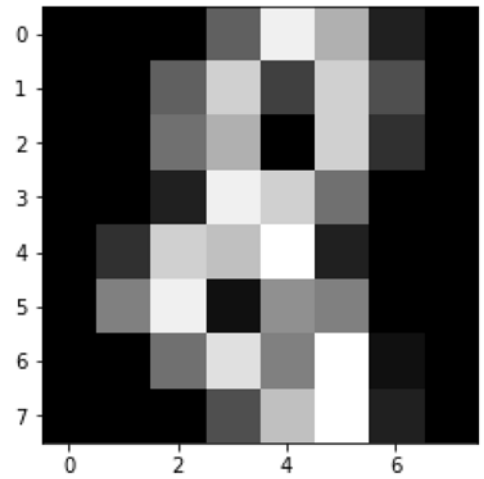
In [2]:
```
# You can load and split the dataset using this code block:

from sklearn.datasets import load_digits
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
digits= load_digits()
from sklearn.model_selection import train_test_split

from sklearn.linear_model import LogisticRegression, Ridge, Lasso
from sklearn.metrics import confusion_matrix

from sklearn.model_selection import StratifiedKFold

x = digits.data
y = digits.target

x_train, x_test, y_train, y_test = train_test_split(digits.data, digits.target
, test_size=0.20, random_state=0)

# You can view the images using this code snippet:

plt.imshow(np.reshape(x_train[7], (8,8)), cmap=plt.cm.gray)
plt.show()
print(digits.data[100])
print(digits.target[100])
print(len(digits.target))
```




```
[  0.   0.   0.   2.  13.   0.   0.   0.   0.   0.   0.   8.  15.   0.   0.
   0.   0.   0.   5.  16.   5.   2.   0.   0.   0.   0.  15.  12.   1.  16.
   4.   0.   0.   4.  16.   2.   9.  16.   8.   0.   0.   0.  10.  14.  16.
  16.   4.   0.   0.   0.   0.   0.  13.   8.   0.   0.   0.   0.   0.   0.
  13.   6.   0.   0.]
4
1797
```

In [91]:
```
logreg_ridge = LogisticRegression() # instantiate

c_vals = np.linspace(0.1,100,10)

skf = StratifiedKFold(n_splits=5)
skf.get_n_splits(x, y)
scores_l2_train = []
scores_l2_test = []
scores_l2_c =[]
scores_l2_split = []
split_count = 0

for c in c_vals:
#     print("L2 Logistic Regression (Ridge)\n")
    split_count = 0
    logreg_ridge = LogisticRegression(C=c)
    for train_index, test_index in skf.split(x, y):
    #     print("TRAIN:", train_index, "TEST:", test_index)
        x_train, x_test = x[train_index], x[test_index]
        y_train, y_test = y[train_index], y[test_index]

        logreg_ridge.fit(x_train, y_train) # fit
        y_pred = logreg_ridge.predict(x_train) # predict
        acc_log = sum(y_pred == y_train)/len(y_train)*100
#         print('Logistic Regression accuracy of train data:', str(round(acc_l
og,2)),'%')
    #     print(confusion_matrix(y_train, y_pred))
        scores_l2_train.append(acc_log)

        y_pred = logreg_ridge.predict(x_test) # predict
        acc_log = sum(y_pred == y_test)/len(y_test)*100
#         print('Logistic Regression accuracy of test data:', str(round(acc_lo
g,2)),'%')
    #     print(confusion_matrix(y_test, y_pred))

#         print("\n")
        scores_l2_test.append(acc_log)
        scores_l2_c.append(c)
        split_count = split_count + 1
        scores_l2_split.append(split_count)
```

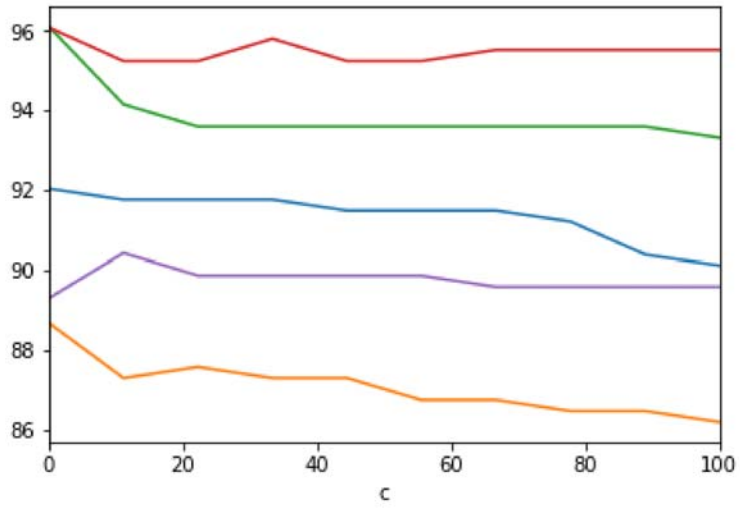
In [92]:
```
data = {"train": scores_l2_train, "test":scores_l2_test, "c":scores_l2_c, "s
plit": scores_l2_split}

# scores_l2 = pd.DataFrame([scores_l2_train, scores_l2_test, scores_l2_c])
scores_l2 = pd.DataFrame(data=data)


scores_l2[scores_l2.columns[::-1]]
# scores_l2



#     logreg_lasso = LogisticRegression(penalty='l1')
#     print("L1 Logistic Regression (Lasso)\n")
#     for train_index, test_index in skf.split(x, y):
#     #     print("TRAIN:", train_index, "TEST:", test_index)
#         x_train, x_test = x[train_index], x[test_index]
#         y_train, y_test = y[train_index], y[test_index]

#         logreg_lasso.fit(x_train, y_train) # fit
#         y_pred = logreg_lasso.predict(x_train) # predict
#         acc_log = sum(y_pred == y_train)/len(y_train)*100
#         print('Logistic Regression accuracy of train data:', str(round(acc
_log,2)),'%')
#     #     print(confusion_matrix(y_train, y_pred))

#         y_pred = logreg_lasso.predict(x_test) # predict
#         acc_log = sum(y_pred == y_test)/len(y_test)*100
#         print('Logistic Regression accuracy of test data:', str(round(acc_
log,2)),'%')
#     #     print(confusion_matrix(y_test, y_pred))

#         print("\n")
```

Out[92]:

	train	test	split	c
0	99.302163	92.032967	1	0.1
1	99.303136	88.674033	2	0.1
2	99.513213	96.100279	3	0.1
3	99.375000	96.078431	4	0.1
4	99.445215	89.295775	5	0.1
5	99.790649	91.758242	1	11.2
6	99.790941	87.292818	2	11.2
7	99.791377	94.150418	3	11.2
8	99.791667	95.238095	4	11.2
9	100.000000	90.422535	5	11.2
10	99.790649	91.758242	1	22.3
11	99.860627	87.569061	2	22.3
12	99.791377	93.593315	3	22.3
13	99.791667	95.238095	4	22.3
14	100.000000	89.859155	5	22.3
15	99.860433	91.758242	1	33.4
16	99.860627	87.292818	2	33.4
17	99.791377	93.593315	3	33.4
18	99.791667	95.798319	4	33.4
19	100.000000	89.859155	5	33.4
20	99.930216	91.483516	1	44.5
21	99.860627	87.292818	2	44.5
22	99.791377	93.593315	3	44.5
23	99.791667	95.238095	4	44.5
24	100.000000	89.859155	5	44.5
25	99.930216	91.483516	1	55.6
26	99.860627	86.740331	2	55.6
27	99.791377	93.593315	3	55.6
28	99.791667	95.238095	4	55.6
29	100.000000	89.859155	5	55.6
30	99.930216	91.483516	1	66.7
31	99.860627	86.740331	2	66.7

	train	test	split	c
32	99.791377	93.593315	3	66.7
33	99.791667	95.518207	4	66.7
34	100.000000	89.577465	5	66.7
35	99.930216	91.208791	1	77.8
36	99.860627	86.464088	2	77.8
37	99.791377	93.593315	3	77.8
38	99.791667	95.518207	4	77.8
39	100.000000	89.577465	5	77.8
40	99.930216	90.384615	1	88.9
41	99.860627	86.464088	2	88.9
42	99.791377	93.593315	3	88.9
43	99.791667	95.518207	4	88.9
44	100.000000	89.577465	5	88.9
45	99.930216	90.109890	1	100.0
46	99.860627	86.187845	2	100.0
47	99.791377	93.314763	3	100.0
48	99.791667	95.518207	4	100.0
49	100.000000	89.577465	5	100.0

In [93]:
```
scores_l2.loc[scores_l2['split']==1]

for i in range(1,6):
#     p_train = pd.Series(scores_l2.loc[scores_l2['split']==i]["train"].value
s, index=scores_l2.loc[scores_l2['split']==1]["c"])
# #     plt.figure()
#     p_train.plot()

    p_test = pd.Series(scores_l2.loc[scores_l2['split']==i]["test"].values, in
dex=scores_l2.loc[scores_l2['split']==1]["c"])
#     plt.figure()
    p_test.plot()

plt.show()
```



In [99]:
```
for c in c_vals:
    print(scores_l2.loc[scores_l2["c"]==c]["test"].mean(),c)
```

```
92.43629695082134 0.1
91.77242154289213 11.2
91.60357349252527 22.3
91.66036969166791 33.4
91.49337981879567 44.5
91.38288258122662 55.6
91.3825669620212 66.7
91.27237328829162 77.8
91.10753812345645 88.9
90.94163414332017 100.0
```

In [114]:
```
# The highest C value is from 0.1, so using that to run on the data set

logreg_ridge_final = LogisticRegression(C=0.1)
x_train, x_test, y_train, y_test = train_test_split(digits.data, digits.target
, test_size=0.20, random_state=0)

logreg_ridge_final.fit(x_train, y_train) # fit
y_pred = logreg_ridge_final.predict(x_train) # predict
acc_log = sum(y_pred == y_train)/len(y_train)*100
print('Logistic Regression accuracy of train data:', str(round(acc_log,2)),'%'
)
print(confusion_matrix(y_train, y_pred))



y_pred = logreg_ridge_final.predict(x_test) # predict
acc_log = sum(y_pred == y_test)/len(y_test)*100
print('Logistic Regression accuracy of test data:', str(round(acc_log,2)),'%')
print(confusion_matrix(y_test, y_pred))
```

```
Logistic Regression accuracy of train data: 99.03 %
[[151   0   0   0   0   0   0   0   0   0]
 [  0 146   0   0   0   0   0   0   0   1]
 [  0   0 141   0   0   0   0   0   0   0]
 [  0   0   0 153   0   0   0   0   1   0]
 [  0   1   0   0 149   0   0   0   1   0]
 [  0   0   0   0   0 142   0   0   0   0]
 [  0   0   0   0   0   0 137   0   0   0]
 [  0   0   0   0   0   0   0 139   0   1]
 [  0   5   0   1   0   0   0   0 129   0]
 [  0   0   0   1   0   0   0   0   2 136]]
Logistic Regression accuracy of test data: 95.83 %
[[27  0  0  0  0  0  0  0  0  0]
 [ 0 33  0  0  0  0  1  0  1  0]
 [ 0  0 35  1  0  0  0  0  0  0]
 [ 0  0  0 29  0  0  0  0  0  0]
 [ 0  0  0  0 30  0  0  0  0  0]
 [ 0  0  0  0  0 39  0  0  0  1]
 [ 0  1  0  0  0  0 43  0  0  0]
 [ 0  1  0  0  1  0  0 37  0  0]
 [ 0  2  1  0  0  0  0  0 36  0]
 [ 0  0  0  1  0  1  0  0  3 36]]
```

In [105]:
```
# LASSO REGRESSION

c_vals_l1 = np.linspace(0.1,1000,10)

scores_l1_train = []
scores_l1_test = []
scores_l1_c =[]
scores_l1_split = []

for c in c_vals_l1:
#     print("L1 Logistic Regression (Lasso)\n")
    split_count = 0
    logreg_lasso = LogisticRegression(penalty="l1", C=c)
    for train_index, test_index in skf.split(x, y):
    #     print("TRAIN:", train_index, "TEST:", test_index)
        x_train, x_test = x[train_index], x[test_index]
        y_train, y_test = y[train_index], y[test_index]

        logreg_lasso.fit(x_train, y_train) # fit
        y_pred = logreg_lasso.predict(x_train) # predict
        acc_log = sum(y_pred == y_train)/len(y_train)*100
#         print('Logistic Regression accuracy of train data:', str(round(acc
_log,2)),'%')
    #     print(confusion_matrix(y_train, y_pred))
        scores_l1_train.append(acc_log)

        y_pred = logreg_lasso.predict(x_test) # predict
        acc_log = sum(y_pred == y_test)/len(y_test)*100
#         print('Logistic Regression accuracy of test data:', str(round(acc_
log,2)),'%')
    #     print(confusion_matrix(y_test, y_pred))

#         print("\n")
        scores_l1_test.append(acc_log)
        scores_l1_c.append(c)
        split_count = split_count + 1
        scores_l1_split.append(split_count)
```

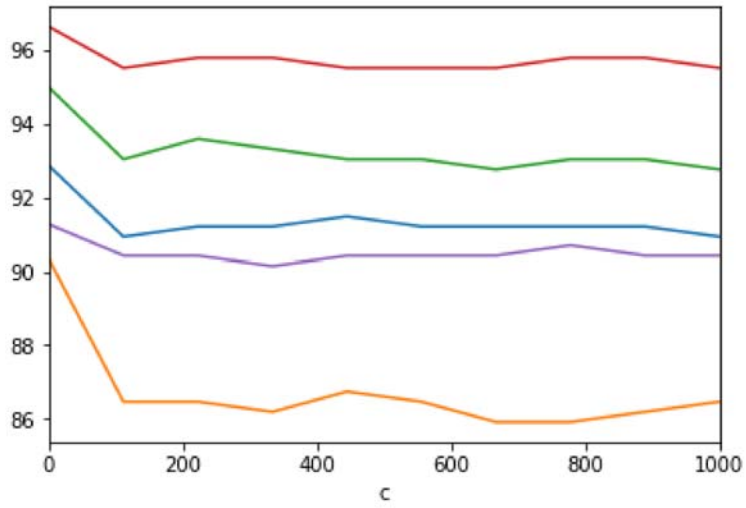
In [106]:
```
data = {"train": scores_l1_train, "test":scores_l1_test, "c":scores_l1_c, "spl
it": scores_l1_split}

scores_l1 = pd.DataFrame(data=data)


scores_l1[scores_l1.columns[::-1]]
```

Out[106]:

	train	test	split	c
0	98.534543	92.857143	1	0.1
1	98.606272	90.331492	2	0.1
2	98.331015	94.986072	3	0.1
3	98.263889	96.638655	4	0.1
4	98.474341	91.267606	5	0.1
5	99.930216	90.934066	1	111.2
6	99.930314	86.464088	2	111.2
7	99.930459	93.036212	3	111.2
8	99.930556	95.518207	4	111.2
9	100.000000	90.422535	5	111.2
10	99.930216	91.208791	1	222.3
11	100.000000	86.464088	2	222.3
12	99.930459	93.593315	3	222.3
13	99.930556	95.798319	4	222.3
14	100.000000	90.422535	5	222.3
15	99.930216	91.208791	1	333.4
16	100.000000	86.187845	2	333.4
17	99.930459	93.314763	3	333.4
18	99.930556	95.798319	4	333.4
19	100.000000	90.140845	5	333.4
20	99.930216	91.483516	1	444.5
21	99.860627	86.740331	2	444.5
22	99.930459	93.036212	3	444.5
23	100.000000	95.518207	4	444.5
24	100.000000	90.422535	5	444.5
25	99.930216	91.208791	1	555.6
26	99.930314	86.464088	2	555.6
27	99.930459	93.036212	3	555.6
28	100.000000	95.518207	4	555.6
29	100.000000	90.422535	5	555.6
30	99.930216	91.208791	1	666.7
31	100.000000	85.911602	2	666.7

	train	test	split	c
32	99.930459	92.757660	3	666.7
33	100.000000	95.518207	4	666.7
34	100.000000	90.422535	5	666.7
35	99.930216	91.208791	1	777.8
36	100.000000	85.911602	2	777.8
37	99.930459	93.036212	3	777.8
38	100.000000	95.798319	4	777.8
39	100.000000	90.704225	5	777.8
40	99.930216	91.208791	1	888.9
41	100.000000	86.187845	2	888.9
42	99.930459	93.036212	3	888.9
43	100.000000	95.798319	4	888.9
44	100.000000	90.422535	5	888.9
45	99.930216	90.934066	1	1000.0
46	100.000000	86.464088	2	1000.0
47	99.930459	92.757660	3	1000.0
48	99.930556	95.518207	4	1000.0
49	100.000000	90.422535	5	1000.0

In [109]:
```
# scores_l1.loc[scores_l1['split']==1]

for i in range(1,6):
#     p_train = pd.Series(scores_l2.loc[scores_l2['split']==i]["train"].value
s, index=scores_l2.loc[scores_l2['split']==1]["c"])
# #     plt.figure()
#     p_train.plot()

    p_test = pd.Series(scores_l1.loc[scores_l1['split']==i]["test"].values, in
dex=scores_l1.loc[scores_l1['split']==1]["c"])
#     plt.figure()
    p_test.plot()

plt.show()
```



In [111]:
```
for c in c_vals_l1:
    print(scores_l1.loc[scores_l1["c"]==c]["test"].mean(),c)
```

```
93.21619361784721 0.1
91.27502170504022 111.2
91.49740978176223 222.3
91.33011282840201 333.4
91.44016043371487 444.5
91.32996675998528 555.6
91.16375921600952 666.7
91.3318299595488 777.8
91.33074055016434 888.9
91.21931139863354 1000.0
```

In [115]:
```
# The highest C value is from 0.1, so using that to run on the data set

logreg_lasso_final = LogisticRegression(penalty="l1", C=0.1)
x_train, x_test, y_train, y_test = train_test_split(digits.data, digits.target
, test_size=0.20, random_state=0)

logreg_lasso_final.fit(x_train, y_train) # fit
y_pred = logreg_lasso_final.predict(x_train) # predict
acc_log = sum(y_pred == y_train)/len(y_train)*100
print('Logistic Regression accuracy of train data:', str(round(acc_log,2)),'%'
)
print(confusion_matrix(y_train, y_pred))



y_pred = logreg_lasso_final.predict(x_test) # predict
acc_log = sum(y_pred == y_test)/len(y_test)*100
print('Logistic Regression accuracy of test data:', str(round(acc_log,2)),'%')
print(confusion_matrix(y_test, y_pred))
```

```
Logistic Regression accuracy of train data: 98.05 %
[[151   0   0   0   0   0   0   0   0   0]
 [  0 145   0   0   0   0   0   0   1   1]
 [  0   0 141   0   0   0   0   0   0   0]
 [  0   0   0 149   0   0   0   1   3   1]
 [  0   2   0   0 148   0   0   0   1   0]
 [  0   0   0   0   1 140   1   0   0   0]
 [  0   0   0   0   0   1 135   0   1   0]
 [  0   0   0   0   0   0   0 138   1   1]
 [  0   6   0   1   0   1   0   0 127   0]
 [  0   0   0   1   0   1   0   0   2 135]]
Logistic Regression accuracy of test data: 95.83 %
[[27  0  0  0  0  0  0  0  0  0]
 [ 0 33  0  0  0  0  1  0  1  0]
 [ 1  0 35  0  0  0  0  0  0  0]
 [ 0  0  0 29  0  0  0  0  0  0]
 [ 0  0  0  0 29  0  0  1  0  0]
 [ 0  0  0  0  0 39  0  0  0  1]
 [ 0  0  0  0  0  0 44  0  0  0]
 [ 0  0  0  0  1  0  0 38  0  0]
 [ 0  2  1  0  0  0  0  0 36  0]
 [ 0  1  0  0  0  1  0  1  3 35]]
```