In [1]:
```
import numpy as np
```

In [2]:
```
from matplotlib import pyplot as plt
```

In [3]:
```
A= 20256 % 8
```

In [4]:
```
A
```

Out[4]:
```
0
```

In [5]:
```
image_size = 28
```

In [6]:
```
intType = np.dtype( 'int32' ).newbyteorder( '>' )
nMetaDataBytes = 4 * intType.itemsize
```

In [7]:
```
def loadMNIST( prefix ):
    intType = np.dtype( 'int32' ).newbyteorder( '>' )
    nMetaDataBytes = 4 * intType.itemsize

    data = np.fromfile(  prefix + '-images.idx3-ubyte', dtype = 'ubyte' )
    magicBytes, nImages, width, height = np.frombuffer( data[:nMetaDataBytes].tobytes(), intType )
    data = data[nMetaDataBytes:].astype( dtype = 'float32' ).reshape( [ nImages, width, height ] )

    labels = np.fromfile( prefix + '-labels.idx1-ubyte',
                          dtype = 'ubyte' )[2 * intType.itemsize:]

    return data, labels

trainingImages, trainingLabels = loadMNIST( "train" )
```

In [8]:
```
np.shape(trainingImages)
```

Out[8]:
```
(60000, 28, 28)
```

In [9]:
```
len(trainingLabels)
```

Out[9]:
```
60000
```

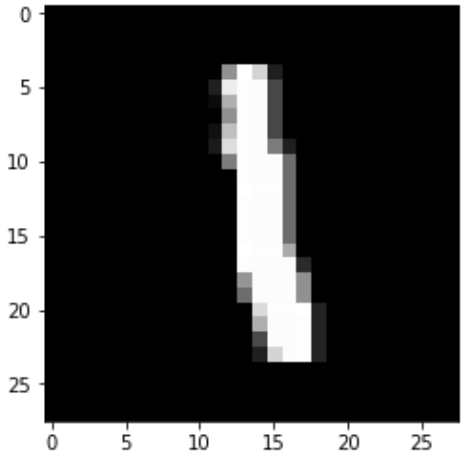
In [10]:
```
trainingLabels[0]
```

Out[10]:
```
5
```

In [11]:
```
import numpy as np
```

In [12]:
```
data = trainingImages.reshape(60000, image_size*image_size)
```

In [13]:
```
img1_2d = np.reshape(data[6,:], (28, 28))
# show it
plt.imshow(img1_2d, cmap=plt.get_cmap('gray'))
plt.show()
```



In [15]:
```
datalabel = trainingLabels.reshape(len(trainingLabels))
```

In [16]:
```
trainlabel=[]
for i in range(len(datalabel)):
    if datalabel[i] == 9:
        trainlabel.append(i)
```

In [17]:
```
np.shape(datalabel)
```

Out[17]: (60000,)

In [18]:
```
traindata=np.array([])
```

In [19]:
```
for i in range(60000):
    if datalabel[i] == 9:
        traindata=np.append(traindata, data[i,:])
```

In [20]:
```
np.shape(traindata)
```

Out[20]: (4664016,)

In [21]:
```
traindata=traindata.reshape(len(trainlabel),image_size*image_size)
```

In [22]:
```
mean = np.array([])
```

In [23]:
```
for i in range(image_size*image_size):
    mean=np.append(mean,[np.mean(traindata[:,i])])
```

In [24]:
```
mean=mean.reshape(image_size*image_size,1)
```

In [25]:
```
##different method for variance(up to multiplication)

variance = np.zeros((image_size*image_size,image_size*image_size))
for i in range(len(trainlabel)):
    variance += (traindata[i,:].reshape(image_size*image_size,1) - mean).dot((traindata[i,:].resha
pe(image_size*image_size,1) - mean).T)
```

In [26]:
```
variance= 1/60000*variance
```

In [27]:
```
eigval, eigvec = np.linalg.eig(variance)
```

In [28]:
```
np.shape(eigvec)
```

Out[28]: (784, 784)

In [29]:
```
eigval[0]
```

Out[29]: (39986.40576927838+0j)

In [30]:
```
eigval[0]
```

Out[30]: (39986.40576927838+0j)

In [31]:
```
eig_pairs = [(np.abs(eigval[i]), eigvec[:,i]) for i in range(len(eigval))]

eig_pairs.sort(key=lambda x: x[0], reverse=True)
```

In [32]:
```
x=np.linspace(0,784,784)
y=eigval.tolist()

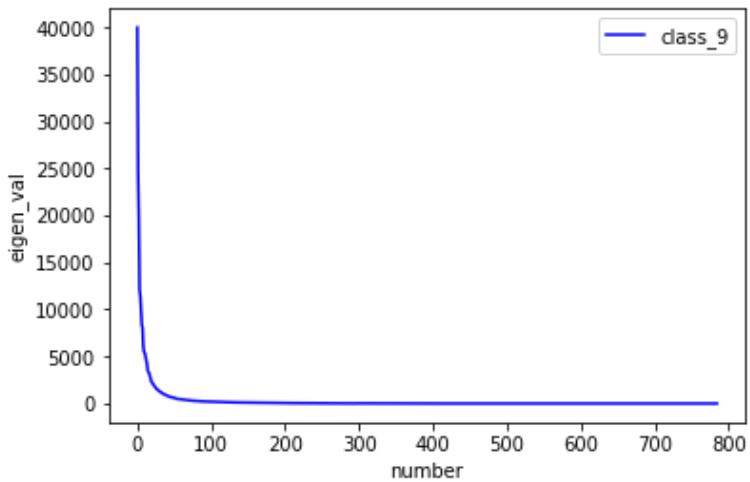
z =[]
a=[eig_pairs[i][0] for i in range(image_size*image_size)]
b= sum([eig_pairs[i][0] for i in range(image_size*image_size)])
```

In [33]:
```
for i in range(image_size*image_size):
    z.append(sum(a[0:i]))
```

In [34]:
```
plt.plot(x, y , color='blue',label='class_9')
plt.xlabel('number')
plt.ylabel('eigen_val')
plt.legend()

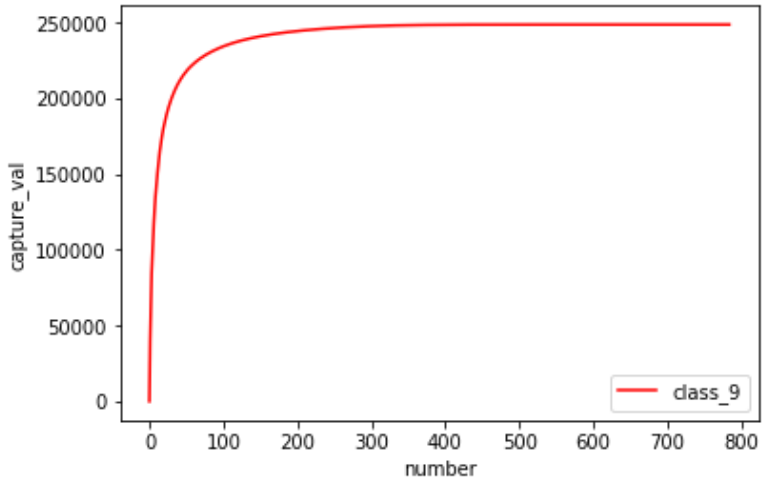
plt.show()
```

```
D:WanacondaWlibWsite-packagesWnumpyWcoreWnumeric.py:501: ComplexWarning: Casting complex values to real discards the imaginary part
  return array(a, dtype, copy=False, order=order)
```



In [35]:
```
plt.plot(x, z , color='red',label='class_9')
plt.xlabel('number')
plt.ylabel('capture_val')
plt.legend()

plt.show()
```



projection to 2 dimensional space.

In [36]:
```
W_j = np.hstack((eig_pairs[0][1].reshape(image_size*image_size,1), eig_pairs[1][1].reshape(image_s
ize*image_size,1)))
```

In [37]:
```
W_j[:,1]
```

```
Out[37]: array([ 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
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                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
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                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j, -8.20844364e-06+0.j,
                -6.08171052e-05+0.j, -1.00739990e-05+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  1.49322375e-06+0.j,  6.74955032e-05+0.j,
                -8.39323600e-05+0.j, -2.30570820e-04+0.j, -2.42393701e-04+0.j,
                -2.54330946e-04+0.j, -5.00125328e-05+0.j,  1.77359849e-04+0.j,
                 2.61603392e-04+0.j,  1.64073339e-04+0.j,  1.68950339e-04+0.j,
                 1.62423353e-04+0.j,  8.97808024e-06+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
                 0.00000000e+00+0.j,  0.00000000e+00+0.j, -1.66749416e-06+0.j,
                 1.87429902e-05+0.j,  5.15031314e-05+0.j,  8.71035068e-05+0.j,
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                -2.41773238e-03+0.j, -2.62993389e-03+0.j,  1.43868340e-04+0.j,
                 4.59902744e-03+0.j,  8.08320302e-03+0.j,  8.16371525e-03+0.j,
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                 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
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```

-2.78571673e-02+0.j, -4.02238460e-02+0.j, -3.26447375e-02+0.j,
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 1.37732269e-02+0.j, 1.55515638e-02+0.j, 7.50570991e-03+0.j,
-1.24139370e-02+0.j, -1.99878227e-02+0.j, -1.48218508e-03+0.j,
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 3.27945029e-04+0.j, 0.00000000e+00+0.j, 0.00000000e+00+0.j,
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 4.36299469e-02+0.j, 6.12668015e-02+0.j, 4.32576159e-02+0.j,
-3.47116435e-03+0.j, -5.25150752e-02+0.j, -5.34301188e-02+0.j,
 2.26844301e-02+0.j, 1.08991126e-01+0.j, 1.26662396e-01+0.j,
 8.80726909e-02+0.j, 3.99603020e-02+0.j, 1.19702528e-02+0.j,
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 0.00000000e+00+0.j, 0.00000000e+00+0.j, 0.00000000e+00+0.j,
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 3.26526463e-02+0.j, 1.16605193e-02+0.j, 3.16460503e-03+0.j,
 2.41555217e-02+0.j, 4.42916776e-02+0.j, 3.65692425e-02+0.j,
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-9.35785532e-02+0.j, 3.97303336e-03+0.j, 1.11417504e-01+0.j,
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 1.23310476e-02+0.j, 2.41978429e-03+0.j, 5.04087419e-04+0.j,
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 0.00000000e+00+0.j, 4.36595308e-05+0.j, 1.11964310e-03+0.j,
 8.25791333e-03+0.j, 2.45939928e-02+0.j, 4.47962551e-02+0.j,
 5.58604682e-02+0.j, 3.75772960e-02+0.j, 6.40413922e-03+0.j,
-5.38345090e-03+0.j, 7.95355420e-03+0.j, 1.49509994e-02+0.j,
 6.55668105e-04+0.j, -2.65085146e-02+0.j, -7.75007917e-02+0.j,
-1.22043094e-01+0.j, -9.09030412e-02+0.j, 2.64803022e-02+0.j,
 1.35669651e-01+0.j, 1.47307359e-01+0.j, 8.96654867e-02+0.j,
 3.73139007e-02+0.j, 1.01797855e-02+0.j, 1.44668440e-03+0.j,
 2.32742771e-04+0.j, -1.06670861e-05+0.j, 0.00000000e+00+0.j,
 0.00000000e+00+0.j, 0.00000000e+00+0.j, 1.42303228e-04+0.j,
 2.72096183e-03+0.j, 1.31084514e-02+0.j, 3.31026535e-02+0.j,
 5.97313079e-02+0.j, 7.15859170e-02+0.j, 3.87039026e-02+0.j,
-1.44137768e-02+0.j, -3.36411284e-02+0.j, -2.28023924e-02+0.j,
-1.86124185e-02+0.j, -3.25106014e-02+0.j, -6.19342018e-02+0.j,
-1.00916046e-01+0.j, -1.11708815e-01+0.j, -5.10275629e-02+0.j,
 7.02055568e-02+0.j, 1.56056261e-01+0.j, 1.38272999e-01+0.j,
 7.26235045e-02+0.j, 2.76676667e-02+0.j, 7.33841794e-03+0.j,
 6.14692041e-04+0.j, 1.28921375e-05+0.j, 0.00000000e+00+0.j,
 0.00000000e+00+0.j, 0.00000000e+00+0.j, 0.00000000e+00+0.j,
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 4.02507393e-02+0.j, 7.34843898e-02+0.j, 8.62246686e-02+0.j,
 4.39891672e-02+0.j, -2.79197110e-02+0.j, -6.08309728e-02+0.j,
-5.63738863e-02+0.j, -5.42903127e-02+0.j, -6.32111183e-02+0.j,
-7.51815663e-02+0.j, -7.83993116e-02+0.j, -6.43265429e-02+0.j,
-2.99751839e-03+0.j, 1.05576845e-01+0.j, 1.55739855e-01+0.j,
 1.12722094e-01+0.j, 5.04892041e-02+0.j, 1.68319500e-02+0.j,
 4.32423213e-03+0.j, 2.99060732e-04+0.j, 1.14270203e-04+0.j,
 2.91276989e-05+0.j, 0.00000000e+00+0.j, 0.00000000e+00+0.j,
 0.00000000e+00+0.j, 1.26531751e-04+0.j, 3.13112613e-03+0.j,
 1.66958630e-02+0.j, 4.18479405e-02+0.j, 7.83649246e-02+0.j,
 9.84187912e-02+0.j, 6.33707536e-02+0.j, -9.43636008e-03+0.j,
-5.42606329e-02+0.j, -5.80032663e-02+0.j, -5.19654717e-02+0.j,
-4.39667970e-02+0.j, -2.58302679e-02+0.j, -1.69286222e-02+0.j,
-1.83864694e-02+0.j, 2.66932388e-02+0.j, 1.15664390e-01+0.j,
 1.33342877e-01+0.j, 7.88796566e-02+0.j, 3.08729779e-02+0.j,

```
 9.51272347e-03+0.j,  2.59954887e-03+0.j,  1.42647513e-04+0.j,
 1.26593460e-04+0.j,  3.47291794e-05+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  3.80628500e-05+0.j,
 2.66446587e-03+0.j,  1.40030458e-02+0.j,  3.67216910e-02+0.j,
 7.30829925e-02+0.j,  1.04411030e-01+0.j,  9.41544898e-02+0.j,
 4.62968140e-02+0.j,  9.26210681e-03+0.j, -8.25130272e-05+0.j,
 7.28885513e-03+0.j,  2.52187129e-02+0.j,  4.30233830e-02+0.j,
 2.79078160e-02+0.j,  2.02249409e-03+0.j,  3.63048169e-02+0.j,
 1.03318552e-01+0.j,  9.88924185e-02+0.j,  5.24095002e-02+0.j,
 1.95444907e-02+0.j,  6.68890413e-03+0.j,  1.78305142e-03+0.j,
 6.84069883e-05+0.j,  1.26593460e-04+0.j,  4.33802202e-05+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 9.03186271e-06+0.j,  1.65411265e-03+0.j,  9.14098352e-03+0.j,
 2.66563003e-02+0.j,  5.54666839e-02+0.j,  8.99515991e-02+0.j,
 1.06830120e-01+0.j,  9.30424140e-02+0.j,  7.28977888e-02+0.j,
 6.35840468e-02+0.j,  6.64621113e-02+0.j,  7.64947063e-02+0.j,
 7.77242673e-02+0.j,  3.94833656e-02+0.j,  3.73139258e-03+0.j,
 2.81905116e-02+0.j,  7.42088104e-02+0.j,  6.87044975e-02+0.j,
 3.72959752e-02+0.j,  1.47522727e-02+0.j,  5.74551787e-03+0.j,
 1.34456911e-03+0.j,  6.90760335e-05+0.j,  2.99034896e-05+0.j,
 1.96051819e-05+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  1.05708652e-05+0.j,  7.69020031e-04+0.j,
 4.60808387e-03+0.j,  1.40830586e-02+0.j,  3.19434283e-02+0.j,
 5.73983464e-02+0.j,  7.84000413e-02+0.j,  8.57442305e-02+0.j,
 8.20387946e-02+0.j,  7.61139312e-02+0.j,  7.37518326e-02+0.j,
 8.18881311e-02+0.j,  7.93028032e-02+0.j,  3.26589525e-02+0.j,
-1.06276989e-02+0.j,  6.64221531e-03+0.j,  4.78692873e-02+0.j,
 5.19556405e-02+0.j,  3.14345027e-02+0.j,  1.29954656e-02+0.j,
 4.62765989e-03+0.j,  1.35097290e-03+0.j,  1.20528466e-04+0.j,
-5.34750587e-06+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
-3.10607597e-06+0.j,  0.00000000e+00+0.j,  2.44090888e-05+0.j,
 4.75659496e-04+0.j,  2.48057505e-03+0.j,  6.51922374e-03+0.j,
 1.47739980e-02+0.j,  2.60636025e-02+0.j,  3.83547836e-02+0.j,
 4.71667189e-02+0.j,  5.04639216e-02+0.j,  5.15844528e-02+0.j,
 5.81712968e-02+0.j,  7.85784902e-02+0.j,  7.10383868e-02+0.j,
 1.39296150e-02+0.j, -3.32582910e-02+0.j, -1.63893810e-02+0.j,
 3.16796233e-02+0.j,  4.35964733e-02+0.j,  2.84808215e-02+0.j,
 1.22581970e-02+0.j,  4.32447301e-03+0.j,  1.44920660e-03+0.j,
 1.50727010e-04+0.j,  1.76408767e-04+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  3.59023274e-04+0.j,  9.30802953e-04+0.j,
 2.70406659e-03+0.j,  6.00333049e-03+0.j,  9.61591269e-03+0.j,
 1.43621033e-02+0.j,  1.87009588e-02+0.j,  2.30471364e-02+0.j,
 3.26973238e-02+0.j,  5.63403074e-02+0.j,  7.89893080e-02+0.j,
 5.70914586e-02+0.j, -1.27763235e-02+0.j, -5.60051338e-02+0.j,
-3.11917167e-02+0.j,  2.30703888e-02+0.j,  3.82541433e-02+0.j,
 2.62958375e-02+0.j,  1.12903093e-02+0.j,  4.10760042e-03+0.j,
 1.43241871e-03+0.j,  2.95705496e-04+0.j,  2.42523703e-04+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  1.46655490e-05+0.j,  1.68029805e-04+0.j,
 4.90103654e-04+0.j,  1.31669293e-03+0.j,  2.57795140e-03+0.j,
 3.41924828e-03+0.j,  5.30192776e-03+0.j,  8.22635502e-03+0.j,
 1.65253622e-02+0.j,  3.81994317e-02+0.j,  6.89849989e-02+0.j,
 7.84703123e-02+0.j,  3.49095039e-02+0.j, -3.97784128e-02+0.j,
-7.18449716e-02+0.j, -3.45610948e-02+0.j,  1.83659797e-02+0.j,
 3.44443797e-02+0.j,  2.43411996e-02+0.j,  1.15604518e-02+0.j,
 4.35596118e-03+0.j,  1.53087805e-03+0.j,  4.94208571e-04+0.j,
 2.60905620e-04+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  2.62330836e-06+0.j,
 3.31877327e-05+0.j,  1.24057635e-04+0.j,  5.75895882e-04+0.j,
 1.55842202e-03+0.j,  2.62918398e-03+0.j,  4.82819474e-03+0.j,
 1.13733788e-02+0.j,  2.73693735e-02+0.j,  5.50942456e-02+0.j,
 8.04626298e-02+0.j,  6.73377384e-02+0.j,  5.60126361e-03+0.j,
-5.98878761e-02+0.j, -7.57350964e-02+0.j, -3.44876559e-02+0.j,
 1.36295279e-02+0.j,  2.94571697e-02+0.j,  2.37724385e-02+0.j,
 1.20775417e-02+0.j,  5.26100460e-03+0.j,  1.82099930e-03+0.j,
 7.37058311e-04+0.j,  1.32356325e-04+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  3.82263345e-05+0.j,  1.51591726e-04+0.j,
```

```
 3.18738313e-04+0.j,  1.20736374e-03+0.j,  3.81802096e-03+0.j,
 9.98522614e-03+0.j,  2.30965916e-02+0.j,  4.56428410e-02+0.j,
 7.23965292e-02+0.j,  7.89646522e-02+0.j,  4.33436313e-02+0.j,
-2.11877928e-02+0.j, -7.20283855e-02+0.j, -7.55551798e-02+0.j,
-3.58410394e-02+0.j,  8.47579924e-03+0.j,  2.48516250e-02+0.j,
 2.30724869e-02+0.j,  1.37325589e-02+0.j,  6.60048231e-03+0.j,
 2.67899127e-03+0.j,  8.21073336e-04+0.j,  6.56591880e-05+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  2.64430181e-05+0.j,
 1.54373464e-04+0.j,  6.58494180e-04+0.j,  2.86286045e-03+0.j,
 8.46260100e-03+0.j,  1.96260840e-02+0.j,  3.76100489e-02+0.j,
 6.15670595e-02+0.j,  7.70674478e-02+0.j,  6.21813292e-02+0.j,
 1.63892710e-02+0.j, -4.13096638e-02+0.j, -7.70068921e-02+0.j,
-7.38437240e-02+0.j, -3.78541200e-02+0.j,  2.93938295e-03+0.j,
 2.14858520e-02+0.j,  2.30012350e-02+0.j,  1.53612910e-02+0.j,
 8.27381061e-03+0.j,  3.46366335e-03+0.j,  8.66977375e-04+0.j,
 1.14799463e-05+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  1.77829691e-04+0.j,  1.41372551e-03+0.j,
 4.81752291e-03+0.j,  1.24907999e-02+0.j,  2.75265340e-02+0.j,
 4.74935172e-02+0.j,  6.70148938e-02+0.j,  7.04318625e-02+0.j,
 4.38719932e-02+0.j, -2.38195610e-03+0.j, -4.71482282e-02+0.j,
-7.43768501e-02+0.j, -6.88948045e-02+0.j, -3.79537058e-02+0.j,
-1.67295054e-03+0.j,  1.87834942e-02+0.j,  2.16623811e-02+0.j,
 1.50501596e-02+0.j,  8.06574373e-03+0.j,  3.41546919e-03+0.j,
 5.86937039e-04+0.j, -3.41741857e-05+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 9.39860580e-06+0.j,  0.00000000e+00+0.j,  2.38838618e-04+0.j,
 1.62322083e-03+0.j,  4.38994760e-03+0.j,  1.13689542e-02+0.j,
 2.50572658e-02+0.j,  4.07924440e-02+0.j,  5.33784639e-02+0.j,
 4.95098639e-02+0.j,  2.40539464e-02+0.j, -1.12987435e-02+0.j,
-4.09668294e-02+0.j, -5.75844580e-02+0.j, -5.28830601e-02+0.j,
-3.12762327e-02+0.j, -5.45836241e-03+0.j,  1.08850840e-02+0.j,
 1.43819661e-02+0.j,  1.00065942e-02+0.j,  4.44103237e-03+0.j,
 2.01180530e-03+0.j,  3.90907522e-04+0.j, -1.91484983e-05+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  4.84287589e-06+0.j,
 1.34904341e-04+0.j,  4.36434413e-04+0.j,  1.38060413e-03+0.j,
 2.60344536e-03+0.j,  5.84383985e-03+0.j,  9.06714739e-03+0.j,
 1.08356165e-02+0.j,  8.83740362e-03+0.j,  1.53773618e-03+0.j,
-8.29086136e-03+0.j, -1.51294469e-02+0.j, -1.64582651e-02+0.j,
-1.54715922e-02+0.j, -1.03979712e-02+0.j, -3.80796747e-03+0.j,
 2.12330834e-03+0.j,  4.35717581e-03+0.j,  2.26907020e-03+0.j,
 5.79130153e-04+0.j,  1.00468613e-04+0.j,  6.03774159e-06+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 1.10452799e-05+0.j,  6.27695177e-05+0.j,  5.86465288e-05+0.j,
 6.07751399e-05+0.j,  4.72507540e-05+0.j,  9.49818951e-05+0.j,
 6.73122641e-05+0.j, -1.53666185e-04+0.j, -4.27952830e-04+0.j,
-2.59740998e-04+0.j, -1.34249643e-04+0.j,  5.26567098e-05+0.j,
 3.48995575e-05+0.j,  1.73935034e-04+0.j,  2.46620286e-04+0.j,
 8.76016806e-05+0.j,  4.08503603e-05+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j])
```

In [38]:
```
eig_pairs[1][1]
```

Out[38]:
```
array([ 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
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        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
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        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
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        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j, -8.20844364e-06+0.j,
       -6.08171052e-05+0.j, -1.00739990e-05+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  1.49322375e-06+0.j,  6.74955032e-05+0.j,
       -8.39323600e-05+0.j, -2.30570820e-04+0.j, -2.42393701e-04+0.j,
       -2.54330946e-04+0.j, -5.00125328e-05+0.j,  1.77359849e-04+0.j,
        2.61603392e-04+0.j,  1.64073339e-04+0.j,  1.68950339e-04+0.j,
        1.62423353e-04+0.j,  8.97808024e-06+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j, -1.66749416e-06+0.j,
        1.87429902e-05+0.j,  5.15031314e-05+0.j,  8.71035068e-05+0.j,
        8.76443966e-05+0.j,  8.86860879e-05+0.j, -5.52675836e-04+0.j,
       -2.41773238e-03+0.j, -2.62993389e-03+0.j,  1.43868340e-04+0.j,
        4.59902744e-03+0.j,  8.08320302e-03+0.j,  8.16371525e-03+0.j,
        5.65387888e-03+0.j,  3.46459253e-03+0.j,  1.85233866e-03+0.j,
        6.56905944e-04+0.j,  3.48591036e-05+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  6.66951674e-06+0.j,  2.60287805e-05+0.j,
        3.32423322e-04+0.j,  7.02587669e-04+0.j,  1.47988430e-03+0.j,
        2.96219224e-03+0.j,  2.05780121e-03+0.j, -7.25481177e-03+0.j,
       -2.18800767e-02+0.j, -3.25026946e-02+0.j, -2.73463979e-02+0.j,
       -1.47174617e-03+0.j,  3.74929085e-02+0.j,  7.11700961e-02+0.j,
        8.40863568e-02+0.j,  6.85499698e-02+0.j,  4.27448574e-02+0.j,
        2.00251773e-02+0.j,  6.78932261e-03+0.j,  1.61655488e-03+0.j,
        2.15826491e-04+0.j,  5.81161676e-05+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
        0.00000000e+00+0.j,  3.10049978e-06+0.j,  1.26793327e-05+0.j,
        3.23945425e-04+0.j,  1.61404335e-03+0.j,  4.69498009e-03+0.j,
        8.53288030e-03+0.j,  6.87059828e-03+0.j, -5.71453518e-03+0.j,
```

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 6.73122641e-05+0.j, -1.53666185e-04+0.j, -4.27952830e-04+0.j,
-2.59740998e-04+0.j, -1.34249643e-04+0.j,  5.26567098e-05+0.j,
 3.48995575e-05+0.j,  1.73935034e-04+0.j,  2.46620286e-04+0.j,
 8.76016806e-05+0.j,  4.08503603e-05+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j,  0.00000000e+00+0.j,  0.00000000e+00+0.j,
 0.00000000e+00+0.j])
```

In [39]:
```
data_tranformed_j_9= W_j.T.dot(traindata.T)
```

In [40]:
```
np.shape(data_tranformed_j_9.T)
```

Out[40]: (5949, 2)

In [41]:
```
data_tranformed_j_9
```

Out[41]:
```
array([[328.30853498+0.j, 842.48380327+0.j, 624.18677955+0.j, ...,
        754.6899828 +0.j, 629.76326346+0.j, 592.87195826+0.j],
       [269.78823348+0.j, 470.15112869+0.j, 643.29210626+0.j, ...,
        794.55679107+0.j, 670.94273596+0.j, 618.15102624+0.j]])
```

Class_7

In [42]:
```
trainlabel1=[]
for i in range(len(datalabel)):
    if datalabel[i] == 7:
        trainlabel1.append(i)
```

In [43]:
```
traindata1=np.array([])
```

In [44]:
```
for i in range(60000):
    if datalabel[i] == 7 :
        traindata1=np.append(traindata1, data[i,:])
```

In [45]:
```
traindata1=traindata1.reshape(len(trainlabel1),image_size*image_size)
```

In [46]:
```
mean1 = np.array([])
```

In [47]:
```
for i in range(image_size*image_size):
    mean1=np.append(mean1,[np.mean(traindata1[:,i])])
```

In [48]:
```
mean1=mean1.reshape(image_size*image_size,1)
```

In [49]:
```
##different method for variance(up to multiplication)

variance1 = np.zeros((image_size*image_size,image_size*image_size))
for i in range(len(trainlabel1)):
    variance1 += (traindata1[i,:].reshape(image_size*image_size,1) - mean1).dot((traindata1[i,:].r
eshape(image_size*image_size,1) - mean1).T)
```

In [50]:
```
variance1=1/60000*variance1
```

In [51]:
```
eigval1, eigvec1 = np.linalg.eig(variance1)
```

In [52]:
```
eigval1[0]
```

Out[52]:
```
(40915.973681179865+0j)
```

In [53]:
```
eig_pairs1 = [(np.abs(eigval1[i]), eigvec1[:,i]) for i in range(len(eigval1))]

eig_pairs1.sort(key=lambda x: x[0], reverse=True)
```

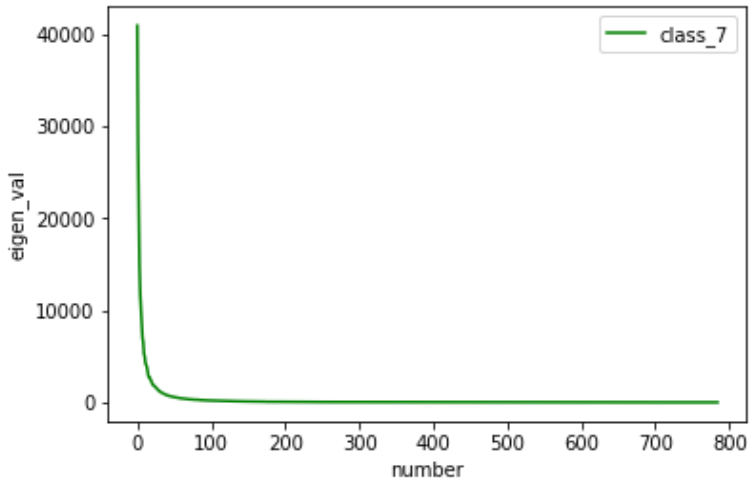
In [54]:
```
x=np.linspace(0,784,784)
y1=eigval1.tolist()

z1 =[]
a1=[eig_pairs1[i][0] for i in range(image_size*image_size)]
b1= sum([eig_pairs1[i][0] for i in range(image_size*image_size)])
```

In [55]:
```
for i in range(image_size*image_size):
    z1.append(sum(a1[0:i]))
```

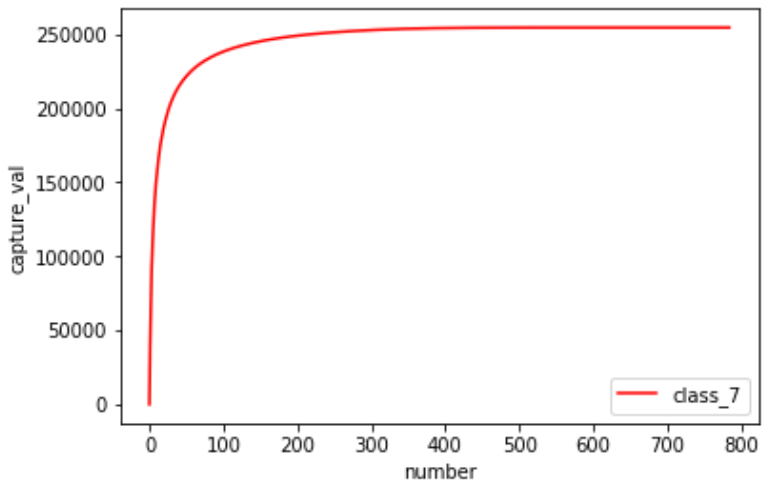
In [56]:
```
plt.plot(x, y1 , color='green',label='class_7')
plt.xlabel('number')
plt.ylabel('eigen_val')
plt.legend()

plt.show()
```



In [57]:
```
plt.plot(x, z1 , color='red',label='class_7')
plt.xlabel('number')
plt.ylabel('capture_val')
plt.legend()

plt.show()
```



In [58]:
```
W_j_7 = np.hstack((eig_pairs1[0][1].reshape(image_size*image_size,1), eig_pairs1[1][1].reshape(ima
ge_size*image_size,1)))
```

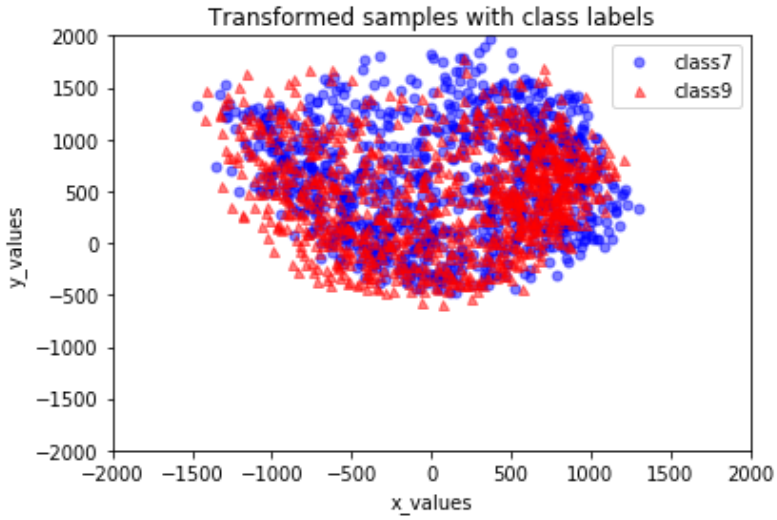
In [60]:
```
data_tranformed_j_7= W_j_7.T.dot(traindata1.T)
```

In [61]:
```
data_tranformed_j_7
```

Out[61]:
```
array([[ 648.28714801+0.j,  390.15892896+0.j, -138.56955908+0.j, ...,
         774.1737905 +0.j,  774.30679971+0.j,  286.12831641+0.j],
       [1469.68654623+0.j,  601.90971465+0.j, -239.76944925+0.j, ...,
        1003.46019056+0.j,  390.96173396+0.j, 1411.31403153+0.j]])
```

In [73]:
```
plt.plot(data_tranformed_j_7[0,0:1000], data_tranformed_j_7[1,0:1000], 'o', markersize=5, color='blue', alpha=0.5, label='class7')
plt.plot(data_tranformed_j_9[0,0:1000], data_tranformed_j_9[1,0:1000], '^', markersize=5, color='red', alpha=0.5, label='class9')
plt.xlim([-2000,2000])
plt.ylim([-2000,2000])
plt.xlabel('x_values')
plt.ylabel('y_values')
plt.legend()
plt.title('Transformed samples with class labels')

plt.show()
```



Using PCA, we can't classify digit 7 and digit 9.

So we need other tecniques. In short, one use PCA only for datacompressing for an analysis.

In [ ]: