11.1_Matplotlib

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1 Introduction to Python for Open Source Geocomputation

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Content:

- What is Matplotlib?
- Options with Matplotlib
  - Different plot types
  - Styling
  - multiple plots
- Saving a plotted figure

2 What is Matplotlib?

- One of the most popular packages for quickly creating figures in python
- Many packages are built on top of and extending Matplotlib
  - Examples
    - pandas: Tabular data analysis and manipulation tool providing a .plot() API for Matplotlib plotting.
    - animatplot: Interactive animated plots.
    - seaborn: High-level interface for drawing attractive statistical graphics.
    - GeoPandas: Pandas extended to support geographical data, algorithms, and visualization
  - See a fuller list here

2.1 Installation of Matplotlib

From a terminal:

`pip install matplotlib`

or

`conda install matplotlib`

`matplotlib` is included in conda installation, so our working environment should already have `matplotlib` installed.

2.2 Support Many Different Types of Plots

- Basic plots: lines, scatter plot, bar plot
- image plots
- statistical plots: histogram, boxplot, pie
- 3D plots

[1]:
```
from IPython.display import IFrame
IFrame(src="https://matplotlib.org/stable/plot_types/index.html", width=1000,␣
↪height=550)
```

[1]:
```
<IPython.lib.display.IFrame at 0x7f7f50c2aca0>
```

2.3 Creating a simple figure in Matplotlib

Two interfaces for plotting with Matplotlib

- implicit interface:
  - procedural approach
  - inspired by and modeled on MATLAB
  - uses an global state-based interface which is is encapsulated in the `pyplot` module to plot to the "current Axes"
  - use `functions`
  - See the pyplot tutorials for a more in-depth look at the pyplot interface.
- explicit interface:
  - object-oriented (OO) interface
  - directly utilize instances of `axes.Axes` to build up the visualization in an instance of `figure.Figure`
  - use `methods` associated with instances of classes `axes.Axes` and `figure.Figure`

[2]:
```
import matplotlib.pyplot as plt #import the pyplot module from matplotlib
```

```
Intel MKL WARNING: Support of Intel(R) Streaming SIMD Extensions 4.2 (Intel(R)
SSE4.2) enabled only processors has been deprecated. Intel oneAPI Math Kernel
Library 2025.0 will require Intel(R) Advanced Vector Extensions (Intel(R) AVX)
instructions.
Intel MKL WARNING: Support of Intel(R) Streaming SIMD Extensions 4.2 (Intel(R)
SSE4.2) enabled only processors has been deprecated. Intel oneAPI Math Kernel
```

```
Library 2025.0 will require Intel(R) Advanced Vector Extensions (Intel(R) AVX)
instructions.
```

[3]:
```
dir(plt)
```

[3]:
```
['Annotation',
 'Arrow',
 'Artist',
 'AutoLocator',
 'Axes',
 'Button',
 'Circle',
 'Enum',
 'ExitStack',
 'Figure',
 'FigureBase',
 'FigureCanvasBase',
 'FigureManagerBase',
 'FixedFormatter',
 'FixedLocator',
 'FormatStrFormatter',
 'Formatter',
 'FuncFormatter',
 'GridSpec',
 'IndexLocator',
 'Line2D',
 'LinearLocator',
 'Locator',
 'LogFormatter',
 'LogFormatterExponent',
 'LogFormatterMathtext',
 'LogLocator',
 'MaxNLocator',
 'MouseButton',
 'MultipleLocator',
 'Normalize',
 'NullFormatter',
 'NullLocator',
 'Number',
 'PolarAxes',
 'Polygon',
 'Rectangle',
 'ScalarFormatter',
 'Slider',
 'Subplot',
 'SubplotSpec',
 'Text',
```

```
'TickHelper',
'Widget',
'_REPL_DISPLAYHOOK',
'_ReplDisplayHook',
'__builtins__',
'__cached__',
'__doc__',
'__file__',
'__loader__',
'__name__',
'__package__',
'__spec__',
'_api',
'_auto_draw_if_interactive',
'_backend_mod',
'_copy_docstring_and_deprecators',
'_docstring',
'_draw_all_if_interactive',
'_get_backend_mod',
'_get_pyplot_commands',
'_get_required_interactive_framework',
'_interactive_bk',
'_log',
'_pylab_helpers',
'_warn_if_gui_out_of_main_thread',
'acorr',
'angle_spectrum',
'annotate',
'arrow',
'autoscale',
'autumn',
'axes',
'axhline',
'axhspan',
'axis',
'axline',
'axvline',
'axvspan',
'bar',
'bar_label',
'barbs',
'barh',
'bone',
'box',
'boxplot',
'broken_barh',
'cbook',
```

```
'cla',
'clabel',
'clf',
'clim',
'close',
'cm',
'cohere',
'color_sequences',
'colorbar',
'colormaps',
'connect',
'contour',
'contourf',
'cool',
'copper',
'csd',
'cycler',
'delaxes',
'disconnect',
'draw',
'draw_all',
'draw_if_interactive',
'errorbar',
'eventplot',
'figaspect',
'figimage',
'figlegend',
'fignum_exists',
'figtext',
'figure',
'fill',
'fill_between',
'fill_betweenx',
'findobj',
'flag',
'functools',
'gca',
'gcf',
'gci',
'get',
'get_backend',
'get_cmap',
'get_current_fig_manager',
'get_figlabels',
'get_fignums',
'get_plot_commands',
'get_scale_names',
```

```
'getp',
'ginput',
'gray',
'grid',
'hexbin',
'hist',
'hist2d',
'hlines',
'hot',
'hsv',
'importlib',
'imread',
'imsave',
'imshow',
'inferno',
'inspect',
'install_repl_displayhook',
'interactive',
'ioff',
'ion',
'isinteractive',
'jet',
'legend',
'locator_params',
'logging',
'loglog',
'magma',
'magnitude_spectrum',
'margins',
'matplotlib',
'matshow',
'minorticks_off',
'minorticks_on',
'mlab',
'new_figure_manager',
'nipy_spectral',
'np',
'pause',
'pcolor',
'pcolormesh',
'phase_spectrum',
'pie',
'pink',
'plasma',
'plot',
'plot_date',
'polar',
```

```
'prism',
'psd',
'quiver',
'quiverkey',
'rc',
'rcParams',
'rcParamsDefault',
'rcParamsOrig',
'rc_context',
'rcdefaults',
'rcsetup',
're',
'register_cmap',
'rgrids',
'savefig',
'sca',
'scatter',
'sci',
'semilogx',
'semilogy',
'set_cmap',
'set_loglevel',
'setp',
'show',
'specgram',
'spring',
'spy',
'stackplot',
'stairs',
'stem',
'step',
'streamplot',
'style',
'subplot',
'subplot2grid',
'subplot_mosaic',
'subplot_tool',
'subplots',
'subplots_adjust',
'summer',
'suptitle',
'switch_backend',
'sys',
'table',
'text',
'thetagrids',
'threading',
```

```
 'tick_params',
 'ticklabel_format',
 'tight_layout',
 'time',
 'title',
 'tricontour',
 'tricontourf',
 'tripcolor',
 'triplot',
 'twinx',
 'twiny',
 'uninstall_repl_displayhook',
 'violinplot',
 'viridis',
 'vlines',
 'waitforbuttonpress',
 'winter',
 'xcorr',
 'xkcd',
 'xlabel',
 'xlim',
 'xscale',
 'xticks',
 'ylabel',
 'ylim',
 'yscale',
 'yticks']
```

[4]:
```
import numpy as np
```

[5]:
```
x = np.arange(10)
y = x * 2
```

[6]:
```
x
```

[6]:
```
array([0, 1, 2, 3, 4, 5, 6, 7, 8, 9])
```

[7]:
```
y
```

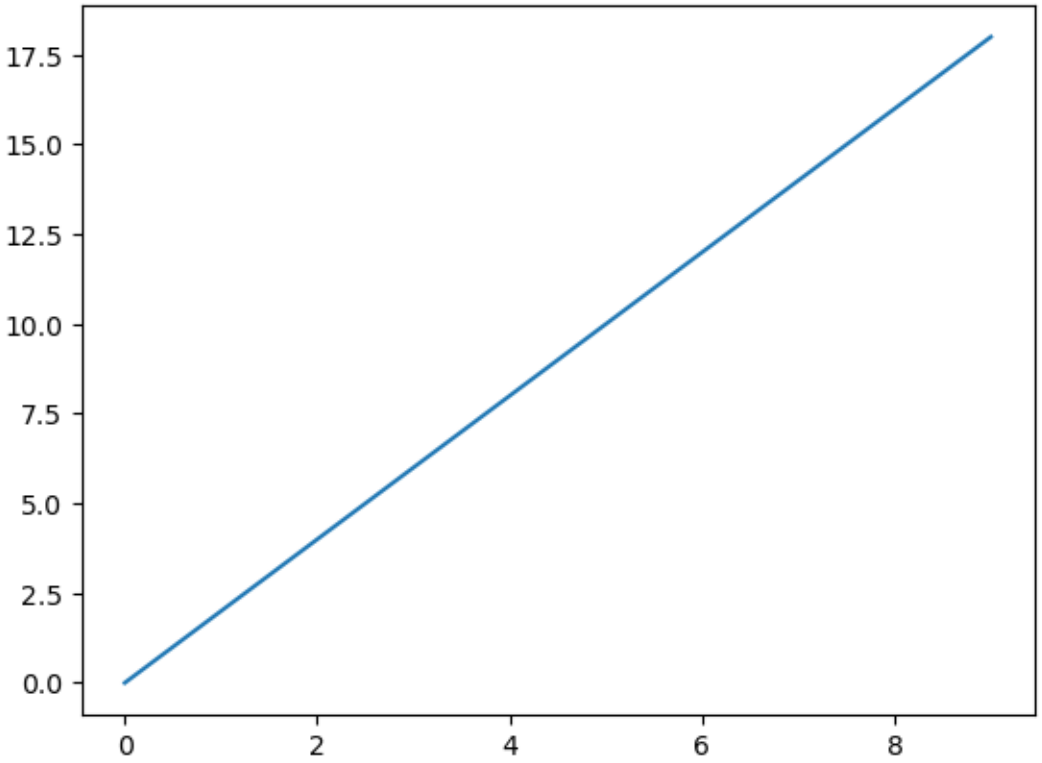
[7]:
```
array([ 0,  2,  4,  6,  8, 10, 12, 14, 16, 18])
```

Explicit interface This interface works by

- instantiating an instance of a Figure class (fig below)
- using a method subplots method (or similar) on that object to create one or more Axes objects (ax below)
- then calling drawing methods on the Axes (plot in this example)

[8]:
```
fig, ax = plt.subplots()  # Create a figure containing a single axes.
ax.plot(x, y)  # Plot some data on the axes.
```

[8]:
```
[<matplotlib.lines.Line2D at 0x7f7f491fd940>]
```

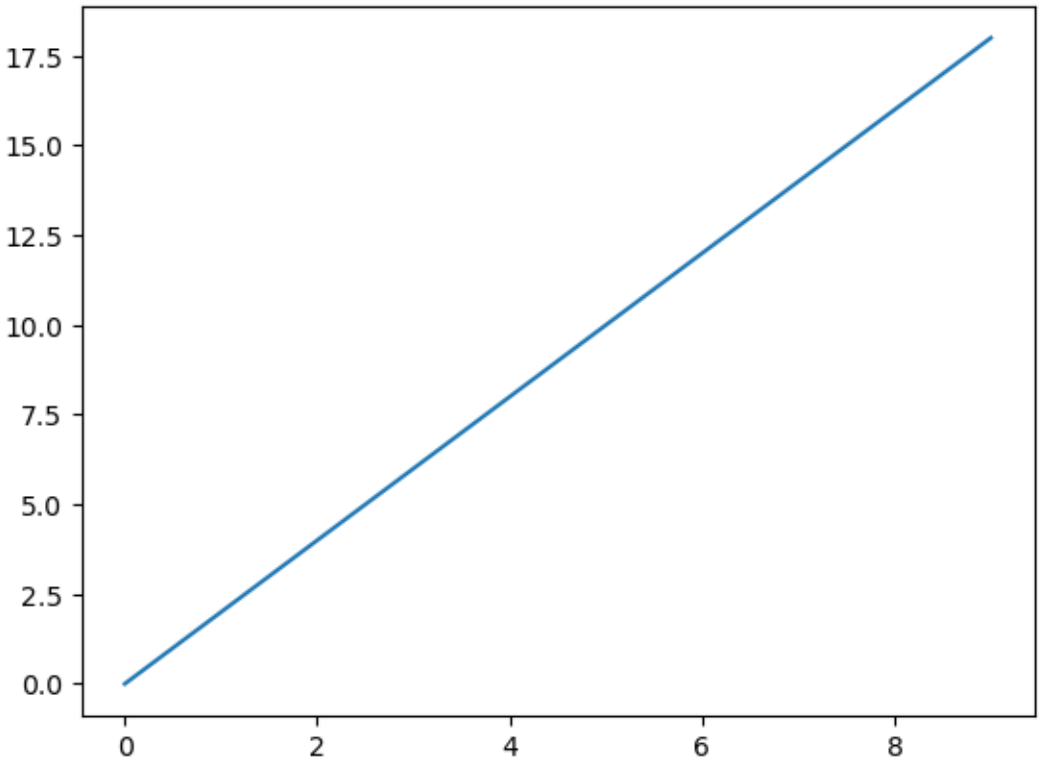


implicit interface

- shadows most of the Axes plotting methods to give the equivalent of the above
- the creation of the Figure and Axes is done for the user

[9]:
```
plt.plot(x,y)
```

[9]:
```
[<matplotlib.lines.Line2D at 0x7f7f786d7fd0>]
```



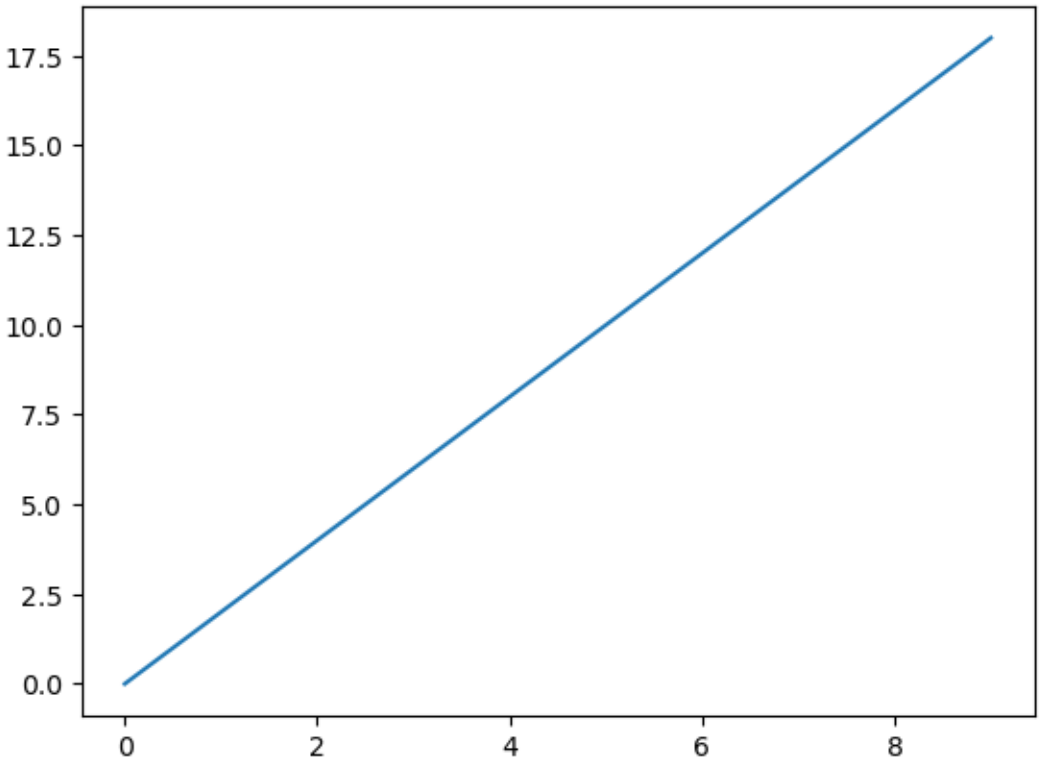
2.4 Anatamy of a Matplotlib Figure

2.4.1 `Figure` and `Axes`

- `Axes`:
  - represent an individual plot
  - differnt from "axis", which refers to the x/y axis of a plot
- `Figure`: the final image that may contain 1 or more `Axes`
- Syntax for creating `Figure` and `Axes`
  - `fig = plt.figure()  # an empty figure with no Axes`
  - `fig, ax = plt.subplots()  # a figure with a single Axes`
  - `fig, axs = plt.subplots(2, 2)  # a figure with a 2x2 grid of Axes`

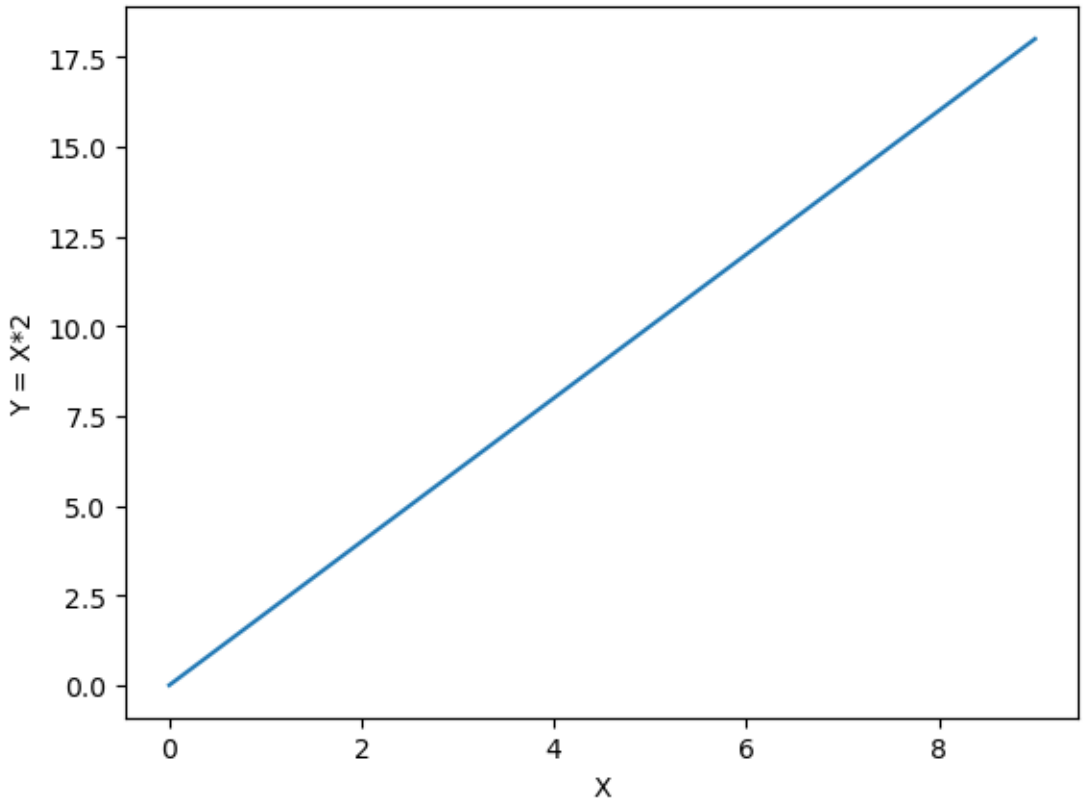
[10]:
```
fig, ax = plt.subplots()  # Create a figure containing a single axes.
ax.plot(x, y)  # Plot some data on the axes.
```

[10]:
```
[<matplotlib.lines.Line2D at 0x7f7f28019ee0>]
```



[11]:
```
fig, ax = plt.subplots()  # Create a figure containing a single axes.
ax.plot(x, y)  # Plot some data on the axes.
ax.set_xlabel("X")
ax.set_ylabel("Y = X*2")
```

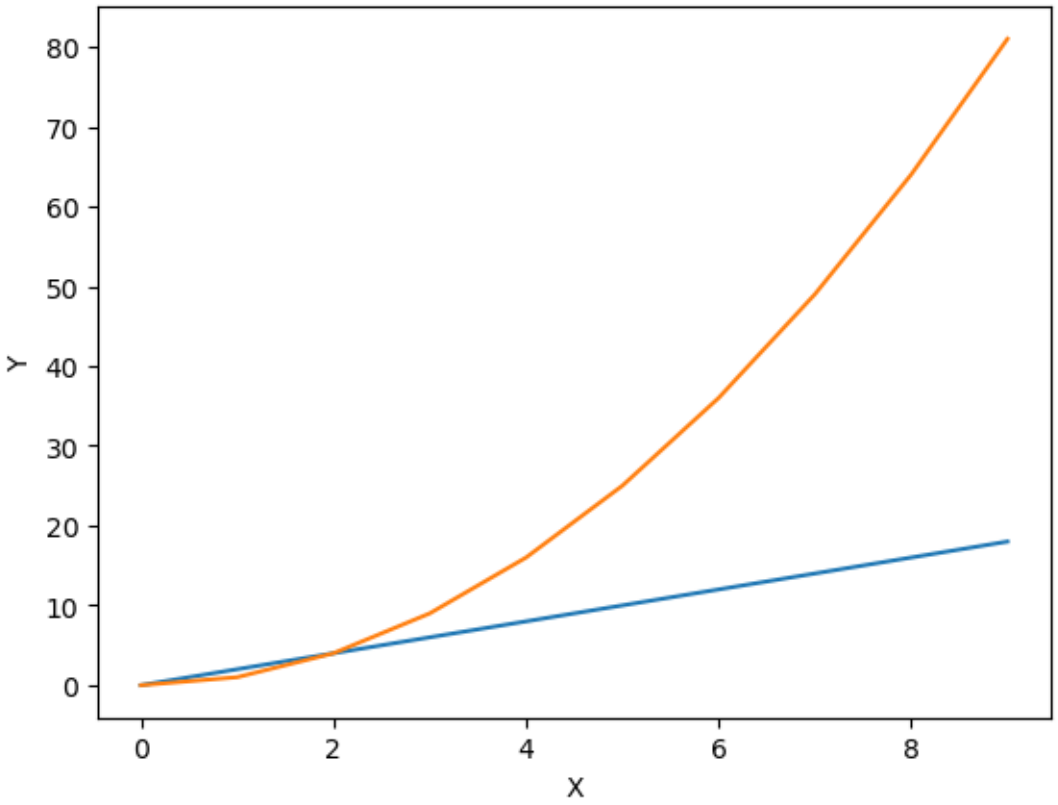
[11]:
```
Text(0, 0.5, 'Y = X*2')
```



What it we want to add another line to the current plot?

[12]:
```
fig, ax = plt.subplots()  # Create a figure containing a single axes.
ax.plot(x, y)  # Plot some data on the axes.


y2 = x ** 2
ax.plot(x, y2)  # Plot some data on the axes.

ax.set_xlabel("X")
ax.set_ylabel("Y")
```

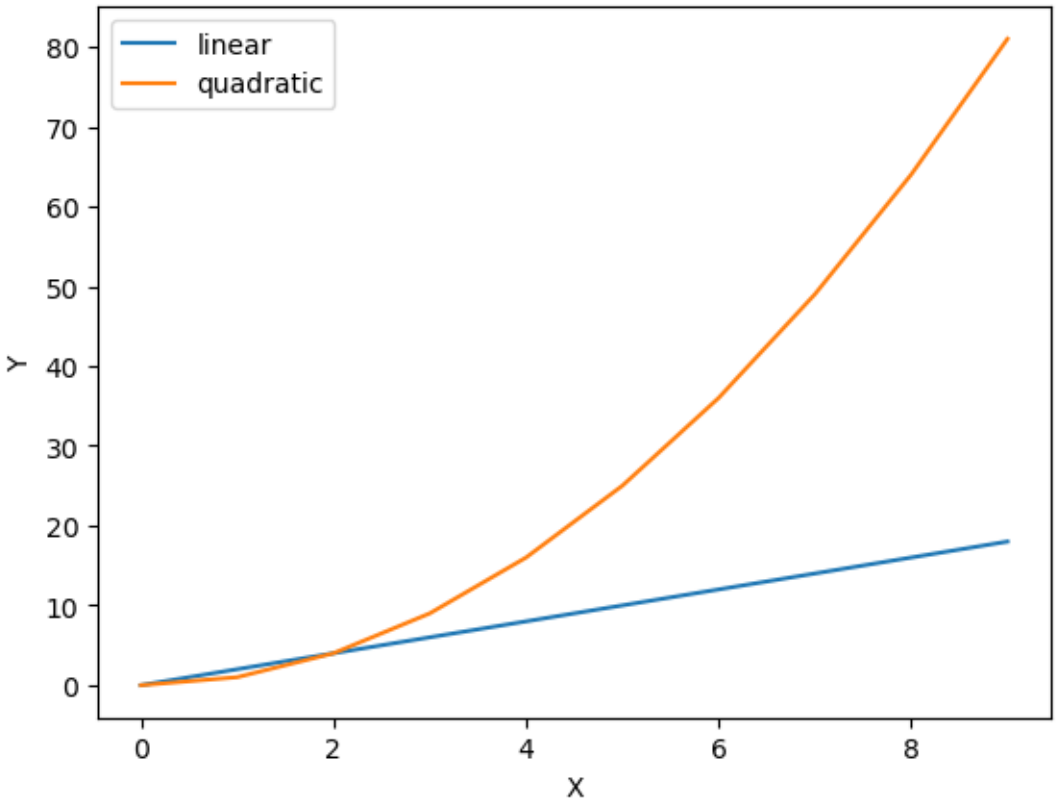
[12]:
```
Text(0, 0.5, 'Y')
```



add legend to different different lines

[13]:
```
fig, ax = plt.subplots()  # Create a figure containing a single axes.
x = np.arange(10)
y = x * 2
ax.plot(x, y, label='linear')

y2 = x ** 2
ax.plot(x, y2, label='quadratic')  # Plot some data on the axes.

ax.set_xlabel("X")
ax.set_ylabel("Y")
ax.legend()
```

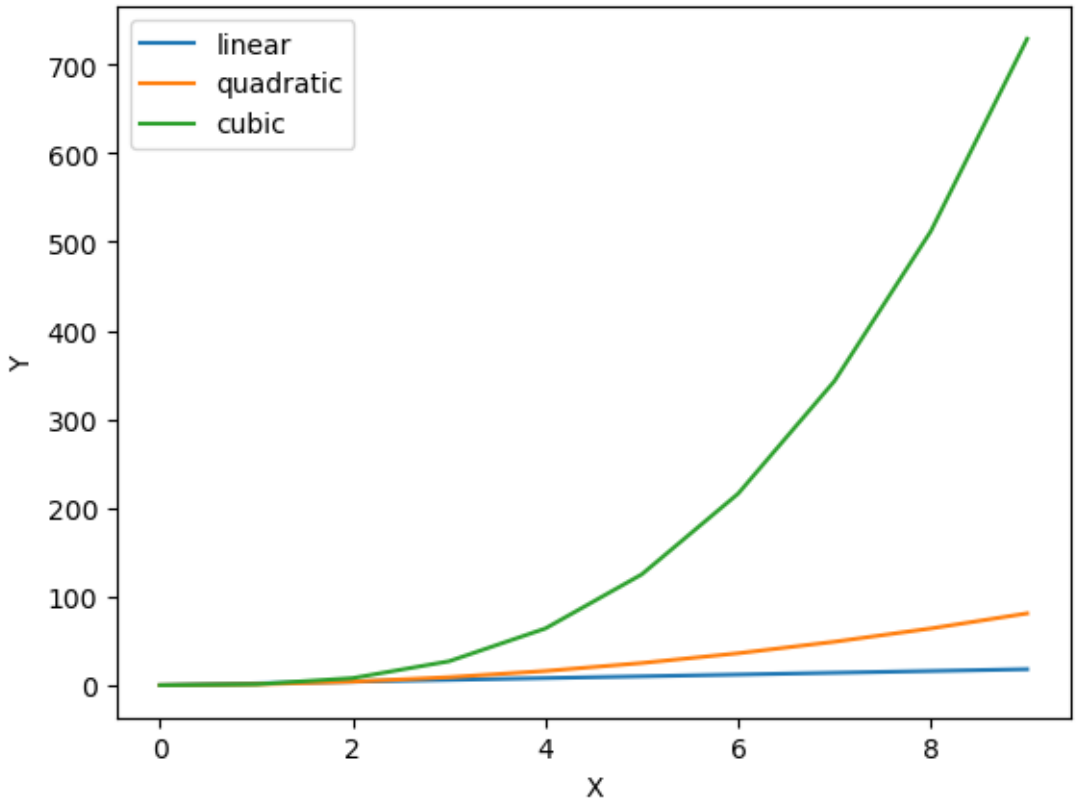
[13]: <matplotlib.legend.Legend at 0x7f7f58ccc400>



add a third line

[14]:
```
fig, ax = plt.subplots()  # Create a figure containing a single axes.
x = np.arange(10)
y = x * 2
ax.plot(x, y, label='linear')

y2 = x ** 2
ax.plot(x, y2, label='quadratic')  # Plot some data on the axes.

y3 = x ** 3
ax.plot(x, y3, label='cubic')

ax.set_xlabel("X")
ax.set_ylabel("Y")
ax.legend()
```

[14]: <matplotlib.legend.Legend at 0x7f7f58efc130>



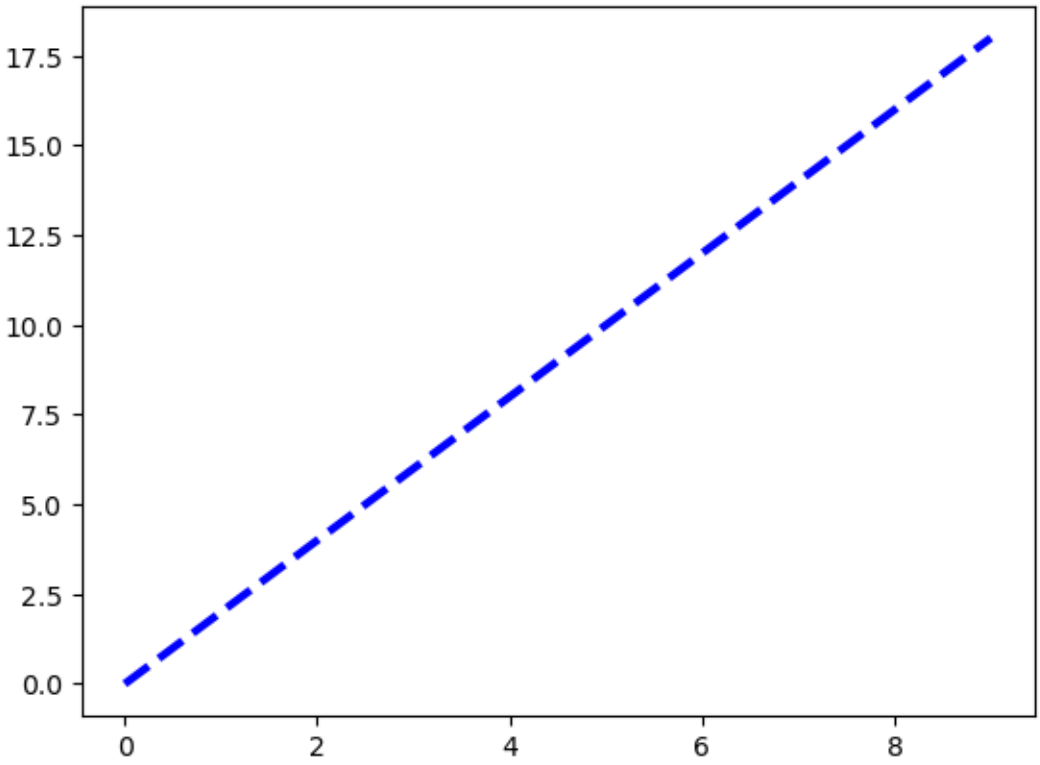
2.4.2 Styling Artists

`Axes`'s plotting methods have styling options for:

- color
- linewidth
- linestyle

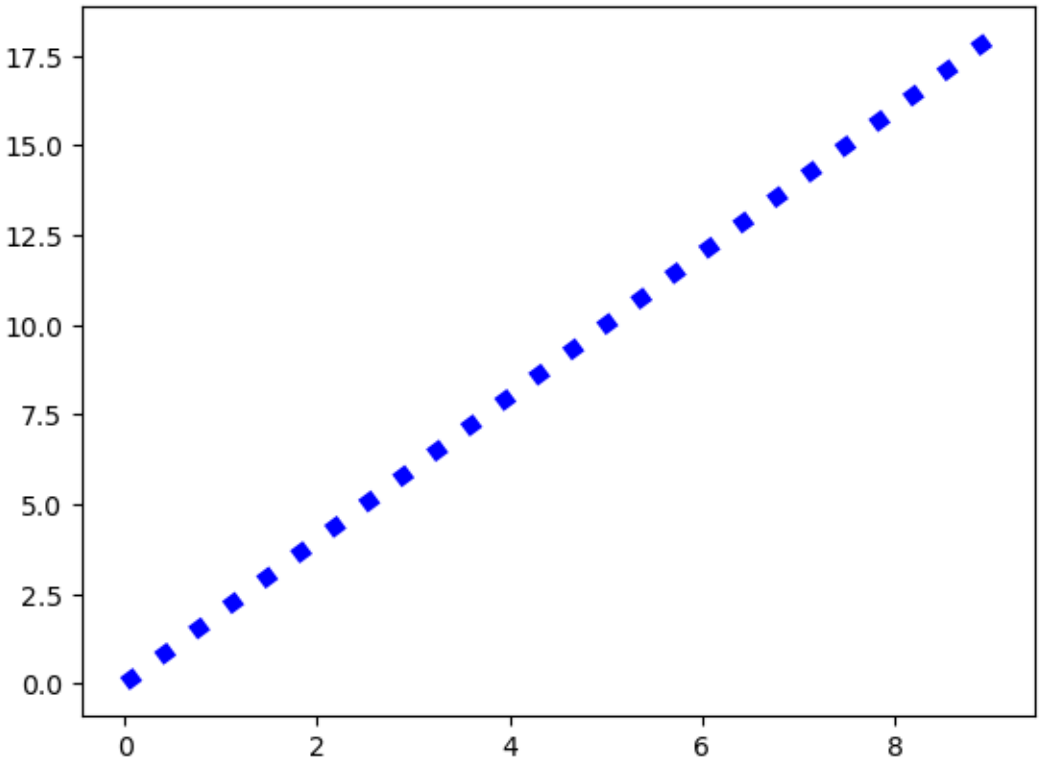
[15]:
```
fig, ax = plt.subplots()
ax.plot(x, y, color='blue', linewidth=3, linestyle='--')
```

[15]:
```
[<matplotlib.lines.Line2D at 0x7f7f49678160>]
```



[16]:
```
fig, ax = plt.subplots()
ax.plot(x, y, color='blue', linewidth=6, linestyle=':')
```

[16]: [<matplotlib.lines.Line2D at 0x7f7f7889e5b0>]



2.4.3 Group exercise

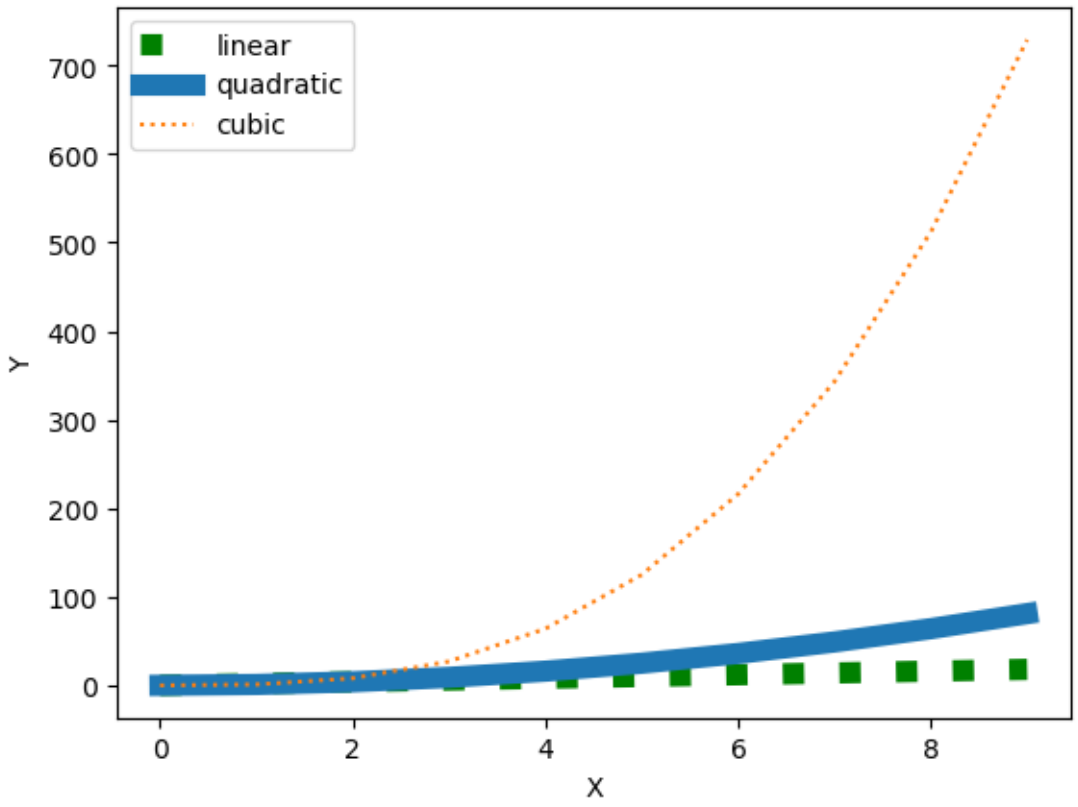
Edit the following python program to change the style (color, linewidth, linestyle) of the three plotted lines

```
fig, ax = plt.subplots()
x = np.arange(10)
y = x * 2
ax.plot(x, y, label='linear')

y2 = x ** 2
ax.plot(x, y2, label='quadratic')

y3 = x ** 3
ax.plot(x, y3, label='cubic')

ax.set_xlabel("X")
ax.set_ylabel("Y")
ax.legend()
```

when you are done, raise your hand!

[17]:
```
fig, ax = plt.subplots()
x = np.arange(10)
y = x * 2
ax.plot(x, y, label='linear', color="green", linewidth = 8, linestyle =␣
 ↪"dotted")

y2 = x ** 2
ax.plot(x, y2, label='quadratic', linewidth = 8)

y3 = x ** 3
ax.plot(x, y3, label='cubic', linestyle = "dotted")

ax.set_xlabel("X")
ax.set_ylabel("Y")
ax.legend()
```

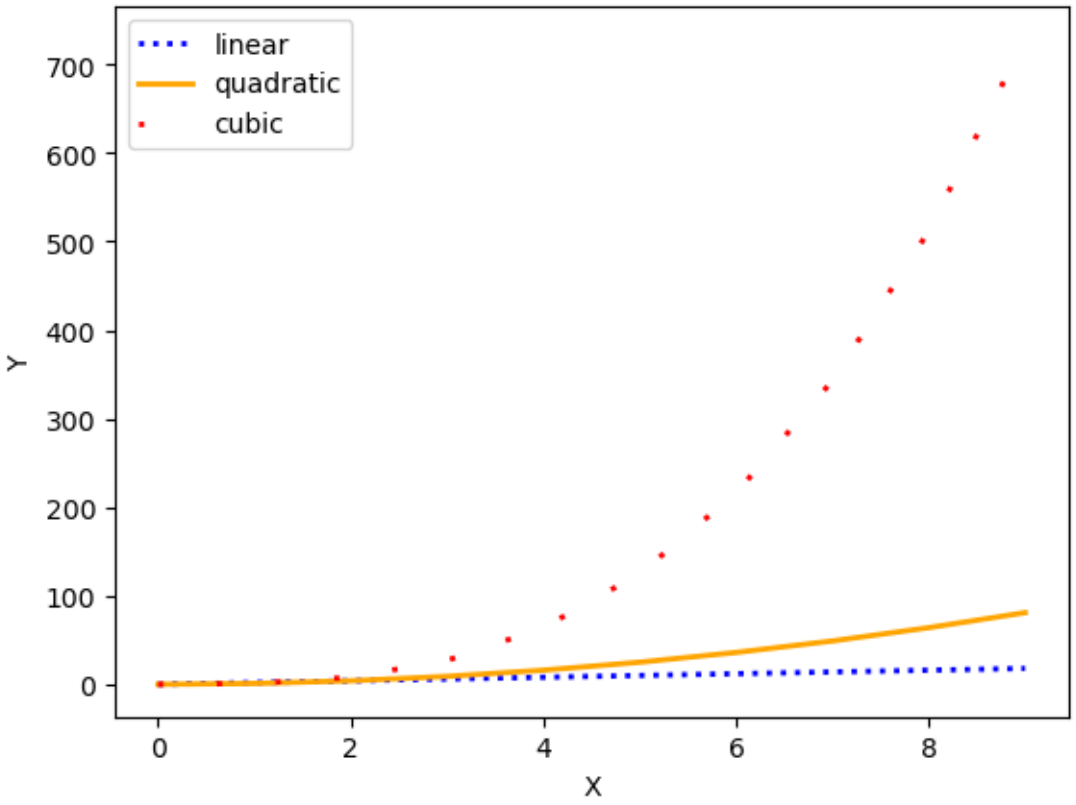
[17]:
```
<matplotlib.legend.Legend at 0x7f7f788b2d60>
```



[18]:
```
fig, ax = plt.subplots()
x = np.arange(10)
y = x * 2
```

```
ax.plot(x, y, label='linear', color='blue', linewidth=2, linestyle=':')

y2 = x ** 2
ax.plot(x, y2, label='quadratic',color='orange', linewidth=2, linestyle='-')

y3 = x ** 3
ax.plot(x, y3, label='cubic',color='red', linewidth=2, linestyle=(0, (1,10)))

ax.set_xlabel("X")
ax.set_ylabel("Y")
ax.legend()
```

[18]: <matplotlib.legend.Legend at 0x7f7f684114f0>



2.5 multiple plots (Axes) in one figure

When to use multiple plots instead of one

- the two plots are on different scales
  - linear: range [0,9]
  - cubic: range [0, 800]

How?

- Create a figure containing two axes.

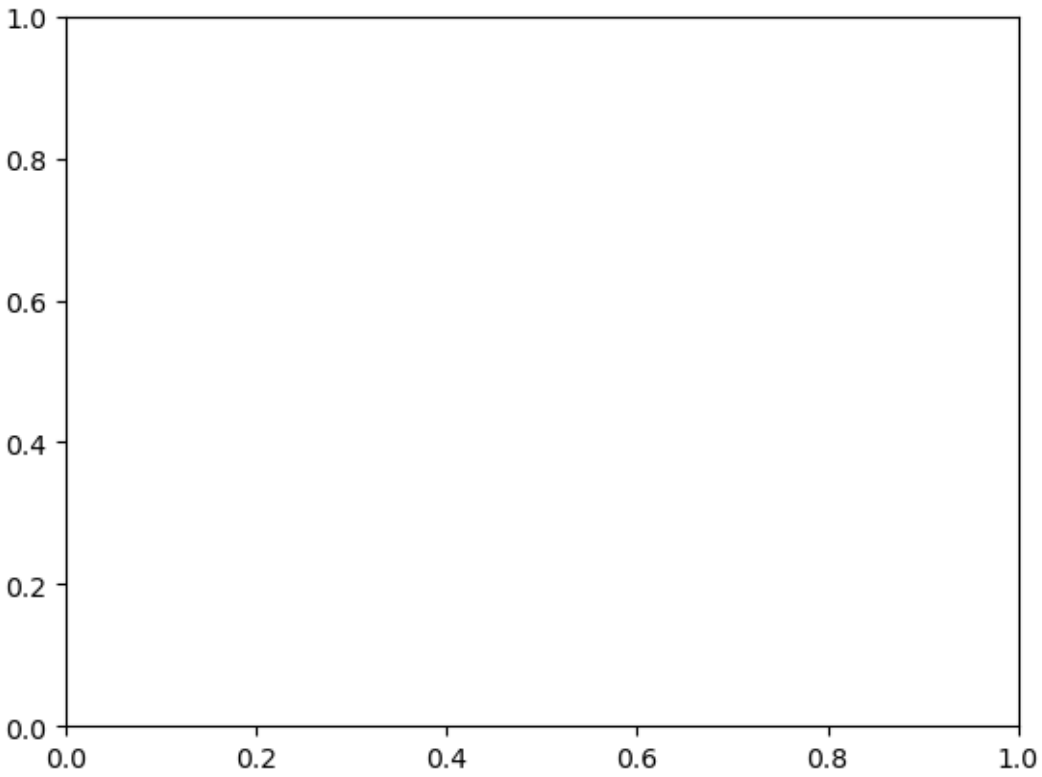
`fig, axes = plt.subplots(1,2)`

- Create a figure containing four axes.

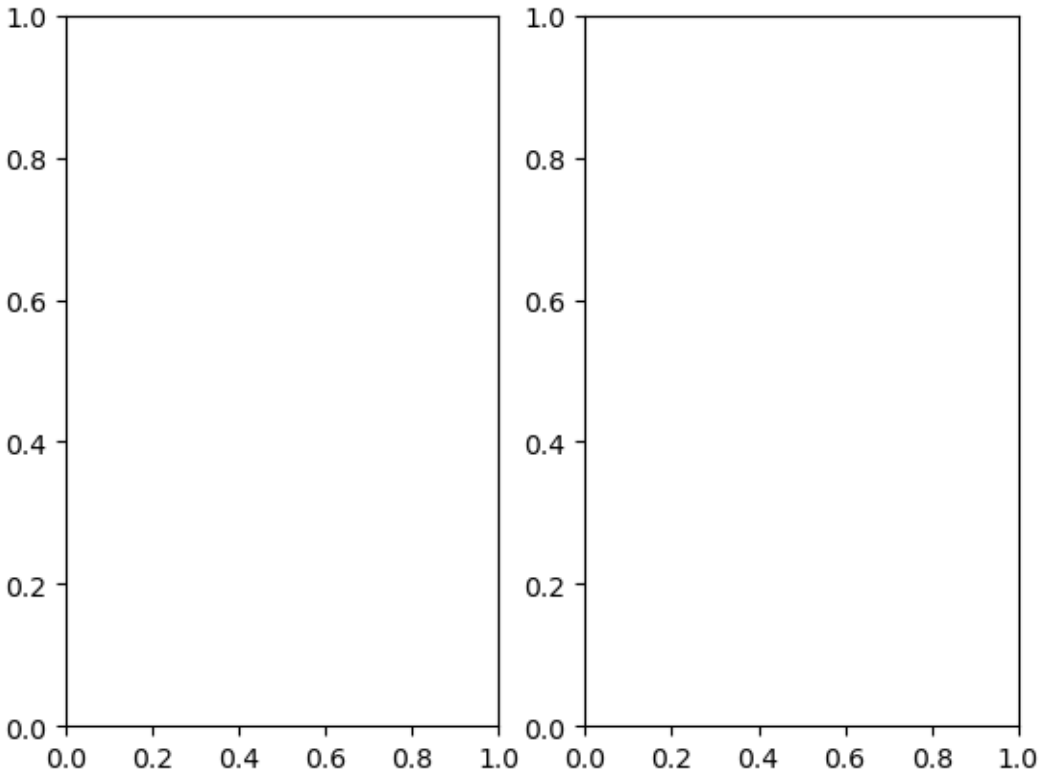
`fig, axes = plt.subplots(2,2)` (2 rows and 2 columns)

`fig, axes = plt.subplots(1,4)` (1 row and 4 columns)

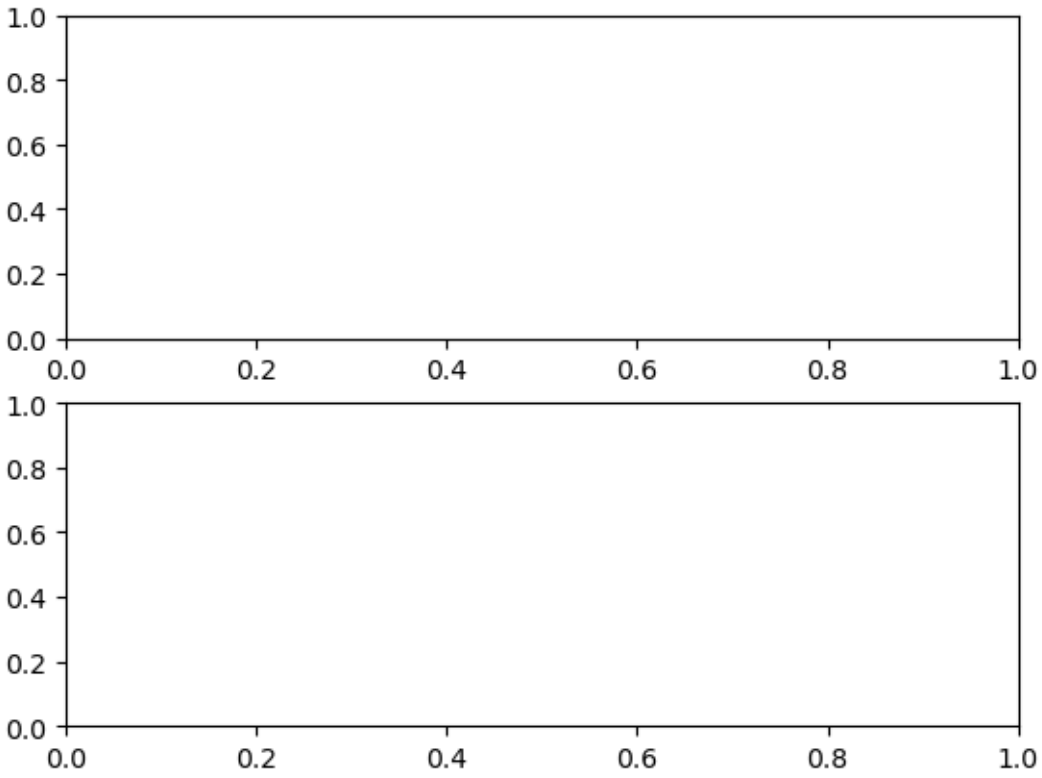
[19]:
```
fig, axes = plt.subplots()
```



[20]:
```
fig, axes = plt.subplots(1,2)  # Create a figure containing two axes.
```

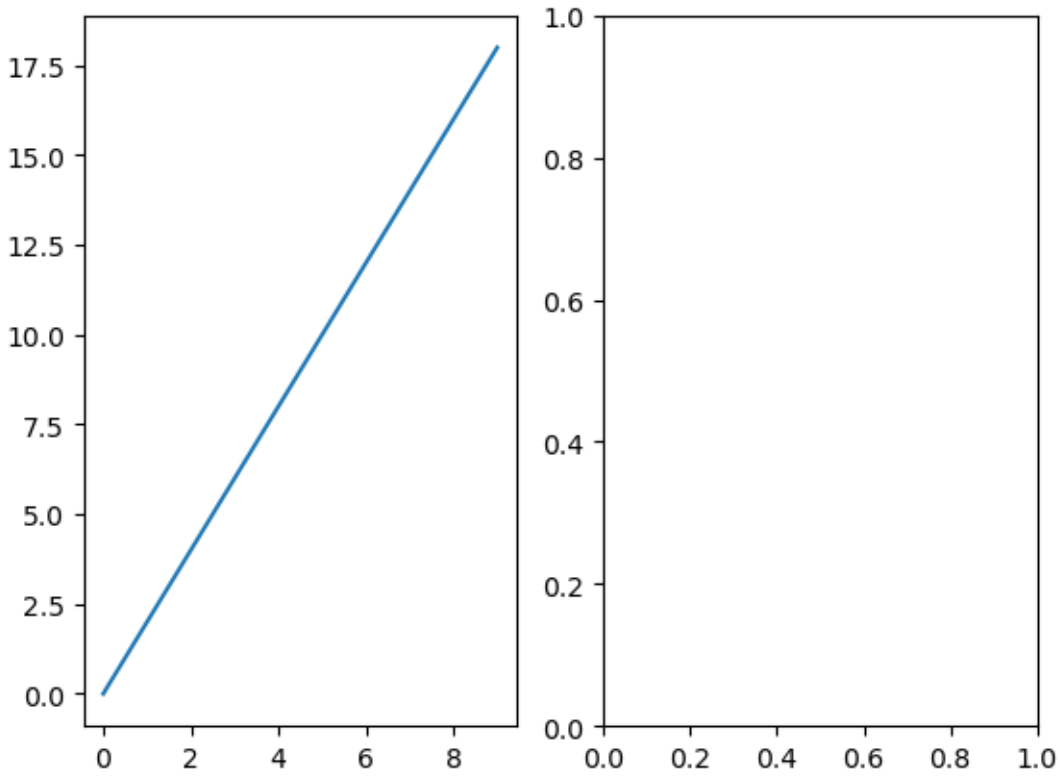


[21]:
```
fig, axes = plt.subplots(2,1)
```



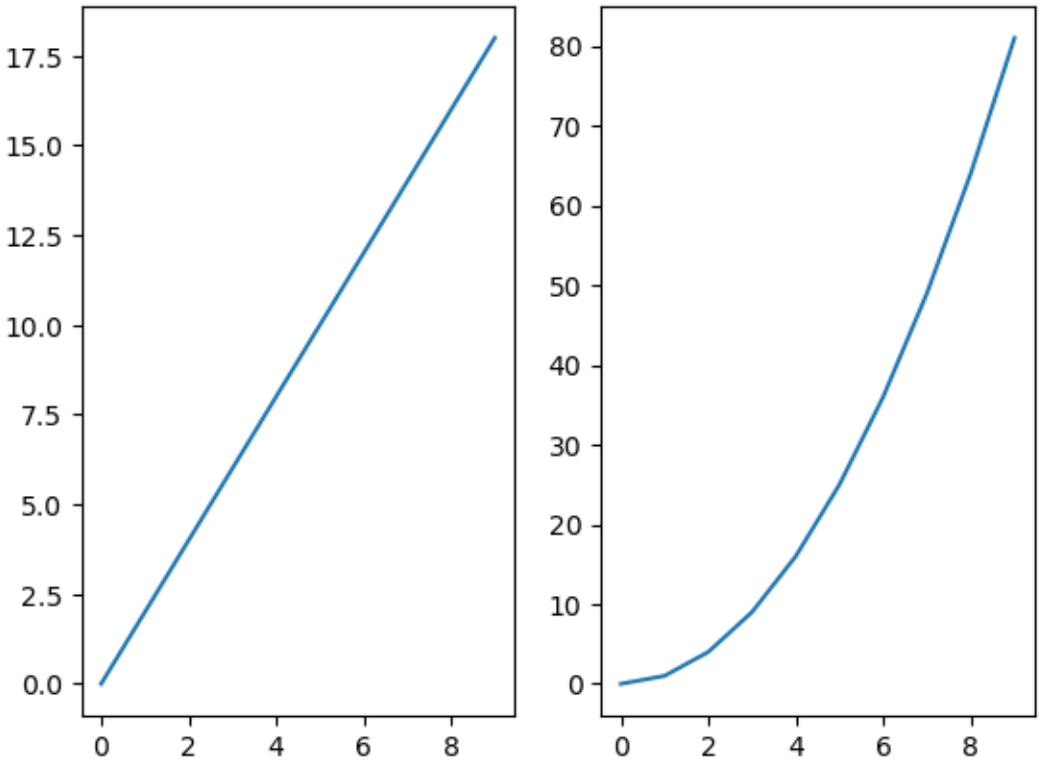
[22]:
```
fig, axes = plt.subplots(1,2)  # Create a figure containing two axes.
ax1 = axes[0]
ax1.plot(x,y)
```

[22]: [<matplotlib.lines.Line2D at 0x7f7f499b60a0>]



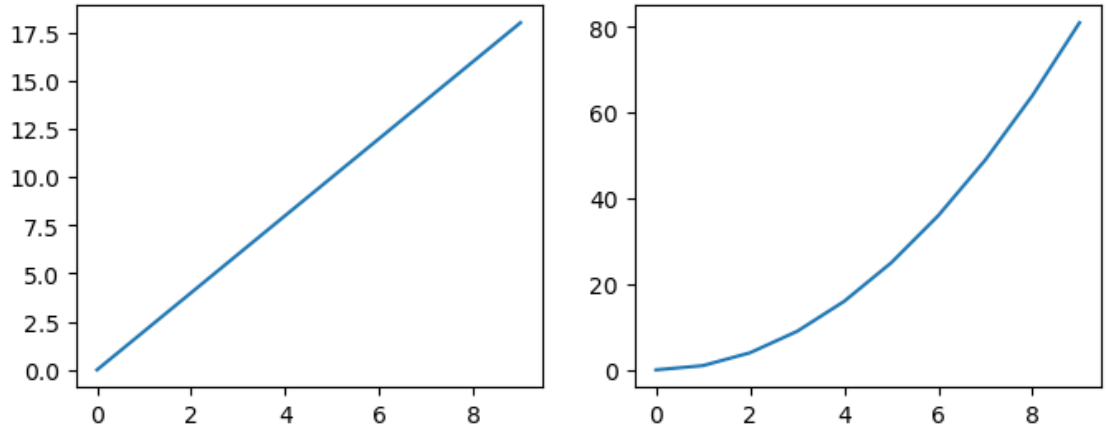
[23]:
```
fig, axes = plt.subplots(1,2)  # Create a figure containing two axes.
ax1 = axes[0]
ax1.plot(x,y)

ax2 = axes[1]
ax2.plot(x,x**2)
```

[23]:
```
[<matplotlib.lines.Line2D at 0x7f7f58ed51c0>]
```



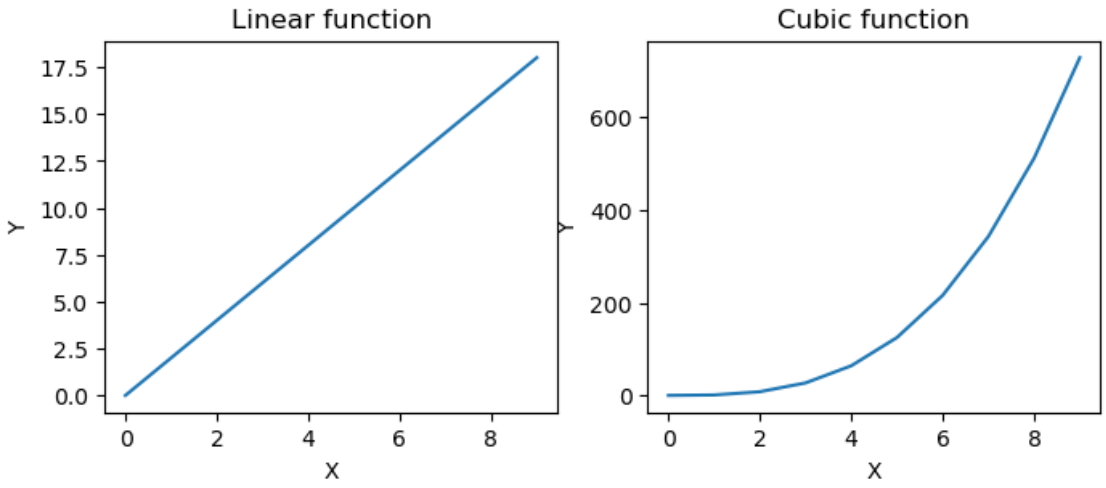
[24]:
```
fig, axes = plt.subplots(1,2,figsize=(8,3))  # Create a figure containing two␣
↪axes.
ax1 = axes[0]
ax1.plot(x,y)

ax2 = axes[1]
ax2.plot(x,x**2)
```

[24]: [<matplotlib.lines.Line2D at 0x7f7f519c0070>]



[25]:
```
fig, axes = plt.subplots(1,2,figsize=(8,3))  # Create a figure containing two␣
↪axes.
ax1 = axes[0]
ax1.plot(x,y)
ax1.set_xlabel("X")
ax1.set_ylabel("Y")
ax1.set_title("Linear function")

ax2 = axes[1]
ax2.plot(x,x**3)
ax2.set_xlabel("X")
ax2.set_ylabel("Y")
ax2.set_title("Cubic function")
```

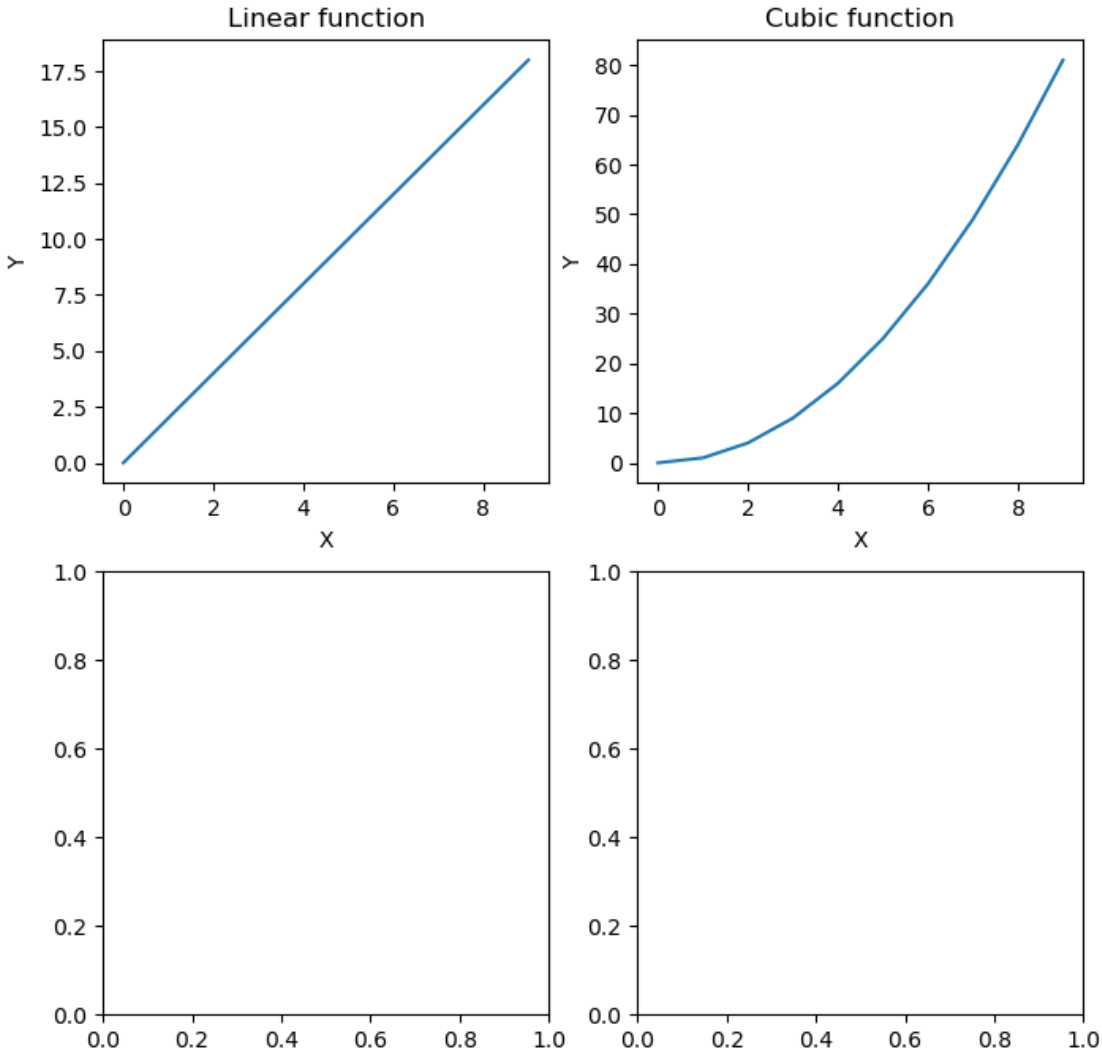
[25]:
```
Text(0.5, 1.0, 'Cubic function')
```



[26]:
```
fig, axes = plt.subplots(2,2,figsize=(8,8))  # Create a figure containing two␣
↪axes.
ax1 = axes[0,0]
ax1.plot(x,y)
ax1.set_xlabel("X")
ax1.set_ylabel("Y")
ax1.set_title("Linear function")

ax2 = axes[0,1]
ax2.plot(x,x**2)
ax2.set_xlabel("X")
```

```
ax2.set_ylabel("Y")
ax2.set_title("Cubic function")
```

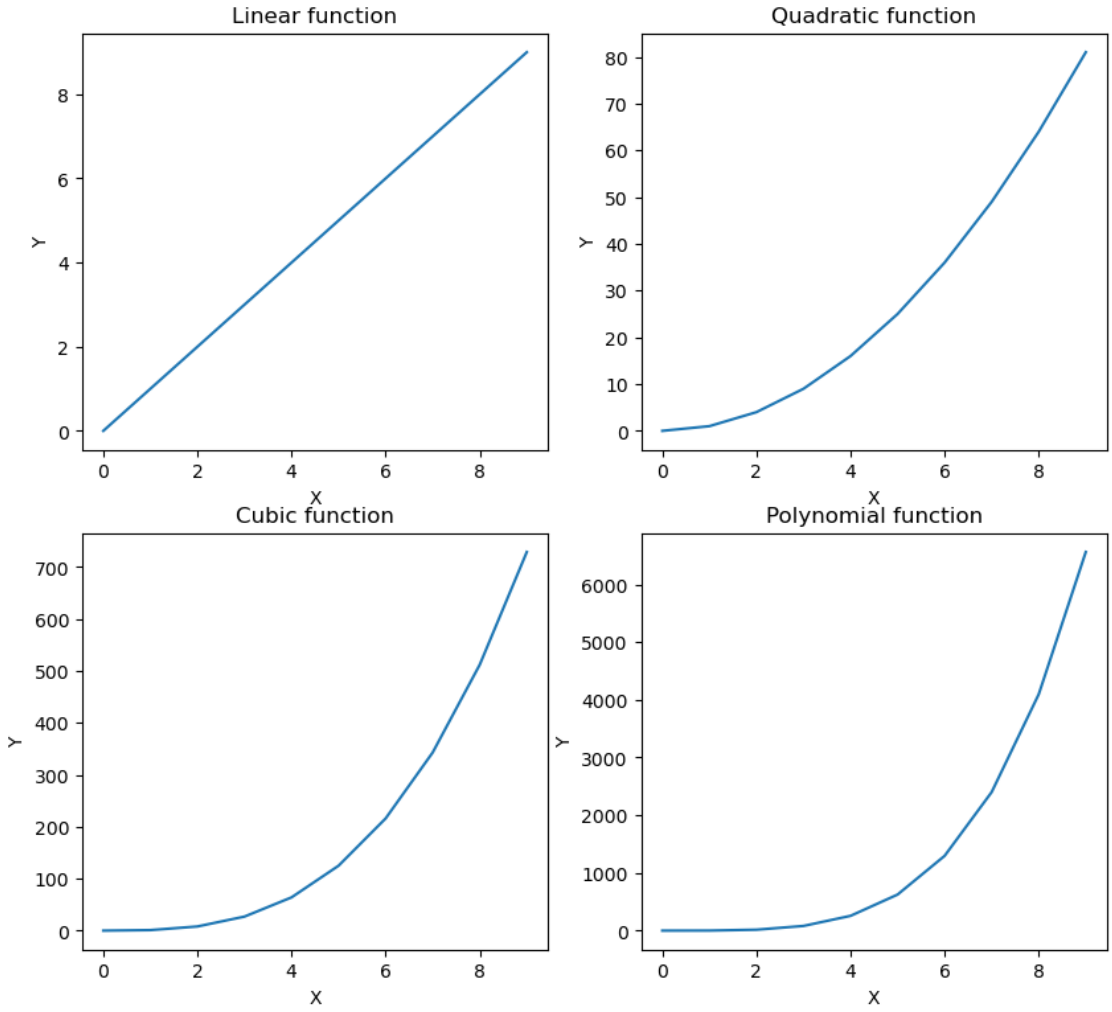
[26]: `Text(0.5, 1.0, 'Cubic function')`



[27]:
```
x = np.arange(10)

fig, axes =plt.subplots(2,2 ,figsize=(10,9))  # Create a figure containing four␣
 ↪axes.
ax1 = axes[0,0]
ax1.plot(x,x)
ax1.set_xlabel("X")
ax1.set_ylabel("Y")
ax1.set_title("Linear function")
```

```
ax2 = axes[0,1]
ax2.plot(x,x**2)
ax2.set_xlabel("X")
ax2.set_ylabel("Y")
ax2.set_title("Quadratic function")

ax3 = axes[1,0]
ax3.plot(x,x**3)
ax3.set_xlabel("X")
ax3.set_ylabel("Y")
ax3.set_title("Cubic function")

ax4 = axes[1,1]
ax4.plot(x,x**4)
ax4.set_xlabel("X")
ax4.set_ylabel("Y")
ax4.set_title("Polynomial function")
```

[27]: `Text(0.5, 1.0, 'Polynomial function')`



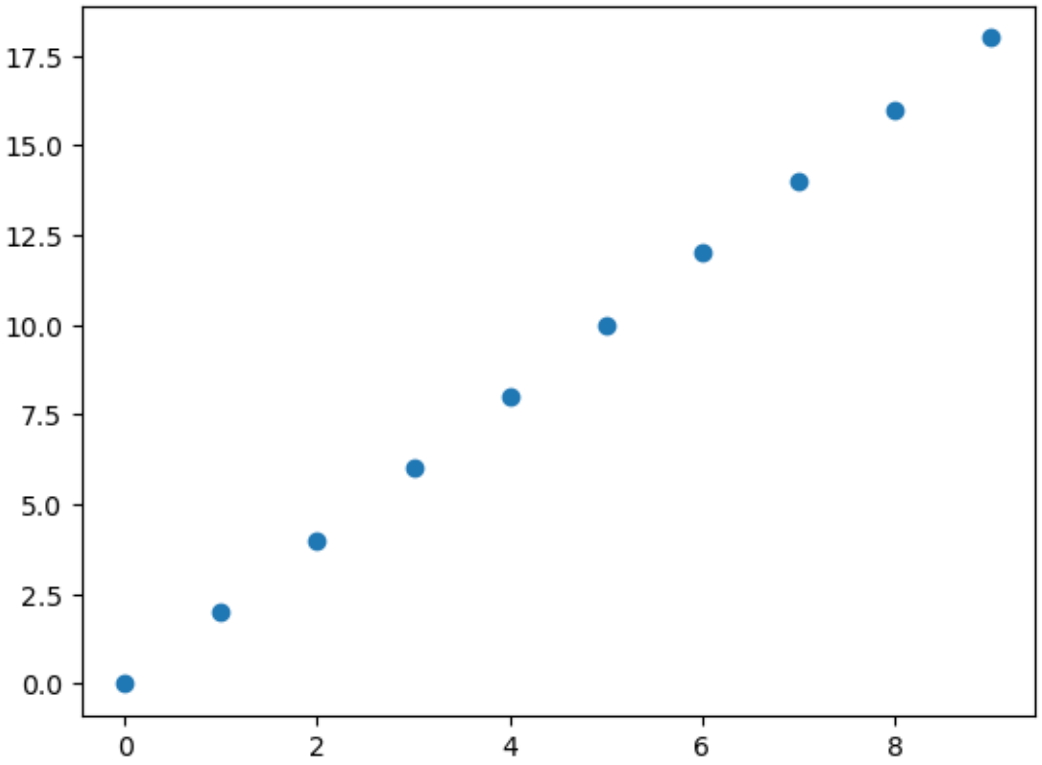
2.6 Scatter plot

`axes.scatter()`

- marker size `s=None`
- marker colors `c=None`
- marker style `marker=None`

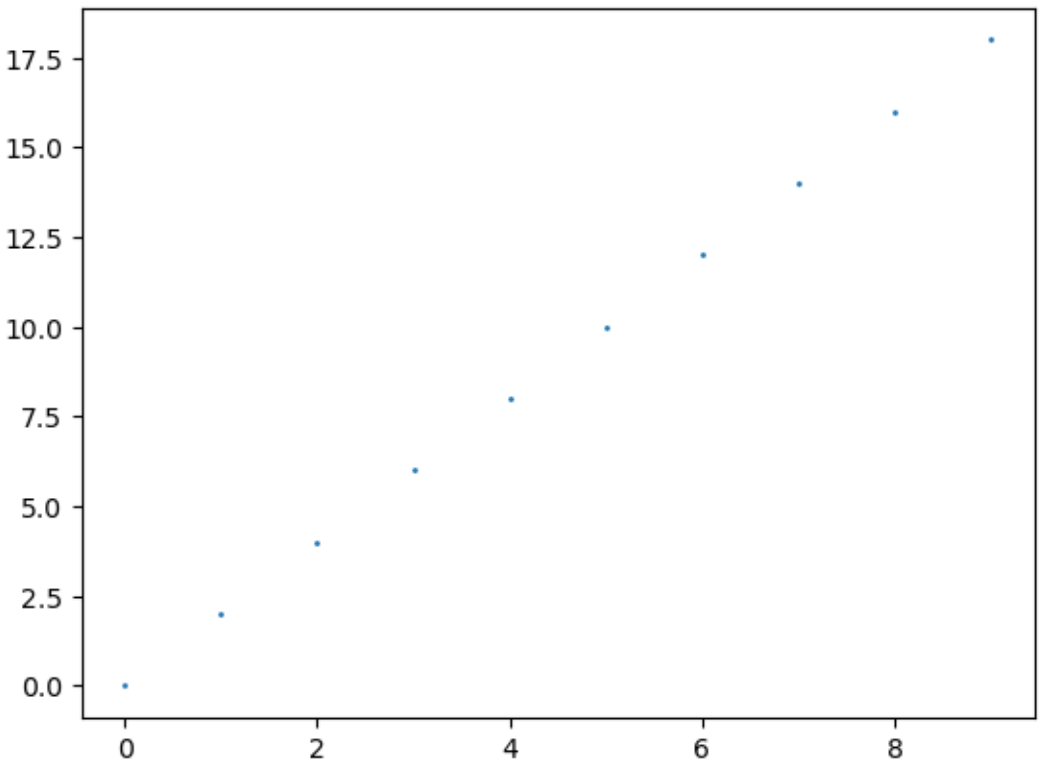
[28]:
```
fig, ax = plt.subplots()
ax.scatter(x,y)
```

[28]:
```
<matplotlib.collections.PathCollection at 0x7f7f59046b50>
```



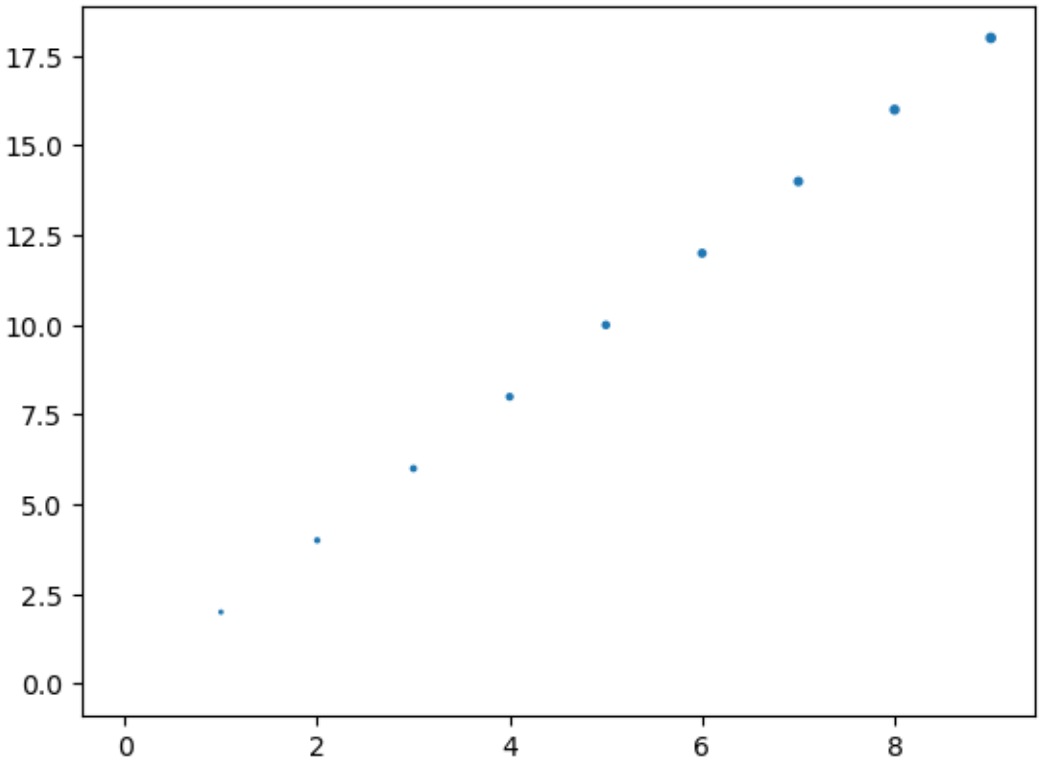
[29]:
```
fig, ax = plt.subplots()
ax.scatter(x,y, s=1)
```

[29]: <matplotlib.collections.PathCollection at 0x7f7f59046850>



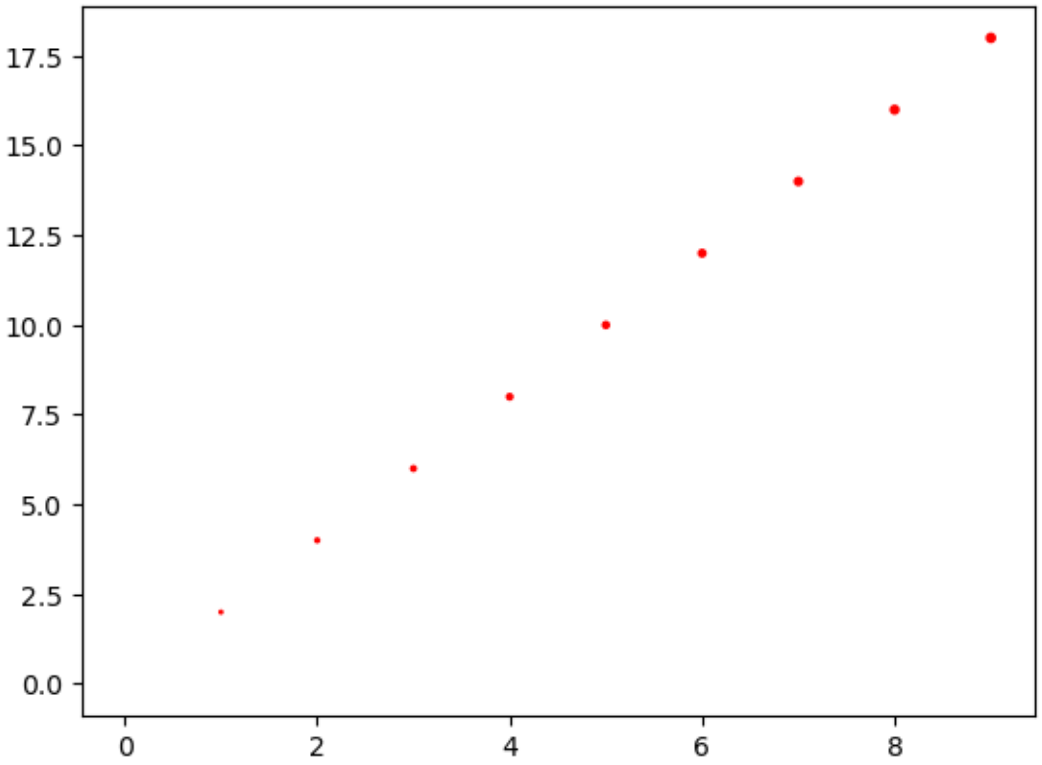
[30]:
```
fig, ax = plt.subplots()
ax.scatter(x,y, s=np.arange(10))
```

[30]: <matplotlib.collections.PathCollection at 0x7f7f590b0fd0>



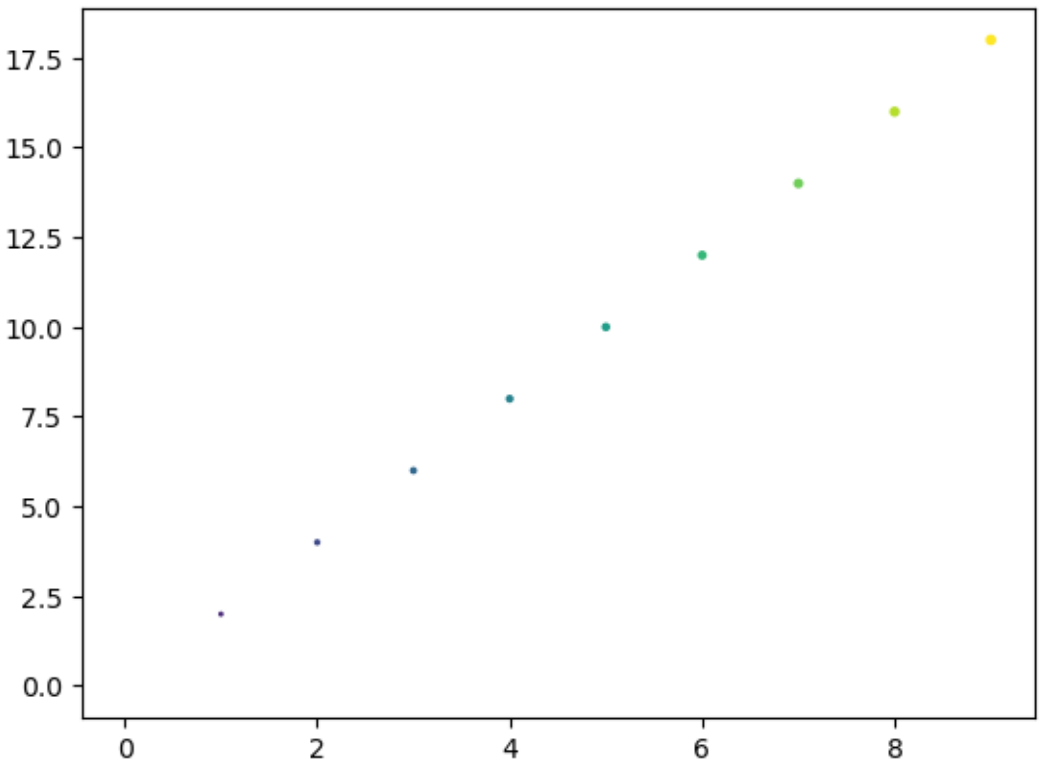
[31]:
```
fig, ax = plt.subplots()
ax.scatter(x,y, s=np.arange(10),c="red")
```

[31]: <matplotlib.collections.PathCollection at 0x7f7f18057910>



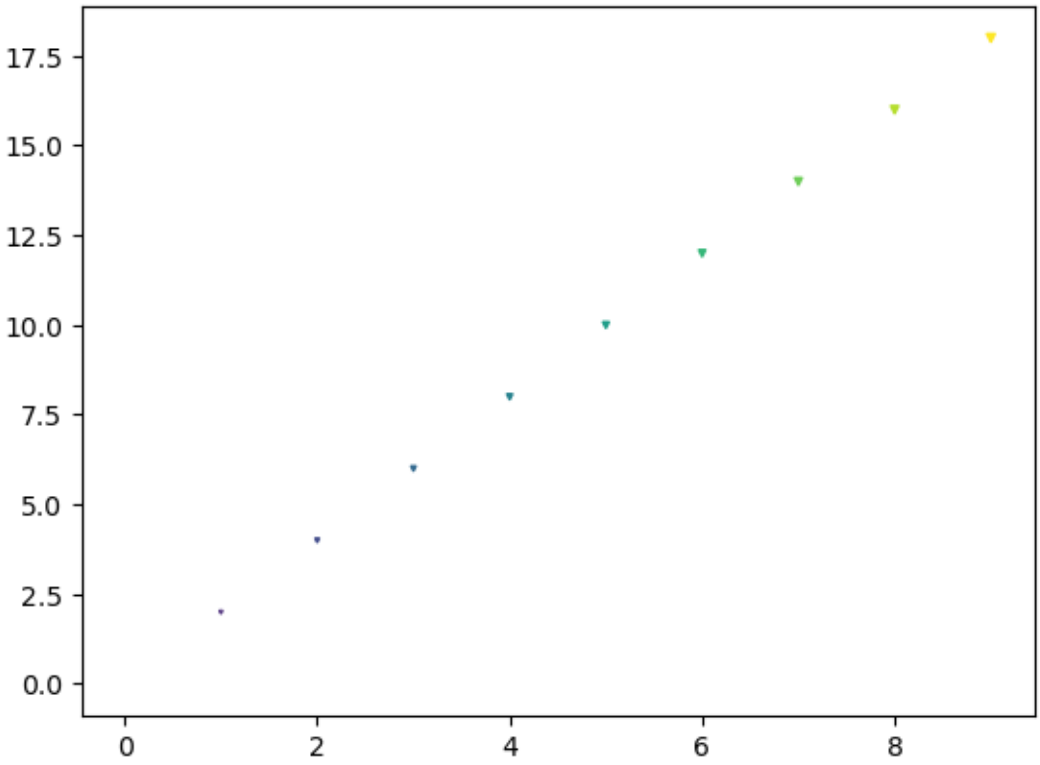
[32]:
```
fig, ax = plt.subplots()
ax.scatter(x,y, s=np.arange(10),c=np.arange(10))
```

[32]: <matplotlib.collections.PathCollection at 0x7f7f59213b50>



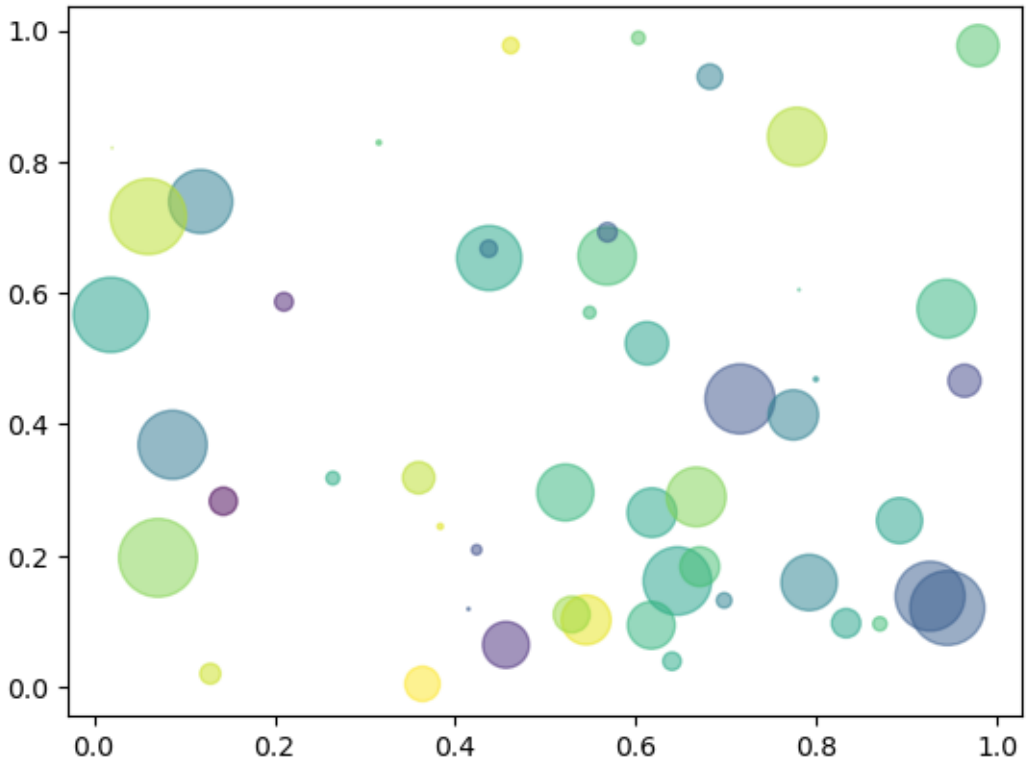
[33]:
```
fig, ax = plt.subplots()
ax.scatter(x,y, s=np.arange(10),c=np.arange(10), marker="v")
```

[33]: <matplotlib.collections.PathCollection at 0x7f7f49a7d040>



[34]:
```
import numpy as np
import matplotlib.pyplot as plt

# Fixing random state for reproducibility
np.random.seed(0)


N = 50
x = np.random.rand(N)
y = np.random.rand(N)
colors = np.random.rand(N)
area = (30 * np.random.rand(N))**2  # 0 to 15 point radii
fig, ax = plt.subplots()
ax.scatter(x, y, s=area, c=colors, alpha=0.5)
```

[34]:
```
<matplotlib.collections.PathCollection at 0x7f7f51b33280>
```



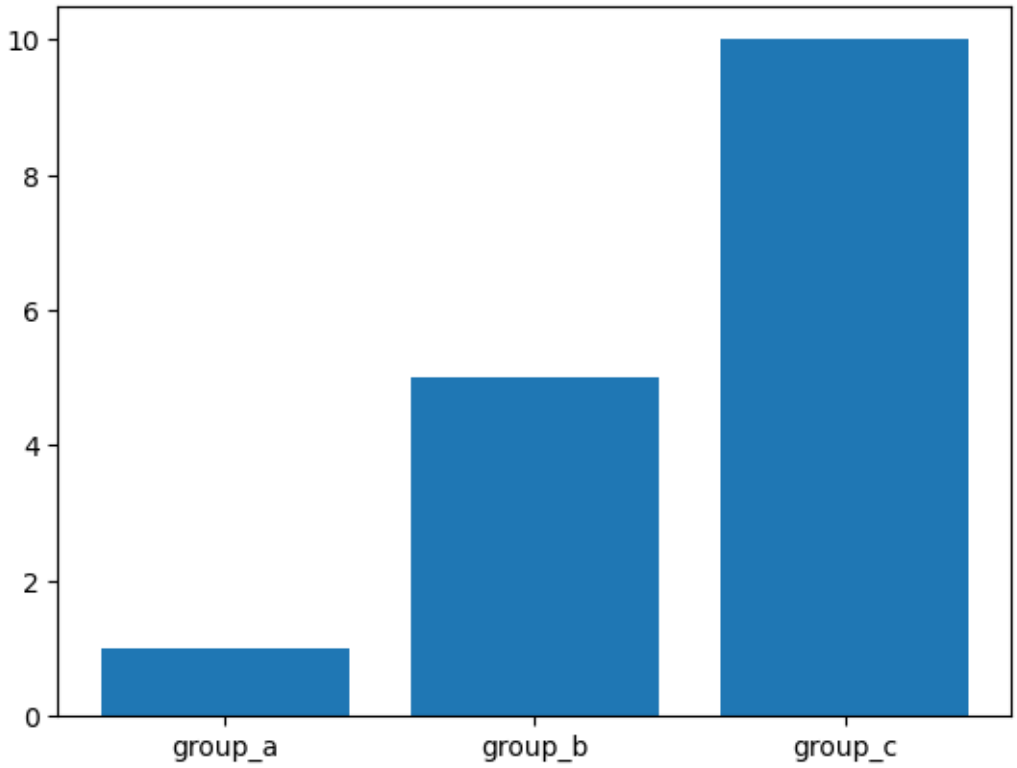
2.7 bar plot for categorical variables

`axes.bar()`: a vertical bar plot.

`axes.barh()`: a horizontal bar plot.

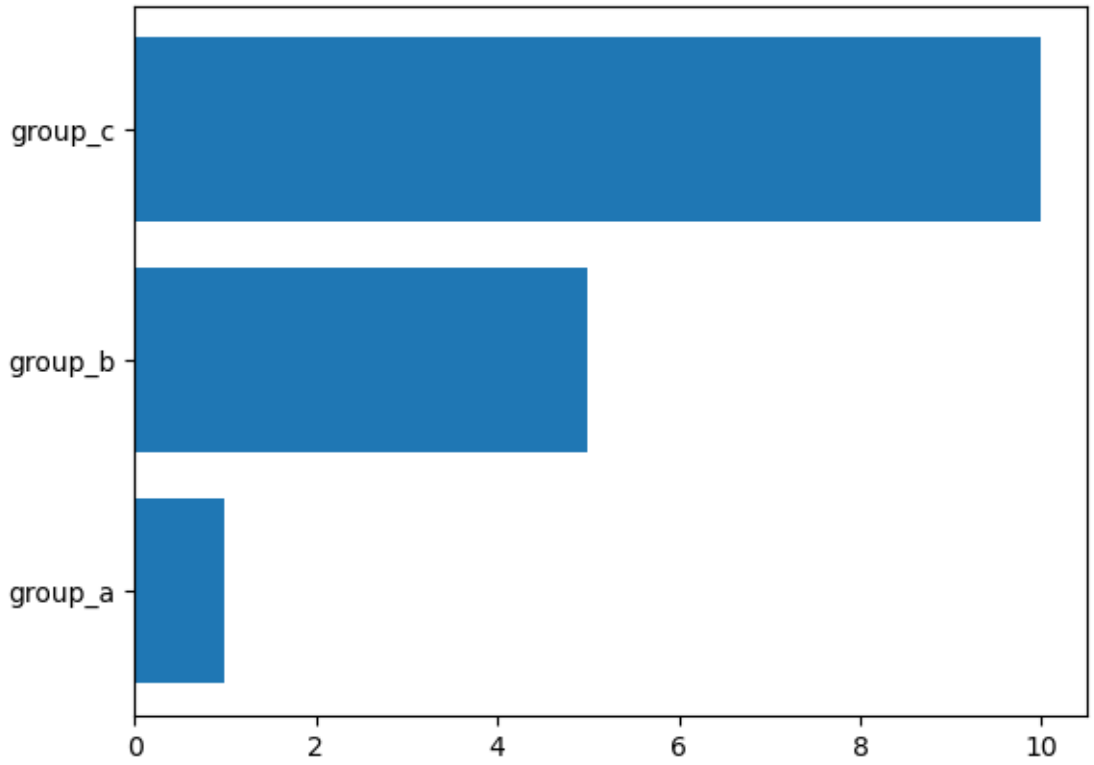
[35]:
```
names = ['group_a', 'group_b', 'group_c']
values = [1, 5, 10]
fig, ax = plt.subplots()
ax.bar(names, values)
```

[35]:
```
<BarContainer object of 3 artists>
```



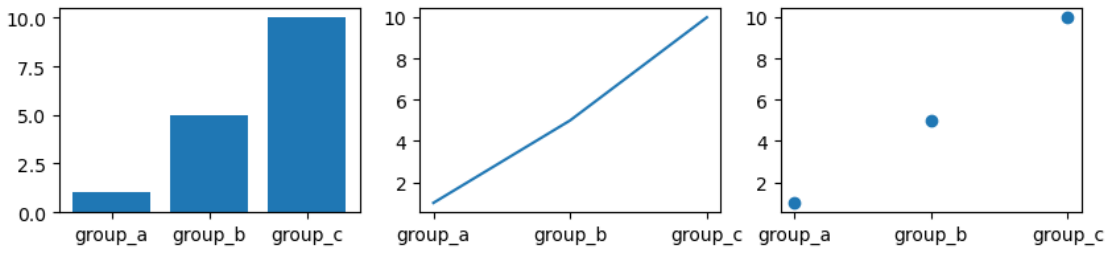
[36]:
```
names = ['group_a', 'group_b', 'group_c']
values = [1, 5, 10]
fig, ax = plt.subplots()
ax.barh(names, values)
```

[36]: <BarContainer object of 3 artists>



[37]:
```
names = ['group_a', 'group_b', 'group_c']
values = [1, 5, 10]
fig, axes = plt.subplots(1,3, figsize=(10,2))
axes[0].bar(names, values)
axes[1].plot(names, values)
axes[2].scatter(names, values)
```

[37]: <matplotlib.collections.PathCollection at 0x7f7f49ab53d0>



2.8 Distributions and Densities

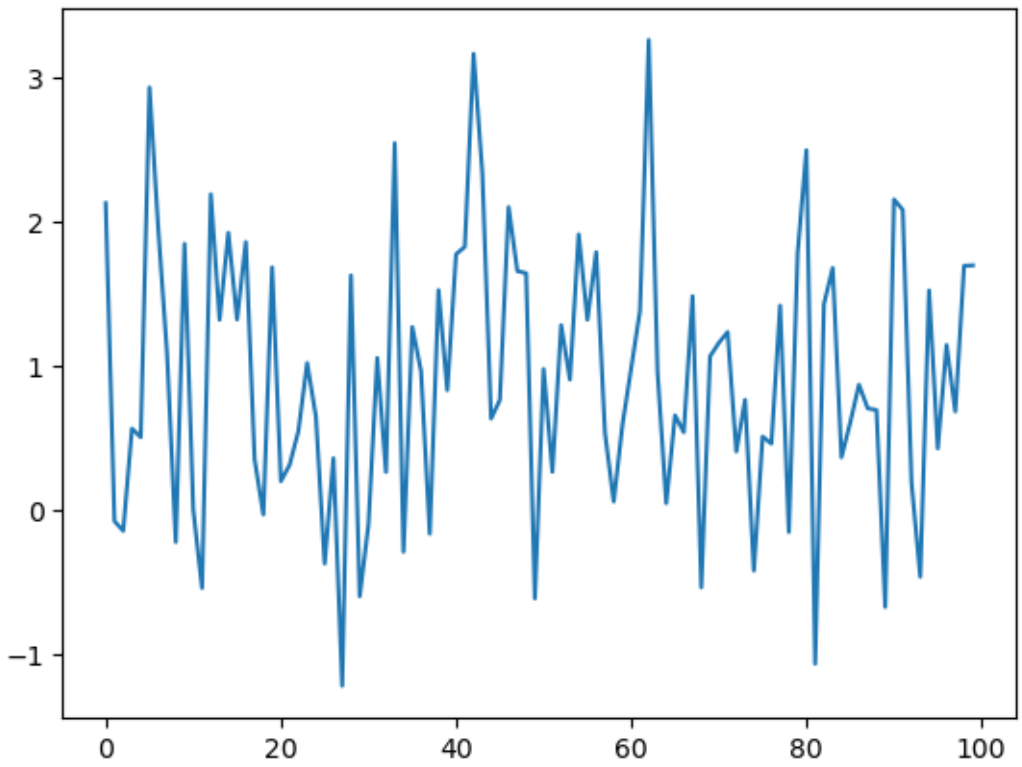
[38]:
```
import numpy as np

x = np.random.normal(1,1,100)
```

[39]:
```
x
```

[39]:
```
array([ 2.12663592e+00, -7.99315084e-02, -1.47468652e-01,  5.62179955e-01,
        5.01967549e-01,  2.92953205e+00,  1.94942081e+00,  1.08755124e+00,
       -2.25435519e-01,  1.84436298e+00, -2.15347390e-04, -5.44771097e-01,
        2.18802979e+00,  1.31694261e+00,  1.92085882e+00,  1.31872765e+00,
        1.85683061e+00,  3.48974407e-01, -3.42428418e-02,  1.68159452e+00,
        1.96590336e-01,  3.10450222e-01,  5.44467496e-01,  1.01747916e+00,
        6.46006089e-01, -3.74951293e-01,  3.56381597e-01, -1.22340315e+00,
        1.62523145e+00, -6.02057656e-01, -1.04383339e-01,  1.05216508e+00,
        2.60437004e-01,  2.54301460e+00, -2.92856910e-01,  1.26705087e+00,
        9.60717182e-01, -1.68093498e-01,  1.52327666e+00,  8.28453669e-01,
        1.77179055e+00,  1.82350415e+00,  3.16323595e+00,  2.33652795e+00,
        6.30818162e-01,  7.60620822e-01,  2.09965960e+00,  1.65526373e+00,
        1.64013153e+00, -6.16956044e-01,  9.75673876e-01,  2.61969091e-01,
        1.27992460e+00,  9.01849610e-01,  1.91017891e+00,  1.31721822e+00,
        1.78632796e+00,  5.33580903e-01,  5.55537441e-02,  5.89950307e-01,
        9.82979586e-01,  1.37915174e+00,  3.25930895e+00,  9.57742848e-01,
        4.40549995e-02,  6.54018224e-01,  5.36404025e-01,  1.48148147e+00,
       -5.40797014e-01,  1.06326199e+00,  1.15650654e+00,  1.23218104e+00,
        4.02683931e-01,  7.62078270e-01, -4.24060909e-01,  5.06680117e-01,
        4.57138524e-01,  1.41605005e+00, -1.56182432e-01,  1.78119810e+00,
        2.49448454e+00, -1.06998503e+00,  1.42625873e+00,  1.67690804e+00,
        3.62562974e-01,  6.02728186e-01,  8.67119422e-01,  7.02209121e-01,
        6.90987031e-01, -6.76003806e-01,  2.15233156e+00,  2.07961859e+00,
        1.86635741e-01, -4.66424328e-01,  1.52106488e+00,  4.24212030e-01,
        1.14195316e+00,  6.80671583e-01,  1.69153875e+00,  1.69474914e+00])
```

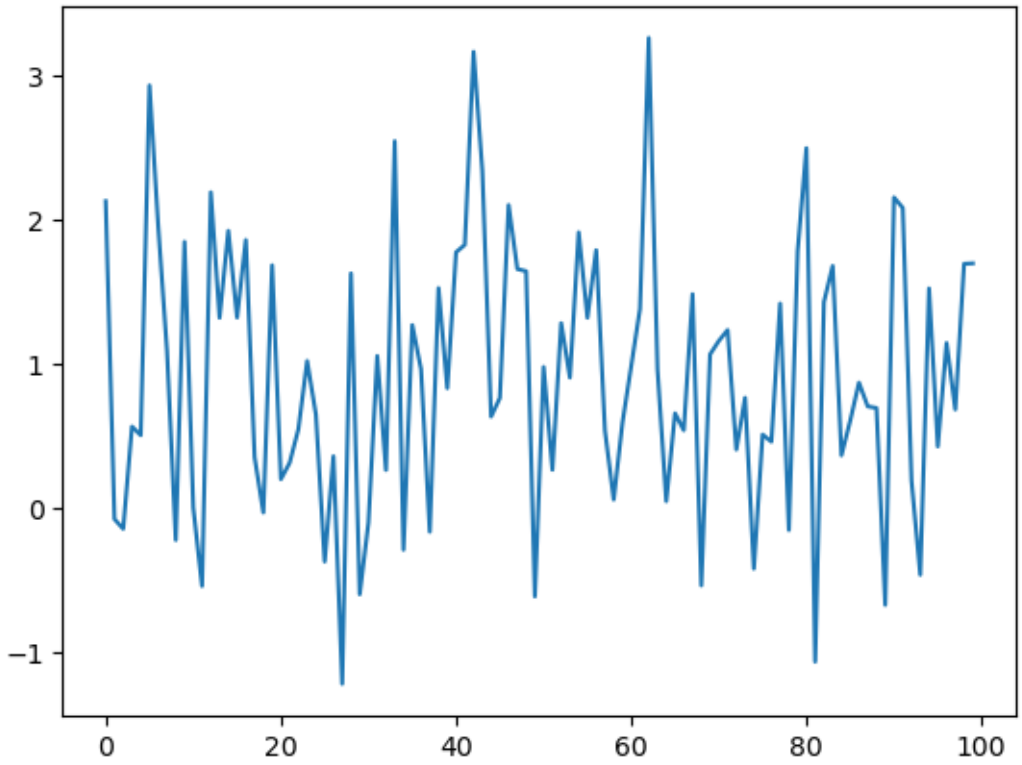
[40]:
```
fig, ax = plt.subplots()
ax.plot(x)
```

[40]:
```
[<matplotlib.lines.Line2D at 0x7f7f59a61910>]
```



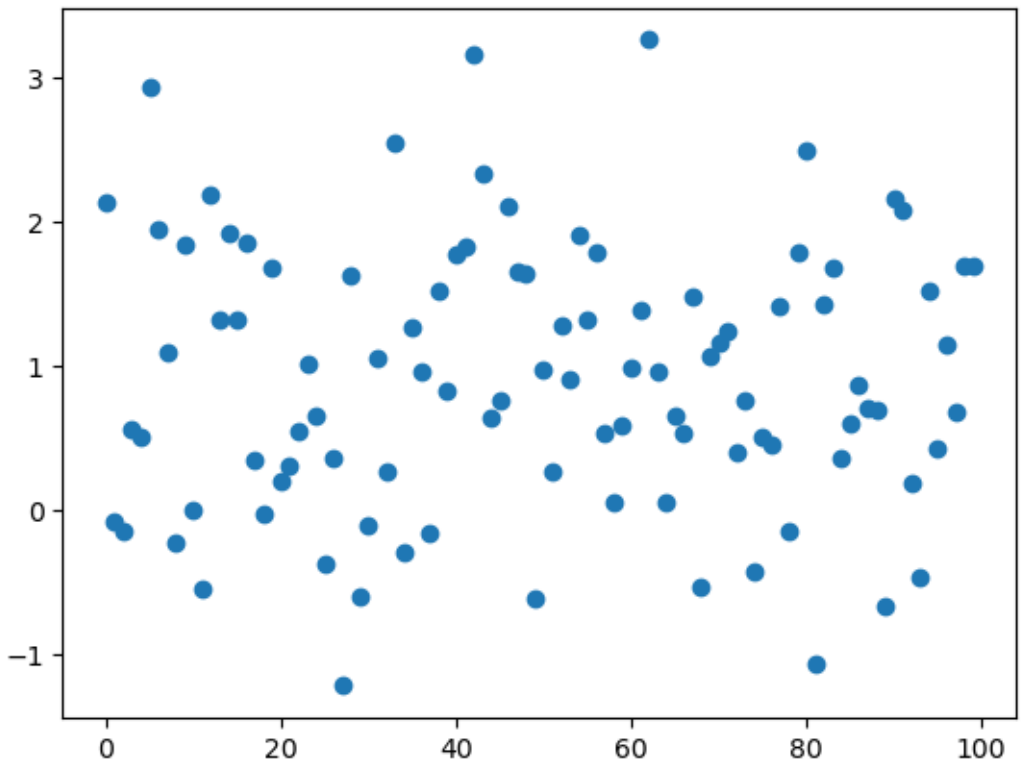
[41]:
```
fig, ax = plt.subplots()
ax.plot(np.arange(100),x)
```

[41]: [<matplotlib.lines.Line2D at 0x7f7f49ddb640>]



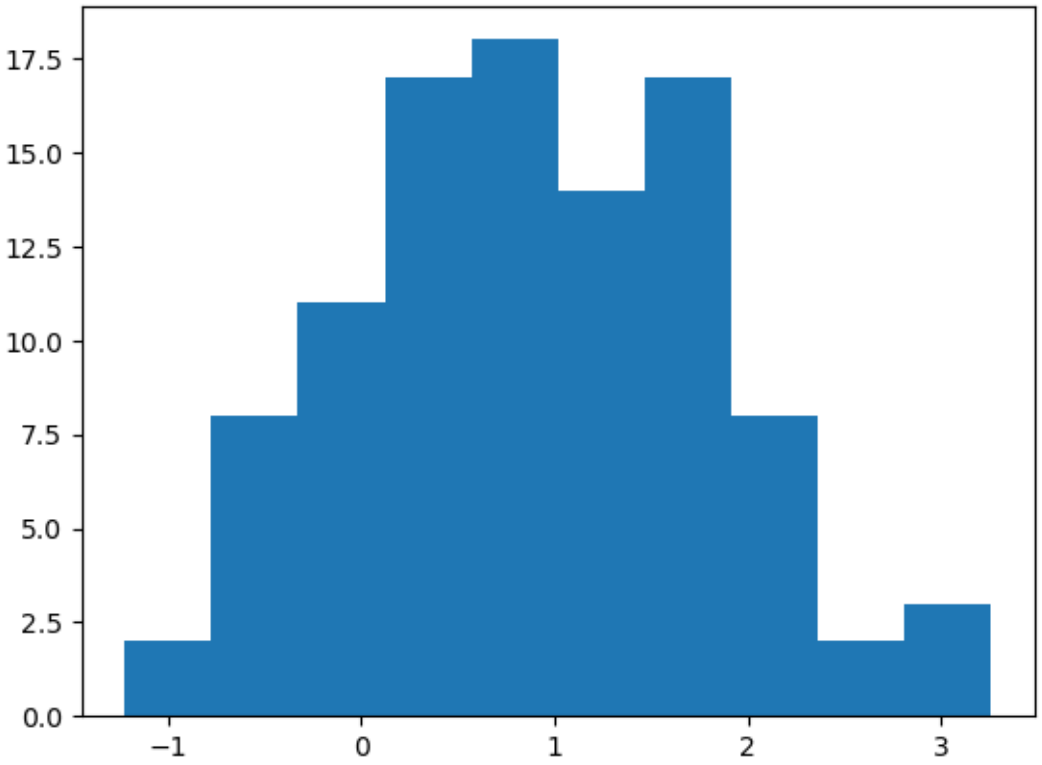
[42]:
```
fig, ax = plt.subplots()
ax.scatter(np.arange(100),x)
```

[42]: <matplotlib.collections.PathCollection at 0x7f7f5956a8e0>



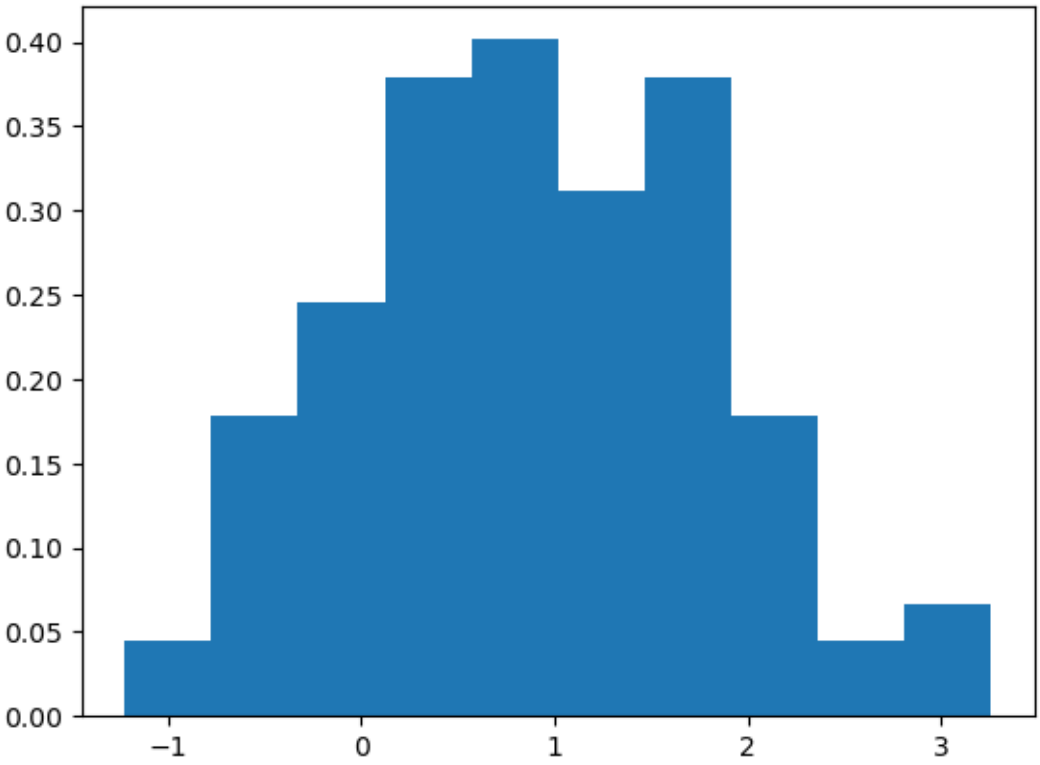
[43]:
```
fig, ax = plt.subplots()
ax.hist(x)
```

[43]:
```
(array([ 2.,  8., 11., 17., 18., 14., 17.,  8.,  2.,  3.]),
 array([-1.22340315, -0.77513194, -0.32686073,  0.12141048,  0.56968169,
         1.0179529 ,  1.46622411,  1.91449532,  2.36276653,  2.81103774,
         3.25930895]),
 <BarContainer object of 10 artists>)
```



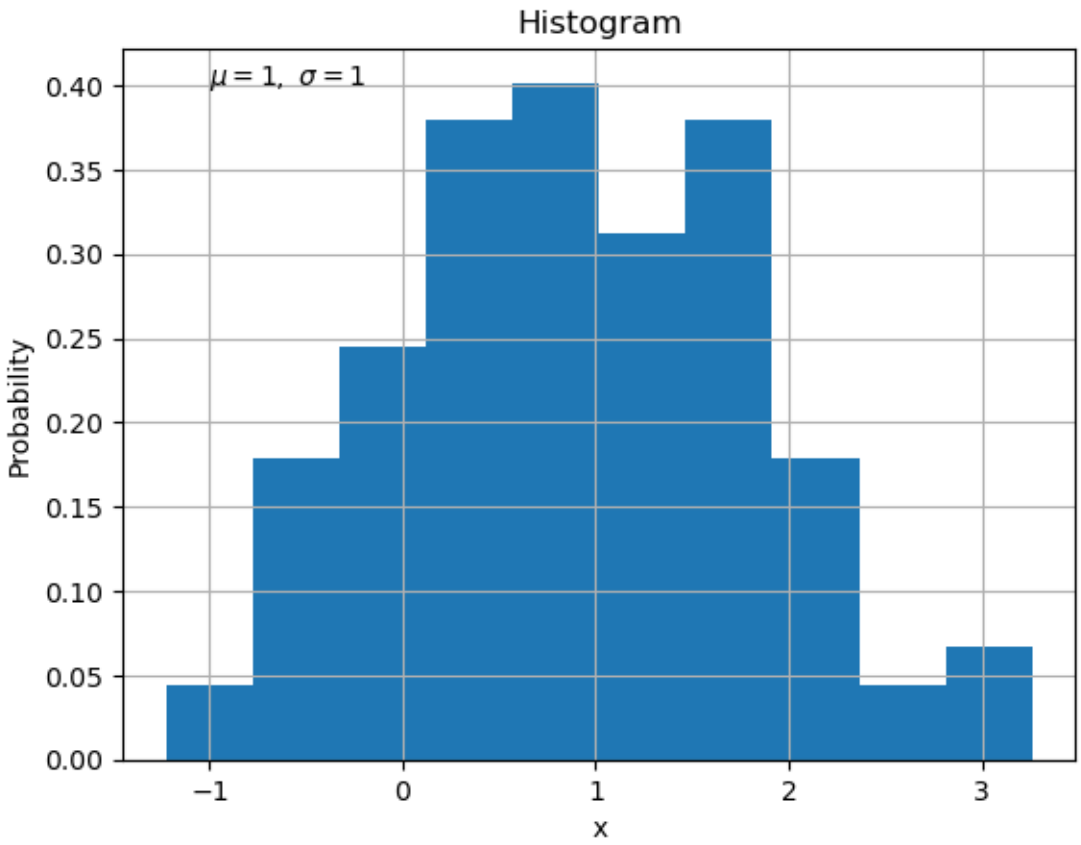
[44]:
```
fig, ax = plt.subplots()
ax.hist(x, density=True)
```

[44]:
```
(array([0.04461585, 0.17846339, 0.24538716, 0.3792347 , 0.40154263,
        0.31231093, 0.3792347 , 0.17846339, 0.04461585, 0.06692377]),
 array([-1.22340315, -0.77513194, -0.32686073,  0.12141048,  0.56968169,
         1.0179529 ,  1.46622411,  1.91449532,  2.36276653,  2.81103774,
         3.25930895]),
 <BarContainer object of 10 artists>)
```



[45]:
```
ax.hist?
```

[46]:
```
fig, ax = plt.subplots()
ax.hist(x, density=True)
ax.set_xlabel('x')
ax.set_ylabel('Probability')
ax.set_title('Histogram')
ax.text(-1, .4, r'$\mu=1,\ \sigma=1$')
ax.grid(True)
```



2.9 Image plotting

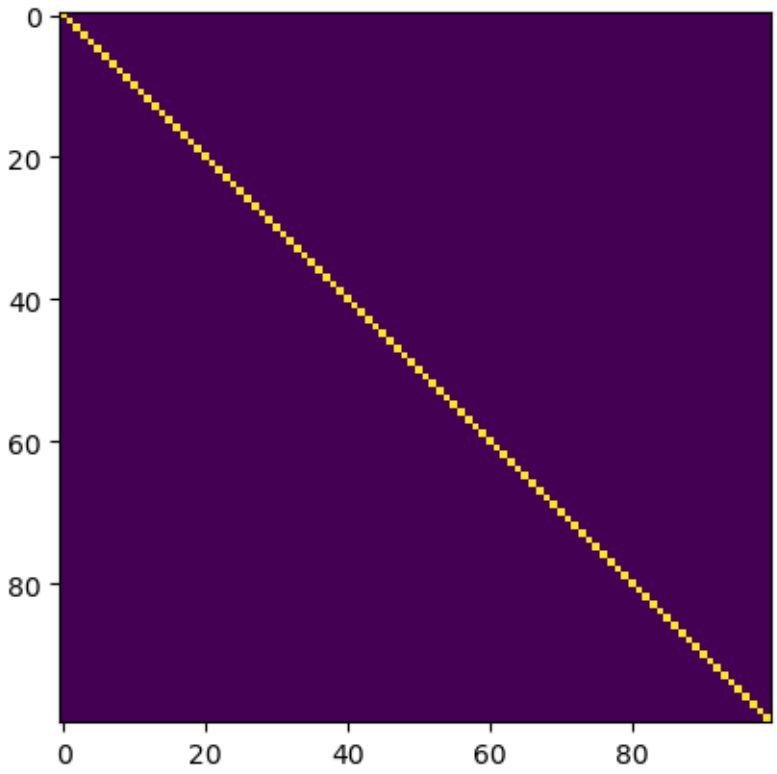
ax.imshow

[47]:
```
image = np.eye(100)
image
```

[47]:
```
array([[1., 0., 0., …, 0., 0., 0.],
       [0., 1., 0., …, 0., 0., 0.],
       [0., 0., 1., …, 0., 0., 0.],
       …,
       [0., 0., 0., …, 1., 0., 0.],
       [0., 0., 0., …, 0., 1., 0.],
       [0., 0., 0., …, 0., 0., 1.]])
```

[48]:
```
fig, ax = plt.subplots()
ax.imshow(image)
```

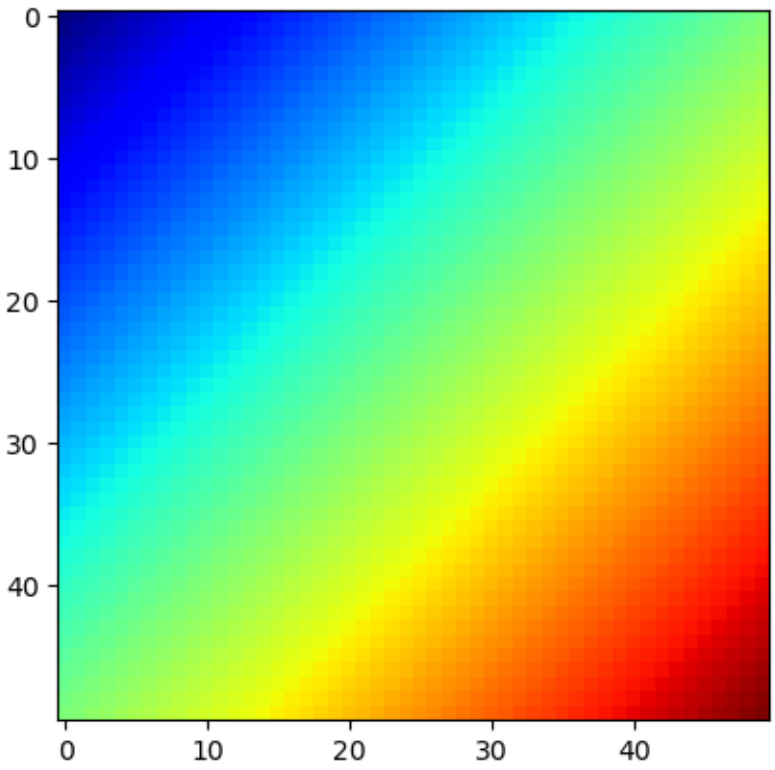
[48]:
```
<matplotlib.image.AxesImage at 0x7f7f59b034f0>
```



[49]:
```
dim = 50
x_coords, y_coords = np.meshgrid(range(dim), range(dim), indexing='ij')
beta_low = np.zeros((dim,dim))
for i in range(x_coords.shape[0]):
    for j in range(x_coords.shape[1]):
        x = x_coords[i,j]
        y = y_coords[i,j]
        beta_low[i,j] = 1 + 1/24*(i+j)
```

[50]:
```
fig, ax = plt.subplots()
ax.imshow(beta_low,cmap="jet")
```

[50]: <matplotlib.image.AxesImage at 0x7f7f59b856a0>

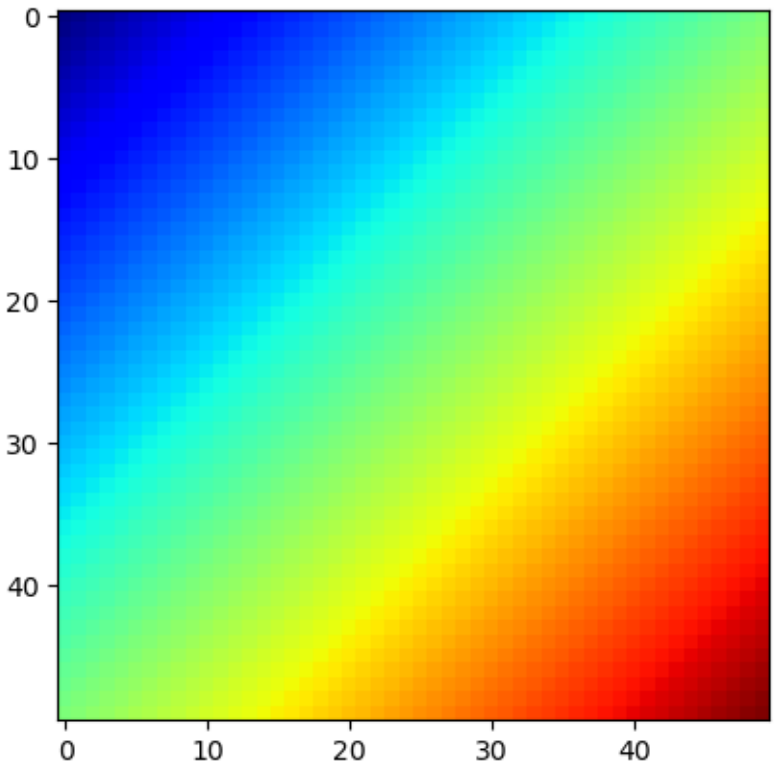


2.10 Saving a figure

`plt.savefig()`

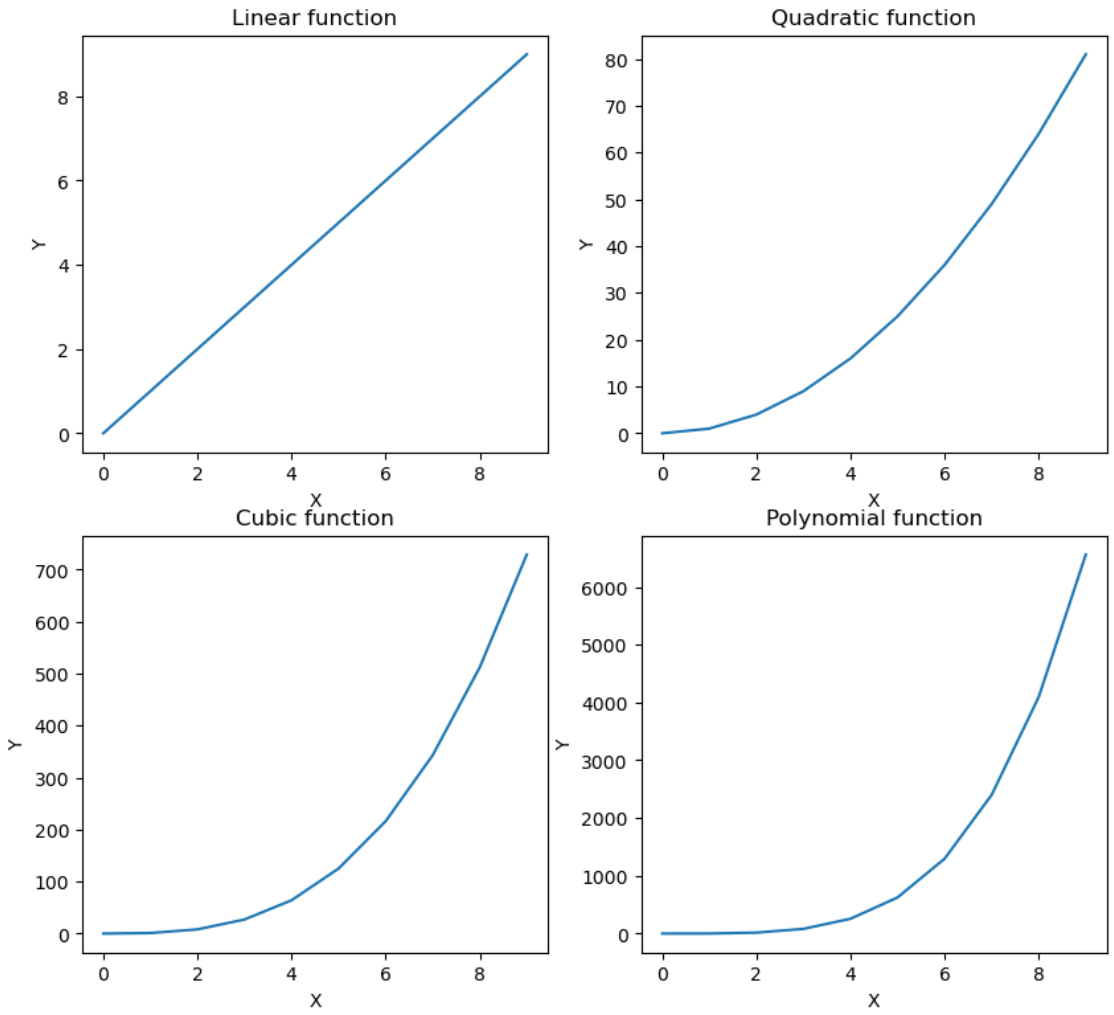
Save the current figure.

[51]:
```
fig, ax = plt.subplots()
ax.imshow(beta_low,cmap='jet')
plt.savefig("image.png")
```



[52]:
```
x = np.arange(10)

fig, axes = plt.subplots(2,2,figsize=(10,9))  # Create a figure containing four
↪axes.
ax1 = axes[0,0]
ax1.plot(x,x)
ax1.set_xlabel("X")
ax1.set_ylabel("Y")
ax1.set_title("Linear function")

ax2 = axes[0,1]
ax2.plot(x,x**2)
ax2.set_xlabel("X")
ax2.set_ylabel("Y")
ax2.set_title("Quadratic function")

ax3 = axes[1,0]
ax3.plot(x,x**3)
ax3.set_xlabel("X")
ax3.set_ylabel("Y")
ax3.set_title("Cubic function")
```

```
ax4 = axes[1,1]
ax4.plot(x,x**4)
ax4.set_xlabel("X")
ax4.set_ylabel("Y")
ax4.set_title("Polynomial function")

plt.savefig("functions_4.png",dpi=500)
```



There is a lot more to matplotlib. One can visit the gallery and pull examples in to get a sense of what is possible, and how to adapt examples for your own purposes.