Lab A: Using Python as a Calculator

2020 Summer — Calculus 1

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A1. If you are reading this as a PDF,
open the live notebook remotely on Binder here (https://mybinder.org/v2/gh/mattsunderland/pycalclab/master)

# Jupyter Notebooks

A2. Click the gray "code cell" below and press **SHIFT+RETURN** to "run" it.
Notice only the last result displays.
Click the cell again and press **ESCAPE,r,y** to clear the output.

In [ ]:
```
1 + 2 + 3
50 - 3
100*5
```

A3. Run the following.
Notice we use a **comma** to display multiple results.

In [ ]:
```
25*3, 100 - 1
```

A4. Click this cell (once) and press "+" on the toolbar to **add a cell.**
Click the new cell and press "⌗ " on the toolbar to **delete the cell.**
Then go to Edit > Undo Delete Cells.

In [ ]:
```

```

A5. Click the cell below, press "Code" on the toolbar, **select "Markdown."**
Press SHIFT+RETURN to "render" the markdown cell.
Double click to type more.

In [ ]:
```
The **quadratic** formula is $ax^2 + bx + c$.

_Type something here._
```

# Python arithmetic + - * / **

**A6 Exercise.** Run the following cell, then answer the following questions.
a) What does each of the 5 arithmetic operations do?
b) Do spaces around the 5 operations matter, or is it just style?

In [ ]:
```
3 + 10*5,  5**2,  27/10
```

a) *Fill in the blank*

\+ is addition.
\- is
* is
/ is
** is

b) *Type your answer here*

# Python # and =

A7. Run the following.
Notice python ignores everything after #

In [ ]:
```
# This is a comment
1 + 1 # This is also a comment
```

A8. Run the following.
Notice we assign variables using =
Assignment does not produce output.

In [ ]:
```
a = 10
a
```

In [ ]:
```
b = 20
```

In [ ]:
```
a = 18
b = 21
c = a - b
c
```

A9. Run the following.
Notice you can assign multiple variables at once with **a comma.**

In [ ]:
```
x, y = 100, 500
x
```

**A10 Exercise.** What would be the output of the commands

```
a,b,c = 3,4,5
a + b/c
```

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

A11. Run the following.
Notice that the two cells do the same computation.
The first cell we compute all at once;
the second cell we assign variables to help us out.

In [ ]:
```
(2 - 3)*-3/(-1 + 2)
```

In [ ]:
```
top = (2 - 3)*-3
bottom = -1 + 2
top/bottom
```

**A12 Exercise.** Assign variables to help you compute $3 - \frac{3^2-2\cdot 3}{2\cdot 3-2}$

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

# Order of Operations

A13. Run the following.
Notice $a - b * c$ equals $a - (b * c)$,
but $(a - b) * c$ is different.

In [ ]:
```
a,b,c = 3,4,5

a - b*c,  a - (b*c),  (a - b)*c
```

**A14 Exercise.** In each row, identify the one that is not equivalent to the other two.

```
(a) a*(b - c)      (b) (a*b) - c      (c) a*b - c
(a) a/b + c        (b) a/(b + c)      (c) (a/b) + c
(a) (a + b)/c      (b) a + (b/c)      (c) a + b/c
```

*Type your answers here:*

**A15 Exercise.** In each row, identify the one that is not equivalent to the other two.

```
(a) a**(b*c)      (b)  (a**b)*c      (c)  a**b*c
(a) a*(b**c)      (b)  a*b**c        (c)  (a*b)**c
(a) a/b**c        (b)  (a/b)**c      (c)  a/(b**c)
(a) a**b/c        (b)  (a**b)/c      (c)  a**(b/c)
```

*Type your answers here:*

**A16 Exercise.** In each row, identify the one that is not equivalent to the other two.

```
(a)  (3 - 3) - 3  (b)  3 - 3 - 3     (b)  3 - (3 - 3)
(a)  (2**3)**2    (b)  2**(3**2)     (b)  2**3**2
(a)  6/3/2        (b)  6/(3/2)       (b)  (6/3)/2
```

*Type your answers here:*

**A17 Exercise.** We can illustrate the order of the 2 operations in `a + b + c` using 2 sets of parentheses

```
((a + b) + c)
```

Illustrate the 4 operations in `7 - 3**2/9 + 4` using 4 sets of parentheses

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

Double-click here to see the answer.

**A18 Exercise.** Assign `a,b,c = 4,5,8` and then evaluate $\frac{a^b-c/b}{c-a}$, $\frac{a^{c-b}}{c-b}$, $\frac{a^{3/2}}{b}$, $\frac{a-b(c-a)}{c-a}$

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

# Making python functions

A19. Run the following.

In [ ]:
```
def f(x):
    return x**2

f(7)
```

In [ ]:
```
def g(n): return n + 100

g(7)
```

**A20 Exercise.** Make the function $P(x) = x^2 - 2x + 1$ and find $P(P(7))$.

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

# Numpy builtin functions via `%pylab`

| Python | Math notation | Meaning |
|---|---|---|
| `abs(x)` | $\|x\|$ | absolute value |
| `sqrt(x)` | $\sqrt{x}$ | square root |
| `exp(x)` | $e^x$ | exponential function |
| `log(x)` | $\ln x$ | natural logarithm |
| `sin(x)` | $\sin x$ | sine |
| `arcsin(x)` | $\sin^{-1} x$ | inverse sine |

A21. Run the following. The command `%pylab` loads the numerical calcuation package `numpy` and the graphing package `matplotlib`, which come included when you install python via Anaconda (see A40).

In [ ]:
```
%pylab

sqrt(49)
```

In [ ]:
```
pi, exp(1)
```

In [ ]:
```
x = pi/3
tan(x),  sin(x)**2 + cos(x)**2
```

A22. Run the following.
Notice the question mark `?` pulls up documentation.

In [ ]:
```
sqrt?
```

**A23 Exercise.** Evaluate $\sin 40^\circ, \sin^2 65^\circ, e^{(10-8.5)/3}, \arcsin(\sin(3\pi/4))$ Note. Python uses radians for all angle measurements, so you need to convert any degrees to radians.

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

# Numpy Arrays with `r_[ ]`

A24. Run the following.
(If you get an error, go back and run A27.)
The numpy function `r_[ ]` can make an array of numbers of your choice.
We will use arrays to graph in Lab B.

In [ ]:
```
x = r_[0, pi/6, pi/4]
cos(x)
```

In [ ]:
```
x = r_[1,2,5,10]
x**2
```

**A25 Exercise.** Use `r_[ ]` to store the numbers 2,3,5 in an array named `x` . Find `x+x` and `x*x` .

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

# Numpy Arrays with `r_[a:b:stride]`

A26. Run the following.
In general, `r_[a:b]` will list integers **from $a$ up to but *not* including $b$.**
A missing $a$ is the same as 0.

In [ ]:
```
r_[-10:10]
```

In [ ]:
```
r_[:5]
```

**A27 Exercise.** Use `r_[a:b]` to make the array 1,2,3,4,5,6,7,8,9?

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

A28. Run the following. In general, `r_[a:b:stride]` spaces out your numbers by the amount `stride` .

In [ ]:
```
r_[0:100:2]
```

**A29 Exercise.** Use `r_[a:b:stride]` to make the arrays $1, 3, 5, \ldots, 99$ and then $10, 20, 30, \ldots, 100$.

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

In [ ]:
```

```

# Numpy arrays with `linspace(a,b,n)`

A30. Run the following.

In general, `linspace(a,b,n)` lists **n numbers from a to b inclusive.**
This is useful for generating a lot of evenly-spaced numbers, such as when graphing (Lab B).
A missing $n$ is the same as 50.

In [ ]:
```
linspace(0,10,6)
```

In [ ]:
```
linspace(0,10)
```

**A31 Exercise.** Use `linspace(a,b,n)` to make the array $1, 1.5, 2, 2.5, 3, 3.5, 4$

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

**A32 Exercise.** What is the last value output by the command `linspace(0,pi)`

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

# Celsius and Fahrenheit

**A33 Exercise.** To convert between Celsius, Fahrenheit we use $F = 9/5C + 32$ and $C = 5/9(F - 32)$.
Convert room temperature $68^\circ F$ and average body temperature $98.6^\circ F$ to Celsius.

In [ ]:
```
# Type your answer below and press SHIFT+ENTER
```

A34. Run the following.
Notice that `x` and `y` are arrays,
`r_[[x,y]]` puts them into a table,
and `.T` transposes the table.

In [ ]:
```
x = r_[:10]
y = x**2
r_[[x,y]]
```

In [ ]:
```
x = r_[:10]
y = x**2
r_[[x,y]].T
```

**A35 Exercise.**
Use `r_` to make an array of Fahrenheit values `x` $= -100, -80, -60, \ldots, 100$.
Make the corresponding array of Celsius values `y`
Put them together in a 2D array and transpose.

```
In [ ]: # Type your answer below and press SHIFT+ENTER
```

Double-click here to see the answer.

# Download Notebook to Computer and Turn In

**A36 Homework.** You must **download your work** to your computer (File > Download as > Notebook .ipynb) and turn it in to your instructor. After you download your notebook file to your computer, to **continue working** on it, go to our Binder (https://mybinder.org/v2/gh/mattsunderland/pycalclab/master), click Upload, and upload your notebook file.

# Downloading Anaconda (free, open-source)

**A37 Homework.** Download Anaconda to your own computer from
http://www.anaconda.com/products/individual (http://www.anaconda.com/products/individual)

After installing, go to the program **Anaconda Navigator**, find JupyterLab, click "Launch." To start a new .ipynb notebook, go to File > New > Notebook > Python 3. To open a .ipynb notebook, click the folder icon on the far left and then navigate to the file.