Binary Classification of Insurance Cross Selling

😀We're studying to predict which customers respond positively to an automobile insurance offer.

Gender: Categorical variable indicating the gender of the customer.

Age: Numeric variable indicating the age of the customer.

Driving_License: Binary variable indicating if the customer has a driving license (1 if yes, 0 if no).

Region_Code: Numeric variable indicating the region code of the customer.

Previously_Insured: Binary variable indicating if the customer was previously insured (1 if yes, 0 if no).

Vehicle_Age: Categorical variable indicating the age of the vehicle.

Vehicle_Damage: Categorical variable indicating if the vehicle was damaged in the past.

Annual_Premium: Numeric variable indicating the annual premium amount.

Policy_Sales_Channel: Numeric variable indicating the sales channel of the policy.

Vintage: Numeric variable indicating the number of days the customer has been associated with the company.

Response: Binary target variable indicating if the customer responded positively to the automobile insurance offer (1 if yes, 0 if no).

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.preprocessing import StandardScaler, LabelEncoder,
OneHotEncoder
from sklearn.metrics import roc_curve, roc_auc_score

from lightgbm import LGBMRegressor
from xgboost import XGBRegressor

import warnings
warnings.filterwarnings("ignore")
pd.set_option('display.max_columns', None)

df_train=pd.read_csv("/kaggle/input/despacitoinsur/trainreduced.csv")
df_test=pd.read_csv("/kaggle/input/despacitoinsur/testreduced.csv")
sample_submission = pd.read_csv('/kaggle/input//playground-series-
s4e7/sample_submission.csv')
```

```
df_train.head()
```

```
   Gender  Age  Driving_License  Region_Code  Previously_Insured
Vehicle_Age  \
0       1   21                1           35                   0
1
1       1   43                1           28                   0
2
2       0   25                1           14                   1
0
3       0   35                1            1                   0
1
4       0   36                1           15                   1
1

   Vehicle_Damage  Annual_Premium  Policy_Sales_Channel  Vintage
Response
0               1         65101.0                   124      187
0
1               1         58911.0                    26      288
1
2               0         38043.0                   152      254
0
3               1          2630.0                   156       76
0
4               0         31951.0                   152      294
0
```

```
df_test.head()
```

```
   Gender  Age  Driving_License  Region_Code  Previously_Insured
Vehicle_Age  \
0       0   20                1           47                   0
0
1       1   47                1           28                   0
1
2       1   47                1           43                   0
1
3       0   22                1           47                   1
0
4       1   51                1           19                   0
1

   Vehicle_Damage  Annual_Premium  Policy_Sales_Channel  Vintage
0               0          2630.0                   160      228
1               1         37483.0                   124      123
2               1          2630.0                    26      271
3               0         24502.0                   152      115
4               0         34115.0                   124      148
```

```python
def NullValues(data):
    null_values = data.isnull().sum()
    duplicate_values = data.duplicated().sum()
    print(f"Null Values: \n{null_values}\n\nDuplicate Values: 
{duplicate_values}")

NullValues(df_train)
```

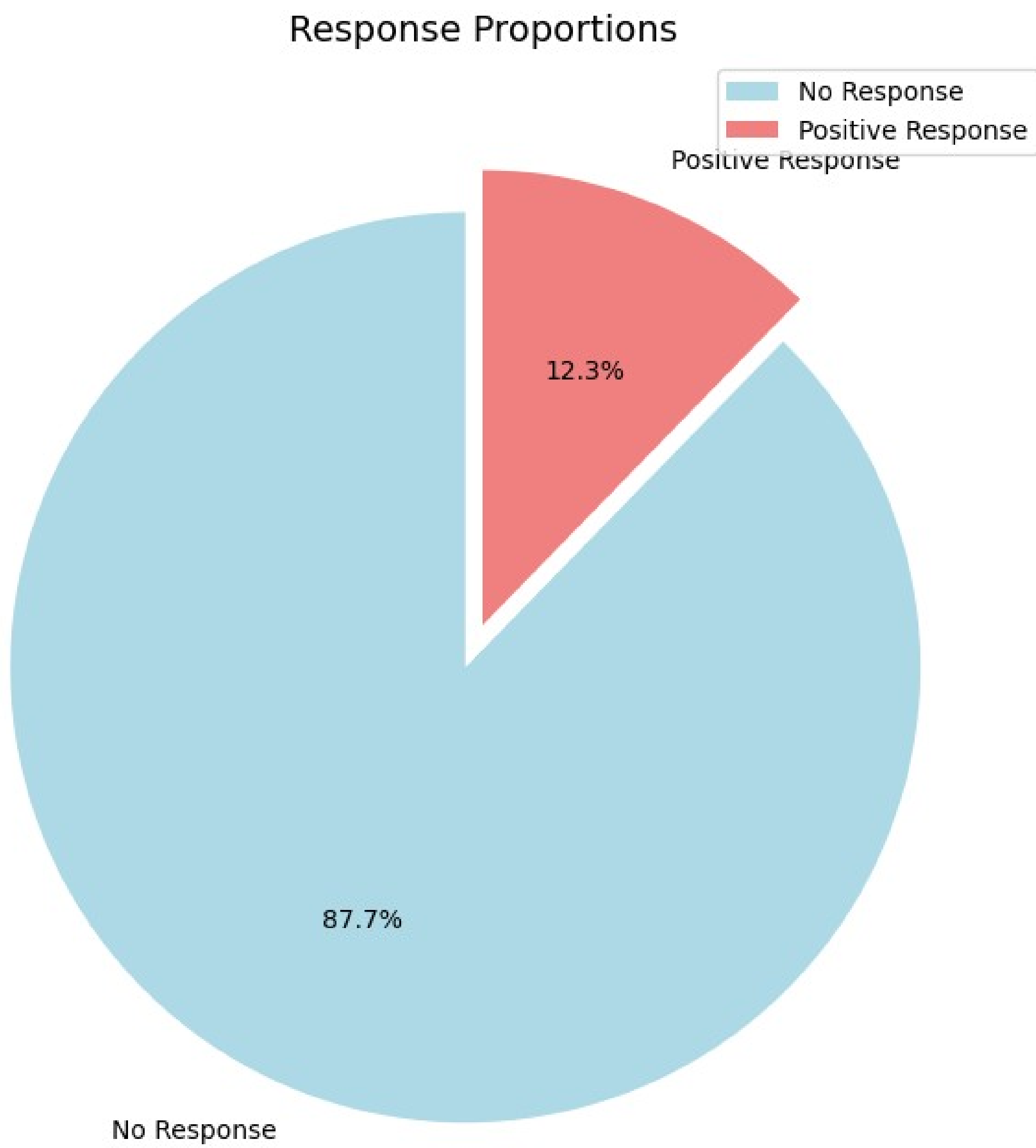
```
Null Values:
Gender                  0
Age                     0
Driving_License         0
Region_Code             0
Previously_Insured      0
Vehicle_Age             0
Vehicle_Damage          0
Annual_Premium          0
Policy_Sales_Channel    0
Vintage                 0
Response                0
dtype: int64

Duplicate Values: 0
```

```python
df_train.describe()
```

```
             Gender           Age  Driving_License   Region_Code  \
count  1.150480e+07  1.150480e+07     1.150480e+07  1.150480e+07
mean   5.413510e-01  3.838356e+01     9.980220e-01  2.641869e+01
std    4.982872e-01  1.499346e+01     4.443120e-02  1.299159e+01
min    0.000000e+00  2.000000e+01     0.000000e+00  0.000000e+00
25%    0.000000e+00  2.400000e+01     1.000000e+00  1.500000e+01
50%    1.000000e+00  3.600000e+01     1.000000e+00  2.800000e+01
75%    1.000000e+00  4.900000e+01     1.000000e+00  3.500000e+01
max    1.000000e+00  8.500000e+01     1.000000e+00  5.200000e+01

       Previously_Insured   Vehicle_Age  Vehicle_Damage 
Annual_Premium  \
count        1.150480e+07  1.150480e+07    1.150480e+07 
1.150480e+07
mean         4.629966e-01  6.031073e-01    5.026798e-01 
3.046137e+04
std          4.986289e-01  5.678559e-01    4.999928e-01 
1.645475e+04
min          0.000000e+00  0.000000e+00    0.000000e+00 
2.630000e+03
25%          0.000000e+00  0.000000e+00    0.000000e+00 
2.527700e+04
50%          0.000000e+00  1.000000e+00    1.000000e+00 
3.182400e+04
```

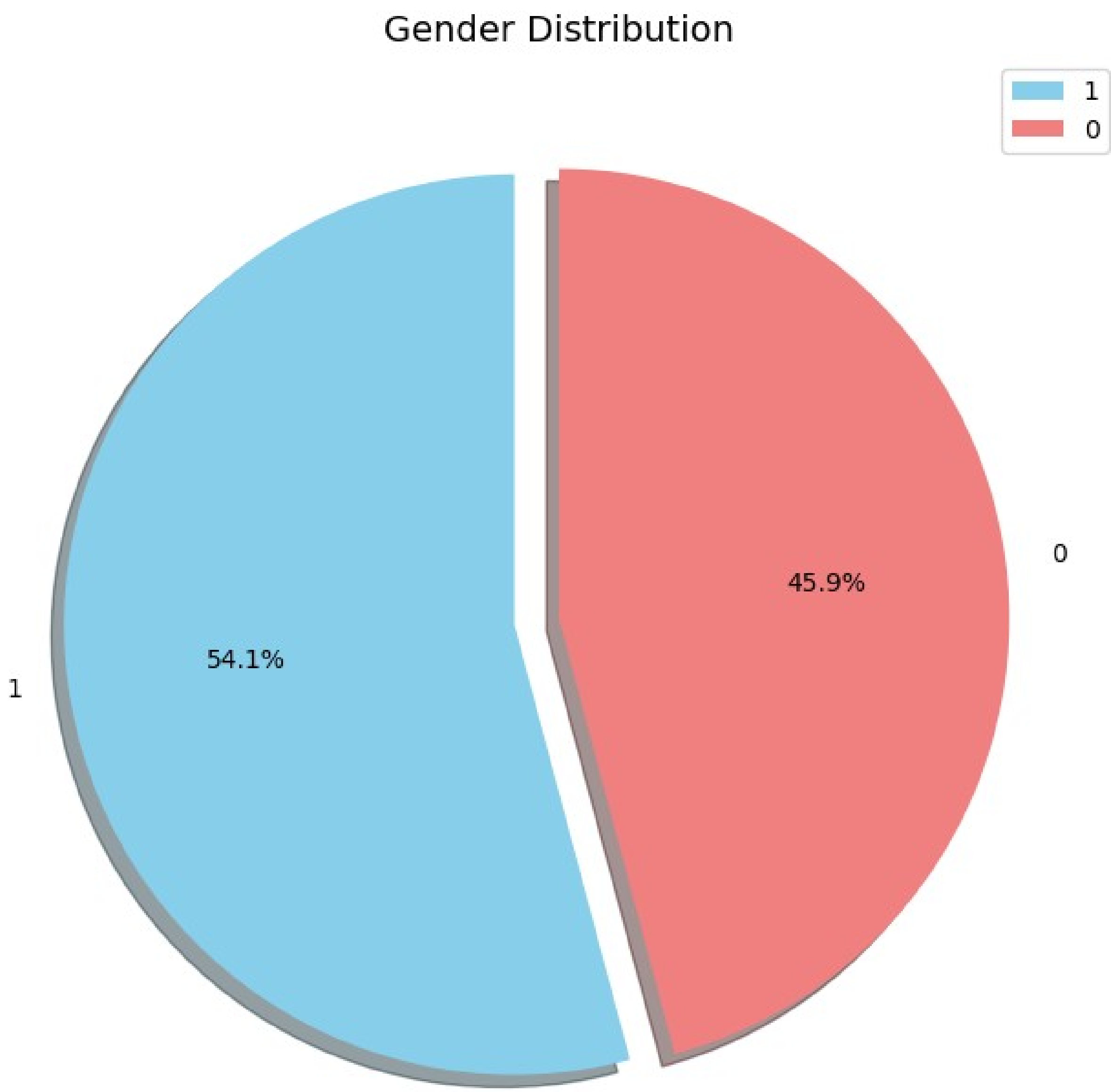
```
75%            1.000000e+00  1.000000e+00    1.000000e+00
3.945100e+04
max            1.000000e+00  2.000000e+00    1.000000e+00
5.401650e+05

       Policy_Sales_Channel       Vintage      Response
count          1.150480e+07  1.150480e+07  1.150480e+07
mean           1.124254e+02  1.638977e+02  1.229973e-01
std            5.403571e+01  7.997953e+01  3.284341e-01
min            1.000000e+00  1.000000e+01  0.000000e+00
25%            2.900000e+01  9.900000e+01  0.000000e+00
50%            1.510000e+02  1.660000e+02  0.000000e+00
75%            1.520000e+02  2.320000e+02  0.000000e+00
max            1.630000e+02  2.990000e+02  1.000000e+00
```

```
if 'Response' in df_train.columns and df_train['Response'].nunique() >
1:
    response_counts = df_train['Response'].value_counts()

    plt.figure(figsize=(8, 8))
    explode = (0.1, 0)

    plt.pie(response_counts, labels=['No Response', 'Positive
Response'], autopct='%1.1f%%',
            colors=['lightblue', 'lightcoral'], startangle=90,
shadow=False, explode=explode)

    plt.title('Response Proportions', fontsize=14)
    plt.legend(loc="best")
    plt.show()
else:
    print("The 'Response' column does not exist or there are unknown
columns.")
```



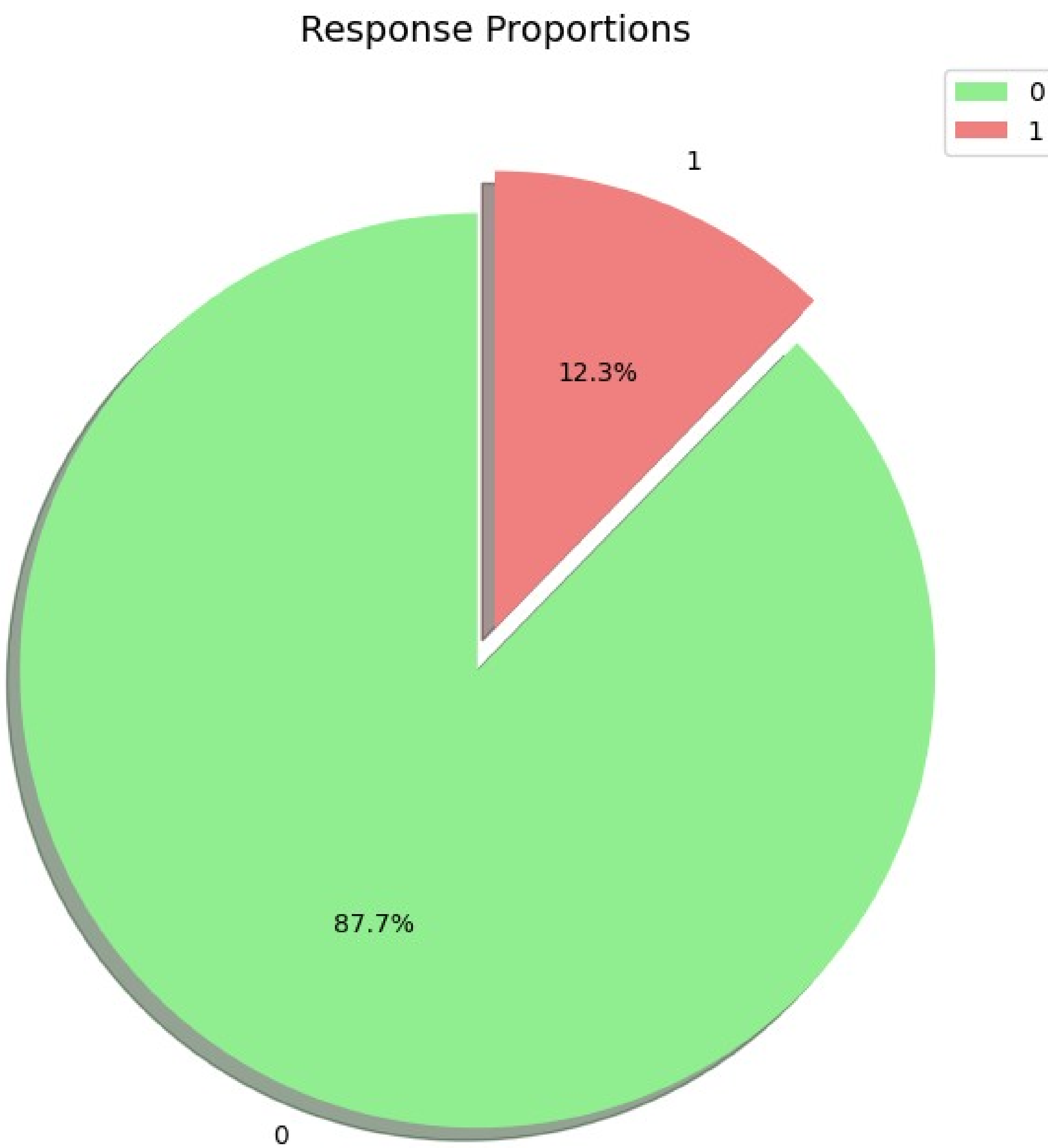

```
if 'Gender' in df_train.columns and df_train['Gender'].nunique() > 1:
      gender_counts = df_train['Gender'].value_counts()

      plt.figure(figsize=(8, 8))
      explode = (0.1, 0)
      plt.pie(gender_counts, labels=gender_counts.index, autopct='%1.1f
%%',
                   colors=['skyblue', 'lightcoral'], startangle=90,
shadow=True, explode=explode)

      plt.title('Gender Distribution', fontsize=14)
```

```
    plt.legend(loc='best')
    plt.show()
else:
    print("The 'Gender' column is missing or does not have enough 
categories to plot.")
```



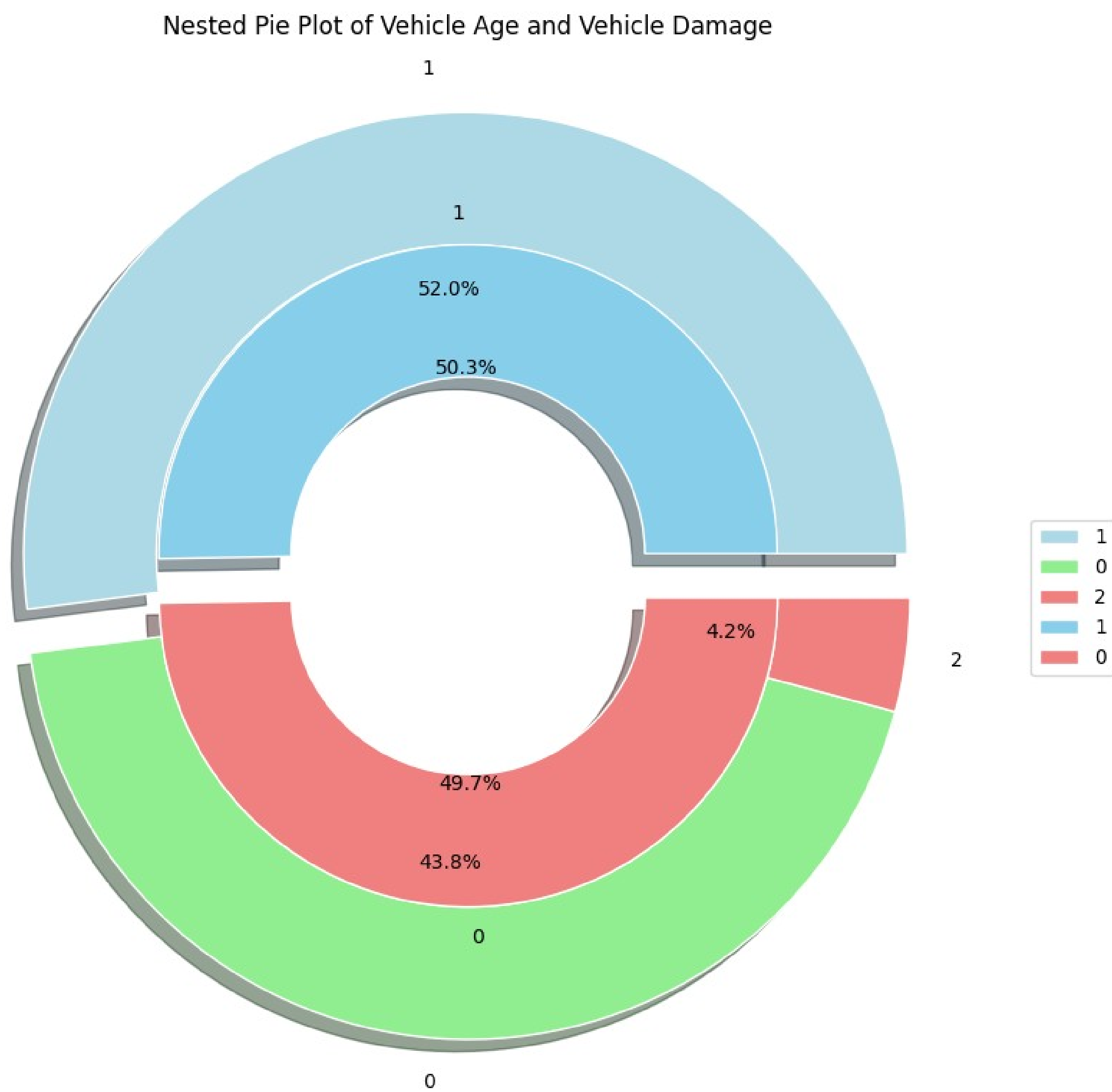

```
if 'Response' in df_train.columns and df_train['Response'].nunique() > 
1:
    response_counts = df_train['Response'].value_counts()

    plt.figure(figsize=(8, 8))
```

```
    explode = (0.1, 0)

    plt.pie(response_counts, labels=response_counts.index,
autopct='%1.1f%%',
            colors=['lightgreen', 'lightcoral'], startangle=90,
shadow=True, explode=explode)

    plt.title('Response Proportions', fontsize=14)
    plt.legend(loc="best")
    plt.show()
else:
    print("The 'Response' column is missing or does not have enough
categories to plot.")
```

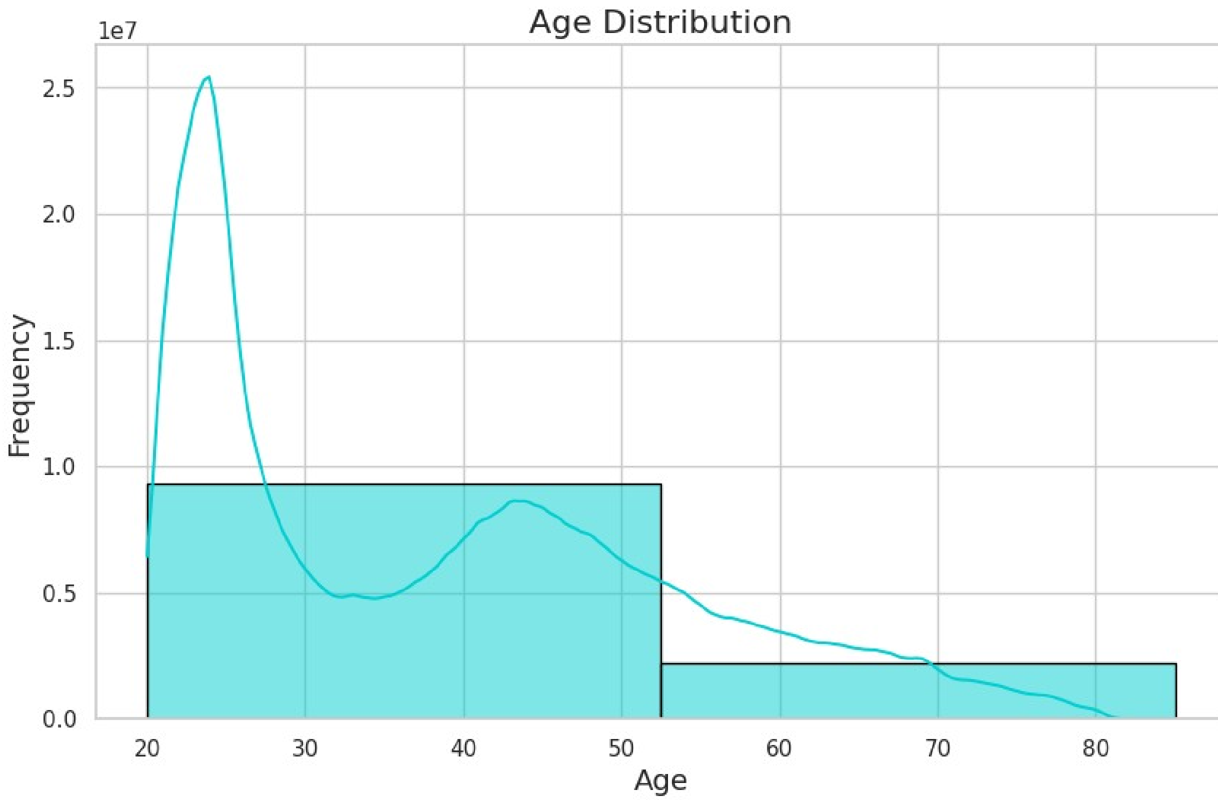



```
if all(column in df_train.columns and df_train[column].nunique() > 1
for column in ['Vehicle_Age', 'Vehicle_Damage']):
    vehicle_age_counts = df_train['Vehicle_Age'].value_counts()
    vehicle_damage_counts = df_train['Vehicle_Damage'].value_counts()

    fig, ax = plt.subplots(figsize=(10, 10))

    explode_outer = (0.1, 0, 0)
    ax.pie(vehicle_age_counts, labels=vehicle_age_counts.index,
autopct='%1.1f%%',
           colors=['lightblue', 'lightgreen', 'lightcoral'], radius=1,
```

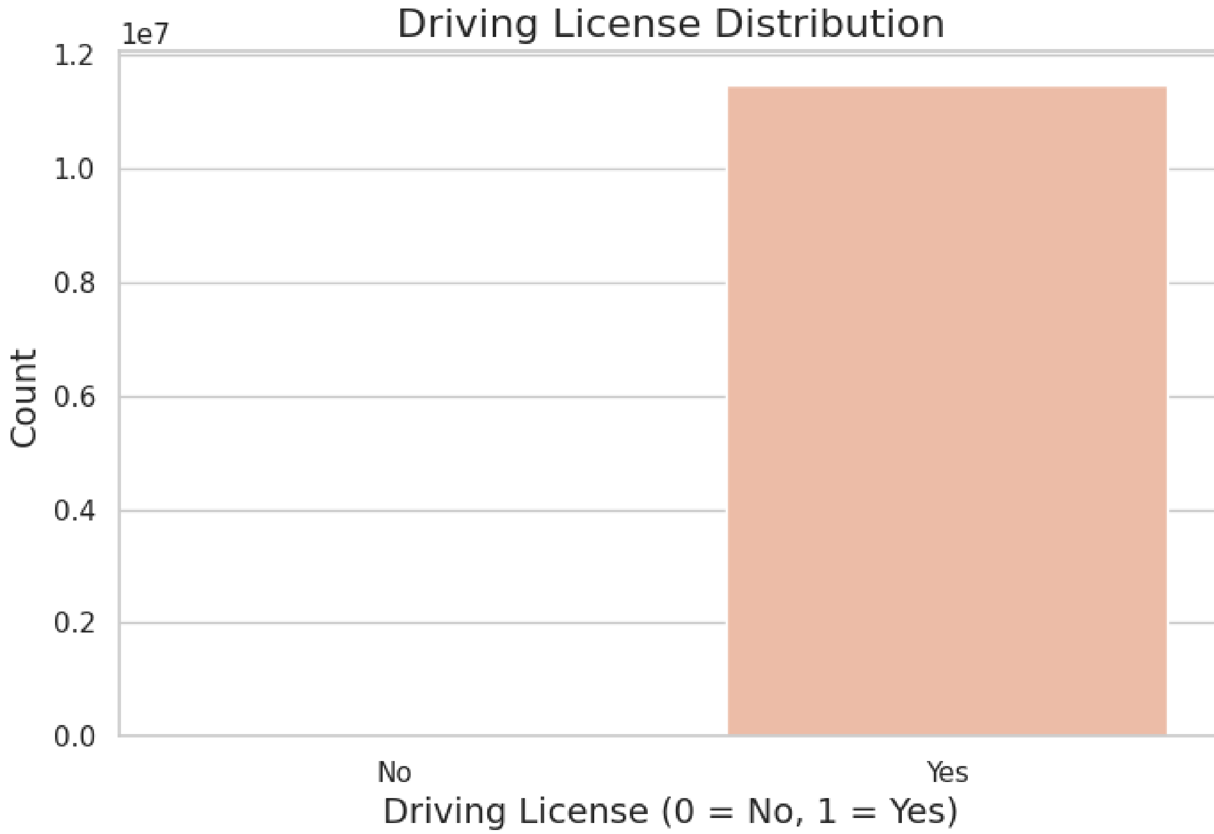
```
shadow=True, explode=explode_outer,
           wedgeprops=dict(width=0.3, edgecolor='w'))

    explode_inner = (0.1, 0)
    ax.pie(vehicle_damage_counts, labels=vehicle_damage_counts.index,
autopct='%1.1f%%',
           colors=['skyblue', 'lightcoral'], radius=0.7, shadow=True,
explode=explode_inner,
           wedgeprops=dict(width=0.3, edgecolor='w'))

    ax.set(aspect="equal", title='Nested Pie Plot of Vehicle Age and
Vehicle Damage')
    plt.legend(loc="center left", bbox_to_anchor=(1, 0, 0.5, 1))
    plt.show()
else:
    print("One or both of the 'Vehicle_Age' or 'Vehicle_Damage'
columns are missing or do not have enough categories to plot.")
```



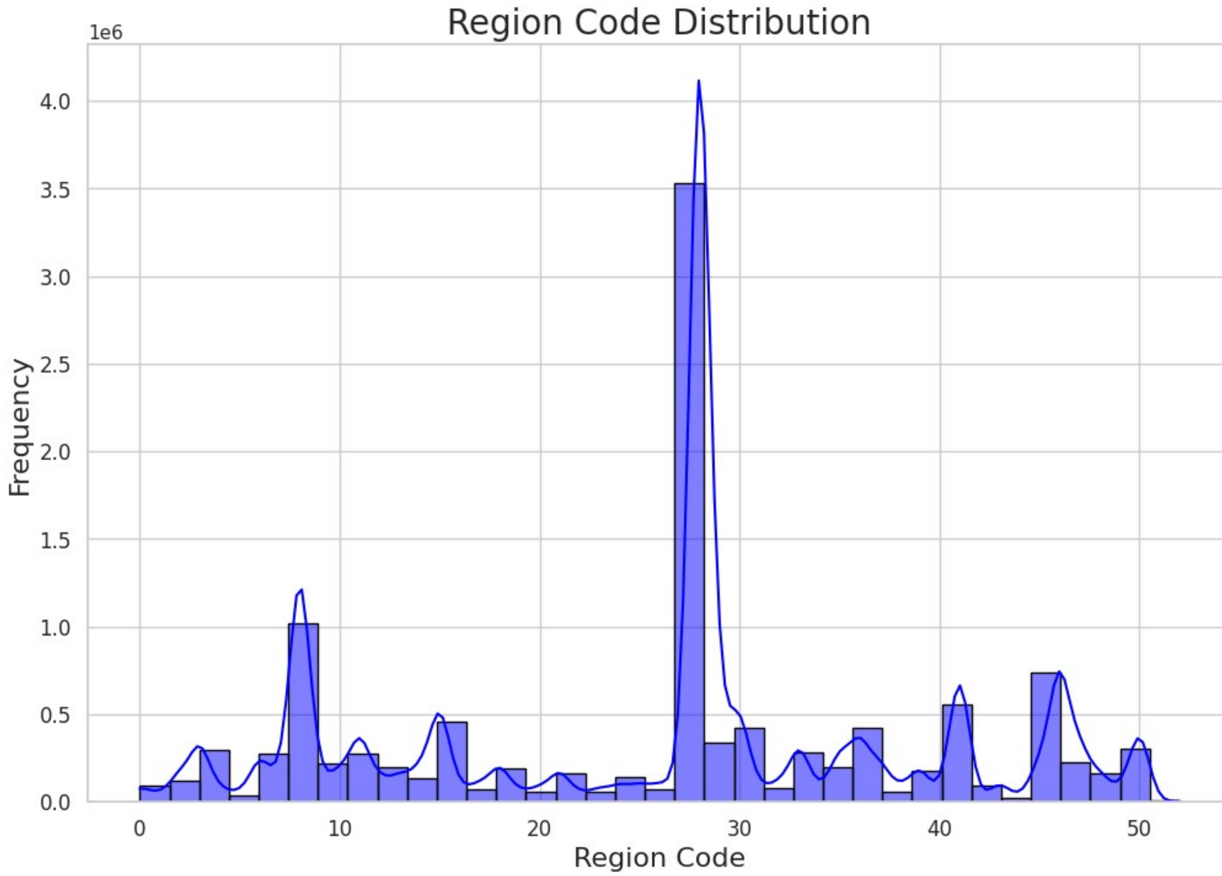

```
sns.set(style="whitegrid")
plt.figure(figsize=(10, 6))
bin_size = int((df_train['Age'].max() - df_train['Age'].min()) / 30)

sns.histplot(df_train['Age'], bins=bin_size, kde=True,
edgecolor='black', color='darkturquoise')

plt.title('Age Distribution', fontsize=16)
plt.xlabel('Age', fontsize=14)
plt.ylabel('Frequency', fontsize=14)
plt.show()
```



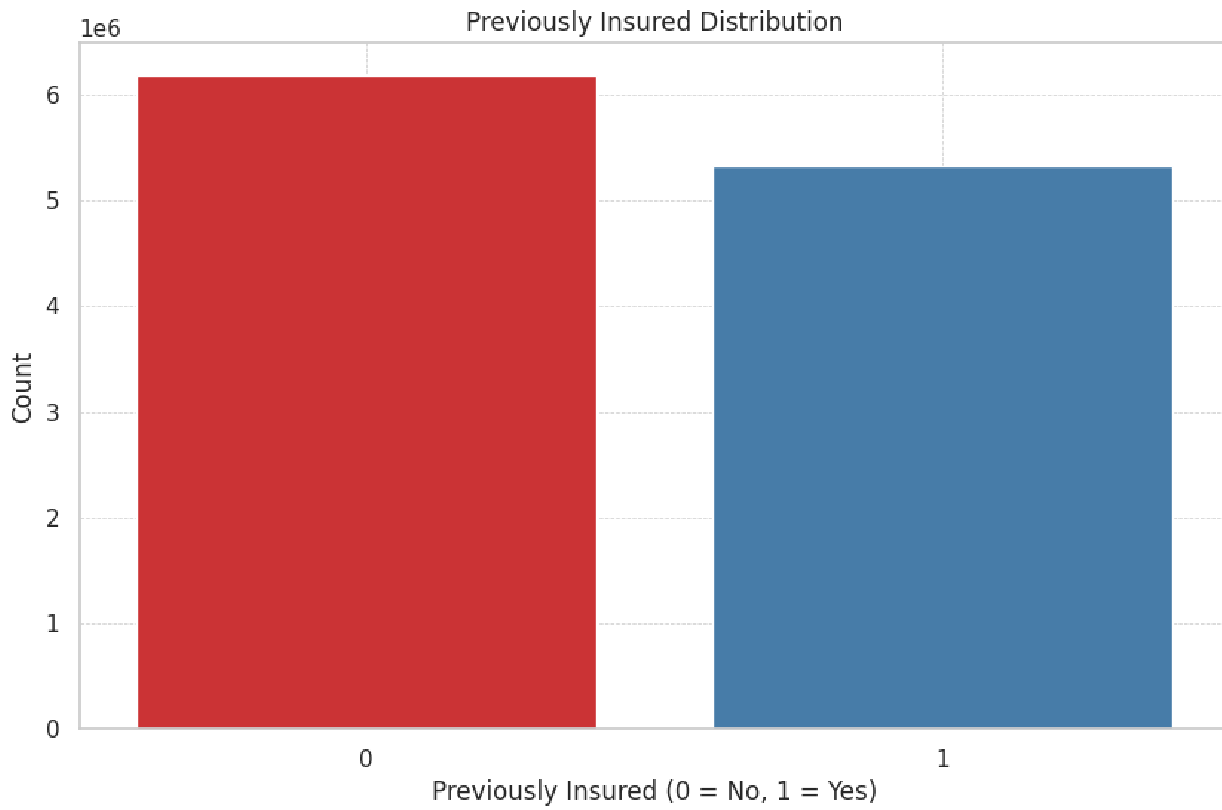

```
plt.figure(figsize=(8, 5))
sns.countplot(x='Driving_License', data=df_train, palette='coolwarm')
plt.title('Driving License Distribution', fontsize=16)
plt.xlabel('Driving License (0 = No, 1 = Yes)', fontsize=14)
plt.ylabel('Count', fontsize=14)
plt.xticks([0, 1], ['No', 'Yes'])
plt.show()
```



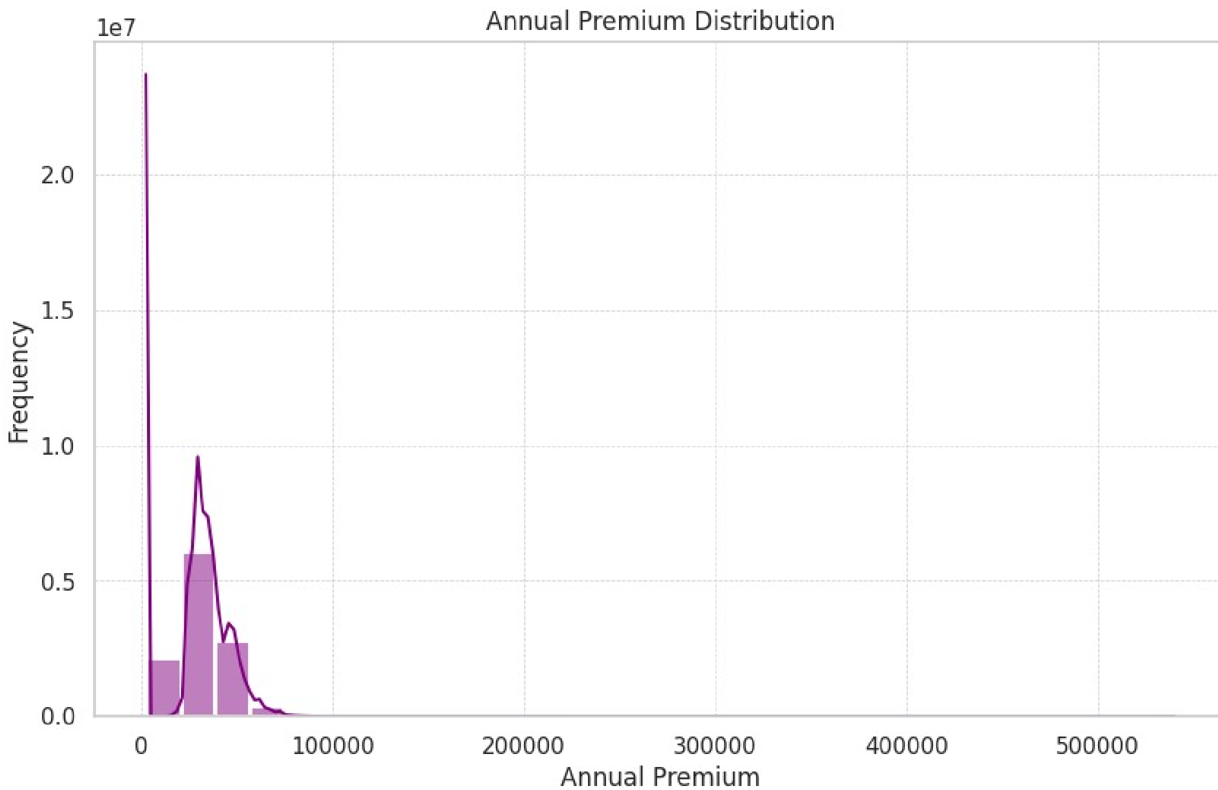

```
plt.figure(figsize=(12, 8))
sns.histplot(df_train['Region_Code'], bins=35, kde=True, color='blue',
edgecolor='black')
plt.title('Region Code Distribution', fontsize=20)
plt.xlabel('Region Code', fontsize=16)
plt.ylabel('Frequency', fontsize=16)
plt.xticks(fontsize=12)
plt.yticks(fontsize=12)
plt.grid(True)
plt.show()
```



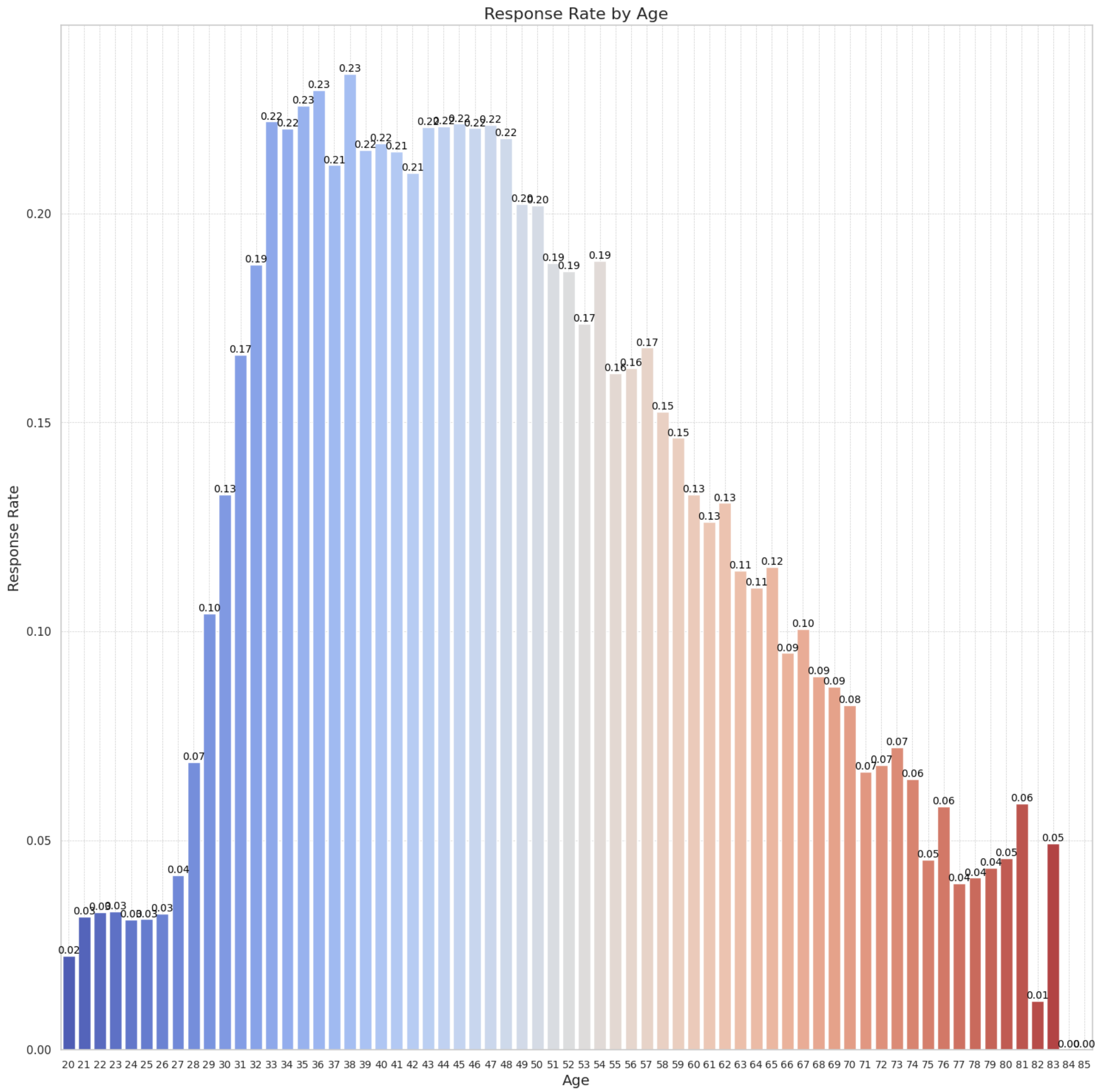

```
plt.figure(figsize=(10, 6))
sns.countplot(x='Previously_Insured', data=df_train, palette='Set1')
plt.title('Previously Insured Distribution')
plt.xlabel('Previously Insured (0 = No, 1 = Yes)')
plt.ylabel('Count')
plt.grid(True, which='both', linestyle='--', linewidth=0.5)
plt.show()
```




```
sns.set_style("whitegrid")
plt.figure(figsize=(10, 6))
sns.histplot(df_train['Annual_Premium'], bins=30, kde=True,
color='purple', linewidth=2)
plt.title('Annual Premium Distribution')
plt.xlabel('Annual Premium')
plt.ylabel('Frequency')
plt.grid(True, which='both', linestyle='--', linewidth=0.5)
plt.show()
```

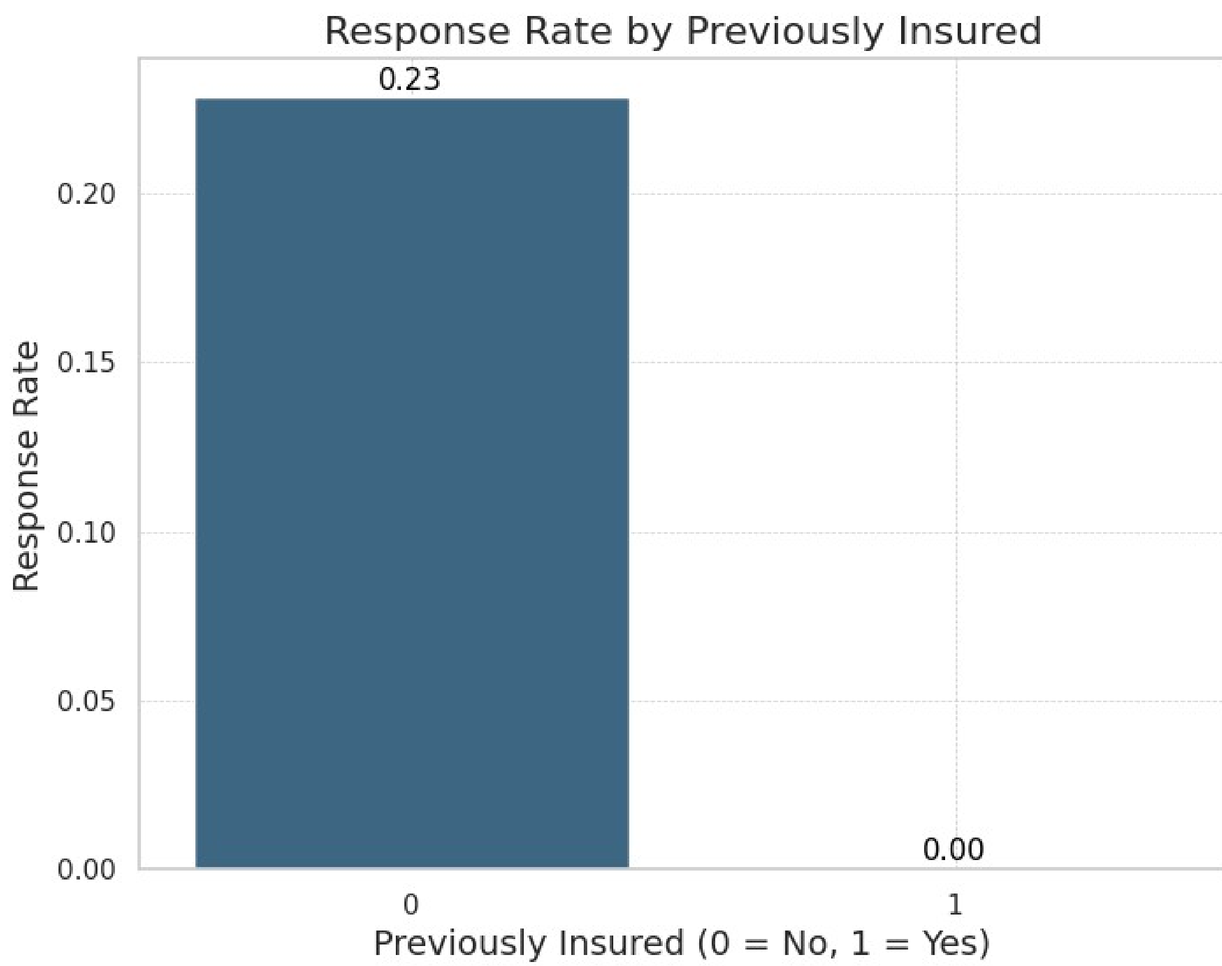



```
sns.set_style("whitegrid")
plt.figure(figsize=(18, 18))
age_response = df_train.groupby('Age')
['Response'].mean().reset_index()
sns.barplot(x='Age', y='Response', data=age_response,
palette='coolwarm')
plt.title('Response Rate by Age', fontsize=16)
plt.xlabel('Age', fontsize=14)
plt.ylabel('Response Rate', fontsize=14)
plt.xticks(rotation=0, fontsize=10)
for index, row in age_response.iterrows():
    plt.text(row.name, row.Response, f'{row.Response:.2f}',
color='black', ha="center", va="bottom", fontsize=10)
plt.grid(True, which='both', linestyle='--', linewidth=0.5)
plt.show()
```

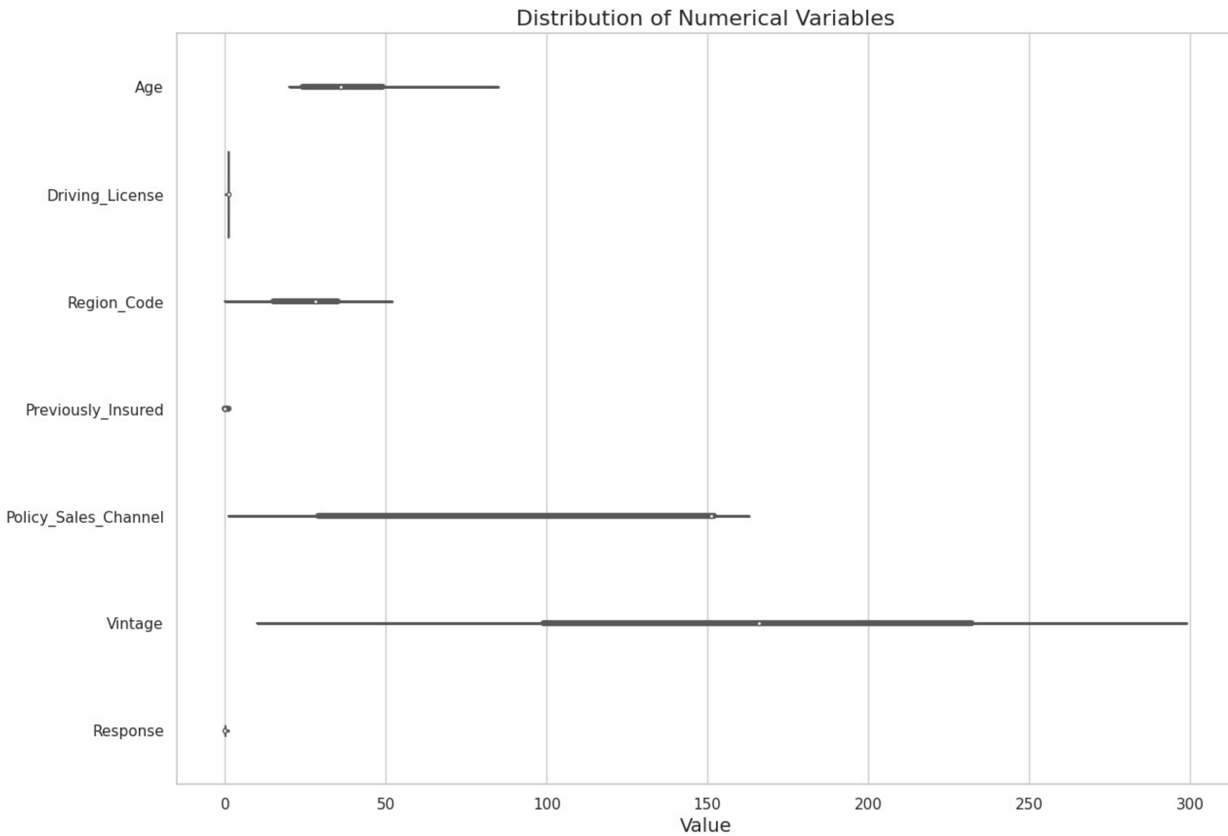



```
sns.set_style("whitegrid")
plt.figure(figsize=(8, 6))
insured_response = df_train.groupby('Previously_Insured')
['Response'].mean().reset_index()
sns.barplot(x='Previously_Insured', y='Response',
data=insured_response, palette='viridis')
plt.title('Response Rate by Previously Insured', fontsize=16)
plt.xlabel('Previously Insured (0 = No, 1 = Yes)', fontsize=14)
plt.ylabel('Response Rate', fontsize=14)
for index, row in insured_response.iterrows():
    plt.text(row.name, row.Response, f'{row.Response:.2f}',
color='black', ha="center", va="bottom", fontsize=12)
```

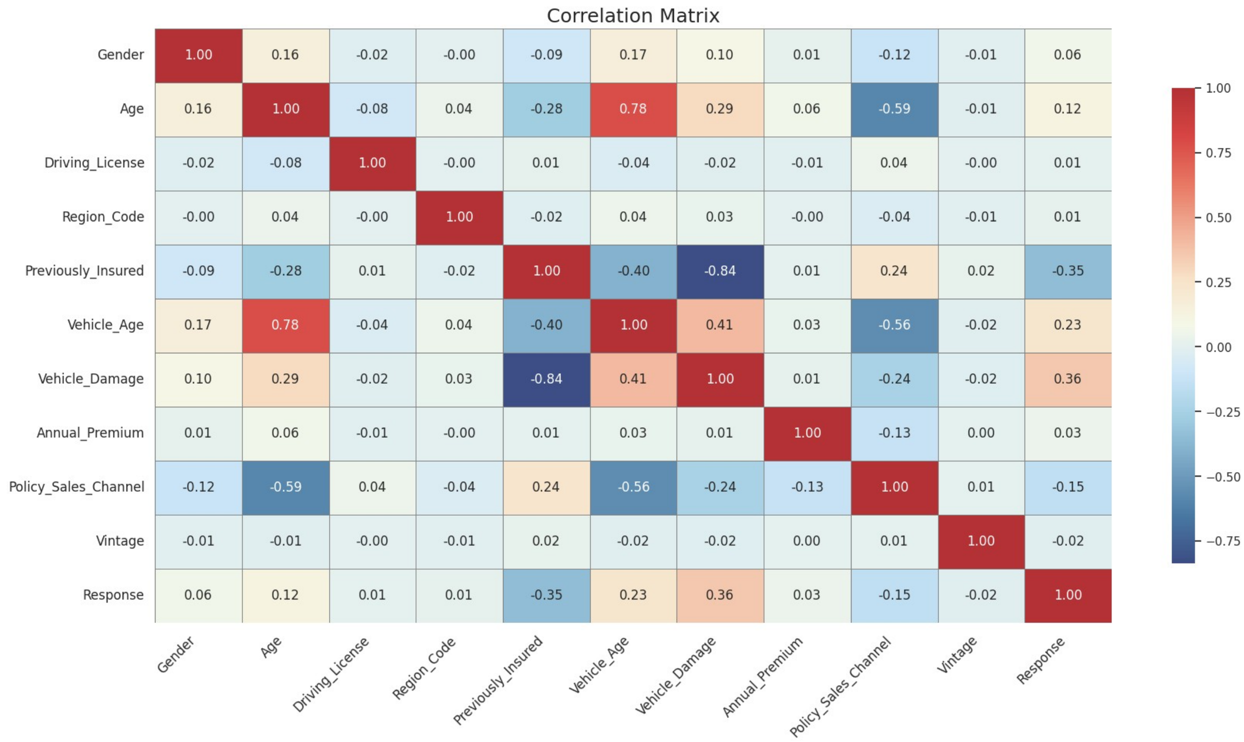
```
plt.grid(True, which='both', linestyle='--', linewidth=0.5)
plt.show()
```




```
sns.set_style("whitegrid")
numerical_cols = ['Age', 'Driving_License', 'Region_Code',
'Previously_Insured',
                  'Policy_Sales_Channel', 'Vintage', 'Response']
plt.figure(figsize=(14, 10))
sns.violinplot(data=df_train[numerical_cols], orient='h',
palette='Set2', cut=0)
plt.title('Distribution of Numerical Variables', fontsize=16)
plt.xlabel('Value', fontsize=14)
plt.show()
```



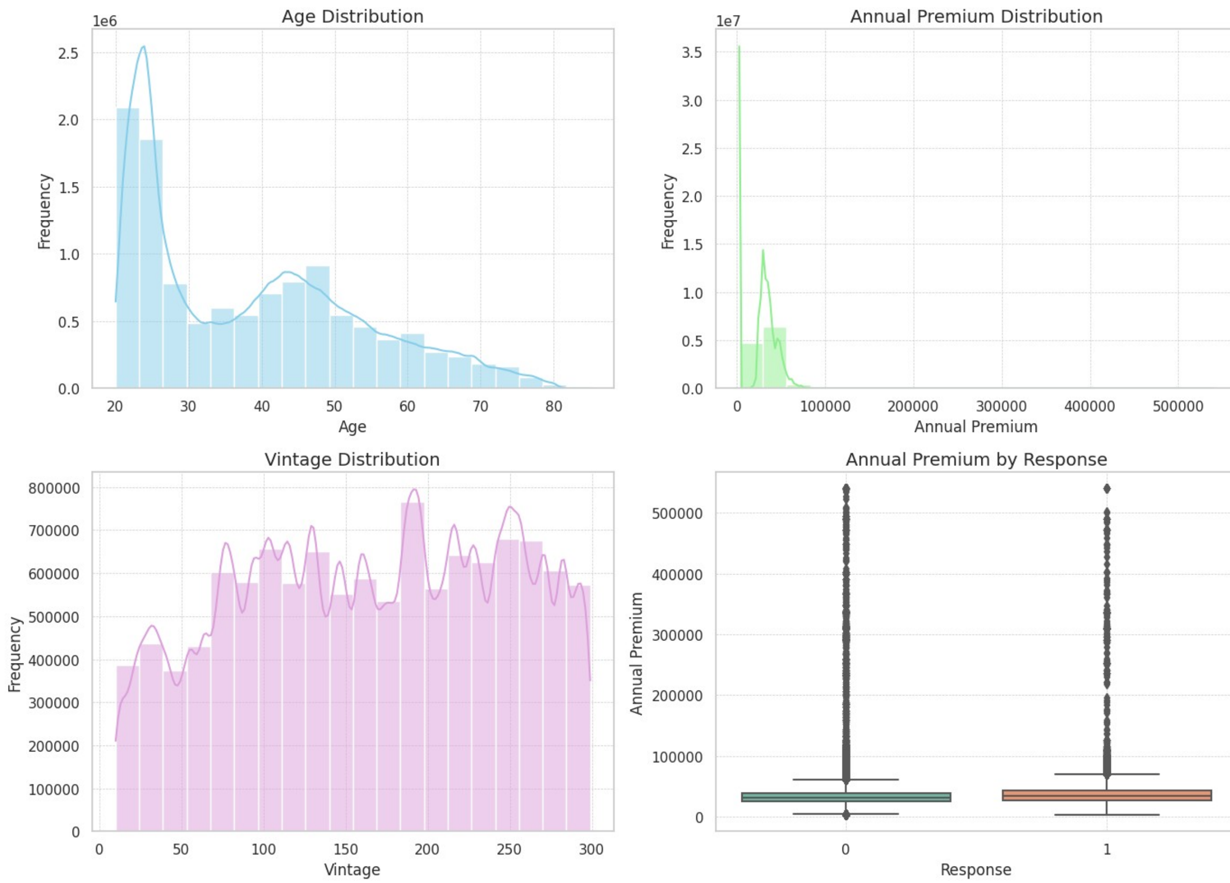

```
custom_palette = ["#3C4E85", "#4979A3", "#75A2C1", "#9FCCE1",
"#CDE6F8", "#F5F8E8", "#F8E2C8", "#F1AF96", "#E87763", "#D74543",
"#B43135"]
from matplotlib.colors import LinearSegmentedColormap
cmap = LinearSegmentedColormap.from_list("custom_cmap",
custom_palette, N=256)
correlation_matrix = df_train.corr()
plt.figure(figsize=(20, 10))
sns.heatmap(correlation_matrix, annot=True, cmap=cmap, fmt=".2f",
linewidths=0.5, linecolor='gray', cbar_kws={"shrink": 0.8})
plt.title('Correlation Matrix', fontsize=18)
plt.xticks(rotation=45, ha='right', fontsize=12)
plt.yticks(rotation=0, fontsize=12)
plt.show()
```



```
correlation_matrix
                        Gender       Age  Driving_License  Region_Code  \
Gender                1.000000  0.157663        -0.018702    -0.000106   
Age                   0.157663  1.000000        -0.078519     0.037041   
Driving_License      -0.018702 -0.078519         1.000000    -0.001329   
Region_Code          -0.000106  0.037041        -0.001329     1.000000   
Previously_Insured   -0.087614 -0.276248         0.013733    -0.022367   
Vehicle_Age           0.167354  0.779041        -0.036511     0.039242   
Vehicle_Damage        0.096989  0.287952        -0.015563     0.026468   
Annual_Premium        0.010652  0.056327        -0.007300    -0.001741   
Policy_Sales_Channel -0.116058 -0.591443         0.042941    -0.037606   
Vintage              -0.009535 -0.013293        -0.000697    -0.005537   
Response              0.055212  0.122134         0.009197     0.012816   

                      Previously_Insured  Vehicle_Age  Vehicle_Damage  
```

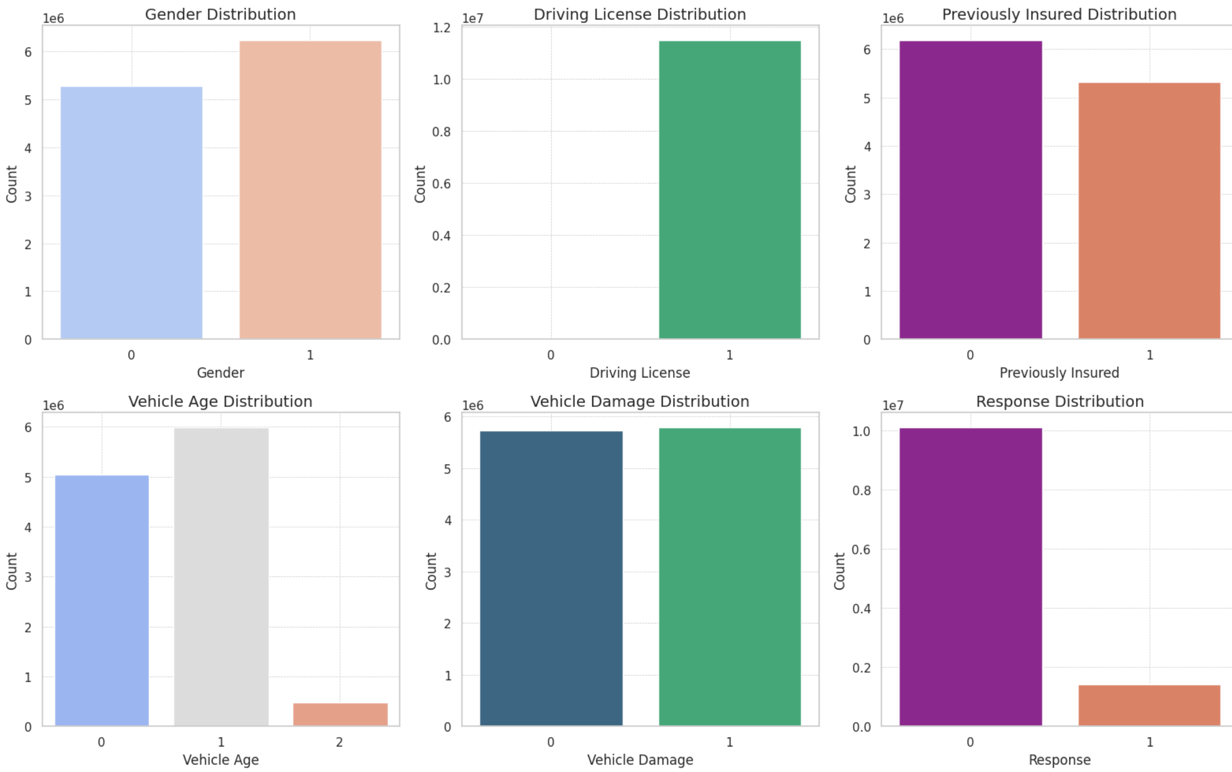
```
\
Gender                               -0.087614     0.167354         0.096989

Age                                  -0.276248     0.779041         0.287952

Driving_License                       0.013733    -0.036511        -0.015563

Region_Code                          -0.022367     0.039242         0.026468

Previously_Insured                    1.000000    -0.396752        -0.836214

Vehicle_Age                          -0.396752     1.000000         0.410515

Vehicle_Damage                       -0.836214     0.410515         1.000000

Annual_Premium                        0.007665     0.028007         0.012728

Policy_Sales_Channel                  0.236838    -0.558992        -0.241036

Vintage                               0.019431    -0.018022        -0.019393

Response                             -0.345930     0.231029         0.359780


                      Annual_Premium  Policy_Sales_Channel   Vintage
Response
Gender                      0.010652             -0.116058 -0.009535
0.055212
Age                         0.056327             -0.591443 -0.013293
0.122134
Driving_License            -0.007300              0.042941 -0.000697
0.009197
Region_Code                -0.001741             -0.037606 -0.005537
0.012816
Previously_Insured          0.007665              0.236838  0.019431 -
0.345930
Vehicle_Age                 0.028007             -0.558992 -0.018022
0.231029
Vehicle_Damage              0.012728             -0.241036 -0.019393
0.359780
Annual_Premium              1.000000             -0.128559  0.003284
0.032261
Policy_Sales_Channel       -0.128559              1.000000  0.008999 -
0.152733
Vintage                     0.003284              0.008999  1.000000 -
0.015177
Response                    0.032261             -0.152733 -0.015177
1.000000

sns.set(style="whitegrid")
plt.figure(figsize=(14, 10))
```

```python
# Subplot 1: Age Distribution
plt.subplot(2, 2, 1)
sns.histplot(df_train['Age'], bins=20, kde=True, color='skyblue')
plt.title('Age Distribution', fontsize=14)
plt.xlabel('Age', fontsize=12)
plt.ylabel('Frequency', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 2: Annual Premium Distribution
plt.subplot(2, 2, 2)
sns.histplot(df_train['Annual_Premium'], bins=20, kde=True,
color='lightgreen')
plt.title('Annual Premium Distribution', fontsize=14)
plt.xlabel('Annual Premium', fontsize=12)
plt.ylabel('Frequency', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 3: Vintage Distribution
plt.subplot(2, 2, 3)
sns.histplot(df_train['Vintage'], bins=20, kde=True, color='plum')
plt.title('Vintage Distribution', fontsize=14)
plt.xlabel('Vintage', fontsize=12)
plt.ylabel('Frequency', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 4: Annual Premium by Response
plt.subplot(2, 2, 4)
sns.boxplot(x='Response', y='Annual_Premium', data=df_train,
palette='Set2')
plt.title('Annual Premium by Response', fontsize=14)
plt.xlabel('Response', fontsize=12)
plt.ylabel('Annual Premium', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Adjusting the layout to prevent overlap
plt.tight_layout()
plt.show()
```

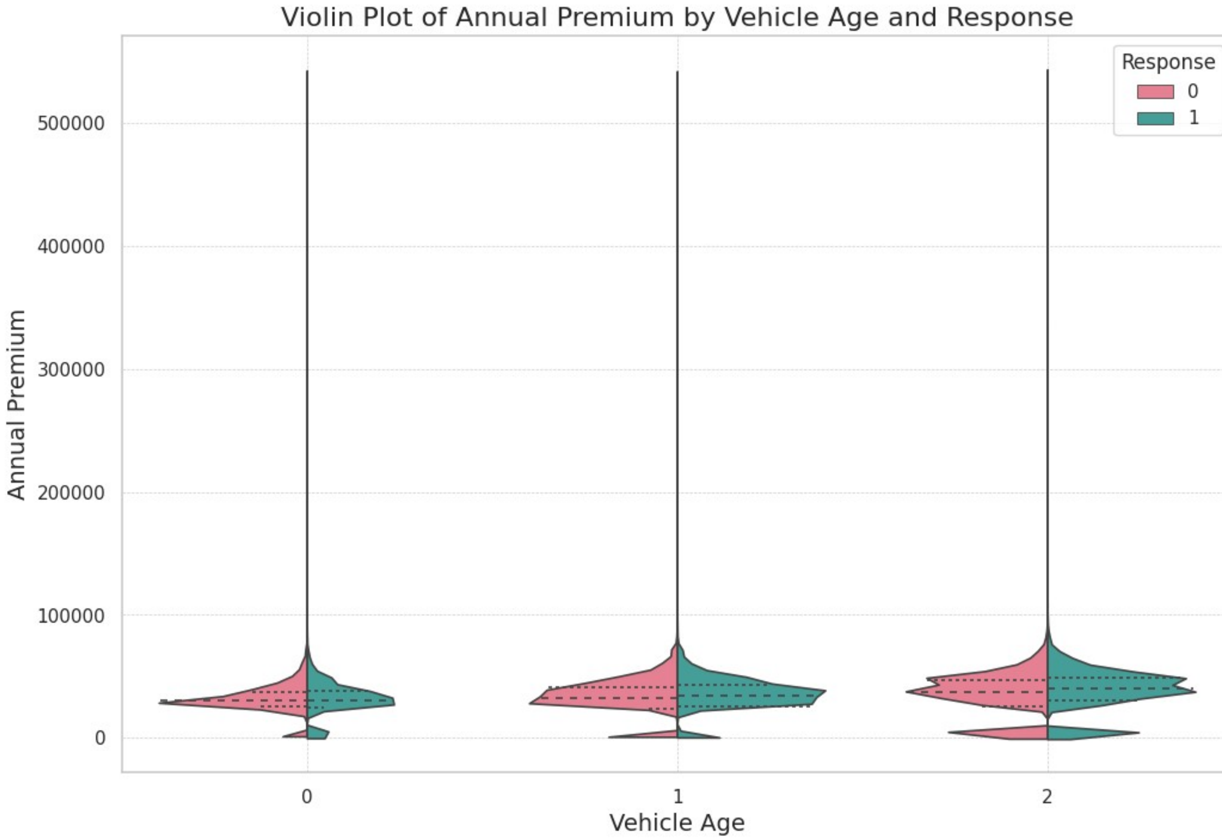



```
sns.set(style="whitegrid")
plt.figure(figsize=(16, 10))

# Subplot 1: Gender Distribution
plt.subplot(2, 3, 1)
sns.countplot(x='Gender', data=df_train, palette='coolwarm')
plt.title('Gender Distribution', fontsize=14)
plt.xlabel('Gender', fontsize=12)
plt.ylabel('Count', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 2: Driving License Distribution
plt.subplot(2, 3, 2)
sns.countplot(x='Driving_License', data=df_train, palette='viridis')
plt.title('Driving License Distribution', fontsize=14)
plt.xlabel('Driving License', fontsize=12)
plt.ylabel('Count', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 3: Previously Insured Distribution
plt.subplot(2, 3, 3)
sns.countplot(x='Previously_Insured', data=df_train, palette='plasma')
plt.title('Previously Insured Distribution', fontsize=14)
```

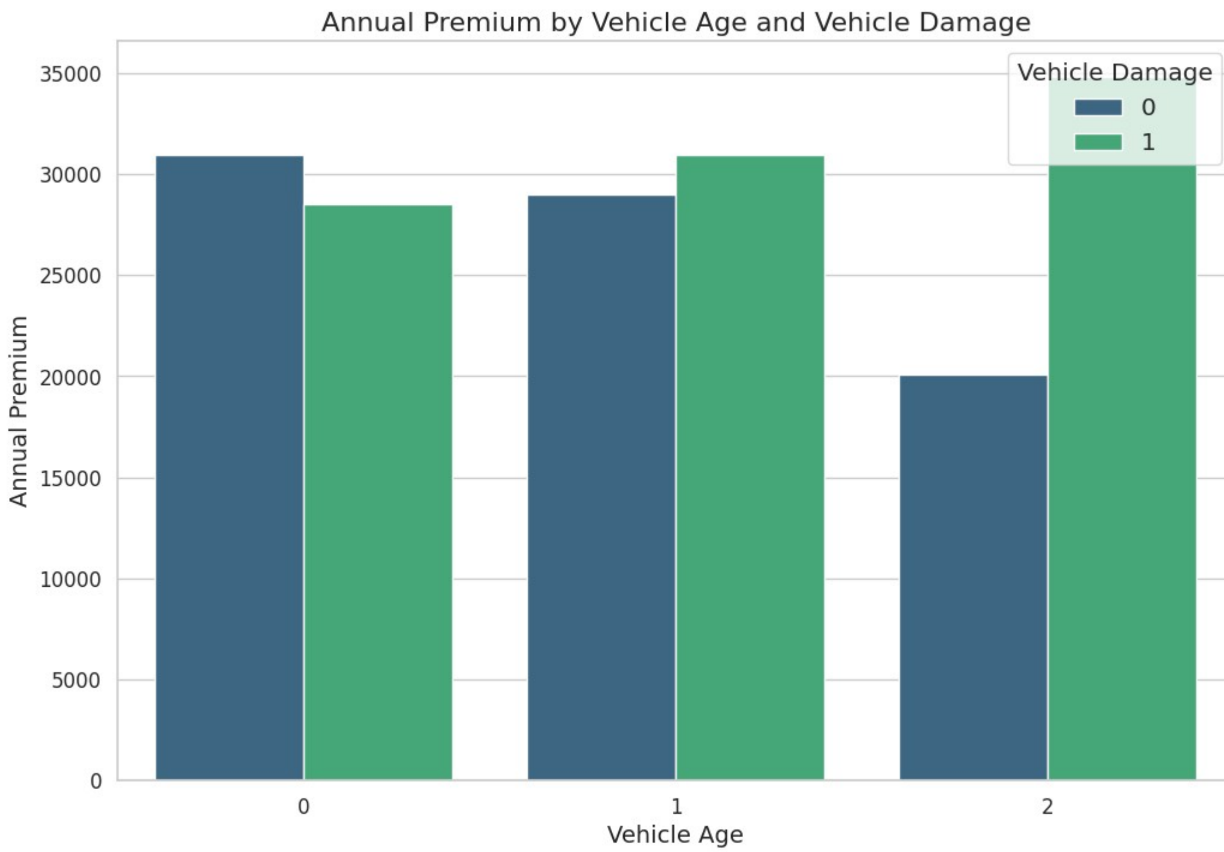
```python
plt.xlabel('Previously Insured', fontsize=12)
plt.ylabel('Count', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 4: Vehicle Age Distribution
plt.subplot(2, 3, 4)
sns.countplot(x='Vehicle_Age', data=df_train, palette='coolwarm')
plt.title('Vehicle Age Distribution', fontsize=14)
plt.xlabel('Vehicle Age', fontsize=12)
plt.ylabel('Count', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 5: Vehicle Damage Distribution
plt.subplot(2, 3, 5)
sns.countplot(x='Vehicle_Damage', data=df_train, palette='viridis')
plt.title('Vehicle Damage Distribution', fontsize=14)
plt.xlabel('Vehicle Damage', fontsize=12)
plt.ylabel('Count', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

# Subplot 6: Response Distribution
plt.subplot(2, 3, 6)
sns.countplot(x='Response', data=df_train, palette='plasma')
plt.title('Response Distribution', fontsize=14)
plt.xlabel('Response', fontsize=12)
plt.ylabel('Count', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)

plt.tight_layout()
plt.show()
```




```
sns.set(style="whitegrid")
plt.figure(figsize=(12, 8))
sns.violinplot(x='Vehicle_Age', y='Annual_Premium', data=df_train,
hue='Response', split=True,
               palette='husl', inner='quartile', linewidth=1.2)
plt.title('Violin Plot of Annual Premium by Vehicle Age and Response',
fontsize=16)
plt.xlabel('Vehicle Age', fontsize=14)
plt.ylabel('Annual Premium', fontsize=14)
plt.grid(True, linestyle='--', linewidth=0.5)
plt.show()
```




```
sns.set(style="whitegrid")
plt.figure(figsize=(12, 8))
sns.barplot(x='Vehicle_Age', y='Annual_Premium', hue='Vehicle_Damage',
data=df_train, palette='viridis', ci=None)
plt.title('Annual Premium by Vehicle Age and Vehicle Damage',
fontsize=16)
plt.xlabel('Vehicle Age', fontsize=14)
plt.ylabel('Annual Premium', fontsize=14)
plt.xticks(fontsize=12)
plt.yticks(fontsize=12)
plt.legend(title='Vehicle Damage', title_fontsize='large',
fontsize='large')
plt.show()
```




```
df_train.head()

   Gender  Age  Driving_License  Region_Code  Previously_Insured
Vehicle_Age  \
0       1   21                1           35                   0
1
1       1   43                1           28                   0
2
2       0   25                1           14                   1
0
3       0   35                1            1                   0
1
4       0   36                1           15                   1
1

   Vehicle_Damage  Annual_Premium  Policy_Sales_Channel  Vintage
Response
0               1         65101.0                   124      187
0
1               1         58911.0                    26      288
1
2               0         38043.0                   152      254
0
3               1          2630.0                   156       76
```

```
0
4                0         31951.0                   152      294
0
```

```python
def feature_engineering(df):

    df['Age_Vehicle_Age'] = df['Age'] * df['Vehicle_Age']
    df['Age_Previously_Insured'] = df['Age'] *
df['Previously_Insured']
    df['Vehicle_Age_Damage'] = df['Vehicle_Age'] *
df['Vehicle_Damage']
    df['Previously_Insured_Damage'] = df['Previously_Insured'] *
df['Vehicle_Damage']
    df['Age_squared'] = df['Age'] ** 2
    df['Vehicle_Age_squared'] = df['Vehicle_Age'] ** 2
    df['Annual_Premium_per_Age'] = df['Annual_Premium'] / (df['Age'] +
1)
    return df

df_train = feature_engineering(df_train)
df_test = feature_engineering(df_test)
```

```python
df_train.dtypes
```

```
Gender                         int64
Age                            int64
Driving_License                int64
Region_Code                    int64
Previously_Insured             int64
Vehicle_Age                    int64
Vehicle_Damage                 int64
Annual_Premium               float64
Policy_Sales_Channel           int64
Vintage                        int64
Response                       int64
Age_Vehicle_Age                int64
Age_Previously_Insured         int64
Vehicle_Age_Damage             int64
Previously_Insured_Damage      int64
Age_squared                    int64
Vehicle_Age_squared            int64
Annual_Premium_per_Age       float64
dtype: object
```

```python
df_train.shape
```

```
(11504798, 18)
```

```python
df_test.shape
```

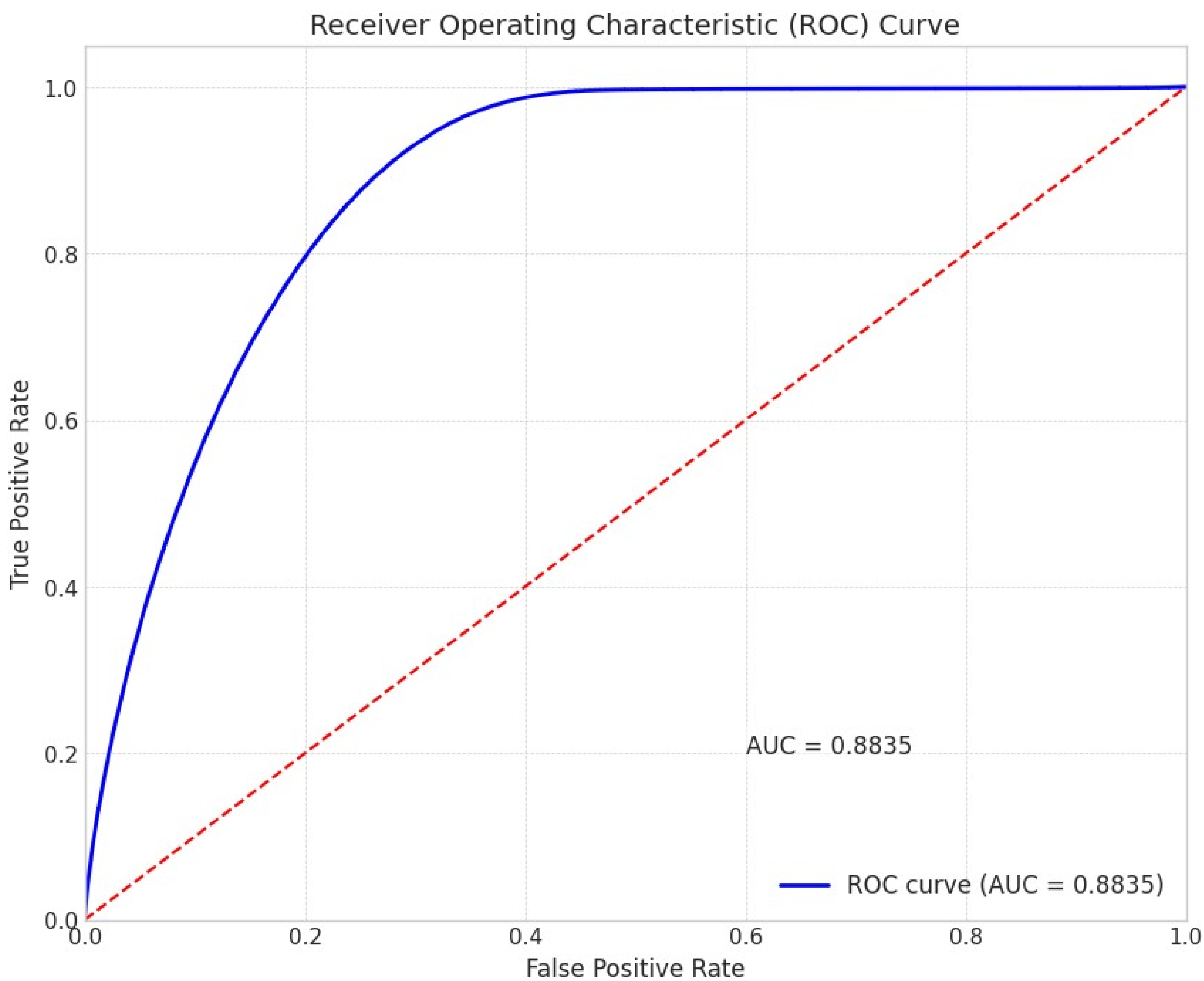
```
(7669866, 17)
```

```
y = df_train['Response']
X = df_train.drop(['Response'],axis=1)

train_X, test_X, train_y, test_y = train_test_split(X, y,test_size =
0.2, random_state =41)

xgb_params = {
    'colsample_bytree': 0.48,
    'learning_rate': 0.01567,
    'max_depth': 10,
    'min_child_weight': 6,
    'max_bin': 3500,
    'n_estimators': 3000,
    'eval_metric': 'auc'
    }

model=XGBRegressor(**xgb_params)
XGB=model.fit(train_X,train_y)
prediction=XGB.predict(test_X)

test_pred = XGB.predict(df_test)

sample_submission
```

```
               id  Response
0        11504798 -0.010802
1        11504799  0.472721
2        11504800  0.245270
3        11504801  0.003398
4        11504802  0.118081
...           ...       ...
7669861  19174659  0.187156
7669862  19174660 -0.001677
7669863  19174661  0.001568
7669864  19174662  0.622429
7669865  19174663 -0.000309

[7669866 rows x 2 columns]
```

```
sample_submission.Response= test_pred


test_pred = XGB.predict(test_X)
fpr, tpr, thresholds = roc_curve(test_y, test_pred)
auc = roc_auc_score(test_y, test_pred)

plt.figure(figsize=(10, 8))
plt.style.use('seaborn-whitegrid')
plt.plot(fpr, tpr, color='blue', lw=2, label='ROC curve (AUC = %0.4f)'
% auc)
plt.plot([0, 1], [0, 1], color='red', linestyle='--')
```

```
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate', fontsize=12)
plt.ylabel('True Positive Rate', fontsize=12)
plt.title('Receiver Operating Characteristic (ROC) Curve',
fontsize=14)
plt.text(0.6, 0.2, f'AUC = {auc:.4f}', fontsize=12,
bbox=dict(facecolor='white', alpha=0.5))
plt.legend(loc='lower right', fontsize=12)
plt.grid(True, linestyle='--', linewidth=0.5)
plt.show()
```




```
sample_submission.to_csv('XGB_submission.csv', index = False)
pd.read_csv('XGB_submission.csv')
```

	id	Response
0	11504798	-0.010802
1	11504799	0.472721

```
2         11504800  0.245270
3         11504801  0.003398
4         11504802  0.118081
...            ...       ...
7669861  19174659  0.187156
7669862  19174660 -0.001677
7669863  19174661  0.001568
7669864  19174662  0.622429
7669865  19174663 -0.000309

[7669866 rows x 2 columns]
```

```
jupyter nbconvert --to webpdf --allow-chromium-download
your_notebook.ipynb
```

```
  Cell In[3], line 1
    jupyter nbconvert --to webpdf --allow-chromium-download
your_notebook.ipynb
            ^
SyntaxError: invalid syntax
```