Load and Explore the Dataset

In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
from sklearn.feature_selection import RFE
from sklearn.linear_model import LogisticRegression
from sklearn import model_selection
from sklearn.model_selection import train_test_split as split
```

In [2]:
```
import warnings
warnings.simplefilter(action='ignore', category=FutureWarning)
%matplotlib inline
sns.set(style="whitegrid", color_codes=True)
```

In [3]:
```
filename = 'assignment04.csv.txt'
df = pd.read_csv(filename, encoding='utf-16', sep='\t')
df.shape
```

Out[3]: (303, 14)

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

Out[4]:

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1

In [5]:
```
df.describe()
```

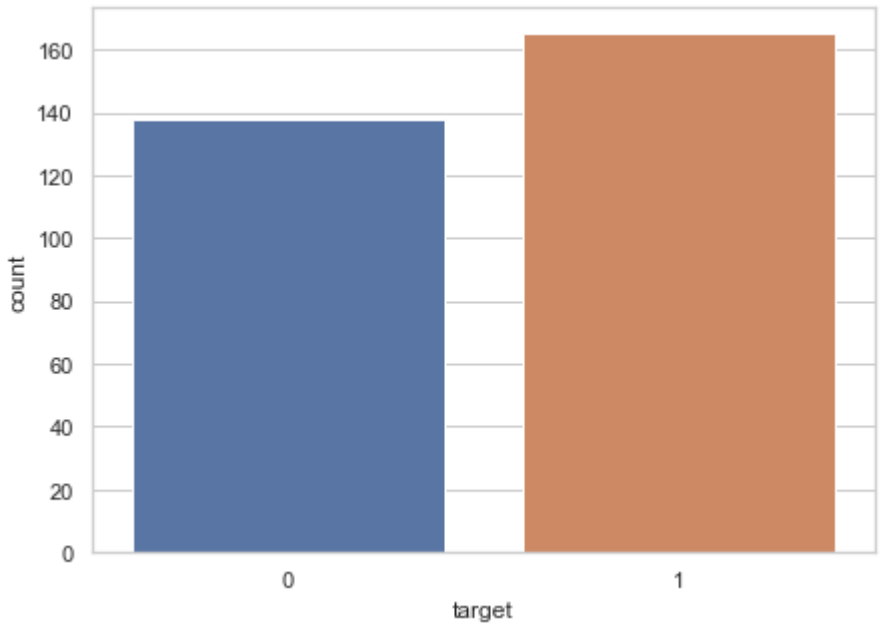
Out[5]:

	age	sex	cp	trestbps	chol	fbs	restecg	tha
count	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.000000	303.00
mean	54.366337	0.683168	0.966997	131.623762	246.264026	0.148515	0.528053	149.64
std	9.082101	0.466011	1.032052	17.538143	51.830751	0.356198	0.525860	22.90
min	29.000000	0.000000	0.000000	94.000000	126.000000	0.000000	0.000000	71.00
25%	47.500000	0.000000	0.000000	120.000000	211.000000	0.000000	0.000000	133.50
50%	55.000000	1.000000	1.000000	130.000000	240.000000	0.000000	1.000000	153.00
75%	61.000000	1.000000	2.000000	140.000000	274.500000	0.000000	1.000000	166.00
max	77.000000	1.000000	3.000000	200.000000	564.000000	1.000000	2.000000	202.00

Data Visualization

In [6]:
```
fig, ax = plt.subplots(figsize=[7, 5])
sns.countplot(x = "target", data = df)
```

Out[6]:
```
<matplotlib.axes._subplots.AxesSubplot at 0xcbd79b2e48>
```



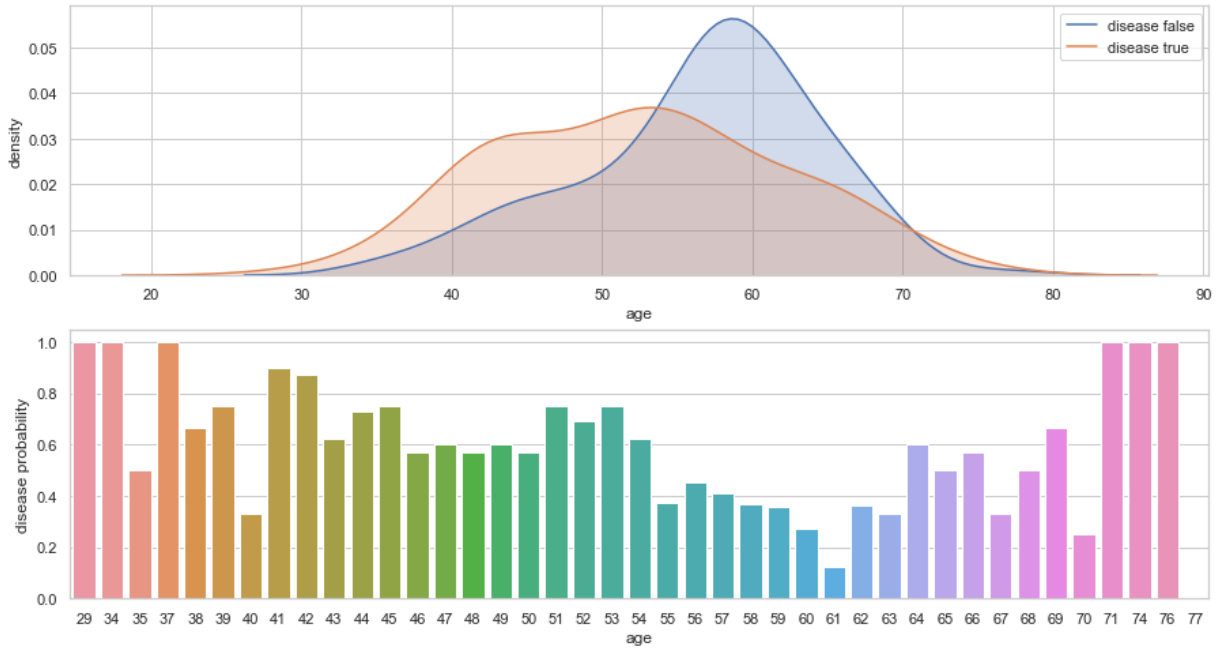
In [7]:
```
df['target'].value_counts()
#count of people having heart disease is apriximately same as not having heart d
```

Out[7]:
```
1    165
0    138
Name: target, dtype: int64
```

Those are having heart disease among them no of male are aproximately same as females

In [8]:
```
categorial = [('sex', ['female', 'male']),
              ('cp', ['typical angina', 'atypical angina', 'non-anginal pain', '
              ('fbs', ['fbs > 120mg', 'fbs <= 120mg']),
              ('restecg', ['normal', 'ST-T wave', 'left ventricular']),
              ('exang', ['yes', 'no']),
              ('slope', ['downsloping','upsloping', 'flat']),
              ('ca', ['0','1', '2','3','4']),
              ('thal', ['normal', 'fixed defect', 'reversible defect'])]
continuous = [('trestbps', 'blood pressure in mm Hg'),
              ('chol', 'serum cholestoral in mg/d'),
              ('thalach', 'maximum heart rate achieved'),
              ('oldpeak', 'ST depression by exercise relative to rest')]


def plotAge():
    facet_grid = sns.FacetGrid(df, hue='target')
    facet_grid.map(sns.kdeplot, "age", shade=True, ax=axes[0])
    legend_labels = ['disease false', 'disease true']
    for t, l in zip(axes[0].get_legend().texts, legend_labels):
        t.set_text(l)
        axes[0].set(xlabel='age', ylabel='density')

    avg = df[["age", "target"]].groupby(['age'], as_index=False).mean()
    sns.barplot(x='age', y='target', data=avg, ax=axes[1])
    axes[1].set(xlabel='age', ylabel='disease probability')

    plt.clf()

def plotCategorial(attribute, labels, ax_index):
    sns.countplot(x=attribute, data=df, ax=axes[ax_index][0])
    sns.countplot(x='target', hue=attribute, data=df, ax=axes[ax_index][1])
    avg = df[[attribute, 'target']].groupby([attribute], as_index=False).mean()
    sns.barplot(x=attribute, y='target', hue=attribute, data=avg, ax=axes[ax_inde

    for t, l in zip(axes[ax_index][1].get_legend().texts, labels):
        t.set_text(l)
    for t, l in zip(axes[ax_index][2].get_legend().texts, labels):
        t.set_text(l)


def plotContinuous(attribute, xlabel, ax_index):
    sns.distplot(df[[attribute]], ax=axes[ax_index][0])
    axes[ax_index][0].set(xlabel=xlabel, ylabel='density')
    sns.boxplot(x='target', y=attribute, data=df, ax=axes[ax_index][1])


def plotGrid(isCategorial):
    if isCategorial:
        [plotCategorial(x[0], x[1], i) for i, x in enumerate(categorial)]
    else:
        [plotContinuous(x[0], x[1], i) for i, x in enumerate(continuous)]
```

In [9]:
```
fig_age, axes = plt.subplots(nrows=2, ncols=1, figsize=(15, 8))

plotAge()
```



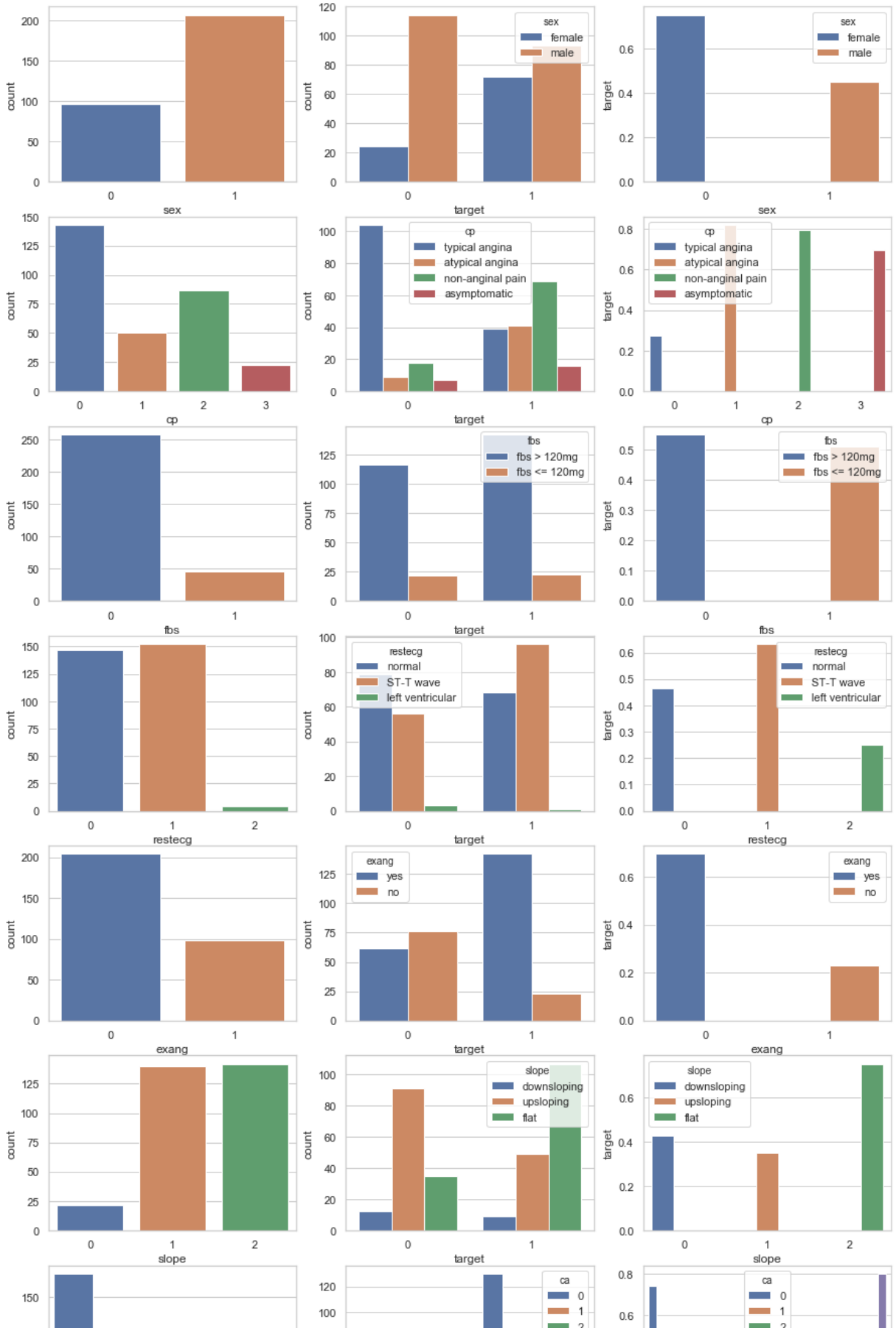

```
<Figure size 216x216 with 0 Axes>
```

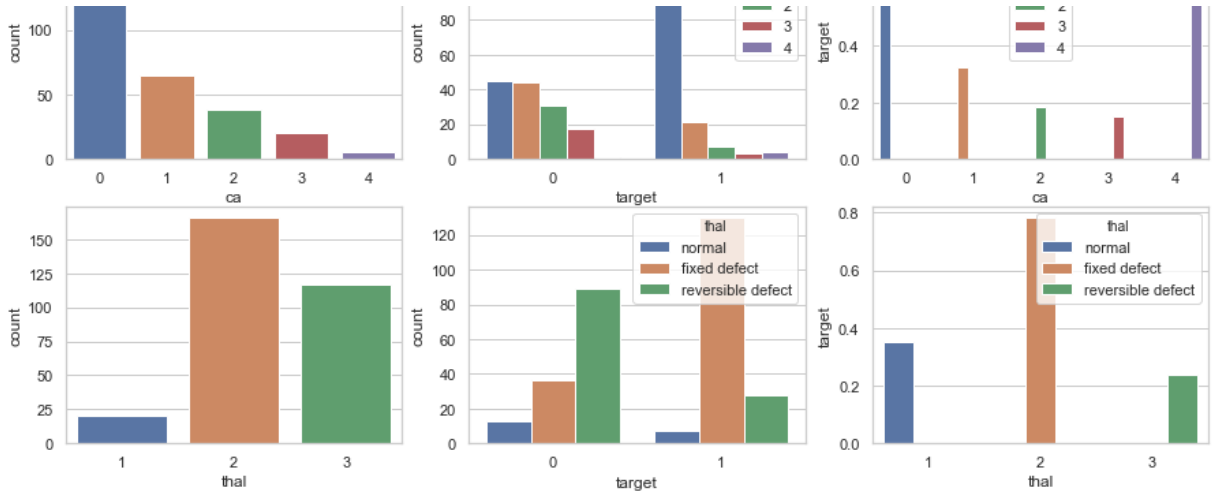
Observations

age has a symmetric and unimodal distribution, where for both target outcomes, the data seems to be centered around 40 to 70 years old

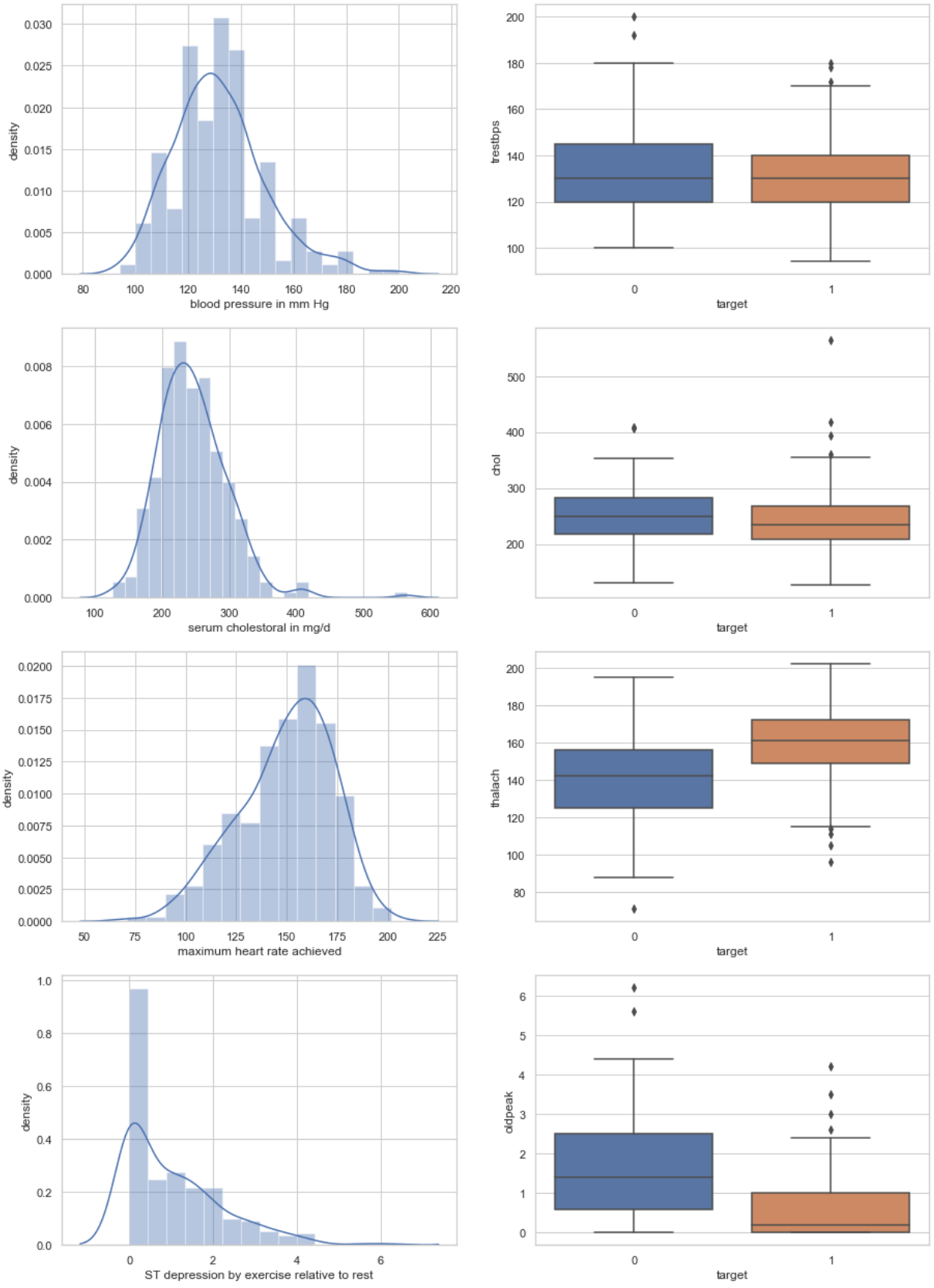
Respondents with a heart disease peak between 40 and 65 years, with the highest density

In [10]:
```
fig_categorial, axes = plt.subplots(nrows=len(categorial), ncols=3, figsize=(15,

plotGrid(isCategorial=True)
```




count
ca
target
thal
normal
fixed defect
reversible defect

In [11]:
```
fig_continuous, axes = plt.subplots(nrows=len(continuous), ncols=2, figsize=(15,

plotGrid(isCategorial=False)
```



Modeling

In [12]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.metrics import accuracy_score

from sklearn.metrics import classification_report
from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve
from sklearn import metrics
from sklearn.metrics import confusion_matrix
```

In [13]:
```
filename = 'assignment04.csv.txt'
df = pd.read_csv(filename, encoding='utf-16', sep='\t')
df.shape
```

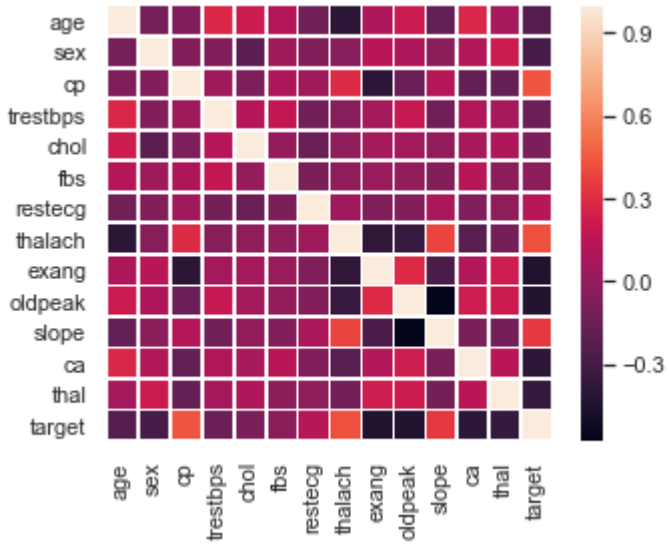
Out[13]:
```
(303, 14)
```

In [14]:
```
# Import train_test_split function
from sklearn.model_selection import train_test_split

X = df.iloc[:,0:13].values
y = df.iloc[:,13].values

#nurmalize the data
from sklearn.preprocessing import StandardScaler
X_std = StandardScaler().fit_transform(X)
dfNorm = pd.DataFrame(X_std, index=df.index, columns=df.columns[0:13])
# # add non-feature target column to dataframe
dfNorm['target'] = df['target']
dfNorm.head(10)
X = dfNorm.iloc[:,0:13].values
y = dfNorm.iloc[:,13].values

X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_s
X_train.shape, y_train.shape, X_test.shape , y_test.shape
```

Out[14]:
```
((212, 13), (212,), (91, 13), (91,))
```

In [15]:
```
# # calculate the correlation matrix
corr = dfNorm.corr()

# plot the heatmap
fig = plt.figure(figsize=(5,4))
sns.heatmap(corr,
        xticklabels=corr.columns,
        yticklabels=corr.columns,
            linewidths=.75)
```

Out[15]:
```
<matplotlib.axes._subplots.AxesSubplot at 0xcbdad06898>
```



In [16]:
```
models = [DecisionTreeClassifier(random_state=100),
          RandomForestClassifier(random_state=100,n_estimators=300),
          LogisticRegression(random_state=100),
          LinearDiscriminantAnalysis()]

for i in models:
    model = i
    model.fit(X_train,y_train)
    pred = model.predict(X_test)
    acc_score = accuracy_score(pred, y_test)
    print('The accuracy for',i,'is',acc_score*100)
```

```
The accuracy for DecisionTreeClassifier(class_weight=None, criterion='gini', ma
x_depth=None,
            max_features=None, max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, presort=False, random_state=100,
            splitter='best') is 72.52747252747253
The accuracy for RandomForestClassifier(bootstrap=True, class_weight=None, crit
erion='gini',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=300, n_jobs=None,
            oob_score=False, random_state=100, verbose=0, warm_start=False) is
82.41758241758241
The accuracy for LogisticRegression(C=1.0, class_weight=None, dual=False, fit_i
ntercept=True,
          intercept_scaling=1, max_iter=100, multi_class='warn',
          n_jobs=None, penalty='l2', random_state=100, solver='warn',
          tol=0.0001, verbose=0, warm_start=False) is 82.41758241758241
The accuracy for LinearDiscriminantAnalysis(n_components=None, priors=None, shr
inkage=None,
              solver='svd', store_covariance=False, tol=0.0001) is 80.219780219
78022
```

In [17]:
```
from mlxtend.feature_selection import SequentialFeatureSelector as SFS
def sfs_features(algo_namem,features_nums):
    sfs_name=SFS(algo_namem,
                 k_features=features_nums,
                 forward=True,
                 floating=False,
                 scoring='accuracy',
                 cv=5)
    return sfs_name
```

In [18]:
```
results_test = {}
results_train = {}
list_algos=[]
```

In [19]:
```
def prdict_date(algo_name,X_train,y_train,X_test,y_test,atype='',verbose=0):
    algo_name.fit(X_train, y_train)
    Y_pred = algo_name.predict(X_test)
    acc_train = round(algo_name.score(X_train, y_train) * 100, 2)
    acc_val = round(algo_name.score(X_test, y_test) * 100, 2)

    results_test[str(algo_name)[0:str(algo_name).find('(')]+'_'+str(atype)] = ac
    results_train[str(algo_name)[0:str(algo_name).find('(')]+'_'+str(atype)] = a
    list_algos.append(str(algo_name)[0:str(algo_name).find('(')])
    if verbose ==0:
        print("acc train: " + str(acc_train))
        print("acc test: "+ str(acc_val))
    else:
        return Y_pred
```

In [20]:
```
def print_fitures(sfs_name='sfs1',verbose=0):
    a= (sfs_name.k_feature_idx_[0],sfs_name.k_feature_idx_[1],sfs_name.k_feature_
    if verbose ==0:
        print('Selected features:', sfs_name.k_feature_idx_)
        for i in range (len (sfs_name.k_feature_idx_)):
            print (df.iloc[:,sfs_name.k_feature_idx_[i]].name)
    return a
```

In [21]:
```
from sklearn.metrics import roc_curve, auc
from sklearn.model_selection import StratifiedKFold
from scipy import interp

def roc_graph_cv(algo_name,X,y,cvn=5):
    # Run classifier with cross-validation and plot ROC curves
    cv = StratifiedKFold(n_splits=cvn)
    classifier =algo_name
    plt.figure(figsize=(5,4))
    tprs = []
    aucs = []
    mean_fpr = np.linspace(0, 1, 100)

    i = 0
    for train, test in cv.split(X, y):
        probas_ = classifier.fit(X[train], y[train].ravel()).predict_proba(X[tes
        # Compute ROC curve and area the curve
        fpr, tpr, thresholds = roc_curve(y[test].ravel(), probas_[:, 1])
        tprs.append(interp(mean_fpr, fpr, tpr))
        tprs[-1][0] = 0.0
        roc_auc = auc(fpr, tpr)
        aucs.append(roc_auc)
        plt.plot(fpr, tpr, lw=1, alpha=0.3,
                 label='ROC fold %d (AUC = %0.2f)' % (i, roc_auc))

        i += 1
    plt.plot([0, 1], [0, 1], linestyle='--', lw=2, color='r',
             label='Luck', alpha=.8)

    mean_tpr = np.mean(tprs, axis=0)
    mean_tpr[-1] = 1.0
    mean_auc = auc(mean_fpr, mean_tpr)
    std_auc = np.std(aucs)

    plt.plot(mean_fpr, mean_tpr, color='b',
             label=r'Mean ROC (AUC = %0.2f $\pm$ %0.2f)' % (mean_auc, std_auc),
             lw=2, alpha=.8)

    std_tpr = np.std(tprs, axis=0)
    tprs_upper = np.minimum(mean_tpr + std_tpr, 1)
    tprs_lower = np.maximum(mean_tpr - std_tpr, 0)
    plt.fill_between(mean_fpr, tprs_lower, tprs_upper, color='grey', alpha=.2,
                     label=r'$\pm$ 1 std. dev.')

    plt.xlim([-0.05, 1.05])
    plt.ylim([-0.05, 1.05])
    plt.xlabel('False Positive Rate')
    plt.ylabel('True Positive Rate')
    plt.title('Receiver operating characteristic example')
    plt.legend(loc="lower right")
    plt.show()
```

In [22]:
```
def conf(algo_name,X_test, y_test):
    y_pred = algo_name.predict(X_test)
    forest_cm = metrics.confusion_matrix(y_pred, y_test, [1,0])
    plt.figure(figsize=(5,4))
    sns.heatmap(forest_cm, annot=True, fmt='.2f',xticklabels = ["1", "0"] , yticl
    plt.ylabel('True class')
    plt.xlabel('Predicted class')
    plt.title(str(algo_name)[0:str(algo_name).find('(')])
```

In [23]:
```
### LDA
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
lda = LinearDiscriminantAnalysis()
prdict_date(lda,X_train,y_train,X_test,y_test)
```

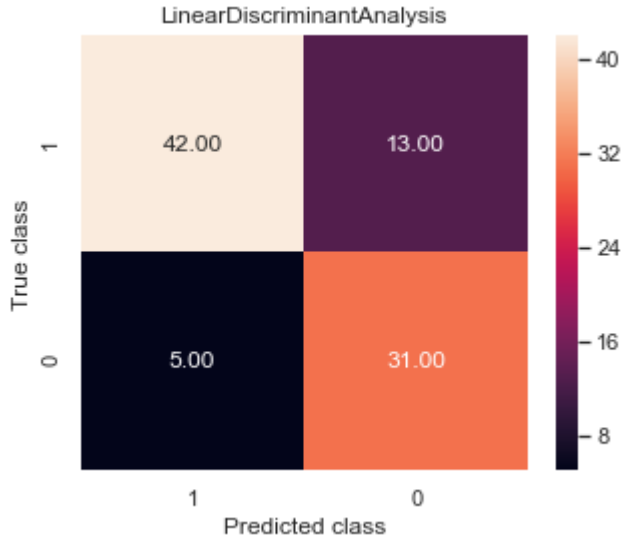
```
acc train: 86.32
acc test: 80.22
```

In [24]:
```
#predictusing sfs:
sfs_1=sfs_features(lda,(1,5))
sfs_1 = sfs_1.fit(X, y)
selectedFeatures = print_fitures(sfs_1)

#plot3D(sfs_1.k_feature_idx_[0],sfs_1.k_feature_idx_[1],sfs_1.k_feature_idx_[2],

X_train_sfs = sfs_1.transform(X_train)
X_test_sfs = sfs_1.transform(X_test)
print ('\n')
prdict_date(lda,X_train_sfs,y_train,X_test_sfs,y_test,'sfs')
```

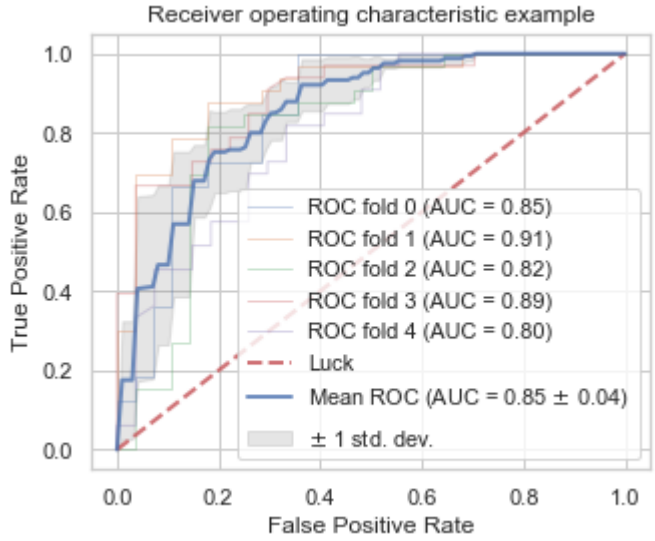
```
Selected features: (2, 7, 9, 10, 12)
cp
thalach
oldpeak
slope
thal


acc train: 81.13
acc test: 80.22
```

In [25]:
```
print(classification_report(y_test, lda.predict(X_test_sfs)))
conf(lda,X_test_sfs, y_test)
```

```
              precision    recall  f1-score   support

           0       0.86      0.70      0.78        44
           1       0.76      0.89      0.82        47

   micro avg       0.80      0.80      0.80        91
   macro avg       0.81      0.80      0.80        91
weighted avg       0.81      0.80      0.80        91
```



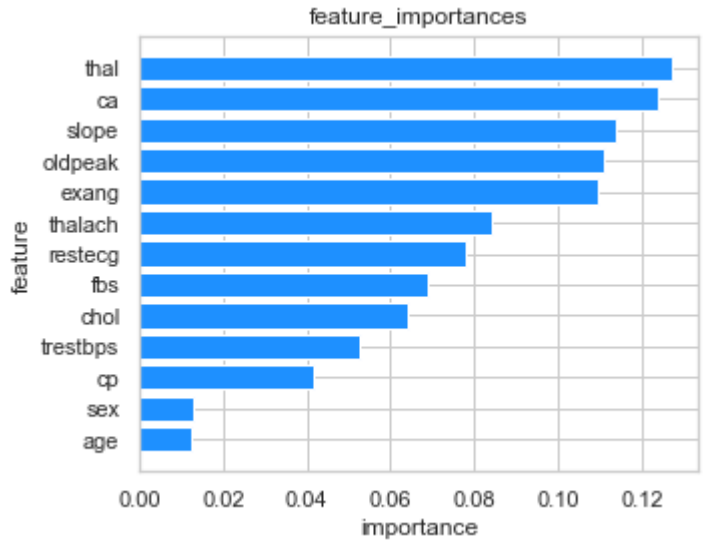
In [26]:
```
roc_graph_cv(lda,X[:,selectedFeatures],y)
```



In [27]:
```
# RANDOM FOREST
random_forest = RandomForestClassifier(n_estimators=50, random_state = 0)
prdict_date(random_forest,X_train,y_train,X_test,y_test)
```

```
acc train: 100.0
acc test: 83.52
```

In [28]:
```
feature_importance = random_forest.feature_importances_
feat_importances = pd.Series(random_forest.feature_importances_, index=df.columns
feat_importances = feat_importances.nlargest(13)

feature = df.columns.values.tolist()[0:-1]
importance = sorted(random_forest.feature_importances_.tolist())


x_pos = [i for i, _ in enumerate(feature)]
plt.figure(figsize=(5,4))
plt.barh(x_pos, importance , color='dodgerblue')
plt.ylabel("feature")
plt.xlabel("importance")
plt.title("feature_importances")

plt.yticks(x_pos, feature)

plt.show()
```



In [29]:
```
#taking the best 5 features give as smaller result.
currlist =[2,12,11,10,9]
# print (currlist)

random_forest = RandomForestClassifier(n_estimators=100, random_state = 0)
prdict_date(random_forest,X_train[:,currlist],y_train,X_test[:,currlist],y_test,
```

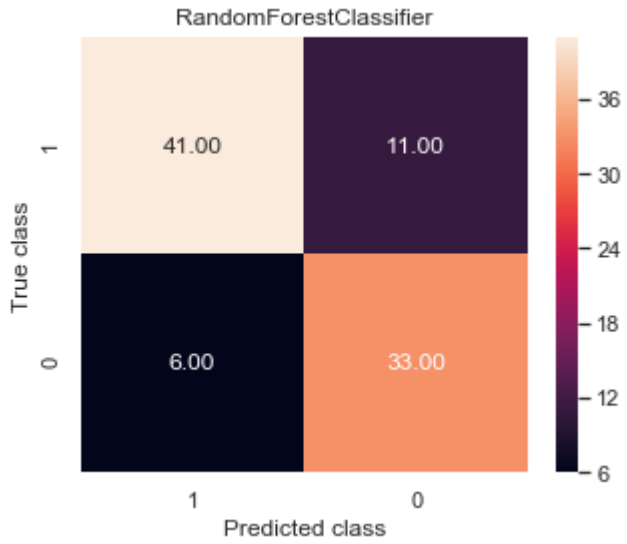
```
acc train: 94.81
acc test: 84.62
```

In [30]:
```
sfs_1=sfs_features(random_forest,(1,5))
sfs_1 = sfs_1.fit(X, y)
selectedFeatures = print_fitures(sfs_1)


X_train_sfs = sfs_1.transform(X_train)
X_test_sfs = sfs_1.transform(X_test)

print ("\n")
prdict_date(random_forest,X_train_sfs,y_train,X_test_sfs,y_test,'sfs')
```

```
Selected features: (2, 11, 12)
cp
ca
thal


acc train: 86.32
acc test: 81.32
```

In [31]:
```
print(classification_report(y_test, random_forest.predict(X_test_sfs)))
conf(random_forest,X_test_sfs, y_test)
```

```
              precision    recall  f1-score   support

           0       0.85      0.75      0.80        44
           1       0.79      0.87      0.83        47

   micro avg       0.81      0.81      0.81        91
   macro avg       0.82      0.81      0.81        91
weighted avg       0.82      0.81      0.81        91
```



In [32]:
```
roc_graph_cv(random_forest,X[:,selectedFeatures],y)
```