In [10]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import warnings
warnings.filterwarnings('ignore')
```

In [11]:

```
df = pd.read_csv('Advertising.csv')
```

In [12]:

```
df.head()
```

Out[12]:

	Unnamed: 0	TV	Radio	Newspaper	Sales
0	1	230.1	37.8	69.2	22.1
1	2	44.5	39.3	45.1	10.4
2	3	17.2	45.9	69.3	9.3
3	4	151.5	41.3	58.5	18.5
4	5	180.8	10.8	58.4	12.9

In [13]:

```
df.shape
```

Out[13]:

```
(200, 5)
```

In [14]:

```
df.columns.values.tolist()
```

Out[14]:

```
['Unnamed: 0', 'TV', 'Radio', 'Newspaper', 'Sales']
```

In [15]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 200 entries, 0 to 199
Data columns (total 5 columns):
 #   Column      Non-Null Count  Dtype  
---  ------      --------------  -----  
 0   Unnamed: 0  200 non-null    int64  
 1   TV          200 non-null    float64
 2   Radio       200 non-null    float64
 3   Newspaper   200 non-null    float64
 4   Sales       200 non-null    float64
dtypes: float64(4), int64(1)
memory usage: 7.9 KB
```

In [16]:

```
df.describe()
```

Out[16]:

	Unnamed: 0	TV	Radio	Newspaper	Sales
count	200.000000	200.000000	200.000000	200.000000	200.000000
mean	100.500000	147.042500	23.264000	30.554000	14.022500
std	57.879185	85.854236	14.846809	21.778621	5.217457
min	1.000000	0.700000	0.000000	0.300000	1.600000
25%	50.750000	74.375000	9.975000	12.750000	10.375000
50%	100.500000	149.750000	22.900000	25.750000	12.900000
75%	150.250000	218.825000	36.525000	45.100000	17.400000
max	200.000000	296.400000	49.600000	114.000000	27.000000

In [17]:

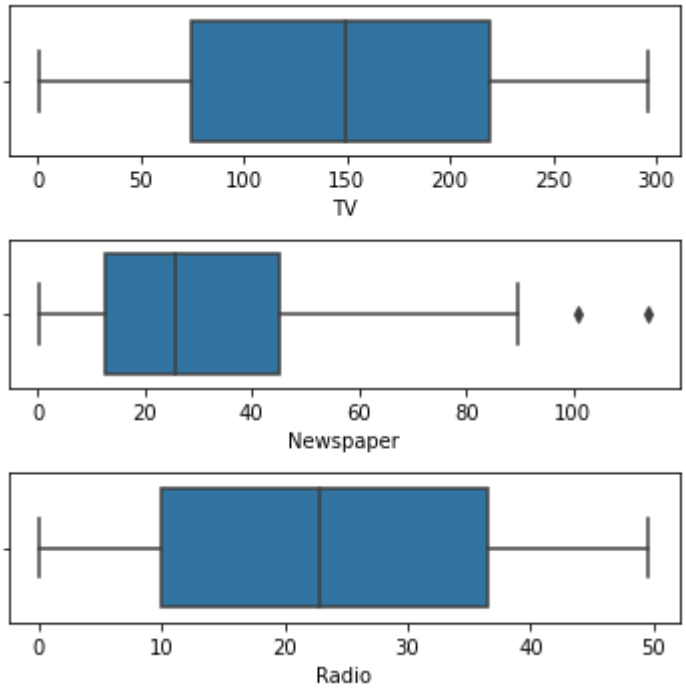
```
df.isnull().sum()
```

Out[17]:

```
Unnamed: 0    0
TV            0
Radio         0
Newspaper     0
Sales         0
dtype: int64
```

In [21]:

```
fig, axs = plt.subplots(3, figsize = (5,5))
plt1 = sns.boxplot(df['TV'], ax = axs[0])
plt2 = sns.boxplot(df['Newspaper'], ax = axs[1])
plt3 = sns.boxplot(df['Radio'], ax = axs[2])
plt.tight_layout()
```

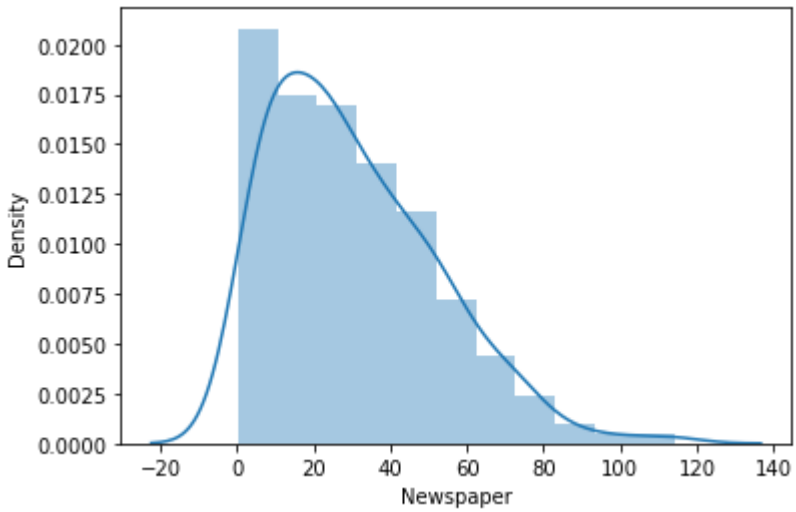


In [22]:

```
sns.distplot(df['Newspaper'])
```

Out[22]:

```
<AxesSubplot:xlabel='Newspaper', ylabel='Density'>
```



In [23]:

```
iqr = df.Newspaper.quantile(0.75) - df.Newspaper.quantile(0.25)
```

In [24]:

```
lower_bridge = df["Newspaper"].quantile(0.25) - (iqr*1.5)
upper_bridge = df["Newspaper"].quantile(0.75) + (iqr*1.5)
print(lower_bridge)
print(upper_bridge)
```

```
-35.775000000000006
93.625
```

In [25]:

```
data = df.copy()
```

In [26]:

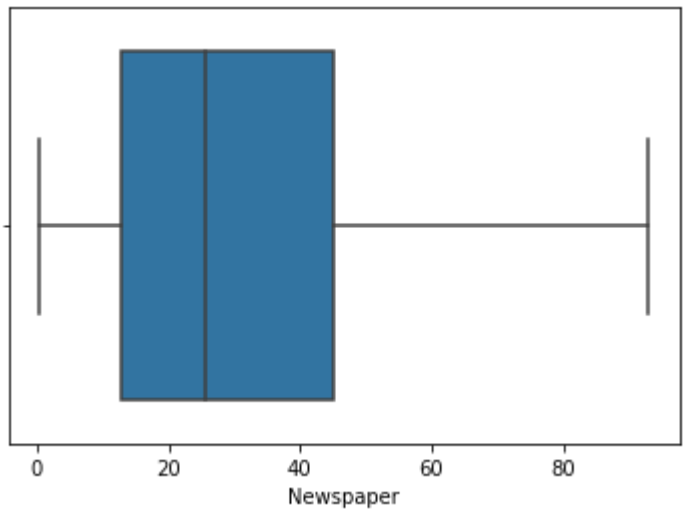
```
data.loc[data['Newspaper']>=93, 'Newspaper']=93
```

In [27]:

```
sns.boxplot(data['Newspaper'])
```

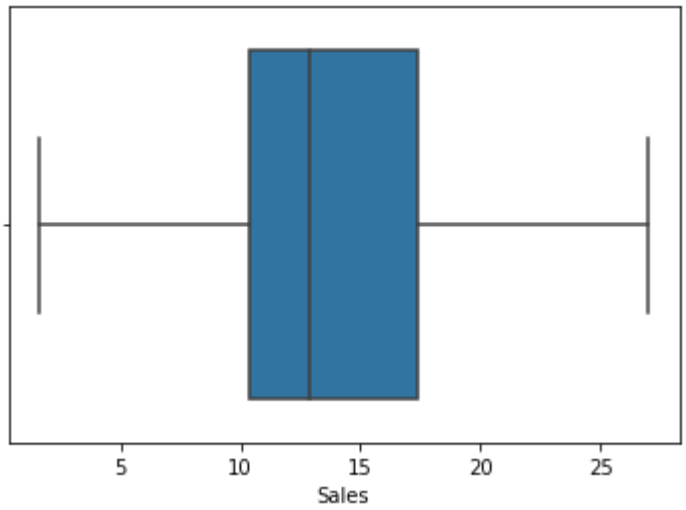
Out[27]:

```
<AxesSubplot:xlabel='Newspaper'>
```



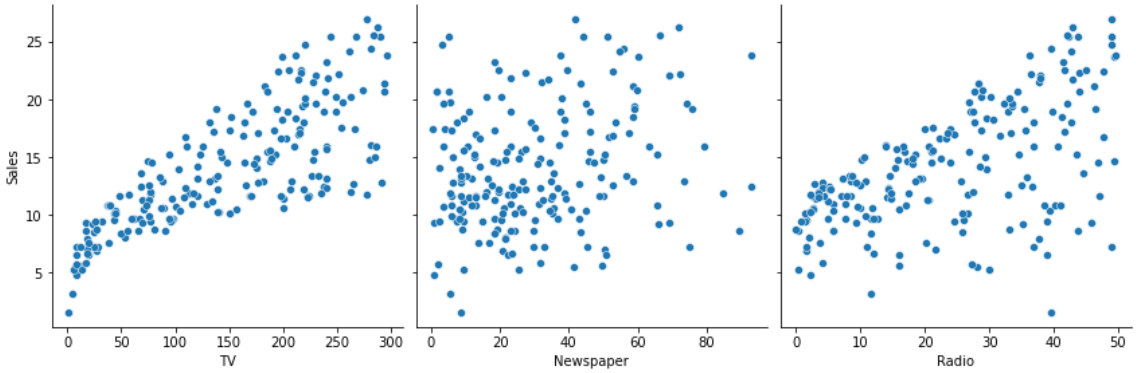
In [28]:

```
sns.boxplot(data['Sales']);
```



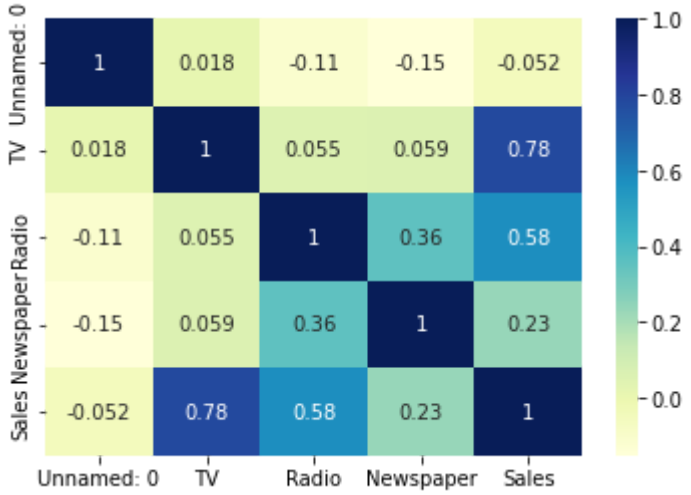
In [29]:

```
sns.pairplot(data, x_vars=['TV', 'Newspaper', 'Radio'],
             y_vars='Sales', height=4, aspect=1, kind='scatter')
plt.show()
```



In [30]:

```
sns.heatmap(data.corr(), cmap="YlGnBu", annot = True)
plt.show()
```



In [32]:

```
important_features = list(df.corr()['Sales'][(df.corr()['Sales']>+0.5)|(df.corr()['Sales
```

In [33]:

```
print(important_features)
```

```
['TV', 'Radio', 'Sales']
```

In [34]:

```
X = data['TV']
y = data['Sales']
```

In [35]:

```
X = X.values.reshape(-1,1)
```

In [36]:

```
X
```

Out[36]:

```
array([[230.1],
       [ 44.5],
       [ 17.2],
       [151.5],
       [180.8],
       [  8.7],
       [ 57.5],
       [120.2],
       [  8.6],
       [199.8],
       [ 66.1],
       [214.7],
       [ 23.8],
       [ 97.5],
       [204.1],
       [195.4],
       [ 67.8],
       [281.4],
```

In [38]:

```
y
```

Out[38]:

```
0      22.1
1      10.4
2       9.3
3      18.5
4      12.9
       ...
195     7.6
196     9.7
197    12.8
198    25.5
199    13.4
Name: Sales, Length: 200, dtype: float64
```

In [39]:

```
print(X.shape,y.shape)
```

```
(200, 1) (200,)
```

In [40]:

```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test=train_test_split(X,y, test_size=0.33)
```

In [41]:

```
print(X_train.shape,y_train.shape)
```

```
(134, 1) (134,)
```

In [42]:

```
from sklearn.metrics import  mean_squared_error , r2_score
from sklearn.model_selection import cross_val_score,GridSearchCV
from sklearn.neighbors import KNeighborsRegressor
from sklearn.svm import SVR
from sklearn.tree import DecisionTreeRegressor
from sklearn.ensemble import RandomForestRegressor
```

In [43]:

```
knn = KNeighborsRegressor().fit(X_train, y_train)
knn
```

Out[43]:

```
KNeighborsRegressor()
```

In [44]:

```
knn_train_pred = knn.predict(X_train)
knn_test_pred = knn.predict(X_test)
print(knn_train_pred, knn_test_pred)
```

```
[12.9  15.18  6.96 15.76 13.74 19.38 17.22  5.92 21.4   9.66 20.14 15.06
 11.38  5.92 18.82 13.58 17.62 19.16 11.44 17.78 14.04 16.52 15.52 13.12
  9.86 15.76 21.6  11.   14.84  9.78  7.82 18.82 12.58 16.9  16.34 13.82
  9.78 16.34 10.28 17.92 18.72 20.38  7.72 12.72 20.14 16.02 15.52 18.72
 11.38  5.92 16.64 10.86 16.44 18.84 16.02  9.78 13.82 19.2  17.5  16.44
 16.72 13.74  7.82 10.96  7.04 12.9  11.6  16.06 16.02  7.38 19.16 16.06
 18.72 12.7  18.72 18.3  16.24 17.8  21.56 15.76 18.3  16.06 16.18 16.06
 14.84 16.7  18.92 13.82 11.38 18.92  8.32 12.34  9.7  10.34 20.8  12.58
 18.3   7.04 18.54 15.26 10.86 18.54  9.7  21.4  17.78 21.6  14.22  5.18
 13.28 18.   16.34 14.84  7.72 10.34  8.96 17.88 11.   21.6  12.58 20.38
 11.44 13.74 10.06 13.12  5.92  7.04 11.38  6.96 16.06 18.84 10.86 15.18
  7.72 15.76] [19.84 10.86 18.72 16.64 10.36 15.34 15.18 11.44 19.8  18.84
7.82  9.78
  8.32 17.12 13.74  5.18 16.52 19.2  11.44  9.78 18.88 15.34 15.76  8.32
 16.7  13.28 10.28 10.06  8.96 11.44 18.    5.92 15.06 16.44 12.7  14.16
 15.52 19.8  16.44  9.86 20.38 13.12  7.04 13.12  5.18 11.38 19.    5.72
 11.44 11.38 13.82 10.96 10.34 18.82 10.28 16.34 17.5  11.38 14.54 14.94
 11.    9.86 10.28 10.34 21.6  14.64]
```

In [45]:

```
Results = pd.DataFrame(columns=["Model","Train R2","Test R2","Test RMSE","Variance"])
```

In [46]:

```
r2 = r2_score(y_test,knn_test_pred)
r2_train = r2_score(y_train,knn_train_pred)
rmse = np.sqrt(mean_squared_error(y_test,knn_test_pred))
variance = r2_train - r2
Results = Results.append({"Model":"K-Nearest Neighbors","Train R2":r2_train,"Test R2":r2
print("R2:",r2)
print("RMSE:",rmse)
```

```
R2: 0.5585102317864145
RMSE: 3.262419626317531
```

In [47]:

```
Results.head()
```

Out[47]:

	Model	Train R2	Test R2	Test RMSE	Variance
0	K-Nearest Neighbors	0.614206	0.55851	3.26242	0.055696

In [48]:

```
svr = SVR().fit(X_train,y_train)
svr
```

Out[48]:

```
SVR()
```

In [50]:

```
svr_train_pred = svr.predict(X_train)
svr_test_pred = svr.predict(X_test)
```

In [51]:

```
print(svr_train_pred,svr_test_pred)
```

```
[13.46963811 13.89453382  7.98658338 14.53101475 13.34658897 17.87906117
 17.99087188  7.89603194 17.81236821  8.80789411 18.26150446 15.74405649
 10.58794417  7.89271959 18.04038918 15.03452741 17.54059708 17.95354901
 10.39991967 17.11873118 15.50920614 17.87084282 15.91491811 12.50254301
  9.15386393 14.52004034 17.5739673  11.18150815 13.07186886  8.92356759
  8.33573897 18.04460633 12.05074208 16.09549806 16.57173092 15.29131485
  8.86532565 16.52376915 11.48687512 16.33412747 18.24186291 18.232348
  8.07845659 12.29893083 18.2647878  18.05850429 15.94326548 18.25197394
 10.62415215  7.89770808 16.21271054 10.18920447 17.80638443 17.30016067
 18.05850429 11.54764363 15.18264172 16.93104584 17.61297971 17.81586969
 16.84119786 13.30922459  8.33220124 10.83358274  8.15544101 13.39362177
 10.52876617 18.11305653 18.07552078  8.10602632 17.93620089 18.11305653
 18.24327889 12.17442483 18.21854681 17.4280653  14.15924162 17.39046811
 17.96568861 14.7135875  17.45683526 18.10929707 13.68358918 18.09774756
 13.15750933 16.79557169 17.51310751 15.21692731 10.66019863 17.53278748
  8.39723826 11.84394279  9.08385763  9.77733993 17.7654973  12.05074208
 17.46091108  8.12888682 16.45388581 14.80303722 11.13517429 16.45388581
  9.08850283 17.86006874 17.12340921 17.59751487 12.69837455  7.80697841
 13.23518569 18.16551574 16.53445778 13.11228338  8.08660874 11.67635078
  8.5795735  17.67133584 11.26923551 17.47687558 11.95528093 18.22877254
 10.26929728 13.29991962  9.415276   12.58942969  7.88310326  8.1317939
 10.66469301  7.98432938 18.10740038 17.33065712 11.07154732 13.80333164
  8.08660874 14.64688316] [17.70119879 10.00835243 18.22249074 16.24043776
9.87865927 12.93031001
 13.80836722 10.29742845 17.24698996 17.37354233  8.29046511 11.55976067
  8.35356263 18.20456827 13.29527254  7.8346338  17.85289001 16.93598043
 10.3348197   8.85643551 17.06681559 12.95660516 14.58604773  8.42328485
 17.92796139 12.347438   11.41350829  9.58396459  8.46503088 10.32548465
 18.14149927  7.87545924 15.74405649 17.7806448  12.08659026 15.61242236
 15.90924354 17.24250916 17.73405884  9.16324854 18.24809388 12.46967752
  8.14946454 12.48198776  7.8495147  10.61511524 16.71336964  7.95408221
 10.22696469 10.60606825 15.29131485 10.74515511 11.76826184 18.10344745
 11.42577231 16.57173092 17.61297971 10.66469301 12.85639961 14.96647521
 11.24009607  9.33384654 11.50716652  9.71450708 17.66951623 14.90429944]
```

In [52]:

```
r2 = r2_score(y_test,svr_test_pred)
r2_train = r2_score(y_train,svr_train_pred)
rmse = np.sqrt(mean_squared_error(y_test,svr_test_pred))
variance = r2_train - r2
Results = Results.append({"Model":"Support Vector Machine","Train R2":r2_train,"Test R2"
print("R2:",r2)
print("RMSE:",rmse)
```

```
R2: 0.5835116884539195
RMSE: 3.1686984285856554
```

In [53]:

```
Results.head()
```

Out[53]:

	Model	Train R2	Test R2	Test RMSE	Variance
0	K-Nearest Neighbors	0.614206	0.55851	3.26242	0.055696
1	Support Vector Machine	0.586535	0.583512	3.168698	0.003024

In [54]:

```
import statsmodels.api as sm
```

In [55]:

```
X_train_constant = sm.add_constant(X_train)
model = sm.OLS(y_train, X_train_constant).fit()
model.params
```

Out[55]:

```
const    6.908115
x1       0.048085
dtype: float64
```

In [56]:

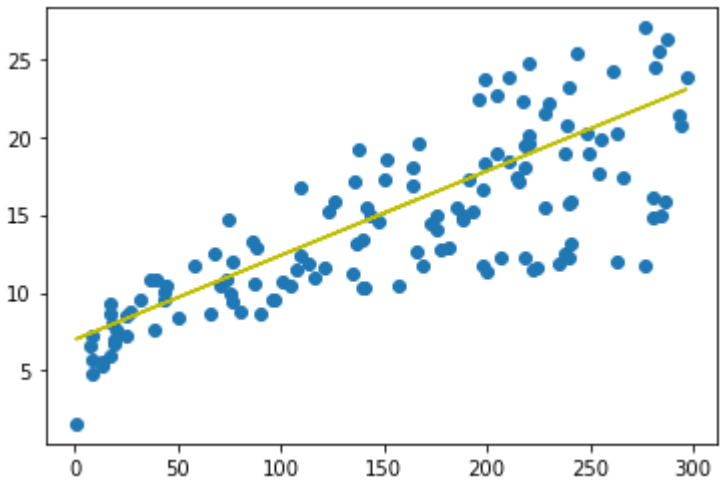
```
print(model.summary())
```

```
                            OLS Regression Results
==============================================================================
====
Dep. Variable:                   Sales   R-squared:
0.613
Model:                             OLS   Adj. R-squared:
0.610
Method:                  Least Squares   F-statistic:                      2
09.2
Date:                Sun, 26 Feb 2023   Prob (F-statistic):           5.34
e-29
Time:                        13:21:54   Log-Likelihood:                -35
0.41
No. Observations:                 134   AIC:                             7
04.8
Df Residuals:                     132   BIC:                             7
10.6
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
====
                 coef    std err          t      P>|t|      [0.025      0.
975]
------------------------------------------------------------------------------
----
const          6.9081      0.588     11.742      0.000       5.744
8.072
x1             0.0481      0.003     14.462      0.000       0.042
0.055
==============================================================================
====
Omnibus:                        0.110   Durbin-Watson:
2.410
Prob(Omnibus):                  0.947   Jarque-Bera (JB):
0.270
Skew:                          -0.020   Prob(JB):
0.874
Kurtosis:                       2.784   Cond. No.
362.
==============================================================================
====

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

In [57]:

```
plt.scatter(X_train, y_train)
plt.plot(X_train, 6.9955 + 0.0541 * X_train, 'y')
plt.show()
```



In [58]:

```
y_train_pred = model.predict(X_train_constant)
res = (y_train - y_train_pred)
res
```

Out[58]:

```
26     1.220470
3      4.306934
22    -1.942843
163    3.229909
145   -3.354508
         ...
168   -0.165728
161    2.270959
194    3.193488
2      1.564815
179   -2.271071
Name: Sales, Length: 134, dtype: float64
```

In [59]:

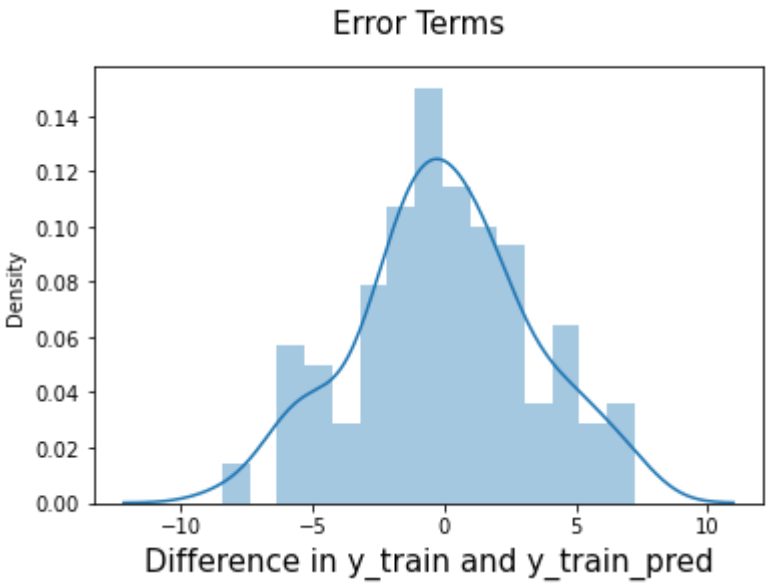
```
y_train_pred
```

Out[59]:

```
array([13.77953044, 14.19306561,  7.54284294, 14.77009144, 13.65450817,
       20.54515828, 18.18416093,  7.3216497 , 20.66056345,  8.68246895,
       19.11221081, 15.79912084, 10.50010031,  7.3120326 , 20.22298553,
       15.20286082, 17.51096413, 20.40571037, 10.30294982, 17.03972637,
       15.60197035, 17.97258479, 15.9433773 , 12.7264583 ,  9.04791864,
       14.76047435, 21.02601314, 11.15406292, 13.36599526,  8.80749121,
        8.11506022, 20.21336843, 12.18790086, 16.09725085, 16.51559458,
       15.4192455 ,  8.74498008, 16.47231764, 11.50989551, 16.30401844,
       19.54978873, 18.87178338,  7.72075923, 12.48603087, 19.18914758,
       18.32360884, 15.96742004, 19.47285195, 10.5385687 ,  7.32645825,
       16.19823037, 10.08656513, 17.87160527, 17.23206831, 18.32360884,
       11.58202374, 15.32788308, 16.85219298, 17.60232655, 17.88603092,
       16.7656391 , 13.61603979,  8.11025167, 10.76457048,  7.85059004,
       13.70259366, 10.43758918, 18.45343965, 18.36207723,  7.76884472,
       20.43937021, 18.45343965, 19.54017163, 12.33696586, 19.67961954,
       17.37632477, 14.43830159, 17.33304783, 20.38166763, 14.92877355,
       17.40998461, 18.44382255, 13.99110657, 18.41497126, 13.45735768,
       16.72236217, 17.47730429, 15.35673437, 10.57703709, 17.50134703,
        8.19680554, 11.93785633,  8.97579041,  9.67302995, 20.73750023,
       12.18790086, 17.41479316,  7.80731311, 16.40980651, 15.00571032,
       11.10116888, 16.40980651,  8.98059896, 20.57881812, 17.04453492,
       20.9923533 , 12.95246008,  6.94177436, 13.53910301, 18.60250466,
       16.48193474, 13.4092722 ,  7.73518488, 11.73589729,  8.42280732,
       17.67926333, 11.25504244, 21.1606525 , 12.07249569, 18.85254918,
       10.16831046, 13.60642269,  9.31238881, 12.82743782,  7.28318131,
        7.81212166, 10.58184563,  7.53803439, 18.43901401, 17.26572815,
       11.02904065, 14.10651174,  7.73518488, 14.87107096])
```

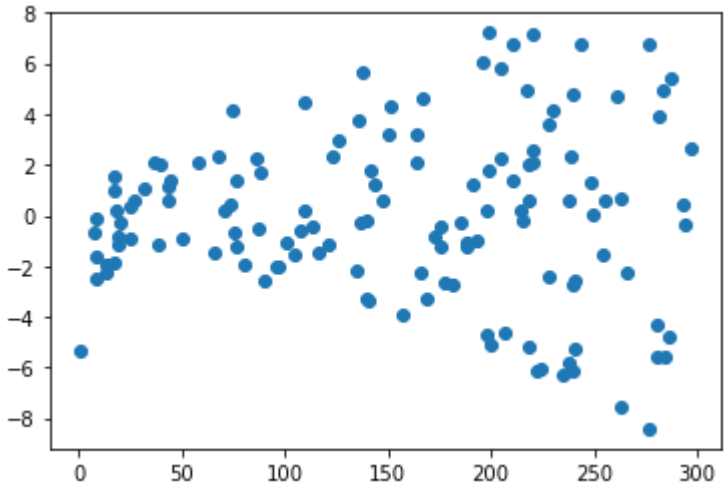
In [60]:

```
fig = plt.figure()
sns.distplot(res, bins = 15)
fig.suptitle('Error Terms', fontsize = 15)
plt.xlabel('Difference in y_train and y_train_pred', fontsize = 15)
plt.show()
```



In [61]:

```
plt.scatter(X_train, res)
plt.show()
```



In [62]:

```
X_test_constant = sm.add_constant(X_test)
y_pred = model.predict(X_test_constant)
y_pred
```

Out[62]:

```
array([20.83847975,  9.90384029, 19.66038534, 16.22227311,  9.77400947,
       13.21212171, 14.11132029, 10.19716175, 17.17436573, 17.31381364,
        8.05254908, 11.59644938,  8.13910296, 19.74213067, 13.60161414,
        7.10526501, 17.9437335 , 16.85700153, 10.23563014,  8.73536298,
       16.98683234, 13.240973  , 14.81817693,  8.23046538, 18.06875577,
       12.54373345, 11.42334164,  9.48068801,  8.28335942, 10.22601304,
       18.53037643,  7.25913857, 15.79912084, 17.83313689, 12.2311778 ,
       15.68852422, 15.93856875, 17.16955718, 17.76581721,  9.05753574,
       18.9727629 , 12.68798991,  7.84097295, 12.70241556,  7.16777615,
       10.5289516 , 16.64542539,  7.47071471, 10.12503352, 10.5193345 ,
       15.4192455 , 10.66839951, 11.84649391, 20.06911197, 11.43776728,
       16.51559458, 17.60232655, 10.58184563, 13.13037638, 15.14515823,
       11.2213826 ,  9.23064349, 11.53393825,  9.61051882, 20.88656523,
       15.0922642 ])
```

In [63]:

```
from sklearn.metrics import mean_squared_error
from sklearn.metrics import r2_score
np.sqrt(mean_squared_error(y_test, y_pred))
```

Out[63]:

```
3.1085747024270622
```

In [64]:

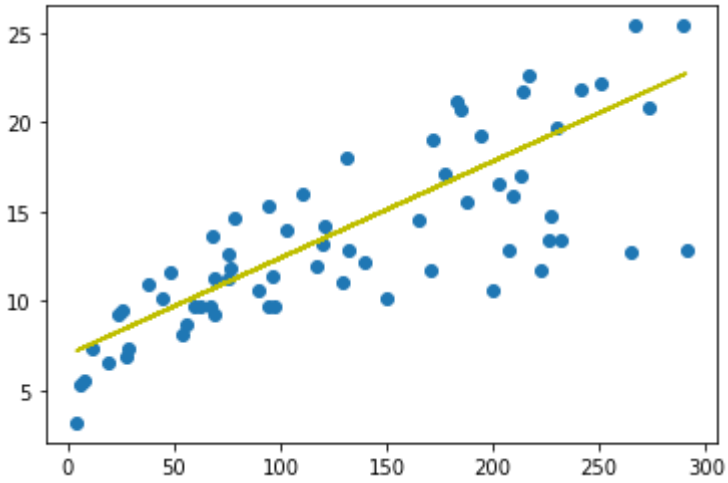
```
r2 = r2_score(y_test, y_pred)
r2
```

Out[64]:

```
0.5991668630162483
```

In [65]:

```
plt.scatter(X_test, y_test)
plt.plot(X_test, 6.9955 + 0.0541 * X_test, 'y')
plt.show()
```



In [ ]: