In [1]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.tree import DecisionTreeClassifier
from sklearn import tree
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import OneClassSVM
from sklearn.metrics import accuracy_score
```

In [2]:

```
spam_path = "data/spambase/spambase.data"
name_path = "data/spambase/spambase.names"

with open(name_path, 'r') as file:
    lines = file.readlines()
    col_names = []
    for line in lines[30:]:
        if ':' in line:
            col_name = line.split(':')[0]
            col_names.append(col_name)
    col_names.append("spam_class")
```

In [3]:

```
spam_data = pd.read_csv(spam_path, header=None, names=col_names)
spam_data.fillna(0)
```

Out[3]:

	word_freq_make	word_freq_address	word_freq_all	word_freq_3d	word_freq_our	word_freq_over
0	0.00	0.64	0.64	0.0	0.32	0.00
1	0.21	0.28	0.50	0.0	0.14	0.28
2	0.06	0.00	0.71	0.0	1.23	0.19
3	0.00	0.00	0.00	0.0	0.63	0.00
4	0.00	0.00	0.00	0.0	0.63	0.00
...	...	...	...	...	...	...
4596	0.31	0.00	0.62	0.0	0.00	0.31
4597	0.00	0.00	0.00	0.0	0.00	0.00
4598	0.30	0.00	0.30	0.0	0.00	0.00
4599	0.96	0.00	0.00	0.0	0.32	0.00
4600	0.00	0.00	0.65	0.0	0.00	0.00

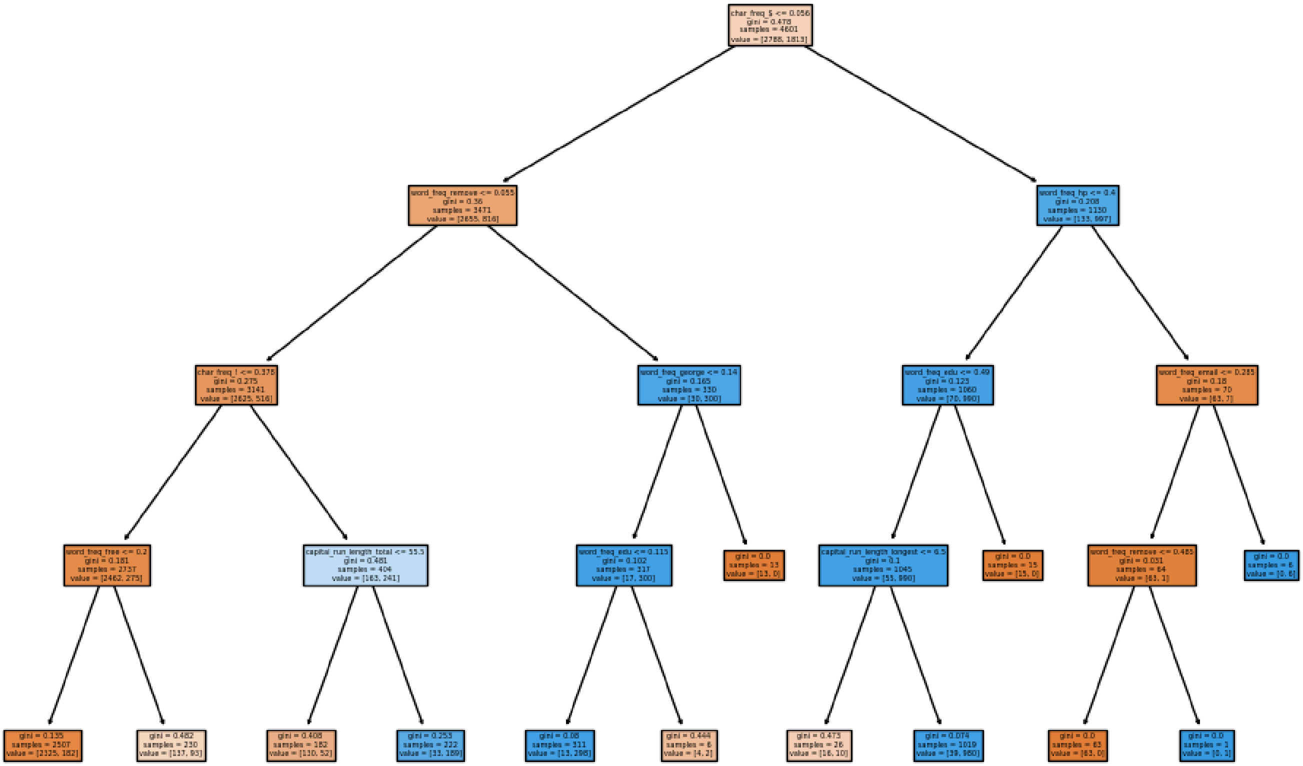
4601 rows × 58 columns

a.

In [4]:

```
X = spam_data.iloc[:, :-1].values
y = spam_data.iloc[:,-1].values

#decision tree classifier
tree_clf = DecisionTreeClassifier(max_depth=4).fit(X,y)

#plot decision tree
plt.figure(figsize=(12,8))
tree.plot_tree(tree_clf, feature_names=col_names, filled=True)
```

```
plt.savefig('cart_model.png')
plt.show()
```

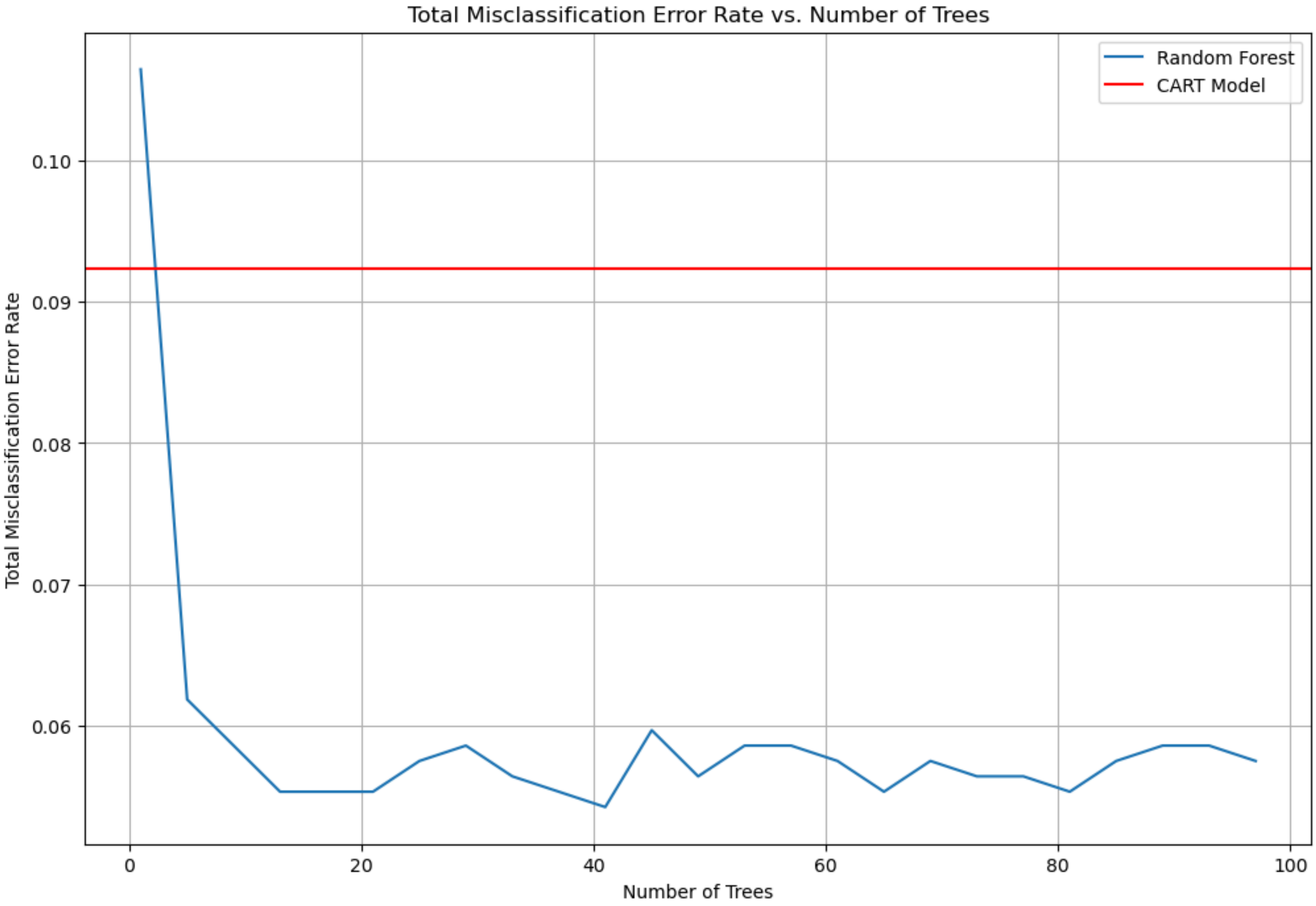


b.

In [5]:

```
#split data and shuffle
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, train_size=0.8,

# random forest classififer
rf_clf = RandomForestClassifier(random_state=55).fit(X_train, y_train)

# Find error rate
tree_clf_error = 1 - accuracy_score(y_test, tree_clf.predict(X_test))
rf_clf_error = 1 - accuracy_score(y_test, rf_clf.predict(X_test))

# Plot the error curve
n_trees_errors = []
for num_trees in range(1, 101, 4):
    rf_clfs = RandomForestClassifier(n_estimators=num_trees, random_state=55).fit(X_trai
    error_rate = 1 - accuracy_score(y_test, rf_clfs.predict(X_test))
    n_trees_errors.append(error_rate)

plt.figure(figsize=(12, 8))
plt.plot(range(1, 101, 4), n_trees_errors, label="Random Forest")
plt.axhline(y=tree_clf_error, color='r', label="CART Model")
plt.xlabel("Number of Trees")
plt.ylabel("Total Misclassification Error Rate")
plt.title("Total Misclassification Error Rate vs. Number of Trees")
plt.grid(True)
plt.legend()
plt.savefig('error_curve.png')
plt.show()
```

```
print("Error Rate for CART Model:", tree_clf_error)
print("Error Rate for Random Forest at 100 trees:", rf_clf_error)
```



```
Error Rate for CART Model: 0.09229098805646041
Error Rate for Random Forest at 100 trees: 0.057546145494028256
```

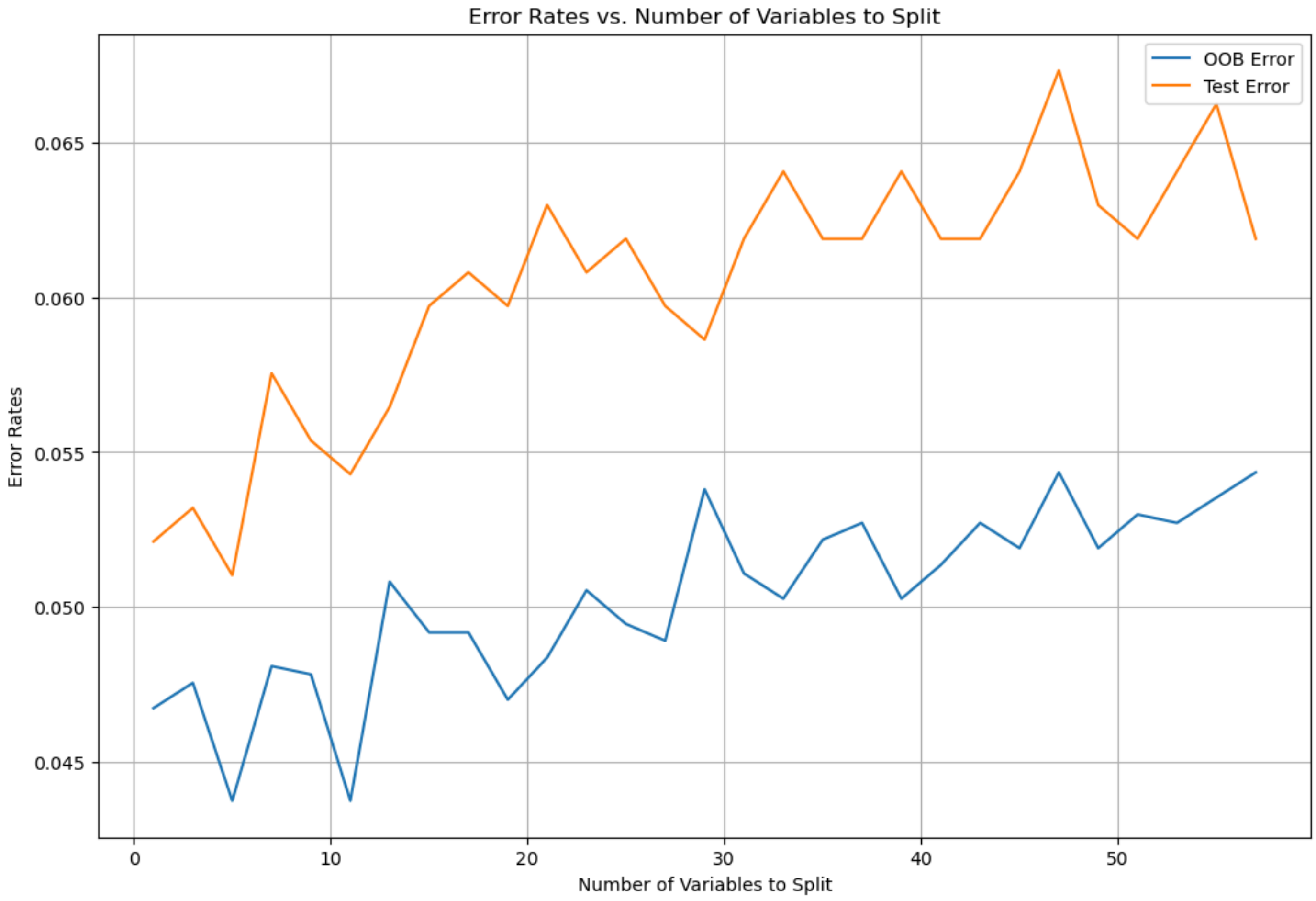
c.

In [6]:

```
num_vars = range(1, X.shape[1]+1, 2)
oob_errors = []
test_errors = []

# create rf classifer for each num of variable splits
for var in num_vars:
    rf_clf = RandomForestClassifier(n_estimators=100, max_features=var, oob_score=True,

    #calculate errors
    oob_error = 1 - rf_clf.oob_score_
    test_error = 1 - accuracy_score(y_test, rf_clf.predict(X_test))
    oob_errors.append(oob_error)
    test_errors.append(test_error)
```

In [7]:

```
# error plot
plt.figure(figsize=(12, 8))
plt.plot(num_vars, oob_errors, label="OOB Error")
plt.plot(num_vars, test_errors, label="Test Error")
plt.xlabel("Number of Variables to Split")
plt.ylabel("Error Rates")
plt.title("Error Rates vs. Number of Variables to Split")
plt.legend()
plt.grid(True)
plt.savefig('OOB_error_curve.png')
plt.show()
```



d.

```
In [8]: # all nonspam from training block
X_nonspam = X_train[y_train == 0]

# one class svm with rbf kernel
svm_clf = OneClassSVM(kernel = 'rbf').fit(X_nonspam)
svm_pred = svm_clf.predict(X_test)

#compare with test data
svm_pred[svm_pred == 1] = 0
svm_pred[svm_pred == -1] = 1
svm_error_rate = 1 - accuracy_score(y_test, svm_pred)
print("One Class SVM using RBF Kernel error rate:", svm_error_rate)
```

```
One Class SVM using RBF Kernel error rate: 0.4755700325732899
```

```
In [9]: # one class svm with rbf kernel and setting gamma to auto
svm_clf = OneClassSVM(kernel = 'rbf', gamma='auto').fit(X_nonspam)
svm_pred = svm_clf.predict(X_test)

#compare with test data
svm_pred[svm_pred == 1] = 0
svm_pred[svm_pred == -1] = 1
svm_error_rate = 1 - accuracy_score(y_test, svm_pred)
print("One Class SVM using RBF Kernel error rate:", svm_error_rate)
```

```
One Class SVM using RBF Kernel error rate: 0.3441910966340934
```