In [13]:
```
import pandas as pd
import matplotlib.pyplot as plt
import numpy as np
import seaborn as sns
from sklearn import tree
from sklearn.model_selection import GridSearchCV
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.svm import LinearSVC, SVC
from sklearn.preprocessing import LabelEncoder, OneHotEncoder
from sklearn.ensemble import RandomForestClassifier
```

In [2]:
```
df = pd.read_csv('bankData.csv')
df.drop(labels=['campaign','pdays','previous','contact','day','month'],axis = 1,

df = pd.get_dummies(df)


df.head()
```

Out[2]:

	age	balance	duration	job_admin.	job_blue-collar	job_entrepreneur	job_housemaid	job_managemer
0	58	2143	261	0	0	0	0	
1	44	29	151	0	0	0	0	
2	33	2	76	0	0	1	0	
3	47	1506	92	0	1	0	0	
4	33	1	198	0	0	0	0	

5 rows × 34 columns

In [3]:
```
X_and_Y = df.values
np.random.shuffle(X_and_Y)
X = X_and_Y[:,1:]
Y = X_and_Y[:,0]

print(X.shape)
print(Y.shape)
```

```
(45211, 33)
(45211,)
```

In [4]:

```
#establish training and test data in 20/50/80 partition

#1 = 0.2
#2 = 0.5
#3 = 0.8

X_train1 = X[:int(0.2*len(X))]
X_test1 = X[int(0.2*len(X)):]

Y_train1 = Y[:int(0.2*len(Y))]
Y_test1 = Y[int(0.2*len(Y)):]

print(X_train1.shape, X_test1.shape, Y_train1.shape, Y_test1.shape)


X_train2 = X[:int(0.5*len(X))]
X_test2 = X[int(0.5*len(X)):]

Y_train2 = Y[:int(0.5*len(Y))]
Y_test2 = Y[int(0.5*len(Y)):]

print(X_train2.shape, X_test2.shape, Y_train2.shape, Y_test2.shape)


X_train3 = X[:int(0.8*len(X))]
X_test3 = X[int(0.8*len(X)):]

Y_train3 = Y[:int(0.8*len(Y))]
Y_test3 = Y[int(0.8*len(Y)):]

print(X_train3.shape, X_test3.shape, Y_train3.shape, Y_test3.shape)
```

```
(9042, 33) (36169, 33) (9042,) (36169,)
(22605, 33) (22606, 33) (22605,) (22606,)
(36168, 33) (9043, 33) (36168,) (9043,)
```

In [5]:

```
def heatmap(training_acc, gamma, C_list):
    plt.figure(figsize = (1,5))
    ax = sns.heatmap(data = training_acc, annot = True, fmt = '.3f', xticklabels
    ax.collections[0].colorbar.set_label("Accuracy")
    ax.set(xlabel = '$\gamma$', ylabel='$C$')
    plt.title('Training Accuracy w.r.t $C$ and $\gamma$')
    plt.show()
```

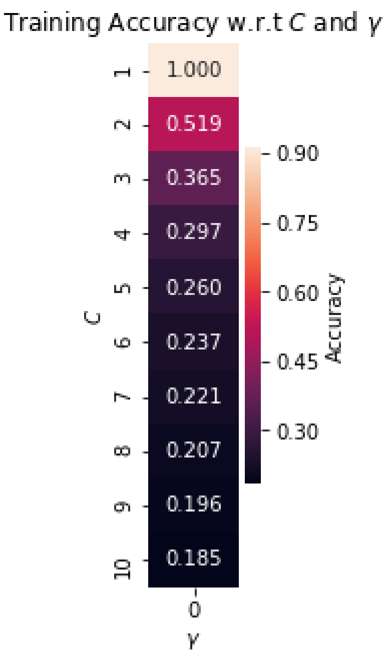
In [6]:

```
#knn classifier using train/test #1

def knn(X_train,Y_train,X_test,Y_test):


    K_list = [1,2,3,4,5,6,7,8,9,10]     #10 features in data

    clf = GridSearchCV(KNeighborsClassifier(), iid= False, param_grid = {'n_neigl
    clf.fit(X_train,Y_train)

    heatmap(clf.cv_results_['mean_train_score'].reshape(10,1), 'KNN Training Accu

    opt_k = clf.best_params_['n_neighbors']

    clf_test = KNeighborsClassifier(n_neighbors=opt_k)
    clf_test.fit(X_train,Y_train)

    knn_accuracy = clf_test.score(X_test,Y_test)
    training_acc = clf.cv_results_['mean_test_score']
    for x,y in enumerate(K_list):
        if y == opt_k:
            opt_training_acc = training_acc[x]

    return knn_accuracy, opt_training_acc, opt_k
```

In [7]:

```
test_acc_KNN1,best_train_KNN1,C_KNN1 = knn(X_train1,Y_train1,X_test1,Y_test1)
test_acc_KNN2,best_train_KNN2,C_KNN2 = knn(X_train2,Y_train2,X_test2,Y_test2)
test_acc_KNN3,best_train_KNN3,C_KNN3 = knn(X_train3,Y_train3,X_test3,Y_test3)
```

```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:65
2: Warning: The least populated class in y has only 1 members, which is too fe
w. The minimum number of members in any class cannot be less than n_splits=5.
  % (min_groups, self.n_splits)), Warning)
```



```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:65
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```
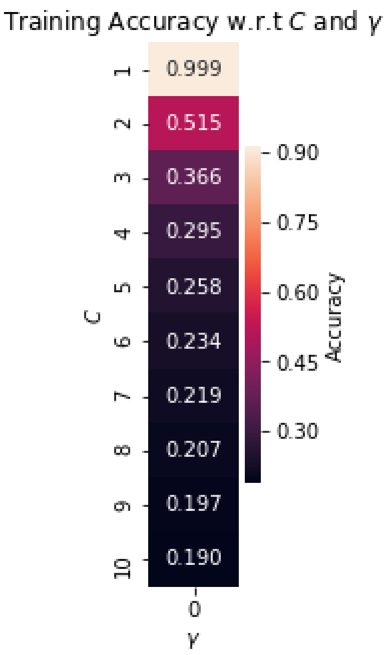
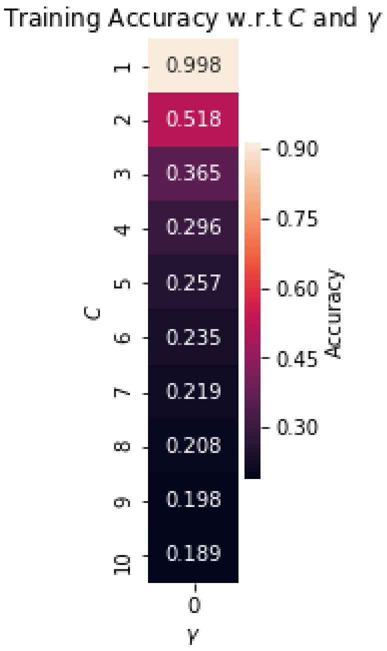



```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:
652: Warning: The least populated class in y has only 1 members, which is too
```

```
few. The minimum number of members in any class cannot be less than n_splits=
5.
  % (min_groups, self.n_splits)), Warning)
```



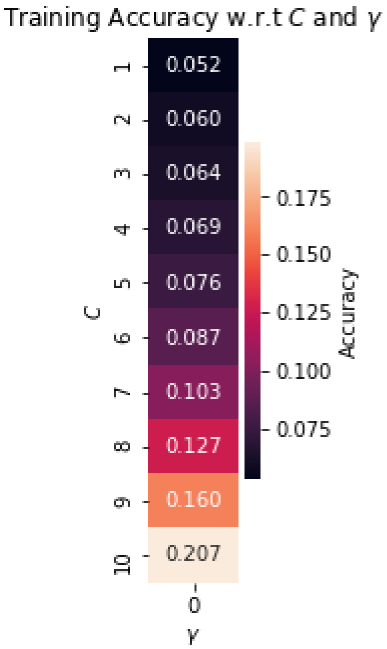
In [8]:

```
def decisionTree(X_train,Y_train,X_test,Y_test):
    D_list = [1,2,3,4,5,6,7,8,9,10]

    clf = GridSearchCV(DecisionTreeClassifier(criterion='entropy'),cv=5,iid = Fa
    clf.fit(X_train,Y_train)
    heatmap(clf.cv_results_['mean_train_score'].reshape(10,1),'Decision Tree Tra

    opt_D = clf.best_params_['max_depth']
    clf_test = DecisionTreeClassifier(max_depth=opt_D, criterion='entropy')

    clf_test.fit(X_train,Y_train)

    tree_accuracy = clf_test.score(X_test,Y_test)

    train_accuracy = clf.cv_results_['mean_train_score']

    for x,y in enumerate(D_list):
        if y == opt_D:
            best_train_accuracy = train_accuracy[x]

    return tree_accuracy, best_train_accuracy, opt_D
```

In [9]:

```
tree_acc1, tree_train_acc1, opt_D1 = decisionTree(X_train1,Y_train1,X_test1,Y_te
tree_acc2, tree_train_acc2, opt_D2 = decisionTree(X_train2,Y_train2,X_test2,Y_te
tree_acc3, tree_train_acc3, opt_D3 = decisionTree(X_train3,Y_train3,X_test3,Y_te
```

```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:65
2: Warning: The least populated class in y has only 1 members, which is too fe
w. The minimum number of members in any class cannot be less than n_splits=5.
  % (min_groups, self.n_splits)), Warning)
```



```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:65
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  % (min_groups, self.n_splits)), Warning)
```

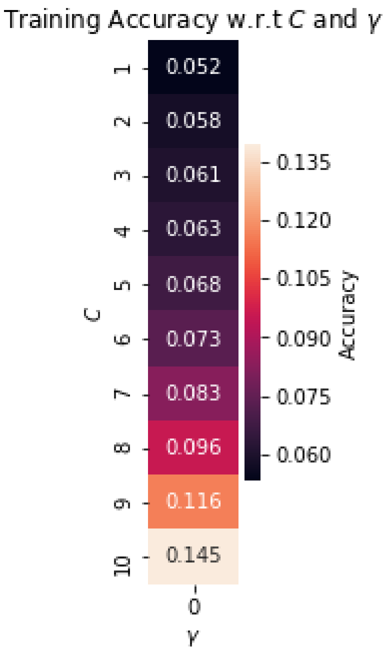

```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:65
2: Warning: The least populated class in y has only 1 members, which is too fe
w. The minimum number of members in any class cannot be less than n_splits=5.
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```

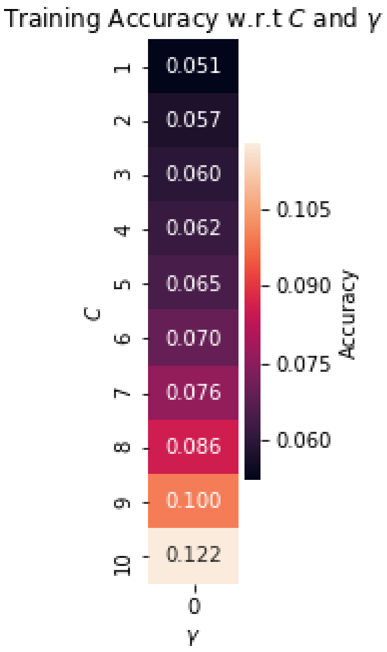

In [10]:

```
def svm(X_train,Y_train,X_test,Y_test):
    #C_list = [10**-5, 10**-4, 10**-3, 10**-2, 10**-1, 1,10]
    C_list = [1,2,3,4,5,6,7,8,9,10]
    gamma_list = [1e-6, 1e-5, 1e-4, 1e-3, 1e-2]
    svc = SVC(C= C_list, kernel = 'linear')
    clf = GridSearchCV(svc, cv=5, iid=False, param_grid={'C':C_list}, return_tra


    #clf = GridSearchCV(LinearSVC(max_iter = 1000000), cv=5, iid=False, param_gr

    clf.fit(X_train,Y_train)

    train_accuracy = clf.cv_results_['mean_train_score']
    heatmap(train_accuracy.reshape(10,1), 'SVM Training Accuracy', C_list)
    opt_C = clf.best_params_['C']
    clf_test = SVC(C = opt_C, kernel='linear')

    clf_test.fit(X_train,Y_train)

    svm_accuracy = clf_test.score(X_test,Y_test)
    train_accuracy = clf.cv_results_['mean_train_score']

    for x,y in enumerate(C_list):
        if y == opt_C:
            best_train_accuracy = train_accuracy[x]

    return svm_accuracy, best_train_accuracy, opt_C
```

In [42]:

```
def randomForest(X_train,Y_train,X_test,Y_test):

    rf_list = np.arange(1,7)

    param_grid = {'max_depth':rf_list, 'n_estimators':[1, 2, 3, 4, 5, 6, 7]}
    rf = RandomForestClassifier(criterion = 'entropy')

    clf = GridSearchCV(rf, param_grid= param_grid, cv = 5, iid = False, return_t

    clf.fit(X_train,Y_train)
    train_accuracy = clf.cv_results_['mean_train_score']

    heatmap(train_accuracy.reshape(42,1), 'RF Train Acc', C_list = rf_list)
    opt_rf = clf.best_params_['max_depth']

    clf_test = RandomForestClassifier(max_depth = opt_rf, criterion = 'entropy')

    clf_test.fit(X_train,Y_train)

    rf_accuracy = clf_test.score(X_test,Y_test)

    train_accuracy = clf.cv_results_['mean_train_score']

    for x,y in enumerate(rf_list):
        if y == opt_rf:
            best_train_accuracy = train_accuracy[x]

    return rf_accuracy, best_train_accuracy, opt_rf
```

```
In [43]: rf_acc1, rf_train_acc1, opt_rf1 = randomForest(X_train1,Y_train1,X_test1,Y_test1
         rf_acc2, rf_train_acc2, opt_rf2 = randomForest(X_train2,Y_train2,X_test2,Y_test2
         rf_acc3, rf_train_acc3, opt_rf3 = randomForest(X_train3,Y_train3,X_test3,Y_test3
```

```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\model_selection\_split.py:65
2: Warning: The least populated class in y has only 1 members, which is too fe
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  % (min_groups, self.n_splits)), Warning)
```

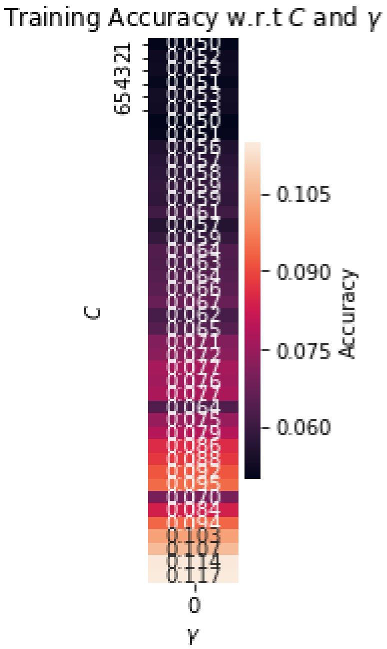

```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:246: Futu
reWarning: The default value of n_estimators will change from 10 in version 0.2
0 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
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  % (min_groups, self.n_splits)), Warning)
```

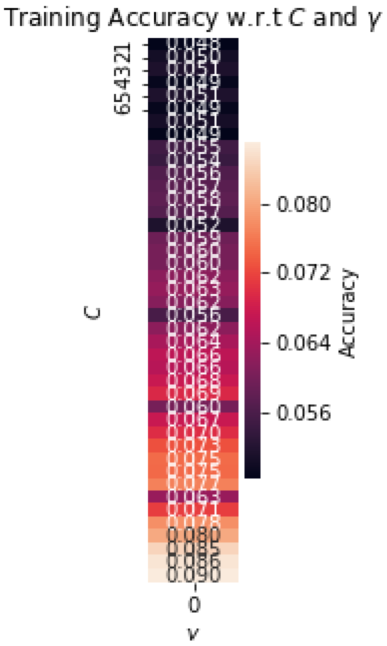

```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:246: Futu
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  % (min_groups, self.n_splits)), Warning)
```

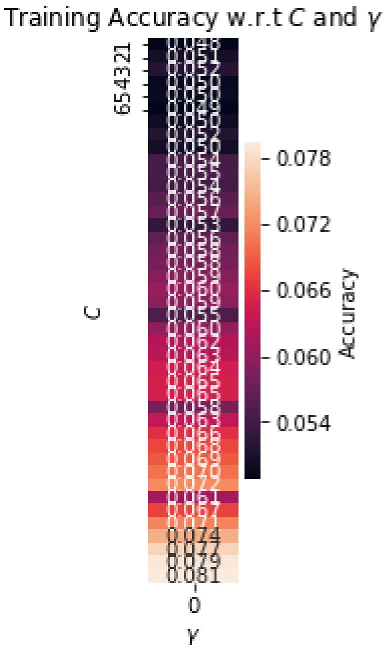

```
C:\Users\baria\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:246: Futu
reWarning: The default value of n_estimators will change from 10 in version 0.2
0 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

In [44]:

```
d = {'Classifier Accuracy':[test_acc_KNN1,test_acc_KNN2,test_acc_KNN3,tree_acc1,t
     'Best Training Accuracy':[best_train_KNN1,best_train_KNN2,best_train_KNN3,tr
     'Optimal Feature':[C_KNN1,C_KNN2,C_KNN3,opt_D1,opt_D2,opt_D3,opt_rf1,opt_rf2

results = pd.DataFrame(data = d)
```

In [46]:

```
#results.index = {'KNN 20/80','KNN 50/50', 'KNN 80/20', 'Decision Tree 20/80', 'D

results.rename(index={0:'KNN 20/80'},inplace=True)
results.rename(index={1:'KNN 50/50'},inplace=True)
results.rename(index={2:'KNN 80/20'},inplace=True)

results.rename(index={3:'Decision Tree 20/80'},inplace=True)
results.rename(index={4:'Decision Tree 50/50'},inplace=True)
results.rename(index={5:'Decision Tree 80/20'},inplace=True)

results.rename(index={6:'Random Forest 20/80'},inplace=True)
results.rename(index={7:'Random Forest 50/50'},inplace=True)
results.rename(index={8:'Random Forest 80/20'},inplace=True)
```

In [47]:

```
results
```

Out[47]:

	Classifier Accuracy	Best Training Accuracy	Optimal Feature
KNN 20/80	0.033150	0.035941	10
KNN 50/50	0.034593	0.036232	2
KNN 80/20	0.033175	0.034227	4
Decision Tree 20/80	0.058503	0.075785	5
Decision Tree 50/50	0.054145	0.082968	7
Decision Tree 80/20	0.057061	0.062230	4
Random Forest 20/80	0.058033	0.053422	5
Random Forest 50/50	0.057374	0.049117	6
Random Forest 80/20	0.063143	0.049828	5

In [ ]: