Linear Regrssion on US Housing Price

In [2]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

In [3]:
```
df = pd.read_csv("USA_Housing.csv")
df.head()
```

Out[3]:

	Unnamed: 0	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price	Address
0	0	79545.458574	5.682861	7.009188	4.09	23086.800503	1.059034e+06	208 Michael Ferry Apt. 674\nLaurabury, NE 3701...
1	1	79248.642455	6.002900	6.730821	3.09	40173.072174	1.505891e+06	188 Johnson Views Suite 079\nLake Kathleen, CA...
2	2	61287.067179	5.865890	8.512727	5.13	36882.159400	1.058988e+06	9127 Elizabeth Stravenue\nDanieltown, WI 06482...
3	3	63345.240046	7.188236	5.586729	3.26	34310.242831	1.260617e+06	USS Barnett\nFPO AP 44820
4	4	59982.197226	5.040555	7.839388	4.23	26354.109472	6.309435e+05	USNS Raymond\nFPO AE 09386

Check basic info on the data set

'info()' method to check the data types and number

In [5]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 8 columns):
Unnamed: 0                      5000 non-null int64
Avg. Area Income                5000 non-null float64
Avg. Area House Age             5000 non-null float64
Avg. Area Number of Rooms       5000 non-null float64
Avg. Area Number of Bedrooms    5000 non-null float64
Area Population                 5000 non-null float64
Price                           5000 non-null float64
Address                         5000 non-null object
dtypes: float64(6), int64(1), object(1)
memory usage: 312.6+ KB
```

'describe()' method to get the statistical summary of the various features of the data set

In [6]:
```
df.describe()
```

Out[6]:

	Unnamed: 0	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price
count	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5000.000000	5.000000e+03
mean	2499.500000	68583.108984	5.977222	6.987792	3.981330	36163.516039	1.232073e+06
std	1443.520003	10657.991214	0.991456	1.005833	1.234137	9925.650114	3.531176e+05
min	0.000000	17796.631190	2.644304	3.236194	2.000000	172.610686	1.593866e+04
25%	1249.750000	61480.562388	5.322283	6.299250	3.140000	29403.928702	9.975771e+05
50%	2499.500000	68804.286404	5.970429	7.002902	4.050000	36199.406689	1.232669e+06
75%	3749.250000	75783.338666	6.650808	7.665871	4.490000	42861.290769	1.471210e+06
max	4999.000000	107701.748378	9.519088	10.759588	6.500000	69621.713378	2.469066e+06

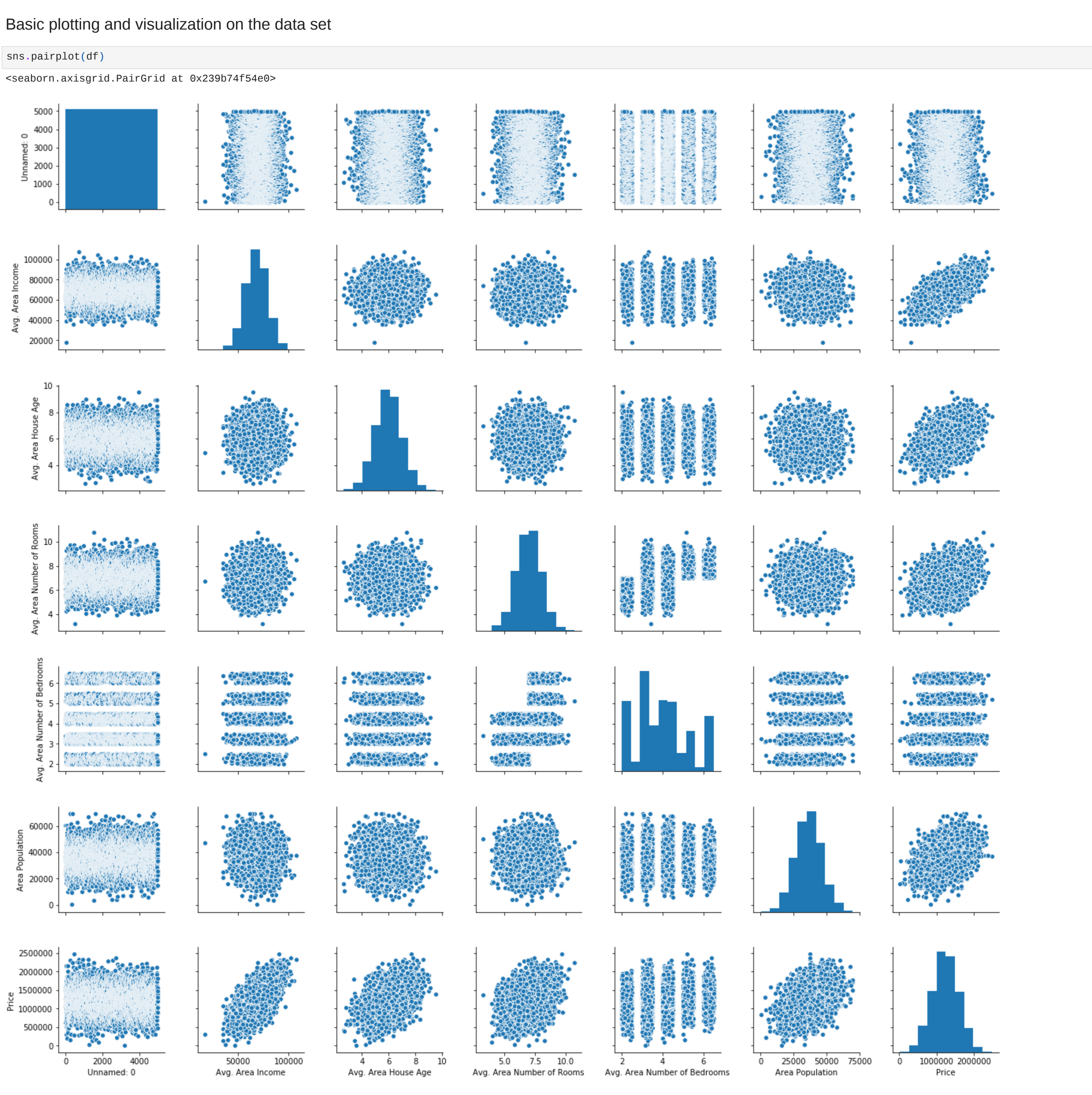
In [7]:
```
df.columns
```

Out[7]:
```
Index(['Unnamed: 0', 'Avg. Area Income', 'Avg. Area House Age',
       'Avg. Area Number of Rooms', 'Avg. Area Number of Bedrooms',
       'Area Population', 'Price', 'Address'],
      dtype='object')
```

Basic plotting and visualization on the data set

In [8]:
```
sns.pairplot(df)
```

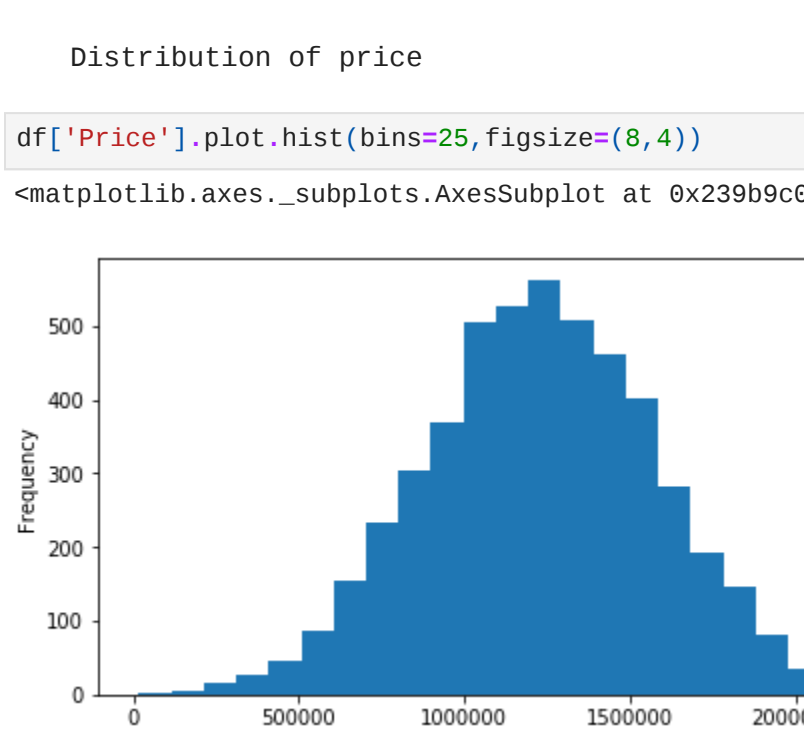
Out[8]:
```
<seaborn.axisgrid.PairGrid at 0x239b74f54e0>
```



Distribution of price

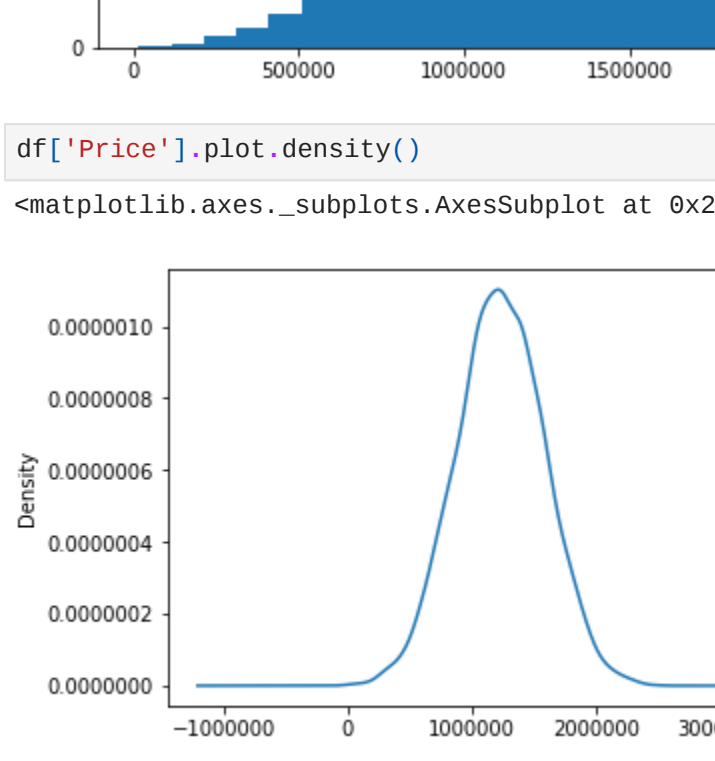
In [9]:
```
df['Price'].plot.hist(bins=25,figsize=(8,4))
```

Out[9]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x239b9c0bc50>
```



In [10]:
```
df['Price'].plot.density()
```

Out[10]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x239ba325ef0>
```



Correlation matrix and heatmap

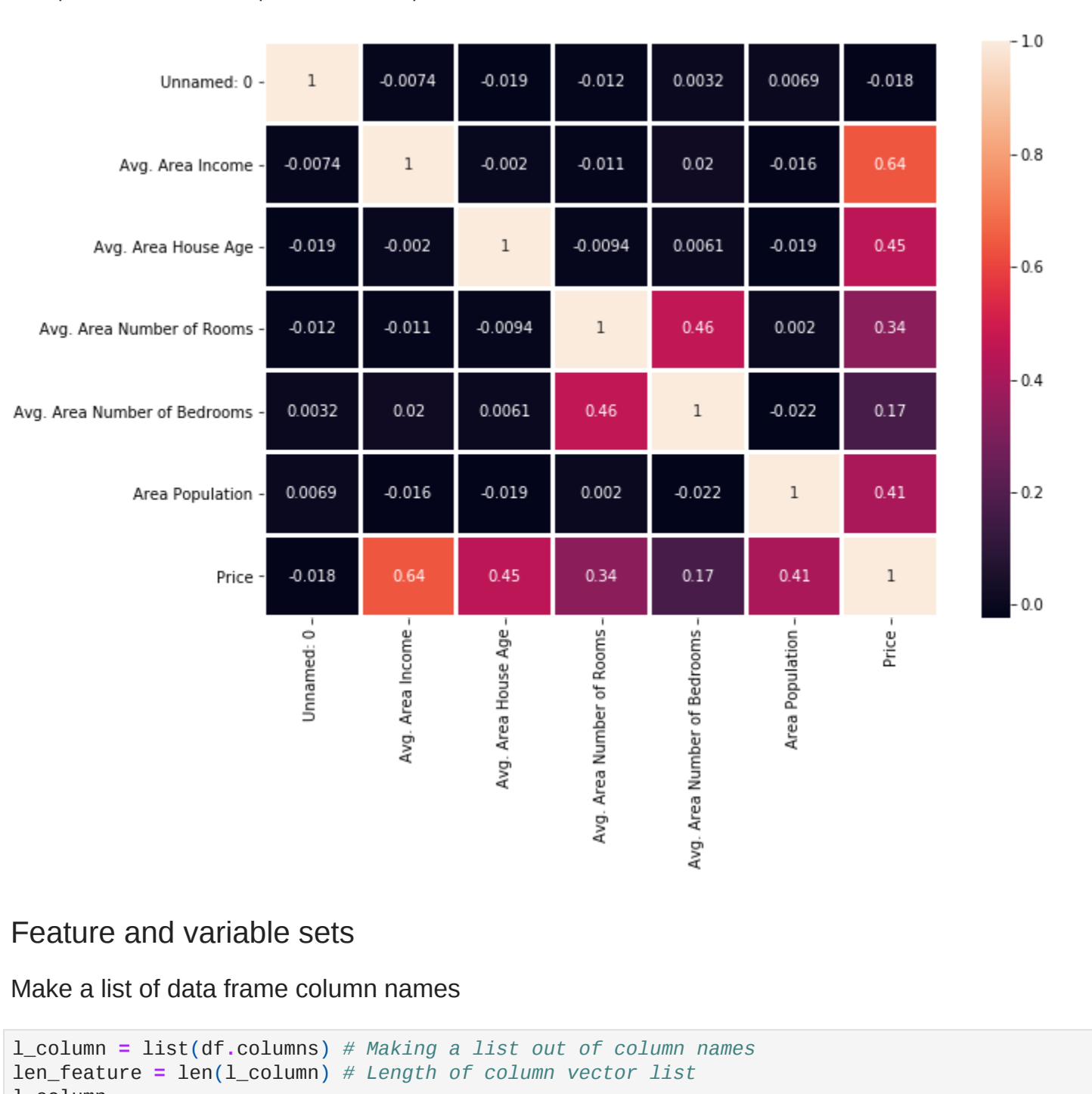
In [11]:
```
df.corr()
```

Out[11]:

	Unnamed: 0	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population	Price
Unnamed: 0	1.000000	-0.007361	-0.019383	-0.012377	0.003176	0.006872	-0.017748
Avg. Area Income	-0.007361	1.000000	-0.002007	-0.011032	0.019788	-0.016234	0.639734
Avg. Area House Age	-0.019383	-0.002007	1.000000	-0.009428	0.006149	-0.018743	0.452543
Avg. Area Number of Rooms	-0.012377	-0.011032	-0.009428	1.000000	0.462695	0.002040	0.335664
Avg. Area Number of Bedrooms	0.003176	0.019788	0.006149	0.462695	1.000000	-0.022168	0.171071
Area Population	0.006872	-0.016234	-0.018743	0.002040	-0.022168	1.000000	0.408556
Price	-0.017748	0.639734	0.452543	0.335664	0.171071	0.408556	1.000000

In [12]:
```
plt.figure(figsize=(10,7))
sns.heatmap(df.corr(),annot=True,linewidths=2)
```

Out[12]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x239baa010b8>
```



Feature and variable sets

Make a list of data frame column names

In [5]:
```
l_column = list(df.columns) # Making a list out of column names
len_feature = len(l_column) # Length of column vector list
l_column
```

Out[5]:
```
['Unnamed: 0',
 'Avg. Area Income',
 'Avg. Area House Age',
 'Avg. Area Number of Rooms',
 'Avg. Area Number of Bedrooms',
 'Area Population',
 'Price',
 'Address']
```

In [10]:
```
l_column[0:len_feature-2]
```

Out[10]:
```
['Unnamed: 0',
 'Avg. Area Income',
 'Avg. Area House Age',
 'Avg. Area Number of Rooms',
 'Avg. Area Number of Bedrooms',
 'Area Population']
```

Put all the numerical features in X and Price in y, ignore Address which is string for linear regression

In [6]:
```
X = df[l_column[0:len_feature-2]]
y = df[l_column[len_feature-2]]
```

In [9]:
```
y
```

Out[9]:
```
0       1.059034e+06
1       1.505891e+06
2       1.058988e+06
3       1.260617e+06
4       6.309435e+05
            ...
4995    1.060194e+06
4996    1.482618e+06
4997    1.030730e+06
4998    1.198657e+06
4999    1.298950e+06
Name: Price, Length: 5000, dtype: float64
```

In [ ]:

In [ ]:

In [21]:
```
print("Feature set size:",X.shape)
print("Variable set size:",y.shape)
```

```
Feature set size: (5000, 6)
Variable set size: (5000,)
```

In [22]:
```
X.head()
```

Out[22]:

	Unnamed: 0	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population
0	0	79545.458574	5.682861	7.009188	4.09	23086.800503
1	1	79248.642455	6.002900	6.730821	3.09	40173.072174
2	2	61287.067179	5.865890	8.512727	5.13	36882.159400
3	3	63345.240046	7.188236	5.586729	3.26	34310.242831
4	4	59982.197226	5.040555	7.839388	4.23	26354.109472

In [24]:
```
X = X.drop(['Unnamed: 0'], axis = 1)
```

In [25]:
```
X.head()
```

Out[25]:

	Avg. Area Income	Avg. Area House Age	Avg. Area Number of Rooms	Avg. Area Number of Bedrooms	Area Population
0	79545.458574	5.682861	7.009188	4.09	23086.800503
1	79248.642455	6.002900	6.730821	3.09	40173.072174
2	61287.067179	5.865890	8.512727	5.13	36882.159400
3	63345.240046	7.188236	5.586729	3.26	34310.242831
4	59982.197226	5.040555	7.839388	4.23	26354.109472

In [26]:
```
y.head()
```

Out[26]:
```
0    1.059034e+06
1    1.505891e+06
2    1.058988e+06
3    1.260617e+06
4    6.309435e+05
Name: Price, dtype: float64
```

Test-train split

Import train_test_split function from scikit-learn

In [28]:
```
from sklearn.model_selection import train_test_split
```

Create X and y train and test splits in one command using a split ratio and a random seed

In [29]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=123)
```

Check the size and shape of train/test splits (it should be in the ratio as per test_size parameter above)

In [30]:
```
print("Training feature set size:",X_train.shape)
print("Test feature set size:",X_test.shape)
print("Training variable set size:",y_train.shape)
print("Test variable set size:",y_test.shape)
```

```
Training feature set size: (3500, 5)
Test feature set size: (1500, 5)
Training variable set size: (3500,)
Test variable set size: (1500,)
```

Model fit and training

Import linear regression model estimator from scikit-learn and instantiate

In [31]:
```
from sklearn.linear_model import LinearRegression
from sklearn import metrics
```

In [32]:
```
lm = LinearRegression() # Creating a Linear Regression object 'lm'
```

Fit the model on to the instantiated object itself

In [33]:
```
lm.fit(X_train,y_train) # Fit the linear model on to the 'lm' object itself i.e. no need to set this to another variable
```

Out[33]:
```
LinearRegression(copy_X=True, fit_intercept=True, n_jobs=None,
         normalize=False)
```

Check the intercept and coefficients and put them in a DataFrame

In [34]:
```
print("The intercept term of the linear model:", lm.intercept_)
```

```
The intercept term of the linear model: -2631028.9017465496
```

In [12]:
```
X.columns
```

Out[12]:
```
Index(['Unnamed: 0', 'Avg. Area Income', 'Avg. Area House Age',
       'Avg. Area Number of Rooms', 'Avg. Area Number of Bedrooms',
       'Area Population'],
      dtype='object')
```

In [35]:
```
print("The coefficients of the linear model:", lm.coef_)
```

```
The coefficients of the linear model: [2.15976020e+01 1.65201105e+05 1.19061464e+05 3.21258561e+03
 1.52281212e+01]
```

In [36]:
```
cdf = pd.DataFrame(data=lm.coef_, index=X_train.columns, columns=["Coefficients"])
cdf
```

Out[36]:

	Coefficients
Avg. Area Income	21.597602
Avg. Area House Age	165201.104954
Avg. Area Number of Rooms	119061.463868
Avg. Area Number of Bedrooms	3212.585606
Area Population	15.228121

Calculation of standard errors and t-statistic for the coefficients

In [ ]:
```
lm.predict()
```

In [37]:
```
n=X_train.shape[0]
k=X_train.shape[1]
dfN = n-k
train_pred=lm.predict(X_train)
train_error = np.square(train_pred - y_train)
sum_error=np.sum(train_error)
se=[0,0,0,0,0]
for i in range(k):
    r = (sum_error/dfN)
    r = r/np.sum(np.square(X_train[list(X_train.columns)[i]]-X_train[list(X_train.columns)[i]].mean()))
    se[i]=np.sqrt(r)
cdf['Standard Error']=se
cdf['t-statistic']=cdf['Coefficients']/cdf['Standard Error']
cdf
```

Out[37]:

	Coefficients	Standard Error	t-statistic
Avg. Area Income	21.597602	0.160361	134.681505
Avg. Area House Age	165201.104954	1722.412068	95.912649
Avg. Area Number of Rooms	119061.463868	1696.546476	70.178722
Avg. Area Number of Bedrooms	3212.585606	1376.451759	2.333962
Area Population	15.228121	0.169882	89.639472

In [38]:
```
print("Therefore, features arranged in the order of importance for predicting the house price\n",'-'*90,sep='')
l=list(cdf.sort_values('t-statistic',ascending=False).index)
print(' > \n'.join(l))
```

```
Therefore, features arranged in the order of importance for predicting the house price
------------------------------------------------------------------------------------------
Avg. Area Income >
Avg. Area House Age >
Area Population >
Avg. Area Number of Rooms >
Avg. Area Number of Bedrooms
```

In [39]:
```
l=list(cdf.index)
from matplotlib import gridspec
fig = plt.figure(figsize=(18, 10))
gs = gridspec.GridSpec(2,3)
#f, ax = plt.subplots(nrows=1,ncols=len(l), sharey=True)
ax0 = plt.subplot(gs[0])
ax0.scatter(df[l[0]],df['Price'])
ax0.set_title(l[0]+" vs. Price", fontdict={'fontsize':20})

ax1 = plt.subplot(gs[1])
ax1.scatter(df[l[1]],df['Price'])
ax1.set_title(l[1]+" vs. Price",fontdict={'fontsize':20})

ax2 = plt.subplot(gs[2])
ax2.scatter(df[l[2]],df['Price'])
ax2.set_title(l[2]+" vs. Price",fontdict={'fontsize':20})

ax3 = plt.subplot(gs[3])
ax3.scatter(df[l[3]],df['Price'])
ax3.set_title(l[3]+" vs. Price",fontdict={'fontsize':20})

ax4 = plt.subplot(gs[4])
ax4.scatter(df[l[4]],df['Price'])
ax4.set_title(l[4]+" vs. Price",fontdict={'fontsize':20})
```

Out[39]:
```
Text(0.5, 1.0, 'Area Population vs. Price')
```

R-square of the model fit

In [40]:
```
print("R-squared value of this fit:",round(metrics.r2_score(y_train,train_pred),3))
```

```
R-squared value of this fit: 0.917
```

Prediction, error estimate, and regression evaluation matrices

Prediction using the lm model

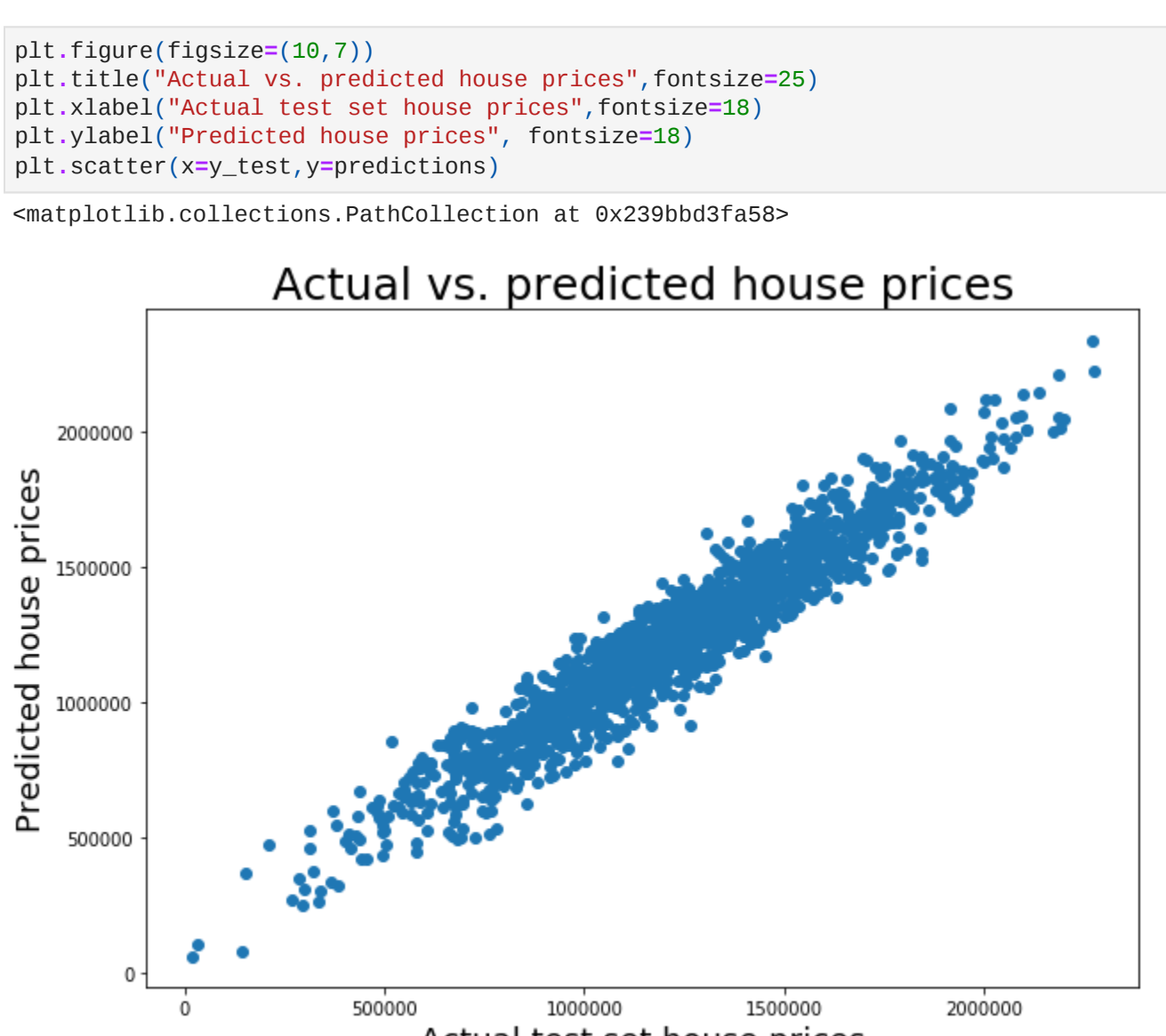
In [42]:
```
predictions = lm.predict(X_test)
print ("Type of the predicted object:", type(predictions))
print ("Size of the predicted object:", predictions.shape)
```

```
Type of the predicted object: <class 'numpy.ndarray'>
Size of the predicted object: (1500,)
```

Scatter plot of predicted price and y_test set to see if the data fall on a 45 degree straight line

In [43]:
```
plt.figure(figsize=(10,7))
plt.title("Actual vs. predicted house prices",fontsize=25)
plt.xlabel("Actual test set house prices",fontsize=18)
plt.ylabel("Predicted house prices", fontsize=18)
plt.scatter(x=y_test,y=predictions)
```

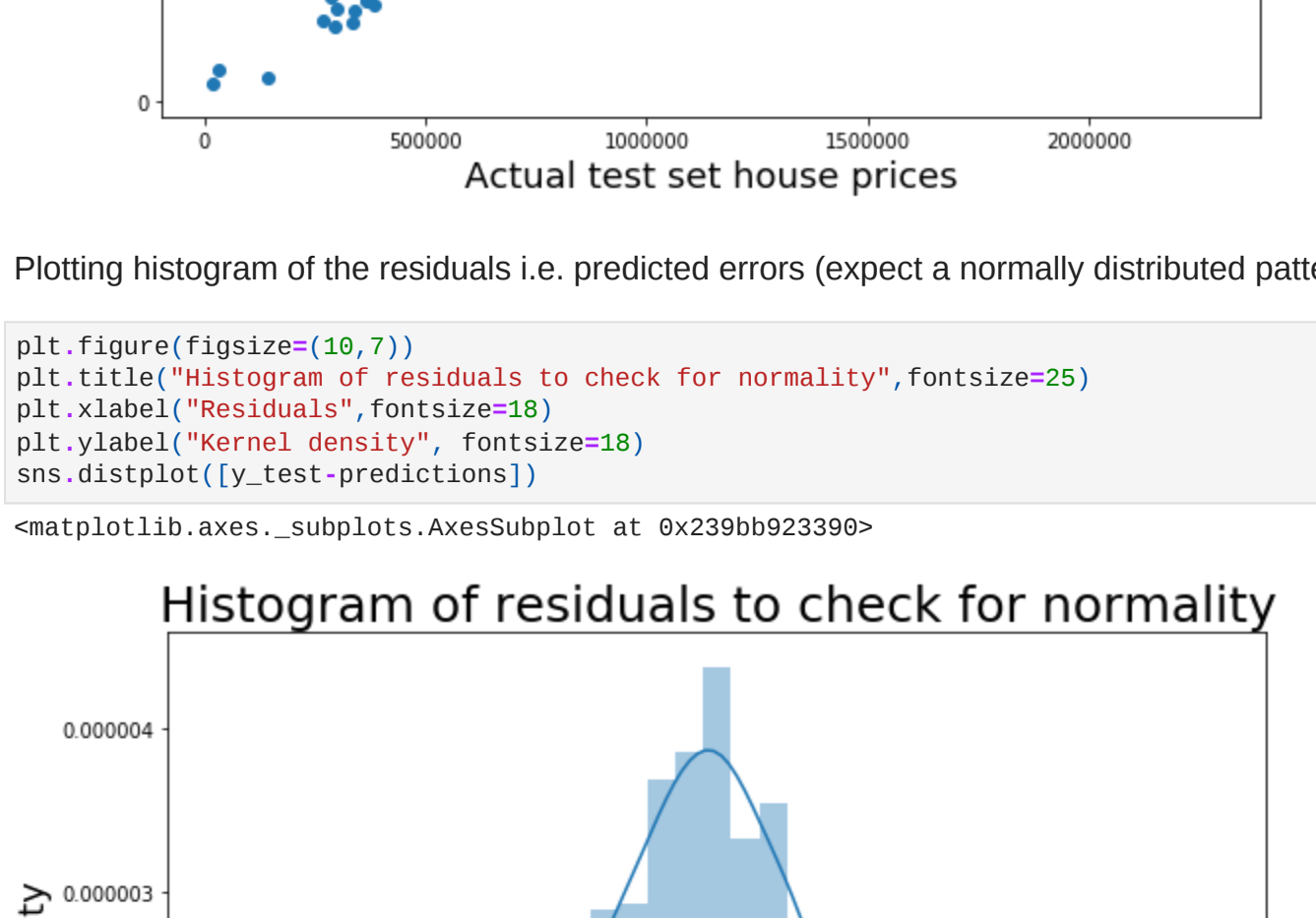
Out[43]:
```
<matplotlib.collections.PathCollection at 0x239bbd3fa58>
```



Plotting histogram of the residuals i.e. predicted errors (expect a normally distributed pattern)

In [45]:
```
plt.figure(figsize=(10,7))
plt.title("Histogram of residuals to check for normality",fontsize=25)
plt.xlabel("Residuals",fontsize=18)
plt.ylabel("Kernel density", fontsize=18)
sns.distplot([y_test-predictions])
```

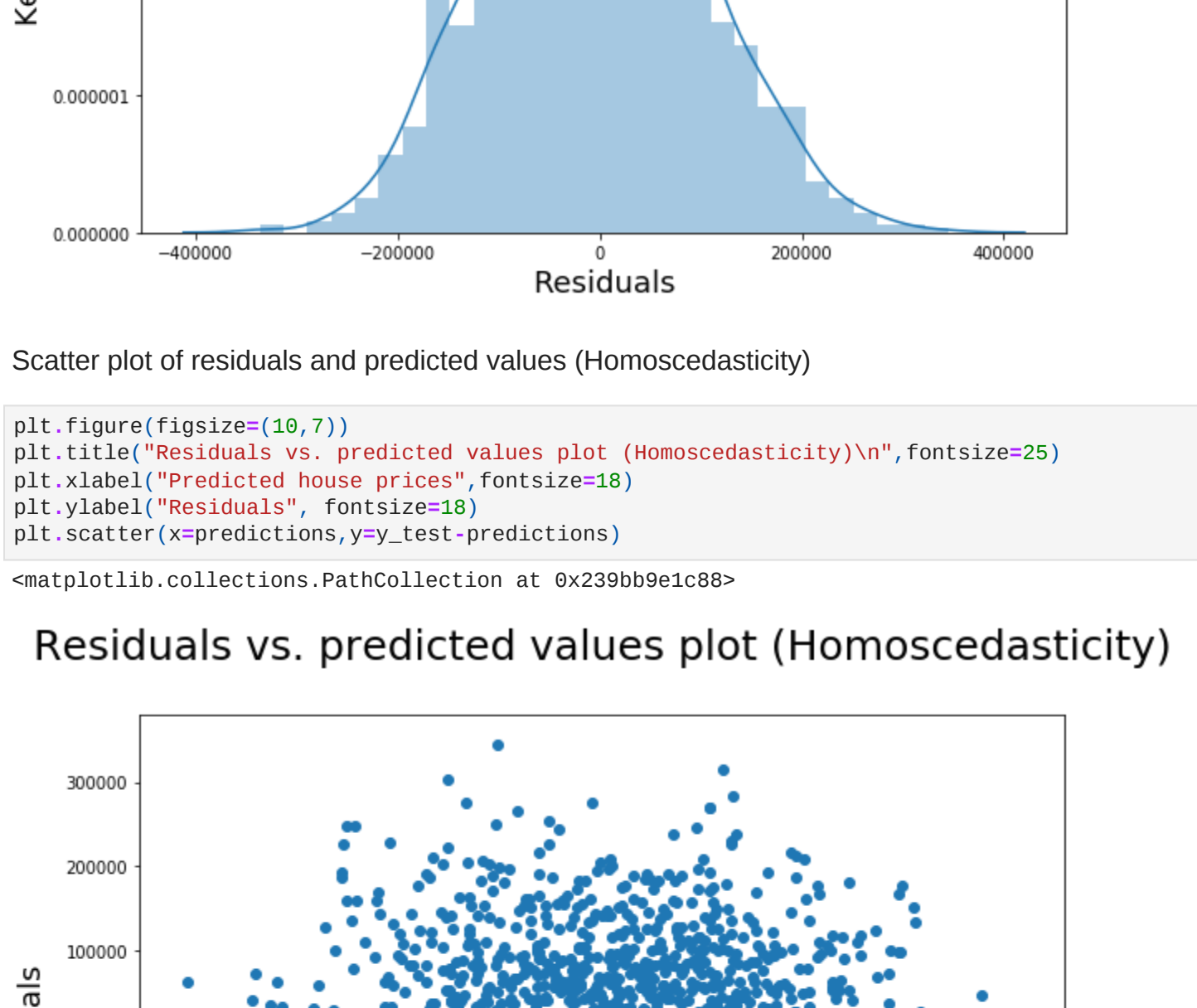
Out[45]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x239bb923390>
```



Scatter plot of residuals and predicted values (Homoscedasticity)

In [46]:
```
plt.figure(figsize=(10,7))
plt.title("Residuals vs. predicted values plot (Homoscedasticity)\n",fontsize=25)
plt.xlabel("Predicted house prices",fontsize=18)
plt.ylabel("Residuals", fontsize=18)
plt.scatter(x=predictions,y=y_test-predictions)
```

Out[46]:
```
<matplotlib.collections.PathCollection at 0x239bb9e1c88>
```



Regression evaluation metrices

In [47]:
```
print("Mean absolute error (MAE):", metrics.mean_absolute_error(y_test,predictions))
print("Mean square error (MSE):", metrics.mean_squared_error(y_test,predictions))
print("Root mean square error (RMSE):", np.sqrt(metrics.mean_squared_error(y_test,predictions)))
```

```
Mean absolute error (MAE): 81739.77482718219
Mean square error (MSE): 10489638335.805494
Root mean square error (RMSE): 102418.93543581429
```

R-square value

In [48]:
```
print("R-squared value of predictions:",round(metrics.r2_score(y_test,predictions),3))
```

```
R-squared value of predictions: 0.919
```