```
from google.colab import files
uploaded = files.upload()
```

Choose Files bank_churn.csv.csv

bank_churn.csv.csv(text/csv) - 837415 bytes, last modified: 9/18/2025 - 100% done

```
Saving bank_churn.csv.csv to bank_churn.csv (1).csv
```

```
import pandas as pd
pd.set_option('display.max_columns', 100)

df = pd.read_csv("bank_churn.csv.csv")
df.head()
```

Gender	Age	Tenure	Balance	NumOfProducts	HasCrCard	IsActiveMember
Female	42	2	0.00	1	1	1
Female	41	1	83807.86	1	0	1
Female	42	8	159660.80	3	1	0
Female	39	1	0.00	2	0	0
Female	43	2	125510.82	1	1	1

Next steps: Generate code with df | New interactive sheet

```
df.isna().sum().sort_values(ascending=False).head(10)
```

	0
RowNumber	0
CustomerId	0
Surname	0
CreditScore	0
Geography	0
Gender	0
Age	0
Tenure	0
Balance	0
NumOfProducts	0

dtype: int64

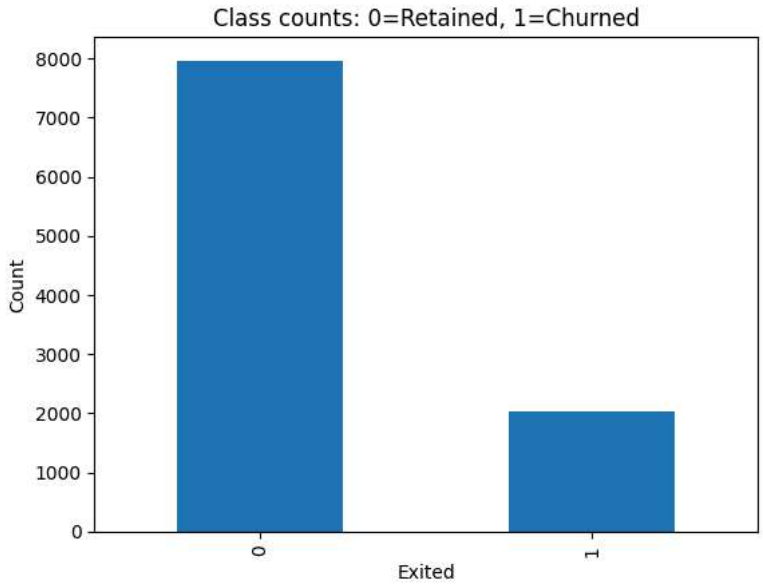
```
churn_rate = df['Exited'].mean()*100
print(f"Churn rate: {churn_rate:.2f}%")
df['Exited'].value_counts(normalize=True)
```

```
Churn rate: 20.38%
```

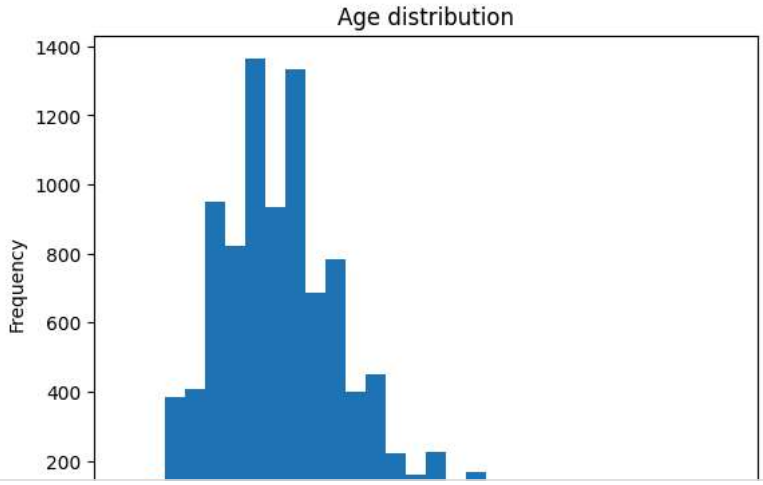
Exited	proportion
0	0.7962
1	0.2038

dtype: float64

```
import matplotlib.pyplot as plt

df['Exited'].value_counts().plot(kind='bar', title='Class counts: 0=Retained, 1=Churned')
plt.xlabel('Exited'); plt.ylabel('Count'); plt.show()
```




```
# Numeric distributions
df['Age'].plot(kind='hist', bins=30, title='Age distribution'); plt.show()
df['Balance'].plot(kind='hist', bins=30, title='Balance distribution'); plt.show()

# Churn rate by categories
df.groupby('Geography')['Exited'].mean().sort_values().plot(kind='bar', title='Churn rate by Geography'); plt.show()
df.groupby('NumOfProducts')['Exited'].mean().plot(kind='bar', title='Churn rate by Number of Products'); plt.show()
```

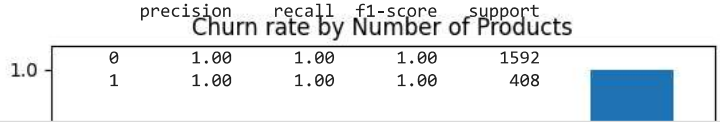



```
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import OneHotEncoder, StandardScaler
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline

# Drop pure identifiers
drop_cols = [c for c in ['RowNumber','CustomerId','Surname'] if c in df.columns]
d2 = df.drop(columns=drop_cols)

# Features/target
X = d2.drop(columns=['Exited'])
y = d2['Exited']

# Define columns (only include those that actually exist)
cat_cols = [c for c in ['Geography','Gender','Card Type'] if c in X.columns]
num_cols = [c for c in ['CreditScore','Age','Tenure','Balance','NumOfProducts','HasCrCard',
                        'IsActiveMember','EstimatedSalary','Complain','Satisfaction Score','Point Earned']
            if c in X.columns]

preprocessor = ColumnTransformer(
    transformers=[
        ('cat', OneHotEncoder(handle_unknown='ignore', sparse_output=False), cat_cols),
        ('num', StandardScaler(), num_cols),
    ],
    remainder='drop'
)

X_train, X_test, y_train, y_test = train_test_split(
    X, y, test_size=0.2, stratify=y, random_state=42
)

len(X_train), len(X_test)
```

```
(8000, 2000)
```

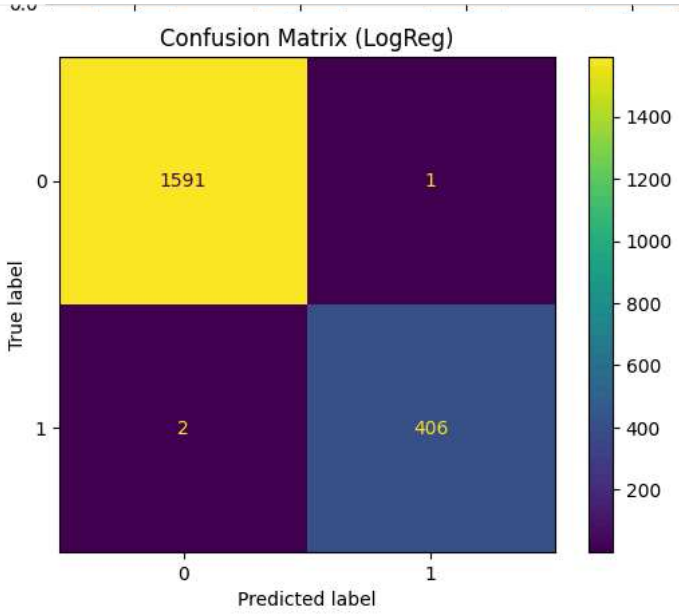

```
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, roc_auc_score

logreg = Pipeline([
    ('pre', preprocessor),
    ('clf', LogisticRegression(max_iter=2000, class_weight=None))
])

logreg.fit(X_train, y_train)
y_pred = logreg.predict(X_test)
y_proba = logreg.predict_proba(X_test)[:,1]

print(classification_report(y_test, y_pred))
print("ROC-AUC:", roc_auc_score(y_test, y_proba))
```

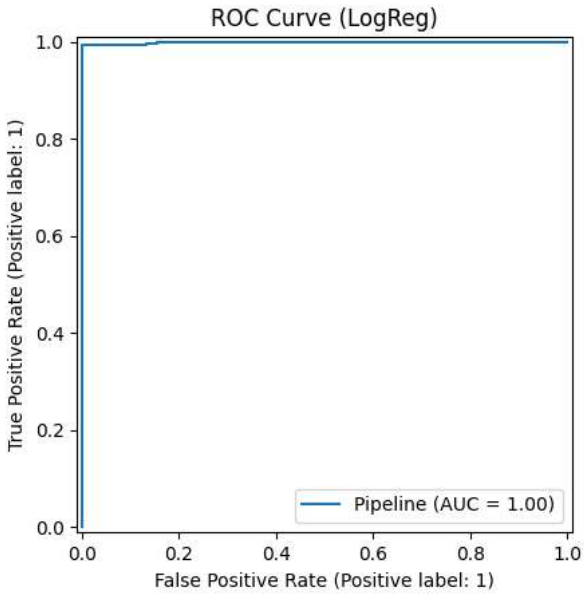
```
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      1592
           1       1.00      1.00      1.00       408
```



```
    accuracy                           1.00      2000
   macro avg       1.00      1.00      1.00      2000
weighted avg       1.00      1.00      1.00      2000

ROC-AUC: 0.999196349394029
```

```
from sklearn.metrics import ConfusionMatrixDisplay, RocCurveDisplay

ConfusionMatrixDisplay.from_estimator(logreg, X_test, y_test)
plt.title("Confusion Matrix (LogReg)")
plt.show()

RocCurveDisplay.from_estimator(logreg, X_test, y_test)
plt.title("ROC Curve (LogReg)")
plt.show()
```






```
import numpy as np

# Get trained OneHot categories to map names
ohe: OneHotEncoder = logreg.named_steps['pre'].transformers_[0][1]
cat_names = []
if hasattr(ohe, 'get_feature_names_out'):
    cat_names = list(ohe.get_feature_names_out(cat_cols))
else:
    # Fallback: generic names
    for c in cat_cols:
```

```
        cat_names.extend([f"{c}_{i}" for i in range(len(df[c].unique()))])

feature_names = cat_names + num_cols
coefs = logreg.named_steps['clf'].coef_[0]

# Align lengths just in case
n = min(len(feature_names), len(coefs))
imp = pd.DataFrame({'feature': feature_names[:n], 'coef': coefs[:n]})
imp.sort_values('coef', ascending=False).head(10)
```

	feature	coef
17	Complain	5.162571
10	Age	0.842630
8	Card Type_SILVER	0.230780
0	Geography_France	0.153102
2	Geography_Spain	0.113863
4	Gender_Male	0.076962
9	CreditScore	0.067107
16	EstimatedSalary	0.031035
12	Balance	0.019445
5	Card Type_DIAMOND	0.011998

```
imp.sort_values('coef').head(10)
```

	feature	coef
15	IsActiveMember	-0.631547
19	Point Earned	-0.398064
1	Geography_Germany	-0.217867
18	Satisfaction Score	-0.210629
6	Card Type_GOLD	-0.098047
7	Card Type_PLATINUM	-0.095633
13	NumOfProducts	-0.088082
11	Tenure	-0.065608
14	HasCrCard	-0.041699
3	Gender_Female	-0.027864

```
from sklearn.ensemble import RandomForestClassifier

rf = Pipeline([
    ('pre', preprocessor),
    ('clf', RandomForestClassifier(
        n_estimators=300, max_depth=None, random_state=42, n_jobs=-1
    ))
])

rf.fit(X_train, y_train)
rf_pred = rf.predict(X_test)
rf_proba = rf.predict_proba(X_test)[:,1]

print(classification_report(y_test, rf_pred))
print("ROC-AUC:", roc_auc_score(y_test, rf_proba))
```

```
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      1592
           1       1.00      1.00      1.00       408

    accuracy                           1.00      2000
   macro avg       1.00      1.00      1.00      2000
```

```
weighted avg       1.00      1.00      1.00      2000

ROC-AUC: 0.9987483372746083
```

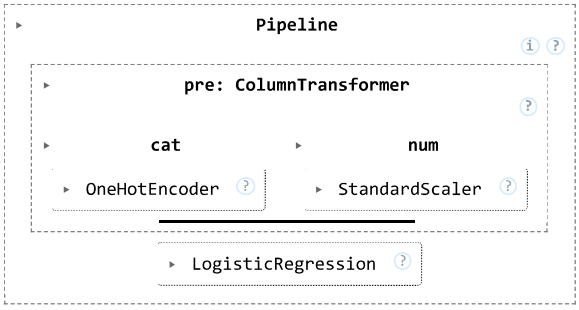
```
import pandas as pd

def predict_single_customer(model,
                            CreditScore=650, Geography="France", Gender="Male", Age=40,
                            Tenure=5, Balance=60000, NumOfProducts=2, HasCrCard=1,
                            IsActiveMember=1, EstimatedSalary=80000, Complain=0,
                            Satisfaction_Score=3, Card_Type="GOLD", Point_Earned=400):
    """
    Takes a trained model pipeline and one customer's details.
    Returns churn probability (0 to 1).
    """
    sample = pd.DataFrame([{
        "CreditScore": CreditScore,
        "Geography": Geography,
        "Gender": Gender,
        "Age": Age,
        "Tenure": Tenure,
        "Balance": Balance,
        "NumOfProducts": NumOfProducts,
        "HasCrCard": HasCrCard,
        "IsActiveMember": IsActiveMember,
        "EstimatedSalary": EstimatedSalary,
        "Complain": Complain,
        "Satisfaction Score": Satisfaction_Score,
        "Card Type": Card_Type,
        "Point Earned": Point_Earned
    }])

    prob = model.predict_proba(sample)[:,1][0]
    return prob
```

```
prob = predict_single_customer(
    logreg,  # or rf
    CreditScore=720,
    Geography="Germany",
    Gender="Female",
    Age=45,
    Tenure=3,
    Balance=90000,
    NumOfProducts=1,
    HasCrCard=1,
    IsActiveMember=0,
    EstimatedSalary=120000,
    Complain=1,
    Satisfaction_Score=2,
    Card_Type="DIAMOND",
    Point_Earned=500
)
print(f"Predicted churn probability: {prob:.2%}")
```

```
Predicted churn probability: 99.82%
```

```
# --- A) Rebuild clean features exactly like training ---
import pandas as pd
from sklearn.preprocessing import OneHotEncoder, StandardScaler
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline

# Drop pure identifiers
drop_cols = [c for c in ['RowNumber','CustomerId','Surname'] if c in df.columns]
d2 = df.drop(columns=drop_cols).copy()

X = d2.drop(columns=['Exited'])
y = d2['Exited']

cat_cols = [c for c in ['Geography','Gender','Card Type'] if c in X.columns]
num_cols = [c for c in [
    'CreditScore','Age','Tenure','Balance','NumOfProducts','HasCrCard',
    'IsActiveMember','EstimatedSalary','Complain','Satisfaction Score','Point Earned'
```

```
] if c in X.columns]

preprocessor = ColumnTransformer(
    transformers=[
        ('cat', OneHotEncoder(handle_unknown='ignore', sparse_output=False), cat_cols),
        ('num', StandardScaler(), num_cols),
    ],
    remainder='drop'
)

# If you trained `logreg` earlier, keep using it; otherwise fit quickly here:
from sklearn.linear_model import LogisticRegression
pipe = Pipeline([('pre', preprocessor), ('clf', LogisticRegression(max_iter=2000))])
pipe.fit(X, y)
```




```
# --- B) Get predictions on ALL rows & create helper fields for the dashboard ---
proba = pipe.predict_proba(X)[:,1]
pred  = (proba >= 0.35).astype(int)   # threshold you can tune in PBI

out = d2.copy()
out['Pred_Prob'] = proba
out['Pred_Label'] = pred  # 1 = predicted churn
out['Actual_Label'] = out['Exited']  # 1 = actually churned

# Helper bands (nice for visuals)
out['Age Band'] = pd.cut(out['Age'], bins=[0,25,35,45,55,200],
                         labels=['≤25','26–35','36–45','46–55','56+'], right=True)

out['Balance Band'] = pd.cut(out['Balance'], bins=[-1,0,10000,50000,100000,99999999],
                             labels=['0','0–10k','10k–50k','50k–100k','100k+'])

out['Satisfaction Band'] = out['Satisfaction Score'].map({1:'1 - Very Low',2:'2 - Low',3:'3 - Mid',4:'4 - High',5:'5 - Very High'}

out[['Geography','Gender','Age','Age Band','Tenure','Balance','Balance Band',
     'NumOfProducts','HasCrCard','IsActiveMember','EstimatedSalary','Complain',
     'Satisfaction Score','Satisfaction Band','Card Type','Point Earned',
     'Actual_Label','Pred_Prob','Pred_Label']].head()
```

	Geography	Gender	Age	Age Band	Tenure	Balance	Balance Band	NumOfProducts	HasCrCard	IsActiveMember	EstimatedSalary	Complain	Sat
				36–									