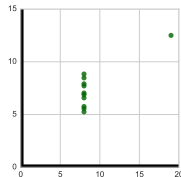
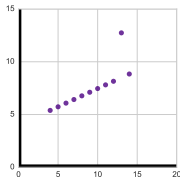
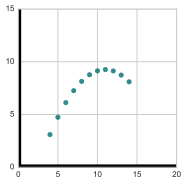
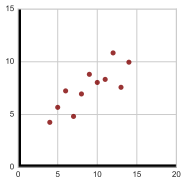


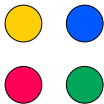
Producing Pretty Plots in Python

Geraint Ian Palmer
@GeraintPalmer

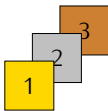
PyCon Namibia 2017



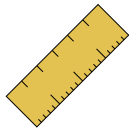
Types of Data



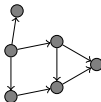
Nominal



Ordinal

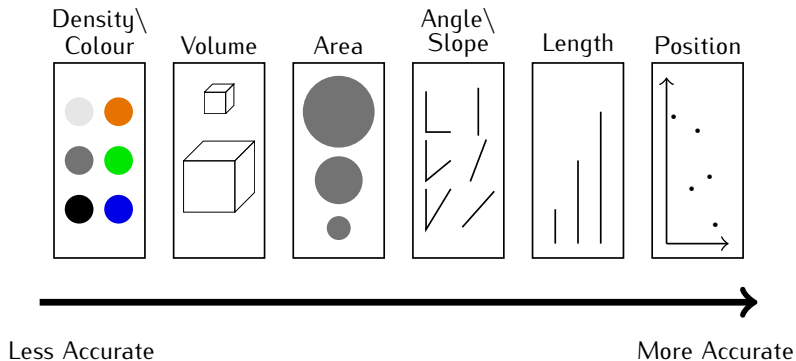


Quantitative



Relational

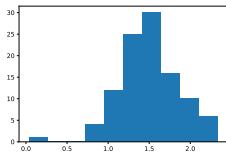
Perceptual Accuracy



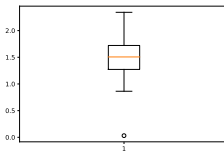
https://youtu.be/k_lvjRCOpJk?list=PLpX1jXuNTXGrj16CxJ6ClY1GK01su9yeD

```
import matplotlib.pyplot as plt
```

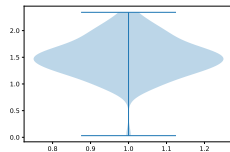
`plt.hist(xs)`



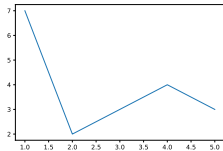
`plt.boxplot(xs)`



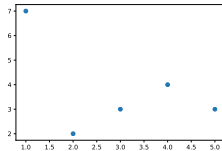
`plt.violinplot(xs)`



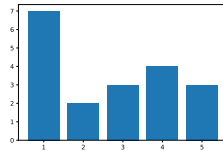
`plt.plot(xs, ys)`



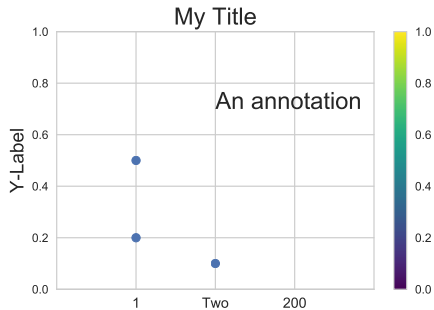
`plt.scatter(xs, ys)`



`plt.bar(xs, ys)`

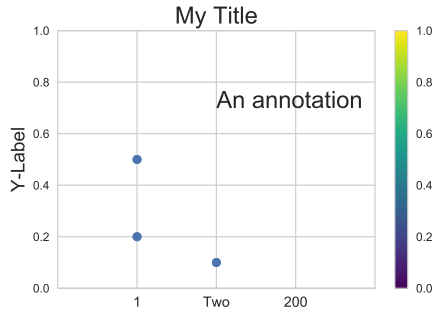


Anatomy of a Plot



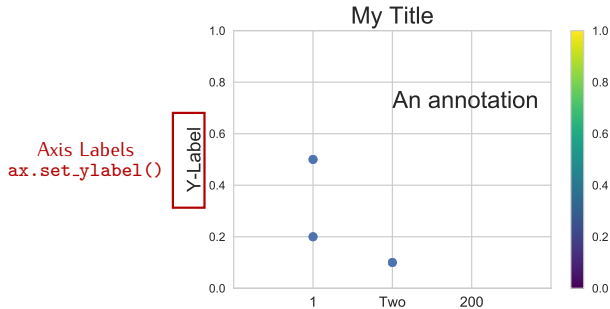
Anatomy of a Plot

```
fig, ax = plt.subplots(1)
```



Anatomy of a Plot

```
fig, ax = plt.subplots(1)
```



Anatomy of a Plot

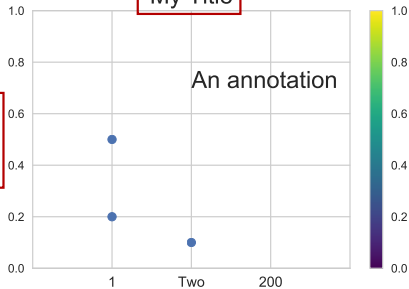
```
fig, ax = plt.subplots(1)
```

Title
`ax.set_title()`

My Title

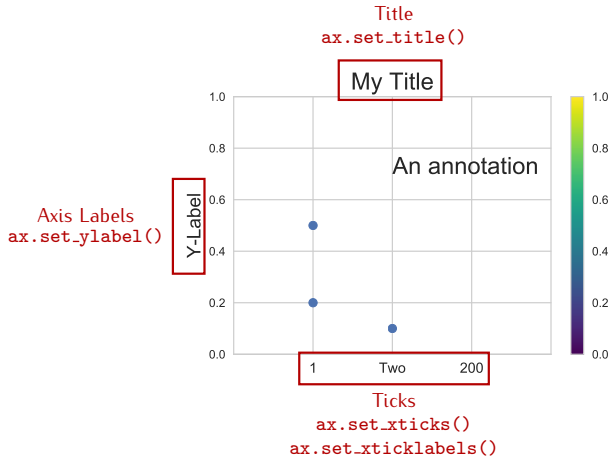
Axis Labels
`ax.set_ylabel()`

Y-Label



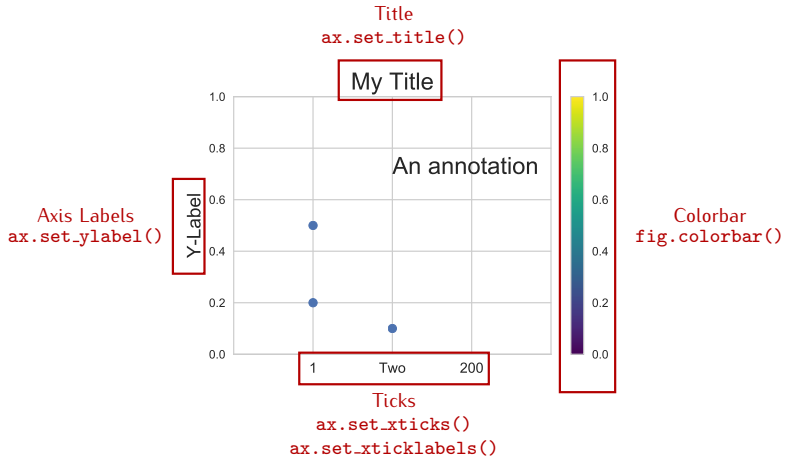
Anatomy of a Plot

```
fig, ax = plt.subplots(1)
```



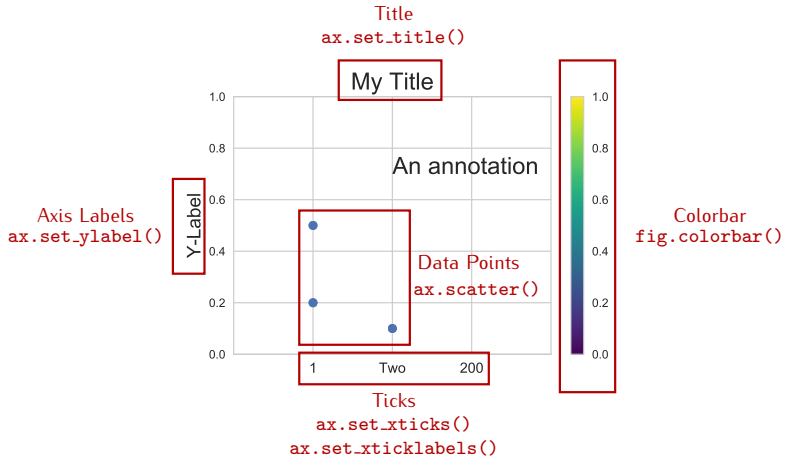
Anatomy of a Plot

```
fig, ax = plt.subplots(1)
```



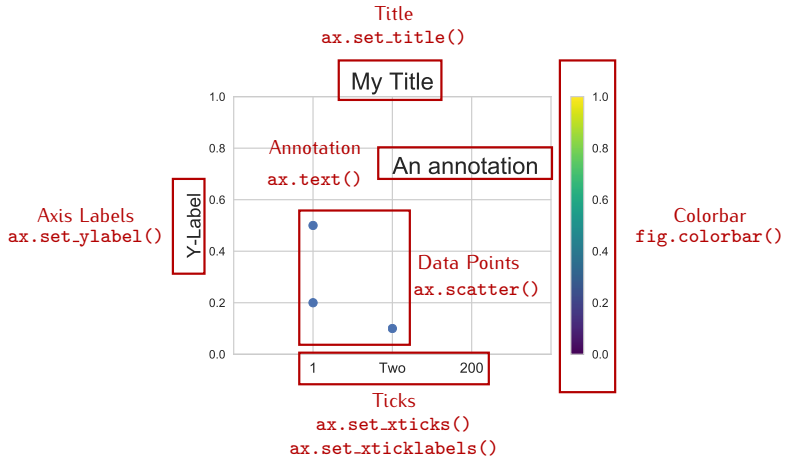
Anatomy of a Plot

```
fig, ax = plt.subplots(1)
```



Anatomy of a Plot

```
fig, ax = plt.subplots(1)
```

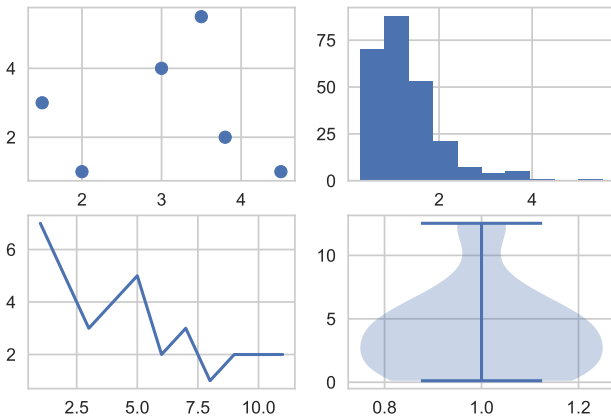


Anatomy of a Plot

```
fig, axarr = plt.subplots(2, 2)
```

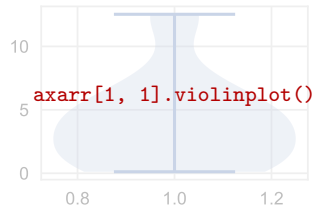
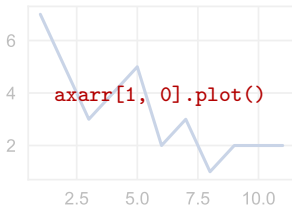
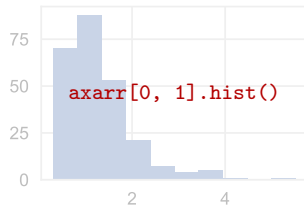
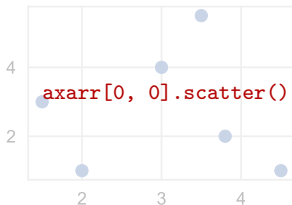
Anatomy of a Plot

```
fig, axarr = plt.subplots(2, 2)
```



Anatomy of a Plot

```
fig, axarr = plt.subplots(2, 2)
```



Women's 200m Olympic Medallists

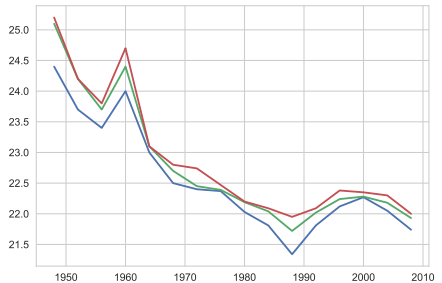
Year	Athlete	Medal	Country	Result
1948	Fanny Blankers-Koen	GOLD	NED	24.40
1948	Audrey Williamson	SILVER	GBR	25.10
1948	Audrey Patterson	BRONZE	USA	25.20
1952	Marjorie Jackson	GOLD	AUS	23.70
1952	Bertha Brouwer	SILVER	NED	24.20
⋮	⋮	⋮	⋮	⋮
2008	Allyson Felix	SILVER	USA	21.93
2008	Kerron Stewart	BRONZE	JAM	22.00


```
fig, ax = plt.subplots(1)
```

```
ax.plot(dates, gold)
```

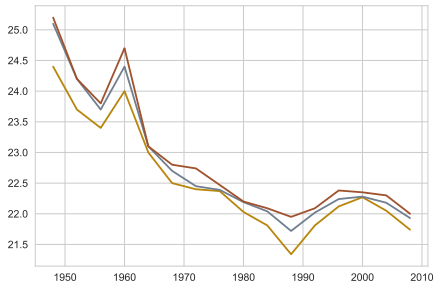
```
ax.plot(dates, silver)
```

```
ax.plot(dates, bronze)
```



```
plt.show()
```

```
fig, ax = plt.subplots(1)
ax.plot(dates, gold, c='darkgoldenrod')
ax.plot(dates, silver, c='slategray')
ax.plot(dates, bronze, c='sienna')
```



```
plt.show()
```

```
fig, ax = plt.subplots(1)

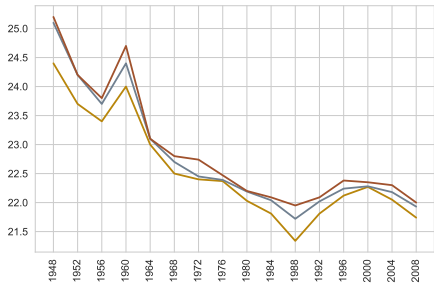
ax.plot(dates, gold, c='darkgoldenrod')

ax.plot(dates, silver, c='slategray')

ax.plot(dates, bronze, c='sienna')

ax.set_xticks(dates)
ax.set_xticklabels(dates, rotation='vertical')
```

```
plt.show()
```



```

fig, ax = plt.subplots(1)

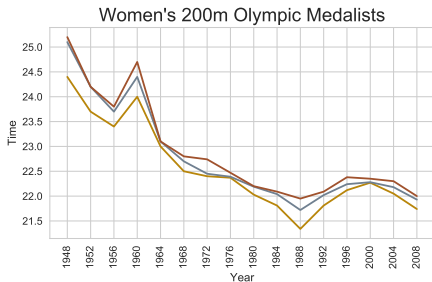
ax.plot(dates, gold, c='darkgoldenrod')
ax.plot(dates, silver, c='slategray')
ax.plot(dates, bronze, c='sienna')

ax.set_xticks(dates)
ax.set_xticklabels(dates, rotation='vertical')

ax.set_xlabel("Year")
ax.set_ylabel("Time")
ax.set_title("Women's 200m Olympic Medalists", fontsize=18)

plt.show()

```



```

fig, ax = plt.subplots(1)

ax.plot(dates, gold, c='darkgoldenrod')

ax.plot(dates, silver, c='slategray')

ax.plot(dates, bronze, c='sienna')

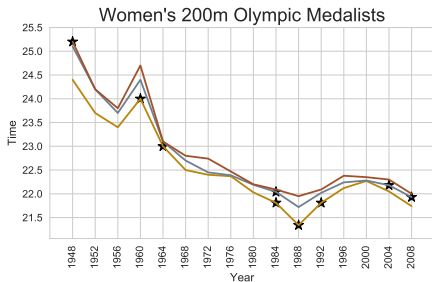
ax.scatter(usa_x, usa_y, lw=0.8,
           facecolor='black',
           marker='*', s=100)

ax.set_xticks(dates)
ax.set_xticklabels(dates, rotation='vertical')

ax.set_xlabel("Year")
ax.set_ylabel("Time")
ax.set_title("Women's 200m Olympic Medalists", fontsize=18)

plt.show()

```



```

fig, ax = plt.subplots(1)

ax.plot(dates, gold, c='darkgoldenrod',
        zorder=1)
ax.plot(dates, silver, c='slategray',
        zorder=1)
ax.plot(dates, bronze, c='sienna',
        zorder=1)

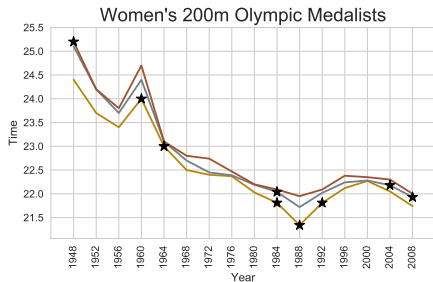
ax.scatter(usa_x, usa_y, lw=0.8,
          facecolor='black',
          marker='*', s=100,
          zorder=2)

ax.set_xticks(dates)
ax.set_xticklabels(dates, rotation='vertical')

ax.set_xlabel("Year")
ax.set_ylabel("Time")
ax.set_title("Women's 200m Olympic Medalists", fontsize=18)

plt.show()

```



```

fig, ax = plt.subplots(1)

ax.plot(dates, gold, c='darkgoldenrod',
        zorder=1)
ax.plot(dates, silver, c='slategray',
        zorder=1)
ax.plot(dates, bronze, c='sienna',
        zorder=1)

ax.scatter(usa_x, usa_y, lw=0.8,
          facecolor='black',
          marker='*', s=100,
          zorder=2)

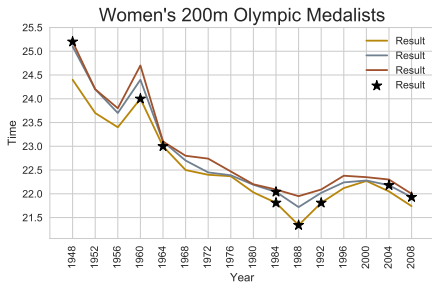
plt.legend()

ax.set_xticks(dates)
ax.set_xticklabels(dates, rotation='vertical')

ax.set_xlabel("Year")
ax.set_ylabel("Time")
ax.set_title("Women's 200m Olympic Medalists", fontsize=18)

plt.show()

```



```

fig, ax = plt.subplots(1)

ax.plot(dates, gold, c='darkgoldenrod',
        zorder=1, label='Gold Medal')
ax.plot(dates, silver, c='slategray',
        zorder=1, label='Silver Medal')
ax.plot(dates, bronze, c='sienna',
        zorder=1, label='Bronze Medal')

ax.scatter(usa_x, usa_y, lw=0.8,
          facecolor='black',
          marker='*', s=100,
          zorder=2, label='USA Athletes')

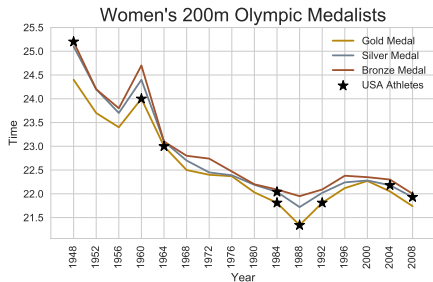
plt.legend()

ax.set_xticks(dates)
ax.set_xticklabels(dates, rotation='vertical')

ax.set_xlabel("Year")
ax.set_ylabel("Time")
ax.set_title("Women's 200m Olympic Medalists", fontsize=18)

plt.show()

```



Choosing Colormaps

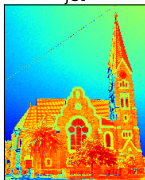


47	58	69	80	1	12	23	34	45
57	68	79	9	11	22	33	44	46
67	78	8	10	21	32	43	54	56
77	7	18	20	31	42	53	55	66
6	17	19	30	41	52	63	65	76
16	27	29	40	51	62	64	75	5
26	28	39	50	61	72	74	4	15
36	38	49	60	71	73	3	14	25
37	48	59	70	81	2	13	24	35

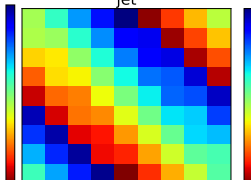
<https://www.youtube.com/watch?v=xAoljeRJ3lU>

Miscellaneous

jet

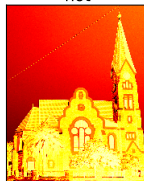


jet

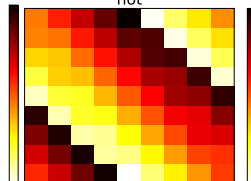


Sequential

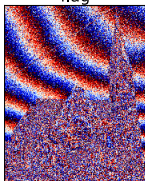
hot



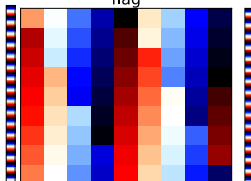
hot



flag



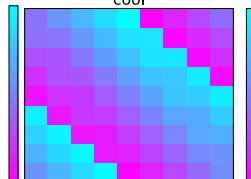
flag



cool



cool

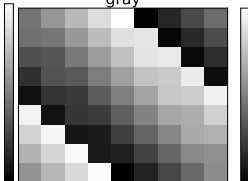


Sequential

gray



gray

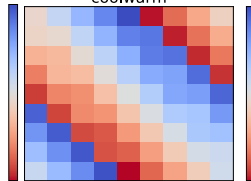


Diverging

coolwarm



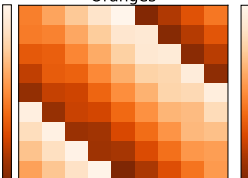
coolwarm



Oranges



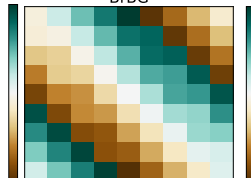
Oranges



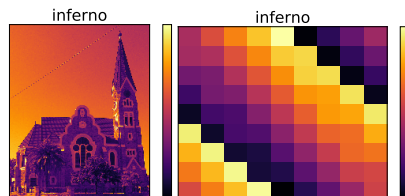
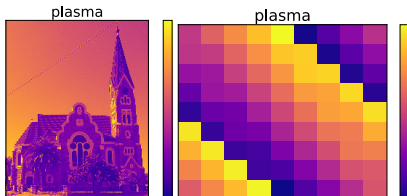
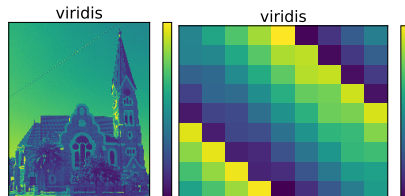
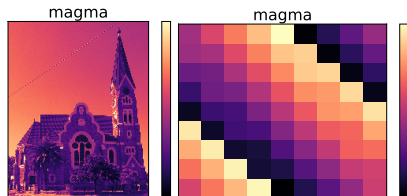
BrBG



BrBG



Perceptually Uniform Sequential Colormaps



Heatmaps with pcolor

$$f(x, y) = -(x^2 + 3y^2) e^{-x^2 - y^2}$$

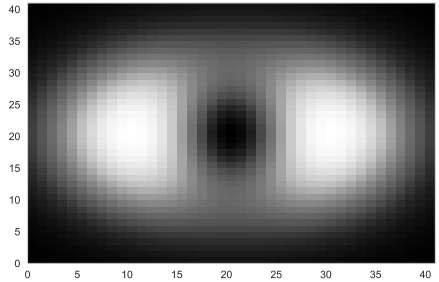
```
xs = np.arange(-2, 2.2, 0.1)
ys = np.arange(-2, 2.2, 0.1)

z = []
for y in ys[:-1]:
    z.append([])
    for x in xs[:-1]:
        z[-1].append(f(x, y))
```

$$\begin{pmatrix} -0.005 & -0.007 & -0.010 & \dots & -0.010 & -0.007 & -0.005 \\ -0.008 & -0.011 & -0.014 & \dots & -0.014 & -0.011 & -0.008 \\ -0.011 & -0.015 & -0.020 & \dots & -0.020 & -0.015 & -0.011 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ -0.011 & -0.015 & -0.020 & \dots & -0.020 & -0.015 & -0.011 \\ -0.008 & -0.011 & -0.014 & \dots & -0.014 & -0.011 & -0.008 \\ -0.005 & -0.007 & -0.010 & \dots & -0.010 & -0.007 & -0.005 \end{pmatrix}$$

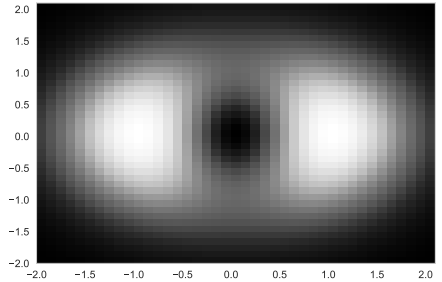
```
fig, ax = plt.subplots(1)
```

```
hm = ax.pcolor(z)
```



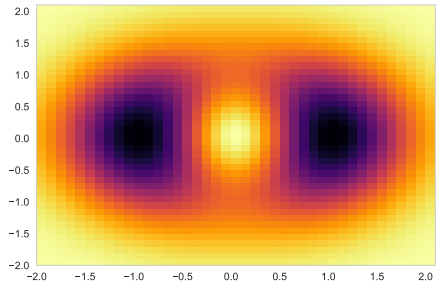
```
plt.show()
```

```
fig, ax = plt.subplots(1)
X,Y = np.meshgrid(xs, ys)
hm = ax.pcolor(X, Y, z)
```



```
plt.show()
```

```
fig, ax = plt.subplots(1)
X,Y = np.meshgrid(xs, ys)
hm = ax.pcolor(X, Y, z, cmap='inferno')
```



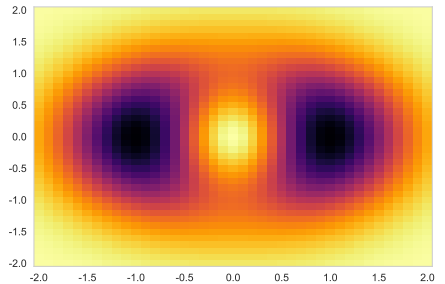
```
plt.show()
```



```
fig, ax = plt.subplots(1)
X,Y = np.meshgrid(xs, ys)
hm = ax.pcolor(X, Y, z, cmap='inferno')
```

```
ticks = np.linspace(-2, 2, 9)
ax.set_xticks([i+0.05 for i in ticks])
ax.set_yticks([i+0.05 for i in ticks])
ax.set_xticklabels(ticks)
ax.set_yticklabels(ticks)
```

```
plt.show()
```

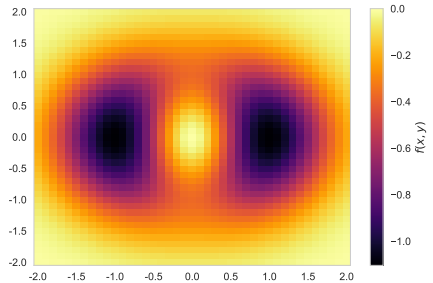


```
fig, ax = plt.subplots(1)
X,Y = np.meshgrid(xs, ys)
hm = ax.pcolor(X, Y, z, cmap='inferno')
```

```
ticks = np.linspace(-2, 2, 9)
ax.set_xticks([i+0.05 for i in ticks])
ax.set_yticks([i+0.05 for i in ticks])
ax.set_xticklabels(ticks)
ax.set_yticklabels(ticks)
```

```
cbar = fig.colorbar(hm)
cbar.set_label(r"$f(x, y)$")
```

```
plt.show()
```



```

fig, ax = plt.subplots(1)
X,Y = np.meshgrid(xs, ys)
hm = ax.pcolor(X, Y, z, cmap='inferno')

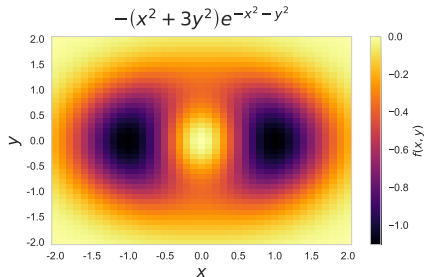
ticks = np.linspace(-2, 2, 9)
ax.set_xticks([i+0.05 for i in ticks])
ax.set_yticks([i+0.05 for i in ticks])
ax.set_xticklabels(ticks)
ax.set_yticklabels(ticks)

cbar = fig.colorbar(hm)
cbar.set_label(r"$f(x, y)$")

title = r"$\left(x^2+3y^2\right)e^{-x^2-y^2}$"
ax.set_title(title, fontsize=18)
ax.set_xlabel(r"$x$", fontsize=16)
ax.set_ylabel(r"$y$", fontsize=16)

plt.show()

```



```

fig, ax = plt.subplots(1)
X,Y = np.meshgrid(xs, ys)
hm = ax.pcolor(X, Y, z, cmap='inferno', zorder=0)

ticks = np.linspace(-2, 2, 9)
ax.set_xticks([i+0.05 for i in ticks])
ax.set_yticks([i+0.05 for i in ticks])
ax.set_xticklabels(ticks)
ax.set_yticklabels(ticks)

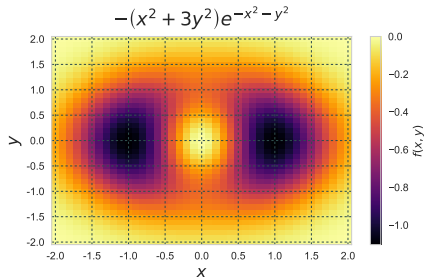
cbar = fig.colorbar(hm)
cbar.set_label(r"$f(x, y)$")

title = r"$\left(x^2+3y^2\right)e^{-x^2-y^2}$"
ax.set_title(title, fontsize=18)
ax.set_xlabel(r"$x$", fontsize=16)
ax.set_ylabel(r"$y$", fontsize=16)

ax.grid(which='major', color='darkslategrey',
        linestyle=':', linewidth=1, axis='both')

plt.show()

```





- Cardiff University Phoenix Project
- Cardiff School of Mathematics
- PyCon Namibia 2017

- matplotlib
- numpy
- seaborn
- jupyter

www.geraintianpalmer.org.uk/talks
@GeraintPalmer

Links

- http://matplotlib.org/api/axes_api.html
- http://matplotlib.org/api/pyplot_summary.html
- <http://matplotlib.org/examples/index.html>
- http://matplotlib.org/examples/color/colormaps_reference.html
- https://www.youtube.com/watch?v=k_lvjRCOpJk&feature=youtu.be&list=PLpX1jXuNTXGrjl6CxJ6Cly1GK01su9yeD
- https://www.youtube.com/watch?v=k_lvjRCOpJk&feature=youtu.be&list=PLpX1jXuNTXGrjl6CxJ6Cly1GK01su9yeD
- <https://vincentarelbundock.github.io/Rdatasets/datasets.html>
- <http://www.databaseolympics.com/>
- https://en.wikipedia.org/wiki/Magic_square