```
# Import necessary libraries
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import seaborn as sns
from sklearn.svm import SVC
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import precision_recall_fscore_support,
classification_report, confusion_matrix, mean_squared_error, r2_score,
roc_curve, auc

# Load dataset
df = pd.read_csv(r"C:\Users\Jaden Lee\CSM148-Fall23\Group Project\
Prostate_Cancer.csv")
df.head()
```

	id	diagnosis_result	radius	texture	perimeter	area	smoothness
0	1	M	23	12	151	954	0.143
1	2	B	9	13	133	1326	0.143
2	3	M	21	27	130	1203	0.125
3	4	M	14	16	78	386	0.070
4	5	M	9	19	135	1297	0.141

	compactness	symmetry	fractal_dimension
0	0.278	0.242	0.079
1	0.079	0.181	0.057
2	0.160	0.207	0.060
3	0.284	0.260	0.097
4	0.133	0.181	0.059

```
# Data preprocessing

# Drop id
df.drop("id", axis = 1, inplace = True)

# Check for missing values (No missing values)
missing_values = df.isnull().sum()

# For diagnosis_result, convert M to 1 and B to 0
classification = {'B' : 0, 'M' : 1}
df['diagnosis_result'] = df['diagnosis_result'].map(classification)

# Separate dependent and independent variables
target = df['diagnosis_result']
independent = df.iloc[:, 1:10]
```

```
# Model Training
x_train, x_test, y_train, y_test = train_test_split(independent,
target, test_size = 0.3, random_state = 0)

# Set optimal hyper parameters using grid search for SVC
(regularization, kernel type, kernel coefficient)
hyper_parameters = {'C' : [0.1,1,10,100,1000], 'kernel':['rbf',
'linear'], 'gamma': [0.0001, 0.001, 0.01, 0.1, 1]}
grid = GridSearchCV(SVC(), hyper_parameters, refit=True, verbose = 3)
grid.fit(x_train, y_train)
print("Best Parameters:", grid.best_params_)

# Make predictions
y_pred = grid.predict(x_test)
```

```
Fitting 5 folds for each of 50 candidates, totalling 250 fits
[CV 1/5] END ...C=0.1, gamma=0.0001, kernel=rbf;, score=0.714 total
time=   0.0s
[CV 2/5] END ...C=0.1, gamma=0.0001, kernel=rbf;, score=0.500 total
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[CV 3/5] END ...C=0.1, gamma=0.0001, kernel=rbf;, score=0.643 total
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[CV 4/5] END ...C=0.1, gamma=0.0001, kernel=rbf;, score=0.643 total
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[CV 3/5] END .....C=1, gamma=0.1, kernel=linear;, score=0.857 total
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[CV 4/5] END .....C=1, gamma=0.1, kernel=linear;, score=0.857 total
time=   0.0s
[CV 5/5] END .....C=1, gamma=0.1, kernel=linear;, score=0.643 total
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[CV 1/5] END .........C=1, gamma=1, kernel=rbf;, score=0.500 total
time=   0.0s
[CV 2/5] END .........C=1, gamma=1, kernel=rbf;, score=0.500 total
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[CV 3/5] END .........C=1, gamma=1, kernel=rbf;, score=0.571 total
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[CV 4/5] END .........C=1, gamma=1, kernel=rbf;, score=0.571 total
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[CV 5/5] END .........C=1, gamma=1, kernel=rbf;, score=0.571 total
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[CV 1/5] END .......C=1, gamma=1, kernel=linear;, score=0.857 total
time=   0.0s
[CV 2/5] END .......C=1, gamma=1, kernel=linear;, score=0.786 total
time=   0.1s
[CV 3/5] END .......C=1, gamma=1, kernel=linear;, score=0.857 total
time=   0.0s
[CV 4/5] END .......C=1, gamma=1, kernel=linear;, score=0.857 total
time=   0.0s
[CV 5/5] END .......C=1, gamma=1, kernel=linear;, score=0.643 total
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time=   0.0s
[CV 2/5] END ....C=10, gamma=0.0001, kernel=rbf;, score=0.857 total
time=   0.0s
[CV 3/5] END ....C=10, gamma=0.0001, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 4/5] END ....C=10, gamma=0.0001, kernel=rbf;, score=0.857 total
time=   0.0s
[CV 5/5] END ....C=10, gamma=0.0001, kernel=rbf;, score=0.643 total
time=   0.0s

[CV 1/5] END .C=10, gamma=0.0001, kernel=linear;, score=0.857 total
time=   1.3s
[CV 2/5] END .C=10, gamma=0.0001, kernel=linear;, score=0.786 total
time=   0.7s
[CV 3/5] END .C=10, gamma=0.0001, kernel=linear;, score=0.786 total
time=   4.0s
[CV 4/5] END .C=10, gamma=0.0001, kernel=linear;, score=0.857 total
time=   0.7s
[CV 5/5] END .C=10, gamma=0.0001, kernel=linear;, score=0.714 total
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[CV 1/5] END .....C=10, gamma=0.001, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 2/5] END .....C=10, gamma=0.001, kernel=rbf;, score=0.786 total
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[CV 3/5] END .....C=10, gamma=0.001, kernel=rbf;, score=0.714 total
time=   0.0s
[CV 4/5] END .....C=10, gamma=0.001, kernel=rbf;, score=0.929 total
time=   0.0s
[CV 5/5] END .....C=10, gamma=0.001, kernel=rbf;, score=0.714 total
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time=   0.0s
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[CV 2/5] END ..C=10, gamma=0.001, kernel=linear;, score=0.786 total
time=   0.6s
[CV 3/5] END ..C=10, gamma=0.001, kernel=linear;, score=0.786 total
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[CV 4/5] END ..C=10, gamma=0.001, kernel=linear;, score=0.857 total
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[CV 5/5] END ..C=10, gamma=0.001, kernel=linear;, score=0.714 total
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[CV 1/5] END ......C=10, gamma=0.01, kernel=rbf;, score=0.643 total
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[CV 2/5] END ......C=10, gamma=0.01, kernel=rbf;, score=0.571 total
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[CV 3/5] END ......C=10, gamma=0.01, kernel=rbf;, score=0.643 total
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[CV 4/5] END ......C=10, gamma=0.01, kernel=rbf;, score=0.714 total
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[CV 5/5] END ......C=10, gamma=0.01, kernel=rbf;, score=0.643 total
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[CV 2/5] END ...C=10, gamma=0.01, kernel=linear;, score=0.786 total
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[CV 3/5] END ...C=10, gamma=0.01, kernel=linear;, score=0.786 total
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[CV 5/5] END ...C=10, gamma=0.01, kernel=linear;, score=0.714 total
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[CV 1/5] END ....C=10, gamma=0.1, kernel=linear;, score=0.857 total
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[CV 3/5] END ....C=10, gamma=0.1, kernel=linear;, score=0.786 total
time=   4.1s
[CV 4/5] END ....C=10, gamma=0.1, kernel=linear;, score=0.857 total
time=   0.7s
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[CV 5/5] END ....C=10, gamma=0.1, kernel=linear;, score=0.714 total
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[CV 1/5] END .........C=10, gamma=1, kernel=rbf;, score=0.500 total
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[CV 3/5] END ......C=10, gamma=1, kernel=linear;, score=0.786 total
time=   4.1s
[CV 4/5] END ......C=10, gamma=1, kernel=linear;, score=0.857 total
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[CV 5/5] END ......C=10, gamma=1, kernel=linear;, score=0.714 total
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[CV 1/5] END C=100, gamma=0.0001, kernel=linear;, score=0.786 total
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[CV 2/5] END C=100, gamma=0.0001, kernel=linear;, score=0.786 total
time=   3.5s
[CV 3/5] END C=100, gamma=0.0001, kernel=linear;, score=0.857 total
time=   4.7s
[CV 4/5] END C=100, gamma=0.0001, kernel=linear;, score=0.857 total
time=   1.7s
[CV 5/5] END C=100, gamma=0.0001, kernel=linear;, score=0.714 total
time=   3.1s
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[CV 4/5] END ....C=100, gamma=0.001, kernel=rbf;, score=0.786 total
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[CV 5/5] END ....C=100, gamma=0.001, kernel=rbf;, score=0.786 total
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time=   1.8s
[CV 5/5] END .C=100, gamma=0.001, kernel=linear;, score=0.714 total
time=   3.1s
[CV 1/5] END .....C=100, gamma=0.01, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 2/5] END .....C=100, gamma=0.01, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 3/5] END .....C=100, gamma=0.01, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 4/5] END .....C=100, gamma=0.01, kernel=rbf;, score=0.714 total
time=   0.0s
[CV 5/5] END .....C=100, gamma=0.01, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 1/5] END ..C=100, gamma=0.01, kernel=linear;, score=0.786 total
time=   1.1s
[CV 2/5] END ..C=100, gamma=0.01, kernel=linear;, score=0.786 total
time=   3.5s
[CV 3/5] END ..C=100, gamma=0.01, kernel=linear;, score=0.857 total
time=   4.7s
[CV 4/5] END ..C=100, gamma=0.01, kernel=linear;, score=0.857 total
time=   1.7s
[CV 5/5] END ..C=100, gamma=0.01, kernel=linear;, score=0.714 total
time=   2.9s
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time=   0.0s
[CV 3/5] END ......C=100, gamma=0.1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 4/5] END ......C=100, gamma=0.1, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 5/5] END ......C=100, gamma=0.1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 1/5] END ...C=100, gamma=0.1, kernel=linear;, score=0.786 total
time=   1.1s
[CV 2/5] END ...C=100, gamma=0.1, kernel=linear;, score=0.786 total
time=   3.4s
[CV 3/5] END ...C=100, gamma=0.1, kernel=linear;, score=0.857 total
time=   4.8s
```

```
[CV 4/5] END ...C=100, gamma=0.1, kernel=linear;, score=0.857 total
time=   1.8s
[CV 5/5] END ...C=100, gamma=0.1, kernel=linear;, score=0.714 total
time=   3.1s
[CV 1/5] END ........C=100, gamma=1, kernel=rbf;, score=0.500 total
time=   0.0s
[CV 2/5] END ........C=100, gamma=1, kernel=rbf;, score=0.500 total
time=   0.0s
[CV 3/5] END ........C=100, gamma=1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 4/5] END ........C=100, gamma=1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 5/5] END ........C=100, gamma=1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 1/5] END .....C=100, gamma=1, kernel=linear;, score=0.786 total
time=   1.1s
[CV 2/5] END .....C=100, gamma=1, kernel=linear;, score=0.786 total
time=   3.5s
[CV 3/5] END .....C=100, gamma=1, kernel=linear;, score=0.857 total
time=   4.7s
[CV 4/5] END .....C=100, gamma=1, kernel=linear;, score=0.857 total
time=   1.8s
[CV 5/5] END .....C=100, gamma=1, kernel=linear;, score=0.714 total
time=   3.0s
[CV 1/5] END ..C=1000, gamma=0.0001, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 2/5] END ..C=1000, gamma=0.0001, kernel=rbf;, score=0.786 total
time=   0.0s
[CV 3/5] END ..C=1000, gamma=0.0001, kernel=rbf;, score=0.714 total
time=   0.0s
[CV 4/5] END ..C=1000, gamma=0.0001, kernel=rbf;, score=0.786 total
time=   0.0s
[CV 5/5] END ..C=1000, gamma=0.0001, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 1/5] END C=1000, gamma=0.0001, kernel=linear;, score=0.786 total
time=   1.4s
[CV 2/5] END C=1000, gamma=0.0001, kernel=linear;, score=0.786 total
time=   3.0s

[CV 3/5] END C=1000, gamma=0.0001, kernel=linear;, score=0.857 total
time=   3.5s
[CV 4/5] END C=1000, gamma=0.0001, kernel=linear;, score=0.929 total
time=   7.1s
[CV 5/5] END C=1000, gamma=0.0001, kernel=linear;, score=0.786 total
time=   2.4s
[CV 1/5] END ...C=1000, gamma=0.001, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 2/5] END ...C=1000, gamma=0.001, kernel=rbf;, score=0.714 total
time=   0.0s
[CV 3/5] END ...C=1000, gamma=0.001, kernel=rbf;, score=0.714 total
```

```
time=   0.0s
[CV 4/5] END ...C=1000, gamma=0.001, kernel=rbf;, score=0.786 total
time=   0.0s
[CV 5/5] END ...C=1000, gamma=0.001, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 1/5] END C=1000, gamma=0.001, kernel=linear;, score=0.786 total
time=   1.3s
[CV 2/5] END C=1000, gamma=0.001, kernel=linear;, score=0.786 total
time=   2.9s
[CV 3/5] END C=1000, gamma=0.001, kernel=linear;, score=0.857 total
time=   3.5s
[CV 4/5] END C=1000, gamma=0.001, kernel=linear;, score=0.929 total
time=   7.0s
[CV 5/5] END C=1000, gamma=0.001, kernel=linear;, score=0.786 total
time=   2.4s
[CV 1/5] END ....C=1000, gamma=0.01, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 2/5] END ....C=1000, gamma=0.01, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 3/5] END ....C=1000, gamma=0.01, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 4/5] END ....C=1000, gamma=0.01, kernel=rbf;, score=0.714 total
time=   0.0s
[CV 5/5] END ....C=1000, gamma=0.01, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 1/5] END .C=1000, gamma=0.01, kernel=linear;, score=0.786 total
time=   1.4s
[CV 2/5] END .C=1000, gamma=0.01, kernel=linear;, score=0.786 total
time=   2.9s
[CV 3/5] END .C=1000, gamma=0.01, kernel=linear;, score=0.857 total
time=   3.6s
[CV 4/5] END .C=1000, gamma=0.01, kernel=linear;, score=0.929 total
time=   7.1s
[CV 5/5] END .C=1000, gamma=0.01, kernel=linear;, score=0.786 total
time=   2.4s
[CV 1/5] END .....C=1000, gamma=0.1, kernel=rbf;, score=0.500 total
time=   0.0s
[CV 2/5] END .....C=1000, gamma=0.1, kernel=rbf;, score=0.500 total
time=   0.0s
[CV 3/5] END .....C=1000, gamma=0.1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 4/5] END .....C=1000, gamma=0.1, kernel=rbf;, score=0.643 total
time=   0.0s
[CV 5/5] END .....C=1000, gamma=0.1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 1/5] END ..C=1000, gamma=0.1, kernel=linear;, score=0.786 total
time=   1.4s
[CV 2/5] END ..C=1000, gamma=0.1, kernel=linear;, score=0.786 total
time=   3.0s
```

```
[CV 3/5] END ..C=1000, gamma=0.1, kernel=linear;, score=0.857 total
time=   3.5s
[CV 4/5] END ..C=1000, gamma=0.1, kernel=linear;, score=0.929 total
time=   6.9s
[CV 5/5] END ..C=1000, gamma=0.1, kernel=linear;, score=0.786 total
time=   2.4s
[CV 1/5] END .......C=1000, gamma=1, kernel=rbf;, score=0.500 total
time=   0.0s
[CV 2/5] END .......C=1000, gamma=1, kernel=rbf;, score=0.500 total
time=   0.0s
[CV 3/5] END .......C=1000, gamma=1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 4/5] END .......C=1000, gamma=1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 5/5] END .......C=1000, gamma=1, kernel=rbf;, score=0.571 total
time=   0.0s
[CV 1/5] END ....C=1000, gamma=1, kernel=linear;, score=0.786 total
time=   1.4s
[CV 2/5] END ....C=1000, gamma=1, kernel=linear;, score=0.786 total
time=   2.9s
[CV 3/5] END ....C=1000, gamma=1, kernel=linear;, score=0.857 total
time=   3.5s
[CV 4/5] END ....C=1000, gamma=1, kernel=linear;, score=0.929 total
time=   7.3s
[CV 5/5] END ....C=1000, gamma=1, kernel=linear;, score=0.786 total
time=   2.4s
Best Parameters: {'C': 1000, 'gamma': 0.0001, 'kernel': 'linear'}
```

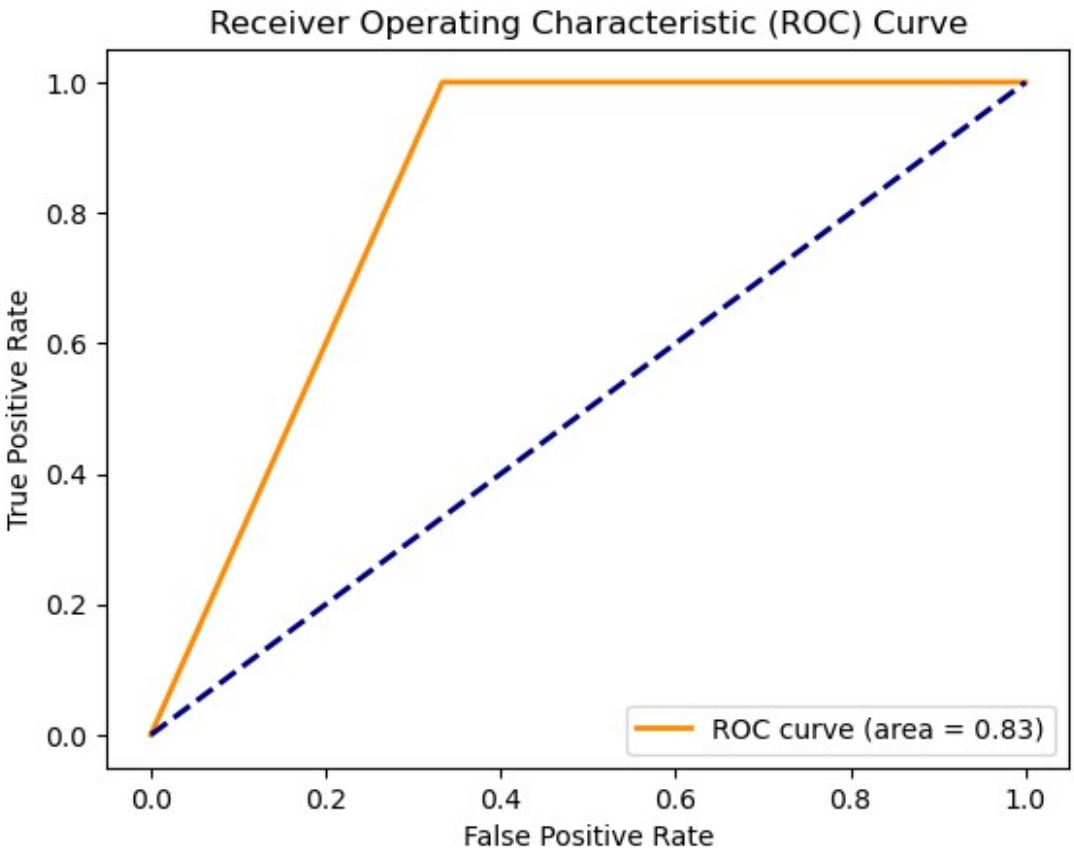
```python
# Evaluate by computing precision, recall, and F1-score for each class
precision, recall, f1_score, _ =
precision_recall_fscore_support(y_test, y_pred, average='weighted')
# Print weighted results
print(f'Weighted Precision: {precision}')
print(f'Weighted Recall: {recall}')
print(f'Weighted F1 Score: {f1_score}')

# Calculate MSE/RMSE/R^2
mse = mean_squared_error(y_test, y_pred)
rmse = np.sqrt(mse)
r2 = r2_score(y_test, y_pred)
print(f'MSE: {mse}')
print(f'RMSE: {rmse}')
print(f'R2: {r2}')
```

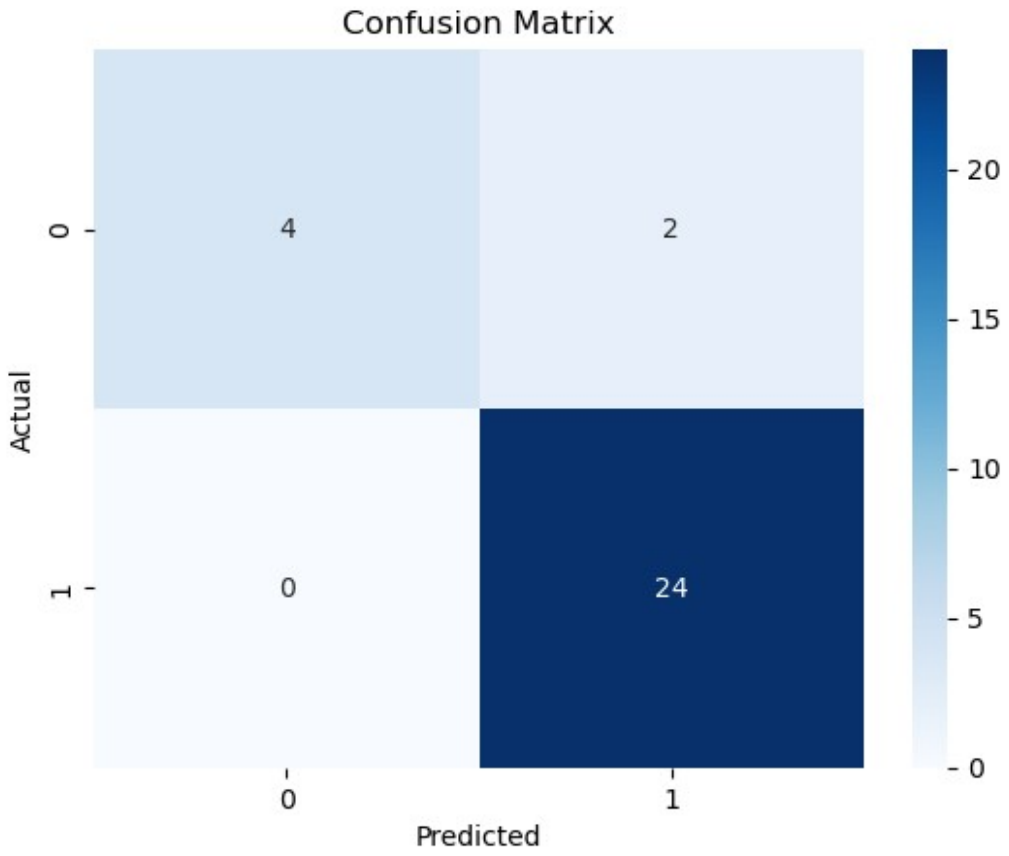
```
Weighted Precision: 0.9384615384615385
Weighted Recall: 0.9333333333333333
Weighted F1 Score: 0.9280000000000002
MSE: 0.06666666666666667
RMSE: 0.2581988897471611
R2: 0.5833333333333334
```

```python
# More in depth statistics for each of B/M (0/1)
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       1.00      0.67      0.80         6
           1       0.92      1.00      0.96        24

    accuracy                           0.93        30
   macro avg       0.96      0.83      0.88        30
weighted avg       0.94      0.93      0.93        30
```

```python
# Visualization of Results

# ROC Curve
fpr, tpr, _ = roc_curve(y_test, y_pred)
roc_auc = auc(fpr, tpr)
plt.figure()
plt.plot(fpr, tpr, color='darkorange', lw=2, label='ROC curve (area = {:.2f})'.format(roc_auc))
plt.plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic (ROC) Curve')
plt.legend(loc='lower right')
plt.show()

# Confusion Matrix Heatmap
cm = confusion_matrix(y_test, y_pred)
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues')
plt.xlabel('Predicted')
plt.ylabel('Actual')
plt.title('Confusion Matrix')
plt.show()
```


Receiver Operating Characteristic (ROC) Curve
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.83)


Confusion Matrix
4
2
0
24
Actual
0
1
0
1
Predicted
20
15
10
5
0