VU1F1920014
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BE comps-A/A

ML Exp No. 2

Aim: To understand and implement the logistic regression algorithm.

Theory:

Logistic Regression is classification algorithm. It is used to predict a binary outcome (1/0, yes/No, True/False) given a set of independent variables. It predicts the probability of occurence of an event by fitting data to a logit function.

$$\phi(z) = \frac{1}{1 + e^{-z}}$$

$$z = w^T x = w_0 x_0 + w_1 x_1 + \dots \; w_n x_n$$

$$\ln\left(\frac{P}{1-p}\right) = \beta_0 + \beta_1 x$$

$$P = \frac{e^{\beta_0 + \beta_1 x}}{1 + e^{\beta_0 + \beta_1 x}}$$

Library used:-

- **Pandas:** It perform five significant steps for processing and analysis of data i.e load, manipulate, prepare, model and analyze.

- Numpy: It consist of multidimensional array object and collection of routines for processing of array.

- Matplotlib: It uses to create 2D graphs and plote by using python scripts.

- Seaborn: It is used for data visualization and exploratory data analysis.

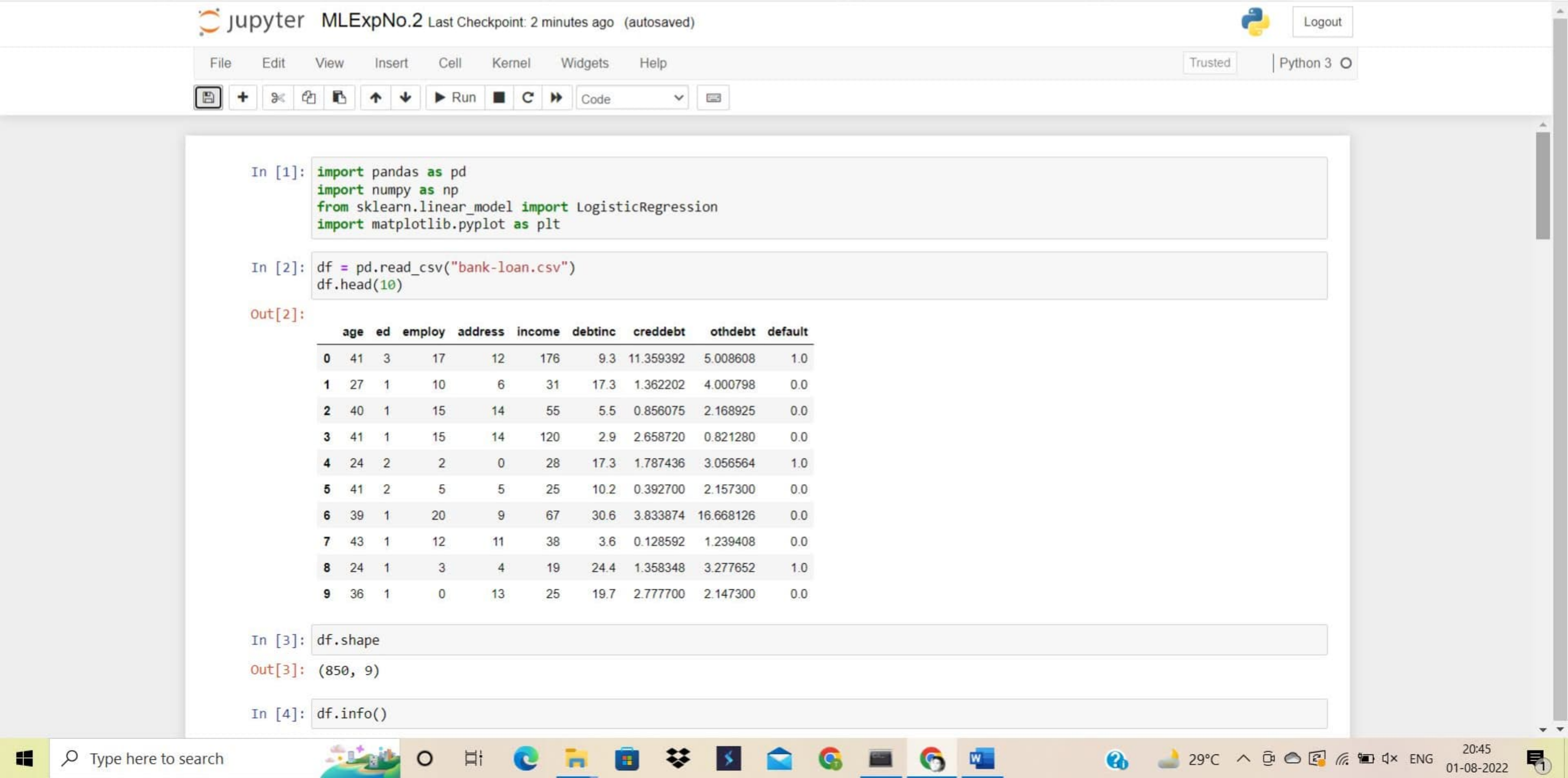
- LogisticRegression: It is used to predict probability of categorical dependent variable.

- sklearn.metrics: It implements several loss, score, and utility function to measure classification performance.

- train_test_split: It performs the split and return four sequences: X-train, X-test, y-train, y-test.

* Dataset: 'bank-loan.csv'

Conclusion: Hence, we have successfully implemented logistic regression algorithm.



In [1]:
```
import pandas as pd
import numpy as np
from sklearn.linear_model import LogisticRegression
import matplotlib.pyplot as plt
```

In [2]:
```
df = pd.read_csv("bank-loan.csv")
df.head(10)
```

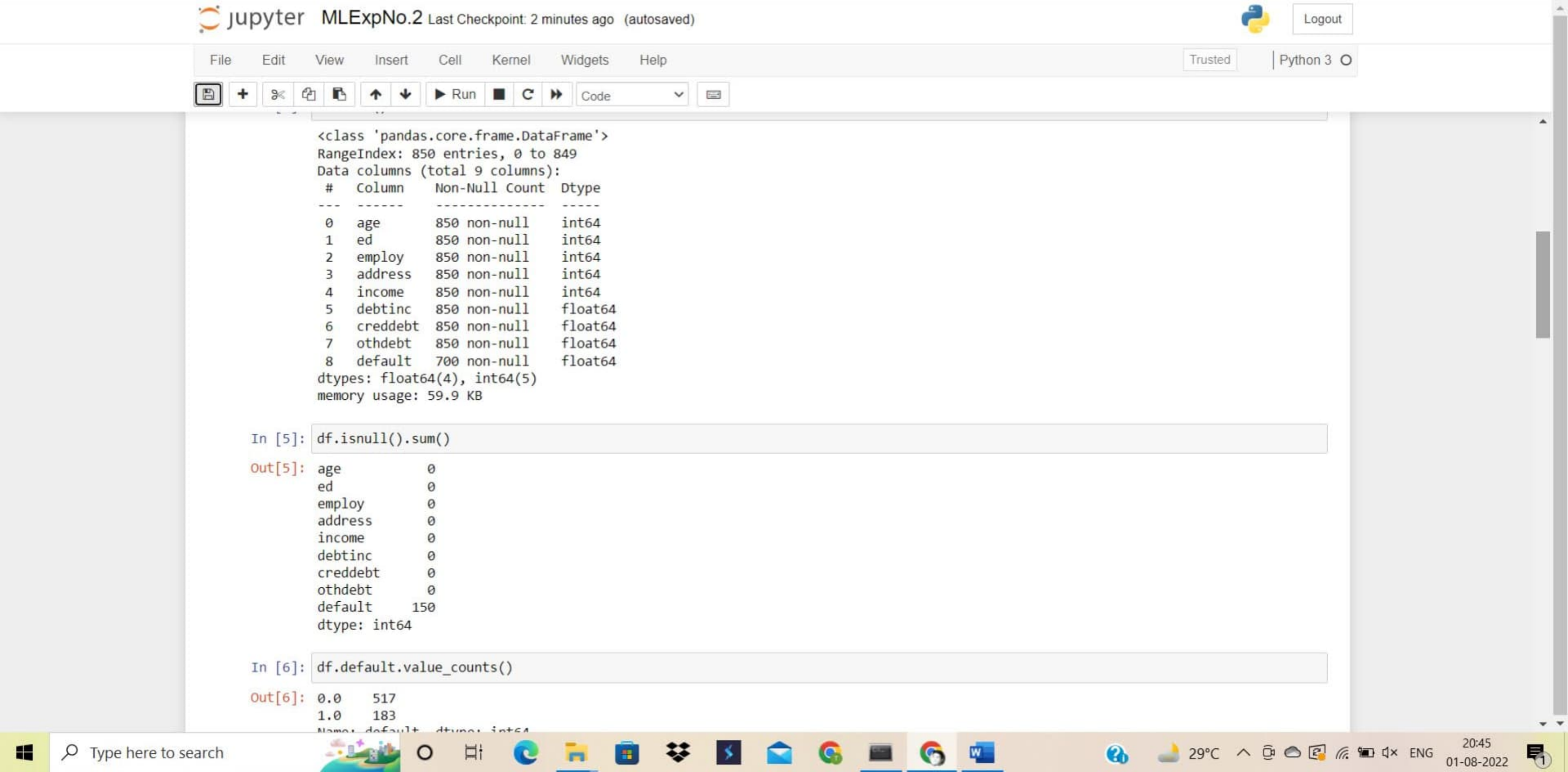
Out[2]:

	age	ed	employ	address	income	debtinc	creddebt	othdebt	default
0	41	3	17	12	176	9.3	11.359392	5.008608	1.0
1	27	1	10	6	31	17.3	1.362202	4.000798	0.0
2	40	1	15	14	55	5.5	0.856075	2.168925	0.0
3	41	1	15	14	120	2.9	2.658720	0.821280	0.0
4	24	2	2	0	28	17.3	1.787436	3.056564	1.0
5	41	2	5	5	25	10.2	0.392700	2.157300	0.0
6	39	1	20	9	67	30.6	3.833874	16.668126	0.0
7	43	1	12	11	38	3.6	0.128592	1.239408	0.0
8	24	1	3	4	19	24.4	1.358348	3.277652	1.0
9	36	1	0	13	25	19.7	2.777700	2.147300	0.0

In [3]:
```
df.shape
```

Out[3]:
```
(850, 9)
```

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



```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 850 entries, 0 to 849
Data columns (total 9 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       850 non-null    int64  
 1   ed        850 non-null    int64  
 2   employ    850 non-null    int64  
 3   address   850 non-null    int64  
 4   income    850 non-null    int64  
 5   debtinc   850 non-null    float64
 6   creddebt  850 non-null    float64
 7   othdebt   850 non-null    float64
 8   default   700 non-null    float64
dtypes: float64(4), int64(5)
memory usage: 59.9 KB
```

In [5]:

```
df.isnull().sum()
```

Out[5]:

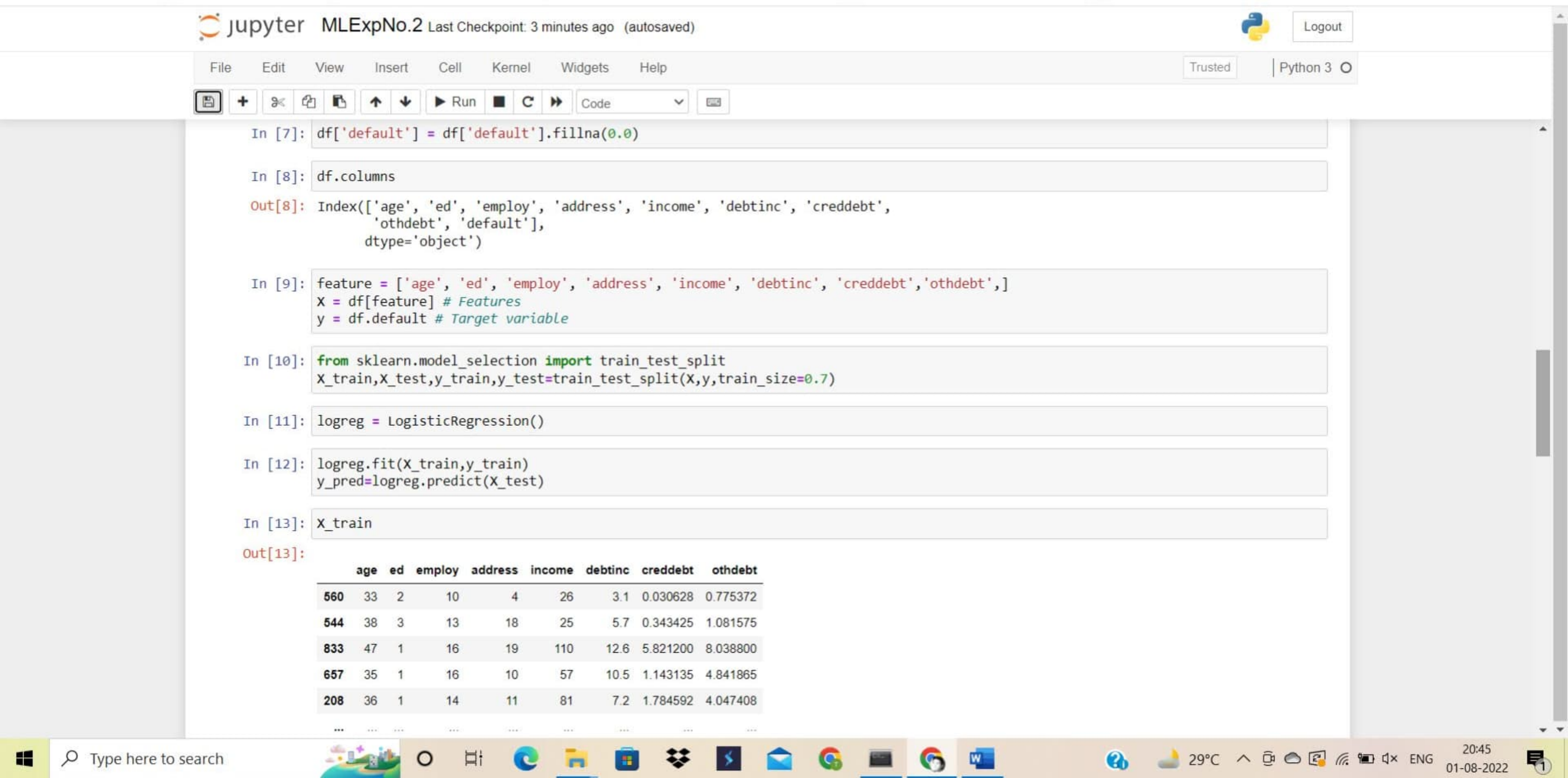
```
age           0
ed            0
employ        0
address       0
income        0
debtinc       0
creddebt      0
othdebt       0
default     150
dtype: int64
```

In [6]:

```
df.default.value_counts()
```

Out[6]:

```
0.0    517
1.0    183
Name: default, dtype: int64
```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```
In [7]: df['default'] = df['default'].fillna(0.0)
```

```
In [8]: df.columns
```

```
Out[8]: Index(['age', 'ed', 'employ', 'address', 'income', 'debtinc', 'creddebt',
               'othdebt', 'default'],
              dtype='object')
```

```
In [9]: feature = ['age', 'ed', 'employ', 'address', 'income', 'debtinc', 'creddebt','othdebt',]
        X = df[feature] # Features
        y = df.default # Target variable
```

```
In [10]: from sklearn.model_selection import train_test_split
         X_train,X_test,y_train,y_test=train_test_split(X,y,train_size=0.7)
```

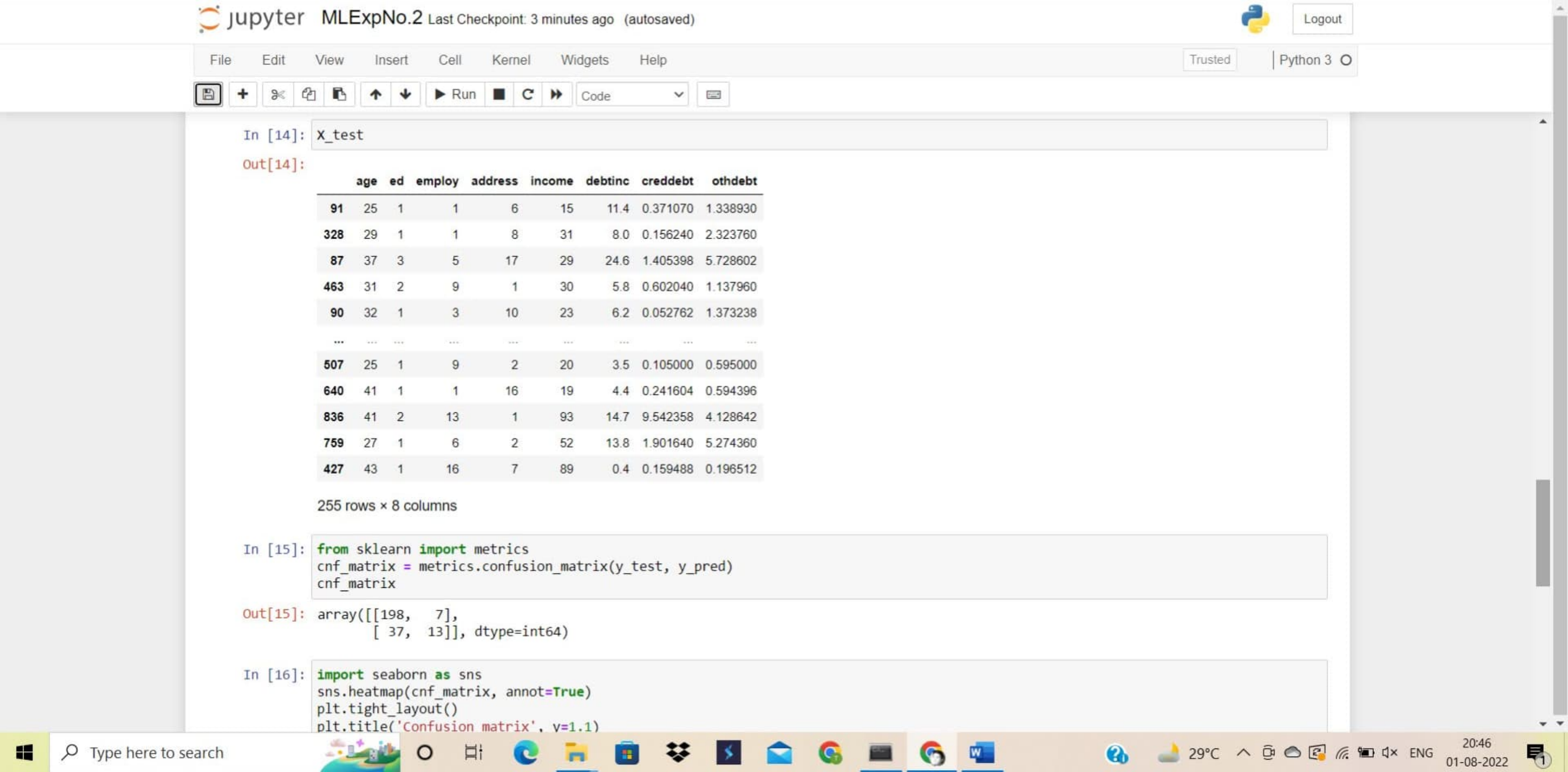
```
In [11]: logreg = LogisticRegression()
```

```
In [12]: logreg.fit(X_train,y_train)
         y_pred=logreg.predict(X_test)
```

```
In [13]: X_train
```

Out[13]:

	age	ed	employ	address	income	debtinc	creddebt	othdebt
560	33	2	10	4	26	3.1	0.030628	0.775372
544	38	3	13	18	25	5.7	0.343425	1.081575
833	47	1	16	19	110	12.6	5.821200	8.038800
657	35	1	16	10	57	10.5	1.143135	4.841865
208	36	1	14	11	81	7.2	1.784592	4.047408
...	...	...	...	...	...	...	...	...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In [14]:
```
X_test
```

Out[14]:

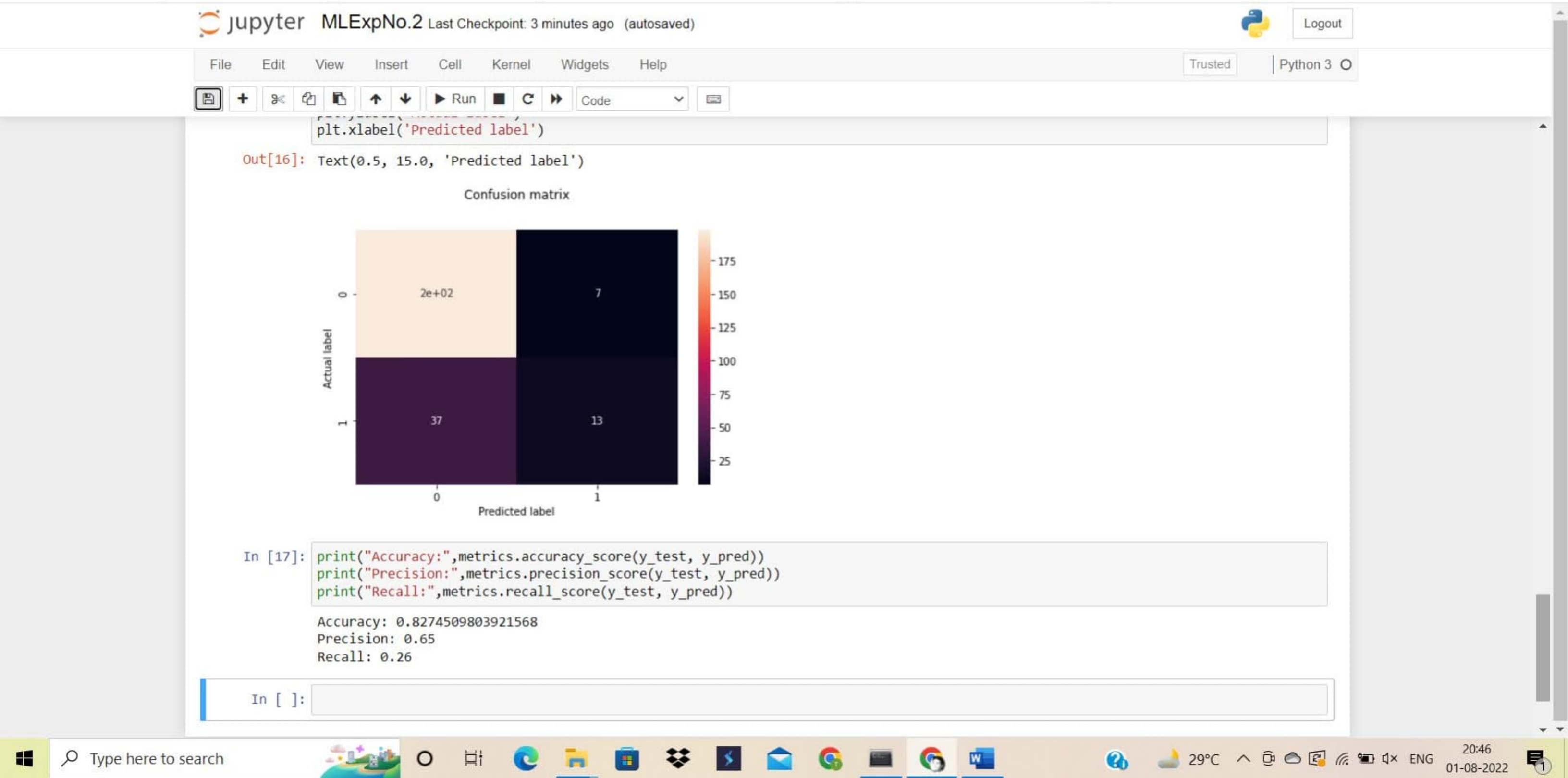
	age	ed	employ	address	income	debtinc	creddebt	othdebt
91	25	1	1	6	15	11.4	0.371070	1.338930
328	29	1	1	8	31	8.0	0.156240	2.323760
87	37	3	5	17	29	24.6	1.405398	5.728602
463	31	2	9	1	30	5.8	0.602040	1.137960
90	32	1	3	10	23	6.2	0.052762	1.373238
...	...	...	...	...	...	...	...	...
507	25	1	9	2	20	3.5	0.105000	0.595000
640	41	1	1	16	19	4.4	0.241604	0.594396
836	41	2	13	1	93	14.7	9.542358	4.128642
759	27	1	6	2	52	13.8	1.901640	5.274360
427	43	1	16	7	89	0.4	0.159488	0.196512

255 rows × 8 columns

In [15]:
```
from sklearn import metrics
cnf_matrix = metrics.confusion_matrix(y_test, y_pred)
cnf_matrix
```

Out[15]:
```
array([[198,   7],
       [ 37,  13]], dtype=int64)
```

In [16]:
```
import seaborn as sns
sns.heatmap(cnf_matrix, annot=True)
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
```



```
plt.xlabel('Predicted label')
```

```
Out[16]: Text(0.5, 15.0, 'Predicted label')
```

```
In [17]: print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
         print("Precision:",metrics.precision_score(y_test, y_pred))
         print("Recall:",metrics.recall_score(y_test, y_pred))
```

```
Accuracy: 0.8274509803921568
Precision: 0.65
Recall: 0.26
```

```
In [ ]:
```