# Visualization

## Topics

1. Matplotlib core framework
2. Pandas plot()
3. Seaborn statistical visualization
4. (not covered) Grammar of graphics (ggplot2 see plotnine )
5. (not covered) Interactive plotting

## Resources

1. Ch 9 in Python for Data Analysis, 2nd Ed, Wes McKinney (UCalgary library and https://github.com/wesm/pydata-book (https://github.com/wesm/pydata-book))
2. Ch 4 in Python Data Science Handbook, Jake VanderPlas (Ucalgary library and https://github.com/jakevdp/PythonDataScienceHandbook (https://github.com/jakevdp/PythonDataScienceHandbook))
3. Fundamentals of Data Visualization, Claus O. Wilke (Ucalgary library and https://serialmentor.com/dataviz/index.html (https://serialmentor.com/dataviz/index.html))
4. Overview by Jake VanderPlas https://www.youtube.com/watch?v=FytuB8nFHPQ (https://www.youtube.com/watch?v=FytuB8nFHPQ)

## Matplotlib

> Matplotlib is a Python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms.
> Matplotlib tries to make easy things easy and hard things possible.
> For simple plotting the pyplot module provides a MATLAB-like interface

https://matplotlib.org (https://matplotlib.org)

Importing matplotlib looks like this

In [59]:

```
%matplotlib inline

import numpy as np
import pandas as pd
import matplotlib as mpl
import matplotlib.pyplot as plt
```

### Two interfaces

There are two ways to interact with Matplot lib: a Matlab style and an object oriented style interface.

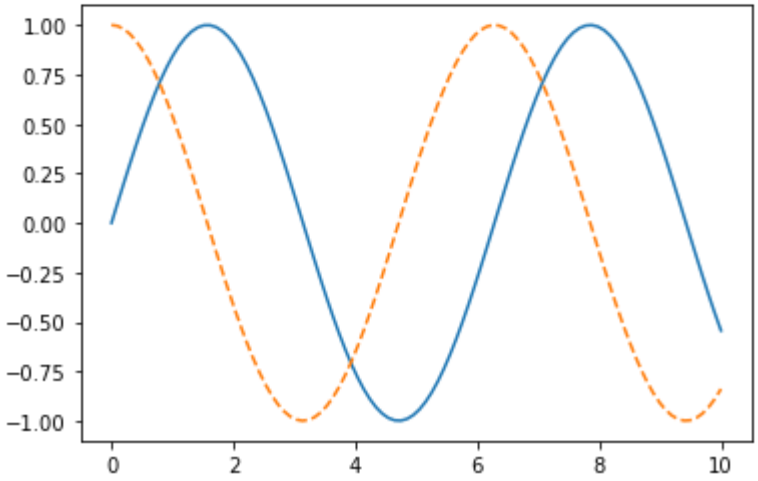
See Ch 4 in Python Data Science Handbook, Jake VanderPlas

- Two Interfaces for the Price of One, pp. 222
- Matplotlib Gotchas, pp. 232

## Matlab style interface

In [60]:
```
x = np.linspace(0, 10, 100)

plt.plot(x, np.sin(x), '-')
plt.plot(x, np.cos(x), '--');
```

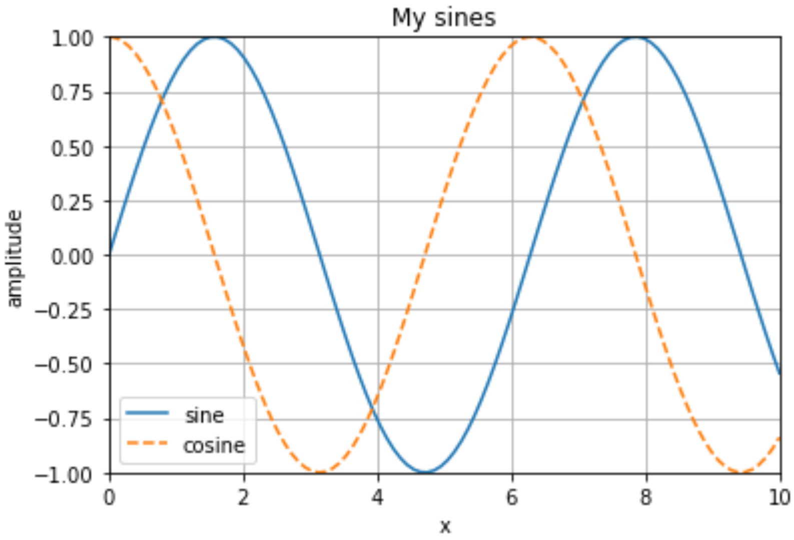


Adding decorations to the plot is done by repeatatly calling functions on the imported `plt` module. All calls within the cell will be applied to the current figure and axes.

In [61]:

```
plt.plot(x, np.sin(x), '-', label='sine')
plt.plot(x, np.cos(x), '--', label ='cosine')

plt.xlim([0, 10])
plt.ylim([-1, 1])
plt.xlabel('x')
plt.ylabel('amplitude')
plt.title('My sines')
plt.grid()
plt.legend();
```

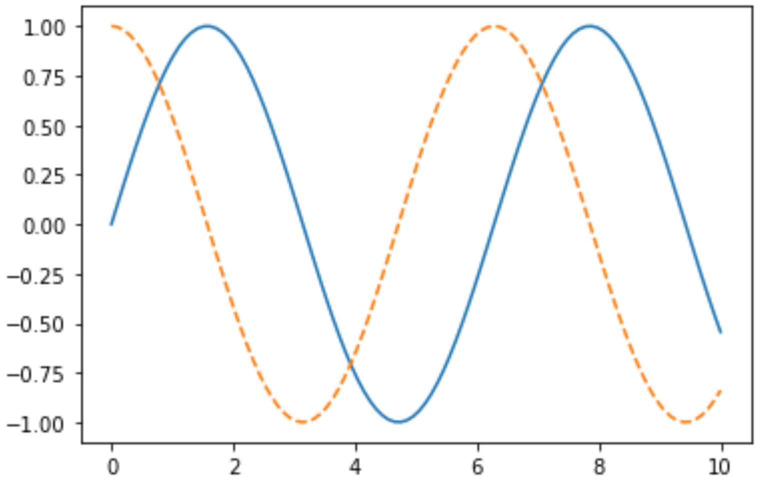


## Object oriented interface

With this interface, you first create a figure and an axes object, then call their methods to change the plot.

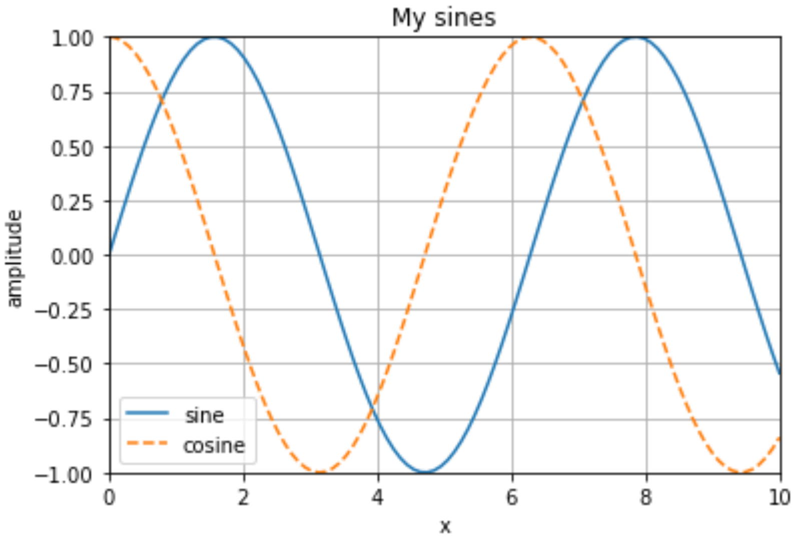
In [62]:

```
fig = plt.figure()
ax = plt.axes()
ax.plot(x, np.sin(x), '-')
ax.plot(x, np.cos(x), '--');
```



In [63]:
```
fig = plt.figure()
ax = plt.axes()
ax.plot(x, np.sin(x), '-', label='sine')
ax.plot(x, np.cos(x), '--', label ='cosine')

ax.set(xlim=[0, 10], ylim=[-1, 1],
       xlabel='x', ylabel='amplitude',
       title='My sines');
ax.grid()
ax.legend();
```



### Save to file

With the figure object at hand, we can save to file

In [64]:
```
fig.savefig('sines.pdf')
```

# Plotting with pandas

> We use the standard convention for referencing the matplotlib API ... We provide the basics in pandas to easily create decent looking plots.

[https://pandas.pydata.org/pandas-docs/stable/user_guide/visualization.html (https://pandas.pydata.org/pandas-docs/stable/user_guide/visualization.html)](https://pandas.pydata.org/pandas-docs/stable/user_guide/visualization.html)

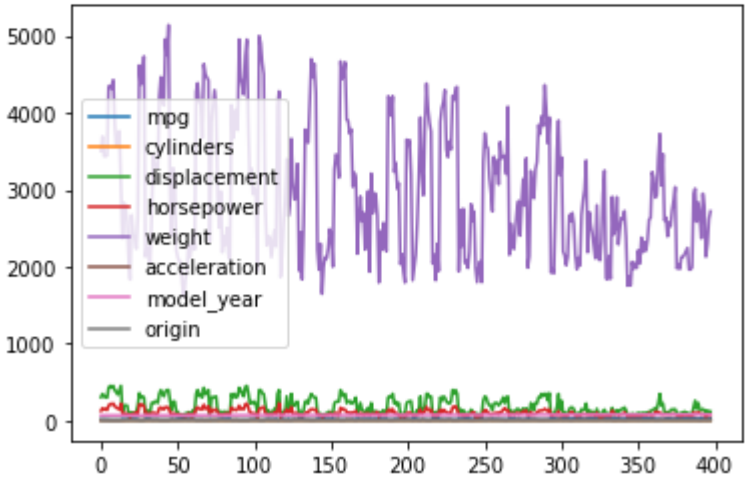
Let's load the heart attack dataset

In [66]:
```
data = pd.read_csv('auto-mpg.csv', na_values='?')
```

Plotting all columns, works, but does not provide a lot of insight.

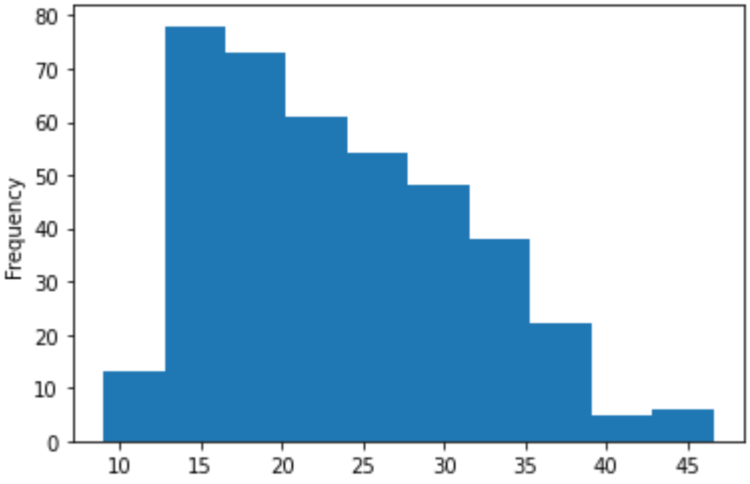
```
In [67]: data.plot()
```

```
Out[67]: <AxesSubplot:>
```



Let's look at the age distribution (a histogram)

```
In [68]: data['mpg'].plot.hist();
```



How many male and female samples do we have?

```
In [69]: data.origin.value_counts()
```

```
Out[69]: 1    249
         3     79
         2     70
         Name: origin, dtype: int64
```

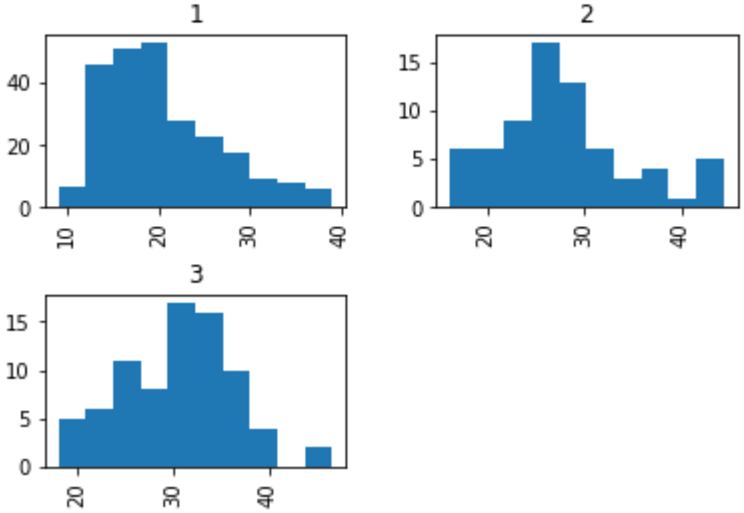
Notice that we accessed the gender column with dot notation. This can be done whenever the column name is 'nice' enough to be a python variable name.

Do we have similar ages in females and males?

Plotting two histograms for each gender side beside directly form the dataframe:

In [70]:

```
axs = data.hist(column='mpg', by='origin')
```

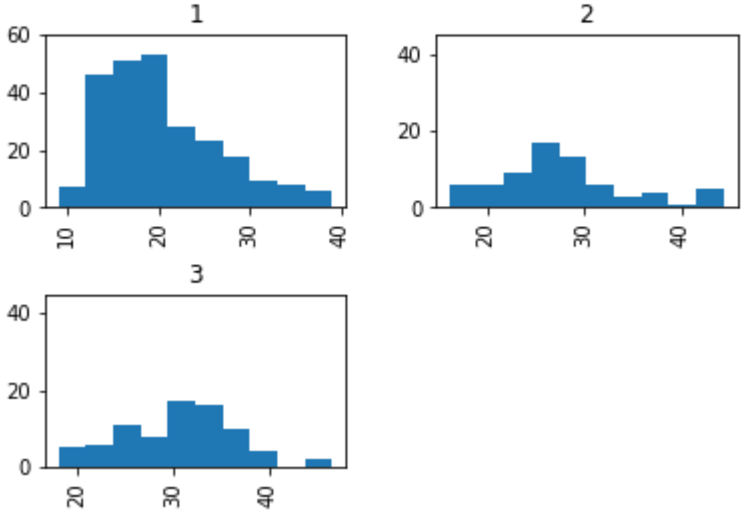


To format this plot, we can work on the axes (array) that is returned by the plot call. We use Matplotlib object oriented interface methods to do this

In [71]:

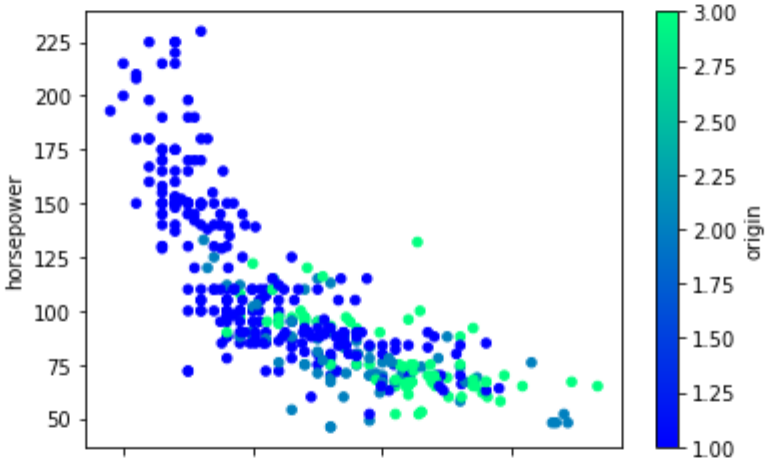
```
axs = data.hist(column='mpg', by='origin')

axs[0,0].set(title='1', ylim=[0, 60])
axs[0,1].set(title='2', ylim=[0, 45]);
axs[1,0].set(title='3', ylim=[0, 45]);
```



Is age and blood pressure correlated? Maybe it is different for females and males? Let's have a look with a scatter plot.

In [72]:
```
data.plot.scatter('mpg', 'horsepower', c='origin', colormap='winter');
```

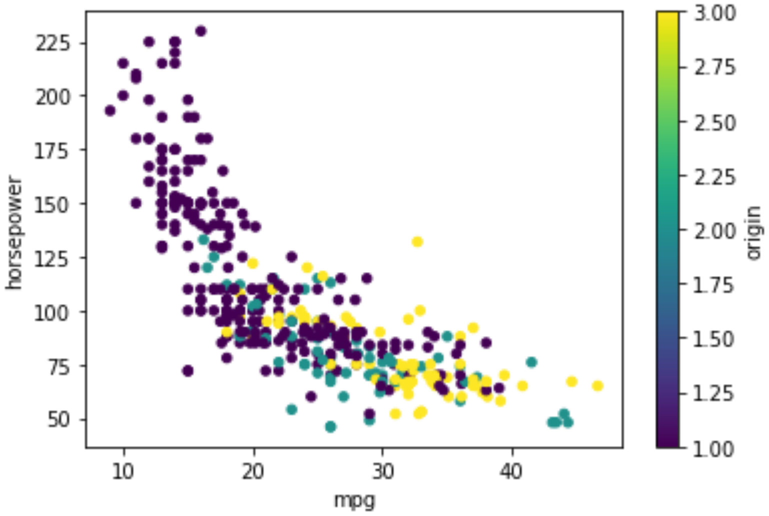


According to:
[https://stackoverflow.com/questions/43578976/pandas-missing-x-tick-labels (https://stackoverflow.com/questions/43578976/pandas-missing-x-tick-labels)](https://stackoverflow.com/questions/43578976/pandas-missing-x-tick-labels)

the missing x-labels are a pandas bug.

Workaraound is to create axes prior to calling plot

In [73]:
```
fig, ax = plt.subplots()
data.plot.scatter('mpg', 'horsepower', c='origin', colormap='viridis', ax=ax);
```

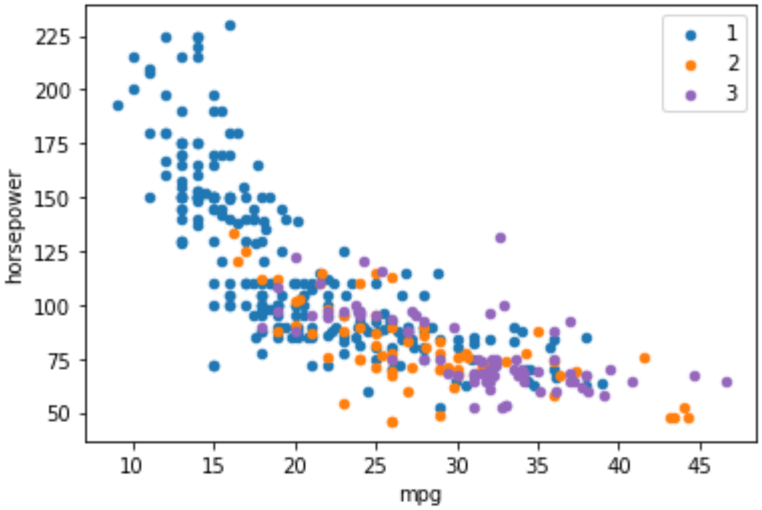


It is a bit annoying that there is a colorbar, we know gender is categorical.

One way to avoid the colorbar is to loop over the categories and assign colors based on the category.

See: [https://stackoverflow.com/questions/26139423/plot-different-color-for-different-categorical-levels-using-matplotlib (https://stackoverflow.com/questions/26139423/plot-different-color-for-different-categorical-levels-using-matplotlib)](https://stackoverflow.com/questions/26139423/plot-different-color-for-different-categorical-levels-using-matplotlib)

In [74]:
```
colors = {1: 'tab:blue', 2: 'tab:orange', 3: 'tab:purple'}
fig, ax = plt.subplots()
for key, group in data.groupby(by='origin'):
    group.plot.scatter('mpg', 'horsepower', c=colors[key], label=key, ax=ax);
```



# Seaborn

> Seaborn is a Python data visualization library based on matplotlib. It provides a high-level interface for drawing attractive and informative statistical graphics.

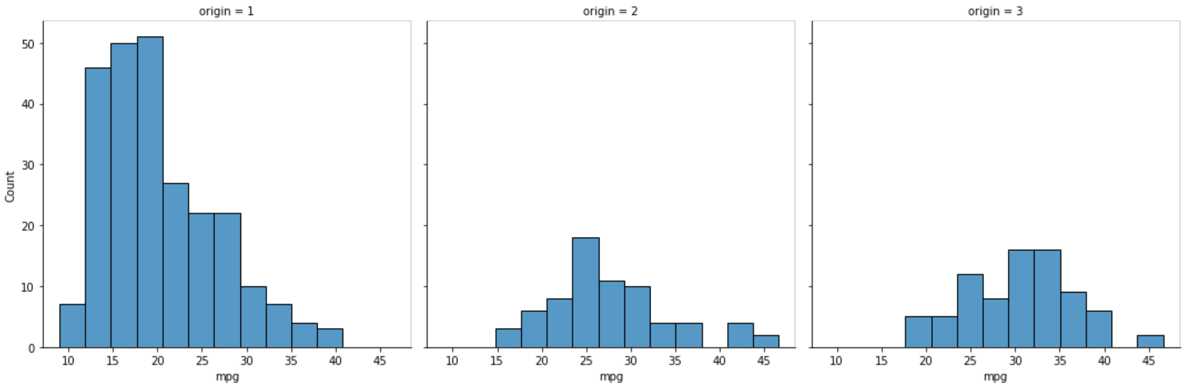
[http://seaborn.pydata.org/index.html (http://seaborn.pydata.org/index.html)](http://seaborn.pydata.org/index.html)

Seaborn is usually imported as `sns`

In [75]:
```
import seaborn as sns
```

Let's re-create the histograms by gender with seaborn with the figure level `displot()` function.

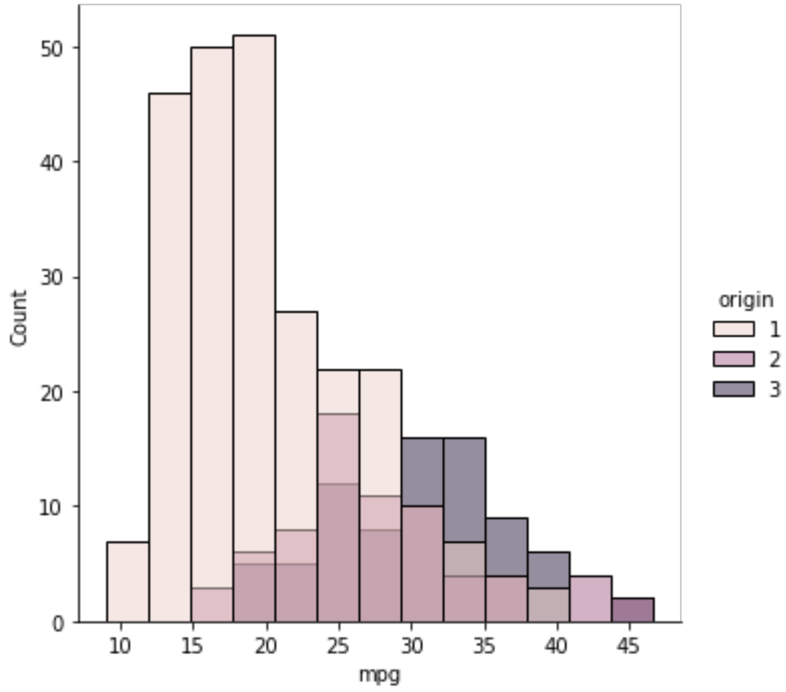
In [76]:
```
# Use gender to split age into columns
sns.displot(x='mpg', col='origin', data=data);
```



We can display the counts in the same plot, one on top of the other.

In [77]:

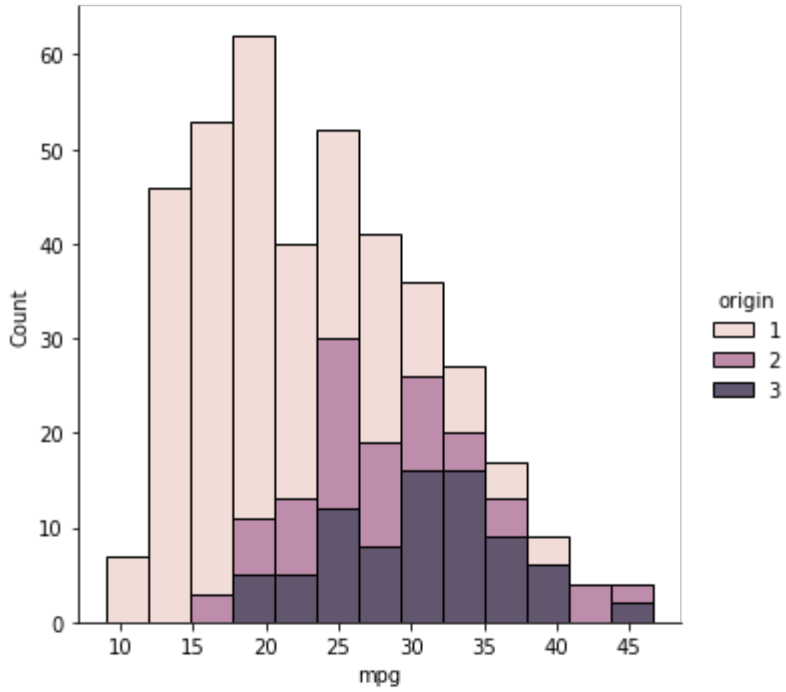
```
# Use gender to color (hue) in the same plot
sns.displot(x='mpg', hue='origin', data=data);
```



To have an idea of the split between male and female, we can stack the counts, adding up to total.

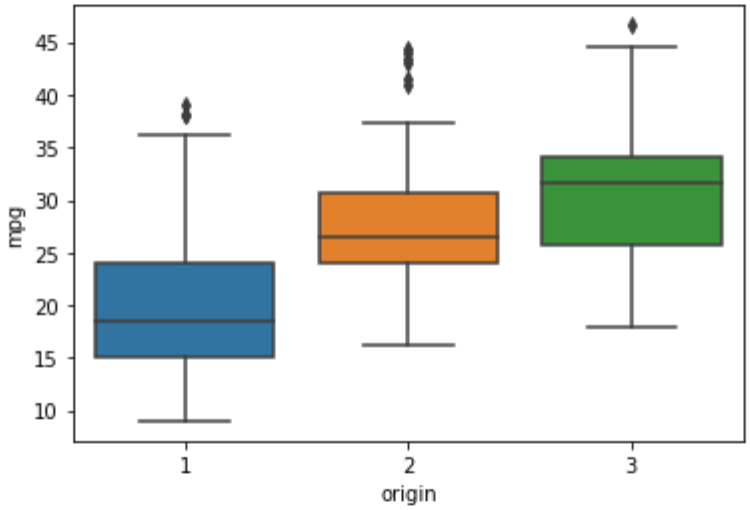
In [78]:

```
sns.displot(x='mpg', hue='origin', data=data, multiple='stack');
```



We can look at the differences in ages with a boxplot too

```
In [79]: sns.boxplot(x='origin', y='mpg', data=data);
```

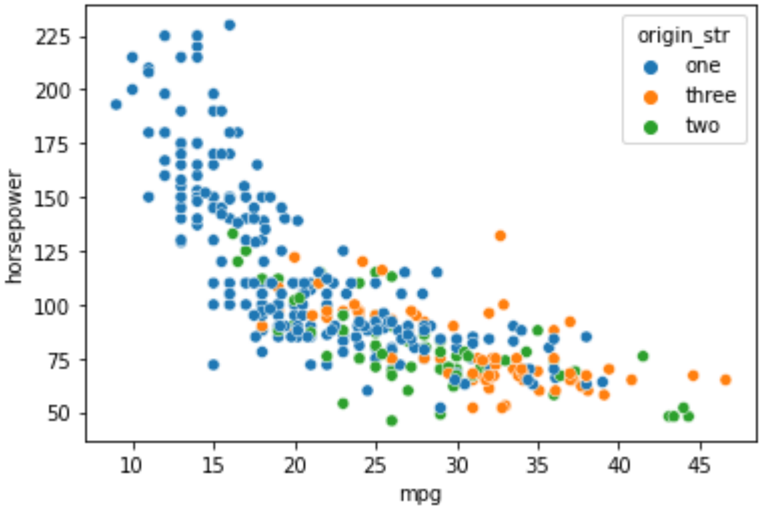


Let's re-create the scatter plot to see if age and blood pressure are correlated by gender.

To make the legend show strings we will create a gender string column with female and male strings rather than 0 and 1.

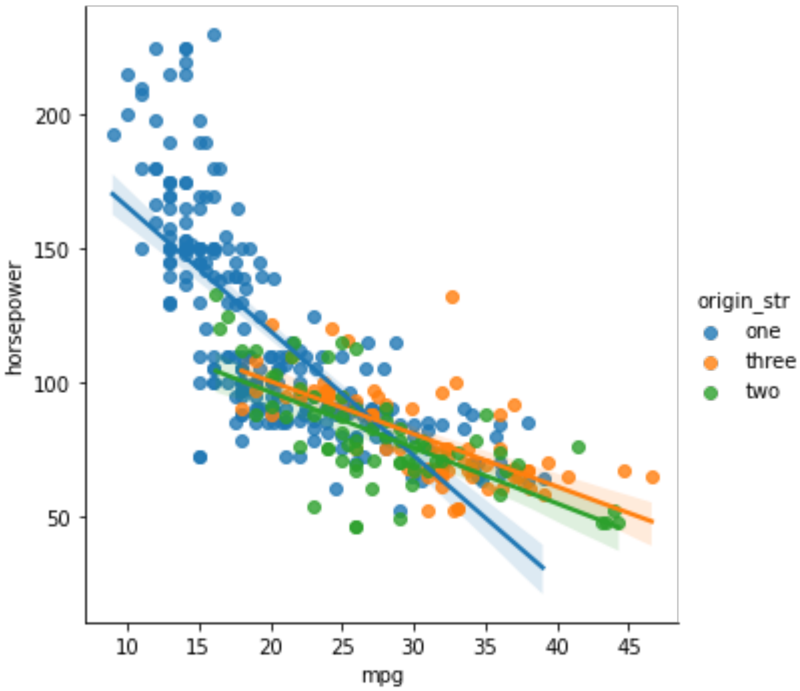
```
In [80]: data['origin_str'] = data['origin'].replace([1, 2, 3], ['one', 'two', 'three']
```

```
In [81]: ax = sns.scatterplot(x='mpg', y='horsepower', data=data, hue='origin_str')
```



Adding a regression line helps with visualizing the relationship

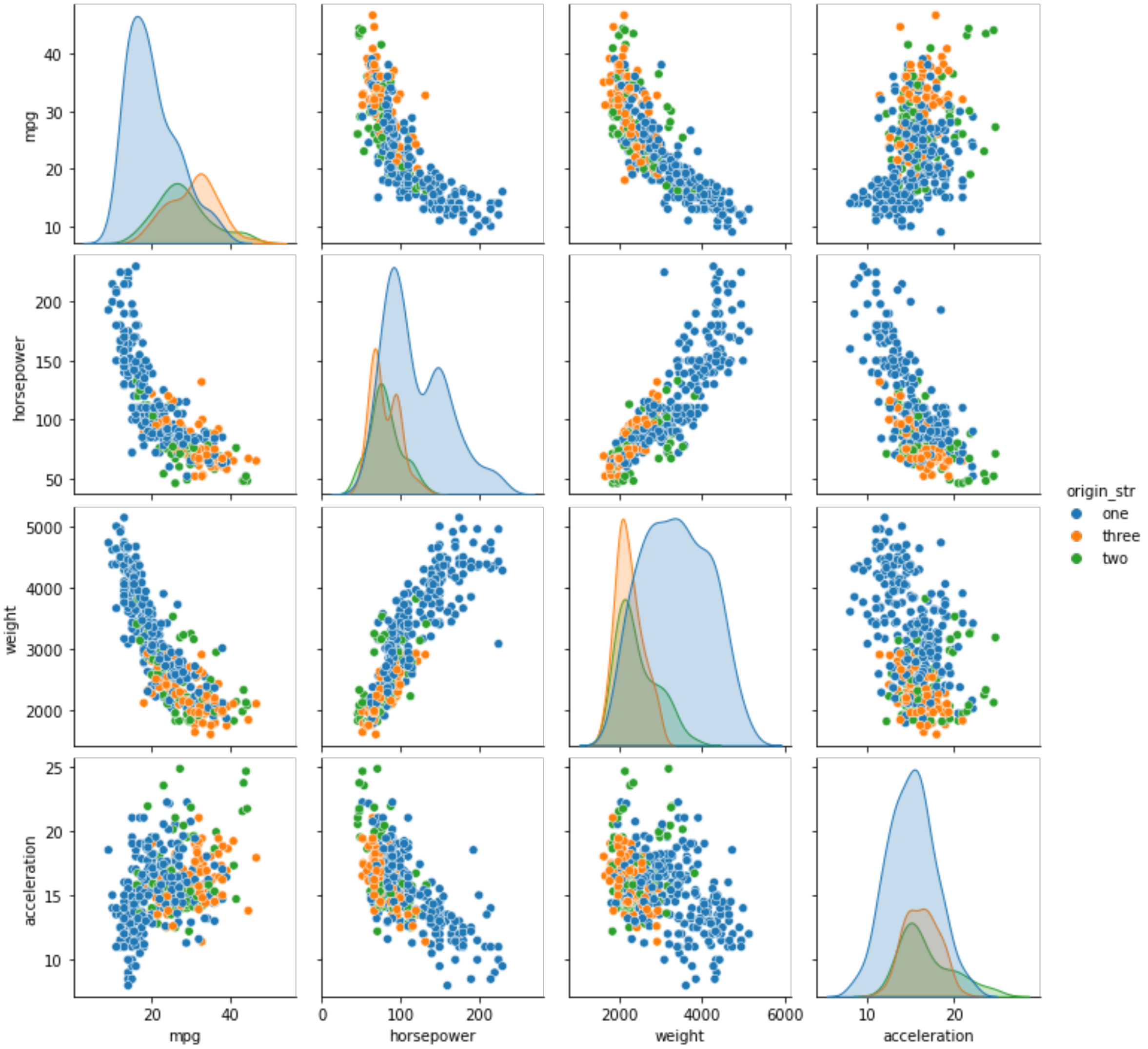
```
In [82]: ax = sns.lmplot(x='mpg', y='horsepower', data=data, hue='origin_str')
```



Maybe there are other correlations in the data set. Pairplot is a great way to get an overview

In [83]:

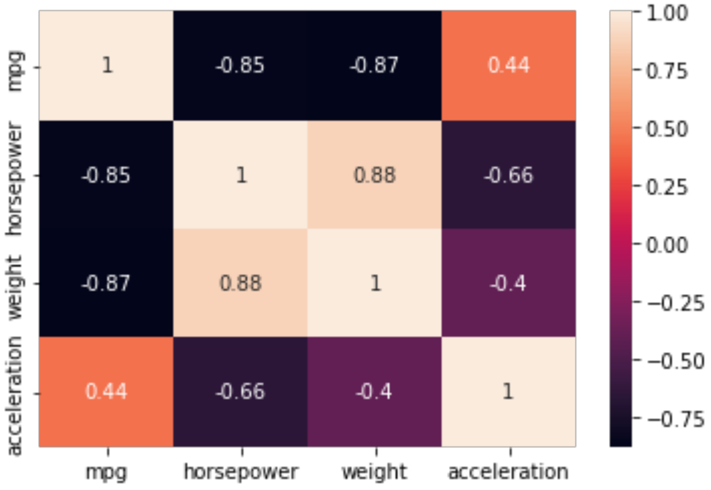
```
sns.pairplot(data, vars=['mpg', 'horsepower', 'weight', 'acceleration'], hue='
```



As an alternative, we can visualize the correlation matrix as a heatmap

In [84]:

```
g = sns.heatmap(data[['mpg', 'horsepower', 'weight', 'acceleration']].corr(met
            annot=True)
```



There are nice tutorials on the Seaborn website, be sure to check these out.

In [ ]: