Q1. Investigate the use of Logistic Regression on a subset of the Kaggle Credit Card Fraud Data set (www.kaggle.com/dalpozz/creditcardfraud). Note that in this data set, the number of fraud data are much smaller than the normal data.

Your first task would be to construct subset data set(s) from the Kaggle data set. Construct three subset data sets of 100K, 20K, and 10K, with normal and fraud data included (make sure you maximize the number of fraud data elements). Out of this data set construct a training data set and a testing data set (using 80% of the data for the former, and 20% for the latter) to build and test the logistic regression model.

In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score,accuracy_score
from sklearn.utils import shuffle

df=pd.read_csv('creditcard.csv')
df.head()
```

Out[1]:

	Time	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V
0	0	-1.359807	-0.072781	2.536347	1.378155	-0.338321	0.462388	0.239599	0.098698	0.363787	0.090794	-0.551600	0.6178
1	0	1.191857	0.266151	0.166480	0.448154	0.060018	-0.082361	-0.078803	0.085102	-0.255425	-0.166974	1.612727	1.0652
2	1	-1.358354	-1.340163	1.773209	0.379780	-0.503198	1.800499	0.791461	0.247676	-1.514654	0.207643	0.624501	0.0660
3	1	-0.966272	-0.185226	1.792993	-0.863291	-0.010309	1.247203	0.237609	0.377436	-1.387024	-0.054952	-0.226487	0.1782
4	2	-1.158233	0.877737	1.548718	0.403034	-0.407193	0.095921	0.592941	-0.270533	0.817739	0.753074	-0.822843	0.5381

In [2]:

```
df.describe()
```

Out[2]:

	Time	V1	V2	V3	V4	V5	V6	
count	140703.000000	140703.000000	140703.000000	140703.000000	140703.000000	140702.000000	140702.000000	140702.000
mean	52017.063240	-0.249590	0.018631	0.672709	0.139629	-0.282394	0.079221	-0.117
std	20935.874366	1.815360	1.612924	1.267514	1.321903	1.306687	1.283716	1.166
min	0.000000	-56.407510	-72.715728	-33.680984	-5.519697	-42.147898	-26.160506	-31.764
25%	38001.000000	-1.020857	-0.563417	0.169911	-0.713458	-0.903456	-0.661857	-0.603

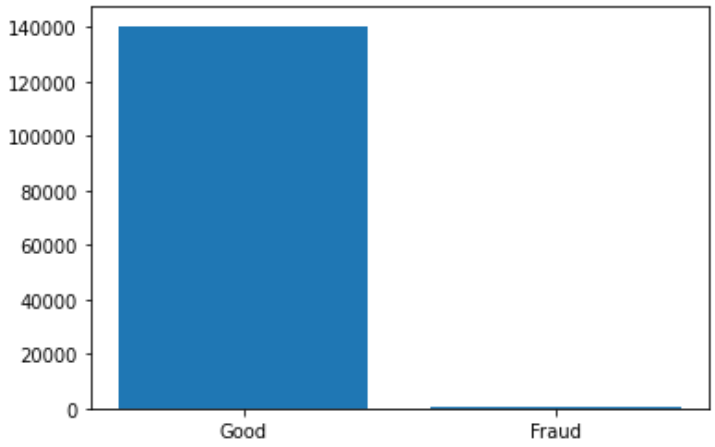
	Time	V1	V2	V3	V4	V5	V6	
50%	53833.000000	-0.270868	0.105003	0.750128	0.167426	-0.314577	-0.176481	-0.064
75%	69573.000000	1.157957	0.777163	1.362846	0.992618	0.237702	0.465523	0.409
max	83879.000000	1.960497	18.902453	9.382558	16.715537	34.801666	22.529298	36.677

In [3]:

```
plt.bar(["Good","Fraud"],df['Class'].value_counts())
```

Out[3]:

```
<BarContainer object of 2 artists>
```



In [4]:

```
df.duplicated().sum()
```

Out[4]:

```
529
```

In [5]:

```
df=df.drop_duplicates()
df_good=df[df['Class']==0]
df_fraud=df[df['Class']==1]

random_state_seed=42
fraud_len=len(df_fraud)
#This set contains 473 fraud cases and 100000 good cases
set_1=shuffle(pd.concat([df_fraud.sample(frac=1, random_state=random_state_seed), df_goo
d.sample(frac=1, random_state=random_state_seed)[:100000]], axis=0))
#This set contains 473 fraud cases and 20000 good cases
set_2=shuffle(pd.concat([df_fraud.sample(frac=1, random_state=random_state_seed), df_goo
d.sample(frac=1, random_state=random_state_seed)[:20000]]))
#This set contains 473 fraud cases and 10000 good cases
set_3=shuffle(pd.concat([df_fraud.sample(frac=1, random_state=random_state_seed), df_goo
d.sample(frac=1, random_state=random_state_seed)[:10000]]))
```

In [6]:

```
set_1.shape,set_2.shape,set_3.shape
```

Out[6]:

```
((100259, 31), (20259, 31), (10259, 31))
```

In [7]:

```
fig, axes = plt.subplots(1,3, figsize = (12,4))
axes[0].bar(["Good","Fraud"],set_1['Class'].value_counts())
axes[1].bar(["Good","Fraud"],set_2['Class'].value_counts())
axes[2].bar(["Good","Fraud"],set_3['Class'].value_counts())
plt.show()
```

In [8]:

```
for dataset in (set_1,set_2,set_3):
    minmax=MinMaxScaler((-1,1))
    for column in dataset.columns:
        if column!='Class':
            dataset[column]=minmax.fit_transform(dataset[[column]])

def create_df(set_):
    train_df=set_[0:round(0.8*len(set_))]
    test_df=set_[round(0.8*len(set_)):]
    X_train=train_df.drop(columns=['Class'])
    y_train=train_df['Class']
    X_test=test_df.drop(columns=['Class'])
    y_test=test_df['Class']
    return (X_train,y_train,X_test,y_test)

for dataset in (set_1,set_2,set_3):
    X_train,y_train,X_test,y_test=create_df(dataset)
    logreg = LogisticRegression(solver='liblinear',random_state=random_state_seed, penal
ty='l2', class_weight='balanced', max_iter=1000).fit(X_train, y_train)
    y_pred=logreg.predict(X_test)
    print("ROC SCORE",roc_auc_score(y_test,y_pred))
    print("ACCURACY ",accuracy_score(y_test,y_pred))
```

```
ROC SCORE 0.9319269330651113
ACCURACY  0.9812487532415719
ROC SCORE 0.9410044977511244
ACCURACY  0.9809970384995064
ROC SCORE 0.9374425274275049
ACCURACY  0.9814814814814815
```

In [9]:

```
df_fraud=df_fraud.append([df_fraud]*100,ignore_index=True )

set_4=shuffle(pd.concat([df_fraud.sample(frac=0.6, random_state=random_state_seed), df_g
ood.sample(frac=0.25, random_state=random_state_seed)], axis=0))
set_5=shuffle(pd.concat([df_fraud.sample(frac=0.1, random_state=random_state_seed), df_g
ood.sample(frac=0.06, random_state=random_state_seed)], axis=0))
set_6=shuffle(pd.concat([df_fraud.sample(frac=0.06, random_state=random_state_seed), df_
good.sample(frac=0.024, random_state=random_state_seed)], axis=0))
```

In [10]:

```
set_4.shape,set_5.shape,set_6.shape
```

Out[10]:

```
((50673, 31), (11011, 31), (4928, 31))
```

In [11]:

```
fig, axes = plt.subplots(1,3, figsize = (12,4))
axes[0].bar(["Good","Fraud"],set_4['Class'].value_counts())
axes[1].bar(["Good","Fraud"],set_5['Class'].value_counts())
```

```
axes[2].bar(["Good","Fraud"],set_6['Class'].value_counts())
plt.plot()
```

Out[11]:

```
[]
```

In [13]:

```
for dataset in (set_4,set_5,set_6):
    X_train,y_train,X_test,y_test=create_df(dataset)
    logreg = LogisticRegression(solver='liblinear',random_state=random_state_seed, penal
ty='l2', class_weight='balanced', max_iter=1000).fit(X_train, y_train)
    y_pred=logreg.predict(X_test)
    print("ROC SCORE",roc_auc_score(y_test,y_pred))
    print("ACCURACY ",accuracy_score(y_test,y_pred))
```

```
ROC SCORE 0.9424417041815237
ACCURACY  0.9530340404538727
ROC SCORE 0.9451612010209676
ACCURACY  0.9573115349682108
ROC SCORE 0.9524766176751288
ACCURACY  0.9563894523326572
```

Q2. Implement the logistic regression model on the Smarket.csv dataset. Use all the attribute as variables. And as output I need all the learned coefficients, and the scatter plot, and the classification graph generated by the logistic regression.

In [15]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.preprocessing import MinMaxScaler,LabelBinarizer
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import roc_auc_score,accuracy_score
from sklearn.utils import shuffle
import seaborn as sns

df=pd.read_csv("Smarket.csv")
df.head()
```

Out[15]:

	Year	Lag1	Lag2	Lag3	Lag4	Lag5	Volume	Today	Direction
0	2001	0.381	-0.192	-2.624	-1.055	5.010	1.1913	0.959	Up
1	2001	0.959	0.381	-0.192	-2.624	-1.055	1.2965	1.032	Up
2	2001	1.032	0.959	0.381	0.192	2.624	1.4112	0.623	Down

	Year	Lag1	Lag2	Lag3	Lag4	Lag5	Volume	Today	Direction
3	2001	0.623	1.032	0.959	0.381	0.192	1.2760	0.614	Up
4	2001	0.614	-0.623	1.032	0.959	0.381	1.2057	0.213	Up

In [16]:

```
df.describe()
```

Out[16]:

	Year	Lag1	Lag2	Lag3	Lag4	Lag5	Volume	Today
count	1250.000000	1250.000000	1250.000000	1250.000000	1250.000000	1250.00000	1250.000000	1250.000000
mean	2003.016000	0.003834	0.003919	0.001716	0.001636	0.00561	1.478305	0.003138
std	1.409018	1.136299	1.136280	1.138703	1.138774	1.14755	0.360357	1.136334
min	2001.000000	-4.922000	-4.922000	-4.922000	-4.922000	-4.92200	0.356070	-4.922000
25%	2002.000000	-0.639500	-0.639500	-0.640000	-0.640000	-0.64000	1.257400	-0.639500
50%	2003.000000	0.039000	0.039000	0.038500	0.038500	0.03850	1.422950	0.038500
75%	2004.000000	0.596750	0.596750	0.596750	0.596750	0.59700	1.641675	0.596750
max	2005.000000	5.733000	5.733000	5.733000	5.733000	5.73300	3.152470	5.733000

In [17]:

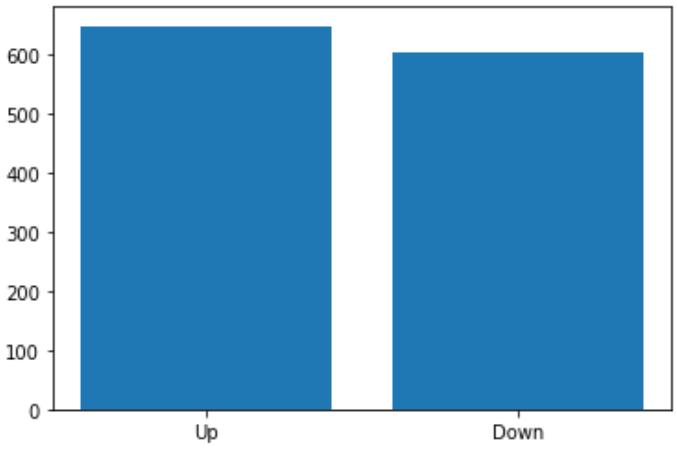
```
df.duplicated().sum()
```

Out[17]:

0

In [18]:

```
plt.bar(["Up","Down"],df['Direction'].value_counts())
plt.show()
```



In [19]:

```
X=df.drop(columns=['Year','Direction'])
y=df['Direction']

mm=MinMaxScaler()

X=mm.fit_transform(X)

lb=LabelBinarizer()
y=pd.DataFrame(lb.fit_transform(y))
```

In [20]:

```
y
```

Out[20]:

	0
0	1
1	1
2	0
3	1
4	1
...	...
1245	1
1246	0
1247	1
1248	0
1249	0

1250 rows × 1 columns

In [23]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.33, random_state=42)

clf=LogisticRegression(random_state=42)
clf.fit(X_train,y_train)
```

```
/usr/local/lib/python3.7/dist-packages/sklearn/utils/validation.py:760: DataConversionWarning: A column-vector y was passed when a 1d array was expected. Please change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

Out[23]:

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='auto', n_jobs=None, penalty='l2',
                   random_state=42, solver='lbfgs', tol=0.0001, verbose=0,
                   warm_start=False)
```

In [24]:

```
y_pred=clf.predict(X_test)
```

In [25]:

```
clf.coef_, clf.intercept_
```

Out[25]:

```
(array([[-0.5817213 , -0.63443731,  0.37935018,  0.06776332,  0.30170363,
          0.1604908 , 12.42067721]]), array([-5.43234864]))
```

In [27]:

```
features=df.columns.to_list()
features.remove('Year')
features.remove('Direction')
logreg_coef=clf.coef_[0]

x_test=pd.DataFrame(X_test)

x_test[0].head()
```

Out[27]:

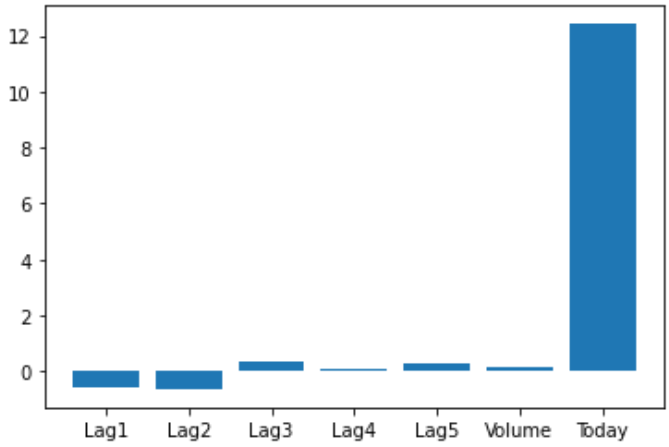
```
0    0.401877
1    0.546410
```

```
2    0.769029
3    0.476771
4    0.672830
Name: 0, dtype: float64
```

In [28]:

```
res=[]
for f, b in zip(features, logreg_coef):
    res.append((f,b))

plt.bar(features,logreg_coef)
plt.show()
```



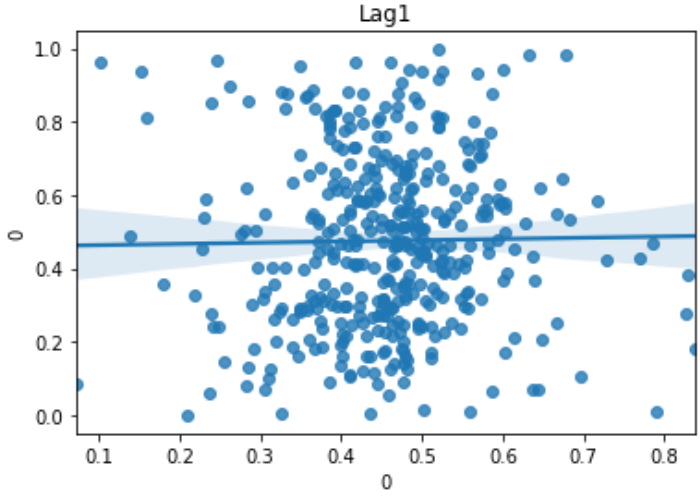
In [29]:

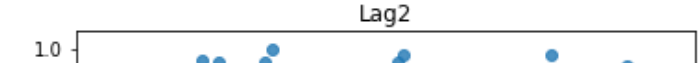
```
print("Learnt Coefficients")
for i in res:
    print(i)
```

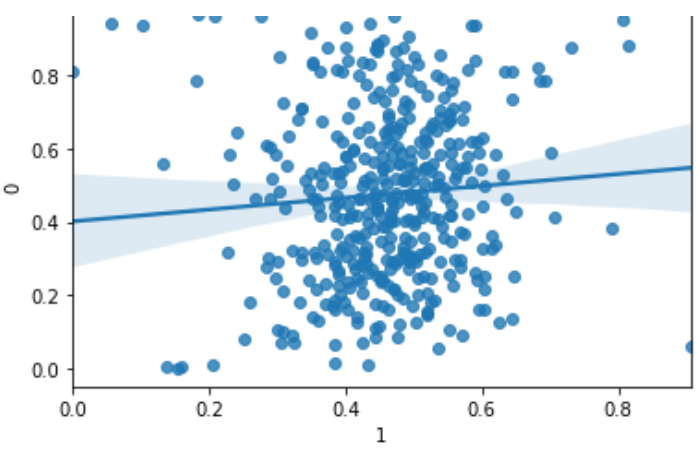
```
Learnt Coefficients
('Lag1', -0.5817213046376338)
('Lag2', -0.6344373061880886)
('Lag3', 0.37935018349055016)
('Lag4', 0.0677633182030959)
('Lag5', 0.3017036344733025)
('Volume', 0.16049080278747863)
('Today', 12.420677211399001)
```

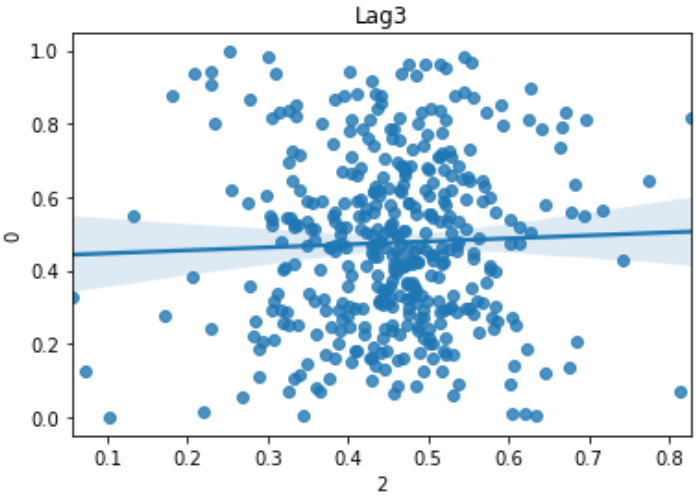
In [30]:

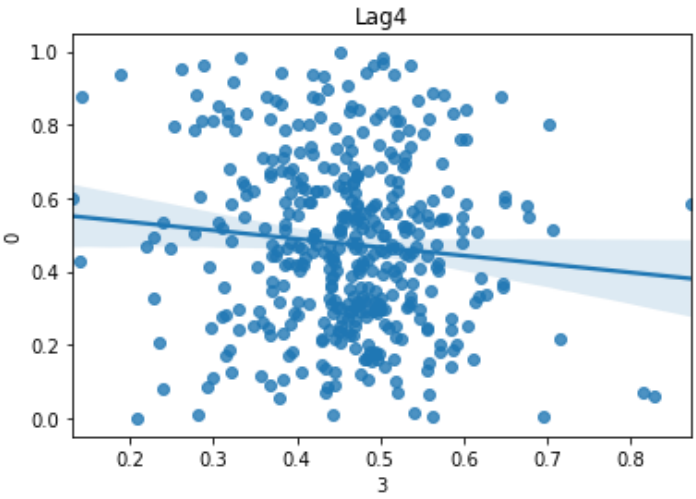
```
for i in range(0,7):
    sns.regplot(x=pd.DataFrame(X_test)[i],y=pd.DataFrame(clf.predict_proba(X_test)[:,0])
)
    plt.title(features[i])
    plt.show()
```

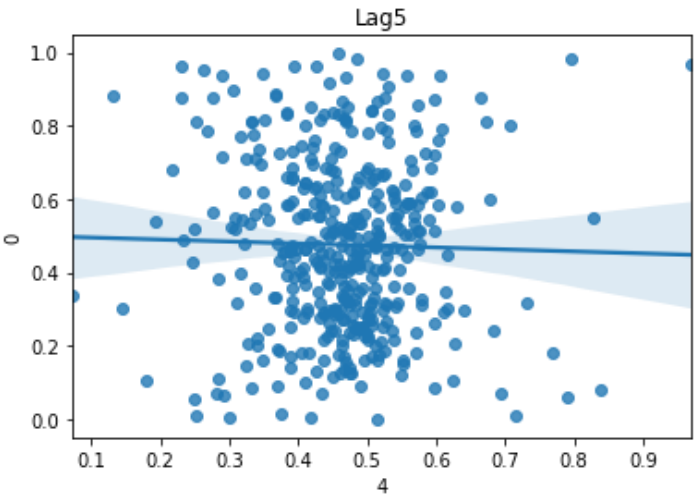


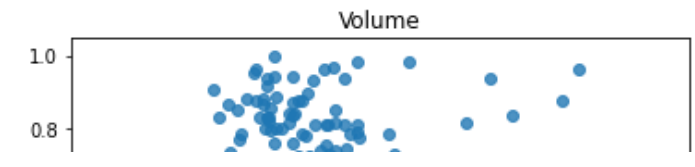


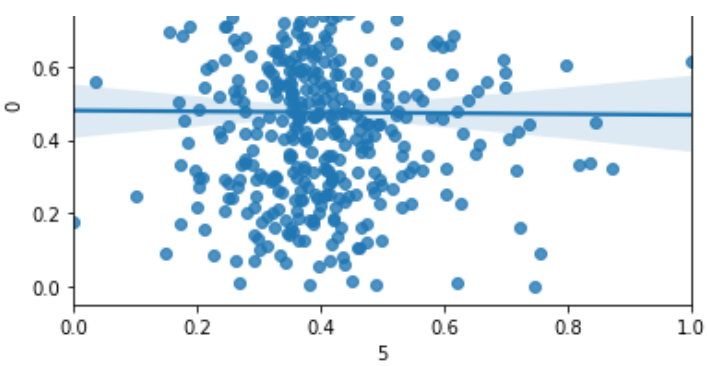

0
1

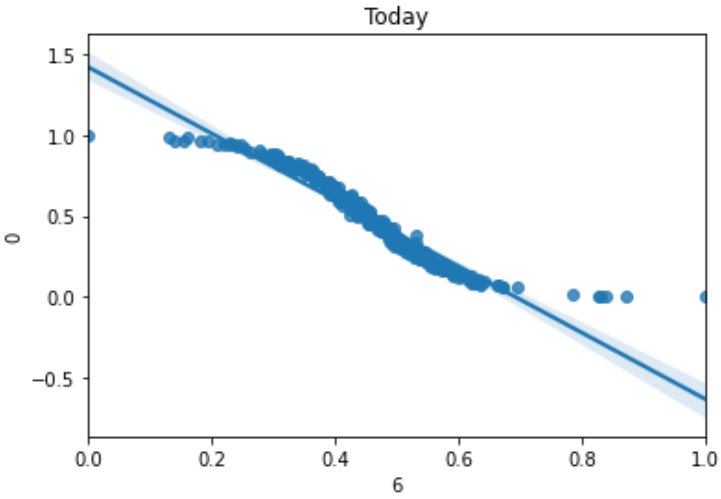

Lag3
0
2


Lag4
0
3


Lag5
0
4


Volume
1.0
0.8


0.6
0.4
0.2
0.0
0
0.0
0.2
0.4
0.6
0.8
1.0
5


Today
1.5
1.0
0.5
0.0
−0.5
0
0.0
0.2
0.4
0.6
0.8
1.0
6