In [1]:
```
import os
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
sns.set()

import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
car_data=pd.read_csv("C:\\Users\\stuti\\Downloads\\Stats & ML\\Car_Insurance_Claim.csv")
```

In [3]:
```
car_data.head()
```

Out[3]:

	ID	AGE	GENDER	RACE	DRIVING_EXPERIENCE	EDUCATION	INCOME	CREDIT_SCORE	VEHICLE_OWNERSHIP	VEHICLE_YEAR
0	569520	65+	female	majority	0-9y	high school	upper class	0.629027	1.0	after 2015
1	750365	16-25	male	majority	0-9y	none	poverty	0.357757	0.0	before 2015
2	199901	16-25	female	majority	0-9y	high school	working class	0.493146	1.0	before 2015
3	478866	16-25	male	majority	0-9y	university	working class	0.206013	1.0	before 2015
4	731664	26-39	male	majority	10-19y	none	working class	0.388366	1.0	before 2015

Preprocessing of dataset

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

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 19 columns):
 #   Column               Non-Null Count  Dtype
---  ------               --------------  -----
 0   ID                   10000 non-null  int64
 1   AGE                  10000 non-null  object
 2   GENDER               10000 non-null  object
 3   RACE                 10000 non-null  object
 4   DRIVING_EXPERIENCE   10000 non-null  object
 5   EDUCATION            10000 non-null  object
 6   INCOME               10000 non-null  object
 7   CREDIT_SCORE         9018 non-null   float64
 8   VEHICLE_OWNERSHIP    10000 non-null  float64
 9   VEHICLE_YEAR         10000 non-null  object
 10  MARRIED              10000 non-null  float64
 11  CHILDREN             10000 non-null  float64
 12  POSTAL_CODE          10000 non-null  int64
 13  ANNUAL_MILEAGE       9043 non-null   float64
 14  VEHICLE_TYPE         10000 non-null  object
 15  SPEEDING_VIOLATIONS  10000 non-null  int64
 16  DUIS                 10000 non-null  int64
 17  PAST_ACCIDENTS       10000 non-null  int64
 18  OUTCOME              10000 non-null  float64
dtypes: float64(6), int64(5), object(8)
memory usage: 1.4+ MB
```

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

Out[5]:

	ID	CREDIT_SCORE	VEHICLE_OWNERSHIP	MARRIED	CHILDREN	POSTAL_CODE	ANNUAL_MILEAGE	SPEEDING_V
count	10000.000000	9018.000000	10000.000000	10000.000000	10000.000000	10000.000000	9043.000000	1(
mean	500521.906800	0.515813	0.697000	0.498200	0.688800	19864.548400	11697.003207	
std	290030.768758	0.137688	0.459578	0.500022	0.463008	18915.613855	2818.434528	
min	101.000000	0.053358	0.000000	0.000000	0.000000	10238.000000	2000.000000	
25%	249638.500000	0.417191	0.000000	0.000000	0.000000	10238.000000	10000.000000	
50%	501777.000000	0.525033	1.000000	0.000000	1.000000	10238.000000	12000.000000	
75%	753974.500000	0.618312	1.000000	1.000000	1.000000	32765.000000	14000.000000	
max	999976.000000	0.960819	1.000000	1.000000	1.000000	92101.000000	22000.000000	

Finding and handling missing value

In [6]:
```
car_data.isnull().sum()
```

Out[6]:
```
ID                      0
AGE                     0
GENDER                  0
RACE                    0
DRIVING_EXPERIENCE      0
EDUCATION               0
INCOME                  0
CREDIT_SCORE          982
VEHICLE_OWNERSHIP       0
VEHICLE_YEAR            0
MARRIED                 0
CHILDREN                0
POSTAL_CODE             0
ANNUAL_MILEAGE        957
VEHICLE_TYPE            0
SPEEDING_VIOLATIONS     0
DUIS                    0
PAST_ACCIDENTS          0
OUTCOME                 0
dtype: int64
```

In [7]:
```
car_data.isnull().sum()/len(car_data)*100
```

Out[7]:
```
ID                     0.00
AGE                    0.00
GENDER                 0.00
RACE                   0.00
DRIVING_EXPERIENCE     0.00
EDUCATION              0.00
INCOME                 0.00
CREDIT_SCORE           9.82
VEHICLE_OWNERSHIP      0.00
VEHICLE_YEAR           0.00
MARRIED                0.00
CHILDREN               0.00
POSTAL_CODE            0.00
ANNUAL_MILEAGE         9.57
VEHICLE_TYPE           0.00
SPEEDING_VIOLATIONS    0.00
DUIS                   0.00
PAST_ACCIDENTS         0.00
OUTCOME                0.00
dtype: float64
```

In [8]:
```
sns.boxplot(y='CREDIT_SCORE', data=car_data)
```

Out[8]:
```
<Axes: ylabel='CREDIT_SCORE'>
```

In [9]:
```
car_data['CREDIT_SCORE']=car_data['CREDIT_SCORE'].fillna(car_data['CREDIT_SCORE'].median())
```

In [10]:
```
sns.boxplot(y='ANNUAL_MILEAGE', data=car_data)
```

Out[10]:
```
<Axes: ylabel='ANNUAL_MILEAGE'>
```

In [11]:
```
car_data['ANNUAL_MILEAGE']=car_data['ANNUAL_MILEAGE'].fillna(car_data['ANNUAL_MILEAGE'].median())
```

In [12]:
```
car_data.isnull().sum()
```

Out[12]:
```
ID                     0
AGE                    0
GENDER                 0
RACE                   0
DRIVING_EXPERIENCE     0
EDUCATION              0
INCOME                 0
CREDIT_SCORE           0
VEHICLE_OWNERSHIP      0
VEHICLE_YEAR           0
MARRIED                0
CHILDREN               0
POSTAL_CODE            0
ANNUAL_MILEAGE         0
VEHICLE_TYPE           0
SPEEDING_VIOLATIONS    0
DUIS                   0
PAST_ACCIDENTS         0
OUTCOME                0
dtype: int64
```

Finding outliers in numerical variable

In [13]:
```
def boxplots(col):
    plt.figure(figsize=(5,5))
    sns.boxplot(car_data[col],color='red')
    plt.show

for i in list(car_data.select_dtypes(exclude=['object']).columns)[0:]:
    boxplots(i)
```

1e6
1.0
0.8
0.6
0.4
0.2
0.0
0

1.0
0.8
0.6
0.4
0.2
0

1.0
0.8
0.6
0.4
0.2
0.0
0

1.0
0.8
0.6
0.4
0.2
0.0
0

1.0
0.8
0.6
0.4
0.2
0.0
0

80000
60000
40000
20000
0

22500
20000
17500
15000
12500
10000
7500
5000
2500
0

20
15
10
5
0
0

6
5
4
3
2
1
0
0

In [64]:
```
## no significant outliers found
```

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

Out[14]:

	ID	AGE	GENDER	RACE	DRIVING_EXPERIENCE	EDUCATION	INCOME	CREDIT_SCORE	VEHICLE_OWNERSHIP	VEHICLE_YEAR
0	569520	65+	female	majority	0-9y	high school	upper class	0.629027	1.0	after 2015
1	750365	16-25	male	majority	0-9y	none	poverty	0.357757	0.0	before 2015
2	199901	16-25	female	majority	0-9y	high school	working class	0.493146	1.0	before 2015
3	478866	16-25	male	majority	0-9y	university	working class	0.206013	1.0	before 2015
4	731664	26-39	male	majority	10-19y	none	working class	0.388366	1.0	before 2015

In [15]:
```
print(car_data['GENDER'].value_counts())
print()
print(car_data['RACE'].value_counts())
print()
print(car_data['DRIVING_EXPERIENCE'].value_counts())
print()
print(car_data['EDUCATION'].value_counts())
print()
print(car_data['INCOME'].value_counts())
print()
print(car_data['VEHICLE_OWNERSHIP'].value_counts())
print()
```

```
print(car_data['MARRIED'].value_counts())
print()
print(car_data['CHILDREN'].value_counts())
print()
print(car_data['VEHICLE_TYPE'].value_counts())
print()
print(car_data['VEHICLE_YEAR'].value_counts())
print()
print(car_data['OUTCOME'].value_counts())
print()
```

```
female    5010
male      4990
Name: GENDER, dtype: int64

majority    9012
minority     988
Name: RACE, dtype: int64

0-9y      3530
10-19y    3299
20-29y    2119
30y+      1052
Name: DRIVING_EXPERIENCE, dtype: int64

high school    4157
university     3928
none           1915
Name: EDUCATION, dtype: int64

upper class      4336
middle class     2138
poverty          1814
working class    1712
Name: INCOME, dtype: int64

1.0    6970
0.0    3030
Name: VEHICLE_OWNERSHIP, dtype: int64

0.0    5018
1.0    4982
Name: MARRIED, dtype: int64

1.0    6888
0.0    3112
Name: CHILDREN, dtype: int64

sedan         9523
sports car     477
Name: VEHICLE_TYPE, dtype: int64

before 2015    6967
after 2015     3033
Name: VEHICLE_YEAR, dtype: int64

0.0    6867
1.0    3133
Name: OUTCOME, dtype: int64
```

In [16]:

```
for i in car_data.columns:
    print("************************************************************", i,
          "************************************************************")
    print()
    print(set(car_data[i].tolist()))
    print()
```

```
************************************************************ ID ************************************************
*********

{32768, 753664, 163840, 425991, 917512, 851978, 294928, 983059, 622612, 786452, 229398, 327702, 950296, 524309,
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********** AGE **********
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{'16-25', '40-64', '65+', '26-39'}

********** GENDER **********
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{'female', 'male'}

********** RACE **********
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{'minority', 'majority'}

********** DRIVING_EXPERIENCE **********
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{'10-19y', '0-9y', '30y+', '20-29y'}

********** EDUCATION **********

{'university', 'none', 'high school'}

********** INCOME **********

{'poverty', 'middle class', 'upper class', 'working class'}

********** CREDIT_SCORE **********

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435451, 0.6603156212983624, 0.5975154414339057, 0.2932795320869824, 0.3412799504711933}

************************************************************ VEHICLE_OWNERSHIP ********************************
************************

{0.0, 1.0}

************************************************************ VEHICLE_YEAR *************************************
********************

{'before 2015', 'after 2015'}

************************************************************ MARRIED ******************************************
**************

{0.0, 1.0}

************************************************************ CHILDREN *****************************************
***************

{0.0, 1.0}

************************************************************ POSTAL_CODE **************************************
******************

{92101, 21217, 32765, 10238}

************************************************************ ANNUAL_MILEAGE ***********************************
**********************

{16000.0, 5000.0, 21000.0, 10000.0, 15000.0, 4000.0, 20000.0, 9000.0, 14000.0, 19000.0, 3000.0, 8000.0, 13000.0
, 18000.0, 2000.0, 7000.0, 12000.0, 17000.0, 6000.0, 22000.0, 11000.0}

************************************************************ VEHICLE_TYPE *************************************
********************

{'sedan', 'sports car'}

************************************************************ SPEEDING_VIOLATIONS ******************************
***************************

{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 22}

************************************************************ DUIS *********************************************
***********

{0, 1, 2, 3, 4, 5, 6}

************************************************************ PAST_ACCIDENTS ***********************************
**********************

{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15}

************************************************************ OUTCOME ******************************************
**************

{0.0, 1.0}
```

In [17]:
```
car_data['NEW_AGE'] = np.where(car_data['AGE'] == '26-39', 30,
```

```
                                np.where(car_data['AGE'] == '40-64', 50,
                                         np.where(car_data['AGE'] == '16-25', 20,
                                                  np.where(car_data['AGE'] == '65+', 65,
                                                           car_data['AGE']))))
```

In [22]:
```
car_data['DRIVING_EXPERIENCE']=car_data['DRIVING_EXPERIENCE'].replace('30y+', 30)
```

In [23]:
```
car_data.head()
```

Out[23]:

	GENDER	RACE	DRIVING_EXPERIENCE	EDUCATION	INCOME	CREDIT_SCORE	VEHICLE_OWNERSHIP	VEHICLE_YEAR	MARRIED	CHILI
0	0	0	0-9y	high school	upper class	0.629027	1.0	0	0.0	
1	1	0	0-9y	none	poverty	0.357757	0.0	1	0.0	
2	0	0	0-9y	high school	working class	0.493146	1.0	1	0.0	
3	1	0	0-9y	university	working class	0.206013	1.0	1	0.0	
4	1	0	10-19y	none	working class	0.388366	1.0	1	0.0	

In [19]:
```
car_data= car_data.drop(['ID','AGE','POSTAL_CODE'],axis=1)
```

In [20]:
```
car_data['GENDER'] = car_data['GENDER'].astype('category')
car_data['GENDER'] = car_data['GENDER'].cat.codes

car_data['RACE'] = car_data['RACE'].astype('category')
car_data['RACE'] = car_data['RACE'].cat.codes

car_data['VEHICLE_TYPE'] = car_data['VEHICLE_TYPE'].astype('category')
car_data['VEHICLE_TYPE'] = car_data['VEHICLE_TYPE'].cat.codes

car_data['VEHICLE_YEAR'] = car_data['VEHICLE_YEAR'].astype('category')
car_data['VEHICLE_YEAR'] = car_data['VEHICLE_YEAR'].cat.codes
car_data.head()
```

Out[20]:

	GENDER	RACE	DRIVING_EXPERIENCE	EDUCATION	INCOME	CREDIT_SCORE	VEHICLE_OWNERSHIP	VEHICLE_YEAR	MARRIED	CHILI
0	0	0	0-9y	high school	upper class	0.629027	1.0	0	0.0	
1	1	0	0-9y	none	poverty	0.357757	0.0	1	0.0	
2	0	0	0-9y	high school	working class	0.493146	1.0	1	0.0	
3	1	0	0-9y	university	working class	0.206013	1.0	1	0.0	
4	1	0	10-19y	none	working class	0.388366	1.0	1	0.0	

In [24]:
```
car_data = pd.get_dummies(car_data, columns=['EDUCATION', 'INCOME','DRIVING_EXPERIENCE','NEW_AGE'])
```

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

Out[25]:

	GENDER	RACE	CREDIT_SCORE	VEHICLE_OWNERSHIP	VEHICLE_YEAR	MARRIED	CHILDREN	ANNUAL_MILEAGE	VEHICLE_TYPE	SPE
0	0	0	0.629027	1.0	0	0.0	1.0	12000.0	0	
1	1	0	0.357757	0.0	1	0.0	0.0	16000.0	0	
2	0	0	0.493146	1.0	1	0.0	0.0	11000.0	0	
3	1	0	0.206013	1.0	1	0.0	1.0	11000.0	0	
4	1	0	0.388366	1.0	1	0.0	0.0	12000.0	0	

5 rows × 28 columns

In [26]:
```
car_data.columns
```

Out[26]:
```
Index(['GENDER', 'RACE', 'CREDIT_SCORE', 'VEHICLE_OWNERSHIP', 'VEHICLE_YEAR',
       'MARRIED', 'CHILDREN', 'ANNUAL_MILEAGE', 'VEHICLE_TYPE',
       'SPEEDING_VIOLATIONS', 'DUIS', 'PAST_ACCIDENTS', 'OUTCOME',
       'EDUCATION_high school', 'EDUCATION_none', 'EDUCATION_university',
       'INCOME_middle class', 'INCOME_poverty', 'INCOME_upper class',
       'INCOME_working class', 'DRIVING_EXPERIENCE_30',
       'DRIVING_EXPERIENCE_0-9y', 'DRIVING_EXPERIENCE_10-19y',
       'DRIVING_EXPERIENCE_20-29y', 'NEW_AGE_20', 'NEW_AGE_30', 'NEW_AGE_50',
       'NEW_AGE_65'],
      dtype='object')
```

In [27]:
```
car_data=car_data.drop(['EDUCATION_high school','INCOME_middle class','DRIVING_EXPERIENCE_30','NEW_AGE_20'],axi
```

EDA

In [31]:
```
plt.figure(figsize=(20,16))
sns.heatmap(car_data.corr(), annot=True, cmap='coolwarm')
plt.show()
```

In [32]:
```
sns.pairplot(car_data)
```

Out[32]:
```
<seaborn.axisgrid.PairGrid at 0x266f3a67b50>
```

Seggregating data for balancing dependent variable and then splitting into training & testing

In [33]:
```
from imblearn.over_sampling import RandomOverSampler
```

```
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report
```

In [34]:
```
X = car_data.drop(columns=['OUTCOME'])
y = car_data['OUTCOME']
oversampler = RandomOverSampler(random_state=100)
```

In [35]:
```
X_train_unbalanced, X_test, y_train_unbalanced, y_test = train_test_split(X, y, test_size=0.25, random_state=10
oversampler = RandomOverSampler(random_state=100)

X_train_resampled, y_train_resampled = oversampler.fit_resample(X_train_unbalanced, y_train_unbalanced)
```

Building Logistic Regression with Binary Class

In [43]:
```
model = LogisticRegression(random_state=100)
model.fit(X_train_resampled, y_train_resampled)

y_train_pred = model.predict(X_train_resampled)
y_pred = model.predict(X_test)

report_train = classification_report(y_train_resampled, y_train_pred)
print("\nClassification Report - Training Set:")
print(report_train)

print("*********"*5)

report = classification_report(y_test, y_pred)
print("Classification Report:Testing Set")
print(report)
```

```
Classification Report - Training Set:
              precision    recall  f1-score   support

         0.0       0.82      0.80      0.81      5150
         1.0       0.81      0.82      0.81      5150

    accuracy                           0.81     10300
   macro avg       0.81      0.81      0.81     10300
weighted avg       0.81      0.81      0.81     10300

*********************************************
Classification Report:Testing Set
              precision    recall  f1-score   support

         0.0       0.92      0.80      0.85      1717
         1.0       0.65      0.84      0.74       783

    accuracy                           0.81      2500
   macro avg       0.78      0.82      0.79      2500
weighted avg       0.83      0.81      0.82      2500
```

Confusion metrics

In [37]:
```
from sklearn.metrics import confusion_matrix, classification_report, accuracy_score
```

In [45]:
```
confusion = confusion_matrix(y_train_resampled, y_train_pred)
print("Confusion Matrix:Training Set")
print(confusion)

print("*********"*5)

confusion = confusion_matrix(y_test, y_pred)
print("Confusion Matrix: Testing Set")
print(confusion)
```

```
Confusion Matrix:Training Set
[[4141 1009]
 [ 932 4218]]
*********************************************
Confusion Matrix: Testing Set
[[1367  350]
 [ 124  659]]
```

Checking with accuracy score

In [46]:
```
print(accuracy_score(y_train_resampled, y_train_pred))
print("Accuracy score:Training Set")
print("*********"*5)
print(accuracy_score(y_test, y_pred))
```

```
print("Accuracy score:Testing Set")
```

```
0.8115533980582524
Accuracy score:Training Set
*********************************************
0.8104
Accuracy score:Testing Set
```

In [50]:

```
from sklearn.model_selection import cross_val_score, cross_val_predict
training_accuracy = cross_val_score(model, X_train_resampled, y_train_resampled, cv=10)
test_accuracy = cross_val_score(model, X_test, y_test, cv=10)
print("Train Accuracy", training_accuracy)
print()
print("Train Mean Accuracy", training_accuracy.mean())
print()
print("Train Max Accuracy", training_accuracy.max())
print()
print("Test Accuracy", test_accuracy)
print()
print("Test Mean Accuracy", test_accuracy.mean())
print()
print("Test Max Accuracy", test_accuracy.max())
```

```
Train Accuracy [0.81165049 0.80970874 0.8223301  0.79029126 0.80097087 0.81650485
 0.79902913 0.81262136 0.80097087 0.80582524]

Train Mean Accuracy 0.8069902912621358

Train Max Accuracy 0.8223300970873786

Test Accuracy [0.764 0.8   0.796 0.784 0.808 0.844 0.832 0.78  0.824 0.848]

Test Mean Accuracy 0.808

Test Max Accuracy 0.848
```

ROC & AUC Curve

In [52]:

```
from sklearn.metrics import roc_auc_score
logistic_roc_auc = roc_auc_score(y_test, y_pred)
logistic_roc_auc
```

Out[52]:

```
0.8188954121916585
```

In [55]:

```
from sklearn.metrics import roc_curve
fpr, tpr, thresholds = roc_curve(y_test, y_pred)

plt.figure(figsize=(8,8))
plt.plot(fpr, tpr, label="ROC Curve (area=%0.2f)" %logistic_roc_auc)
plt.plot([0,1], [0,1], 'k--')
plt.xlim([0.0,1.0])
plt.ylim([0.0,1.0])
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title("Receiver Operating Characteristic with Area Under Curve")
plt.legend(loc='lower right')
plt.show()
```

Final- predicting OUTCOME on the model

In [58]:
```
final_result = model.predict(X)
```

In [59]:
```
final_result_1 = pd.concat([X, pd.DataFrame(final_result)], axis=1)
```

In [60]:
```
final_result_1
```

Out[60]:

	GENDER	RACE	CREDIT_SCORE	VEHICLE_OWNERSHIP	VEHICLE_YEAR	MARRIED	CHILDREN	ANNUAL_MILEAGE	VEHICLE_TYPE
0	0	0	0.629027	1.0	0	0.0	1.0	12000.0	0
1	1	0	0.357757	0.0	1	0.0	0.0	16000.0	0
2	0	0	0.493146	1.0	1	0.0	0.0	11000.0	0
3	1	0	0.206013	1.0	1	0.0	1.0	11000.0	0
4	1	0	0.388366	1.0	1	0.0	0.0	12000.0	0
...	...	...	...	...	...	...	...	...	...
9995	0	0	0.582787	1.0	1	0.0	0.0	16000.0	0
9996	0	0	0.522231	1.0	0	0.0	1.0	12000.0	0
9997	1	0	0.470940	1.0	1	0.0	1.0	14000.0	0
9998	0	0	0.364185	0.0	1	0.0	1.0	13000.0	0
9999	0	0	0.435225	1.0	1	1.0	1.0	13000.0	0

10000 rows × 24 columns

In [61]:
```
final_result_1 = final_result_1.rename(columns = {0 : "OUTCOME"})
```

In [65]:
```
final_result_1
```

Out[65]:

	GENDER	RACE	CREDIT_SCORE	VEHICLE_OWNERSHIP	VEHICLE_YEAR	MARRIED	CHILDREN	ANNUAL_MILEAGE	VEHICLE_TYPE
0	0	0	0.629027	1.0	0	0.0	1.0	12000.0	0
1	1	0	0.357757	0.0	1	0.0	0.0	16000.0	0
2	0	0	0.493146	1.0	1	0.0	0.0	11000.0	0
3	1	0	0.206013	1.0	1	0.0	1.0	11000.0	0
4	1	0	0.388366	1.0	1	0.0	0.0	12000.0	0
...	...	...	...	...	...	...	...	...	...
9995	0	0	0.582787	1.0	1	0.0	0.0	16000.0	0
9996	0	0	0.522231	1.0	0	0.0	1.0	12000.0	0
9997	1	0	0.470940	1.0	1	0.0	1.0	14000.0	0
9998	0	0	0.364185	0.0	1	0.0	1.0	13000.0	0
9999	0	0	0.435225	1.0	1	1.0	1.0	13000.0	0

10000 rows × 24 columns

In [66]:

```
## Successfully predicted the outcome as shown above in dataframe
```