Etivity 5 Higher Dimensions

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You may add two extra libraries: one to make a train-test split and one to perform a grid search

In [79]:

```
import random
import numpy as np
import matplotlib.pyplot as plt
from sklearn import svm
import math

# Additional two libraries
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV

# Also adding Pandas to import CSVs
import pandas as pd
```

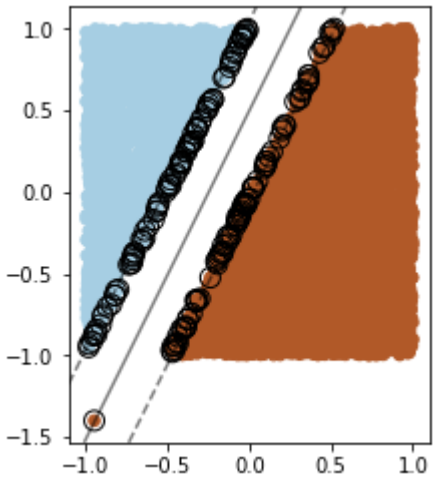
Sample code to plot SVM margin, 'gutters' and support vectors

In [24]:

```
plt.scatter(X_train[:, 0], X_train[:, 1], c=y_train, s=30, cmap=plt.cm.Paired)


# plot the decision function
ax = plt.gca()
ax.set_aspect(aspect=1)
xlim = ax.get_xlim()
ylim = ax.get_ylim()

# create grid to evaluate model
xx = np.linspace(xlim[0], xlim[1], 30)
yy = np.linspace(ylim[0], ylim[1], 30)
YY, XX = np.meshgrid(yy, xx)
xy = np.vstack([XX.ravel(), YY.ravel()]).T
Z = clf.best_estimator_.decision_function(xy).reshape(XX.shape)

# plot decision boundary and margins
ax.contour(XX, YY, Z, colors='k', levels=[-1, 0, 1], alpha=0.5,
           linestyles=['--', '-', '--'])
# plot support vectors
ax.scatter(clf.best_estimator_.support_vectors_[:, 0], clf.best_estimator_.support_vect
ors_[:, 1], s=100,
           linewidth=1, facecolors='none', edgecolors='k')
```

Out[24]:

```
<matplotlib.collections.PathCollection at 0x5141dd8>
```



Task 4

In [18]:

```
df1 = pd.read_csv("./dataset_1.csv")
df1 = df1.drop(['Unnamed: 0'],axis=1)
df1.describe()
```

Out[18]:

	0	1	2
count	10001.000000	10001.000000	10001.000000
mean	0.082508	-0.004040	0.668233
std	0.615153	0.575639	0.470871
min	-0.999635	-1.400000	0.000000
25%	-0.496767	-0.496319	0.000000
50%	0.208210	-0.006960	1.000000
75%	0.614940	0.491170	1.000000
max	0.999983	0.999918	1.000000

In [19]:

```
df1.head()
```

Out[19]:

	0	1	2
0	-0.331982	-0.926029	1.0
1	-0.819310	-0.242368	0.0
2	0.922427	0.499088	1.0
3	-0.570793	0.562286	0.0
4	0.375817	-0.941165	1.0

In [ ]:

```
df1.tail()
```

In [22]:

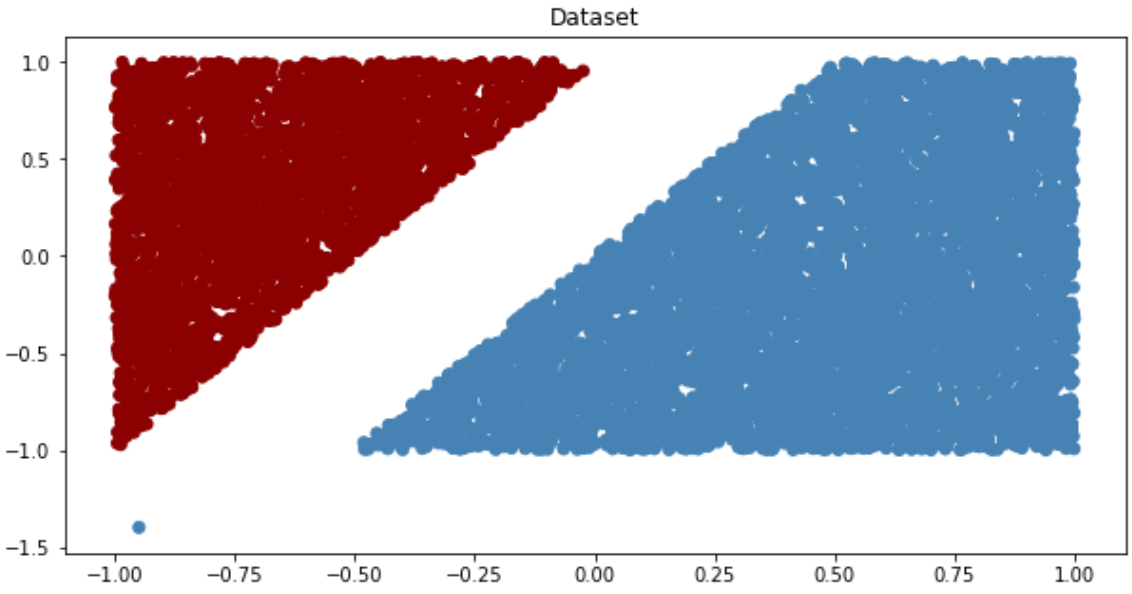
```
# target attribute
y = df1['2']

# predictor attributes
X = df1.drop('2', axis=1).values
```

In [23]:

```
def print_dataset(X, y):
    # Plot the dataset

    # Assign colours based on the labels (1,-1) = (steelblue,darkred)
    colors = ['steelblue' if label == 1 else 'darkred' for label in y]

    # Plot Training Data
    plt.rcParams["figure.figsize"] = (10, 5)
    plt.title("Dataset")
    plt.scatter(X[:,0], X[:,1], color=colors)

    plt.show()
```

In [24]:

```
print_dataset(X,y)
```

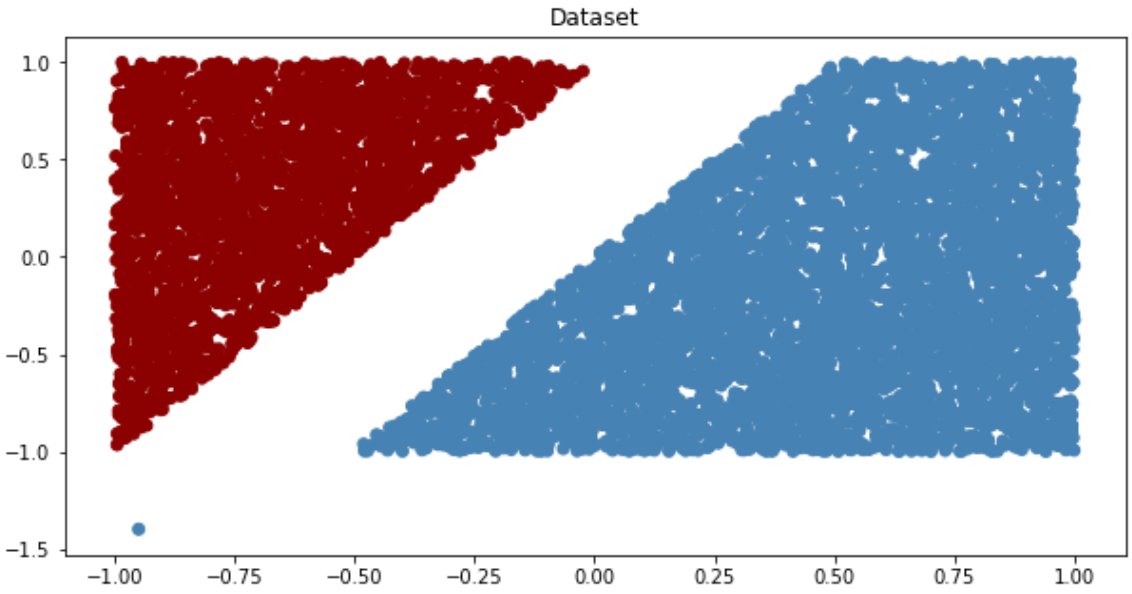


In [26]:

```
# Split into test set and training set
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=4
2)
```

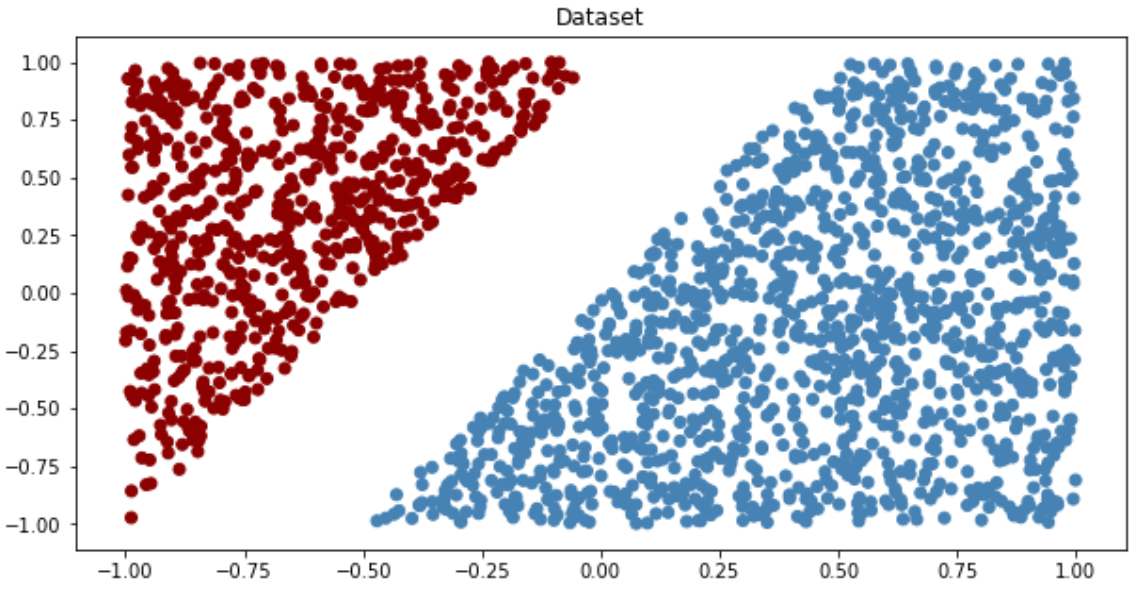
In [27]:

```
print_dataset(X_train,y_train)
```



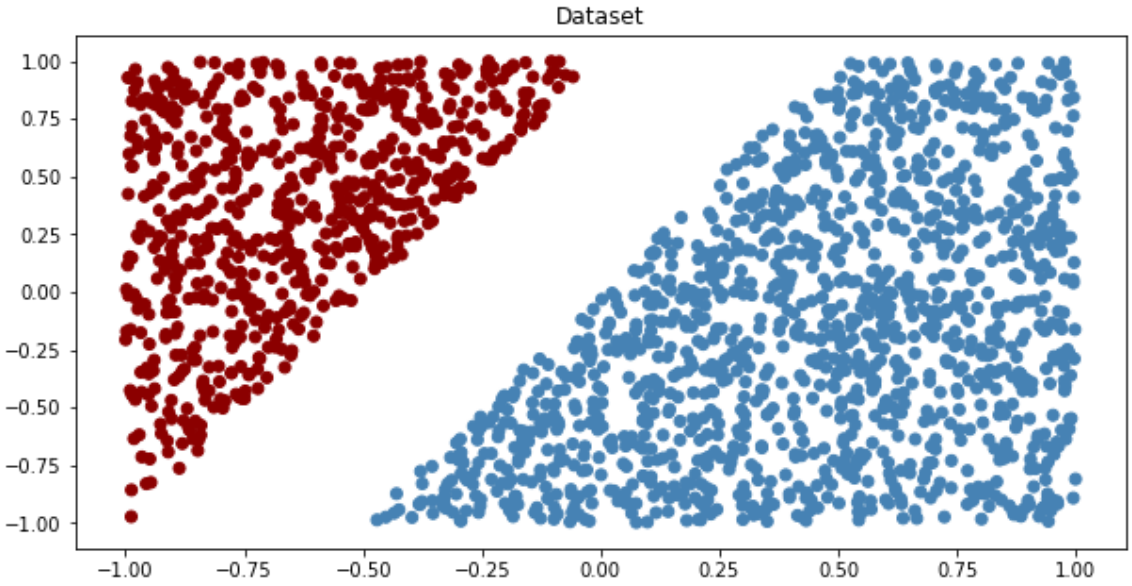
In [28]:

```
print_dataset(X_test,y_test)
```



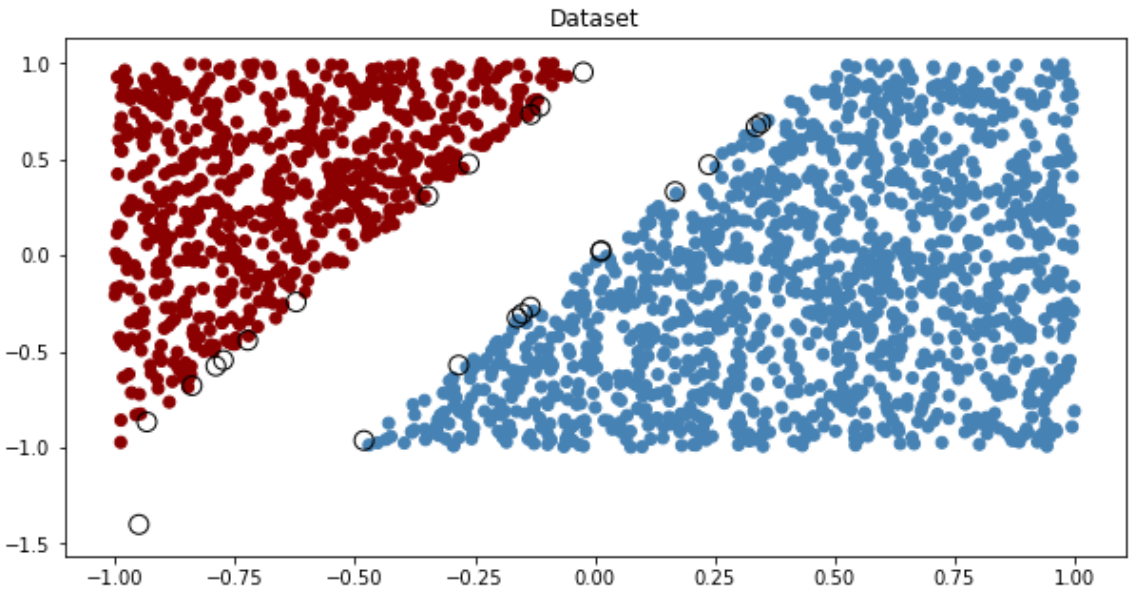
In [32]:

```
# Set kernel to 'linear' for task4
t4_kernel = 'linear'

t4_svm = svm.SVC(kernel=t4_kernel)
t4_svm.fit(X_train,y_train)
t4_svm.score(X_test,y_test)

yhat = t4_svm.predict(X_test)

print_dataset(X_test,yhat)
```



In [34]:

```
# Assign colours based on the labels (1,-1) = (steelblue,darkred)
colors = ['steelblue' if label == 1 else 'darkred' for label in y_test]

# Plot Training Data
plt.rcParams["figure.figsize"] = (10, 5)
plt.title("Dataset")
plt.scatter(X_test[:,0], X_test[:,1], color=colors)

plt.scatter(t4_svm.support_vectors_[:, 0], t4_svm.support_vectors_[:, 1], s=100,
            linewidth=1, facecolors='none', edgecolors='k')

plt.show()
```

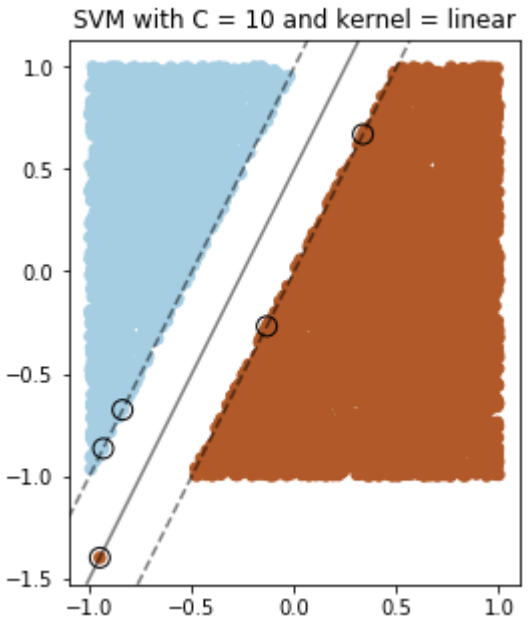


In [60]:

```
def plot_svm_results(svmc, X, y):

    plt.scatter(X[:, 0], X[:, 1], c=y, s=30, cmap=plt.cm.Paired)

    # plot the decision function
    ax = plt.gca()
    ax.set_aspect(aspect=1)
    xlim = ax.get_xlim()
    ylim = ax.get_ylim()

    # create grid to evaluate model
    xx = np.linspace(xlim[0], xlim[1], 30)
    yy = np.linspace(ylim[0], ylim[1], 30)
    YY, XX = np.meshgrid(yy, xx)
    xy = np.vstack([XX.ravel(), YY.ravel()]).T
    Z = svmc.decision_function(xy).reshape(XX.shape)

    # plot decision boundary and margins
    ax.contour(XX, YY, Z, colors='k', levels=[-1, 0, 1], alpha=0.5,
               linestyles=['--', '-', '--'])
    # plot support vectors
    ax.scatter(svmc.support_vectors_[:, 0], svmc.support_vectors_[:, 1], s=100,
               linewidth=1, facecolors='none', edgecolors='k')

    # Annotate Graph
    plt.title('SVM with C = ' + str(svmc.C) + " and kernel = " + svmc.kernel)
    #plt.title('Accuracy Boxplot with Number of Selected Features = ')

    plt.show()
```

In [61]:

```
plot_svm_results(t4_svm, X_train, y_train)
```



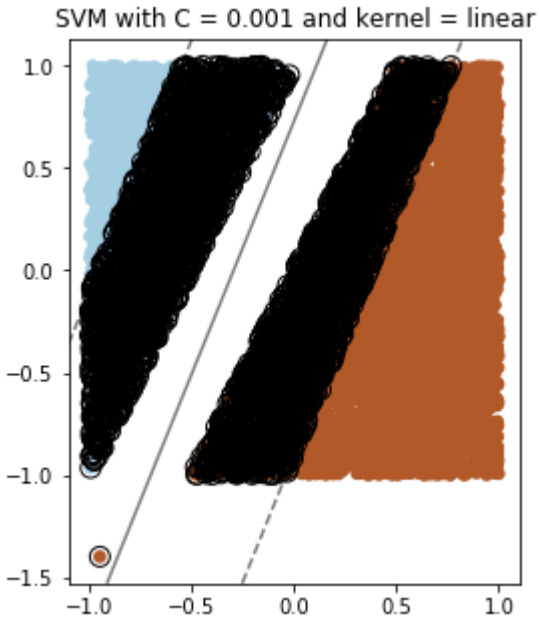
In [62]:

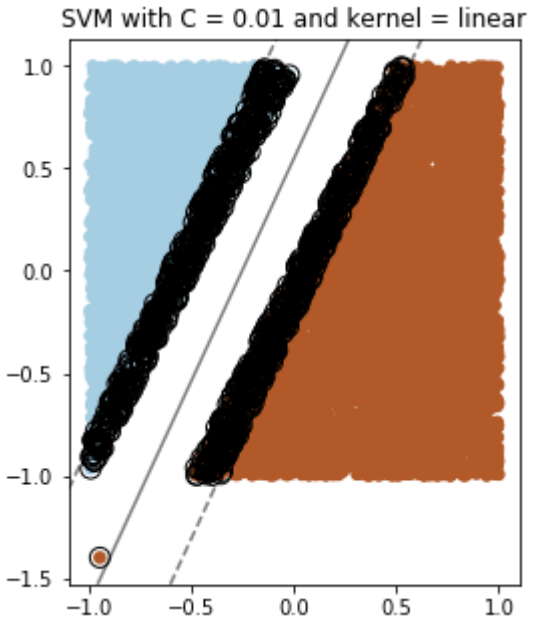
```
print(t4_svm.C)
```

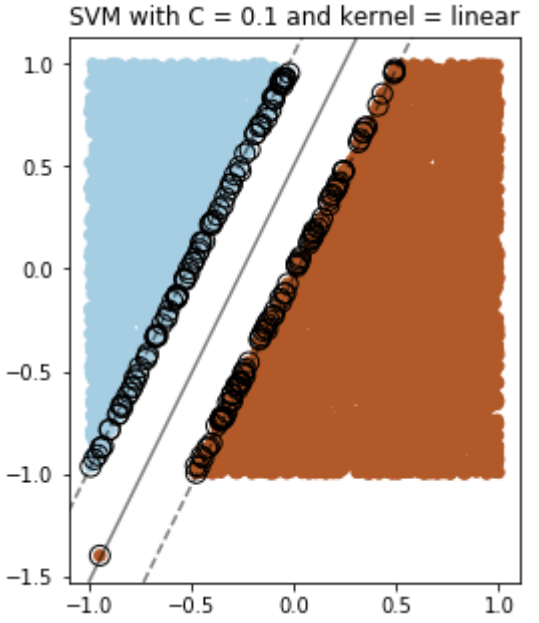
```
10
```

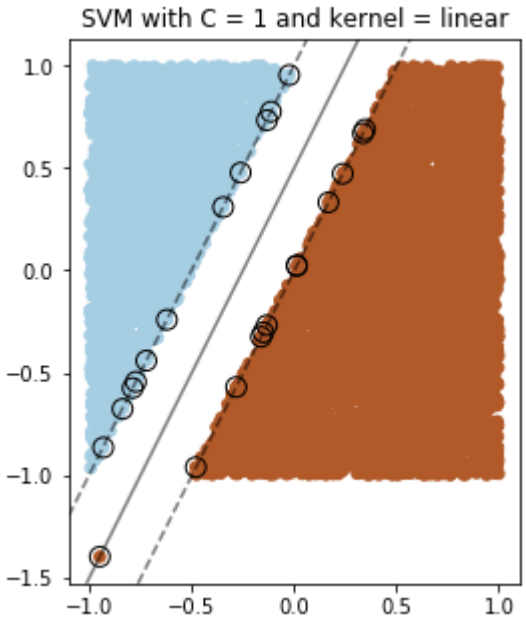
In [65]:

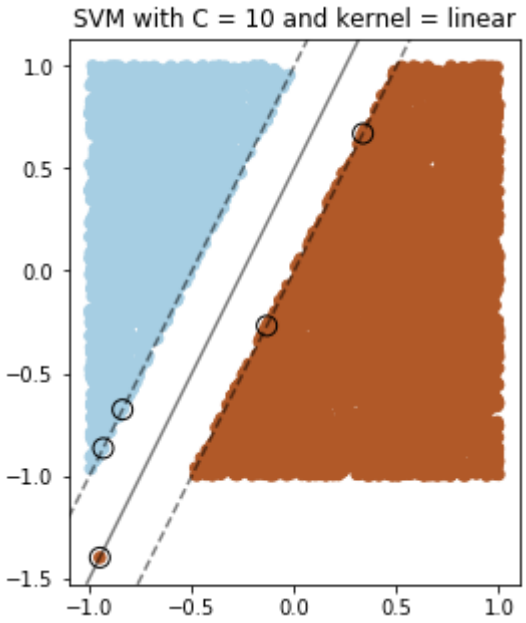
```
t4_C_vals = [0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]

for i in range(len(t4_C_vals)):
    # Set kernel to 'linear' for task4
    t4_kernel = 'linear'

    t4_svm = svm.SVC(kernel=t4_kernel, C=t4_C_vals[i])
    t4_svm.fit(X_train,y_train)
    t4_svm.score(X_test,y_test)

    #yhat = t4_svm.predict(X_test)

    plot_svm_results(t4_svm, X_train, y_train)
```

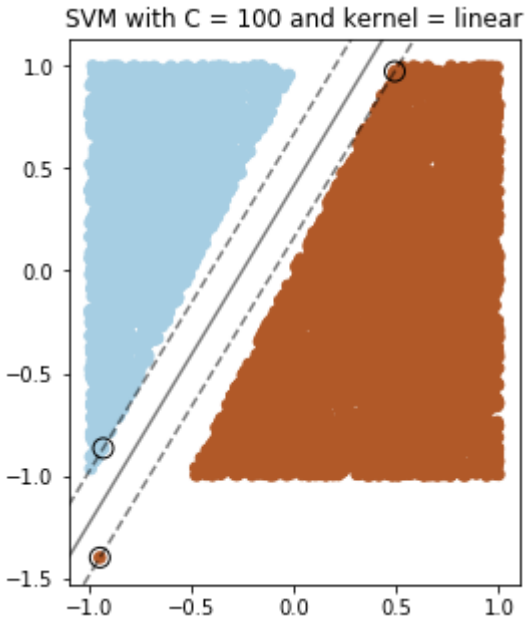

SVM with C = 0.001 and kernel = linear
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.0
−0.5
0.0
0.5
1.0

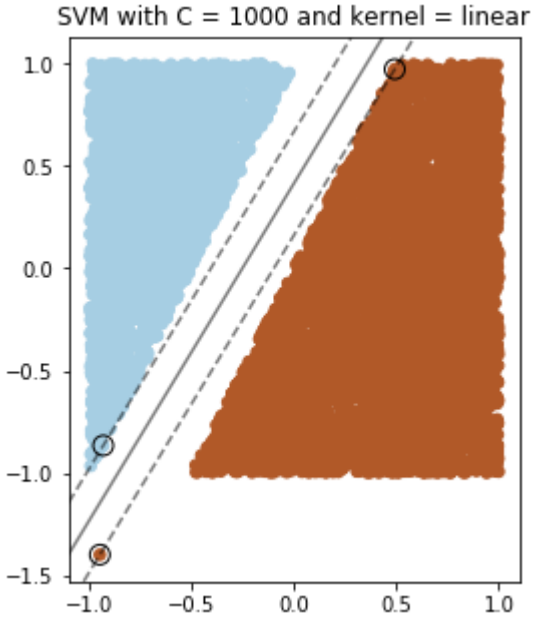

SVM with C = 0.01 and kernel = linear
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.0
−0.5
0.0
0.5
1.0

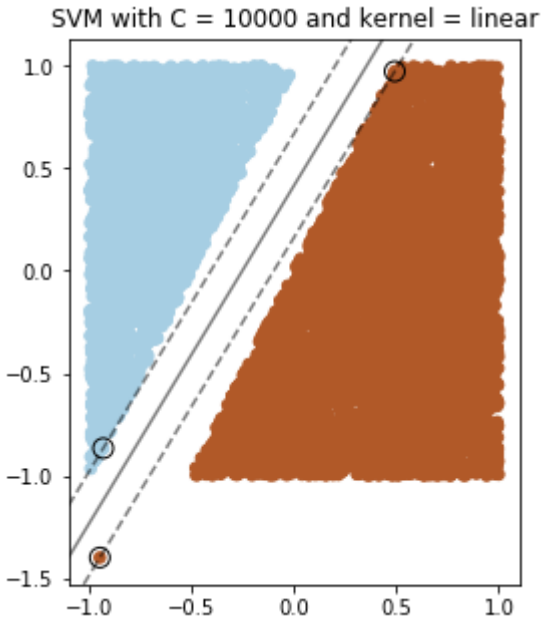

SVM with C = 0.1 and kernel = linear
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.0
−0.5
0.0
0.5
1.0


SVM with C = 1 and kernel = linear
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.0
−0.5
0.0
0.5
1.0


SVM with C = 10 and kernel = linear
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.0
−0.5
0.0
0.5
1.0


SVM with C = 100 and kernel = linear
1.0
0.5
0.0
−0.5
−1.0
−1.5
−1.0
−0.5
0.0
0.5
1.0





In [ ]:

```
## Dataset 1 Attribute Search
```

In [70]:

```
df2 = pd.read_csv("./dataset_2.csv")
df2 = df2.drop(['Unnamed: 0'],axis=1)
df2.describe()
```

Out[70]:

	0	1	2
count	10000.000000	10000.000000	10000.000000
mean	0.000081	-0.000563	0.332800
std	0.574913	0.274366	0.471239
min	-0.999780	-0.951513	0.000000
25%	-0.506704	-0.182047	0.000000
50%	0.001152	-0.002540	0.000000
75%	0.494439	0.180595	1.000000
max	0.999979	0.956530	1.000000

In [71]:

```
df2.head()
```

Out[71]:

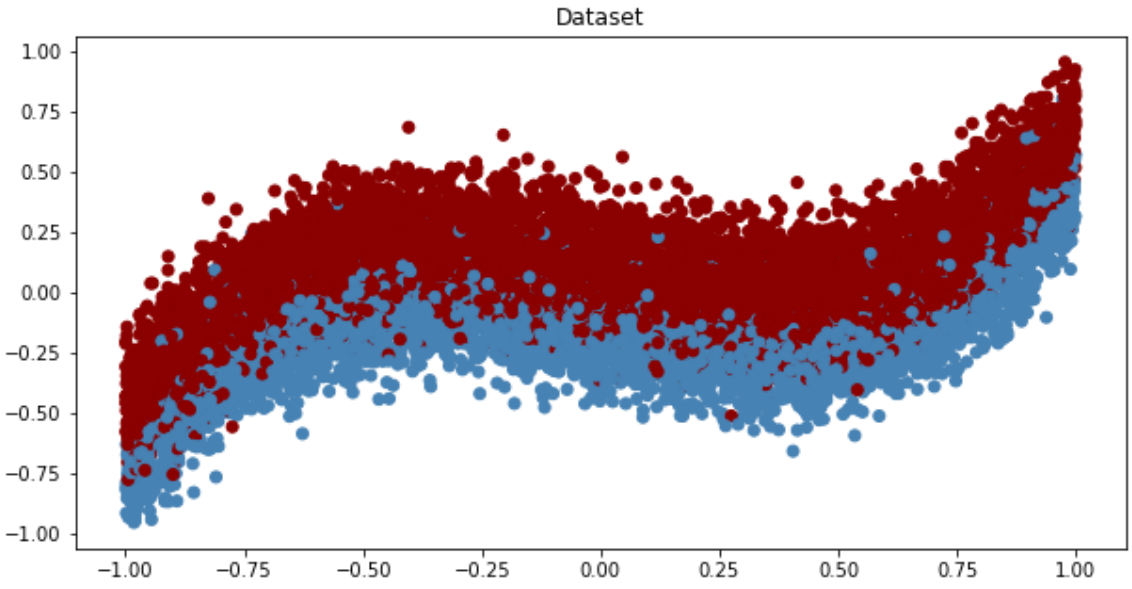
	0	1	2
0	0.799315	0.219275	0.0
1	-0.731615	-0.403627	1.0
2	0.424460	0.138607	0.0
3	0.586654	-0.187708	0.0
4	0.832493	0.241860	0.0

In [72]:

```
# target attribute
y2 = df2['2']

# predictor attributes
X2 = df2.drop('2', axis=1).values
```

In [73]:

```
print_dataset(X2,y2)
```



In [246]:

```
# Parameters to be varied
C_vals = [0.001, 0.01, 0.1, 1, 10]
gamma_vals = [0.001, 0.01, 0.1, 1, 'scale']
kernel_vals = ['rbf', 'poly']
#kernel_vals = ['rbf', 'sigmoid', 'linear']
#kernel_vals = ['rbf', 'poly', 'sigmoid', 'linear']
#param_grid = {'C': C_vals,
#              'kernel' : kernel_vals,
#              'gamma' : gamma_vals}

param_grid = [
    {'kernel': ['linear'], 'C': [1, 10], },
    {'kernel': ['rbf'],    'C': [1, 10, 100, 1000], 'gamma': [0.001, 0.0001], },
    {'kernel': ['poly'],   'C': [1, 10, 100, 1000], 'gamma': [0.001, 0.0001], 'degree'
:[2,3,4], 'coef0' : [0,1], }
]



SVC_CV2  = svm.SVC()

# run grid search
#grid_search_SVC2 = GridSearchCV(SVC_CV2, cv=10, param_grid=param_grid, n_jobs=-1 )
grid_search_SVC2 = GridSearchCV(SVC_CV2, cv=5, param_grid=param_grid, n_jobs=-1 )

# View parameters for search
grid_search_SVC2.get_params()
```

Out[246]:

```
{'cv': 5,
 'error_score': 'raise-deprecating',
 'estimator__C': 1.0,
 'estimator__cache_size': 200,
 'estimator__class_weight': None,
 'estimator__coef0': 0.0,
 'estimator__decision_function_shape': 'ovr',
 'estimator__degree': 3,
 'estimator__gamma': 'auto_deprecated',
 'estimator__kernel': 'rbf',
 'estimator__max_iter': -1,
 'estimator__probability': False,
 'estimator__random_state': None,
 'estimator__shrinking': True,
 'estimator__tol': 0.001,
 'estimator__verbose': False,
 'estimator': SVC(C=1.0, cache_size=200, class_weight=None, coef0=0.0,
   decision_function_shape='ovr', degree=3, gamma='auto_deprecated',
   kernel='rbf', max_iter=-1, probability=False, random_state=None,
   shrinking=True, tol=0.001, verbose=False),
 'fit_params': None,
 'iid': 'warn',
 'n_jobs': -1,
 'param_grid': [{'kernel': ['linear'], 'C': [1, 10]},
  {'kernel': ['rbf'], 'C': [1, 10, 100, 1000], 'gamma': [0.001, 0.0001]},
  {'kernel': ['poly'],
   'C': [1, 10, 100, 1000],
   'gamma': [0.001, 0.0001],
   'degree': [2, 3, 4],
   'coef0': [0, 1]}],
 'pre_dispatch': '2*n_jobs',
 'refit': True,
 'return_train_score': 'warn',
 'scoring': None,
 'verbose': 0}
```

In [247]:

```
# Perform GridSearch
grid_search_SVC2.fit(X2, y2)

# Build new SVM classifier based on best parameters
grid_svc2 = grid_search_SVC2.best_estimator_
```

In [248]:

```
# View best parameters
grid_search_SVC2.best_params_
```

Out[248]:

```
{'C': 1000, 'coef0': 1, 'degree': 4, 'gamma': 0.001, 'kernel': 'poly'}
```

In [249]:

```
# Split into test set and training set
X2_train, X2_test, y2_train, y2_test = train_test_split(X2, y2, test_size=0.2, random_s
tate=42)
```

In [250]:

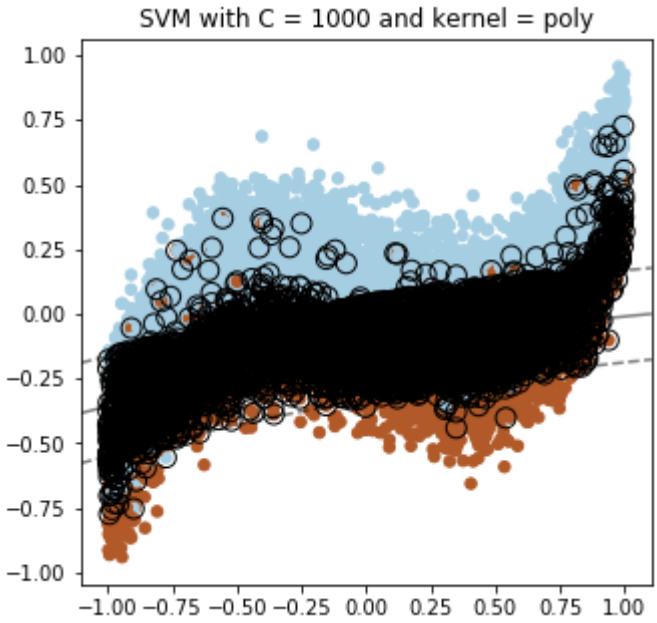
```
grid_svc2.fit(X2_train, y2_train)
```

Out[250]:

```
SVC(C=1000, cache_size=200, class_weight=None, coef0=1,
  decision_function_shape='ovr', degree=4, gamma=0.001, kernel='poly',
  max_iter=-1, probability=False, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
```

In [251]:

```
plot_svm_results(grid_svc2, X2_train, y2_train)
```



In [253]:

```
grid_svc2.score(X2_test, y2_test)
```

Out[253]:

```
0.7705
```

In [ ]:

```

```

In [75]:

```
df3 = pd.read_csv("./dataset_3.csv")
df3 = df3.drop(['Unnamed: 0'],axis=1)
df3.describe()
```

Out[75]:

	0	1	2
count	10000.000000	10000.000000	10000.00000
mean	-0.004890	-0.002304	0.88240
std	0.612958	0.616565	0.32215
min	-0.999962	-0.999991	0.00000
25%	-0.571095	-0.585002	1.00000
50%	-0.007848	-0.007517	1.00000
75%	0.561483	0.585625	1.00000
max	0.999805	0.999790	1.00000

In [76]:

```
df3.head()
```

Out[76]:

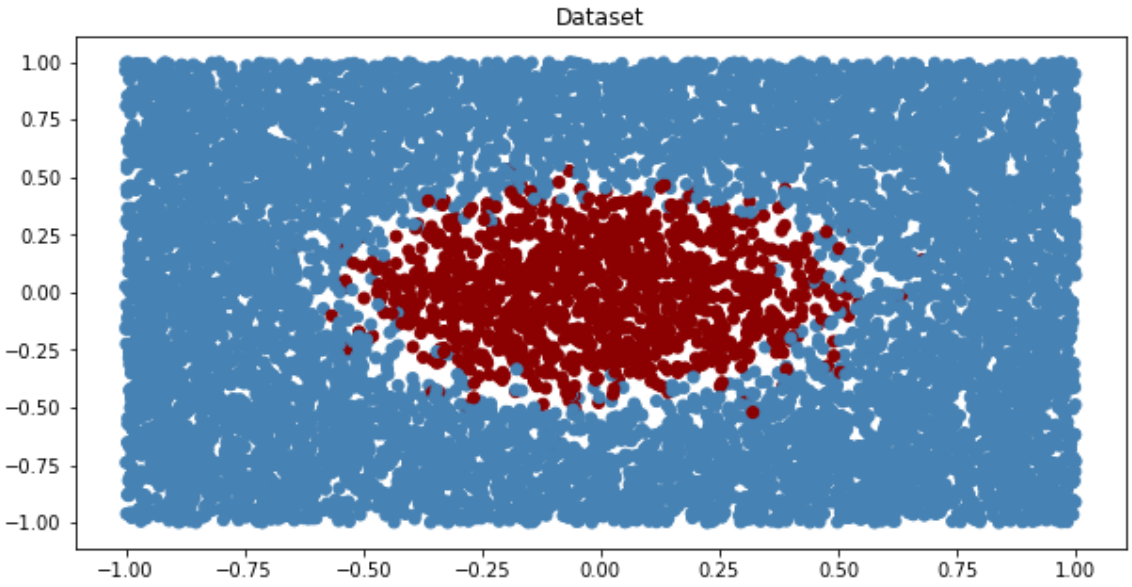
	0	1	2
0	-0.532786	0.661453	1.0
1	-0.500866	0.695587	1.0
2	-0.697046	-0.116419	1.0
3	0.557011	0.332436	1.0
4	-0.012738	0.858232	1.0

In [77]:

```
# target attribute
y3 = df3['2']

# predictor attributes
X3 = df3.drop('2', axis=1).values
```

In [78]:

```
print_dataset(X3,y3)
```



In [81]:

```
# Parameters to be varied
C_vals = [0.001, 0.01, 0.1, 1, 10]
gamma_vals = [0.001, 0.01, 0.1, 1, 'scale']
kernel_vals = ['rbf', 'sigmoid', 'linear']
#kernel_vals = ['rbf', 'poly', 'sigmoid', 'linear']
param_grid = {'C': C_vals,
              'kernel' : kernel_vals,
              'gamma' : gamma_vals}

SVC_CV  = svm.SVC()

# run grid search
grid_search_SVC = GridSearchCV(SVC_CV, cv=10, param_grid=param_grid, n_jobs=-1 )

# View parameters for search
grid_search_SVC.get_params()

# Perform GridSearch
grid_search_SVC.fit(X3, y3)

# Build new SVM classifier based on best parameters
grid_svc = grid_search_SVC.best_estimator_

# View best parameters
grid_search_SVC.best_params_
```

Out[81]:

```
{'C': 0.1, 'gamma': 1, 'kernel': 'rbf'}
```

In [82]:

```
# Split into test set and training set
X3_train, X3_test, y3_train, y3_test = train_test_split(X3, y3, test_size=0.2, random_s
tate=42)
```

In [83]:

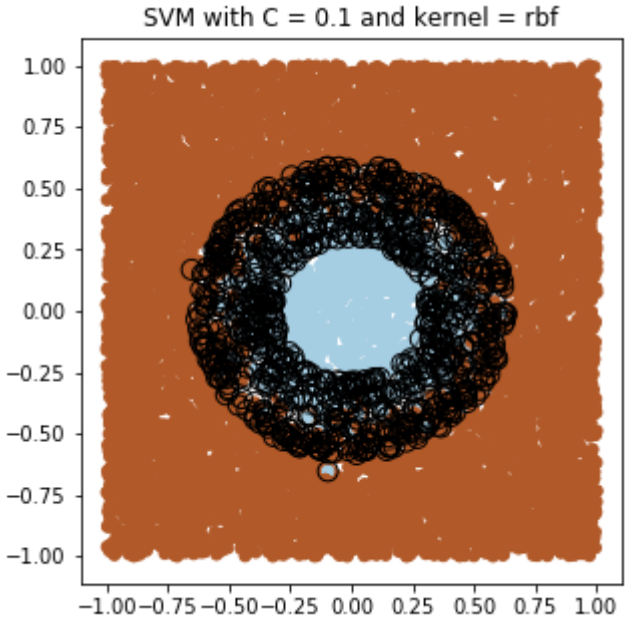
```
grid_svc.fit(X3_train, y3_train)
```

Out[83]:

```
SVC(C=0.1, cache_size=200, class_weight=None, coef0=0.0,
  decision_function_shape='ovr', degree=3, gamma=1, kernel='rbf',
  max_iter=-1, probability=False, random_state=None, shrinking=True,
  tol=0.001, verbose=False)
```

In [84]:

```
plot_svm_results(grid_svc, X3_train, y3_train)
```



In [85]:

```
grid_svc.score(X3_test, y3_test)
```

Out[85]:

```
0.99
```

15 Point Example Dataset (Demo dataset)

In [226]:

```
# Create from 15 random entries from dataset_1
# Convert to new values by cubing original point and add original point to create new p
oit
X_demo = np.empty([15,2])
y_demo = np.empty([15])

random.seed(100)
idx = random.sample(range(0,1000),15)
print(idx)

for i in range(len(idx)):
    rand_idx = idx[i]
    X_demo[i] = X[rand_idx]**3+X[rand_idx]
    y_demo[i] = y[rand_idx]
```

```
[149, 470, 465, 974, 789, 178, 722, 402, 749, 358, 443, 519, 819, 112, 54
5]
```

In [227]:

```
print(X_demo)
print(y_demo)
```

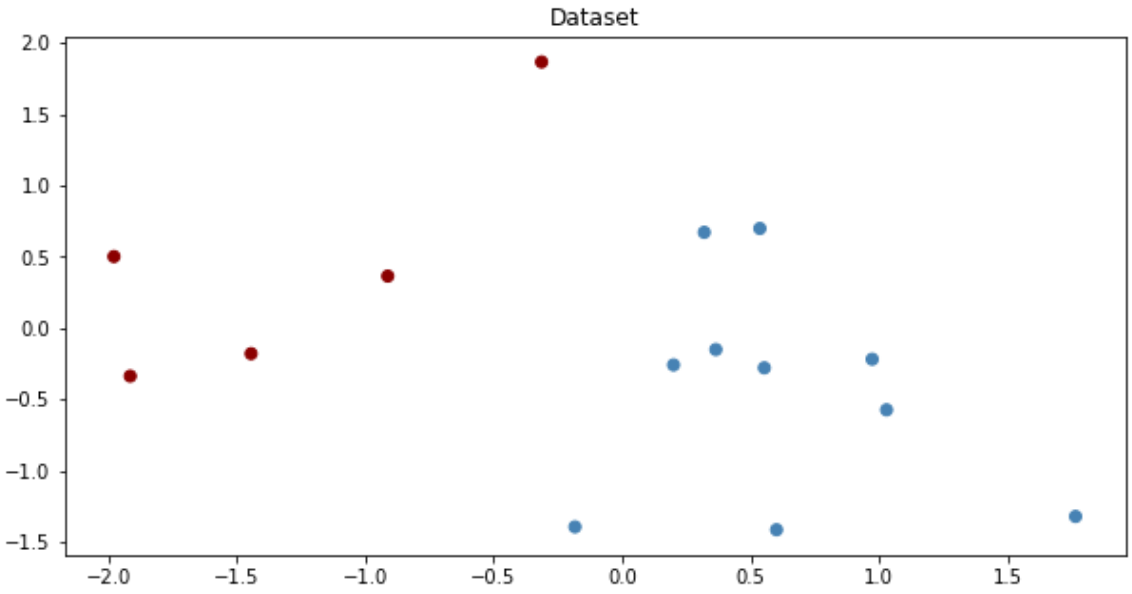
```
[[-1.97697387  0.50151661]
 [-1.91358977 -0.33622935]
 [-0.91155473  0.36453075]
 [ 0.20042021 -0.25793884]
 [ 0.60111533 -1.41280824]
 [ 1.76452589 -1.31966776]
 [ 0.55356995 -0.27836423]
 [-1.4432535  -0.17904772]
 [-0.31295624  1.86499861]
 [ 0.31982465  0.6710673 ]
 [-0.18310293 -1.39264615]
 [ 0.97328821 -0.2178078 ]
 [ 1.02920485 -0.57257397]
 [ 0.53623081  0.69815897]
 [ 0.36510741 -0.1501749 ]]
[0. 0. 0. 1. 1. 1. 1. 0. 0. 1. 1. 1. 1. 1. 1.]
```

In [180]:

```
idx = random.sample(range(0,1000),15)
```

In [228]:

```
print_dataset(X_demo,y_demo)
```



In [234]:

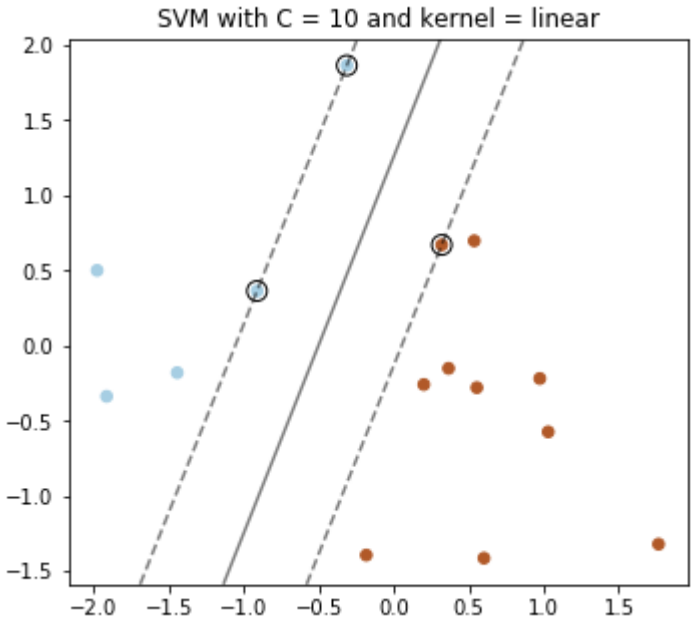
```
demo_svm = svm.SVC(kernel='linear', C=10)
demo_svm.fit(X_demo,y_demo)
demo_svm.score(X_demo, y_demo)
```

Out[234]:

```
1.0
```

In [235]:

```
plot_svm_results(demo_svm, X_demo, y_demo)
```



In [236]:

```
print(demo_svm.support_vectors_)
```

```
[[-0.91155473  0.36453075]
 [-0.31295624  1.86499861]
 [ 0.31982465  0.6710673 ]]
```

In [237]:

```
demo_svm.score(X_demo, y_demo)
```

Out[237]:

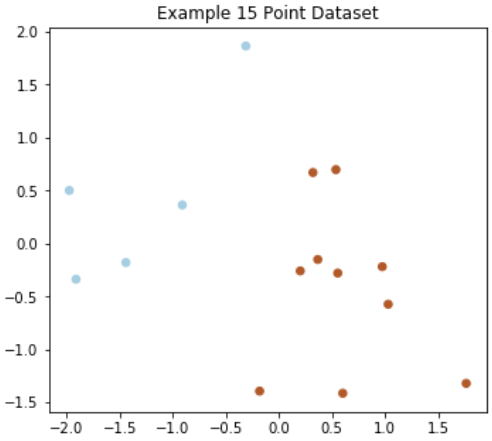
```
1.0
```

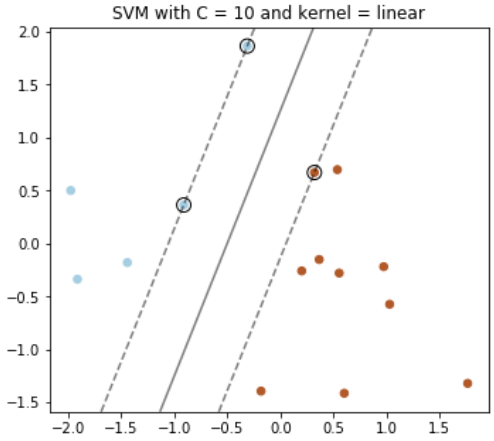
In [238]:

```
def plot_svm_results_with_orig(svmc, X, y, img_name='default.png'):

    plt.subplots(1, 2, figsize=(15, 5))


    plt.subplot(1,2,1)

    ax0 = plt.gca()
    ax0.set_aspect(aspect=1)
    plt.title('Example 15 Point Dataset')
    plt.scatter(X[:, 0], X[:, 1], c=y, s=30, cmap=plt.cm.Paired)

    plt.subplot(1,2,2)

    plt.scatter(X[:, 0], X[:, 1], c=y, s=30, cmap=plt.cm.Paired)

    # plot the decision function
    ax = plt.gca()
    ax.set_aspect(aspect=1)
    xlim = ax.get_xlim()
    ylim = ax.get_ylim()

    # create grid to evaluate model
    xx = np.linspace(xlim[0], xlim[1], 30)
    yy = np.linspace(ylim[0], ylim[1], 30)
    YY, XX = np.meshgrid(yy, xx)
    xy = np.vstack([XX.ravel(), YY.ravel()]).T
    Z = svmc.decision_function(xy).reshape(XX.shape)

    # plot decision boundary and margins
    ax.contour(XX, YY, Z, colors='k', levels=[-1, 0, 1], alpha=0.5,
               linestyles=['--', '-', '--'])
    # plot support vectors
    ax.scatter(svmc.support_vectors_[:, 0], svmc.support_vectors_[:, 1], s=100,
               linewidth=1, facecolors='none', edgecolors='k')

    # Annotate Graph
    plt.title('SVM with C = ' + str(svmc.C) + " and kernel = " + svmc.kernel)
    #plt.title('Accuracy Boxplot with Number of Selected Features = ')

    plt.savefig(img_name)
    plt.show()
```

In [239]:

```
plot_svm_results_with_orig(demo_svm, X_demo, y_demo, 'example_dataset.png')
```





In [ ]:

```

```