In [1]:
```
import numpy as np
import pandas as pd

# Data Visualization
import matplotlib.pyplot as plt
import seaborn as sns
```

In [2]:
```
advertising = pd.DataFrame(pd.read_csv("advertising.csv"))
advertising.head()
```

Out[2]:

	TV	Radio	Newspaper	Sales
0	230.1	37.8	69.2	22.1
1	44.5	39.3	45.1	10.4
2	17.2	45.9	69.3	12.0
3	151.5	41.3	58.5	16.5
4	180.8	10.8	58.4	17.9

Data Inspection

In [3]:
```
advertising.shape
```

Out[3]:
```
(200, 4)
```

In [4]:
```
advertising.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 200 entries, 0 to 199
Data columns (total 4 columns):
 #   Column     Non-Null Count  Dtype  
---  ------     --------------  -----  
 0   TV         200 non-null    float64
 1   Radio      200 non-null    float64
 2   Newspaper  200 non-null    float64
 3   Sales      200 non-null    float64
dtypes: float64(4)
memory usage: 6.4 KB
```

In [5]:
```
advertising.describe()
```

Out[5]:

	TV	Radio	Newspaper	Sales
count	200.000000	200.000000	200.000000	200.000000
mean	147.042500	23.264000	30.554000	15.130500
std	85.854236	14.846809	21.778621	5.283892
min	0.700000	0.000000	0.300000	1.600000
25%	74.375000	9.975000	12.750000	11.000000
50%	149.750000	22.900000	25.750000	16.000000
75%	218.825000	36.525000	45.100000	19.050000
max	296.400000	49.600000	114.000000	27.000000

Data Cleansing

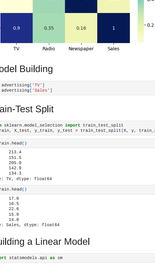
In [6]:
```
# Checking Null values
advertising.isnull().sum()*100/advertising.shape[0]
# There are no NULL values in the dataset, hence it is clean.
```

Out[6]:
```
TV           0.0
Radio        0.0
Newspaper    0.0
Sales        0.0
dtype: float64
```

In [7]:
```
# Outlier Analysis
fig, axs = plt.subplots(3, figsize = (5,5))
plt1 = sns.boxplot(advertising['TV'], ax = axs[0])
plt2 = sns.boxplot(advertising['Newspaper'], ax = axs[1])
plt3 = sns.boxplot(advertising['Radio'], ax = axs[2])
plt.tight_layout()
```

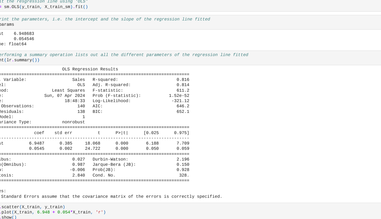
Exploratory Data Analysis

In [8]:
```
sns.boxplot(advertising['Sales'])
plt.show()
```

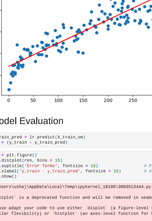


In [9]:
```
# Let's see how Sales are related with other variables using scatter plot.
sns.pairplot(advertising, x_vars=['TV', 'Newspaper', 'Radio'], y_vars='Sales', height=4, aspect=1, kind='scatter')
plt.show()
```

```
C:\Users\susha\Anaconda3\lib\site-packages\seaborn\axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
```



In [10]:
```
# Let's see the correlation between different variables.
sns.heatmap(advertising.corr(), cmap="YlGnBu", annot = True)
plt.show()
```



Model Building

In [11]:
```
X = advertising['TV']
y = advertising['Sales']
```

Train-Test Split

In [12]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, train_size = 0.7, test_size = 0.3, random_state = 100)
```

In [13]:
```
X_train.head()
```

Out[13]:
```
74     213.4
3      151.5
185    205.0
26     142.9
90     134.3
Name: TV, dtype: float64
```

In [14]:
```
y_train.head()
```

Out[14]:
```
74     17.0
3      16.5
185    22.6
26     15.0
90     14.0
Name: Sales, dtype: float64
```

Building a Linear Model

In [15]:
```
import statsmodels.api as sm
```

In [16]:
```
# Add a constant to get an intercept
X_train_sm = sm.add_constant(X_train)

# Fit the regression line using 'OLS'
lr = sm.OLS(y_train, X_train_sm).fit()
```

In [17]:
```
# Print the parameters, i.e. the intercept and the slope of the regression line fitted
lr.params
```

Out[17]:
```
const    6.948683
TV       0.054546
dtype: float64
```

In [18]:
```
# Performing a summary operation lists out all the different parameters of the regression line fitted
print(lr.summary())
```

```
                            OLS Regression Results                            
==============================================================================
Dep. Variable:                  Sales   R-squared:                       0.816
Model:                            OLS   Adj. R-squared:                  0.814
Method:                 Least Squares   F-statistic:                     611.2
Date:                Sun, 07 Apr 2019   Prob (F-statistic):           1.52e-52
Time:                        18:48:31   Log-Likelihood:                -321.12
No. Observations:                 140   AIC:                             646.2
Df Residuals:                     138   BIC:                             652.1
Df Model:                           1                                         
Covariance Type:            nonrobust                                         
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const          6.9487      0.385     18.068      0.000      6.188      7.709
TV             0.0545      0.002     24.722      0.000      0.050      0.059
==============================================================================
Omnibus:                        0.027   Durbin-Watson:                   2.196
Prob(Omnibus):                  0.987   Jarque-Bera (JB):                0.158
Skew:                          -0.006   Prob(JB):                        0.924
Kurtosis:                       2.840   Cond. No.                         328.
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

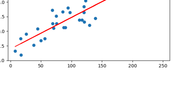
In [19]:
```
plt.scatter(X_train, y_train)
plt.plot(X_train, 6.948 + 0.054*X_train, 'r')
plt.show()
```

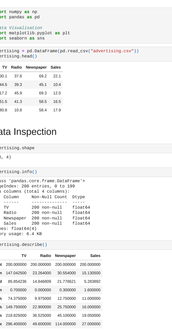
Model Evaluation

In [20]:
```
y_train_pred = lr.predict(X_train_sm)
res = (y_train - y_train_pred)
```

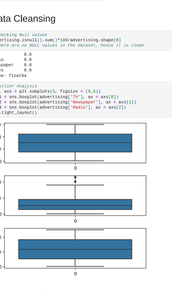
In [21]:
```
fig = plt.figure()
sns.distplot(res, bins = 15)
fig.suptitle('Error Terms', fontsize = 15)                  # Plot heading
plt.xlabel('y_train - y_train_pred', fontsize = 15)         # X-label
plt.show()
```

```
C:\Users\susha]\AppData\Local\Temp\ipykernel_18104\3053153444.py:2: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(res, bins = 15)
```





In [22]:
```
plt.scatter(X_train,res)
plt.show()
```



Predictions on the Test Set

In [23]:
```
# Add a constant to X_test
X_test_sm = sm.add_constant(X_test)

# Predict the y values corresponding to X_test_sm
y_pred = lr.predict(X_test_sm)
```

In [24]:
```
y_pred.head()
```

Out[24]:
```
126     7.374140
104    19.941482
99     14.323269
92     18.823294
111    20.132392
dtype: float64
```

In [25]:
```
from sklearn.metrics import mean_squared_error
from sklearn.metrics import r2_score
```

In [26]:
```
#Returns the mean squared error; we'll take a square root
np.sqrt(mean_squared_error(y_test, y_pred))
```

Out[26]:
```
2.019296008966232
```

Checking the R-squared on the test set

In [27]:
```
r_squared = r2_score(y_test, y_pred)
r_squared
```

Out[27]:
```
0.7921031601245659
```

Visualizing the fit on the test set

In [28]:
```
plt.scatter(X_test, y_test)
plt.plot(X_test, 6.948 + 0.054 * X_test, 'r')
plt.show()
```