matplotlib basics

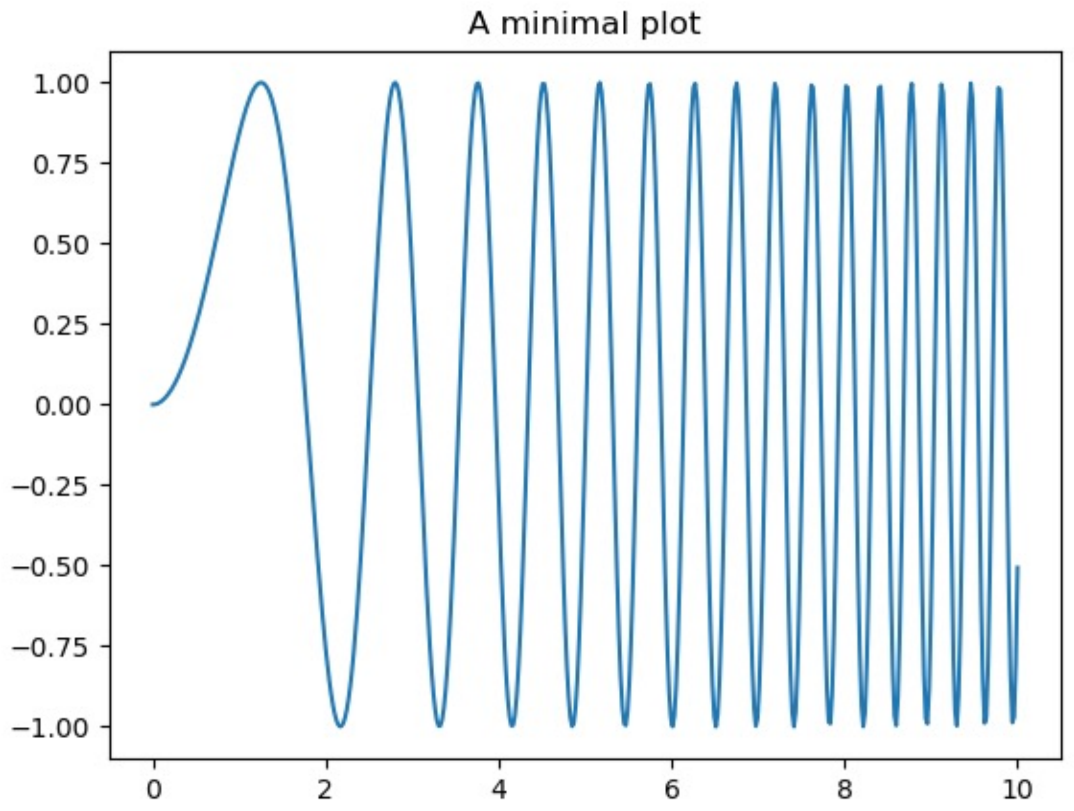
matplotlib is the main plotting module to use with python

- typical import in a python program is:
  - `import matplotlib.pyplot as plt`
- however sometimes we import other parts of matplotlib, e.g. to create custom colormaps (see Thursday's lecture)
- matplotlib excels at 2-D plots. In my experience MATLAB is better, and faster for fancy 3-D plots, like objects with lighting, but there may be python modules I don't know about

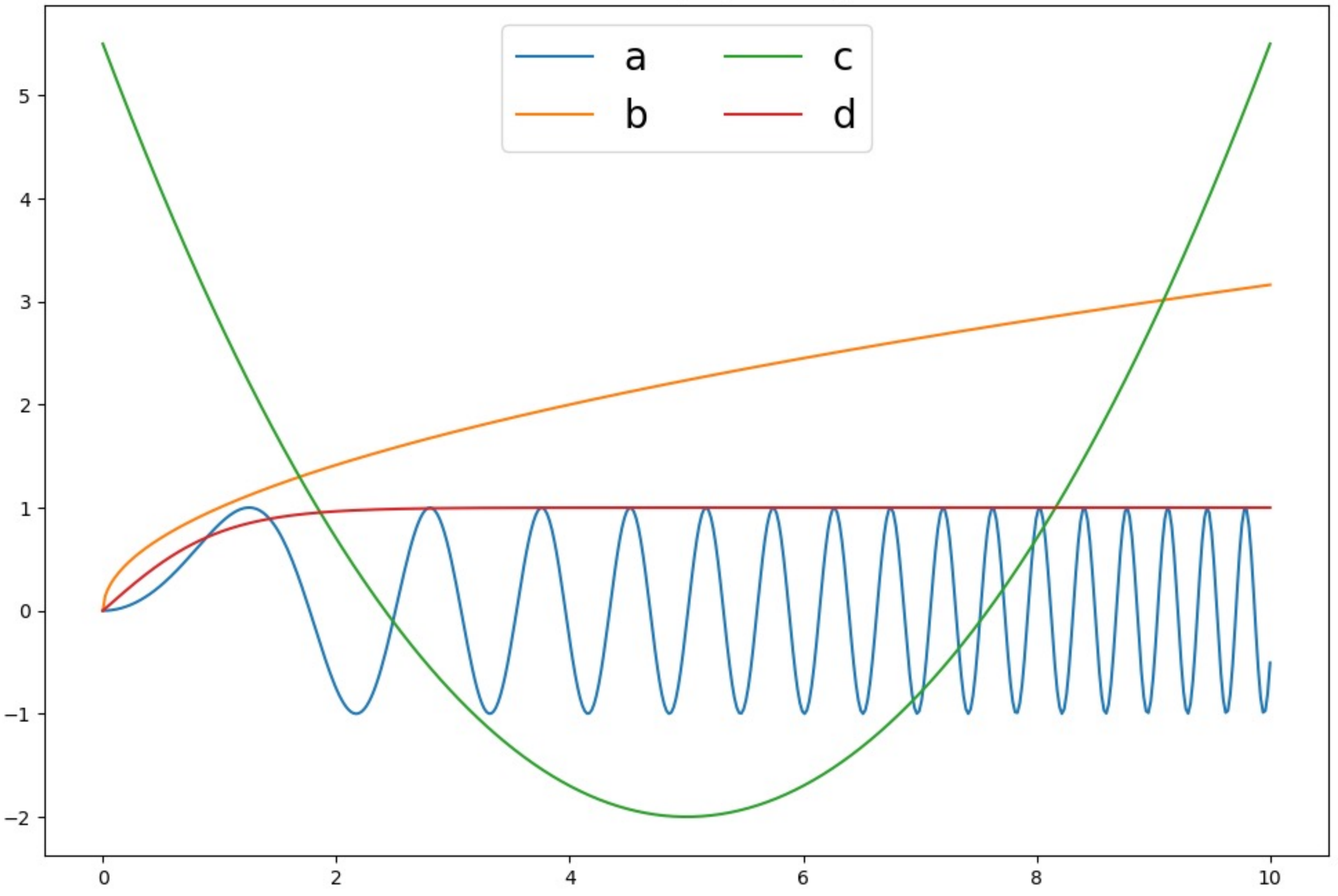
my examples

- Examples are available on the parkermac GitHub repo "pmec" in the folder ex_matplotlib
- plt_basics.py covers basic line plotting operations, and ways to make multiple plots on a figure
- fields.py covers ways to plot 2-D fields using colors and contours

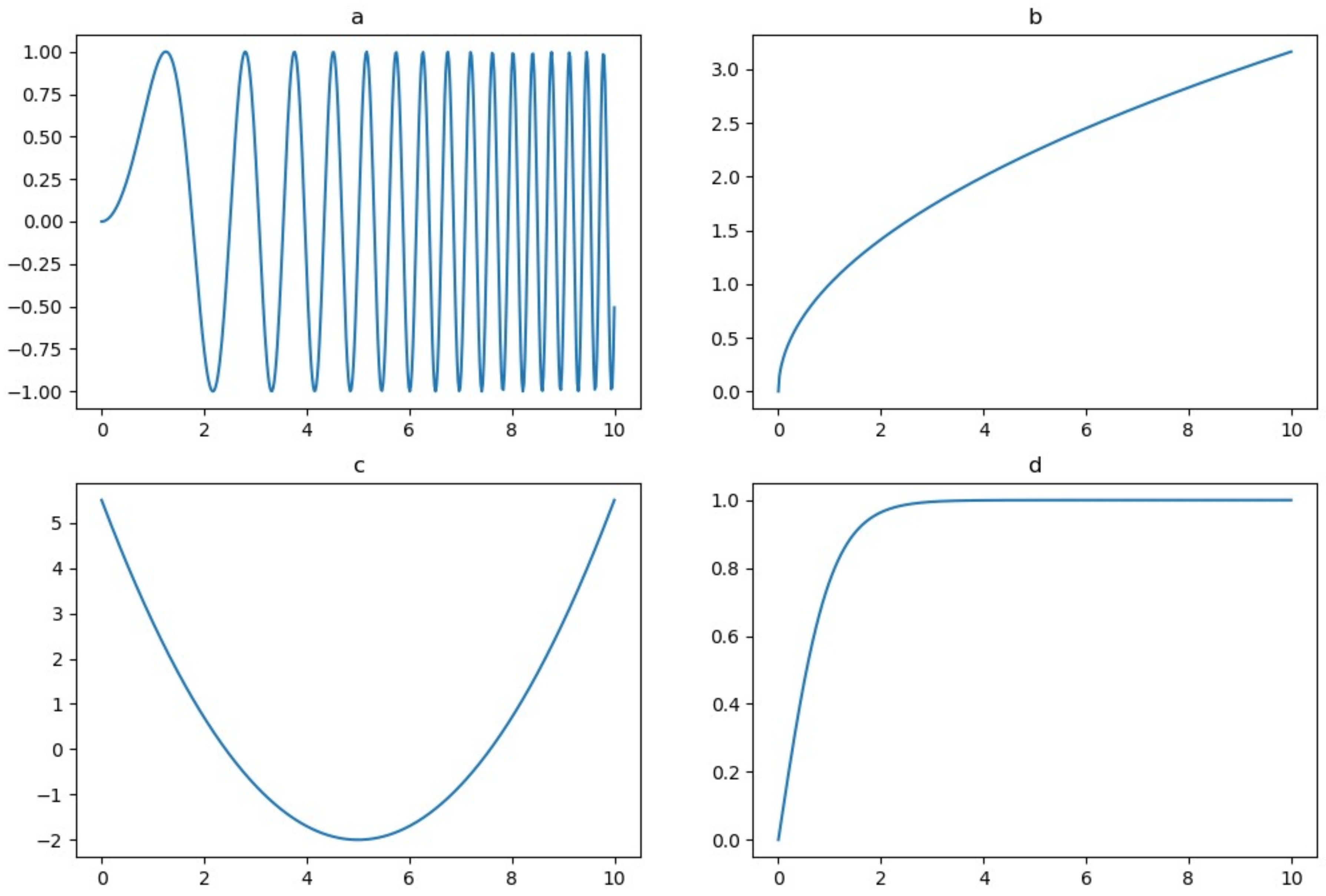
plt_basics.py


A minimal plot
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
0
2
4
6
8
10

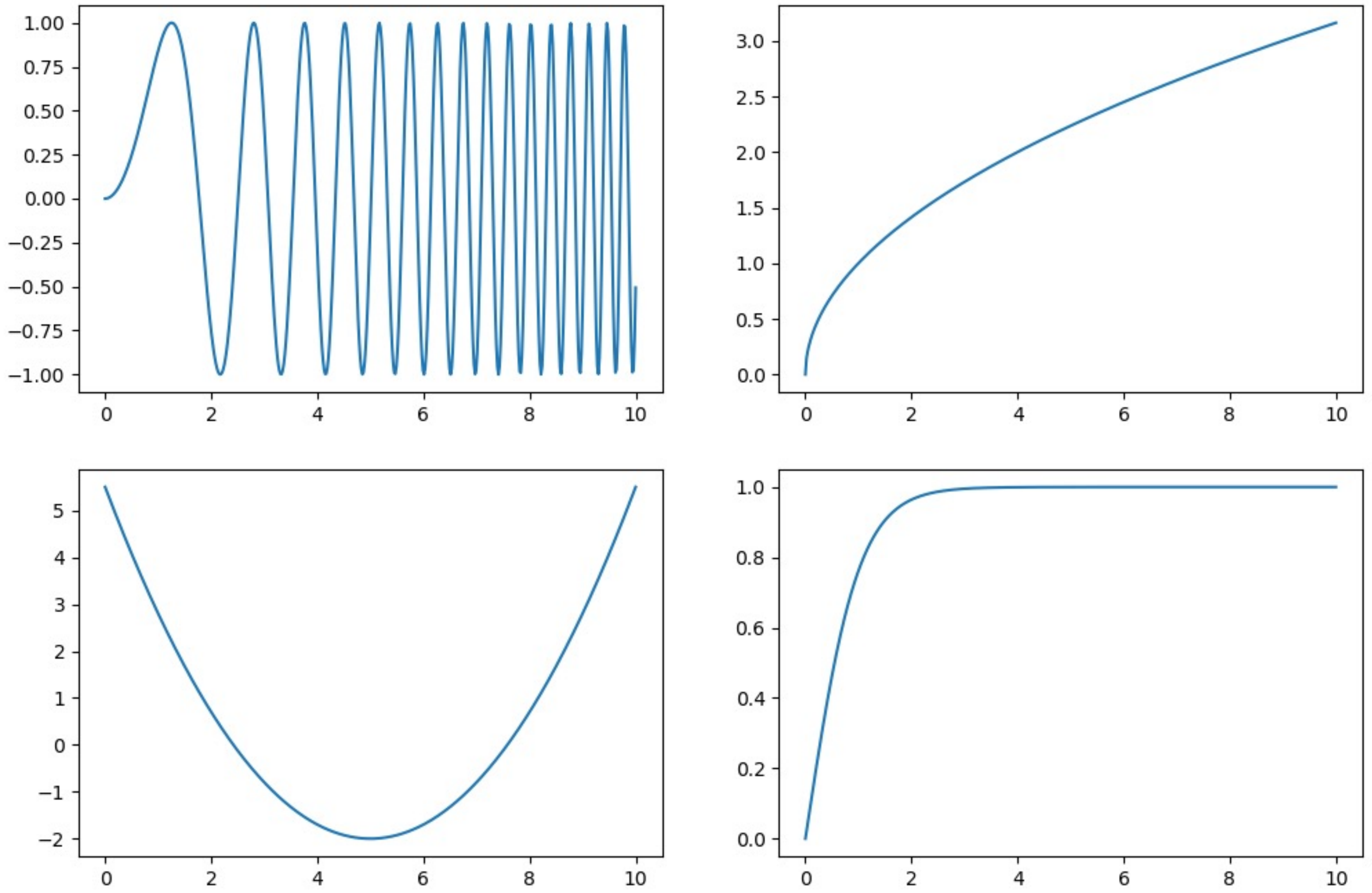
Four lines on one plot, with a legend



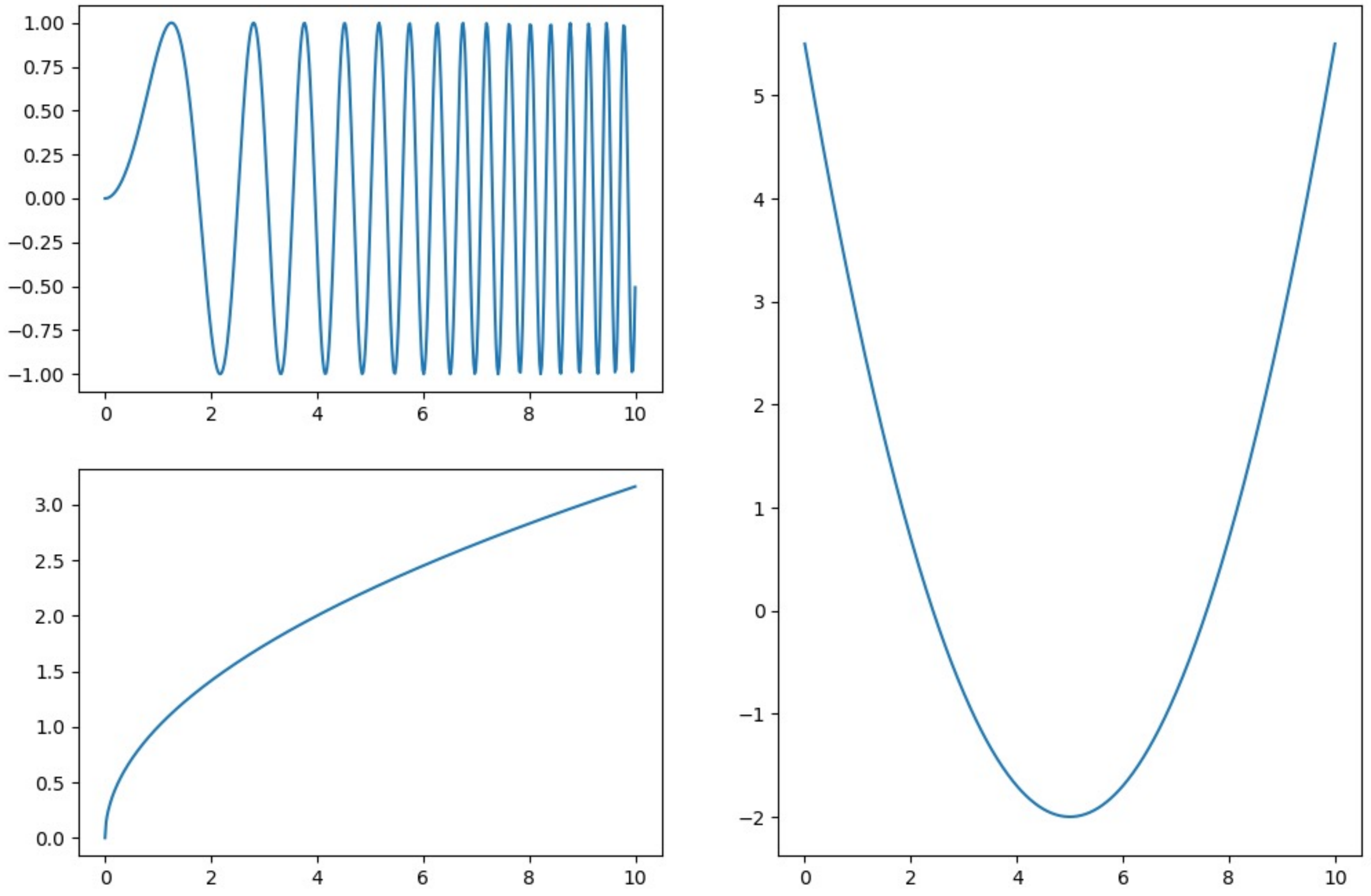
Four plots in a grid, using y_dict to make it a for-loop



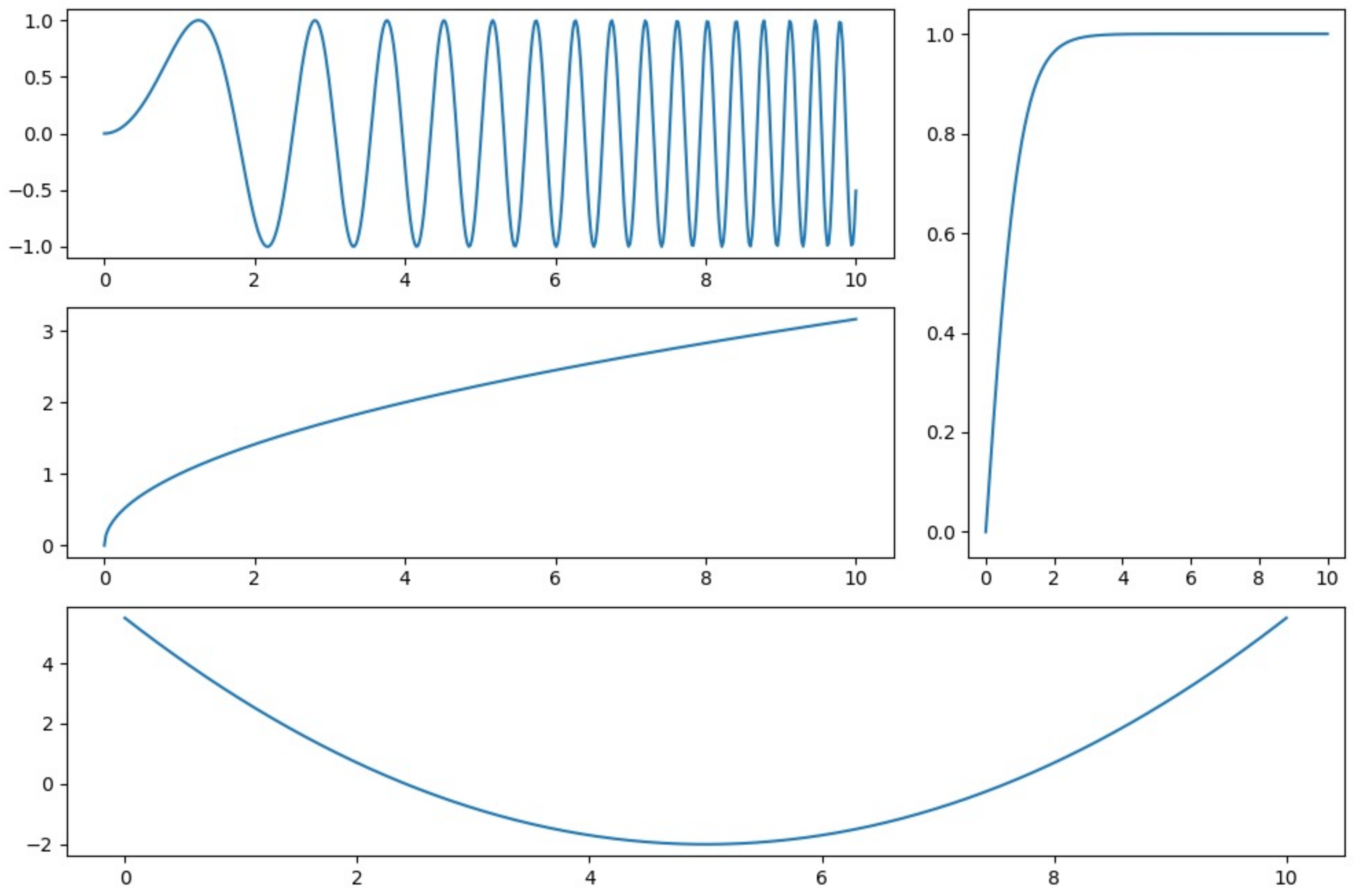
Four plots in a grid, using subplots array

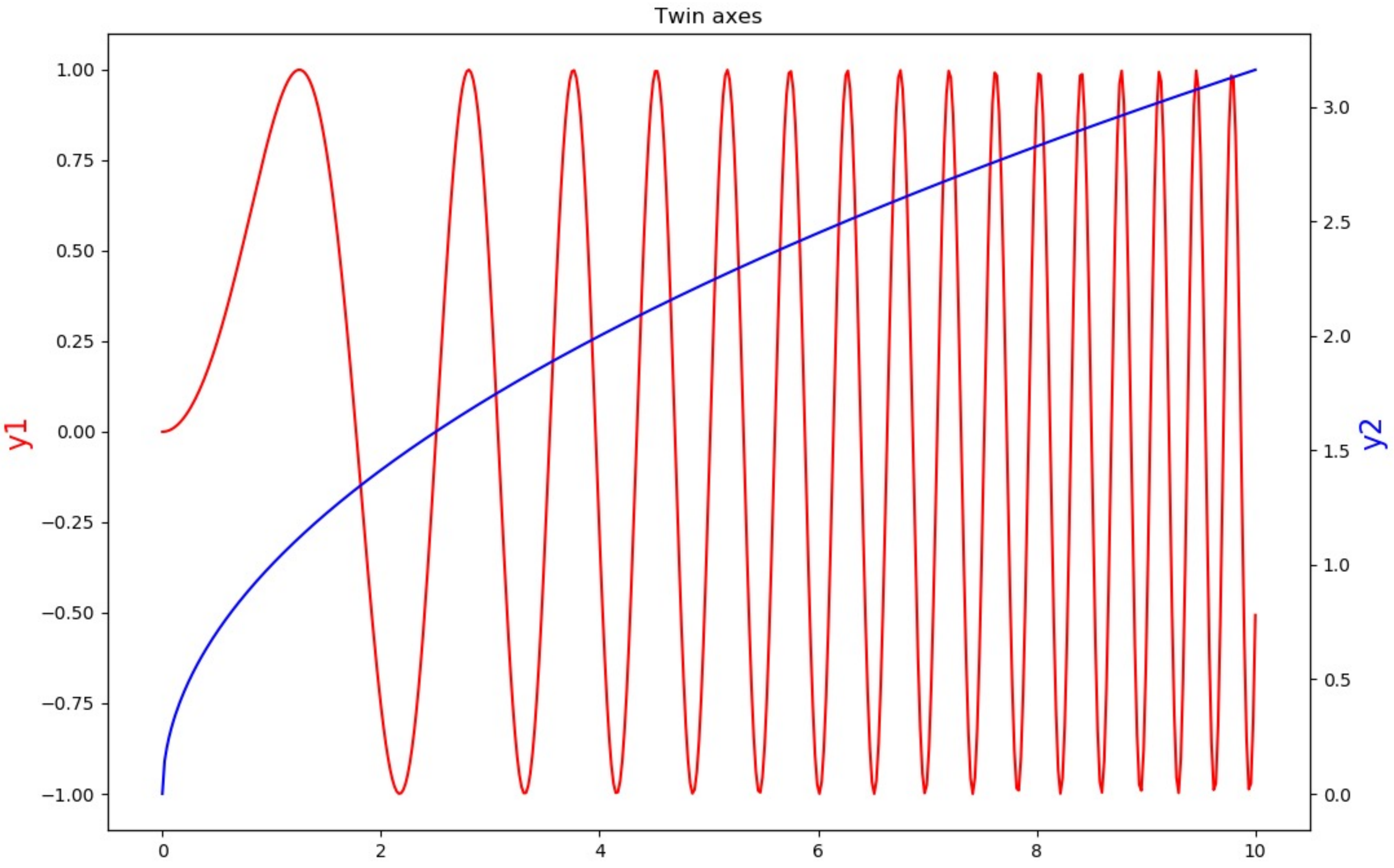


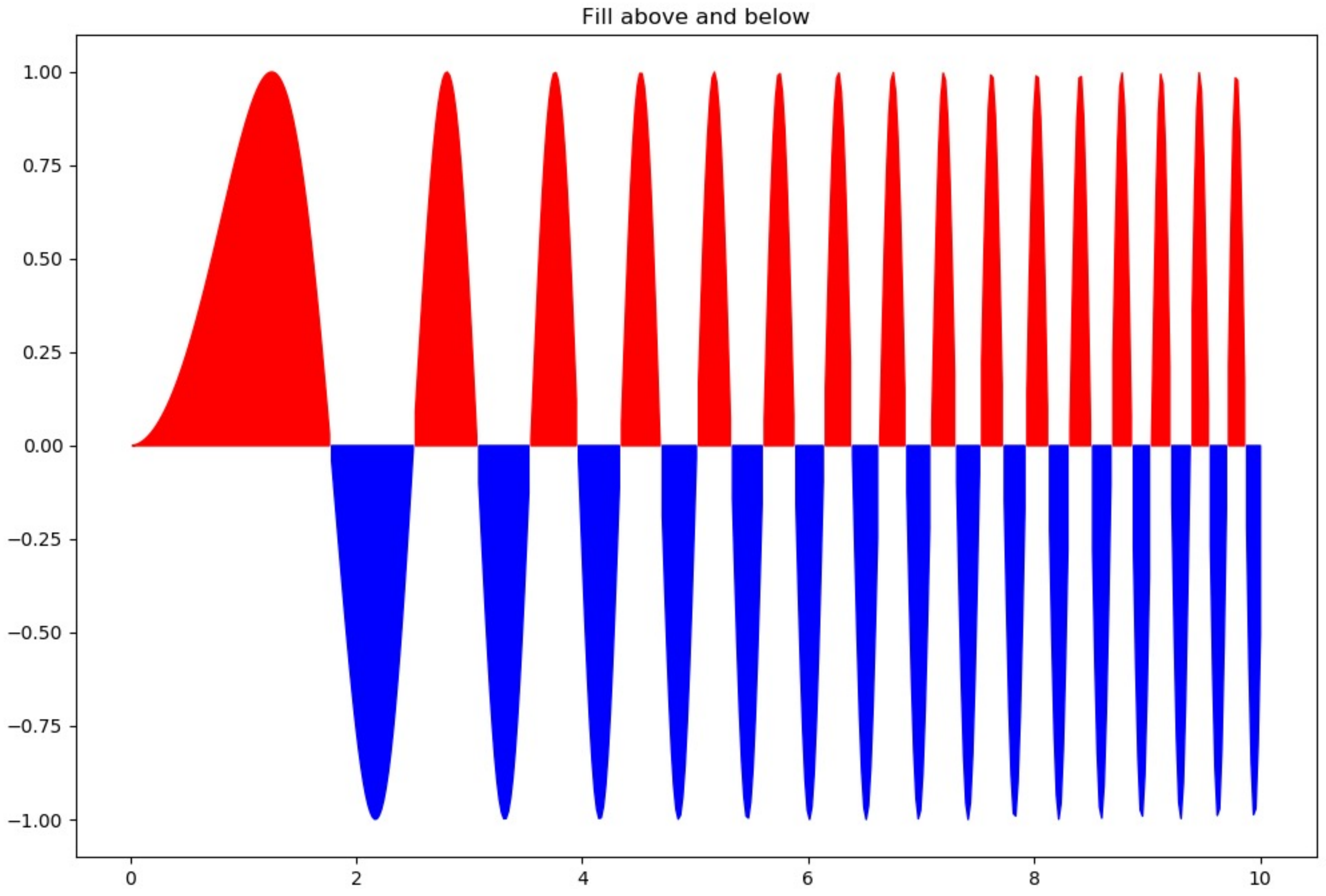
Mix and match grids of subplots



More flexible axes widths in a grid using subplot2grid()

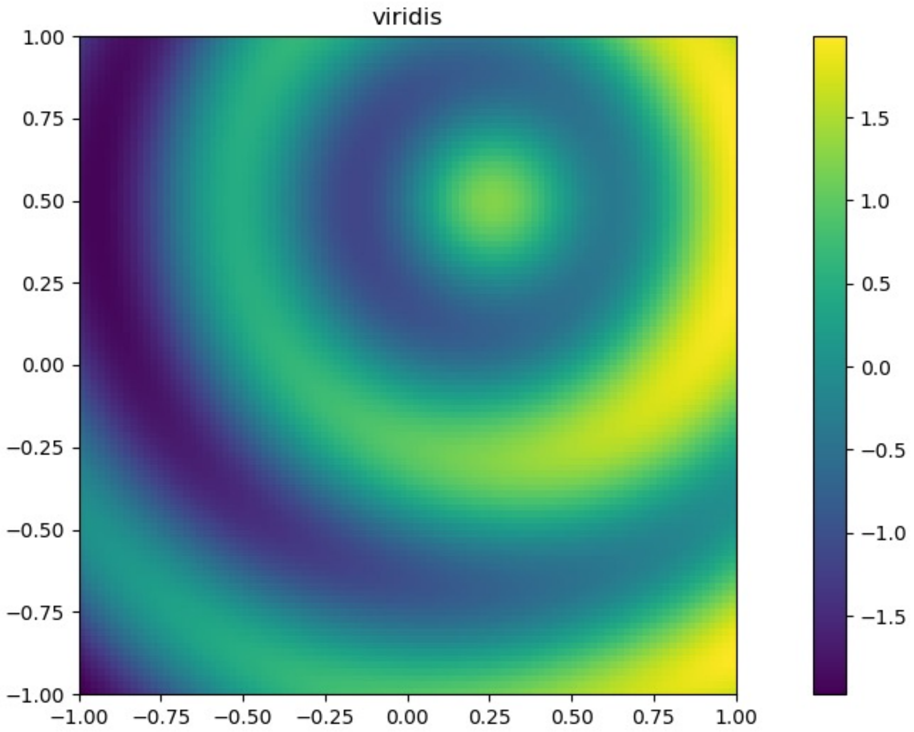
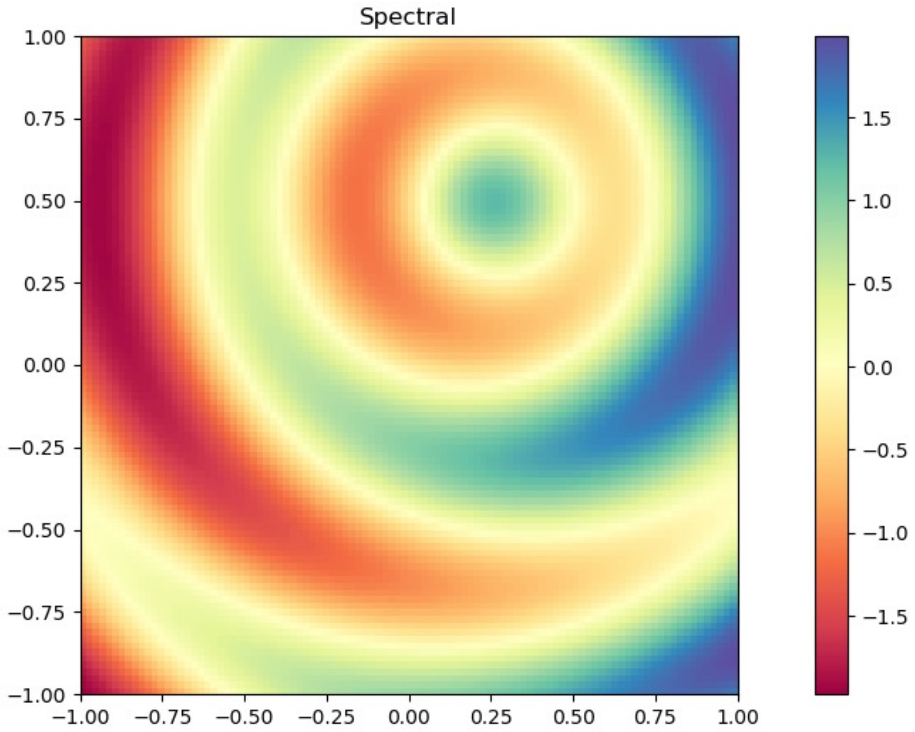


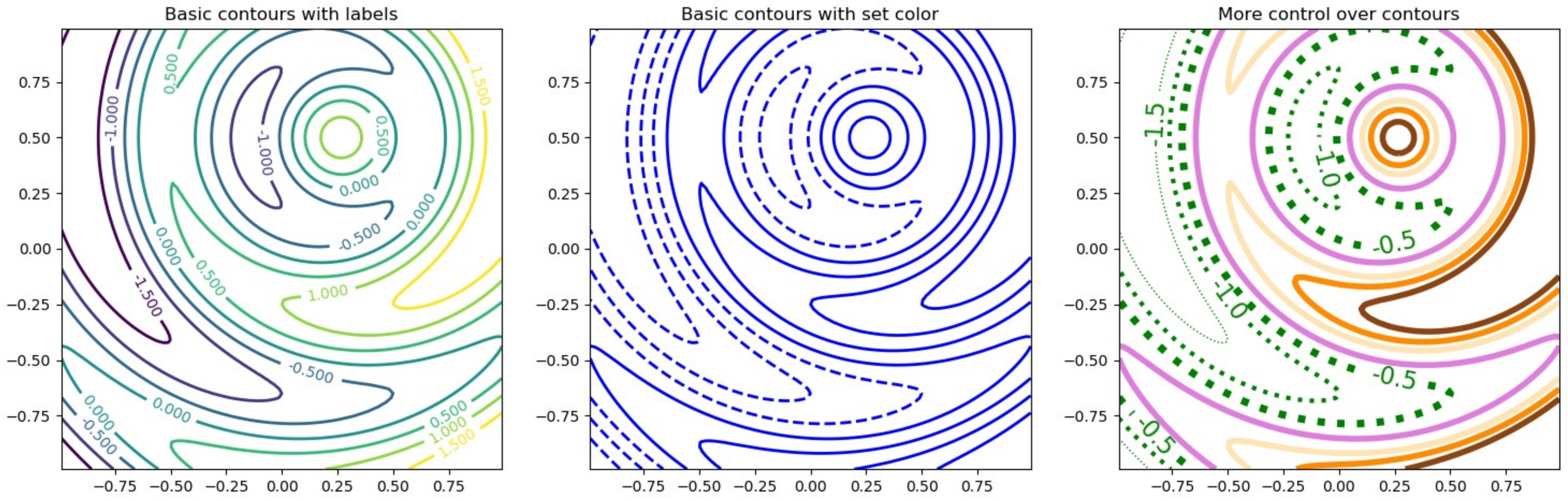

Twin axes
y1
y2
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10



Fill above and below
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
0
2
4
6
8
10

fields.py


viridis
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.00 −0.75 −0.50 −0.25 0.00 0.25 0.50 0.75 1.00
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5

Spectral
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.00 −0.75 −0.50 −0.25 0.00 0.25 0.50 0.75 1.00
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5


Basic contours with labels
Basic contours with set color
More control over contours
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−0.75 −0.50 −0.25 0.00 0.25 0.50 0.75
-1.500
-1.000
-0.500
0.000
0.500
1.000
1.500
-1.5
-1.0
-0.5

plotting on a remote machine (like fjord)

- On your laptop you typically launch python as "ipython --pylab" which sets the graphical backend. Then you can see plots on your screen, as well as saving them as .png's. The typical laptop launch is:

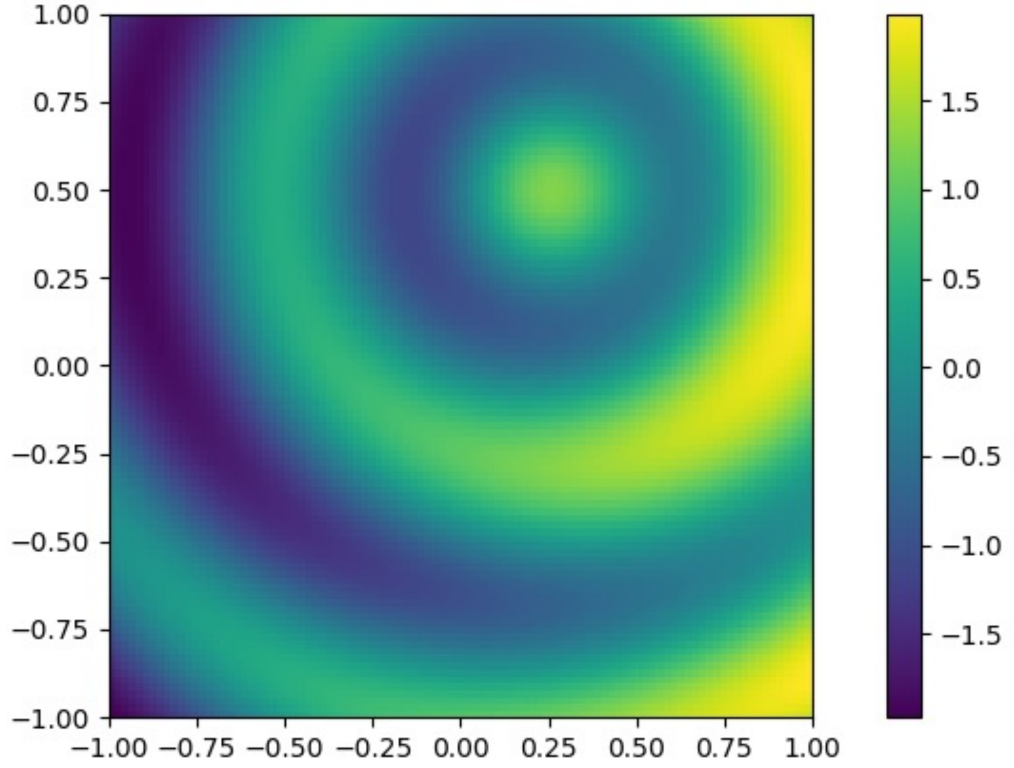
```
 ipython --pylab
 import matplotlip.pyplot as plt
```

- On a remote machine you are working from the terminal, and so you can't see plots, but you can still save .png's. On fjord the typical launch sequence is:

```
 ipython
 import matplotlib as mpl
mpl.use('Agg')
 import matplotlib.pyplot as plt
```

- I build these into my plotting programs with an if-statement that uses some knowledge of which machine I am working on. You could also make it a command line argument using argparse.
- See the example "remote_printing.py" in pmec/ex_matplotlib

remote_printing.png on fjord from remote_printing.py



Finding information

- The primary module is matplotlib.pyplot (plt), and typical objects you create are figures (fig), axes (ax), colormaps or contours (cs), and text (h)
- Each of these has its own methods, and each method accepts some required arguments (like x and y for a line plot) and some optional "keyword arguments" or "kwargs" (like linewidth=4).
- It can sometimes (often!) be confusing which object and which method to use to achieve a desired result.
- Sometimes there is an obvious hierarchy:
  - plt has a method for making figures
  - figures have a method for adding subplots (axes)
  - axes have methods for actual plotting
  - and when you do a plotting operation (e.g. add contours) it will return an object that you can inspect to find applicable methods

Finding information, continued...

- To find out what methods can be used with an object, and what required and keyword arguments are possible with a method there are several techniques.
- Say you have an axis object "ax":
- dir(ax) will give a list of all valid methods, e.g. plot
- help(ax.plot) gives, sometimes, a useful tutorial, although it can take some patience to read them
- ax.plot? will give more succinct information (often my favorite) such as this for the "linestyle" kwarg:
    - linestyle or ls: {'-', '--', '-.', ':', '', (offset, on-off-seq), ...}
- which is saying that you could plot a dashed line using ax.plot(x,y, ls='--')
- ax.plot?? give a nicely colorized, but over-long version of **everything** you can do
- Sometimes you need to dig deeper, e.g. if you want to add some fancy text:
- help(ax.text) will give basic information, but will suggest you look at **kwargs : `~matplotlib.text.Text` properties to find kwargs info
- to follow this suggestion use help(matplotlib.text.Text) or matplotlib.text.Text? which will also show all valid kwargs, but to do this you first have to import matplotlib (not just matplotlib.pyplot)
- NOTE: Text is the *class* for creating text *object* instances.

Resources

- https://matplotlib.org/ the home page
- https://matplotlib.org/users/index.html a Users Guide
- https://matplotlib.org/gallery/index.html an incredibly useful galley of examples, including plots and the code that made them