Lab B: Plotting Graphs in Python

2020 Summer — Calculus 1

Dr Matthew H Sunderland

B1. If you are reading this as a PDF,
open the live notebook remotely on Binder here (https://mybinder.org/v2/gh/mattsunderland/pycalclab/master).

Plotting with `plot`

B2 Example. To graph $f(x) = x^2$ over $[-2, 2]$ by hand, make an xy table: choose some x values,

x	-2	-1	0	1	2
y					

and then use f to compute the corresponding y values.
Graphing in python is similar. **Run the following (SHIFT+ENTER), then run it again.**

In [ ]:
```
%pylab inline

x = r_[-2, -1, 0, 1, 2]
y = r_[4, 1, 0, 1, 4]
plot(x,y)
```

B3. Run the code cell below. Notes:

- We make the `x` with `linspace(a,b,n)`, which gives `n` numbers evenly spaced `a` to `b` inclusive (see A30)
- We make the `y` by doing arithmetic on `x`
- `plot(x,y)` makes the plot
- `title()` adds a title
- `grid()` add a grid
- `r_[[x,y]]` displays an xy table

In [ ]:
```
x = linspace(-2,2,9)
y = x**2

plot(x,y)
title('$f(x) = x^2$ plotted with 9 points')
grid()

r_[[x,y]]
```

B4 Example. Run the following cells, which graph $f(x) = e^x$ over the interval $[0, 7]$.

- `r_[a:b:stride]` gives you the numbers **from** a **up to but *not* including** b spaced `stride` apart (see A28)
- `exp(x)` is how you write e^x in python (see A21)

In [ ]:
```
x = r_[:7]
y = exp(x)
plot(x,y)
```

B5. Run the following.
When we change the x we must recompute the y;
there are two ways to do it (compare B4 to B3).

In [ ]:
```
x = r_[:10]
plot(x, exp(x))
```

B6 Exercise. We want to graph $y = \cos 4x$ over $[0, \pi]$ with a step size of `pi/10` .

i. Which command gives the desired values for x? (a) x = 0:pi/10:pi (b) x = 0:pi:pi/10 (c) x = linspace(0,pi)
ii. Which gives the correct answer for y? (a) y = cos(4x) (b) y = cos4*x (c) y = cos(4*x)
iii. Plot the graph.
iv. Redo your plot from iii. using `x = linspace(0,pi)`
v. Which plot looks more like the plot of a cosine curve?
(a) The first one, (b) the second one, (c) both of them.

In [ ]:
```
# i. Type your answer in this comment:
# ii. Type your answer in this comment:

# iii. Type and run your code here.
```

In [ ]:
```
# iv. Type and run your code here.

# ii. Type your answer in this comment:
```

B7 Exercise.

i. Plot the function $f(x) = e^{\cos x}$ over the interval $[0, 2\pi]$.

ii. What command generates a sufficient number of values for x?
(a) `linspace(0,2*pi)` (b) `linspace(0,100,2*pi)`
(c) `r_[0:2*pi]` (d) `r_[0:0.01:2*pi]`

iii. Which command will generate the corresponding yvalues?
(a) `exp^cos(x)` (b) `e^cos(x)` (c) `exp(cos(x))` (d) `exp(x)cos(x)`

In [ ]:
```
# i. Type and run your code here.

# ii. Type your answer in this comment:
# iii. Type your answer in this comment:
```

Doing arthmetic on arrays

B8. Run the following.
We make numpy arrays with `r_` or `linspace`
Numpy arrays "know" how to do "elementwise" arithmetic.
Warning: x^2 is written `x**2` .

In [ ]:
```
x = r_[1:5]
x, 10 - x, x + 10, 10*x, x**2, 12/x, x**x, 10**x
```

B9. Run the following.

In [ ]:
```
# We can add arrays of the same shape (same length)

x = r_[10, 20, 50, 100]
y = r_[3, 0, 7, -1]
x + y
```

In [ ]:
```
# We can add an array (x) and a scalar (y)

x = r_[10, 20, 50, 100]
y = 100
x + y
```

In [ ]:
```
# We CANNOT add arrays of DIFFERENT shape

x = r_[10, 20, 50, 100]
y = r_[3, 0, 7]
x + y
```

B10 Examples. Run the cells below, which plot the following.

- $y = \sin x + \cos 3x$ over the domain $[0, 2\pi]$
- $y = e^{-x/2} \cos 6x$ over the domain $[0, 10\pi]$
- $y = 1/(x^2 - 1)$ over the domain $[2, 5]$

In [ ]:
```
x = linspace(0,2*pi)
y = sin(x) + cos(3*x)
plot(x,y)
```

In [ ]:
```
x = linspace(0, 10*pi, 300)
y1 = exp(-x/2) # Here we break up the
y2 = cos(6*x)  # computation into
y = y1*y2      # bite-sized pieces
plot(x,y)
```

In [ ]:
```
x = r_[2:5.1:0.1]
y = 1/(x**2 - 1)
plot(x,y)
```

B11 Exercise. Define a, b, and c by

```
a = r_[1:21:2]
b = r_[1:11]
c = r_[1:12:2]
```

Which of the following is/are defined?
(a) `b+c` (b) `a + b` (c) `a./ b` (d) `a * b` (e) `a ^ 2`

In [ ]:
```
# Type your answer in this comment:
```

B12 Example. Let x be the array 1,2,3. Write Python commands to compute x^3.
The output you get should be `array([ 1,  8, 27])`.

In [ ]:
```
x = r_[1,2,3]

# Write out and run your code here.
x**3
```

B13 Exercise. Let x be the array 1,2,3.

i. Write Python commands to compute $\cos x \sin x$.
You should get `array([ 0.45464871, -0.37840125, -0.13970775])`

ii. Write Python commands to compute $\sin^2 x$.
You should get `array([0.70807342, 0.82682181, 0.01991486])`

iii. Write Python commands to compute $\sin x^2$.
You should get `array([ 0.84147098, -0.7568025 ,  0.41211849])`

iv. Write Python commands to compute $7x^2 \sin \frac{1}{7x^2}$.
You should get `array([0.99660211, 0.99978743, 0.99995801])`

v. Write Python commands to compute $x - \frac{\cos x - \sin x}{\sin x + \cos x}$
You should get `array([1.2179581 , 4.68770694, 1.66751188])`

vi. Write Python commands to compute $\frac{1}{10}(x - \frac{x^{3/2}}{10})^2$
You should get `array([0.081     , 0.29486292, 0.61523085])`

```
In [ ]: # i. Write out and run your code here.
```

```
In [ ]: # ii. Write out and run your code here.
```

```
In [ ]: # iii. Write out and run your code here.
```

```
In [ ]: # iv. Write out and run your code here.
```

```
In [ ]: # v. Write out and run your code here.
```

```
In [ ]: # vi. Write out and run your code here.
```

B14 Exercise.
i. Graph the function $f(x) = \sin(\frac{\pi}{2}x) + \sin(\frac{2}{5}\pi x)$ over the interval $[0, 40]$.

ii. How many peaks (relative maxima) does your graph B21 have?
(a) 2 (b) 3 (c) 4 (d) 5 (e) none of the above

iii. The function in B21 is periodic; how many periods are graphed in $[0, 40]$?
(a) 2 (b) 3 (c) 4 (d) 5 (e) none of the above

iv. Estimate from your graph B21 the value of $f(10)$ to 1 decimal point.

In [ ]:
```
# i. Make your graph here.

# ii. Type your answer in this comment:

# iii. Type your answer in this comment:

# iv. Type your answer in this comment:
```

B15 Exercise.
i. Graph the function $f(x) = \cos^2 x - \sin^2 x$ over the interval $[-2\pi, 2\pi]$. Use 50 points in the domain.
ii. Does the graph B24 resemble any graph that you are familiar with?
(a) $\cos 2x$ (b) $\cos x/2$ (c) $\cos x$

In [ ]:
```
# i. Make your graph here.

# ii. Type your answer in this comment:
```

B16 Exercise.
i. Plot the polynomial function $f(x) = x^3 - 20x^2 + 10x - 1$ over the interval $[-10, 10]$.
ii. What is the approximate range for the y-axis?
(a) $[-10, 10]$ (b) $(-10, 10)$ (c) $[-3100, 0]$ (d) $[0, 2\pi]$

In [ ]:
```
# i. Make your graph here.

# ii. Type your answer in this comment:
```

B17 Exercise. We wish to investigate when (if) the is positive.
We can't readily tell from our graph B27 so we will replot over a smaller domain.

i. Which of these domains seems appropriate for this task?
(a) $[0, 500]$ (b) $[0, 10]$ (c) $[-1, 1]$ (d) $[0, 2\pi]$

ii. Replot the graph over the selected domain. Turn on the grid using `grid()`

iii. From your graph, which of these x values have $f(x) > 0$? Indicate all that apply:
(a) 0 (b) 0.25 (c) 0.50 (d) 0.75

In [ ]:
```
# i. Type your answer in this comment:

# ii. Make your graph here.

# iii. Type your answer in this comment:
```