Predict Heart Disease

In [1]:
```
#Packages
#Data
from ucimlrepo import fetch_ucirepo
import pandas as pd
import numpy as np
#Graphs
import matplotlib.pyplot as plt
import seaborn as sns
# Models
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import classification_report, accuracy_score, ConfusionMatrixDisplay
```

Upload data

In [2]:
```
# Import code from Datasource

# fetch dataset
heart_disease = fetch_ucirepo(id=45)

# data (as pandas dataframes)
X = heart_disease.data.features
y1 = heart_disease.data.targets
```

Clean and EDA

In [3]:
```
# Copy date
heart_data = X.copy()
```

In [4]:
```
# If they have heart disease
y1.head(5)
```

Out[4]:

	num
0	0
1	2
2	1
3	0
4	0

In [5]:
```
# Check unique values
y1.value_counts()
```

Out[5]:
```
num
0      164
1       55
2       36
3       35
4       13
Name: count, dtype: int64
```

In [6]:
```
# Change all levels of heart disease to binary
heart_data['Heart Disease'] = y1['num'].replace([1,2,3,4], 1)
```

In [7]:
```
# Check Values
heart_data
```

Out[7]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	Heart Disease
0	63	1	1	145	233	1	2	150	0	2.3	3	0.0	6.0	0
1	67	1	4	160	286	0	2	108	1	1.5	2	3.0	3.0	1
2	67	1	4	120	229	0	2	129	1	2.6	2	2.0	7.0	1
3	37	1	3	130	250	0	0	187	0	3.5	3	0.0	3.0	0
4	41	0	2	130	204	0	2	172	0	1.4	1	0.0	3.0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
298	45	1	1	110	264	0	0	132	0	1.2	2	0.0	7.0	1
299	68	1	4	144	193	1	0	141	0	3.4	2	2.0	7.0	1
300	57	1	4	130	131	0	0	115	1	1.2	2	1.0	7.0	1
301	57	0	2	130	236	0	2	174	0	0.0	2	1.0	3.0	1
302	38	1	3	138	175	0	0	173	0	0.0	1	NaN	3.0	0

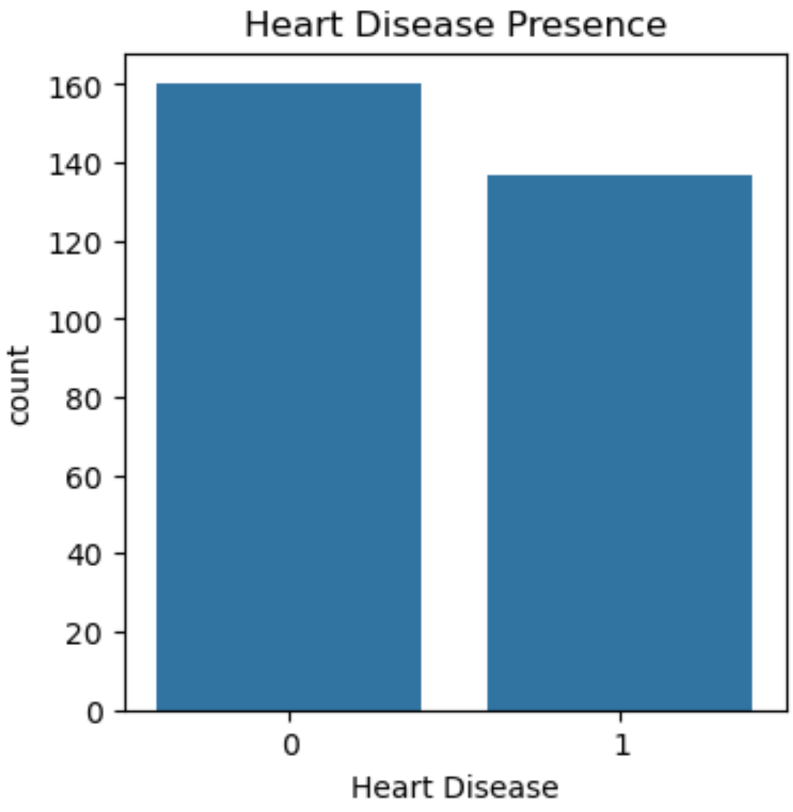
303 rows × 14 columns

In [8]:
```
#Check NAs
heart_data.isnull().sum()
```

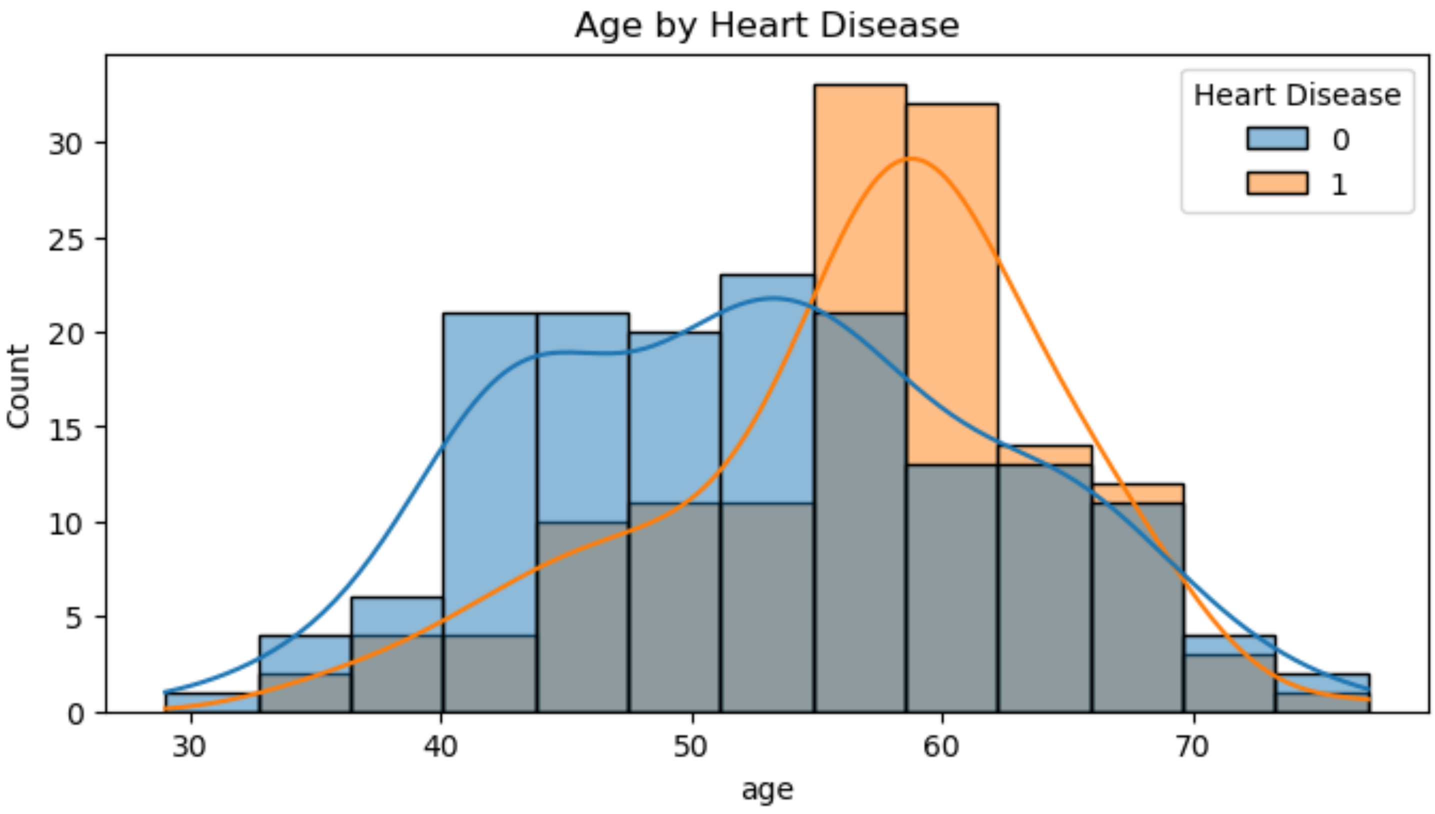
Out[8]:
```
age              0
sex              0
cp               0
trestbps         0
chol             0
fbs              0
restecg          0
thalach          0
exang            0
oldpeak          0
slope            0
ca               4
thal             2
Heart Disease    0
dtype: int64
```

In [9]:
```
# Not many NAs, but drop for model
heart_data = heart_data.dropna()
```

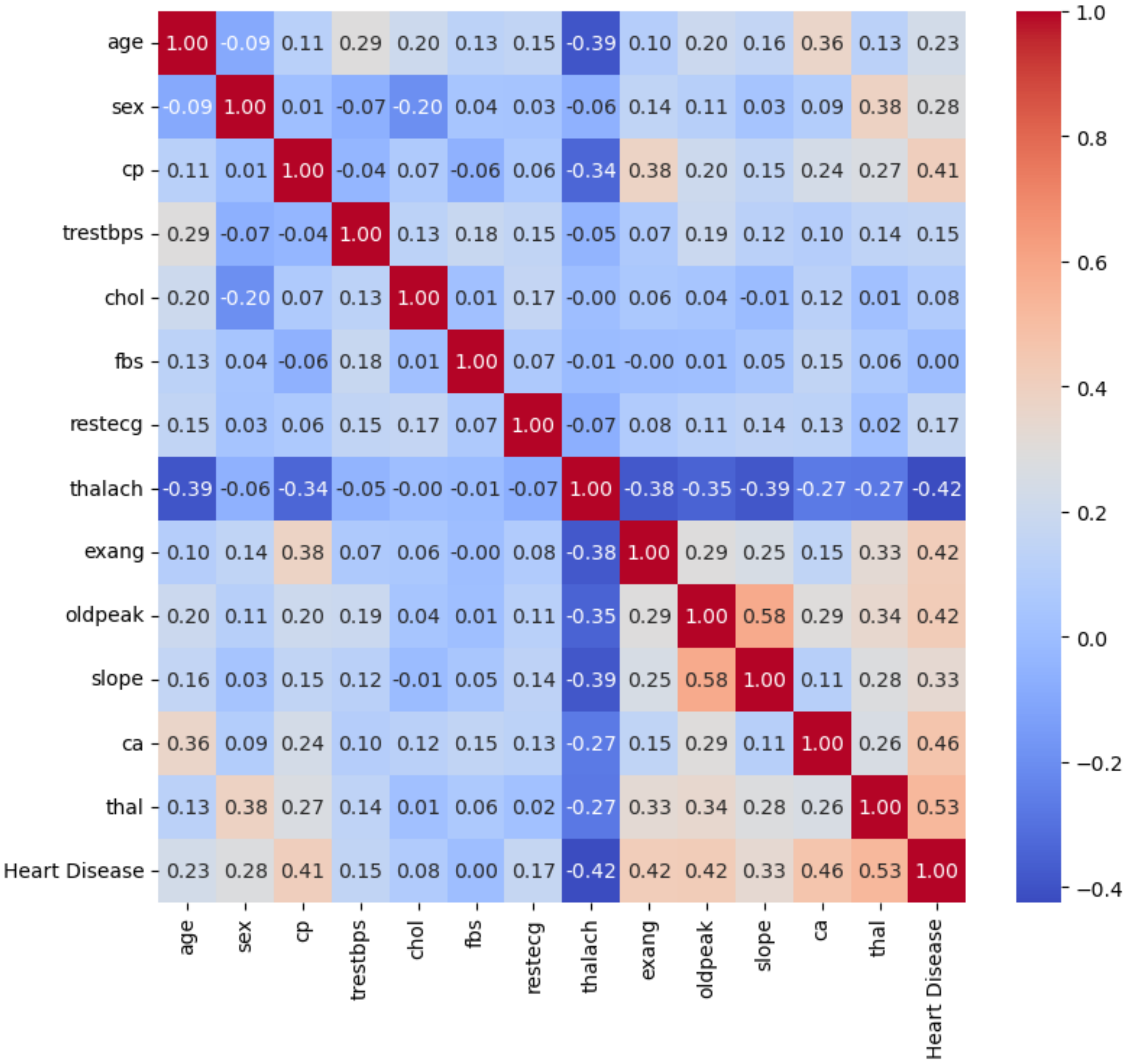
In [10]:
```
#Figure Size
plt.figure(figsize=(4,4))
# Bar chart of people with and without heart disease
sns.countplot(x='Heart Disease', data=heart_data)
# Title
plt.title('Heart Disease Presence')
# Show graph
plt.show()
```



In [11]:
```
# Figure size
plt.figure(figsize=(8,4))
# Check the ranges of ages to know if it is distributed
sns.histplot(data=heart_data, x='age', hue='Heart Disease', kde=True)
# Title
plt.title('Age by Heart Disease')
#Show Graph
plt.show()
```

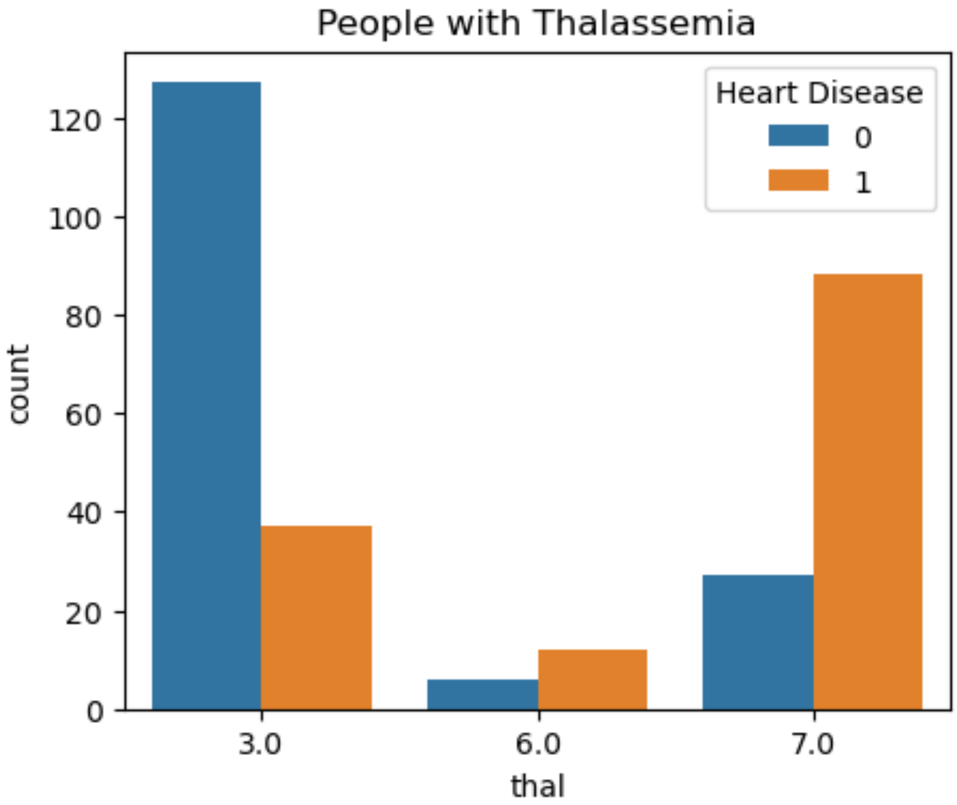


In [12]:
```
# Figure Size
plt.figure(figsize=(9,8))
# Heatmap to find what correlates with heart disease. Round. Change color to an easy to read color.
sns.heatmap(heart_data.corr(), annot=True, fmt=".2f", cmap='coolwarm')
#Show results
plt.show()
```



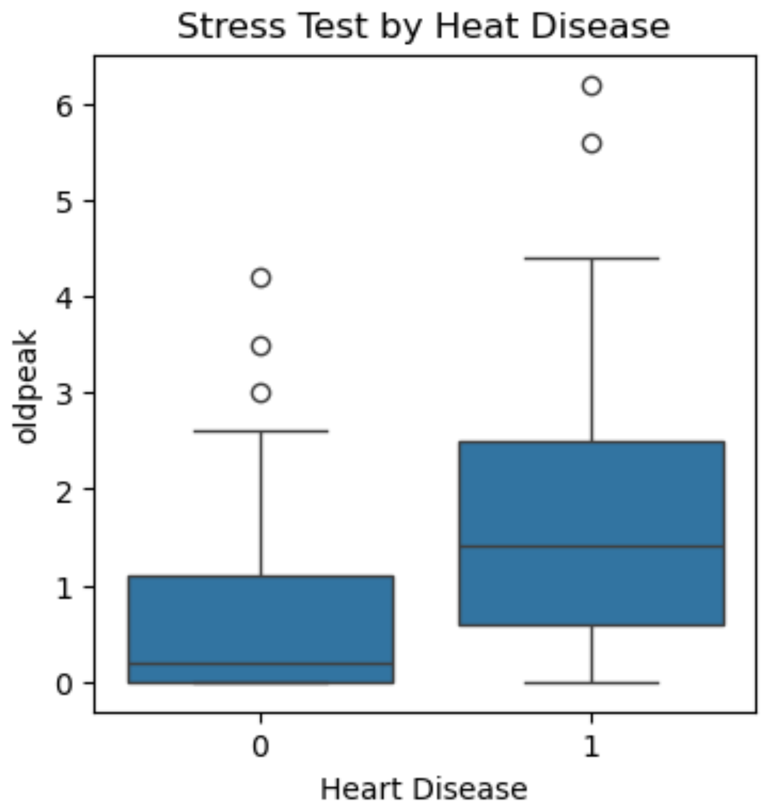
In [13]:

```
# Figure size
plt.figure(figsize=(5,4))
# Count of the number of major blood vessels visible during imaging
sns.countplot(x='thal', hue='Heart Disease', data=heart_data)
# Title
plt.title('People with Thalassemia')
# Show Graph
plt.show()
```

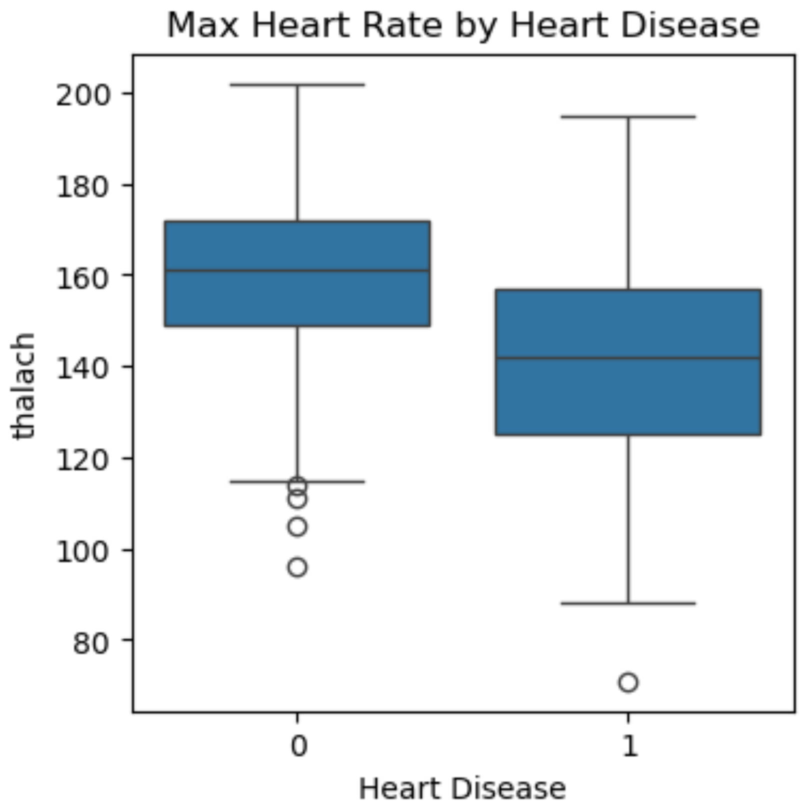


In [14]:

```
# Figure Size
plt.figure(figsize=(4,4))
# Check
sns.boxplot(x='Heart Disease', y='oldpeak', data=heart_data)
# Title
plt.title('Stress Test by Heat Disease')
# Show Graph
plt.show()
```



In [15]:
```
# Figure Size
plt.figure(figsize=(4,4))
# Max Heart RateBox Plot
sns.boxplot(x='Heart Disease', y='thalach', data=heart_data)
# Title
plt.title('Max Heart Rate by Heart Disease')
# Show Results
plt.show()
```



Train Model and Results

Logistic Regression

In [16]:
```
#Split y
y = heart_data['Heart Disease']
X = heart_data.drop(columns = ['Heart Disease'])
```

In [17]:
```
# Split data
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

In [18]:
```
# Allow scaler
scaler = StandardScaler()
```

In [19]:
```
# Fit and transform only training data
X_train_s = scaler.fit_transform(X_train)
# Transform test data
X_test_s = scaler.transform(X_test)
```

In [20]:
```
# Allow Logistic Regression
lg = LogisticRegression(max_iter=1000)
```

In [21]:
```
# Fit Model
lg.fit(X_train_s, y_train)
```

Out[21]:
```
▾ LogisticRegression
▶ Parameters
```

In [22]:
```
# Logistic Regression Predict
y_pred_lr = lg.predict(X_test_s)
```

In [23]:
```
# Print results
print("Logistic Regression:\n", classification_report(y_test, y_pred_lr))
```

```
Logistic Regression:
              precision    recall  f1-score   support

           0       0.89      0.89      0.89        36
           1       0.83      0.83      0.83        24

    accuracy                           0.87        60
   macro avg       0.86      0.86      0.86        60
weighted avg       0.87      0.87      0.87        60
```

Results are good, but see if random forest does better.

Random Forest

In [24]:
```
# Allow Random Forest
rf = RandomForestClassifier(random_state=42, max_depth=5)
```

In [25]:
```
# Fit model
rf.fit(X_train, y_train)
```

Out[25]:
```
▾ RandomForestClassifier
▶ Parameters
```

In [26]:
```
# Predict results
y_pred_rf= rf.predict(X_test)
```

In [27]:
```
# Print Results
print("Random Forest:\n", classification_report(y_test, y_pred_rf))
```

```
Random Forest:
              precision    recall  f1-score   support

           0       0.89      0.89      0.89        36
           1       0.83      0.83      0.83        24

    accuracy                           0.87        60
   macro avg       0.86      0.86      0.86        60
weighted avg       0.87      0.87      0.87        60
```

In [28]:
```
# Predict the train and test results
y_train_pred = rf.predict(X_train)
y_test_pred = rf.predict(X_test)
```

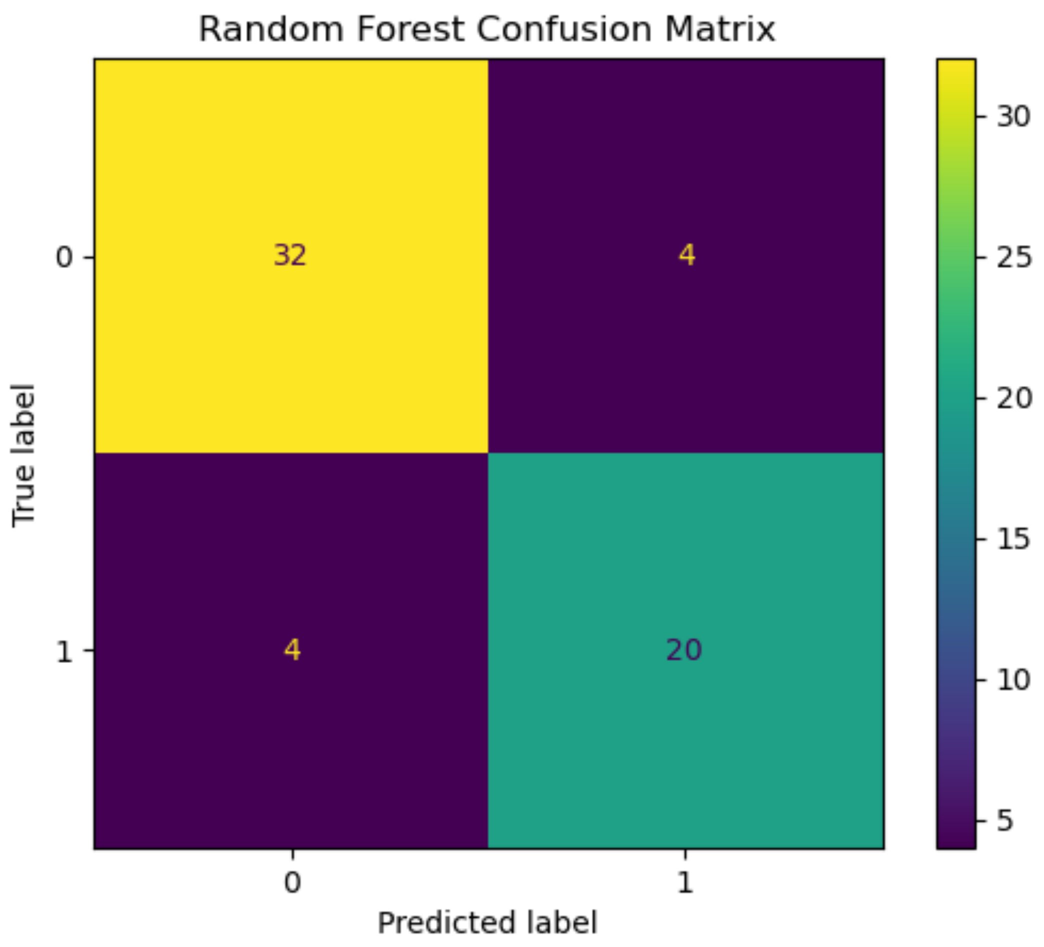
In [29]:
```
# Test train accuracy score
train_accuracy = accuracy_score(y_train, y_train_pred)
test_accuracy = accuracy_score(y_test, y_test_pred)
```

In [30]:
```
# Print results
print("Training Accuracy:", train_accuracy)
print("Test Accuracy:", test_accuracy)
```

```
Training Accuracy: 0.9240506329113924
Test Accuracy: 0.8666666666666667
```

Results improved a little, but see if they can imporve more.

In [31]:
```
# Confusion Matrix for random forest
ConfusionMatrixDisplay.from_estimator(rf, X_test, y_test)
# Title
plt.title('Random Forest Confusion Matrix')
# Show Results
plt.show()
```



Random Forest - GridSearch

In [32]:
```
#Split y
y = heart_data['Heart Disease']
X = heart_data.drop(columns = ['Heart Disease'])
```

In [33]:
```
# Test different param
param_grid = {'n_estimators': [25, 50, 100],
              'max_depth': [None, 5, 10, 15],
              'max_features': ['sqrt', 'log2'],
              'min_samples_split': [2, 5, 10]}
```

In [34]:
```
# Grid search
grid_search = GridSearchCV(estimator=rf,
                           param_grid=param_grid,
                           cv=5,
                           scoring='accuracy')
```

In [36]:
```
# Fit on training data
grid_search.fit(X_train, y_train);
```

In [37]:
```
print("Best Parameters: ", grid_search.best_params_)
```

```
Best Parameters:  {'max_depth': 5, 'max_features': 'sqrt', 'min_samples_split': 2, 'n_estimators': 25}
```

In [38]:
```
# Save the best model
best_rf = grid_search.best_estimator_
```

In [39]:
```
# Predict results
y_pred = best_rf.predict(X_test)
```

In [40]:
```
print("Random Forest - GridSearch \nClassfication Report:\n", classification_report(y_test, y_pred))
```

```
Random Forest - GridSearch
Classfication Report:
               precision    recall  f1-score   support

           0       0.89      0.94      0.92        36
           1       0.91      0.83      0.87        24

    accuracy                           0.90        60
   macro avg       0.90      0.89      0.89        60
weighted avg       0.90      0.90      0.90        60
```

Gridsearch decreased the results. Best results,first random forest.

In [41]:
```
# Pull the features with the largest impact
importances = rf.feature_importances_
```

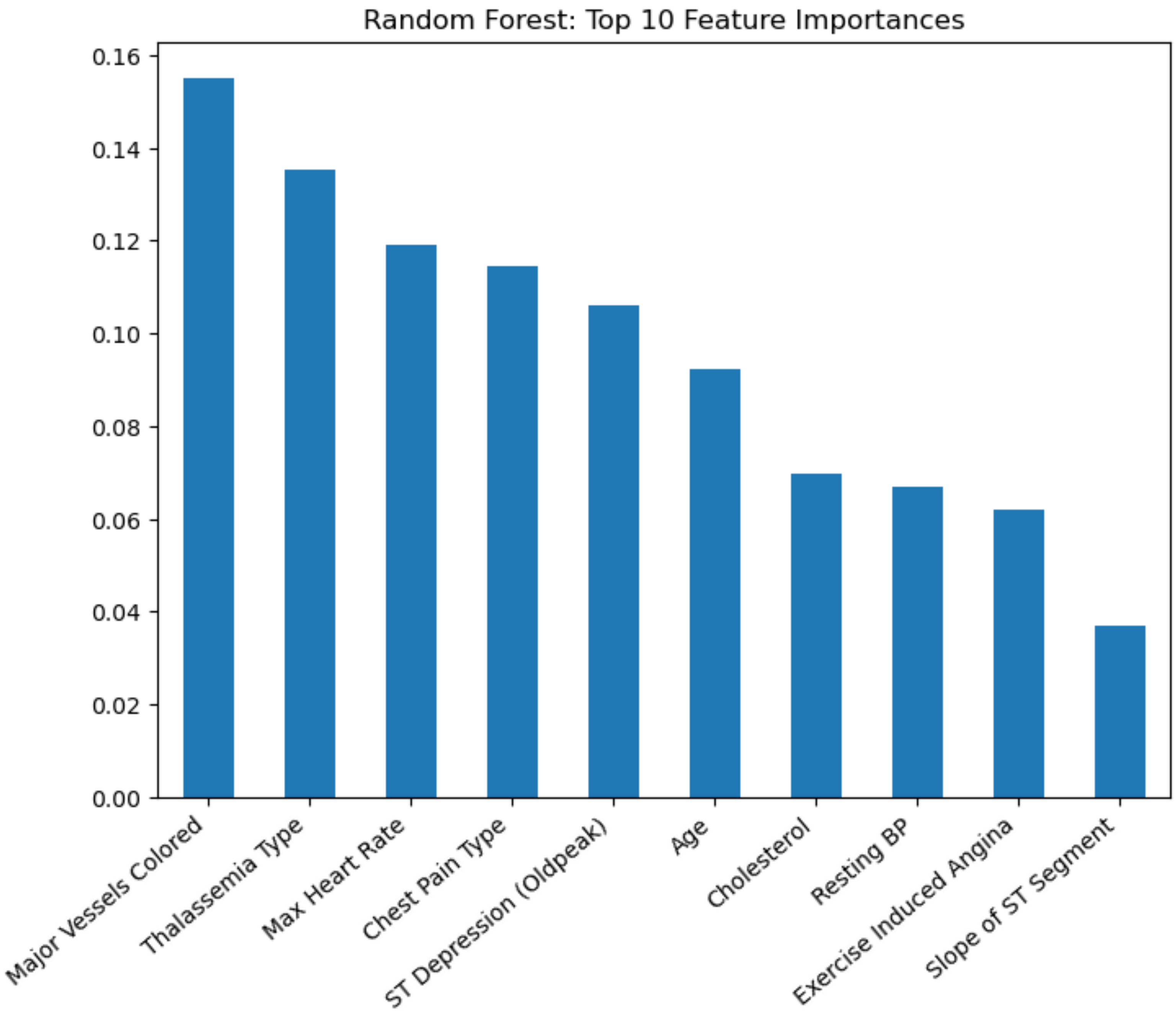
In [42]:
```
# Rename to read graph
r_dict = {'age': 'Age',
          'sex': 'Sex (1=Male)',
          'cp': 'Chest Pain Type',
          'trestbps': 'Resting BP',
          'chol': 'Cholesterol',
          'fbs': 'Fasting Blood Sugar',
          'restecg': 'Resting ECG Results',
          'thalach': 'Max Heart Rate',
          'exang': 'Exercise Induced Angina',
          'oldpeak': 'ST Depression (Oldpeak)',
          'slope': 'Slope of ST Segment',
          'ca': 'Major Vessels Colored',
          'thal': 'Thalassemia Type'}
```

In [43]:
```
# Save list of column names
feat_names = X.columns
```

In [44]:
```
# Make values into a series in order from highest to lowest
feat_imp = pd.Series(importances, index=feat_names).sort_values(ascending=False)
```

In [45]:
```
# Rename columns
feat_imp_r = feat_imp.rename(index=r_dict)
```

In [46]:
```
# Figure size
plt.figure(figsize=(8,6))
# bar graph of top 10 features
feat_imp_r.head(10).plot(kind='bar')
# Turn labels and align
plt.xticks(rotation=40, ha='right')
# Title
plt.title('Random Forest: Top 10 Feature Importances')
# Show Results
plt.show()
```


Random Forest: Top 10 Feature Importances
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Major Vessels Colored
Thalassemia Type
Max Heart Rate
Chest Pain Type
ST Depression (Oldpeak)
Age
Cholesterol
Resting BP
Exercise Induced Angina
Slope of ST Segment