Logistic Regression

In [1]:
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, classification_report, confusion_m
```

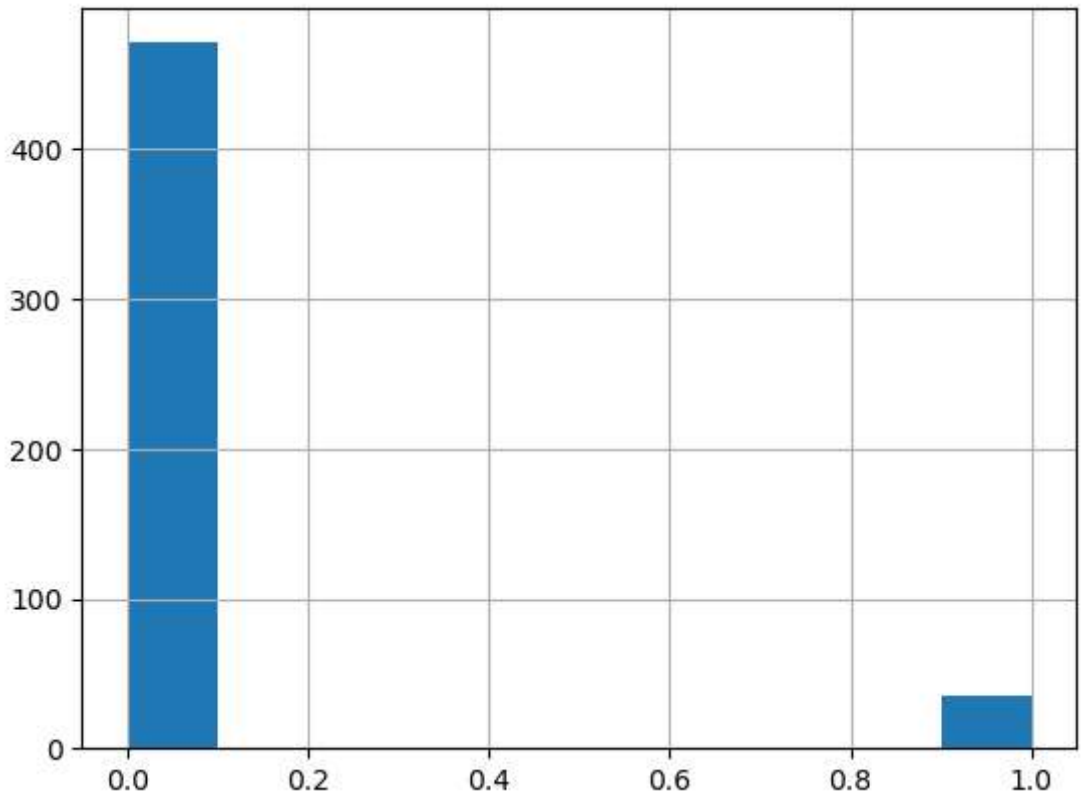
In [2]:
```
df = pd.read_csv('E:\\MCA\\sem_3\\ML_Lab\\programs\\week5\\boston_house_prices
df.head()
```

Out[2]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS	RAD	TAX	PTRATIO	B	LSTA
0	0.00632	18.0	2.31	0	0.538	6.575	65.2	4.0900	1	296	15.3	396.90	4.9
1	0.02731	0.0	7.07	0	0.469	6.421	78.9	4.9671	2	242	17.8	396.90	9.1
2	0.02729	0.0	7.07	0	0.469	7.185	61.1	4.9671	2	242	17.8	392.83	4.0
3	0.03237	0.0	2.18	0	0.458	6.998	45.8	6.0622	3	222	18.7	394.63	2.9
4	0.06905	0.0	2.18	0	0.458	7.147	54.2	6.0622	3	222	18.7	396.90	5.3

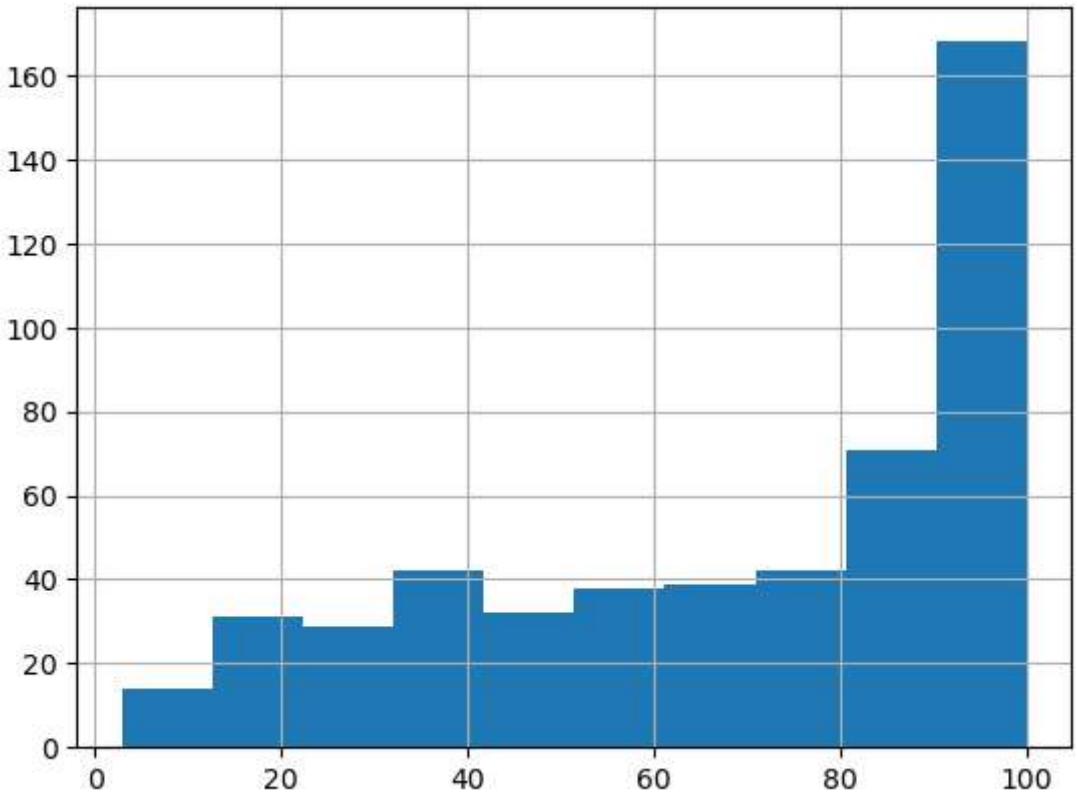
In [3]:
```
df['CHAS'].hist()
```

Out[3]:
```
<Axes: >
```



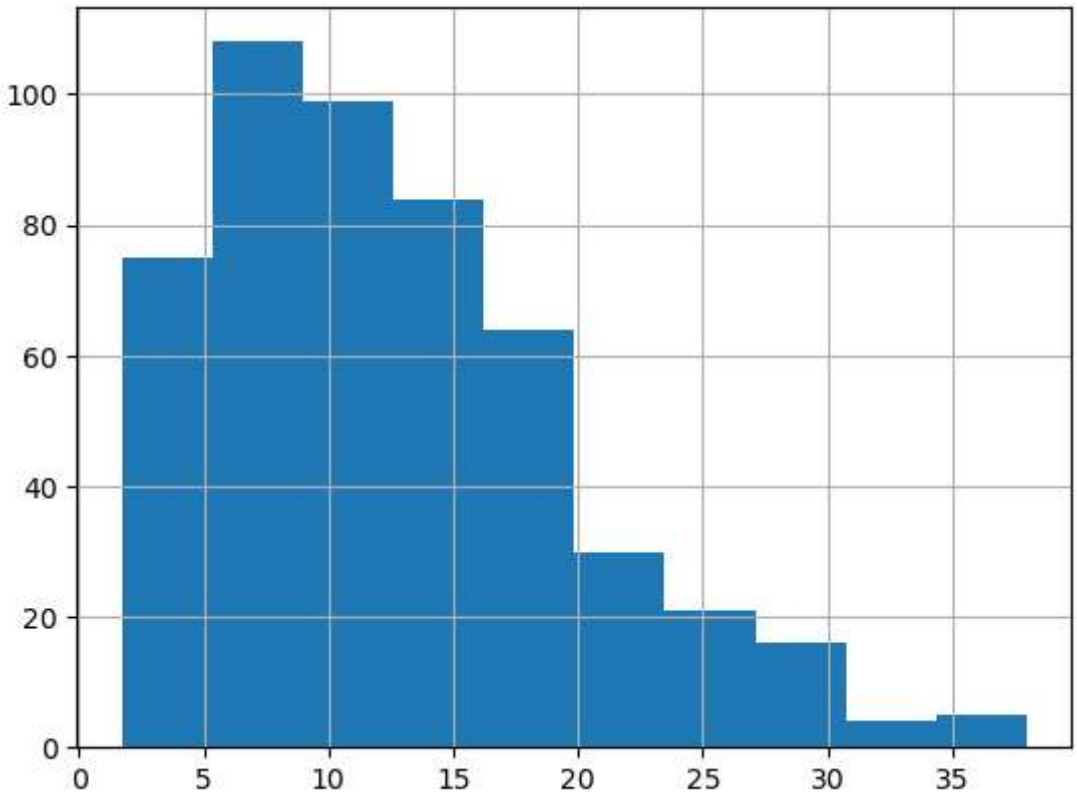
In [4]:
```
df['AGE'].hist()
```

Out[4]: <Axes: >



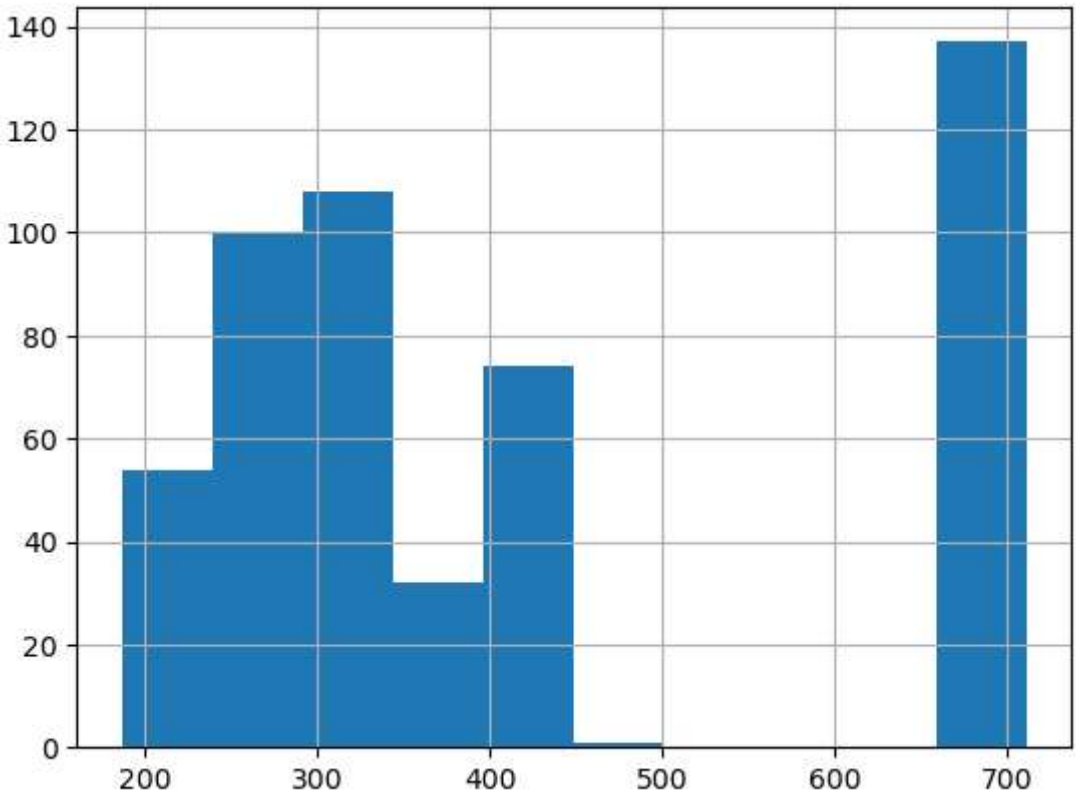
In [5]:
```
df['LSTAT'].hist()
```

Out[5]: <Axes: >



In [6]:
```
df['TAX'].hist()
```

Out[6]: <Axes: >



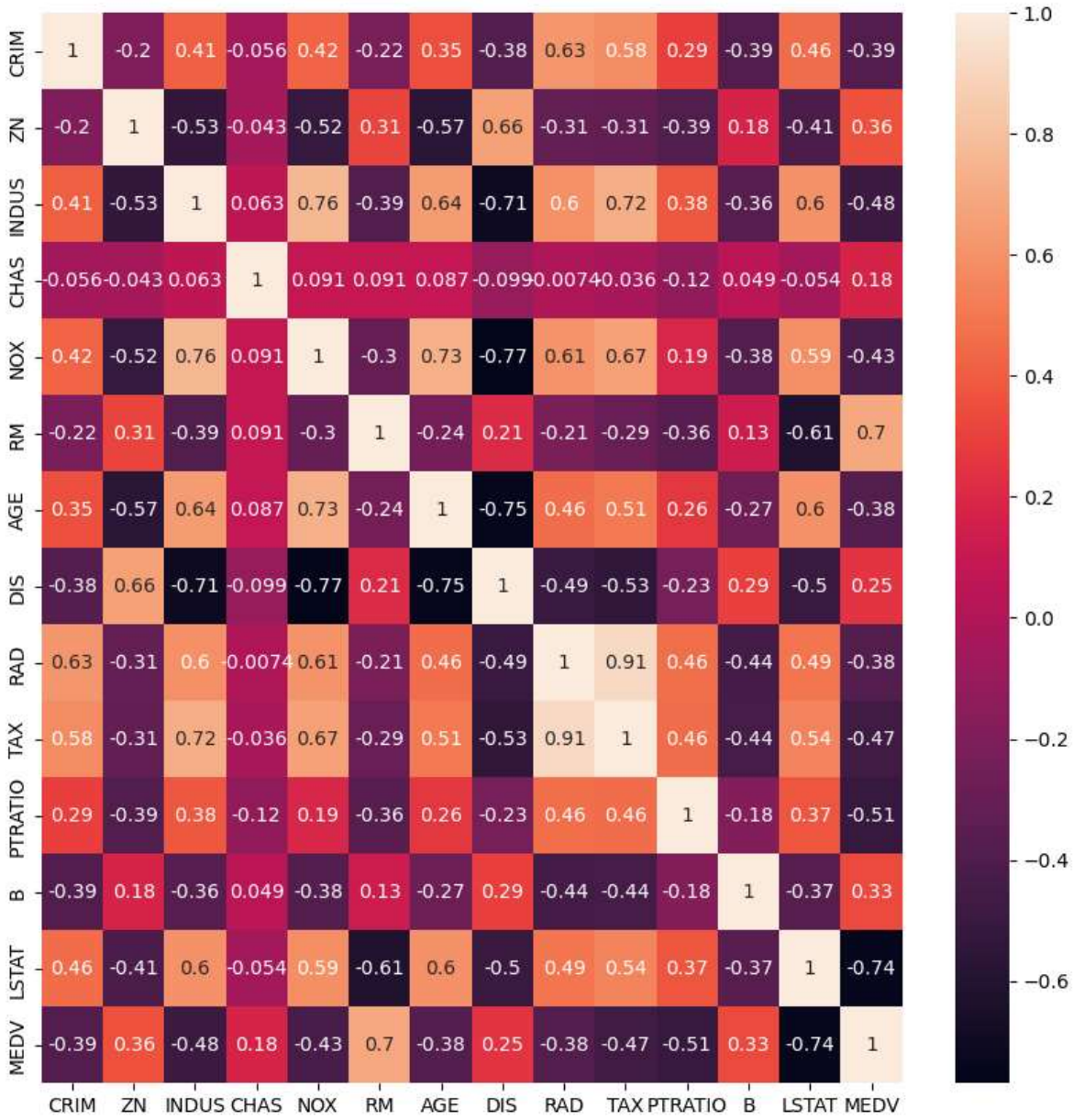
In [7]:
```
df.corr()
```

Out[7]:

	CRIM	ZN	INDUS	CHAS	NOX	RM	AGE	DIS
CRIM	1.000000	-0.200469	0.406583	-0.055892	0.420972	-0.219247	0.352734	-0.379670
ZN	-0.200469	1.000000	-0.533828	-0.042697	-0.516604	0.311991	-0.569537	0.664408
INDUS	0.406583	-0.533828	1.000000	0.062938	0.763651	-0.391676	0.644779	-0.708027
CHAS	-0.055892	-0.042697	0.062938	1.000000	0.091203	0.091251	0.086518	-0.099176
NOX	0.420972	-0.516604	0.763651	0.091203	1.000000	-0.302188	0.731470	-0.769230
RM	-0.219247	0.311991	-0.391676	0.091251	-0.302188	1.000000	-0.240265	0.205246
AGE	0.352734	-0.569537	0.644779	0.086518	0.731470	-0.240265	1.000000	-0.747881
DIS	-0.379670	0.664408	-0.708027	-0.099176	-0.769230	0.205246	-0.747881	1.000000
RAD	0.625505	-0.311948	0.595129	-0.007368	0.611441	-0.209847	0.456022	-0.494588
TAX	0.582764	-0.314563	0.720760	-0.035587	0.668023	-0.292048	0.506456	-0.534432
PTRATIO	0.289946	-0.391679	0.383248	-0.121515	0.188933	-0.355501	0.261515	-0.232471
B	-0.385064	0.175520	-0.356977	0.048788	-0.380051	0.128069	-0.273534	0.291512
LSTAT	0.455621	-0.412995	0.603800	-0.053929	0.590879	-0.613808	0.602339	-0.496996
MEDV	-0.388305	0.360445	-0.483725	0.175260	-0.427321	0.695360	-0.376955	0.249929

In [8]:
```
import seaborn as sns
corr = df.corr()
fig, ax = plt.subplots(figsize=(10,10))
sns.heatmap(corr,annot=True,ax=ax)
```

Out[8]: <Axes: >



In [9]:
```
x = df.drop(['CHAS'],axis = 1).values
x
```

Out[9]:
```
array([[6.3200e-03, 1.8000e+01, 2.3100e+00, ..., 3.9690e+02, 4.9800e+00,
        2.4000e+01],
       [2.7310e-02, 0.0000e+00, 7.0700e+00, ..., 3.9690e+02, 9.1400e+00,
        2.1600e+01],
       [2.7290e-02, 0.0000e+00, 7.0700e+00, ..., 3.9283e+02, 4.0300e+00,
        3.4700e+01],
       ...,
       [6.0760e-02, 0.0000e+00, 1.1930e+01, ..., 3.9690e+02, 5.6400e+00,
        2.3900e+01],
       [1.0959e-01, 0.0000e+00, 1.1930e+01, ..., 3.9345e+02, 6.4800e+00,
        2.2000e+01],
       [4.7410e-02, 0.0000e+00, 1.1930e+01, ..., 3.9690e+02, 7.8800e+00,
        1.1900e+01]])
```

In [10]:
```
y = df['CHAS'].values
y
```

Out[10]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0,
       1, 1, 0, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 0, 0, 1, 0, 1, 1,
       1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 1, 0, 0, 0, 1, 1, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 1, 1, 0, 1, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
      dtype=int64)
```

Iteration 1

i. test_size = 0.3 random_state = 0

In [11]:
```
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size = 0.3,random
```

In [12]:
```
model = LogisticRegression(max_iter=1000)
```

In [13]:
```
model.fit(x_train,y_train)
```

```
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\linear_model\_logistic.py:4
58: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sciki
t-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regres
sion (https://scikit-learn.org/stable/modules/linear_model.html#logistic-regr
ession)
  n_iter_i = _check_optimize_result(
```

Out[13]:
```
LogisticRegression(max_iter=1000)
```

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In [14]:
```
y_pred = model.predict(x_test)
```

In [15]:
```
y_pred
```

Out[15]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
      dtype=int64)
```

In [16]:
```
model.score(x,y)
```

Out[16]:
```
0.9308300395256917
```

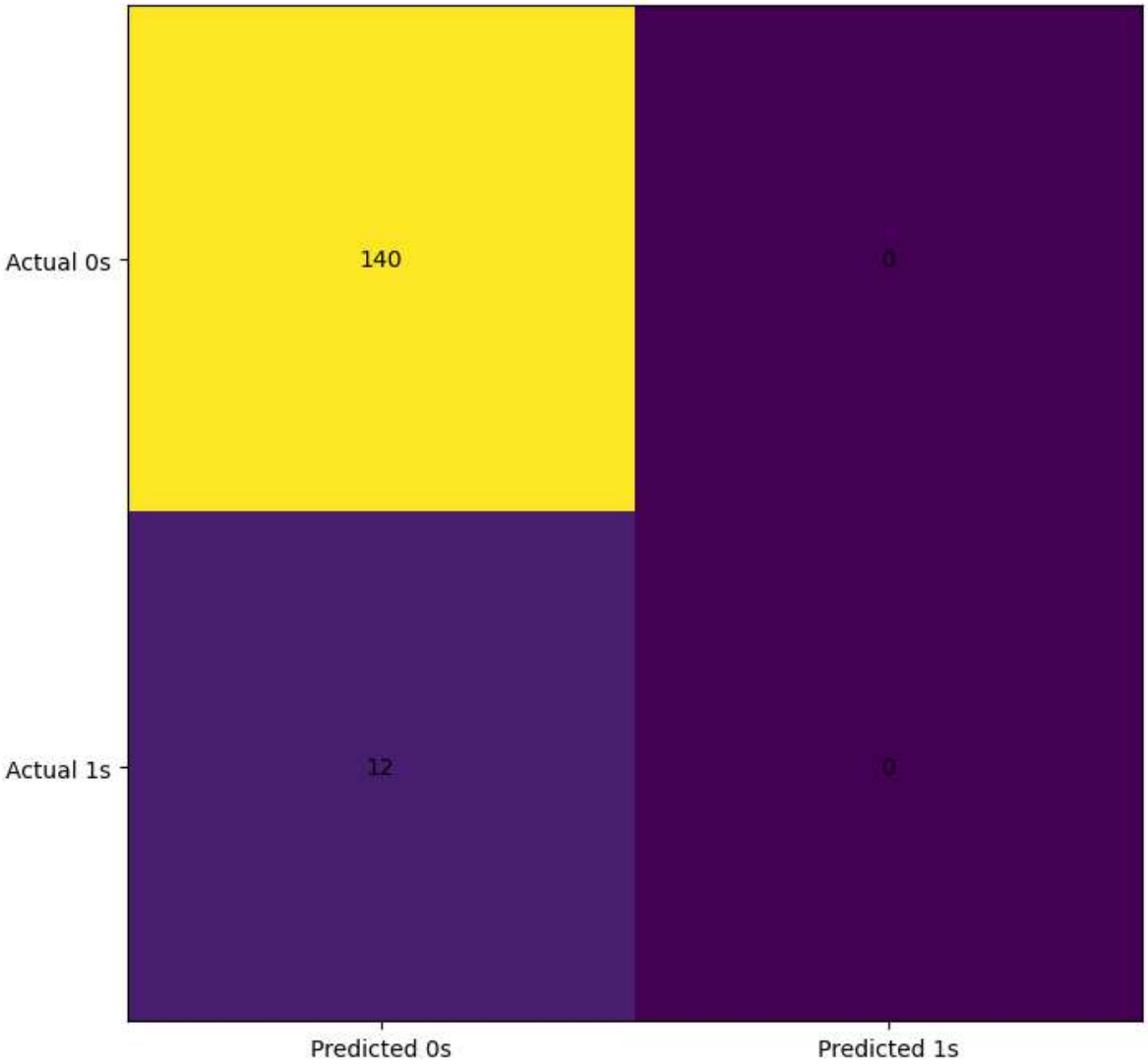
In [17]:
```
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"Mean Squared Error: {mse:.2f}")
print(f"R-squared: {r2:.2f}")
```

```
Mean Squared Error: 0.08
R-squared: -0.09
```

In [18]:
```
confusion_matrix(y_test, y_pred)
```

Out[18]:
```
array([[140,   0],
       [ 12,   0]], dtype=int64)
```

In [19]:
```
cm = confusion_matrix(y_test, y_pred)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(cm)
ax.grid(False)
ax.xaxis.set(ticks=(0, 1), ticklabels=('Predicted 0s', 'Predicted 1s'))
ax.yaxis.set(ticks=(0, 1), ticklabels=('Actual 0s', 'Actual 1s'))
ax.set_ylim(1.5, -0.5)
for i in range(2):
    for j in range(2):
        ax.text(j, i, cm[i, j], ha='center', va='center', color='black')
plt.show()
```



In [20]:
```
accuracy = accuracy_score(y_test, y_pred)
classification_report_result = classification_report(y_test, y_pred)
confusion_matrix_result = confusion_matrix(y_test, y_pred)

print("Accuracy:", accuracy)
print("Classification Report:\n", classification_report_result)
print("Confusion Matrix:\n", confusion_matrix_result)
```

```
Accuracy: 0.9210526315789473
Classification Report:
               precision    recall  f1-score   support

           0       0.92      1.00      0.96       140
           1       0.00      0.00      0.00        12

    accuracy                           0.92       152
   macro avg       0.46      0.50      0.48       152
weighted avg       0.85      0.92      0.88       152

Confusion Matrix:
 [[140   0]
 [ 12   0]]

C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
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1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

ii. test_size = 0.3 random_state = 42

In [21]:
```
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size = 0.3,random
```

In [22]:
```
model = LogisticRegression(max_iter=1000)
```

In [23]:
```
model.fit(x_train,y_train)
```

Out[23]:
```
LogisticRegression(max_iter=1000)
```

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In [24]:
```
y_pred = model.predict(x_test)
```

In [25]:
```
y_pred
```

Out[25]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
      dtype=int64)
```

In [26]:
```
model.score(x,y)
```

Out[26]:
```
0.932806324110672
```

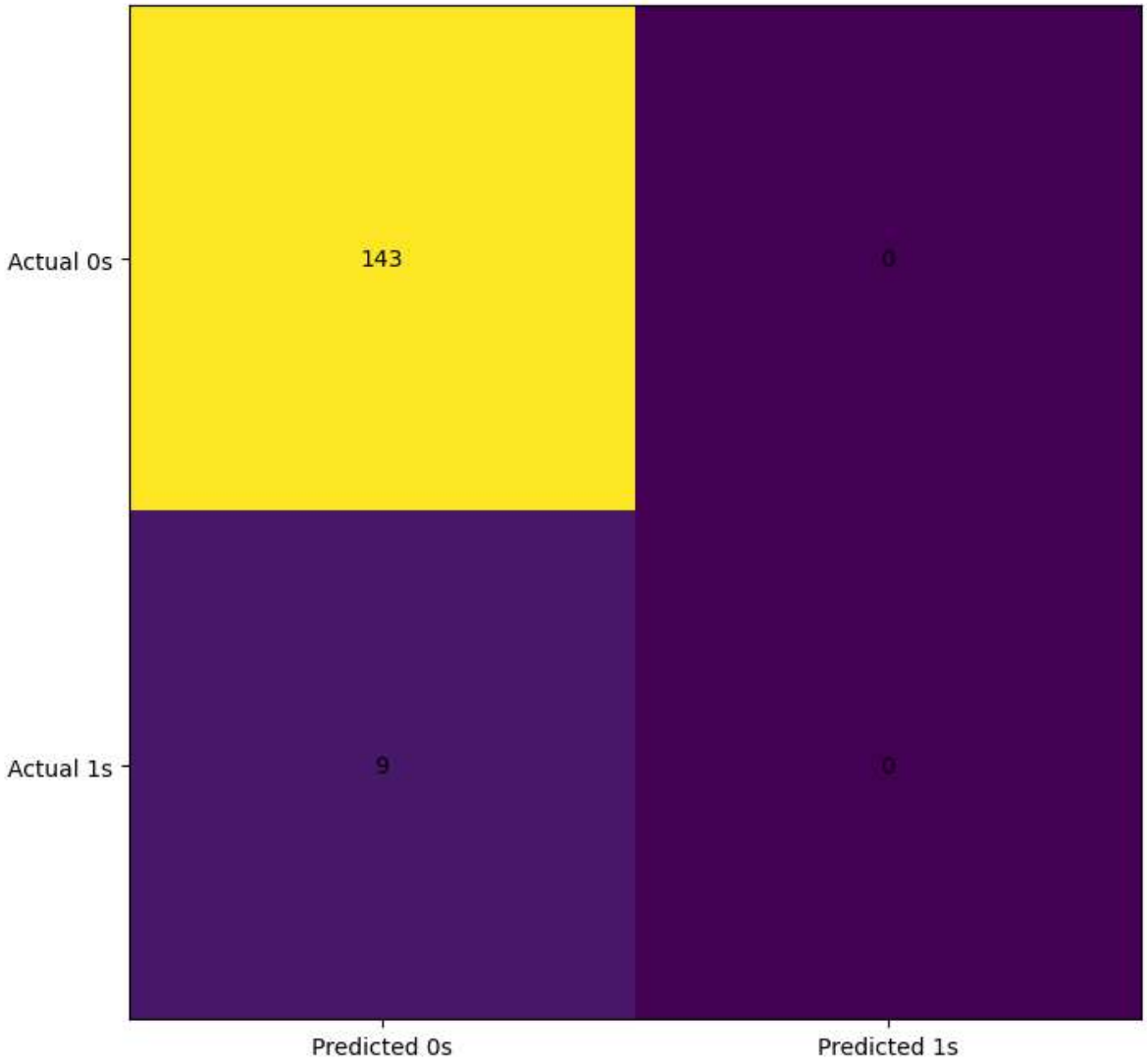
In [27]:
```
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"Mean Squared Error: {mse:.2f}")
print(f"R-squared: {r2:.2f}")
```

```
Mean Squared Error: 0.06
R-squared: -0.06
```

In [28]:
```
confusion_matrix(y_test, y_pred)
```

Out[28]:
```
array([[143,   0],
       [  9,   0]], dtype=int64)
```

In [29]:
```
cm = confusion_matrix(y_test, y_pred)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(cm)
ax.grid(False)
ax.xaxis.set(ticks=(0, 1), ticklabels=('Predicted 0s', 'Predicted 1s'))
ax.yaxis.set(ticks=(0, 1), ticklabels=('Actual 0s', 'Actual 1s'))
ax.set_ylim(1.5, -0.5)
for i in range(2):
    for j in range(2):
        ax.text(j, i, cm[i, j], ha='center', va='center', color='black')
plt.show()
```



In [30]:
```
accuracy = accuracy_score(y_test, y_pred)
classification_report_result = classification_report(y_test, y_pred)
confusion_matrix_result = confusion_matrix(y_test, y_pred)

print("Accuracy:", accuracy)
print("Classification Report:\n", classification_report_result)
print("Confusion Matrix:\n", confusion_matrix_result)
```

```
Accuracy: 0.9407894736842105
Classification Report:
               precision    recall  f1-score   support

           0       0.94      1.00      0.97       143
           1       0.00      0.00      0.00         9

    accuracy                           0.94       152
   macro avg       0.47      0.50      0.48       152
weighted avg       0.89      0.94      0.91       152

Confusion Matrix:
 [[143   0]
 [  9   0]]

C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
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1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

Iteration 2

i. test_size = 0.4 random_state = 0

In [31]:
```
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size = 0.4,random
```

In [32]:
```
model = LogisticRegression(max_iter=1000)
```

In [33]:
```
model.fit(x_train,y_train)
```

```
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\linear_model\_logistic.py:4
58: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sciki
t-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regres
sion (https://scikit-learn.org/stable/modules/linear_model.html#logistic-regr
ession)
  n_iter_i = _check_optimize_result(
```

Out[33]:
```
LogisticRegression(max_iter=1000)
```

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In [34]:
```
y_pred = model.predict(x_test)
```

In [35]:
```
y_pred
```

Out[35]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0], dtype=int64)
```

In [36]:
```
model.score(x,y)
```

Out[36]:
```
0.9288537549407114
```

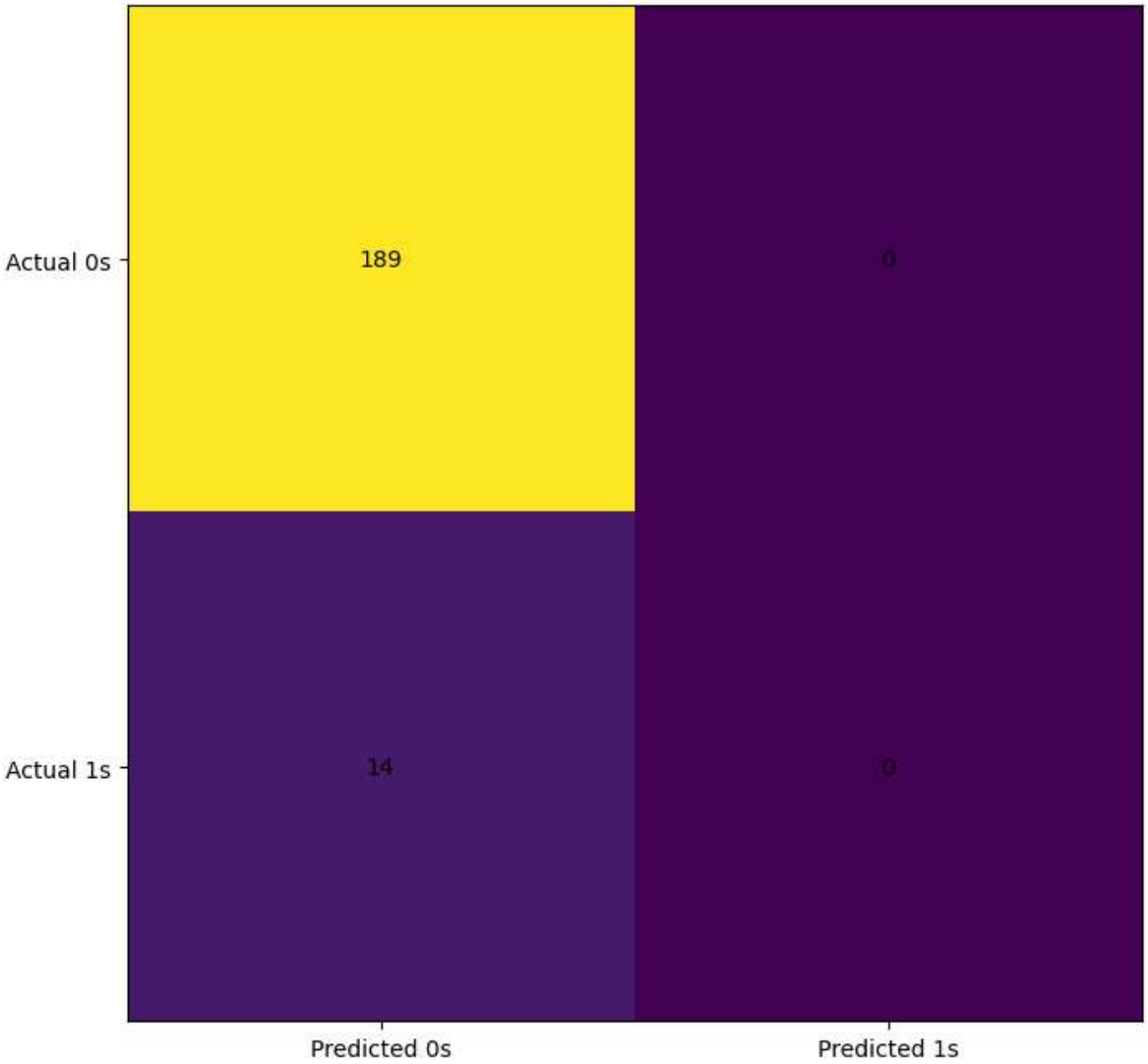
In [37]:
```
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"Mean Squared Error: {mse:.2f}")
print(f"R-squared: {r2:.2f}")
```

```
Mean Squared Error: 0.07
R-squared: -0.07
```

In [38]:
```
confusion_matrix(y_test, y_pred)
```

Out[38]:
```
array([[189,   0],
       [ 14,   0]], dtype=int64)
```

In [39]:
```
cm = confusion_matrix(y_test, y_pred)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(cm)
ax.grid(False)
ax.xaxis.set(ticks=(0, 1), ticklabels=('Predicted 0s', 'Predicted 1s'))
ax.yaxis.set(ticks=(0, 1), ticklabels=('Actual 0s', 'Actual 1s'))
ax.set_ylim(1.5, -0.5)
for i in range(2):
    for j in range(2):
        ax.text(j, i, cm[i, j], ha='center', va='center', color='black')
plt.show()
```



In [40]:
```
accuracy = accuracy_score(y_test, y_pred)
classification_report_result = classification_report(y_test, y_pred)
confusion_matrix_result = confusion_matrix(y_test, y_pred)

print("Accuracy:", accuracy)
print("Classification Report:\n", classification_report_result)
print("Confusion Matrix:\n", confusion_matrix_result)
```

```
Accuracy: 0.9310344827586207
Classification Report:
               precision    recall  f1-score   support

           0       0.93      1.00      0.96       189
           1       0.00      0.00      0.00        14

    accuracy                           0.93       203
   macro avg       0.47      0.50      0.48       203
weighted avg       0.87      0.93      0.90       203

Confusion Matrix:
 [[189   0]
 [ 14   0]]

C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

ii. test_size = 0.4 random_state = 42

In [41]:
```
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size = 0.4,random
```

In [42]:
```
model = LogisticRegression(max_iter=1000)
```

In [43]:
```
model.fit(x_train,y_train)
```

```
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\linear_model\_logistic.py:4
58: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sciki
t-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regres
sion (https://scikit-learn.org/stable/modules/linear_model.html#logistic-regr
ession)
  n_iter_i = _check_optimize_result(
```

Out[43]:
```
LogisticRegression(max_iter=1000)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [44]:
```
y_pred = model.predict(x_test)
```

In [45]:
```
y_pred
```

Out[45]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0], dtype=int64)
```

In [46]:
```
model.score(x,y)
```

Out[46]:
```
0.9347826086956522
```

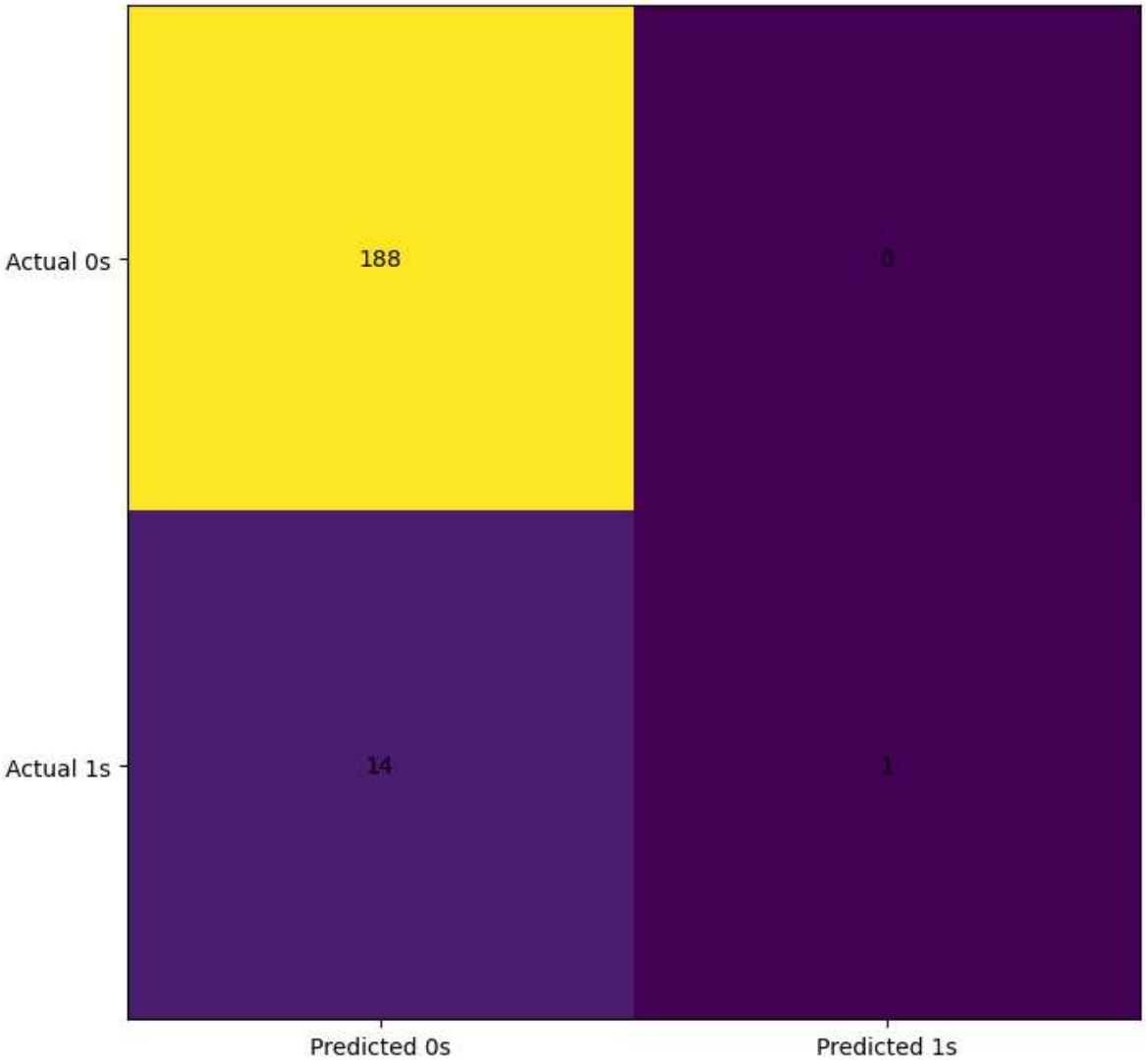
In [47]:
```
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"Mean Squared Error: {mse:.2f}")
print(f"R-squared: {r2:.2f}")
```

```
Mean Squared Error: 0.07
R-squared: -0.01
```

In [48]:
```
confusion_matrix(y_test, y_pred)
```

Out[48]:
```
array([[188,   0],
       [ 14,   1]], dtype=int64)
```

In [49]:
```
cm = confusion_matrix(y_test, y_pred)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(cm)
ax.grid(False)
ax.xaxis.set(ticks=(0, 1), ticklabels=('Predicted 0s', 'Predicted 1s'))
ax.yaxis.set(ticks=(0, 1), ticklabels=('Actual 0s', 'Actual 1s'))
ax.set_ylim(1.5, -0.5)
for i in range(2):
    for j in range(2):
        ax.text(j, i, cm[i, j], ha='center', va='center', color='black')
plt.show()
```



In [50]:
```
accuracy = accuracy_score(y_test, y_pred)
classification_report_result = classification_report(y_test, y_pred)
confusion_matrix_result = confusion_matrix(y_test, y_pred)

print("Accuracy:", accuracy)
print("Classification Report:\n", classification_report_result)
print("Confusion Matrix:\n", confusion_matrix_result)
```

```
Accuracy: 0.9310344827586207
Classification Report:
               precision    recall  f1-score   support

           0       0.93      1.00      0.96       188
           1       1.00      0.07      0.12        15

    accuracy                           0.93       203
   macro avg       0.97      0.53      0.54       203
weighted avg       0.94      0.93      0.90       203

Confusion Matrix:
 [[188   0]
 [ 14   1]]
```

Iteration 3

i. test_size = 0.5 random_state = 0

In [51]:
```
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size = 0.5,random
```

In [52]:
```
model = LogisticRegression(max_iter=1000)
```

In [53]:
```
model.fit(x_train,y_train)
```

```
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\linear_model\_logistic.py:4
58: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://sciki
t-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regres
sion (https://scikit-learn.org/stable/modules/linear_model.html#logistic-regr
ession)
  n_iter_i = _check_optimize_result(
```

Out[53]:
```
LogisticRegression(max_iter=1000)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [54]:
```
y_pred = model.predict(x_test)
```

In [55]:
```
y_pred
```

Out[55]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0], dtype=int64)
```

In [56]:
```
model.score(x,y)
```

Out[56]:
```
0.9288537549407114
```

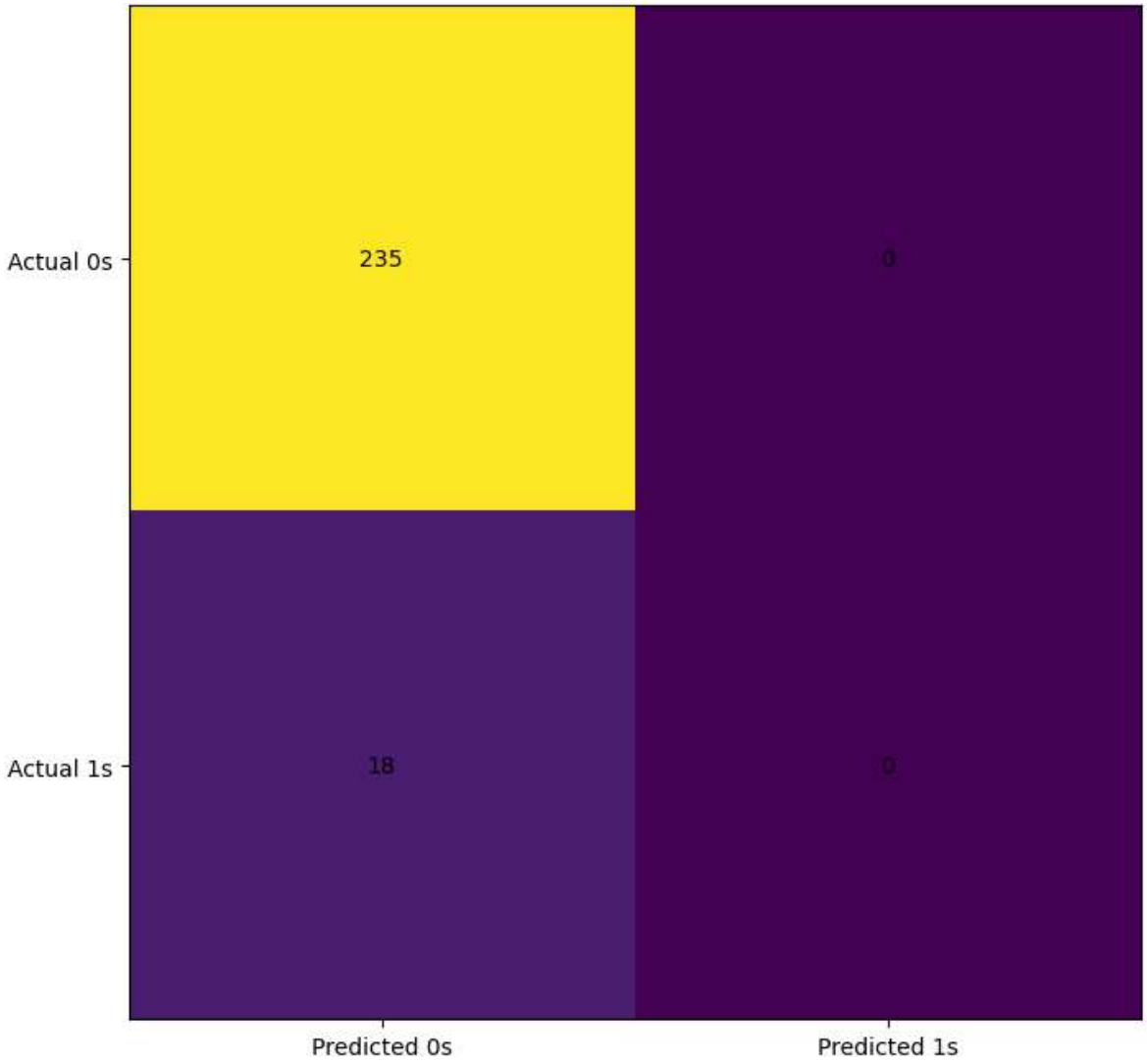
In [57]:
```
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"Mean Squared Error: {mse:.2f}")
print(f"R-squared: {r2:.2f}")
```

```
Mean Squared Error: 0.07
R-squared: -0.08
```

In [58]:
```
confusion_matrix(y_test, y_pred)
```

Out[58]:
```
array([[235,   0],
       [ 18,   0]], dtype=int64)
```

In [59]:
```
cm = confusion_matrix(y_test, y_pred)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(cm)
ax.grid(False)
ax.xaxis.set(ticks=(0, 1), ticklabels=('Predicted 0s', 'Predicted 1s'))
ax.yaxis.set(ticks=(0, 1), ticklabels=('Actual 0s', 'Actual 1s'))
ax.set_ylim(1.5, -0.5)
for i in range(2):
    for j in range(2):
        ax.text(j, i, cm[i, j], ha='center', va='center', color='black')
plt.show()
```



In [60]:
```
accuracy = accuracy_score(y_test, y_pred)
classification_report_result = classification_report(y_test, y_pred)
confusion_matrix_result = confusion_matrix(y_test, y_pred)

print("Accuracy:", accuracy)
print("Classification Report:\n", classification_report_result)
print("Confusion Matrix:\n", confusion_matrix_result)
```

```
Accuracy: 0.9288537549407114
Classification Report:
               precision    recall  f1-score   support

           0       0.93      1.00      0.96       235
           1       0.00      0.00      0.00        18

    accuracy                           0.93       253
   macro avg       0.46      0.50      0.48       253
weighted avg       0.86      0.93      0.89       253

Confusion Matrix:
 [[235   0]
 [ 18   0]]

C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
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to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

ii. test_size = 0.5 random_state = 42

In [61]:
```
x_train, x_test, y_train, y_test = train_test_split(x,y,test_size = 0.3,random
```

In [62]:
```
model = LogisticRegression(max_iter=1000)
```

In [63]:
```
model.fit(x_train,y_train)
```

Out[63]:
```
LogisticRegression(max_iter=1000)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [64]:
```
y_pred = model.predict(x_test)
```

In [65]:
```
y_pred
```

Out[65]:
```
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
       0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0],
      dtype=int64)
```

In [66]:
```
model.score(x,y)
```

Out[66]:
```
0.932806324110672
```

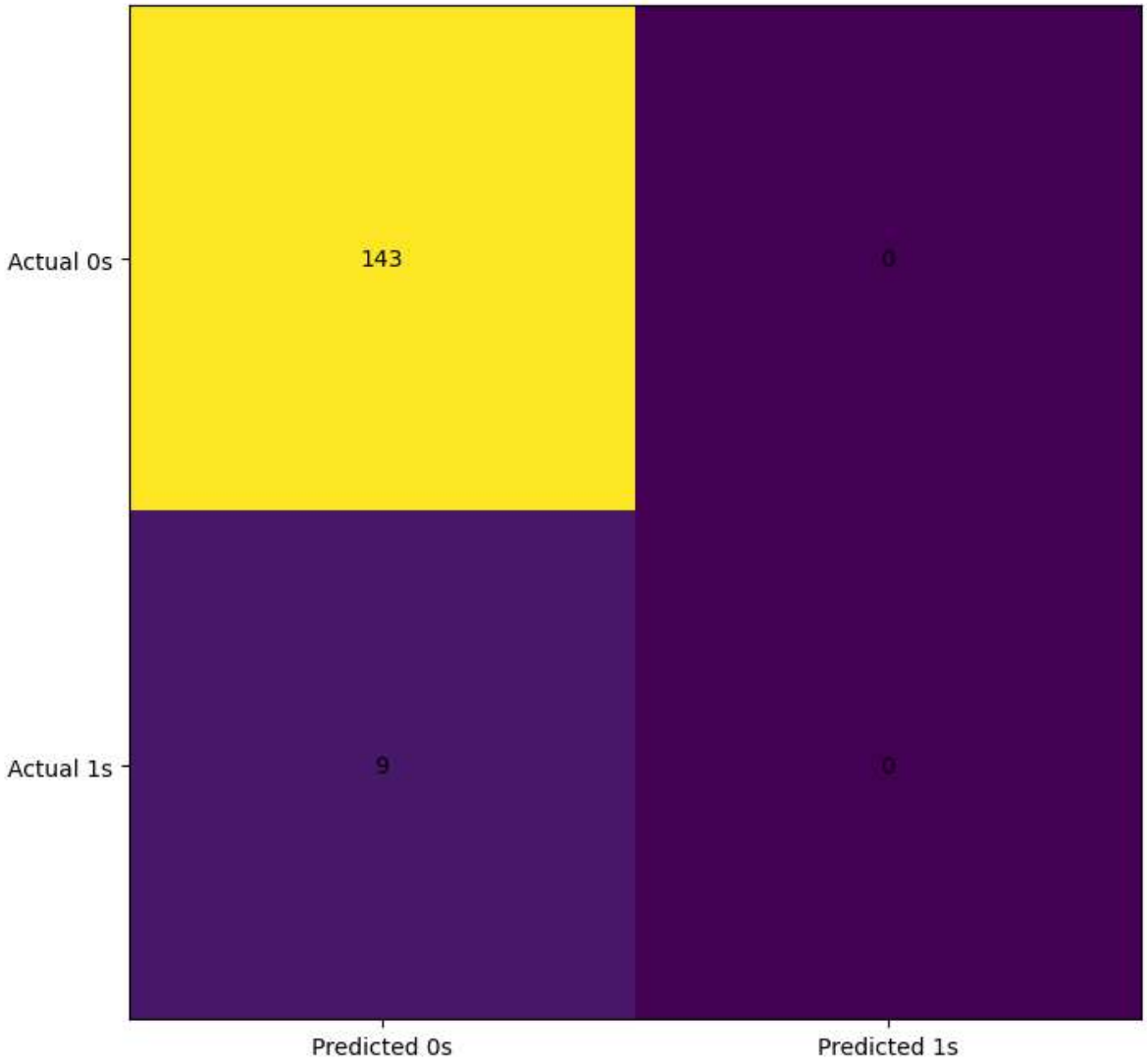
In [67]:
```
mse = mean_squared_error(y_test, y_pred)
r2 = r2_score(y_test, y_pred)

print(f"Mean Squared Error: {mse:.2f}")
print(f"R-squared: {r2:.2f}")
```

```
Mean Squared Error: 0.06
R-squared: -0.06
```

In [68]:
```
confusion_matrix(y_test, y_pred)
```

Out[68]:
```
array([[143,   0],
       [  9,   0]], dtype=int64)
```

In [69]:
```
cm = confusion_matrix(y_test, y_pred)
fig, ax = plt.subplots(figsize=(8, 8))
ax.imshow(cm)
ax.grid(False)
ax.xaxis.set(ticks=(0, 1), ticklabels=('Predicted 0s', 'Predicted 1s'))
ax.yaxis.set(ticks=(0, 1), ticklabels=('Actual 0s', 'Actual 1s'))
ax.set_ylim(1.5, -0.5)
for i in range(2):
    for j in range(2):
        ax.text(j, i, cm[i, j], ha='center', va='center', color='black')
plt.show()
```



In [70]:
```
accuracy = accuracy_score(y_test, y_pred)
classification_report_result = classification_report(y_test, y_pred)
confusion_matrix_result = confusion_matrix(y_test, y_pred)

print("Accuracy:", accuracy)
print("Classification Report:\n", classification_report_result)
print("Confusion Matrix:\n", confusion_matrix_result)
```

```
Accuracy: 0.9407894736842105
Classification Report:
               precision    recall  f1-score   support

           0       0.94      1.00      0.97       143
           1       0.00      0.00      0.00         9

    accuracy                           0.94       152
   macro avg       0.47      0.50      0.48       152
weighted avg       0.89      0.94      0.91       152

Confusion Matrix:
 [[143   0]
 [  9   0]]

C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
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C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
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to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
C:\Users\Dell\anaconda3\Lib\site-packages\sklearn\metrics\_classification.py:
1344: UndefinedMetricWarning: Precision and F-score are ill-defined and being
set to 0.0 in labels with no predicted samples. Use `zero_division` parameter
to control this behavior.
  _warn_prf(average, modifier, msg_start, len(result))
```

In [71]:
```
df.shape
```

Out[71]:
```
(506, 14)
```