Lab A: Using Python as a Calculator
mybinder.org/v2/gh/anniebmcc/pycalclab/master
2020 Summer — Calculus 1
Dr Matthew H Sunderland

Jupyter Notebooks

A1. **RUN** the following "code cell" (gray rectangle with `In[ ]` next to it), by CLICKING the code cell and pressing SHIFT+RETURN. Notice that only the last result will display.

In [1]:
```
1 + 2 + 3
50 - 3
100*5
```
Out[1]: `500`

A2. **RUN** the following. As always, only the last result displays, but the last result has 2 parts because of the comma.

In [2]:
```
1 + 2 + 3
50 - 3, 1000*1000
100*5, 7*7
```
Out[2]: `(500, 49)`

A3. The "+" on the toolbar adds a code cell. The "scissors" deletes a cell.

Python arithmetic + - * / **

A4. **RUN** the following.

In [3]:
```
3 + 10*5,  5**2,  27/10
```
Out[3]: `(53, 25, 2.7)`

A5. **EXERCISE.**
a) What does each of the 5 arithmetic operations do?
b) Do spaces around the 5 operations matter, or is it just style?

In [4]:
```
# TYPE YOUR ANSWERS BELOW
#
#  a) + is   addition
#     - is   subtraction
#     * is   multiplication
#     / is   division
#    ** is   exponentiation
#
#  b) No, spaces aroung + - * / ** don't matter
```

Python # and =

A6. **RUN** the following. You will notice python ignores everything after #

In [5]:
```
# This is a comment
1 + 1 # This is also a comment
```
Out[5]:
```
2
```

A7. **RUN** the following. Notice we assign variables using = Assignment itself does NOT produce output.

In [6]:
```
a = 10
a
```
Out[6]:
```
10
```

In [7]:
```
b = 20
```

In [8]:
```
a = 18
b = 21
c = a - b
c
```
Out[8]:
```
-3
```

A8. **RUN** the following. Notice you can assign multiple variables at once with a comma.

In [9]:
```
x, y = 100, 500
x
```
Out[9]:
```
100
```

In [10]:
```
a,b,c = 3,4,5
a + b/c
```
Out[10]:
```
3.8
```

A9. **RUN** the following. See that we can compute $\frac{(2-3)*-3}{-1+2}$ all at once (1st cell below), or we can assign variables to help us (2nd cell below).

In [11]:
```
(2 - 3)*-3/(-1 + 2)
```
Out[11]:
```
3.0
```

In [12]:
```
top = (2 - 3)*-3
bottom = -1 + 2
top/bottom
```
Out[12]:
```
3.0
```

A10. **EXERCISE.** Assign variables to help you compute $3 - \frac{3^2-2\cdot3}{2\cdot3-2}$

In [13]:
```
# Type your answer below and press SHIFT+ENTER

top = 3**2 - 2*3
bottom = 2*3 - 2
3 - top/bottom
```
Out[13]:
```
2.25
```

Order of Operations

A11. **RUN** the following. Notice $a - b * c = a - (b * c)$, but they do not equal $(a - b) * c$.

In [14]:
```
a,b,c = 3,4,5

a - b*c,  a - (b*c),  (a - b)*c
```
Out[14]:
```
(-17, -17, -5)
```

A12. **EXERCISE.** In each row, identify NON-equivalent choice. For example, the answer to (1) is $(a - b) * c$ because $a - b * c = a - (b * c)$

(1)	$a - b * c$	$a - (b * c)$	$(a - b) * c$
(2)	$a * (b - c)$	$(a * b) - c$	$a * b - c$
(3)	$a \,/\, b + c$	$a \,/\, (b + c)$	$(a \,/\, b) + c$
(4)	$(a + b) \,/\, c$	$a + (b \,/\, c)$	$a + b \,/\, c$
(5)	$a ** (b * c)$	$(a ** b) * c$	$a ** b * c$
(6)	$a * (b ** c)$	$a * b ** c$	$(a * b) ** c$
(7)	$a/b ** c$	$(a/b) ** c$	$a/(b ** c)$
(8)	$a ** b/c$	$(a ** b)/c$	$a ** (b/c)$
(9)	$(3 - 3) - 3$	$3 - 3 - 3$	$3 - (3 - 3)$
(10)	$(2 ** 3) ** 2$	$2 ** (3 ** 2)$	$2 ** 3 ** 2$
(11)	$6 \,/\, 3 \,/\, 2$	$6 \,/\, (3 \,/\, 2)$	$(6 \,/\, 3) \,/\, 2$

In [15]:
```
# TYPE YOUR ANSWERS BELOW.
#
#  (1)    (a - b)*c
#  (2)    a*(b - c)
#  (3)    a/(b + c)
#  (4)    (a + b)/c
#  (5)    a ** (b*c)
#  (6)    (a*b) ** c
#  (7)    (a/b) ** c
#  (8)    a ** (b/c)
#  (9)    3 - (3 - 3)
# (10)    (2 ** 3) ** 2
# (11)    6/(3/2)
```

A13. **RUN** the following example, where we add 2 sets of parentheses which show the order of the 2 operations.

In [16]:
```
1 + 3/5
```
Out[16]: 1.6

In [17]:
```
(1 + (3/5))
```
Out[17]: 1.6

A14. **EXERCISE.** Add 4 sets of parentheses, which show the order of the 4 operations.

In [18]:
```
7 - 3 ** 2/9 + 4
```
Out[18]: 10.0

In [19]:
```
# Type your answer below and press SHIFT+ENTER

((7 - ((3 ** 2)/9)) + 4)
```
Out[19]: 10.0

A15. **EXERCISE.** Assign `a,b,c = 4,5,8` and then evaluate $\dfrac{a^b - c/b}{c-a}, \dfrac{a^{c-b}}{c-b}, \dfrac{a^{3/2}}{b}, \dfrac{a-b(c-a)}{c-a}$

In [20]:
```
# Type your answer below and press SHIFT+ENTER

a,b,c = 4,5,8

(a**b - c/b)/(c-a),  a**(c-b)/(c-b),  a**(3/2)/b,  (a - b*(c-a))/(c-a)
```
Out[20]: (255.6, 21.333333333333332, 1.6, -4.0)

Making python functions

A16. **RUN** the following.

In [21]:
```
def g(x):
    return x**2

g(7)
```
Out[21]: 49

In [22]:
```
def h(n): return n + 100

h(7)
```
Out[22]: 107

A17. **EXERCISE.** Make the function $P(x) = x^2 - 2x + 1$ and find $P(P(7))$.

```
In [23]: # Type your answer below and press SHIFT+ENTER

         def P(x):
             return x**2 - 2*x + 1

         P(P(7))

Out[23]: 1225
```

Built-in `%pylab` functions

Python	Math notation	Meaning
`abs(x)`	$\lvert x \rvert$	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
`radians(x)`		converts degrees to radians

A18. **RUN** the code cells below. The command `%pylab` only needs to be run once per lab; it loads "built-in functions" (from python packages numpy and matplotlib).

```
In [24]: %pylab

         sqrt(49)

Using matplotlib backend: MacOSX
Populating the interactive namespace from numpy and matplotlib

Out[24]: 7.0
```

```
In [25]: pi, exp(1), sin(pi/2)

Out[25]: (3.141592653589793, 2.718281828459045, 1.0)
```

A19. **EXERCISE.** Evaluate

1. $\sin 40^\circ$
2. $\sin^2 65^\circ$
3. $e^{(10-8.5)/3}$
4. $\arcsin(\sin(3\pi/4))$

Note. Python uses radians for all angle measurements, so you need to convert any degrees to radians.

In [26]:
```
# Type your answer below and press SHIFT+ENTER

sin(radians(40)),  sin(radians(65))**2,  exp((10-8.5)/3),  arcsin(sin(3*pi/
4))
```

Out[26]:
```
(0.6427876096865393,
 0.8213938048432696,
 1.6487212707001282,
 0.7853981633974484)
```

Making an array with `r_[ ]`

A20. **RUN** the following. (If you get an error, go back and run A17.) The function `r_[ ]` can make an array of numbers of your choice. We will need arrays for graphing (Lab B).

In [27]:
```
x = r_[5,7,9,10]
x**2
```

Out[27]:
```
array([ 25,  49,  81, 100])
```

A21. **EXERCISE.** Use `r_[ ]` to store the numbers 2,3,5,7,11 in an array named `x` . Find `x*x` .

In [28]:
```
# Type your answer below and press SHIFT+ENTER

x = r_[2,3,5,7,11]
x*x
```

Out[28]:
```
array([  4,   9,  25,  49, 121])
```

Making an array with `r_[a:b:stride]`

A22. **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 [29]:
```
r_[5:10]
```

Out[29]:
```
array([5, 6, 7, 8, 9])
```

In [30]:
```
r_[:5]
```

Out[30]:
```
array([0, 1, 2, 3, 4])
```

A23. **EXERCISE.** Use `r_[a:b]` to make the array 1,2,3,4,5,6,7,8,9

```
In [31]: # Type your answer below and press SHIFT+ENTER

         r_[1:10]

Out[31]: array([1, 2, 3, 4, 5, 6, 7, 8, 9])
```

A24. **RUN** the following. In general, `r_[a:b:stride]` spaces out your numbers by the amount `stride` .

```
In [32]: r_[0:100:2]

Out[32]: array([ 0,  2,  4,  6,  8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32,
                34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58, 60, 62, 64, 66,
                68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 92, 94, 96, 98])
```

A25. **EXERCISE.** Use `r_[a:b:stride]` to make the array $1, 3, 5, \ldots, 99$

```
In [33]: # Type your answer below and press SHIFT+ENTER

         r_[1:100:2]

Out[33]: array([ 1,  3,  5,  7,  9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33,
                35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 61, 63, 65, 67,
                69, 71, 73, 75, 77, 79, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99])
```

Making an array with `linspace(a,b,n)`

A26. **RUN** the following. Observe that `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). Observe that `linspace(a,b)` lists 50 numbers from a to b inclusive.

```
In [34]: linspace(0,10,6)

Out[34]: array([  0.,   2.,   4.,   6.,   8.,  10.])
```

```
In [35]: linspace(0,10)

Out[35]: array([  0.        ,   0.20408163,   0.40816327,   0.6122449 ,   0.81632653,
                  1.02040816,   1.2244898 ,   1.42857143,   1.63265306,   1.83673469,
                  2.04081633,   2.24489796,   2.44897959,   2.65306122,   2.85714286,
                  3.06122449,   3.26530612,   3.46938776,   3.67346939,   3.87755102,
                  4.08163265,   4.28571429,   4.48979592,   4.69387755,   4.89795918,
                  5.10204082,   5.30612245,   5.51020408,   5.71428571,   5.91836735,
                  6.12244898,   6.32653061,   6.53061224,   6.73469388,   6.93877551,
                  7.14285714,   7.34693878,   7.55102041,   7.75510204,   7.95918367,
                  8.16326531,   8.36734694,   8.57142857,   8.7755102 ,   8.97959184,
                  9.18367347,   9.3877551 ,   9.59183673,   9.79591837,  10.        ])
```

A27. **EXERCISE.** Use `linspace(a,b,n)` to make the array $1, 1.5, 2, 2.5, 3, 3.5, 4$

In [36]:
```
# Type your answer below and press SHIFT+ENTER

linspace(1,4,7)
```

Out[36]:
```
array([1. , 1.5, 2. , 2.5, 3. , 3.5, 4. ])
```

A28. **EXERCISE.**
Convert average body temperature $98.6^\circ F$ to Celsius using $C = 5/9(F - 32)$.

In [37]:
```
# Type your answer below and press SHIFT+ENTER

5/9*(98.6 - 32)
```

Out[37]:
```
37.0
```

A29. **RUN** the following.
Notice that `x` and `y` are arrays,
`c_[x,y]` puts them into a table.

In [38]:
```
x = r_[:10]
y = x**2
c_[x,y]
```

Out[38]:
```
array([[ 0,  0],
       [ 1,  1],
       [ 2,  4],
       [ 3,  9],
       [ 4, 16],
       [ 5, 25],
       [ 6, 36],
       [ 7, 49],
       [ 8, 64],
       [ 9, 81]])
```

A30. **EXERCISE.**
Use `r_` to make an array of Fahrenheit values `x` $= -100, -80, -60, \ldots, 100$.
Make the corresponding array of Celsius values `y`
Use `c_` to put `x` and `y` into a table.

In [39]:
```
# Type your answer below and press SHIFT+ENTER

x = r_[-100:101:20]
y = 5/9*(x - 32)
c_[x,y]
```

Out[39]:
```
array([[-100.        ,  -73.33333333],
       [ -80.        ,  -62.22222222],
       [ -60.        ,  -51.11111111],
       [ -40.        ,  -40.        ],
       [ -20.        ,  -28.88888889],
       [   0.        ,  -17.77777778],
       [  20.        ,   -6.66666667],
       [  40.        ,    4.44444444],
       [  60.        ,   15.55555556],
       [  80.        ,   26.66666667],
       [ 100.        ,   37.77777778]])
```