# Testing the model

Using your solution so far, test the model on new data.

The new data is located in the 'Bank_data_testing.csv'.

Good luck!

## Import the relevant libraries

In [ ]:
```
import numpy as np
import pandas as pd
import statsmodels.api as sm
import matplotlib.pyplot as plt
import seaborn as sns

sns.set()

from scipy import stats
stats.chisqprob = lambda chisq, df: stats.chi2.sf(chisq, df)
```

## Load the data

Load the 'Bank_data.csv' dataset.

In [ ]:
```
datatemp = pd.read_csv("Bank_data (1).csv")
datatemp.head()
```

Out[ ]:

| | Unnamed: 0 | interest_rate | credit | march | may | previous | duration | y |
|---|---|---|---|---|---|---|---|---|
| **0** | 0 | 1.334 | 0.0 | 1.0 | 0.0 | 0.0 | 117.0 | no |
| **1** | 1 | 0.767 | 0.0 | 0.0 | 2.0 | 1.0 | 274.0 | yes |
| **2** | 2 | 4.858 | 0.0 | 1.0 | 0.0 | 0.0 | 167.0 | no |
| **3** | 3 | 4.120 | 0.0 | 0.0 | 0.0 | 0.0 | 686.0 | yes |
| **4** | 4 | 4.856 | 0.0 | 1.0 | 0.0 | 0.0 | 157.0 | no |

In [ ]:
```
data = datatemp.copy()
data = data.drop(['Unnamed: 0'], axis = 1)
data['y'] = data['y'].map({'yes':1, 'no':0})
data.head()
```

Out[ ]:

| | interest_rate | credit | march | may | previous | duration | y |
|---|---|---|---|---|---|---|---|
| **0** | 1.334 | 0.0 | 1.0 | 0.0 | 0.0 | 117.0 | 0 |
| **1** | 0.767 | 0.0 | 0.0 | 2.0 | 1.0 | 274.0 | 1 |
| **2** | 4.858 | 0.0 | 1.0 | 0.0 | 0.0 | 167.0 | 0 |
| **3** | 4.120 | 0.0 | 0.0 | 0.0 | 0.0 | 686.0 | 1 |
| **4** | 4.856 | 0.0 | 1.0 | 0.0 | 0.0 | 157.0 | 0 |

In [ ]:
```
data.describe()
```

Out[ ]:

| | interest_rate | credit | march | may | previous | duration | y |
|---|---|---|---|---|---|---|---|
| **count** | 518.000000 | 518.000000 | 518.000000 | 518.000000 | 518.000000 | 518.000000 | 518.000000 |
| **mean** | 2.835776 | 0.034749 | 0.266409 | 0.388031 | 0.127413 | 382.177606 | 0.500000 |
| **std** | 1.876903 | 0.183321 | 0.442508 | 0.814527 | 0.333758 | 344.295990 | 0.500483 |
| **min** | 0.635000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 9.000000 | 0.000000 |
| **25%** | 1.042750 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 155.000000 | 0.000000 |
| **50%** | 1.466000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 266.500000 | 0.500000 |
| **75%** | 4.956500 | 0.000000 | 1.000000 | 0.000000 | 0.000000 | 482.750000 | 1.000000 |
| **max** | 4.970000 | 1.000000 | 1.000000 | 5.000000 | 1.000000 | 2653.000000 | 1.000000 |

## Declare the dependent and independent variables

Use 'duration' as the independet variable.

In [ ]:
```
y = data['y']
x = data['duration']
```

## Simple Logistic Regression

Run the regression and graph the scatter plot.

In [ ]:
```
x1 = sm.add_constant(x)
reg_log = sm.Logit(y,x1)
results_log = reg_log.fit()
results_log.summary()
```

```
Optimization terminated successfully.
         Current function value: 0.546118
         Iterations 7
```

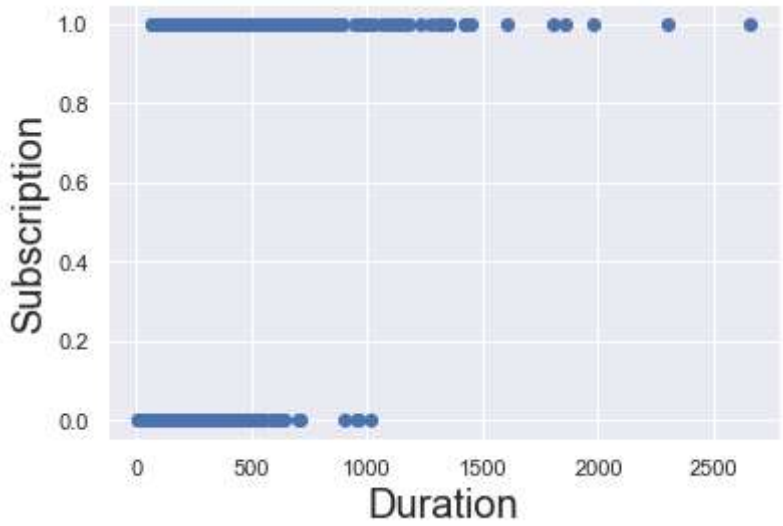
Out[ ]:

Logit Regression Results

| | | | |
|---|---|---|---|
| **Dep. Variable:** | y | **No. Observations:** | 518 |
| **Model:** | Logit | **Df Residuals:** | 516 |
| **Method:** | MLE | **Df Model:** | 1 |
| **Date:** | Wed, 15 Feb 2023 | **Pseudo R-squ.:** | 0.2121 |
| **Time:** | 18:27:59 | **Log-Likelihood:** | -282.89 |
| **converged:** | True | **LL-Null:** | -359.05 |
| **Covariance Type:** | nonrobust | **LLR p-value:** | 5.387e-35 |

| | coef | std err | z | P>\|z\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| **const** | -1.7001 | 0.192 | -8.863 | 0.000 | -2.076 | -1.324 |
| **duration** | 0.0051 | 0.001 | 9.159 | 0.000 | 0.004 | 0.006 |

In [ ]:
```
plt.scatter(x,y,color = 'C0')
plt.xlabel('Duration', fontsize = 20)
plt.ylabel('Subscription', fontsize = 20)
plt.show()
```




# Expand the model

We can be omitting many causal factors in our simple logistic model, so we instead switch to a multivariate logistic regression model. Add the 'interest_rate', 'march', 'credit' and 'previous' estimators to our model and run the regression again.

## Declare the independent variable(s)

In [ ]:
```
X_all = data[['interest_rate','credit','march','previous','duration']]
y = data['y']
```

In [ ]:
```
X_all = sm.add_constant(X_all)
reg_logit = sm.Logit(y,X_all)
results_logit = reg_logit.fit()
results_logit.summary()
```

```
Optimization terminated successfully.
         Current function value: 0.336664
         Iterations 7
```

Out[ ]:

Logit Regression Results

| | | | |
|---|---|---|---|
| **Dep. Variable:** | y | **No. Observations:** | 518 |
| **Model:** | Logit | **Df Residuals:** | 512 |
| **Method:** | MLE | **Df Model:** | 5 |
| **Date:** | Wed, 15 Feb 2023 | **Pseudo R-squ.:** | 0.5143 |
| **Time:** | 18:28:01 | **Log-Likelihood:** | -174.39 |
| **converged:** | True | **LL-Null:** | -359.05 |
| **Covariance Type:** | nonrobust | **LLR p-value:** | 1.211e-77 |

| | coef | std err | z | P>\|z\| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| **const** | -0.0211 | 0.311 | -0.068 | 0.946 | -0.631 | 0.589 |
| **interest_rate** | -0.8001 | 0.089 | -8.943 | 0.000 | -0.975 | -0.625 |
| **credit** | 2.3585 | 1.088 | 2.169 | 0.030 | 0.227 | 4.490 |
| **march** | -1.8322 | 0.330 | -5.556 | 0.000 | -2.478 | -1.186 |
| **previous** | 1.5363 | 0.501 | 3.067 | 0.002 | 0.554 | 2.518 |
| **duration** | 0.0070 | 0.001 | 9.381 | 0.000 | 0.006 | 0.008 |

## Confusion Matrix

Find the confusion matrix of the model and estimate its accuracy.

*For convenience we have already provided you with a function that finds the confusion matrix and the model accuracy.*

In [ ]:
```
def confusion_matrix(data,actual_values,model):
        pred_values = model.predict(data)
        bins=np.array([0,0.5,1])
        cm = np.histogram2d(actual_values, pred_values, bins=bins)[0]
        accuracy = (cm[0,0]+cm[1,1])/cm.sum()
        return cm, accuracy
```

In [ ]:
```
confusion_matrix(X_all,y,results_logit)
```

Out[ ]:
```
(array([[218.,  41.],
        [ 30., 229.]]),
 0.862934362934363)
```

# Test the model

Load the test data from the 'Bank_data_testing.csv' file provided. (Remember to convert the outcome variable 'y' into Boolean).

## Load new data

In [ ]:
```
raw_data2 = pd.read_csv('Bank_data_testing.csv')
data_test = raw_data2.copy()
data_test = data_test.drop(['Unnamed: 0'], axis = 1)
```

In [ ]:
```
data_test['y'] = data_test['y'].map({'yes':1, 'no':0})
data_test.head()
```

Out[ ]:

| | interest_rate | credit | march | may | previous | duration | y |
|---|---|---|---|---|---|---|---|
| **0** | 1.313 | 0.0 | 1.0 | 0.0 | 0.0 | 487.0 | 0 |
| **1** | 4.961 | 0.0 | 0.0 | 0.0 | 0.0 | 132.0 | 0 |
| **2** | 4.856 | 0.0 | 1.0 | 0.0 | 0.0 | 92.0 | 0 |
| **3** | 4.120 | 0.0 | 0.0 | 0.0 | 0.0 | 1468.0 | 1 |
| **4** | 4.963 | 0.0 | 0.0 | 0.0 | 0.0 | 36.0 | 0 |

## Declare the dependent and the independent variables

In [ ]:
```
y_test = data_test['y']
X1_test = data_test[['interest_rate','credit','march','previous','duration']]
X_test = sm.add_constant(X1_test)
```

In [ ]:
```
confusion_matrix(X_test, y_test, results_logit)
```

Out[ ]:
```
(array([[93., 18.],
        [13., 98.]]),
 0.8603603603603603)
```

Determine the test confusion matrix and the test accuracy and compare them with the train confusion matrix and the train accuracy.