `i` held when it was created; they all simply say to look up the *current* value of `i` and add it to their inputs! So as we continue to loop and call each of these function objects in turn, they all produce the same output!

2.5) Default and Keyword Arguments

For functions we've seen so far, we indicate the arguments by positions. For example, with this function:

```python
def percent(num, total):
    if not total:
        # avoid divide by 0 errors
        return f'0?'
    else:
        return f'{(num / total):.1%}'

print(percent(7, 0))  # 0?
print(percent(7, 11)) # 63.6%
```

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When we call `percent(7, 11)`, python knows that `num` should be `7` and `total` should be `11` because that's the order we defined the arguments to come in.

However, there is another way to pass in arguments, using the name instead of the position. For example, we write the argument name, an equal sign, and the value we want it to take on.

```python
print(percent(total=11, num=7)) # this would still print '63.6%'
```

Finally, there's a way to specify a function to have *optional* arguments. We signify these arguments with a variable name as usual, but we also add an equal sign and a default value. For example, if we wanted our function to have the option of adding the fraction in addition to the percent, we could add the optional argument `verbose`.

```python
def percent(num, total, verbose=False):
    extra = ''
    if verbose:
        extra = f' ({num}/{total})'

    if not total:
        # avoid divide by 0 errors
        return f'0?{extra}'
    else:
        return f'{(num / total):.1%}{extra}'
```

Note that we can still call `percent` like we did before. If we don't specify a value for `verbose` it will be `False` by default as we indicated in the function definition.

```python
print(percent(7, 11))  # prints 63.6%
```

But we can also specify a value for `verbose`. For example:

```python
print(percent(7, 11, verbose=False)) # 63.6%
print(percent(7, 11, verbose=True))  # 63.6% (7/11)
```

It's common practice to use keyword specification for optional arguments because if there are multiple default arguments, it's not immediately clear which ones are being set. For example, we can add another default argument to change the number of digits to round the percentage to as follows:

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```
def percent(num, total, n=1, verbose=False):
    extra = ''
    if verbose:
        extra = f' ({num}/{total})'

    if not total:
        # avoid divide by 0 errors
        return f'0?{extra}'
    else:
        return f'{(num / total):.{n}%}{extra}'


print(percent(7, 11)) # 63.6%
print(percent(7, 11, n=5)) # 63.63636%
print(percent(7, 11, n=0, verbose=True)) # 64% (7/11)
```

It turns out that default arguments are what allow some of the built-in functions like `round` to take in different numbers of arguments, as we saw in unit 3's readings.

3) Assert statements

So far, we have debugged and tested our programs mainly with print statements. However, Python comes with additional tools to help us test whether our code actually does what we intend.

Assert statements check a conditional statement. If the statement evaluates to True, the program continues as normal, but if it evaluates to False an AssertionError will be raised and stop the program.

```
>>> assert 5 > 4 # evaluates to True, does nothing
>>> assert 5 < 4
...
AssertionError
```

For example, we could test the `add_s` function below with assert statements with the following code:

```
def add_s(words):
    """
    Given a list of words, output a new list of words with s added to
    the end without modifying the input.
    """
    new_words = []
    for word in words:
        new_words.append(word + "s")
    return new_words

if __name__ == '__main__':
    assert add_s(['can', 'add', 's']) == ['cans', 'adds', 'ss']
    assert add_s(['']) == ['s']
```

```
    assert add_s([]) == []
    print("done testing")
```

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While this program only prints `done testing`, it also silently checks that the output matches what we expect, saving us from the hassle of manually checking whether the printed output is correct or not.

We can optionally add a string at the end of the assert statement to provide a more descriptive error message:

```
x = 5
y = 4
assert y > x, f'{y=} is not greater than {x=}!'
# AssertionError: y=4 is not greater than x=5!
```

We can also use assert statements within functions to check that the input is valid. For example:

```
def square(num):
    assert type(num) == float or type(num) == int, f"Expected float or int, got {num} which is a
{type(num)}."
    return num ** 2

print(square(5))
print(square("uh oh"))
```

Outputs:

```
25
...
AssertionError: Expected float or int, got uh oh which is of <class 'str'>.
```

4) `import` statements

So far, we have explored a number of features that are built-in to Python. But sometimes, we want to split a large program into multiple smaller files or use a package that someone else wrote without having to manually copy and paste all of their code into our program. `import` statements are useful for exactly these kinds of situations.

For example, earlier we saw `import math` as part of our `response` program. This finds and imports a module called `math`, which becomes a variable in our program. To use the constant `pi` or the `sin` function which are defined within `math`, we need to use dot notation as follows:

```
import math
print(math)     # <module 'math' (built-in)>
print(math.pi)  # 3.141592653589793
print(math.sin) # <built-in function sin>
print(pi)       # NameError: name 'pi' is not defined
```

It turns out, the `math` module contains quite a number of things, which we can see using the `dir` command.

```
import math
print(dir(math))
"""
['__doc__', '__loader__', '__name__', '__package__', '__spec__', 'acos', 'acosh', 'asin', 'asinh', 'atan',
'atan2', 'atanh', 'cbrt', 'ceil', 'comb', 'copysign', 'cos', 'cosh', 'degrees', 'dist', 'e', 'erf', 'erfc',
'exp', 'exp2', 'expm1', 'fabs', 'factorial', 'floor', 'fma', 'fmod', 'frexp', 'fsum', 'gamma', 'gcd',
'hypot', 'inf', 'isclose', 'isfinite', 'isinf', 'isnan', 'isqrt', 'lcm', 'ldexp', 'lgamma', 'log', 'log10',
'log1p', 'log2', 'modf', 'nan', 'nextafter', 'perm', 'pi', 'pow', 'prod', 'radians', 'remainder', 'sin',
'sinh', 'sqrt', 'sumprod', 'tan', 'tanh', 'tau', 'trunc', 'ulp']
"""
```

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We can avoid using `math.` and selectively import only what we want to use with `from PACKAGE import THING1, THING2, ...` as follows:

```
from math import pi, sin
print(pi)    # 3.141592653589793
print(sin)   # <built-in function sin>
print(math)  # NameError: name 'math' is not defined. Did you forget to import 'math'?
```

Or we can avoid using `math.` and import everything using `from PACKAGE import *` as follows:

```
from math import *
print(pi)    # 3.141592653589793
print(sqrt)  # <built-in function sqrt>
print(math)  # NameError: name 'math' is not defined. Did you forget to import 'math'?
```

Programmers like to use short abbreviations, especially for commonly imported modules like `pandas` (`pd`), `numpy` (`np`), and `matplotlib.pyplot` (`plt`). We can import a package and give it a different name with `import LONG_PACKAGE as PACKAGE`:

```
import pandas as pd
print(pd) # <module 'pandas' from SOME/LONG/FILE/PATH/__init__.py>
print(pandas) # NameError: name 'pandas' is not defined
```

This is essentially the same as importing a package and then re-naming it without needing to use two different variable names:

```
import pandas
pd = pandas
print(pd)     # <module 'pandas' from SOME/LONG/FILE/PATH/__init__.py>
print(pandas) # <module 'pandas' from SOME/LONG/FILE/PATH/__init__.py>
```

As we have seen, `import` statements can take many different forms. When in doubt, a plain `import PACKAGE` statement will usually work. If you are interested in learning more about how Python modules work, see the official Python documentation here. If you want to learn more about the difference between a module and a package, see the StackOverflow post here.

Now that we know how `import` statements work, we can explore some of exciting functionality we can get from importing `matplotlib.pyplot` to generate graphs and importing the `csv` module to read and write `.csv` files.

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5) Generating Graphs with matplotlib

The `matplotlib.pyplot` module provides a number of useful functions for creating plots with Python. In this section we'll go over a few examples of how to generate different plots.

To import the `pyplot` module, add the following to the top of your script:

```
import matplotlib.pyplot as plt
```

Once you have done so, you can make a new plot by calling `plt.figure()` with no arguments. After that, you can use various functions to add data to the figures. When you are ready, calling the `plt.show()` function with no arguments will cause `matplotlib` to open windows displaying the resulting graphs. You can also add a legend and/or a title to the plot, as well as labels to the axes, as shown in the example below.

The following code will cause four windows to be displayed. Try running the code below on your own machine to see the results. Notice that the `plt.show()` function does not return until the plotting windows are closed.

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```
import matplotlib.pyplot as plt
import numpy as np

# here we plot a set of "y" values only; these are associated automatically
# with integer "x" values starting with 0.
plt.figure()
plt.plot([9, 4, 7, 6])

# if given two arguments, the first list/array will be used as the "x" values,
# and the second as the associated "y" values
plt.figure()
plt.plot([10, 9, 8, 7], [1, 2, 3, 4])
plt.grid()  # this adds a background grid to the plot

# we can also create scatter plots.  scatter plots require both "x" and "y"
# values.
plt.figure()
plt.scatter([10, 25, 37, 42], [12, 28, 5, 37], label='scatter')
# multiple calls to plt.plot or plt.scatter will operate on the same axes
plt.plot([10, 40], [5, 20], 'r', label='a line') # the 'r' means 'red'
plt.plot([5, 9, 15, 30], [10, 20, 30, 35], 'k', label='more data')
plt.legend()


plt.figure()

# generates 250 random points using a normal distribution
# with a mean of 170 and standard deviation of 10
```

```
x = np.random.normal(170, 10, 250)
plt.hist(x, bins=20, alpha = .5) # 20 bins, 50% transparency
plt.hist(np.random.normal(185, 10, 250), alpha = .5)
plt.title('A Histogram example')
plt.xlabel('A label for x')
plt.ylabel('The vertical axis')
plt.show()


# finally, display the results
print('Showing Graphs')
plt.show()
# Note that all figures need to be closed before the program prints Done
print('Done')
```

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Using our graphing skills, we can now finally plot the graphs of the functions we defined earlier:

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```
# Generally import statements go at the top of the Python file,
# organized in alphabetical order
import math
import matplotlib.pyplot as plt

def response(f, lo, hi, step):
    x_vals = []
    y_vals = []
    x = lo
    while x <= hi:
        x_vals.append(x)
        y_vals.append(f(x))
        x += step
    return x_vals, y_vals

def double(x):
    return 2 * x

def square(x):
    return x ** 2

if __name__ == "__main__":
    sinx, siny = response(math.sin, 0, 5, 0.1)
    cosx, cosy = response(math.cos, 0, 5, 0.1)
    doublex, doubley = response(double, 0, 5, 0.1)
    squarex, squarey = response(square, 0, 5, 0.1)

    plt.figure()
    # connected line
    plt.plot(sinx, siny, label='sin')
    plt.plot(cosx, cosy, label='cos')
    # scattered points
    plt.scatter(doublex, doubley, label='double', color='orange', marker='o')
```

```
    plt.scatter(squarex, squarey, label='square', color='green', marker='s')
    # axes and title
    plt.title('A final example')
    plt.xlabel('A label for x')
    plt.ylabel('The vertical axis')
    plt.legend()
    plt.show()
    # display to screen -- remember to exit the graph to finish the program
    print("done")
```

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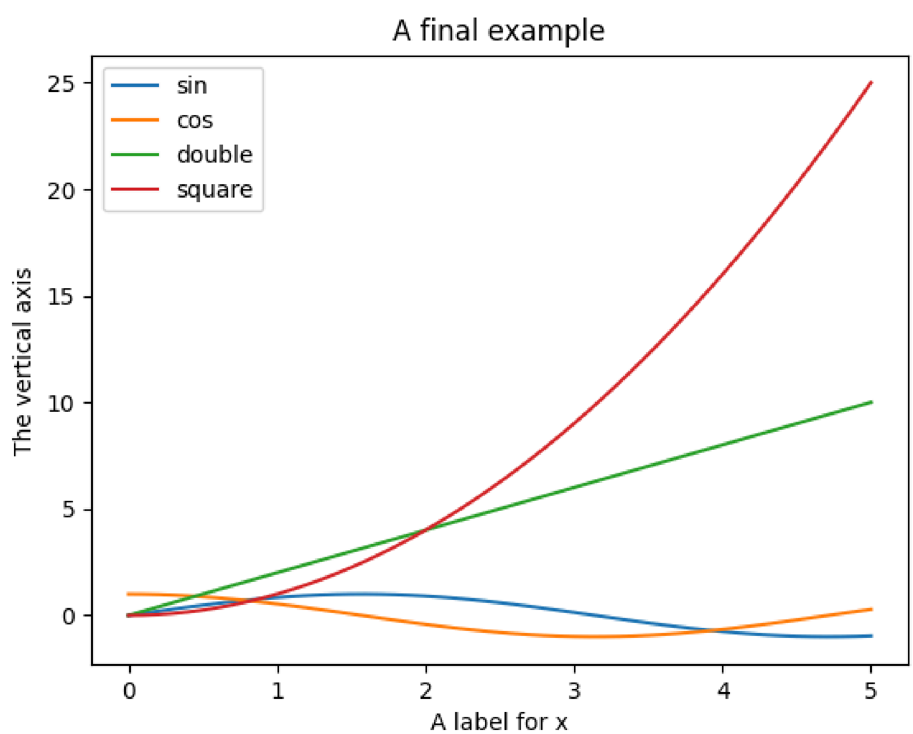
Running the code above will produce a graph like the one below:



6) Reading and Writing csv Files

Finally, let's talk about one more useful built-in module.

Sometimes the input to your program might be stored in a file. For example, if I am writing a program to process items in my grocery list, and my grocery list lives in a comma-separated values file called grocery_list.csv, it'd be convenient if my program could access the contents of that file. Python can do just that!

The first thing to do in order to use a file is to *open* it. This is done by invoking the built-in function `open`

We can open a file in different modes, like read mode or write mode. Since we're just reading from the file for now, we'll tell that to the function `open` by writing the string `'r'`. If my grocery_list.csv file is in the same directory as my Python program[1], I can write

```
opened_file = open("grocery_list.csv", "r")
```

`opened_file` is now an object. With `opened_file` in hand, we can use the csv module to read the file contents.

We must tell Python that we plan to use it by writing `import csv` at the top of our file. Then we can create a reade[r by] calling a function `reader` which the `csv` module makes available to us. Our code is now:

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```
import csv

opened_file = open("grocery_list.csv", "r")
reader = csv.reader(opened_file)
```

`reader` is an object that allows for iteration. We can print out all the rows in the file, which the reader stores as lists of strings, by looping:

```
for row in reader:
    print(row)
```

For a few reasons[2] (which admittedly aren't likely to be critical for us), if we open a file, we should close it as well, after we're done with it:

```
opened_file.close()
```

Since it's very easy to forget to close a file, Python has some great syntactic sugar which automatically does it for us. We can create a `with/as` block, inside of which the opened file will be open, but outside of which it is automatically closed.

The block doesn't explicitly use the `=` assignment operator to set the `opened_file` variable, but it still gives `opened_file` the same value as before.

Our final program would look like this:

```
import csv

with open("grocery_list.csv", "r") as opened_file:
    reader = csv.reader(opened_file)
    for row in reader:
        print(row)
```

Try Now:

Below is an example grocery list and the Python code we just wrote. Save them into the same directory, and run `read.py` to see the printed list output. Experiment with what happens if you add more columns to the CSV file.[3]

grocery_list.csv

read.py

Try Now:

What do you expect to be printed if we run the following code, which just repeats the printing for loop? Try i Back to Top check.

```
import csv

with open("grocery_list.csv", "r") as opened_file:
    reader = csv.reader(opened_file)
    for row in reader:
        print(row)
    for row in reader:
        print(row)
```

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The reason you get this unexpected result is subtle. The relevant mental model is that the `reader` object is a sort of one-directional pointer inside the file. That is, it starts at the beginning of the file when you open it, and it advances forward row by row when it is looped over, but it does not automatically go back to the beginning. If you wish to use data in a file multiple times, a good approach is to store the data from the reader into a variable (likely a list or other sequence) just once, then manipulate the data stored in that variable, instead of going back to the file directly to get the data again:

```
import csv

data_rows = []
with open("grocery_list.csv", "r") as opened_file:
    reader = csv.reader(opened_file)
    for row in reader:
        data_rows.append(row)

# Can now use data_rows multiple times
```

Try Now:

As an exercise, try to write code that will read in the grocery_list.csv file and create a dictionary that maps the Back to Top of the item to the integer quantity of the item (not including the first row).

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This can be accomplished with the following code:

```
import csv

groceries = {}

with open("grocery_list.csv", "r") as opened_file:
    csv_reader = csv.reader(opened_file)
    for row in csv_reader:
        if row[1] != "Quantity":
            groceries[row[0]] = int(row[1])
            # note all values are read as strings. If we want a value we
            # read to be treated as a number, we need to cast it to an
            # int or a float!


print(groceries)
```

Now let's say we wanted to add something to our grocery list, like oranges. While we could append this to our `data_rows` while running our program, this would not actually change the grocery_list.csv file. Luckily, Python also allows us to write to files. Check out the write.py file below, which does just that:

```
import csv

data_rows = []
with open("grocery_list.csv", "r") as opened_file:
    reader = csv.reader(opened_file)
    for row in reader:
        data_rows.append(row)

data_rows.append(['Oranges', 3])

# make a new grocery list file
with open('new_grocery_list.csv', 'w', newline='') as csvfile:
    writer = csv.writer(csvfile, delimiter=',')
    for row in data_rows:
        writer.writerow(row)
```

Note how when we make the new grocery list, we opened the file in 'w' or write mode. Instead of using the csv library to read the file, now we create an object that can write individual rows one at a time. Note that each row is a lists of values, where each element represents the value of a single column.

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For more information on the csv library, see the Python documentation.

While working with spreadsheets directly can often be useful, as we'll see in the exercises, using Python to do data analysis can allow us to more easily analyze large amounts of data, especially when it is in a raw or unprocessed format.

7) Summary

In this set of readings, we revisited the details of how Python invokes functions. We also learned the ways in which Python functions are *first-class objects*. They can be treated just like any other objects in Python: among other things, they can be passed as arguments to functions and can be returned as the result of other functions! We saw `assert`, which can be used to test programs. And we explored import statements and python packages such as `matplotlib`, `math`, and `csv` which can be used to generate graphs and read and write CSV files.

In next week's readings, we'll investigate one way to *use* functions: recursion. And we'll talk about strategies for designing large programs.

Footnotes

[1] If the files were *not* in the same directory, we may need to give a lengthier absolute path to the grocery_list.csv file, so Python knew where to look for it.

[2] Some of those reasons: there could be limits on the number of files you can open at a time, opened files might not be accessible elsewhere, file changes (if we were writing, not reading) might not go into effect until the file is closed, open files can slow down your program, and it's just cleaner programming.

[3] Note this is not my actual grocery list; this part of the reading was written by a previous instructor.