----> Importing libraries

In [73]:
```
import pandas as pd
import numpy as np

import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline

import warnings
warnings.filterwarnings('ignore')

from sklearn.metrics import accuracy_score,classification_report,confusion_mat
```

--->Data Extraction

In [2]:
```
data = pd.read_csv('C://Datascience Projects/ML/Datasets/Loans_data.csv')
```

--->Data auditing

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

Out[3]:
```
(50000, 10)
```

In [4]:
```
data.head()
```

Out[4]:

	age	income	years_experience	credit_score	loan_amount	employment_type
0	56	128388	7	658.435992	43858	Salaried
1	69	33280	13	723.267738	284064	Self-Employed
2	46	22754	27	741.598799	98582	Self-Employed
3	32	70258	34	616.773385	282408	Salaried
4	60	63386	6	756.487805	171925	Salaried

In [5]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 50000 entries, 0 to 49999
Data columns (total 10 columns):
 #   Column            Non-Null Count  Dtype  
---  ------            --------------  -----  
 0   age               50000 non-null  int64  
 1   income            50000 non-null  int64  
 2   years_experience  50000 non-null  int64  
 3   credit_score      50000 non-null  float64
 4   loan_amount       50000 non-null  int64  
 5   employment_type   50000 non-null  object 
 6   city              50000 non-null  object 
 7   education         50000 non-null  object 
 8   marital_status    50000 non-null  object 
 9   target            50000 non-null  int64  
dtypes: float64(1), int64(5), object(4)
memory usage: 3.8+ MB
```

In [6]:
```
data.isna().sum()
```

Out[6]:
```
age                 0
income              0
years_experience    0
credit_score        0
loan_amount         0
employment_type     0
city                0
education           0
marital_status      0
target              0
dtype: int64
```

In [7]:
```
data.duplicated().sum()
```

Out[7]:
```
0
```

---> Exploratory Data Analysis

In [8]:
```
data.head()
```

Out[8]:

	age	income	years_experience	credit_score	loan_amount	employment_type
0	56	128388	7	658.435992	43858	Salaried
1	69	33280	13	723.267738	284064	Self-Employed
2	46	22754	27	741.598799	98582	Self-Employed
3	32	70258	34	616.773385	282408	Salaried
4	60	63386	6	756.487805	171925	Salaried

In [9]:
```python
data = data.rename(columns = {"target": "loan_status"})
```

In [10]:
```python
data.head()
```

Out[10]:

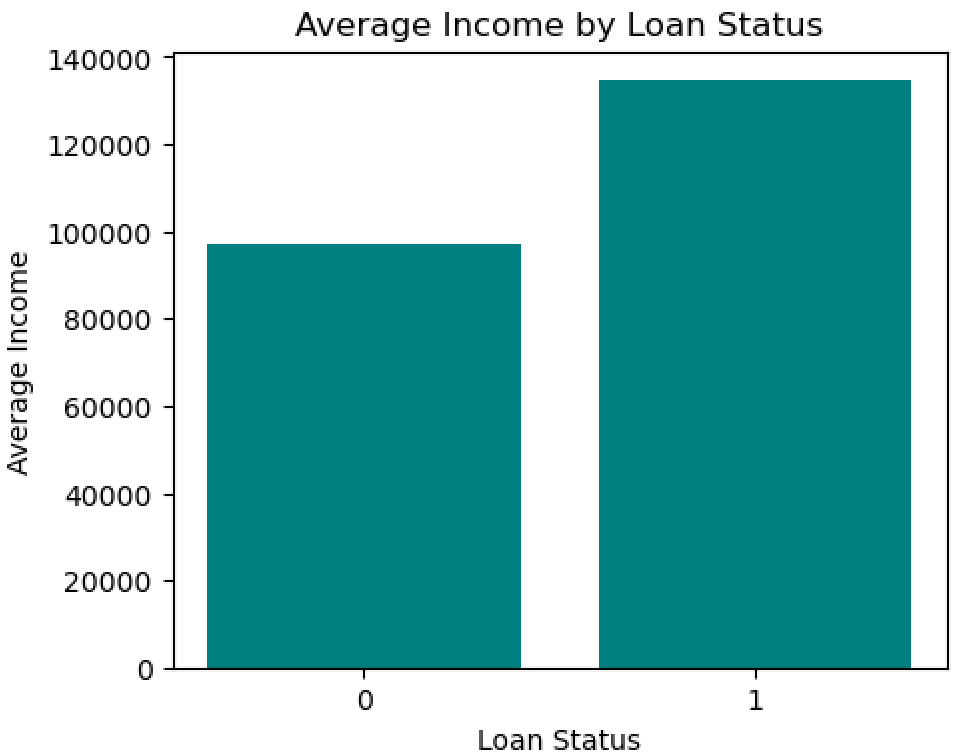
	age	income	years_experience	credit_score	loan_amount	employment_type
0	56	128388	7	658.435992	43858	Salaried
1	69	33280	13	723.267738	284064	Self-Employed
2	46	22754	27	741.598799	98582	Self-Employed
3	32	70258	34	616.773385	282408	Salaried
4	60	63386	6	756.487805	171925	Salaried

In [11]:
```python
avg_income = data.groupby("loan_status")["income"].mean()
```

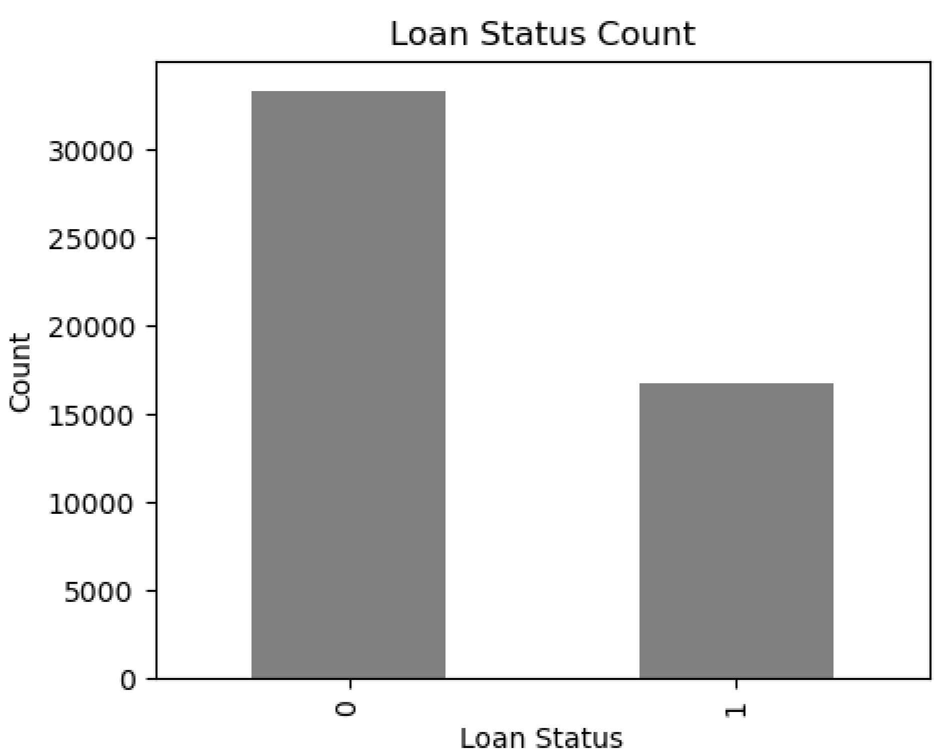
In [12]:
```python
avg_income
```

Out[12]:
```
loan_status
0     97034.294072
1    134526.051963
Name: income, dtype: float64
```

In [13]:
```python
plt.figure(figsize=(5,4))
plt.bar([0,1], avg_income.values, color = 'teal')
plt.xticks([0, 1], ["0", "1"])
plt.xlabel("Loan Status")
plt.ylabel("Average Income")
plt.title("Average Income by Loan Status")
plt.show()
```



In [14]:
```
plt.figure(figsize=(5,4))
data["loan_status"].value_counts().plot(kind="bar", color="grey")
plt.title("Loan Status Count")
plt.xlabel("Loan Status")
plt.ylabel("Count")
plt.show()
```



In [15]:
```
data.describe().T
```

Out[15]:

	count	mean	std	min	
age	50000.0	43.508260	14.987668	18.000000	31.0
income	50000.0	109545.293680	52043.634207	20002.000000	64528.7
years_experience	50000.0	16.956200	10.083428	0.000000	8.0
credit_score	50000.0	649.947228	79.915648	344.399734	596.1
loan_amount	50000.0	252918.827020	142876.555386	5018.000000	128997.2
loan_status	50000.0	0.333700	0.471539	0.000000	0.0

In [16]:
```
data.head()
```

Out[16]:

	age	income	years_experience	credit_score	loan_amount	employment_type
0	56	128388	7	658.435992	43858	Salaried
1	69	33280	13	723.267738	284064	Self-Employed
2	46	22754	27	741.598799	98582	Self-Employed
3	32	70258	34	616.773385	282408	Salaried
4	60	63386	6	756.487805	171925	Salaried

In [17]:
```
data = data.drop(['city', 'education', 'years_experience', 'marital_status'],a
```

In [18]:
```
data.head()
```

Out[18]:

	age	income	credit_score	loan_amount	employment_type	loan_status
0	56	128388	658.435992	43858	Salaried	0
1	69	33280	723.267738	284064	Self-Employed	0
2	46	22754	741.598799	98582	Self-Employed	1
3	32	70258	616.773385	282408	Salaried	0
4	60	63386	756.487805	171925	Salaried	0

In [19]:
```
y = data['loan_status']
```

In [20]:
```
y.isna().sum()
```

Out[20]: 0

In [21]:
```
num_df = data.select_dtypes(exclude = 'object')
```

```python
cat_df = data.select_dtypes(include = 'object')
```

In [22]:
```python
num_df = num_df.drop(['loan_status'],axis=1)
```

In [23]:
```python
num_df.head()
```

Out[23]:

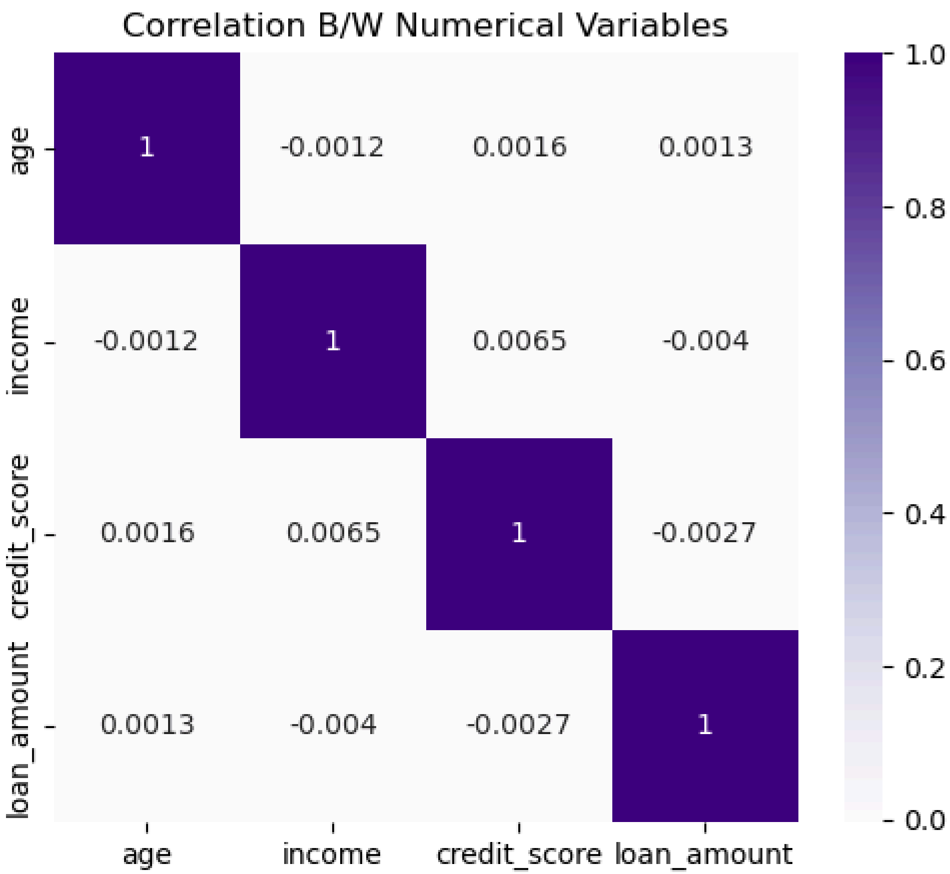
	age	income	credit_score	loan_amount
0	56	128388	658.435992	43858
1	69	33280	723.267738	284064
2	46	22754	741.598799	98582
3	32	70258	616.773385	282408
4	60	63386	756.487805	171925

In [24]:
```python
num_df.corr().T
```

Out[24]:

	age	income	credit_score	loan_amount
age	1.000000	-0.001247	0.001625	0.001323
income	-0.001247	1.000000	0.006499	-0.004037
credit_score	0.001625	0.006499	1.000000	-0.002746
loan_amount	0.001323	-0.004037	-0.002746	1.000000

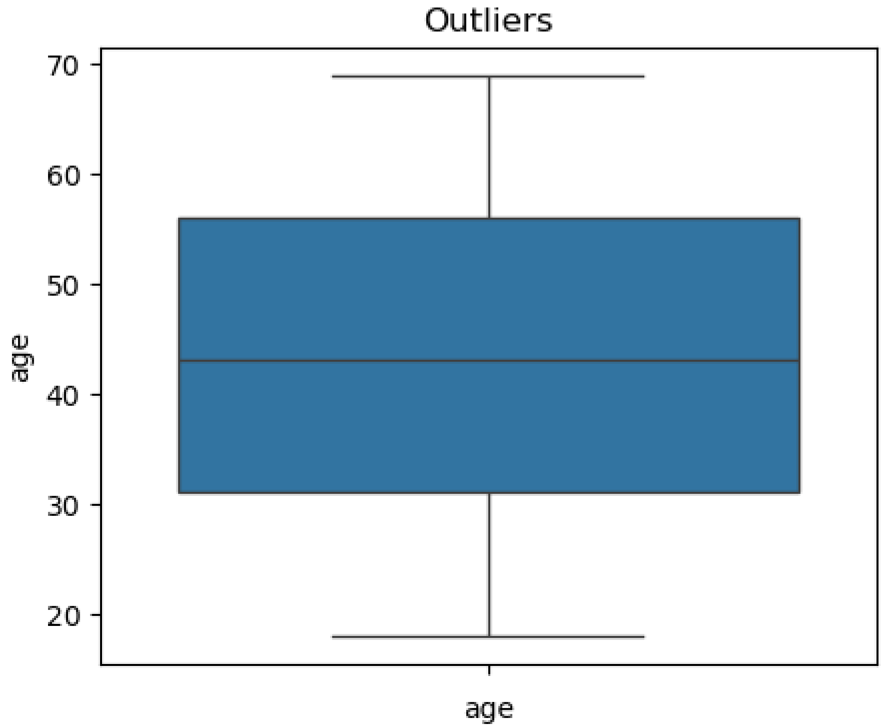
In [25]:
```python
plt.figure(figsize=(6,5))
sns.heatmap(num_df.corr(), annot=True, cmap='Purples')
plt.title("Correlation B/W Numerical Variables")
plt.show()
```



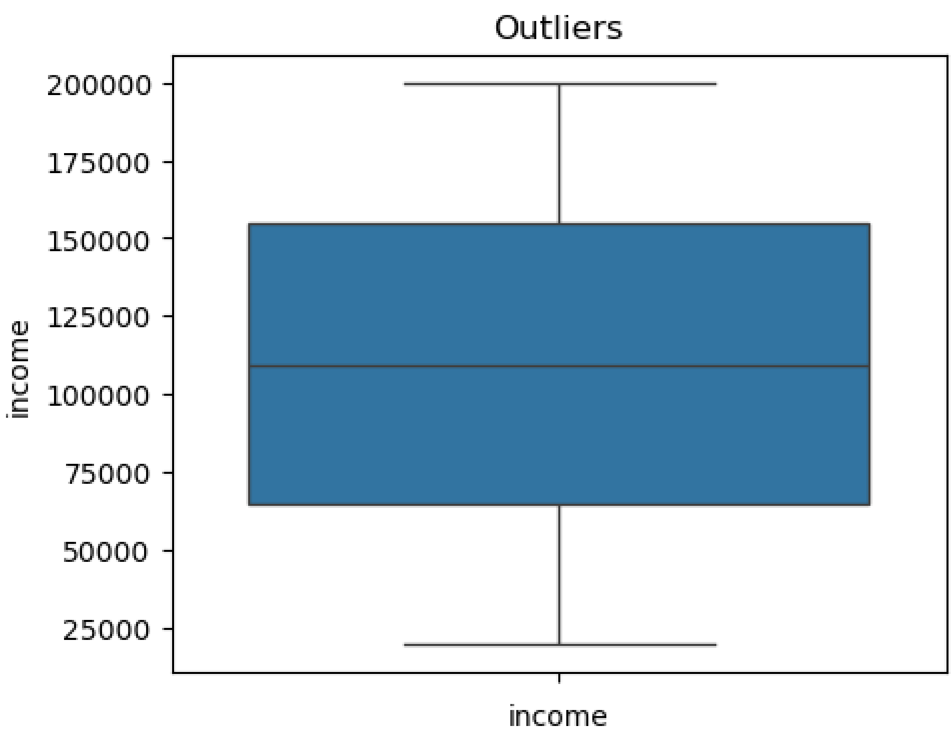
---> Outlier Checking

In [26]:

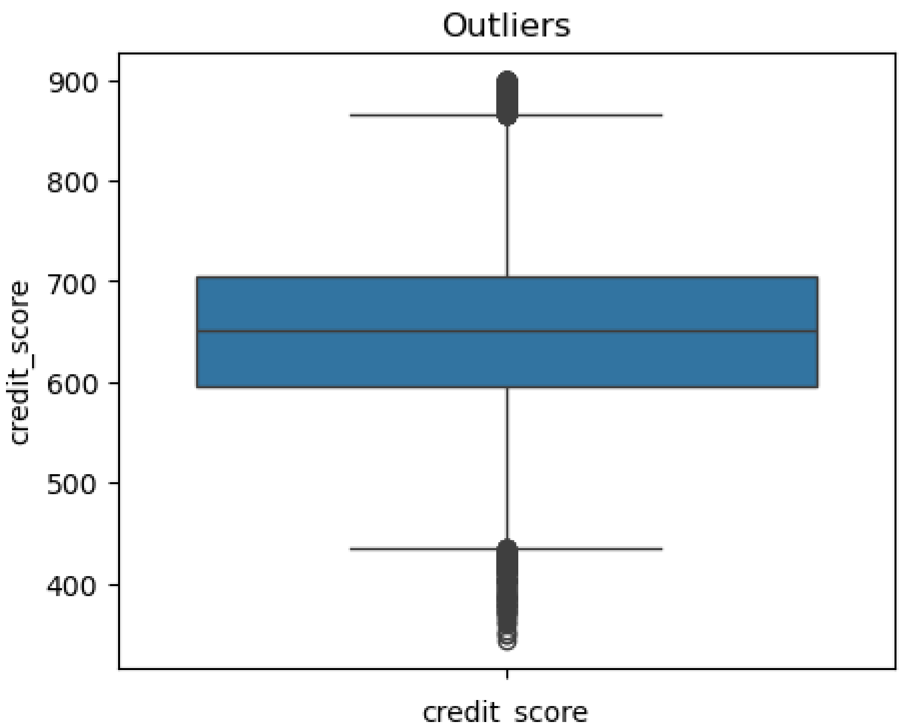
```
for col in num_df.columns:
    plt.figure(figsize=(5,4))
    sns.boxplot(num_df[col])
    plt.xlabel(col)
    plt.title("Outliers")
    plt.show()
```

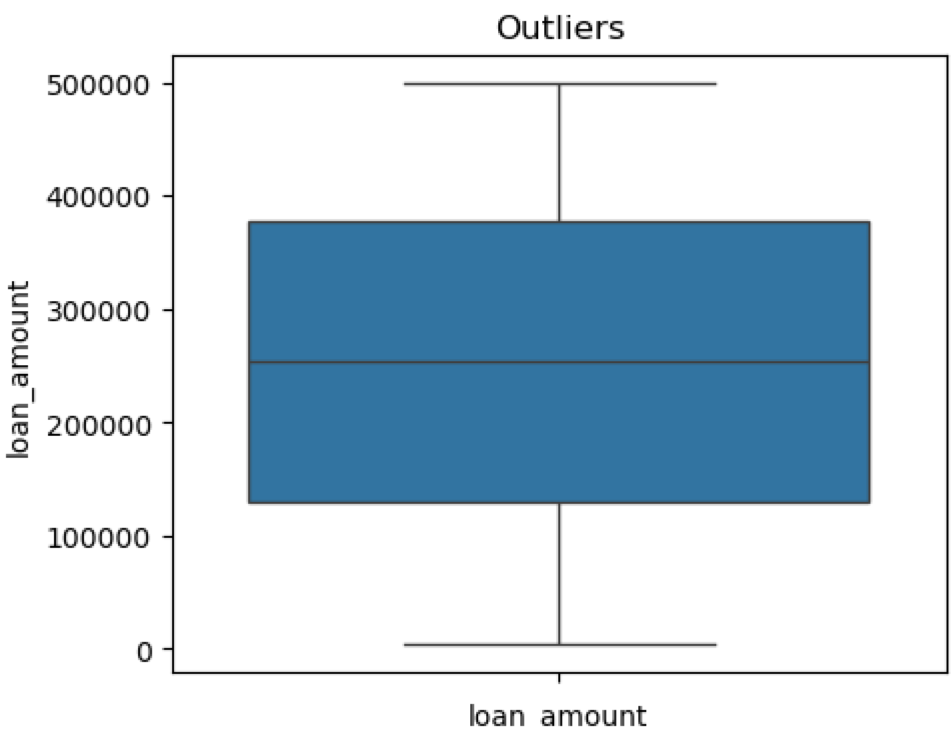


Outliers
70
60
50
40
30
20
age
age



Outliers
200000
175000
150000
125000
100000
75000
50000
25000
income
income





---> Outlier Treating

In [27]:
```
def outlier_treat(x):
    q1 = x.quantile(0.25)
    q3 = x.quantile(0.75)
    iqr = q3-q1
    uw = q3+1.5*iqr
```

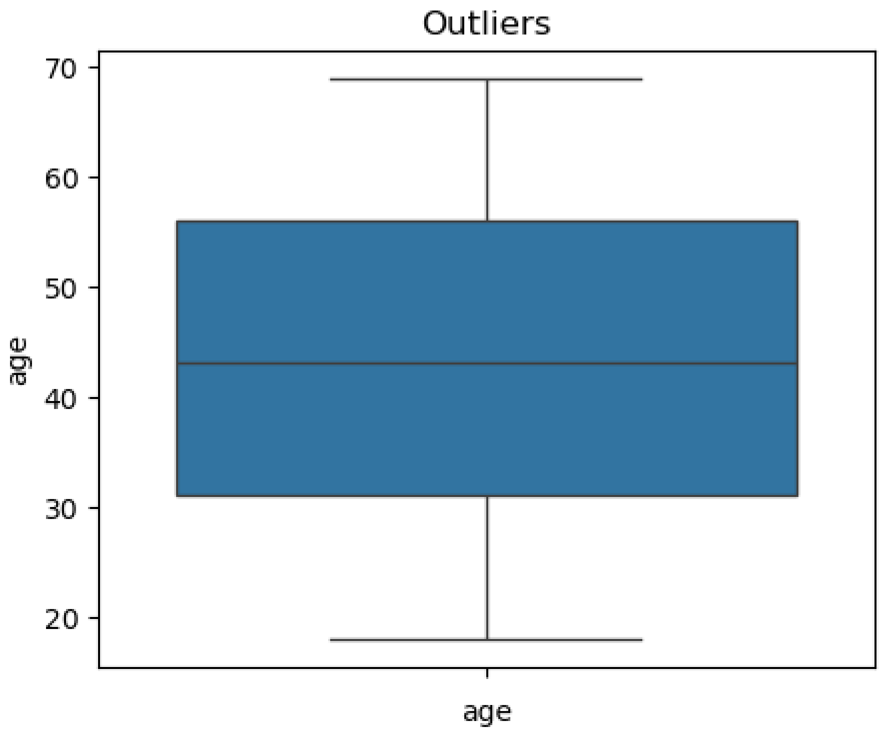
```
    lw = q1-1.5*iqr
    return(x.clip(upper = uw, lower = lw))
```

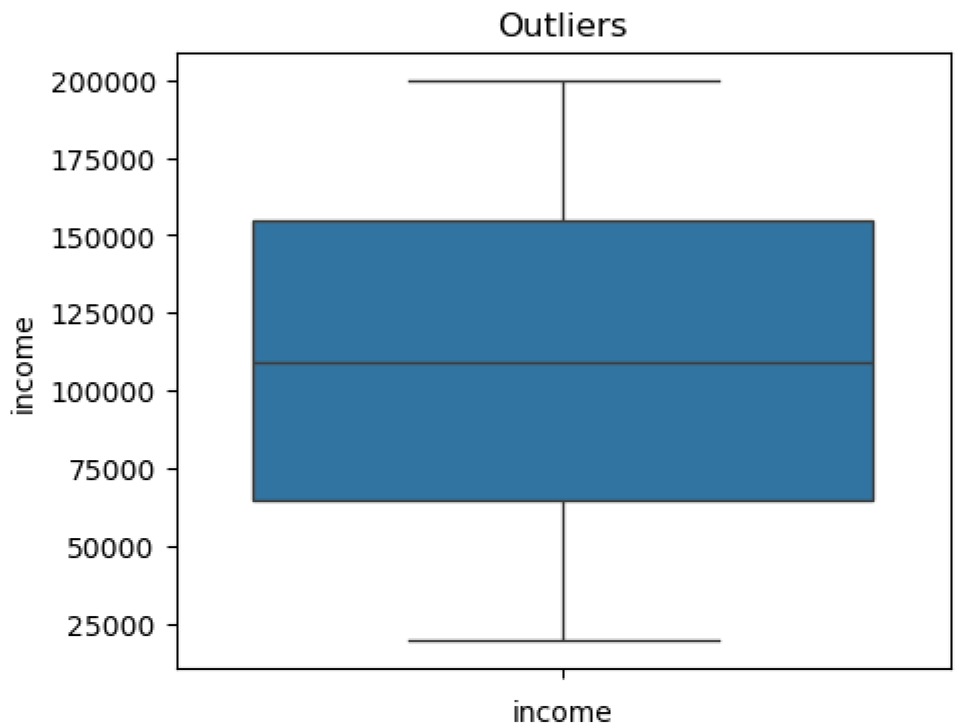
In [28]:

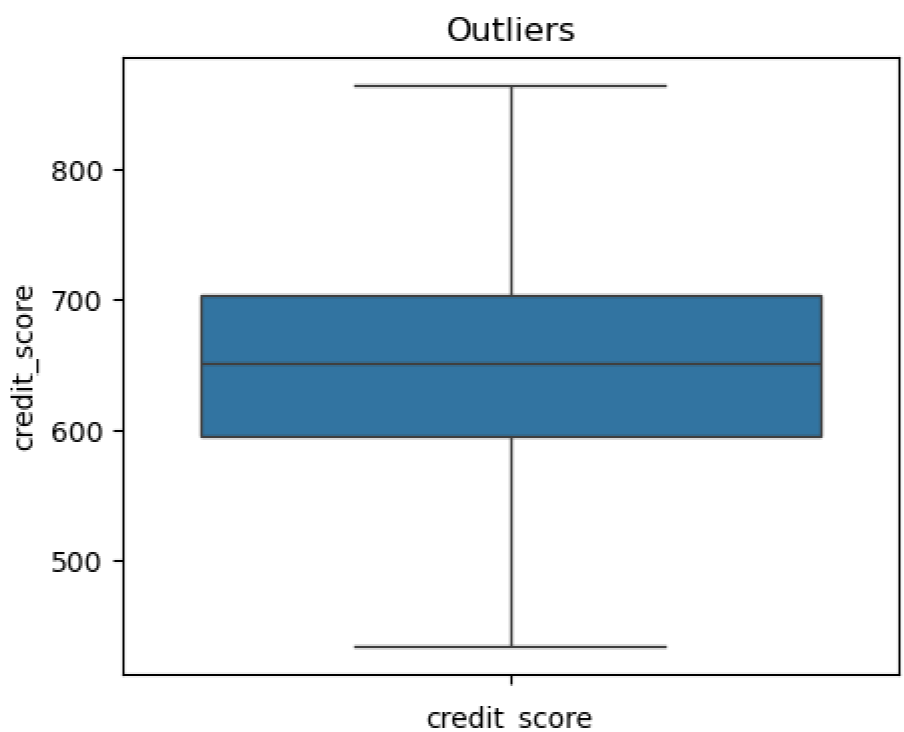
```
num_df = num_df.apply(outlier_treat)
```

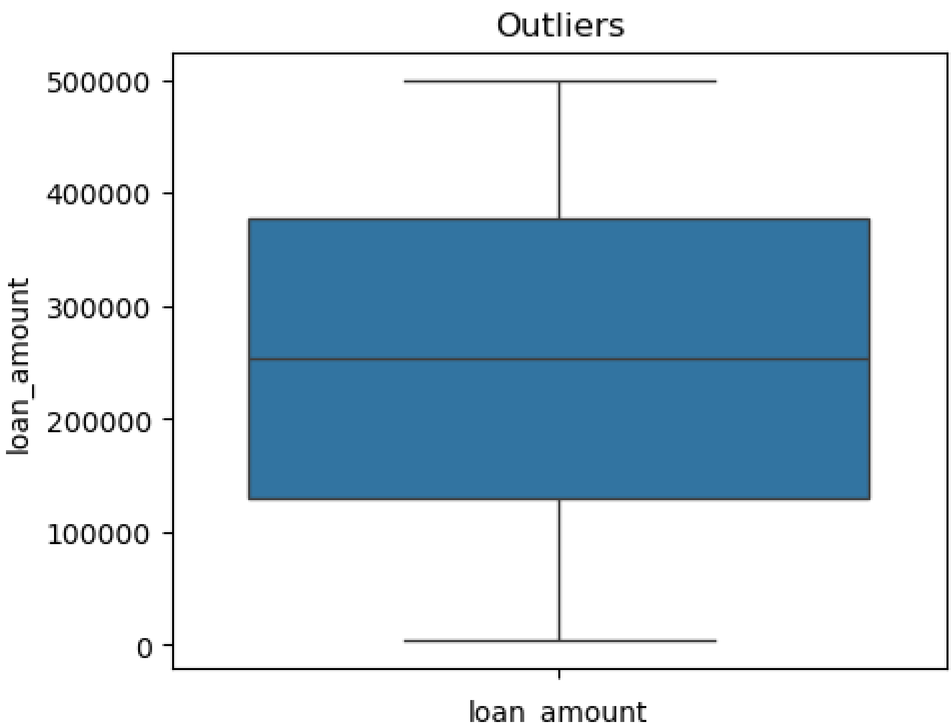
In [29]:

```
for col in num_df.columns:
    plt.figure(figsize=(5,4))
    sns.boxplot(num_df[col])
    plt.xlabel(col)
    plt.title("Outliers")
    plt.show()
```




Outliers
200000
175000
150000
125000
100000
75000
50000
25000
income
income


Outliers
800
700
600
500
credit_score
credit_score



---> Pre Processing

In [30]:
```
from sklearn.preprocessing import LabelEncoder
```

In [31]:
```
le = LabelEncoder()

cat_df["employment_type"] = le.fit_transform(cat_df["employment_type"])
```

In [32]:
```
cat_df.head()
```

Out[32]:

	employment_type
0	0
1	1
2	1
3	0
4	0

In [33]:
```
cat_df['employment_type'].value_counts()
```

Out[33]:
```
employment_type
2    12545
0    12535
1    12460
3    12460
Name: count, dtype: int64
```

0 → Student

1 → Self-Employed

2 → Salaried

3 → Unemployed

In [34]:
```
df = pd.concat([num_df,cat_df],axis=1)
```

In [35]:
```
df.head()
```

Out[35]:

	age	income	credit_score	loan_amount	employment_type
0	56	128388	658.435992	43858	0
1	69	33280	723.267738	284064	1
2	46	22754	741.598799	98582	1
3	32	70258	616.773385	282408	0
4	60	63386	756.487805	171925	0

---> Data Splitting

In [36]:
```
X = df[['age','income','credit_score','loan_amount','employment_type']]
```

In [37]:
```
X.head()
```

Out[37]:

	age	income	credit_score	loan_amount	employment_type
0	56	128388	658.435992	43858	0
1	69	33280	723.267738	284064	1
2	46	22754	741.598799	98582	1
3	32	70258	616.773385	282408	0
4	60	63386	756.487805	171925	0

In [38]:
```
from sklearn.model_selection import train_test_split
```

In [39]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, randc
```

In [40]:
```
print(X_train.value_counts())
print(X_test.value_counts())
print(y_train.value_counts())
print(y_test.value_counts())
```

```
age  income  credit_score  loan_amount  employment_type
18   20067   674.656879    248088       1                  1
52   118037  651.707385    144755       3                  1
     116501  596.399498    263253       0                  1
     116552  544.206175    37147        2                  1
     117202  681.804282    370532       3                  1
                                                          ..
35   46543   671.251005    200503       0                  1
     46393   552.898044    75309        1                  1
     46335   668.462596    452183       1                  1
     45908   612.436593    77777        1                  1
69   199833  627.048528    91015        2                  1
Name: count, Length: 35000, dtype: int64
age  income  credit_score  loan_amount  employment_type
18   20667   675.929909    253120       2                  1
52   196684  668.788866    58391        0                  1
     184069  826.338051    126415       2                  1
     185765  474.724262    90597        1                  1
     187021  703.327453    446742       0                  1
                                                          ..
35   130532  638.750137    369392       2                  1
     131318  536.860174    372916       3                  1
     131641  660.092813    41481        3                  1
     133795  534.397632    91425        3                  1
69   199821  710.769631    403616       0                  1
Name: count, Length: 15000, dtype: int64
loan_status
0    23323
1    11677
Name: count, dtype: int64
loan_status
0    9992
1    5008
Name: count, dtype: int64
```

Model Building

Decision Trees

In [41]:
```python
from sklearn.tree import DecisionTreeClassifier
```

In [42]:
```python
dt = DecisionTreeClassifier()
```

In [43]:
```python
dt.fit(X_train,y_train)
```

Out[43]:
```
▾ DecisionTreeClassifier
DecisionTreeClassifier()
```

In [47]:
```python
dt.predict(X_train)
```

Out[47]: array([1, 0, 0, ..., 0, 0, 0], dtype=int64)

In [48]:
```
accuracy_score(y_train,dt.predict(X_train))
```

Out[48]: 1.0

In [49]:
```
dt.predict(X_test)
```

Out[49]: array([1, 0, 0, ..., 1, 0, 0], dtype=int64)

In [50]:
```
accuracy_score(y_test,dt.predict(X_test))
```

Out[50]: 0.8666666666666667

Hyper Tuning

In [51]:
```
dt_model = DecisionTreeClassifier(
    max_depth=6,
    min_samples_split=10,
    min_samples_leaf=5,
    criterion="gini",
    random_state=42
)
```

In [52]:
```
dt_model.fit(X_train,y_train)
```

Out[52]:

▾ DecisionTreeClassifier

```
DecisionTreeClassifier(max_depth=6, min_samples_leaf=5, min_samples_split=10,
                       random_state=42)
```

In [53]:
```
dt_model.predict(X_train)
```

Out[53]: array([1, 0, 0, ..., 1, 0, 0], dtype=int64)

In [54]:
```
accuracy_score(y_train,dt_model.predict(X_train))
```

Out[54]: 0.9157142857142857

In [55]:
```
print(classification_report(y_train,dt_model.predict(X_train)))
```

```
              precision    recall  f1-score   support

           0       1.00      0.87      0.93     23323
           1       0.80      1.00      0.89     11677

    accuracy                           0.92     35000
   macro avg       0.90      0.94      0.91     35000
weighted avg       0.93      0.92      0.92     35000
```

In [56]:
```python
dt_model.predict(X_test)
```

Out[56]: array([1, 0, 0, ..., 1, 1, 0], dtype=int64)

In [57]:
```python
accuracy_score(y_test,dt_model.predict(X_test))
```

Out[57]: 0.9106

In [58]:
```python
print(classification_report(y_test,dt_model.predict(X_test)))
```

```
              precision    recall  f1-score   support

           0       1.00      0.87      0.93      9992
           1       0.79      0.99      0.88      5008

    accuracy                           0.91     15000
   macro avg       0.89      0.93      0.90     15000
weighted avg       0.93      0.91      0.91     15000
```

Ensemble Models

Gradient Boosting

In [59]:
```python
from sklearn.ensemble import GradientBoostingClassifier
gbc = GradientBoostingClassifier()
gbc.fit(X_train,y_train)
```

Out[59]:

▾ GradientBoostingClassifier

GradientBoostingClassifier()

In [60]:
```python
gbc.predict(X_train)
```

Out[60]: array([1, 0, 0, ..., 1, 0, 0], dtype=int64)

In [61]:
```python
accuracy_score(y_train,gbc.predict(X_train))
```

Out[61]: 0.9158285714285714

In [62]:
```
gbc.predict(X_test)
```
Out[62]:
```
array([1, 0, 0, ..., 1, 1, 0], dtype=int64)
```
In [63]:
```
accuracy_score(y_test,gbc.predict(X_test))
```
Out[63]:
```
0.9119333333333334
```
Hyper tuning

In [68]:
```
gb_model=GradientBoostingClassifier(learning_rate=0.05,
    n_estimators=300,
    max_depth=3,
    min_samples_split=5,
    min_samples_leaf=2,
    random_state=42)
```
In [69]:
```
gb_model.fit(X_train,y_train)
```
Out[69]:
```
GradientBoostingClassifier

GradientBoostingClassifier(learning_rate=0.05, min_samples_leaf=2,
                           min_samples_split=5, n_estimators=300,
                           random_state=42)
```
In [70]:
```
gb_model.predict(X_train)
```
Out[70]:
```
array([1, 0, 0, ..., 1, 0, 0], dtype=int64)
```
In [71]:
```
accuracy_score(y_train,gb_model.predict(X_train))
```
Out[71]:
```
0.9159428571428572
```
In [72]:
```
print(classification_report(y_train,gb_model.predict(X_train)))
```
```
              precision    recall  f1-score   support

           0       1.00      0.87      0.93     23323
           1       0.80      1.00      0.89     11677

    accuracy                           0.92     35000
   macro avg       0.90      0.94      0.91     35000
weighted avg       0.93      0.92      0.92     35000
```
In [74]:
```
print(confusion_matrix(y_train,gb_model.predict(X_train)))
```
```
[[20385  2938]
 [    4 11673]]
```

In [75]:
```
gb_model.predict(X_test)
```
Out[75]:
```
array([1, 0, 0, ..., 1, 1, 0], dtype=int64)
```
In [76]:
```
print(accuracy_score(y_test,gb_model.predict(X_test)))
```
```
0.9116
```
In [77]:
```
print(classification_report(y_test,gb_model.predict(X_test)))
```
```
              precision    recall  f1-score   support

           0       1.00      0.87      0.93      9992
           1       0.79      1.00      0.88      5008

    accuracy                           0.91     15000
   macro avg       0.90      0.93      0.91     15000
weighted avg       0.93      0.91      0.91     15000
```
In [78]:
```
print(confusion_matrix(y_test,gb_model.predict(X_test)))
```
```
[[8673 1319]
 [   7 5001]]
```
Random Forest

In [79]:
```
from sklearn.ensemble import RandomForestClassifier
rf = RandomForestClassifier()
```
In [80]:
```
rf.fit(X_train,y_train)
```
Out[80]:
```
▾ RandomForestClassifier
RandomForestClassifier()
```
In [81]:
```
rf.predict(X_train)
```
Out[81]:
```
array([1, 0, 0, ..., 0, 0, 0], dtype=int64)
```
In [82]:
```
accuracy_score(y_train,rf.predict(X_train))
```
Out[82]:
```
1.0
```
In [83]:
```
rf.predict(X_test)
```
Out[83]:
```
array([1, 0, 0, ..., 1, 0, 0], dtype=int64)
```
In [84]:
```
accuracy_score(y_test,rf.predict(X_test))
```
Out[84]:
```
0.9078
```

Hyper Tuning

In [85]:
```
rf_model = RandomForestClassifier(
    n_estimators=300,
    max_depth=12,
    max_features='sqrt',
    min_samples_leaf=3,
    min_samples_split=5,
    random_state=42
)
```

In [86]:
```
rf_model.fit(X_train,y_train)
```

Out[86]:

```
▾ RandomForestClassifier

RandomForestClassifier(max_depth=12, min_samples_leaf=3, min_sample
s_split=5,
                       n_estimators=300, random_state=42)
```

In [87]:
```
rf_model.predict(X_train)
```

Out[87]:
```
array([1, 0, 0, ..., 1, 0, 0], dtype=int64)
```

In [88]:
```
accuracy_score(y_train,rf_model.predict(X_train))
```

Out[88]:
```
0.9168857142857143
```

In [89]:
```
print(classification_report(y_train,rf_model.predict(X_train)))
```

```
              precision    recall  f1-score   support

           0       1.00      0.88      0.93     23323
           1       0.80      1.00      0.89     11677

    accuracy                           0.92     35000
   macro avg       0.90      0.94      0.91     35000
weighted avg       0.93      0.92      0.92     35000
```

In [90]:
```
print(confusion_matrix(y_train,rf_model.predict(X_train)))
```

```
[[20415  2908]
 [    1 11676]]
```

In [91]:
```
rf_model.predict(X_test)
```

Out[91]:
```
array([1, 0, 0, ..., 1, 1, 0], dtype=int64)
```

In [92]:
```
accuracy_score(y_test,rf_model.predict(X_test))
```

Out[92]: 0.9115333333333333

In [93]:
```
print(classification_report(y_test,rf_model.predict(X_test)))
```

```
              precision    recall  f1-score   support

           0       1.00      0.87      0.93      9992
           1       0.79      1.00      0.88      5008

    accuracy                           0.91     15000
   macro avg       0.90      0.93      0.91     15000
weighted avg       0.93      0.91      0.91     15000
```

In [94]:
```
print(confusion_matrix(y_test,rf_model.predict(X_test)))
```

```
[[8672 1320]
 [   7 5001]]
```

XG Boost

In [97]:
```
from xgboost import XGBClassifier
xgb = XGBClassifier()
```

In [98]:
```
xgb.fit(X_train,y_train)
```

Out[98]:

▾ XGBClassifier

```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_roun
ds=None,
              enable_categorical=False, eval_metric=None, feature_typ
es=None,
              feature_weights=None, gamma=None, grow_policy=None,
              importance_type=None, interaction_constraints=None,
              learning_rate=None, max_bin=None, max_cat_threshold=Non
e,
```

In [99]:
```
xgb.predict(X_train)
```

Out[99]: array([1, 0, 0, ..., 1, 0, 0])

In [100…
```
accuracy_score(y_train,xgb.predict(X_train))
```

Out[100… 0.9377142857142857

In [101…
```
xgb.predict(X_test)
```

Out[101… array([1, 0, 0, ..., 1, 1, 0])

In [102…
```
accuracy_score(y_test,xgb.predict(X_test))
```

Out[102… 0.9046

Hyper Tuning

In [103…
```
xgb_model = XGBClassifier(
    n_estimators=300,
    learning_rate=0.05,
    max_depth=6,
    subsample=0.8,
    colsample_bytree=0.8,
    gamma=0,
    reg_lambda=1,
    random_state=42,
    n_jobs=-1
)
```

In [104…
```
xgb_model.fit(X_train,y_train)
```

Out[104…

XGBClassifier

```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=0.8, device=None, early_stopping_round
s=None,
              enable_categorical=False, eval_metric=None, feature_typ
es=None,
              feature_weights=None, gamma=0, grow_policy=None,
              importance_type=None, interaction_constraints=None,
              learning_rate=0.05, max_bin=None, max_cat_threshold=Non
e,
```

In [105…
```
xgb_model.predict(X_train)
```

Out[105… array([1, 0, 0, ..., 1, 0, 0])

In [106…
```
accuracy_score(y_train,xgb_model.predict(X_train))
```

Out[106… 0.9194857142857142

In [107…
```
print(classification_report(y_train,xgb_model.predict(X_train)))
```

```
              precision    recall  f1-score   support

           0       1.00      0.88      0.94     23323
           1       0.81      1.00      0.89     11677

    accuracy                           0.92     35000
   macro avg       0.90      0.94      0.91     35000
weighted avg       0.93      0.92      0.92     35000
```

In [108…
```
print(confusion_matrix(y_train,xgb_model.predict(X_train)))
```
```
[[20529  2794]
 [   24 11653]]
```

In [109…
```
xgb_model.predict(X_test)
```
Out[109…
```
array([1, 0, 0, ..., 1, 1, 0])
```

In [110…
```
accuracy_score(y_test,xgb_model.predict(X_test))
```
Out[110…
```
0.9099333333333334
```

In [111…
```
print(classification_report(y_test,xgb_model.predict(X_test)))
```
```
              precision    recall  f1-score   support

           0       1.00      0.87      0.93      9992
           1       0.79      0.99      0.88      5008

    accuracy                           0.91     15000
   macro avg       0.89      0.93      0.90     15000
weighted avg       0.93      0.91      0.91     15000
```

In [112…
```
print(confusion_matrix(y_test,xgb_model.predict(X_test)))
```
```
[[8681 1311]
 [  40 4968]]
```

Model Accuracies Table

In [120…
```
dt_train_acc = accuracy_score(y_train,dt_model.predict(X_train))
```

In [121…
```
dt_test_acc = accuracy_score(y_test,dt_model.predict(X_test))
```

In [122…
```
rf_train_acc = accuracy_score(y_train,rf_model.predict(X_train))
```

In [123…
```
rf_test_acc = accuracy_score(y_test,rf_model.predict(X_test))
```

In [124…
```
xgb_train_acc = accuracy_score(y_train,xgb_model.predict(X_train))
```

In [125…

```
gb_train_acc = accuracy_score(y_train,gb_model.predict(X_train))
```

In [126…

```
gb_test_acc = accuracy_score(y_test,gb_model.predict(X_test))
```

In [127…

```
xgb_test_acc = accuracy_score(y_test,xgb_model.predict(X_test))
```

In [129…

```
results = {
    "Model": ["Decision Tree", "Random Forest", "XGBoost","Gradient Boosting"]
    "Train Accuracy": [dt_train_acc, rf_train_acc, xgb_train_acc,gb_train_acc]
    "Test Accuracy": [dt_test_acc, rf_test_acc, xgb_test_acc,gb_test_acc]
}

accuracy_df = pd.DataFrame(results)
accuracy_df
```

Out[129…

	Model	Train Accuracy	Test Accuracy
0	Decision Tree	0.915714	0.910600
1	Random Forest	0.916886	0.911533
2	XGBoost	0.919486	0.909933
3	Gradient Boosting	0.915943	0.911600

In [ ]: