In [1]:
```python
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib import rcParams
from sklearn.model_selection import train_test_split
from sklearn.metrics import classification_report, accuracy_score, roc_auc_score, plot_confusion_matrix
, roc_curve, auc
```

In [4]:
```python
data = pd.read_csv('insurance_claims.csv')

#info on the data
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 39 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
 0   policy_number                1000 non-null   int64
 1   months_as_customer           1000 non-null   int64
 2   age                          1000 non-null   int64
 3   policy_bind_date             1000 non-null   object
 4   policy_state                 1000 non-null   object
 5   policy_csl                   1000 non-null   object
 6   policy_deductable            1000 non-null   int64
 7   policy_annual_premium        1000 non-null   float64
 8   umbrella_limit               1000 non-null   int64
 9   insured_zip                  1000 non-null   int64
 10  insured_sex                  1000 non-null   object
 11  insured_education_level      1000 non-null   object
 12  insured_occupation           1000 non-null   object
 13  insured_hobbies              1000 non-null   object
 14  insured_relationship         1000 non-null   object
 15  capital_gains                1000 non-null   int64
 16  capital_loss                 1000 non-null   int64
 17  incident_date                1000 non-null   object
 18  incident_type                1000 non-null   object
 19  collision_type               1000 non-null   object
 20  incident_severity            1000 non-null   object
 21  authorities_contacted        1000 non-null   object
 22  incident_state               1000 non-null   object
 23  incident_city                1000 non-null   object
 24  incident_location            1000 non-null   object
 25  incident_hour_of_the_day     1000 non-null   int64
 26  number_of_vehicles_involved  1000 non-null   int64
 27  property_damage              1000 non-null   object
 28  bodily_injuries              1000 non-null   int64
 29  witnesses                    1000 non-null   int64
 30  police_report_available      1000 non-null   object
 31  total_claim_amount           1000 non-null   int64
 32  injury_claim                 1000 non-null   int64
 33  property_claim               1000 non-null   int64
 34  vehicle_claim                1000 non-null   int64
 35  auto_make                    1000 non-null   object
 36  auto_model                   1000 non-null   object
 37  auto_year                    1000 non-null   int64
 38  fraud_reported               1000 non-null   object
dtypes: float64(1), int64(17), object(21)
memory usage: 304.8+ KB
```

In [6]:
```python
# data stats
data.describe()
```

Out[6]:

	policy_number	months_as_customer	age	policy_deductable	policy_annual_premium	umbrella_limit	insured_zip	capi
count	1000.000000	1000.000000	1000.000000	1000.000000	1000.000000	1.000000e+03	1000.000000	100
mean	546238.648000	203.954000	38.948000	1136.000000	1256.406150	1.101000e+06	501214.488000	2512
std	257063.005276	115.113174	9.140287	611.864673	244.167395	2.297407e+06	71701.610941	2787
min	100804.000000	0.000000	19.000000	500.000000	433.330000	-1.000000e+06	430104.000000	
25%	335980.250000	115.750000	32.000000	500.000000	1089.607500	0.000000e+00	448404.500000	
50%	533135.000000	199.500000	38.000000	1000.000000	1257.200000	0.000000e+00	466445.500000	
75%	759099.750000	276.250000	44.000000	2000.000000	1415.695000	0.000000e+00	603251.000000	5102
max	999435.000000	479.000000	64.000000	2000.000000	2047.590000	1.000000e+07	620962.000000	1005C

In [7]:
```python
# checking the nan values
data.isnull().sum()
```

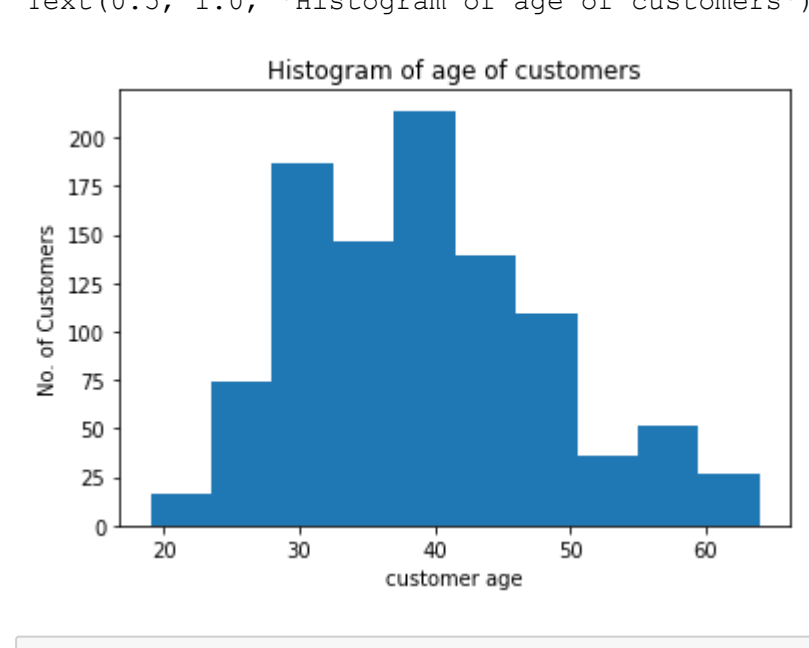
Out[7]:
```
policy_number                  0
months_as_customer             0
age                            0
policy_bind_date               0
policy_state                   0
policy_csl                     0
policy_deductable              0
policy_annual_premium          0
umbrella_limit                 0
insured_zip                    0
insured_sex                    0
insured_education_level        0
insured_occupation             0
insured_hobbies                0
insured_relationship           0
capital_gains                  0
capital_loss                   0
incident_date                  0
incident_type                  0
collision_type                 0
incident_severity              0
authorities_contacted          0
incident_state                 0
incident_city                  0
incident_location              0
incident_hour_of_the_day       0
number_of_vehicles_involved    0
property_damage                0
bodily_injuries                0
witnesses                      0
police_report_available        0
total_claim_amount             0
injury_claim                   0
property_claim                 0
vehicle_claim                  0
auto_make                      0
auto_model                     0
auto_year                      0
fraud_reported                 0
dtype: int64
```

In [8]:
```python
data['fraud_reported']

fraud_output = []
response = data.iloc[:,-1]

# converting output to binary
for i in  range(len(response)):
    fraud_output.append(1 if response[i] == 'Y' else 0 )

data['fraud_reported'] = pd.Series(fraud_output)
print(data)
```

```
     policy_number  months_as_customer  age policy_bind_date policy_state  \
0           521585                 328   48       10/17/2014           OH
1           342868                 228   42        6/27/2006           IN
2           687698                 134   29       09-06-2000           OH
3           227811                 256   41        5/25/1990           IL
4           367455                 228   44       06-06-2014           IL
..             ...                 ...  ...              ...          ...
995         941851                   3   38        7/16/1991           OH
996         186934                 285   41       01-05-2014           IL
997         918516                 130   34        2/17/2003           OH
998         533940                 458   62       11/18/2011           IL
999         556080                 456   60       11-11-1996           OH

    policy_csl  policy_deductable  policy_annual_premium  umbrella_limit  \
0      250/500               1000                1406.91               0
1      250/500               2000                1197.22         5000000
2      100/300               2000                1413.14         5000000
3      250/500               2000                1415.74         6000000
4     500/1000               1000                1583.91         6000000
..         ...                ...                    ...             ...
995   500/1000               1000                1310.80               0
996    100/300               1000                1436.79               0
997    250/500                500                1383.49         3000000
998   500/1000               2000                1356.92         5000000
999    250/500               1000                 766.19               0

     insured_zip  ... witnesses police_report_available total_claim_amount  \
0         466132  ...         2                     YES              71610
1         468176  ...         0                       ?               5070
2         430632  ...         3                      NO              34650
3         608117  ...         2                      NO              63400
4         610706  ...         1                      NO               6500
..           ...  ...       ...                     ...                ...
995       431289  ...         1                       ?              87200
996       608177  ...         3                       ?             108480
997       442797  ...         3                     YES              67500
998       441714  ...         1                     YES              46980
999       612260  ...         3                       ?               5060

    injury_claim property_claim  vehicle_claim   auto_make auto_model  \
0           6510          13020          52080        Saab        92x
1            780            780           3510    Mercedes       E400
2           7700           3850          23100       Dodge        RAM
3           6340           6340          50720   Chevrolet      Tahoe
4           1300            650           4550      Accura        RSX
..           ...            ...            ...         ...        ...
995        17440           8720          61040       Honda     Accord
996        18080          18080          72320  Volkswagen     Passat
997         7500           7500          52500      Suburu    Impreza
998         5220           5220          36540        Audi         A5
999          460            920           3680    Mercedes       E400

    auto_year fraud_reported
0        2004              1
1        2007              1
2        2007              0
3        2014              1
4        2009              0
..        ...            ...
995      2006              0
996      2015              0
997      1996              0
998      1998              0
999      2007              0

[1000 rows x 39 columns]
```

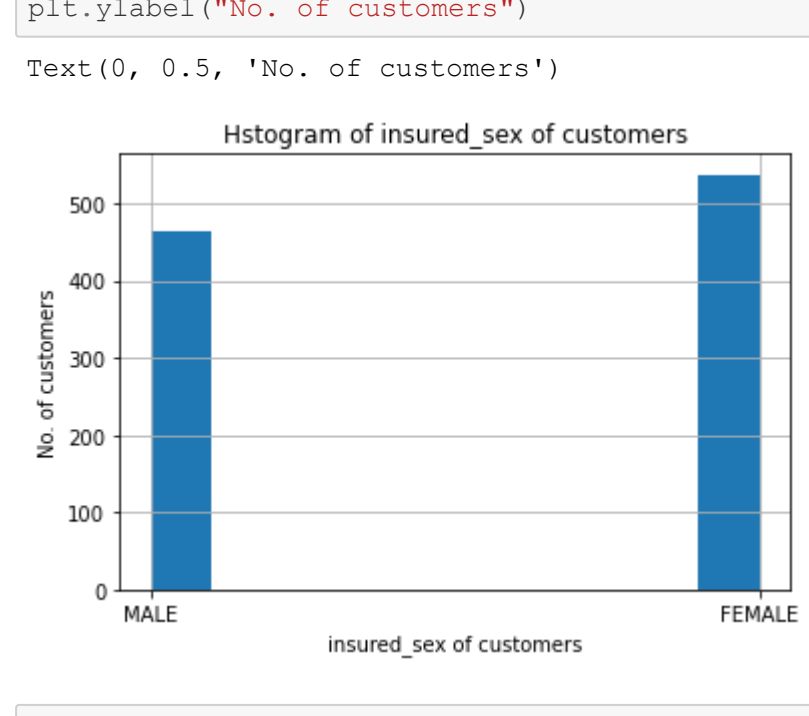
In [9]:
```python
# data analysis
plt.hist(data['age'])
plt.ylabel('No. of Customers')
plt.xlabel('customer age')
plt.title("Histogram of age of customers")
```

Out[9]: `Text(0.5, 1.0, 'Histogram of age of customers')`



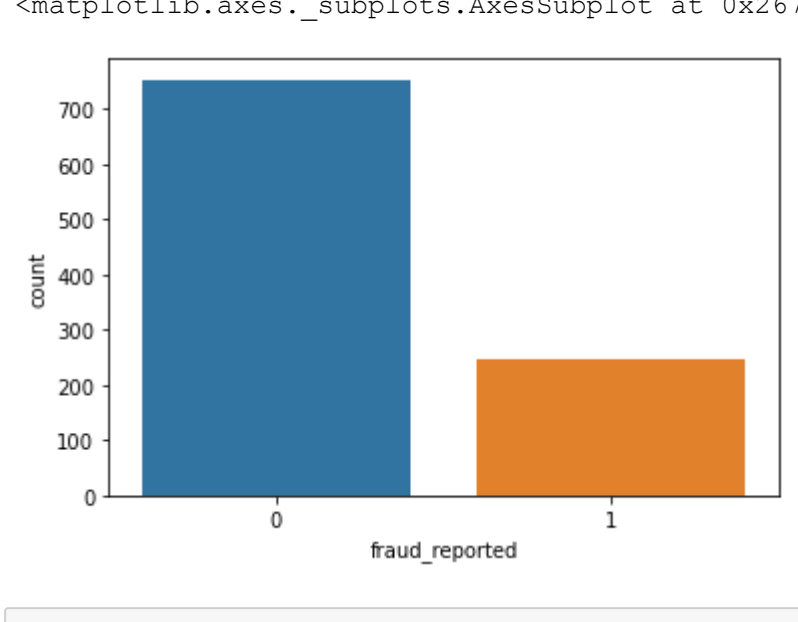
In [10]:
```python
data["insured_sex"].hist()
plt.title("Hstogram of insured_sex of customers")
plt.xlabel("insured_sex of customers")
plt.ylabel("No. of customers")
```

Out[10]: `Text(0, 0.5, 'No. of customers')`



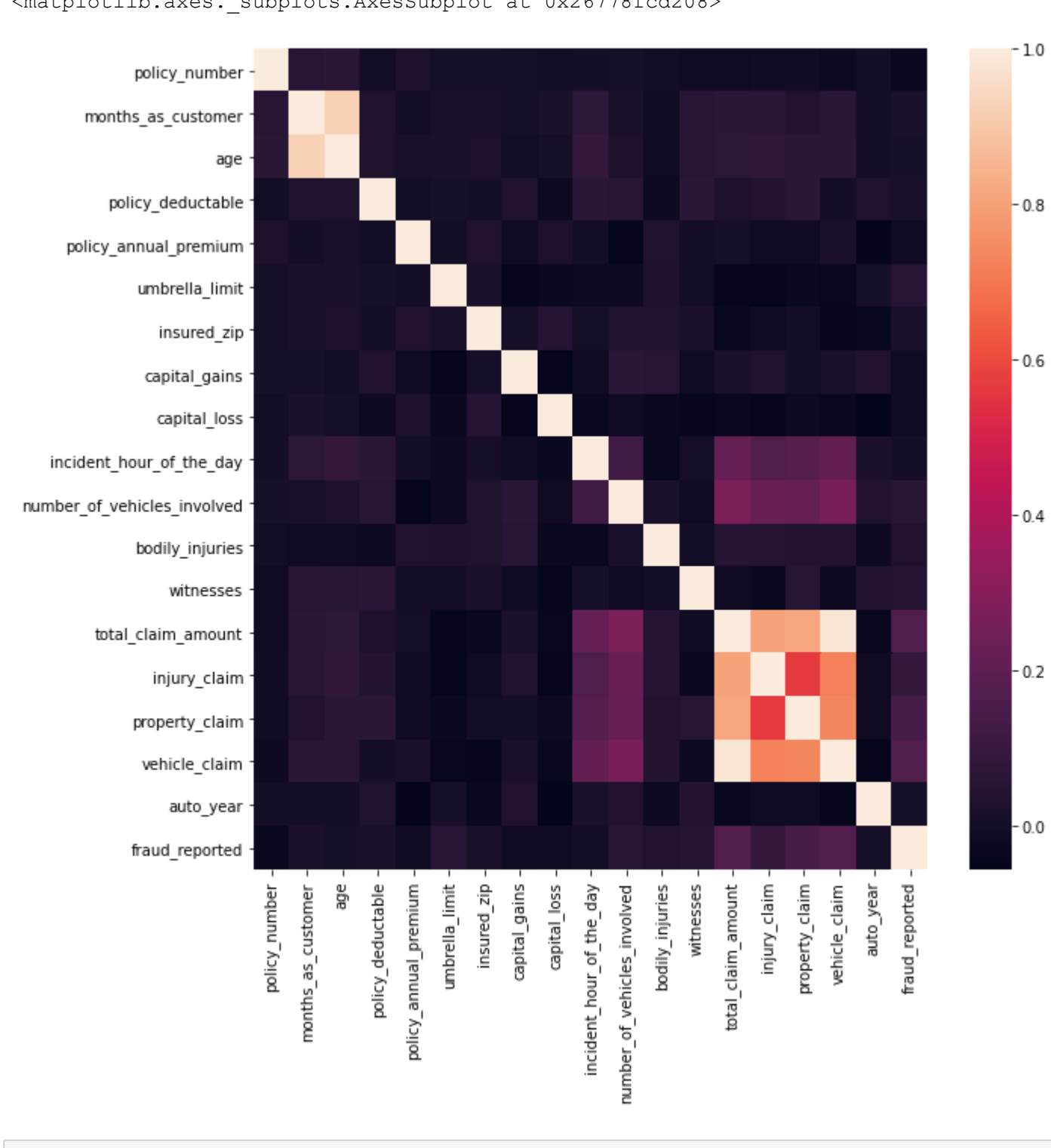
In [11]:
```python
# checking the output if its balanced!!
sns.countplot(data.iloc[:,-1]) #imbalanced
```

Out[11]: `<matplotlib.axes._subplots.AxesSubplot at 0x267790948c8>`



In [12]:
```python
#feature selection#
rcParams['figure.figsize'] = [10,10]
sns.heatmap(data.corr())
```

Out[12]: `<matplotlib.axes._subplots.AxesSubplot at 0x26778fcd208>`



In [13]:
```python
data.info()
#policy number in x is irrelevant for prediction
x = data.iloc[:,1:38]
x_columns = x.columns
y = data.iloc[:,-1]
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 39 columns):
 #   Column                       Non-Null Count  Dtype
---  ------                       --------------  -----
 0   policy_number                1000 non-null   int64
 1   months_as_customer           1000 non-null   int64
 2   age                          1000 non-null   int64
 3   policy_bind_date             1000 non-null   object
 4   policy_state                 1000 non-null   object
 5   policy_csl                   1000 non-null   object
 6   policy_deductable            1000 non-null   int64
 7   policy_annual_premium        1000 non-null   float64
 8   umbrella_limit               1000 non-null   int64
 9   insured_zip                  1000 non-null   int64
 10  insured_sex                  1000 non-null   object
 11  insured_education_level      1000 non-null   object
 12  insured_occupation           1000 non-null   object
 13  insured_hobbies              1000 non-null   object
 14  insured_relationship         1000 non-null   object
 15  capital_gains                1000 non-null   int64
 16  capital_loss                 1000 non-null   int64
 17  incident_date                1000 non-null   object
 18  incident_type                1000 non-null   object
 19  collision_type               1000 non-null   object
 20  incident_severity            1000 non-null   object
 21  authorities_contacted        1000 non-null   object
 22  incident_state               1000 non-null   object
 23  incident_city                1000 non-null   object
 24  incident_location            1000 non-null   object
 25  incident_hour_of_the_day     1000 non-null   int64
 26  number_of_vehicles_involved  1000 non-null   int64
 27  property_damage              1000 non-null   object
 28  bodily_injuries              1000 non-null   int64
 29  witnesses                    1000 non-null   int64
 30  police_report_available      1000 non-null   object
 31  total_claim_amount           1000 non-null   int64
 32  injury_claim                 1000 non-null   int64
 33  property_claim               1000 non-null   int64
 34  vehicle_claim                1000 non-null   int64
 35  auto_make                    1000 non-null   object
 36  auto_model                   1000 non-null   object
 37  auto_year                    1000 non-null   int64
 38  fraud_reported               1000 non-null   int64
dtypes: float64(1), int64(18), object(20)
memory usage: 304.8+ KB
```

In [14]:
```python
#feature selection
#ordinal encoder
#encode categorical features as an integer array.
from sklearn.preprocessing import OrdinalEncoder
oe = OrdinalEncoder()
oe.fit(x)
x_enc = oe.transform(x)
x_enc = pd.DataFrame(x_enc , columns= x_columns )
columns = pd.DataFrame(x_enc.columns)

#Label encoder
#Encode target labels with value between 0 and n_classes-1
#This transformer should be used to encode target values, i.e. y, and not the input X.
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
le.fit(y)
y_enc = pd.DataFrame((le.transform(y)), columns =['fraud_reported'])


#extracting the features
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import chi2

best_features = SelectKBest(score_func=chi2, k = 'all')
fit = best_features.fit(x_enc,y_enc)

#scores of the features
scores = pd.DataFrame(fit.scores_)

feature_scores = pd.concat([columns,scores], axis = 1)
feature_scores.columns = ['features','scores']
feature_scores.nlargest(37,'scores')
```

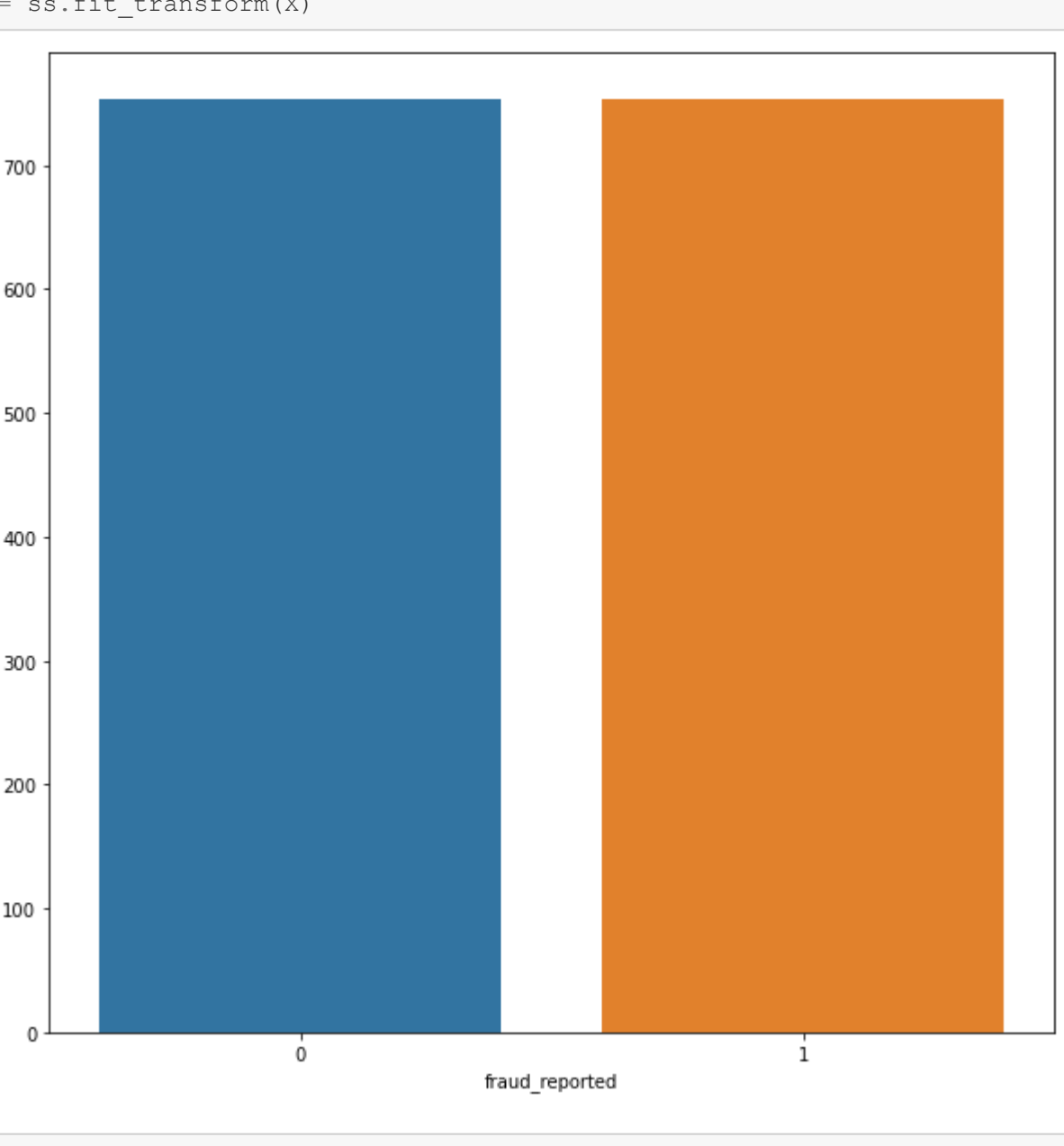
Out[14]:

	features	scores
33	vehicle_claim	2644.587085
30	total_claim_amount	2549.783115
32	property_claim	2085.626042
31	injury_claim	933.096711
8	insured_zip	633.756096
19	incident_severity	122.804296
2	policy_bind_date	85.918188
14	capital_gains	62.553620
16	incident_date	38.748357
6	policy_annual_premium	38.355350
0	months_as_customer	15.808667
23	incident_location	13.012569
18	collision_type	8.229651
12	insured_hobbies	7.250932
7	umbrella_limit	6.438597
21	incident_state	3.785108
25	number_of_vehicles_involved	3.321679
15	capital_loss	2.967067
17	incident_type	2.530024
22	incident_city	2.297660
20	authorities_contacted	2.270237
28	witnesses	2.032810
34	auto_make	1.881541
4	policy_csl	0.940383
27	bodily_injuries	0.777356
26	property_damage	0.650297
1	age	0.616969
3	policy_state	0.589272
29	police_report_available	0.535814
13	insured_relationship	0.517412
9	insured_sex	0.511838
36	auto_year	0.224937
10	insured_education_level	0.099212
24	incident_hour_of_the_day	0.077221
5	policy_deductable	0.038979
11	insured_occupation	0.005931
35	auto_model	0.003320

In [15]:
```python
#dropping the columns with least scores
columns_to_drop = ['collision_type',
                   'insured_hobbies',
                   'umbrella_limit',
                   'incident_state',
                   'number_of_vehicles_involved',
                   'capital_loss',
                   'incident_type',
                   'incident_city',
                   'authorities_contacted',
                   'witnesses',
                   'auto_make',
                   'policy_csl',
                   'bodily_injuries',
                   'property_damage',
                   'age',
                   'policy_state',
                   'police_report_available',
                   'insured_relationship',
                   'insured_sex',
                   'auto_year',
                   'insured_education_level',
                   'incident_hour_of_the_day',
                   'policy_deductable',
                   'insured_occupation',
                   'auto_model']

imp_data = data.drop(columns_to_drop, axis =1)

imp_data.info()

X = imp_data.iloc[:,1:13]
Y = imp_data.iloc[:,-1]
```

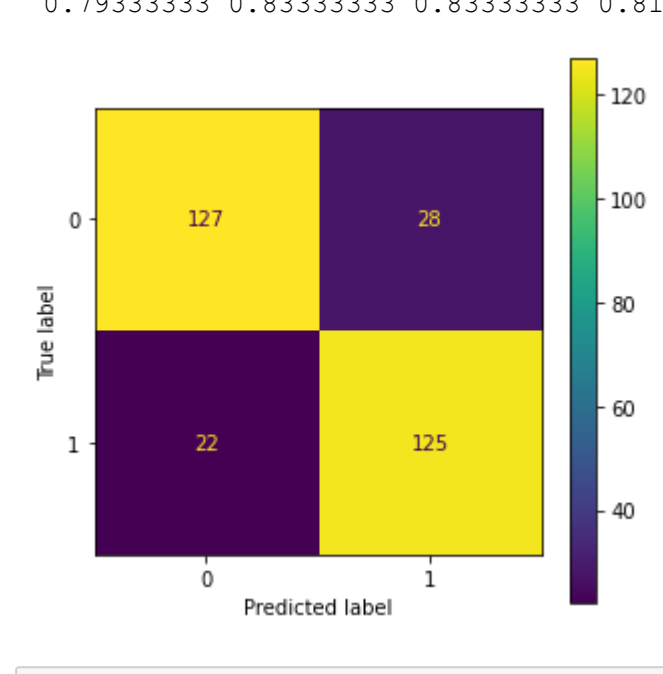
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1000 entries, 0 to 999
Data columns (total 14 columns):
 #   Column                 Non-Null Count  Dtype
---  ------                 --------------  -----
 0   policy_number          1000 non-null   int64
 1   months_as_customer     1000 non-null   int64
 2   policy_bind_date       1000 non-null   object
 3   policy_annual_premium  1000 non-null   float64
 4   insured_zip            1000 non-null   int64
 5   capital_gains          1000 non-null   int64
 6   incident_date          1000 non-null   object
 7   incident_severity      1000 non-null   object
 8   incident_location      1000 non-null   object
 9   total_claim_amount     1000 non-null   int64
 10  injury_claim           1000 non-null   int64
 11  property_claim         1000 non-null   int64
 12  vehicle_claim          1000 non-null   int64
 13  fraud_reported         1000 non-null   int64
dtypes: float64(1), int64(9), object(4)
memory usage: 109.5+ KB
```

In [16]:
```python
#dummy coding
X = pd.get_dummies(X, drop_first=True)

#we are using an minority class over sampling technique
#and converting it into a balanced dataset

#from imblearn.over_sampling import SMOTE
#sm = SMOTE(randon_state = 24)
#X , Y = sm.fit_resample(X, Y)

from imblearn.over_sampling import RandomOverSampler
ROS = RandomOverSampler()
X, Y = ROS.fit_sample(X,Y)


#plotting the independent variable
sns.countplot(Y)

#scaling the data
from sklearn.preprocessing import StandardScaler
ss = StandardScaler()
X = ss.fit_transform(X)
```



In [17]:
```python
#splitting the training and testing data
x_train, x_test, y_train, y_test = train_test_split(X, Y, test_size=(0.2))

rcParams['figure.figsize'] = [5,5]

#xgboost

from xgboost import  XGBClassifier
XGB = XGBClassifier()
XGB.fit(x_train,y_train)
XGB_Predictions = XGB.predict(x_test)
print(accuracy_score(y_test, XGB_Predictions))
print(classification_report(y_test, XGB_Predictions))
plot_confusion_matrix(XGB , x_test , y_test)
```

```
0.8344370860927153
              precision    recall  f1-score   support

           0       0.85      0.82      0.84       155
           1       0.82      0.85      0.83       147

    accuracy                           0.83       302
   macro avg       0.83      0.83      0.83       302
weighted avg       0.84      0.83      0.83       302

[0.78145695 0.78807947 0.82119205 0.78807947 0.8013245  0.81456954
 0.79333333 0.83333333 0.83333333 0.81333333]
```



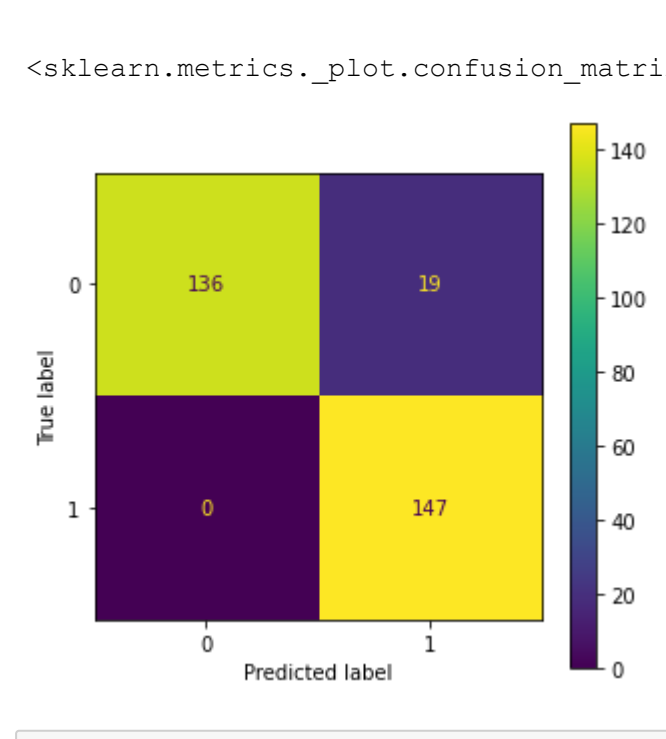
In [18]:
```python
#cross validation accuracy scores for xgb
from sklearn.model_selection import cross_val_score
print(cross_val_score(XGB,X,Y,cv=10,scoring='accuracy'))
```

```
[0.78145695 0.78807947 0.82119205 0.78807947 0.8013245  0.81456954
 0.79333333 0.83333333 0.83333333 0.81333333]
```

In [19]:
```python
#random forest classifier
from sklearn.ensemble import RandomForestClassifier
RF = RandomForestClassifier()
RF.fit(x_train,y_train)
RF_Predictions = RF.predict(x_test)
print(accuracy_score(y_test, RF_Predictions))
print(classification_report(y_test, RF_Predictions))
plot_confusion_matrix(RF , x_test , y_test)
```

```
0.9370860927152318
              precision    recall  f1-score   support

           0       1.00      0.88      0.93       155
           1       0.89      1.00      0.94       147

    accuracy                           0.94       302
   macro avg       0.94      0.94      0.94       302
weighted avg       0.94      0.94      0.94       302
```

Out[19]: `<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x2677c9b03c8>`



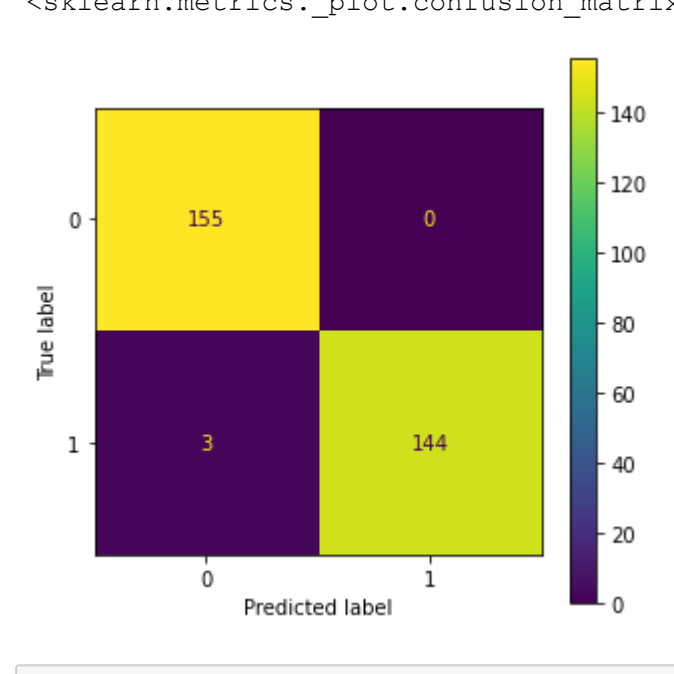
In [20]:
```python
#cross validation accuracy scores rf
print(cross_val_score(RF,X,Y,cv=10,scoring='accuracy'))
```

```
[0.90066225 0.91390728 0.8807947  0.94039735 0.95364238 0.93377483
 0.92666667 0.97333333 0.96666667 0.95333333]
```

In [21]:
```python
#support vector machine classifier # best model
from sklearn import svm
SVC = svm.SVC()
SVC.fit(x_train,y_train)
SVC_Predictions = SVC.predict(x_test)
print(accuracy_score(y_test,SVC_Predictions))
print(classification_report(y_test, SVC_Predictions))
plot_confusion_matrix(SVC , x_test , y_test)
```

```
0.9900662251655629
              precision    recall  f1-score   support

           0       0.98      1.00      0.99       155
           1       1.00      0.98      0.99       147

    accuracy                           0.99       302
   macro avg       0.99      0.99      0.99       302
weighted avg       0.99      0.99      0.99       302
```

Out[21]: `<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x2677c96da08>`

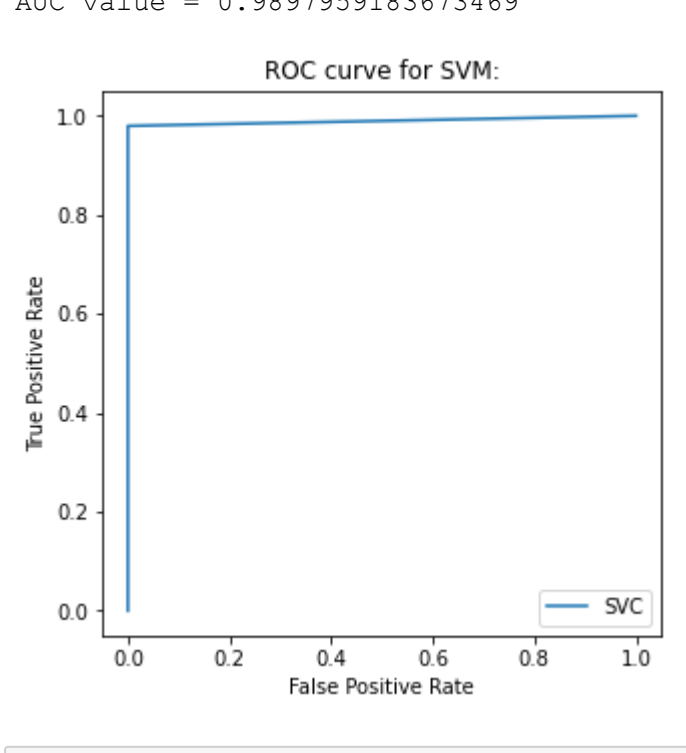


In [22]:
```python
#cross validation accuracy scores svm
print(cross_val_score(SVC,X,Y,cv=10,scoring='accuracy'))
```

```
[0.94039735 0.92715232 0.9205298  0.96688742 0.99337748 1.
 1.         1.         1.         1.        ]
```

In [23]:
```python
#Receiving Operator Charecteristic for SVM
plt.title("ROC curve for SVM:")
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")

model_pred = {}

tpr , fpr , threshold = roc_curve(y_test, SVC_Predictions, pos_label = 1)
model_pred["SVC"] = [tpr, fpr]
print("AUC value = " +str(auc(tpr,fpr)))


for key, value in model_pred.items():
    model_list = model_pred[key]
    plt.plot(model_list[0], model_list[1], label=key)
    plt.legend()
plt.show()
```

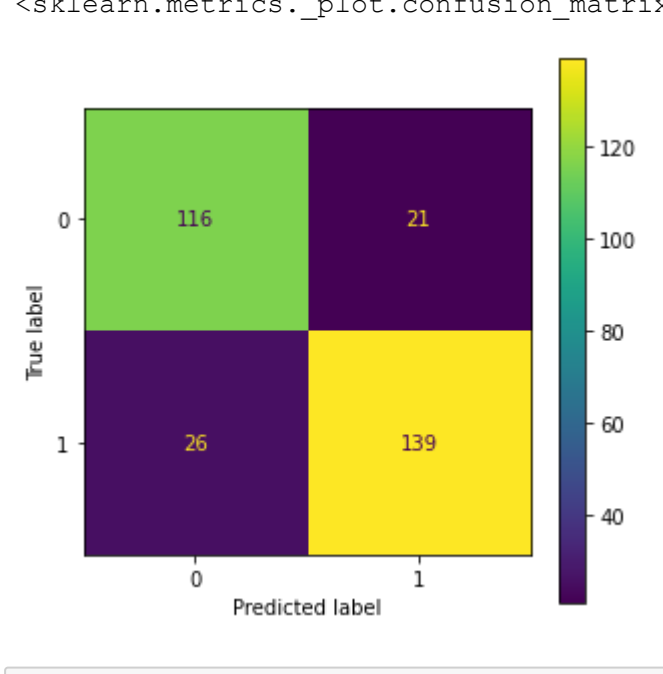
```
AUC value = 0.9897959183673469
```



In [25]:
```python
#LDA gives you best result out of all incase you filter out minimal irrelevant features.
#since its a dimensionality reduction algorithm.
#lets try

data
x_lda = data.iloc[:,1:38]
y_lda = data.iloc[:,-1]


columns_to_drop_lda = ["auto_model",
                       "policy_bind_date",
                       "policy_state",
                       "incident_date",
                       "incident_state",
                       "incident_city",
                       "incident_location",
                       "policy_csl"]

x_lda = x_lda.drop(columns_to_drop_lda, axis=1)

x_lda = pd.get_dummies(x_lda, drop_first=True)
x_lda, y_lda = ROS.fit_sample(x_lda,y_lda)
x_lda = ss.fit_transform(x_lda)

#splitting the training and testing data
x_lda_train, x_lda_test, y_lda_train, y_lda_test = train_test_split(x_lda, y_lda, test_size=(0.2))


from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
LDA = LinearDiscriminantAnalysis()
LDA.fit(x_lda_train,y_lda_train)
LDA_Predictions = LDA.predict(x_lda_test)
print(accuracy_score(y_lda_test, LDA_Predictions))
print(classification_report(y_lda_test, LDA_Predictions))
plot_confusion_matrix(LDA , x_lda_test , y_lda_test)
```

```
0.8443708609271523
              precision    recall  f1-score   support

           0       0.82      0.85      0.83       137
           1       0.87      0.84      0.86       165

    accuracy                           0.84       302
   macro avg       0.84      0.84      0.84       302
weighted avg       0.85      0.84      0.84       302
```

Out[25]: `<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at 0x2677cb41d08>`



In [ ]:

In [ ]: