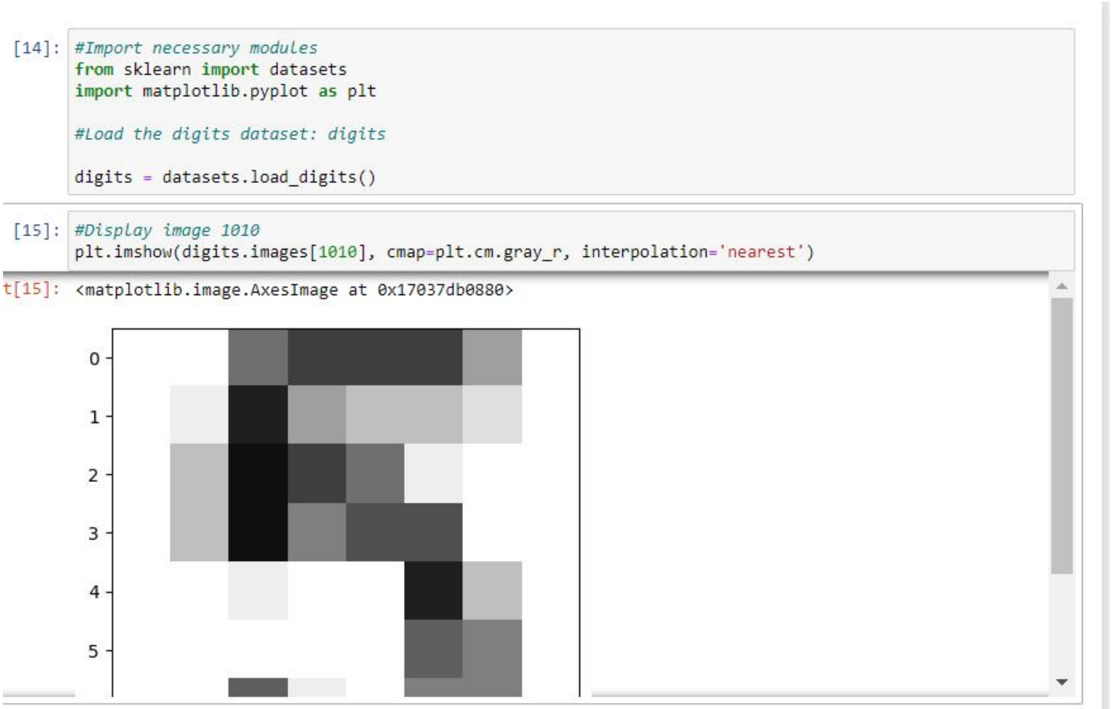
Link Github: https://github.com/paulbboone/DataMining_ThucHanh

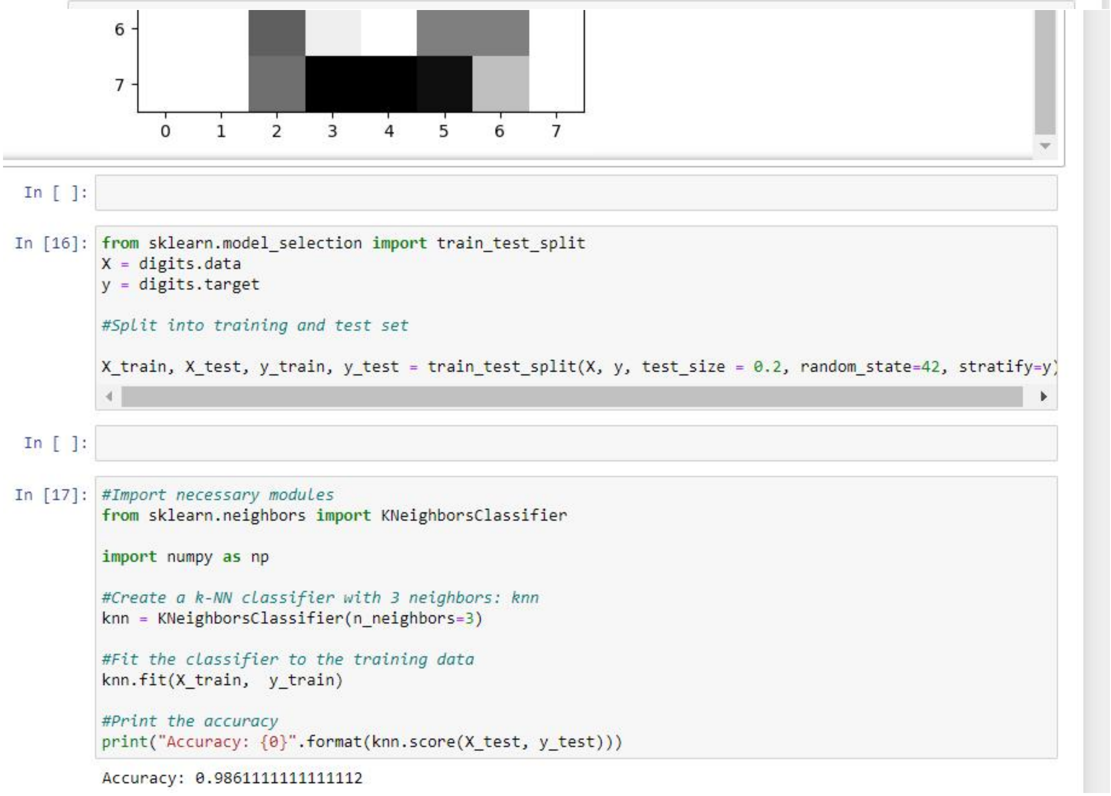
HOMEWORK LAB 04



```
[14]: #Import necessary modules
      from sklearn import datasets
      import matplotlib.pyplot as plt

      #Load the digits dataset: digits

      digits = datasets.load_digits()
```

```
[15]: #Display image 1010
      plt.imshow(digits.images[1010], cmap=plt.cm.gray_r, interpolation='nearest')
```

```
t[15]: <matplotlib.image.AxesImage at 0x17037db0880>
```

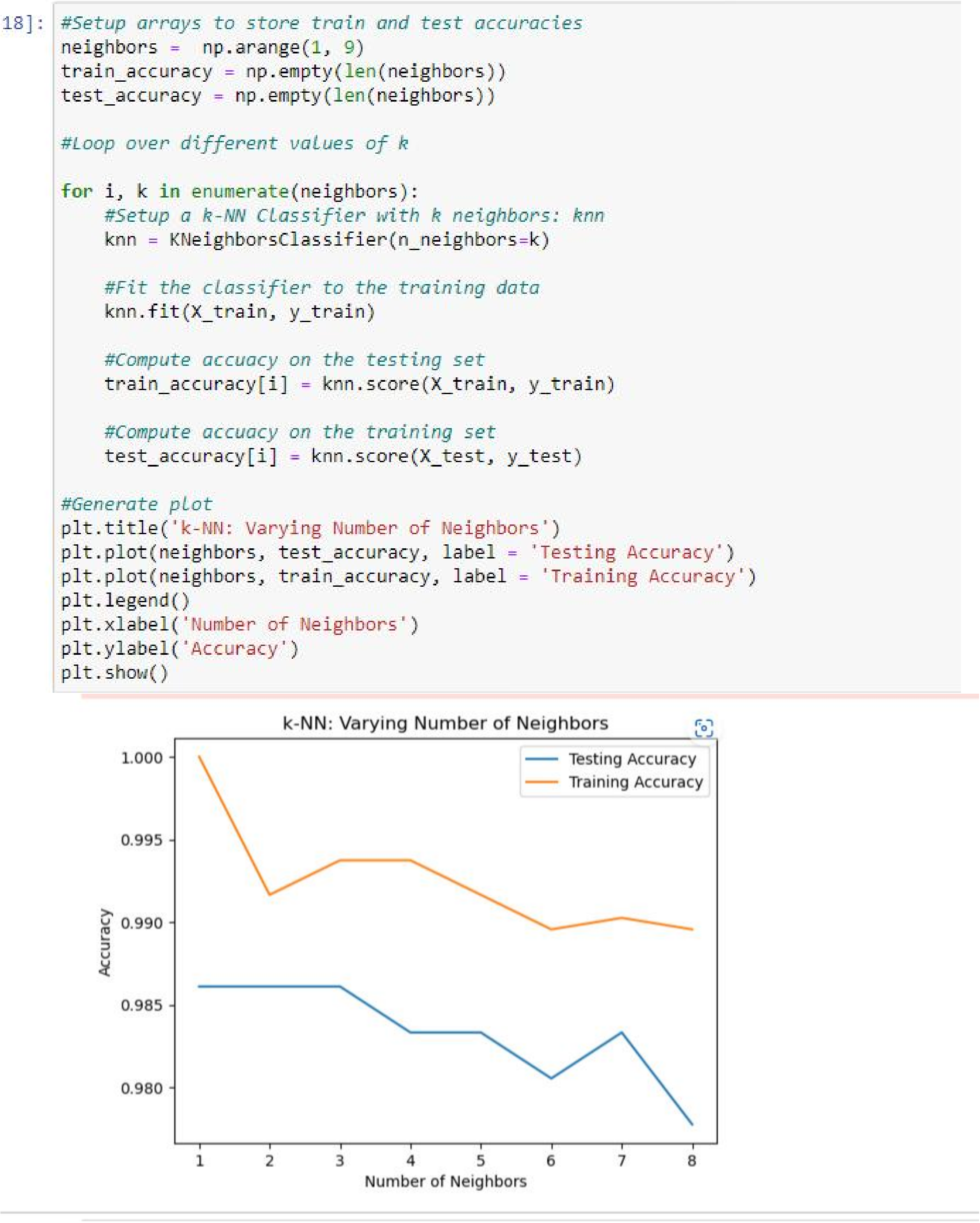


```
In [ ]:
```

```
In [16]: from sklearn.model_selection import train_test_split
         X = digits.data
         y = digits.target

         #Split into training and test set

         X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2, random_state=42, stratify=y)
```

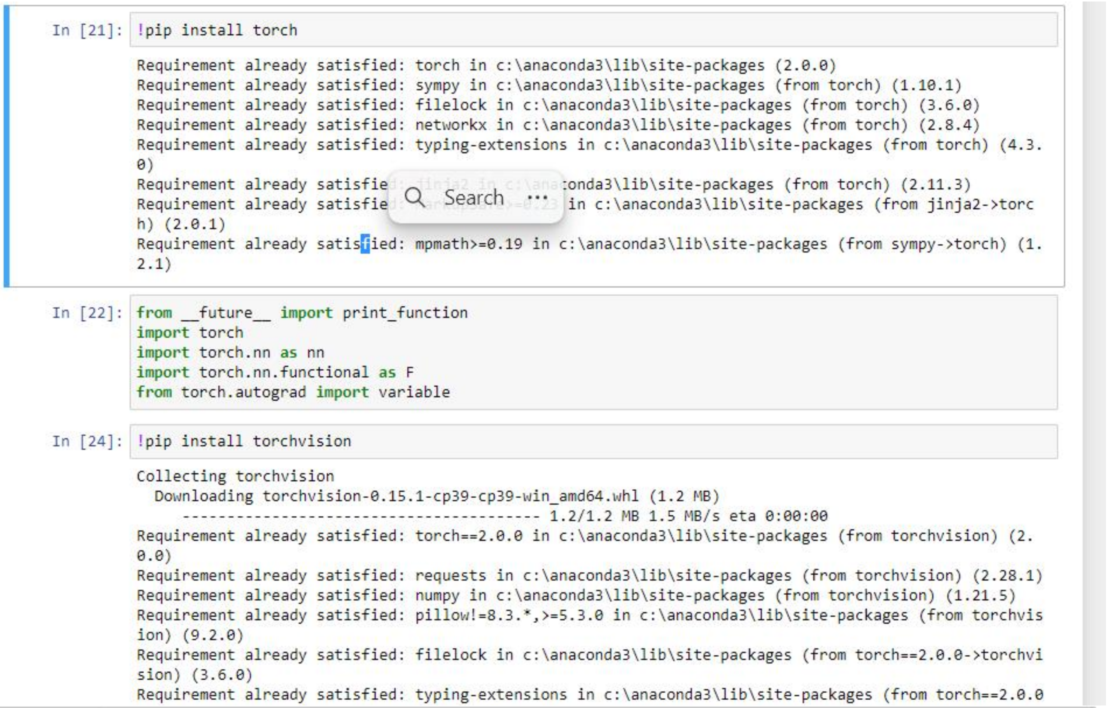
```
In [ ]:
```

```
In [17]: #Import necessary modules
         from sklearn.neighbors import KNeighborsClassifier

         import numpy as np

         #Create a k-NN classifier with 3 neighbors: knn
         knn = KNeighborsClassifier(n_neighbors=3)

         #Fit the classifier to the training data
         knn.fit(X_train,  y_train)

         #Print the accuracy
         print("Accuracy: {0}".format(knn.score(X_test, y_test)))

         Accuracy: 0.9861111111111112
```



18]:

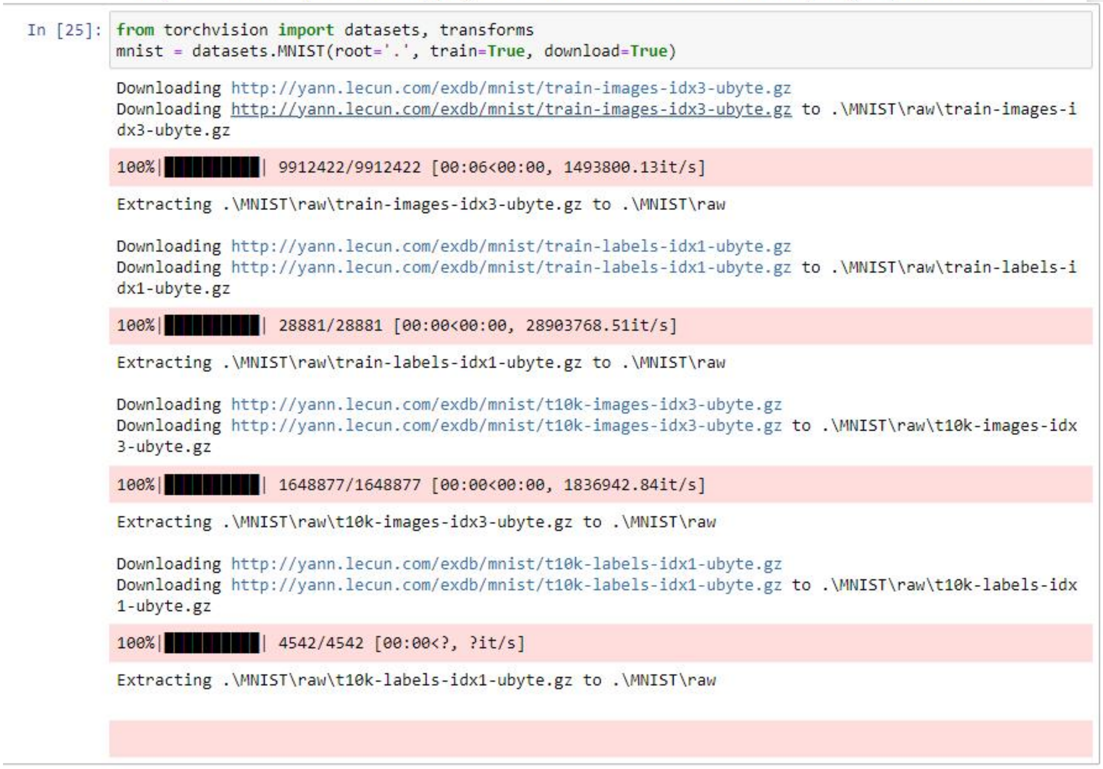
```python
#Setup arrays to store train and test accuracies
neighbors =  np.arange(1, 9)
train_accuracy = np.empty(len(neighbors))
test_accuracy = np.empty(len(neighbors))

#Loop over different values of k

for i, k in enumerate(neighbors):
    #Setup a k-NN Classifier with k neighbors: knn
    knn = KNeighborsClassifier(n_neighbors=k)

    #Fit the classifier to the training data
    knn.fit(X_train, y_train)

    #Compute accuacy on the testing set
    train_accuracy[i] = knn.score(X_train, y_train)

    #Compute accuacy on the training set
    test_accuracy[i] = knn.score(X_test, y_test)

#Generate plot
plt.title('k-NN: Varying Number of Neighbors')
plt.plot(neighbors, test_accuracy, label = 'Testing Accuracy')
plt.plot(neighbors, train_accuracy, label = 'Training Accuracy')
plt.legend()
plt.xlabel('Number of Neighbors')
plt.ylabel('Accuracy')
plt.show()
```



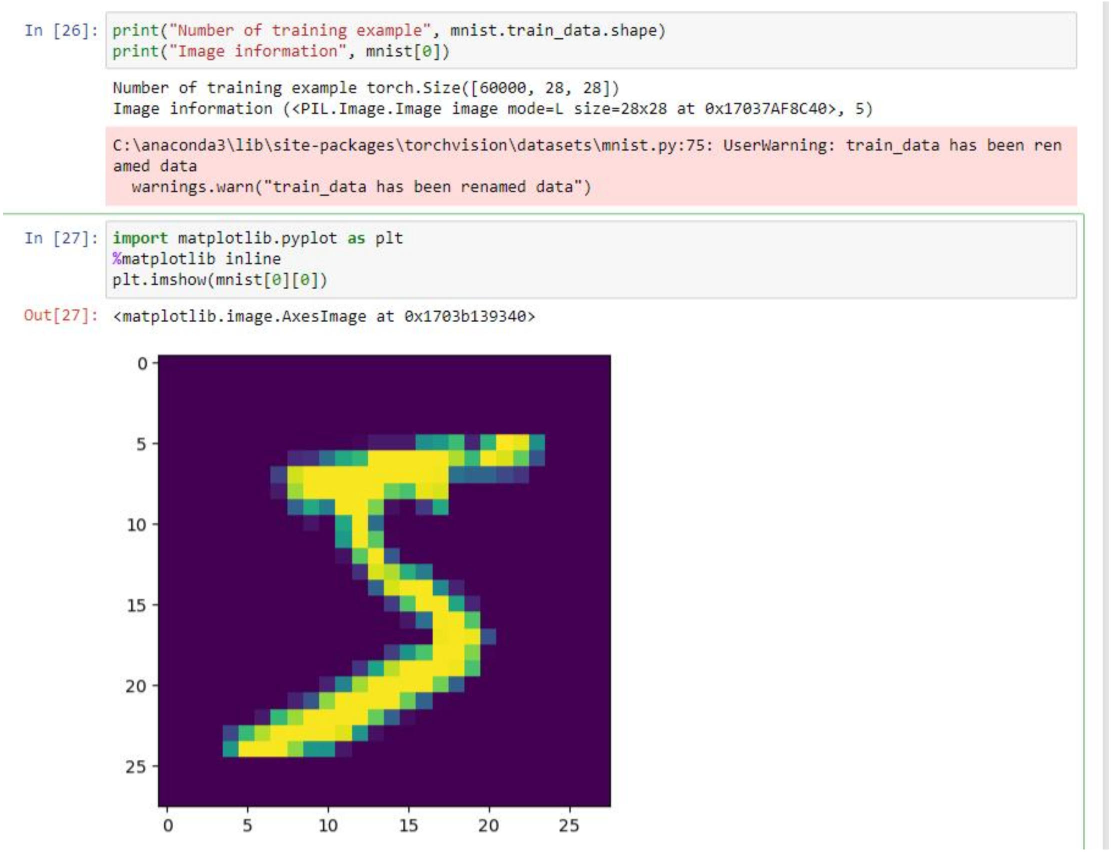
```
In [21]: !pip install torch

         Requirement already satisfied: torch in c:\anaconda3\lib\site-packages (2.0.0)
         Requirement already satisfied: sympy in c:\anaconda3\lib\site-packages (from torch) (1.10.1)
         Requirement already satisfied: filelock in c:\anaconda3\lib\site-packages (from torch) (3.6.0)
         Requirement already satisfied: networkx in c:\anaconda3\lib\site-packages (from torch) (2.8.4)
         Requirement already satisfied: typing-extensions in c:\anaconda3\lib\site-packages (from torch) (4.3.
         0)
         Requirement already satisfied: jinja2 in c:\anaconda3\lib\site-packages (from torch) (2.11.3)
         Requirement already satisfied: MarkupSafe>=0.23 in c:\anaconda3\lib\site-packages (from jinja2->torc
         h) (2.0.1)
         Requirement already satisfied: mpmath>=0.19 in c:\anaconda3\lib\site-packages (from sympy->torch) (1.
         2.1)
```

```
In [22]: from __future__ import print_function
         import torch
         import torch.nn as nn
         import torch.nn.functional as F
         from torch.autograd import variable
```

```
In [24]: !pip install torchvision

         Collecting torchvision
           Downloading torchvision-0.15.1-cp39-cp39-win_amd64.whl (1.2 MB)
              ---------------------------------------- 1.2/1.2 MB 1.5 MB/s eta 0:00:00
         Requirement already satisfied: torch==2.0.0 in c:\anaconda3\lib\site-packages (from torchvision) (2.
         0.0)
         Requirement already satisfied: requests in c:\anaconda3\lib\site-packages (from torchvision) (2.28.1)
         Requirement already satisfied: numpy in c:\anaconda3\lib\site-packages (from torchvision) (1.21.5)
         Requirement already satisfied: pillow!=8.3.*,>=5.3.0 in c:\anaconda3\lib\site-packages (from torchvis
         ion) (9.2.0)
         Requirement already satisfied: filelock in c:\anaconda3\lib\site-packages (from torch==2.0.0->torchvi
         sion) (3.6.0)
         Requirement already satisfied: typing-extensions in c:\anaconda3\lib\site-packages (from torch==2.0.0
```



```
In [25]: from torchvision import datasets, transforms
         mnist = datasets.MNIST(root='.', train=True, download=True)

         Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz
         Downloading http://yann.lecun.com/exdb/mnist/train-images-idx3-ubyte.gz to .\MNIST\raw\train-images-i
         dx3-ubyte.gz

         100%|██████████| 9912422/9912422 [00:06<00:00, 1493800.13it/s]

         Extracting .\MNIST\raw\train-images-idx3-ubyte.gz to .\MNIST\raw

         Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz
         Downloading http://yann.lecun.com/exdb/mnist/train-labels-idx1-ubyte.gz to .\MNIST\raw\train-labels-i
         dx1-ubyte.gz

         100%|██████████| 28881/28881 [00:00<00:00, 28903768.51it/s]

         Extracting .\MNIST\raw\train-labels-idx1-ubyte.gz to .\MNIST\raw

         Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz
         Downloading http://yann.lecun.com/exdb/mnist/t10k-images-idx3-ubyte.gz to .\MNIST\raw\t10k-images-idx
         3-ubyte.gz

         100%|██████████| 1648877/1648877 [00:00<00:00, 1836942.84it/s]

         Extracting .\MNIST\raw\t10k-images-idx3-ubyte.gz to .\MNIST\raw

         Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz
         Downloading http://yann.lecun.com/exdb/mnist/t10k-labels-idx1-ubyte.gz to .\MNIST\raw\t10k-labels-idx
         1-ubyte.gz

         100%|██████████| 4542/4542 [00:00<?, ?it/s]

         Extracting .\MNIST\raw\t10k-labels-idx1-ubyte.gz to .\MNIST\raw
```



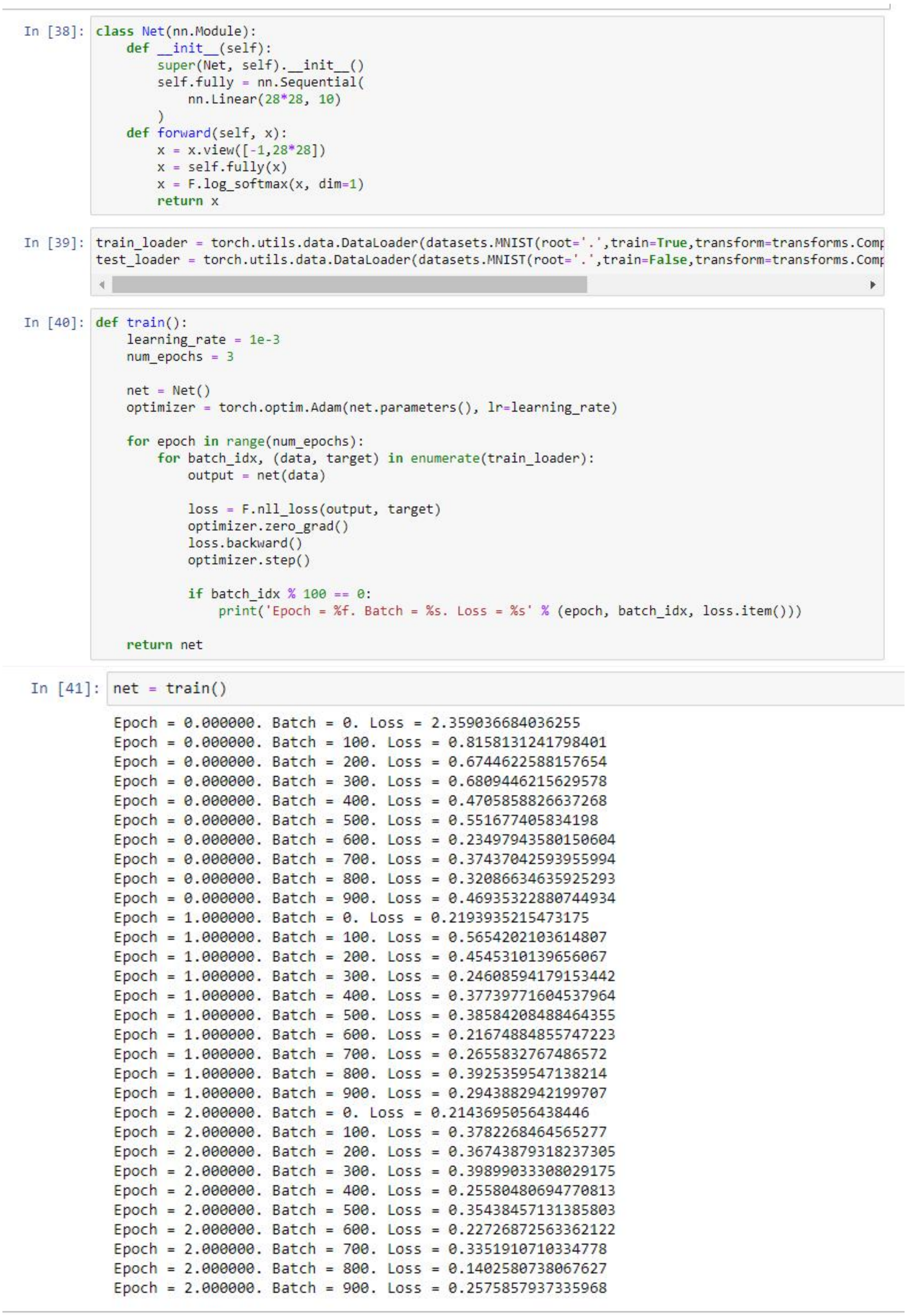
```
In [26]: print("Number of training example", mnist.train_data.shape)
         print("Image information", mnist[0])
```

```
Number of training example torch.Size([60000, 28, 28])
Image information (<PIL.Image.Image image mode=L size=28x28 at 0x17037AF8C40>, 5)
```

```
C:\anaconda3\lib\site-packages\torchvision\datasets\mnist.py:75: UserWarning: train_data has been ren
amed data
  warnings.warn("train_data has been renamed data")
```

```
In [27]: import matplotlib.pyplot as plt
         %matplotlib inline
         plt.imshow(mnist[0][0])
```

```
Out[27]: <matplotlib.image.AxesImage at 0x1703b139340>
```



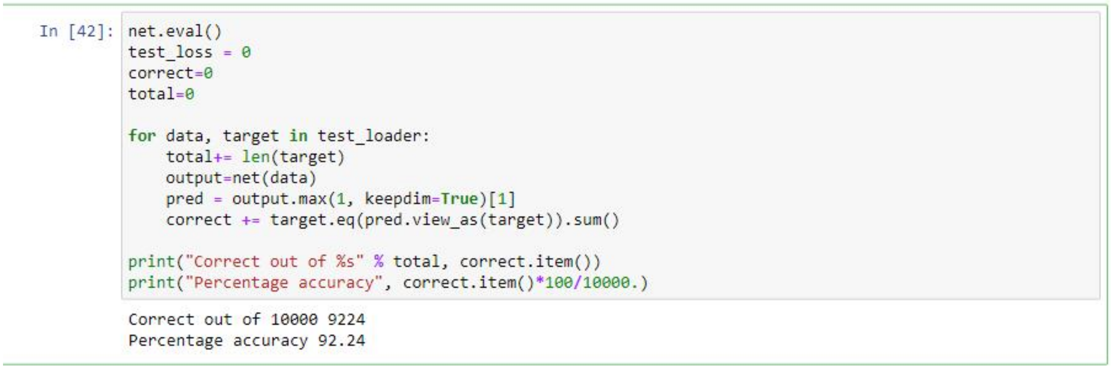
```
In [38]: class Net(nn.Module):
             def __init__(self):
                 super(Net, self).__init__()
                 self.fully = nn.Sequential(
                     nn.Linear(28*28, 10)
                 )
             def forward(self, x):
                 x = x.view([-1,28*28])
                 x = self.fully(x)
                 x = F.log_softmax(x, dim=1)
                 return x
```

```
In [39]: train_loader = torch.utils.data.DataLoader(datasets.MNIST(root='.',train=True,transform=transforms.Comp
         test_loader = torch.utils.data.DataLoader(datasets.MNIST(root='.',train=False,transform=transforms.Comp
```

```
In [40]: def train():
             learning_rate = 1e-3
             num_epochs = 3

             net = Net()
             optimizer = torch.optim.Adam(net.parameters(), lr=learning_rate)

             for epoch in range(num_epochs):
                 for batch_idx, (data, target) in enumerate(train_loader):
                     output = net(data)

                     loss = F.nll_loss(output, target)
                     optimizer.zero_grad()
                     loss.backward()
                     optimizer.step()

                     if batch_idx % 100 == 0:
                         print('Epoch = %f. Batch = %s. Loss = %s' % (epoch, batch_idx, loss.item()))

             return net
```

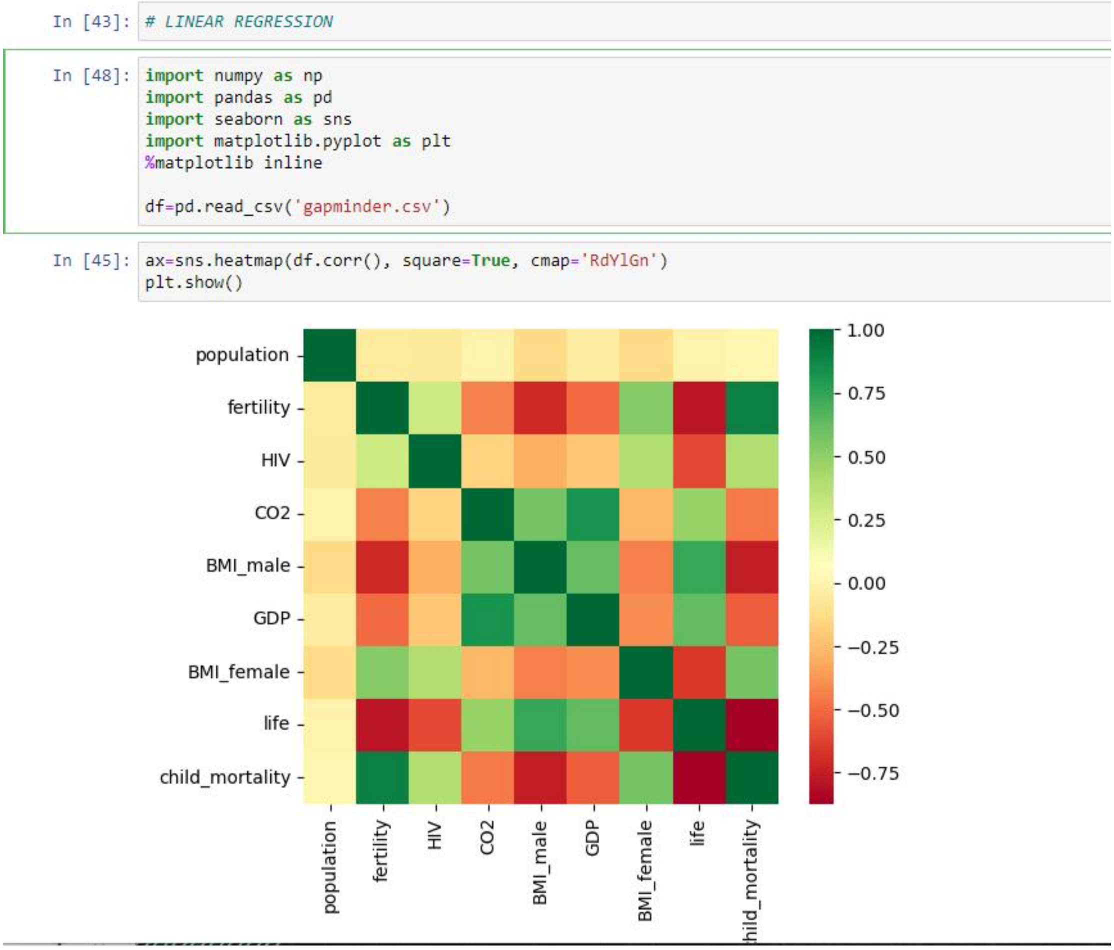
```
In [41]: net = train()
```

```
Epoch = 0.000000. Batch = 0. Loss = 2.359036684036255
Epoch = 0.000000. Batch = 100. Loss = 0.815813124179840l
Epoch = 0.000000. Batch = 200. Loss = 0.6744622588157654
Epoch = 0.000000. Batch = 300. Loss = 0.6809446215629578
Epoch = 0.000000. Batch = 400. Loss = 0.4705858826637268
Epoch = 0.000000. Batch = 500. Loss = 0.551677405834198
Epoch = 0.000000. Batch = 600. Loss = 0.23497943580150604
Epoch = 0.000000. Batch = 700. Loss = 0.37437042593955994
Epoch = 0.000000. Batch = 800. Loss = 0.32086634635925293
Epoch = 0.000000. Batch = 900. Loss = 0.46935322880744934
Epoch = 1.000000. Batch = 0. Loss = 0.2193935215473175
Epoch = 1.000000. Batch = 100. Loss = 0.5654202103614807
Epoch = 1.000000. Batch = 200. Loss = 0.4545310139656067
Epoch = 1.000000. Batch = 300. Loss = 0.24608594179153442
Epoch = 1.000000. Batch = 400. Loss = 0.37739771604537964
Epoch = 1.000000. Batch = 500. Loss = 0.38584208488464355
Epoch = 1.000000. Batch = 600. Loss = 0.21674884855747223
Epoch = 1.000000. Batch = 700. Loss = 0.2655832767486572
Epoch = 1.000000. Batch = 800. Loss = 0.3925359547138214
Epoch = 1.000000. Batch = 900. Loss = 0.2943882942199707
Epoch = 2.000000. Batch = 0. Loss = 0.2143695056438446
Epoch = 2.000000. Batch = 100. Loss = 0.3782268464565277
Epoch = 2.000000. Batch = 200. Loss = 0.36743879318237305
Epoch = 2.000000. Batch = 300. Loss = 0.39899033308029175
Epoch = 2.000000. Batch = 400. Loss = 0.25580480694770813
Epoch = 2.000000. Batch = 500. Loss = 0.35438457131385803
Epoch = 2.000000. Batch = 600. Loss = 0.22726872563362122
Epoch = 2.000000. Batch = 700. Loss = 0.3351910710334778
Epoch = 2.000000. Batch = 800. Loss = 0.1402580738067627
Epoch = 2.000000. Batch = 900. Loss = 0.2575857937335968
```



```
In [42]: net.eval()
         test_loss = 0
         correct=0
         total=0

         for data, target in test_loader:
             total+= len(target)
             output=net(data)
             pred = output.max(1, keepdim=True)[1]
             correct += target.eq(pred.view_as(target)).sum()

         print("Correct out of %s" % total, correct.item())
         print("Percentage accuracy", correct.item()*100/10000.)
```

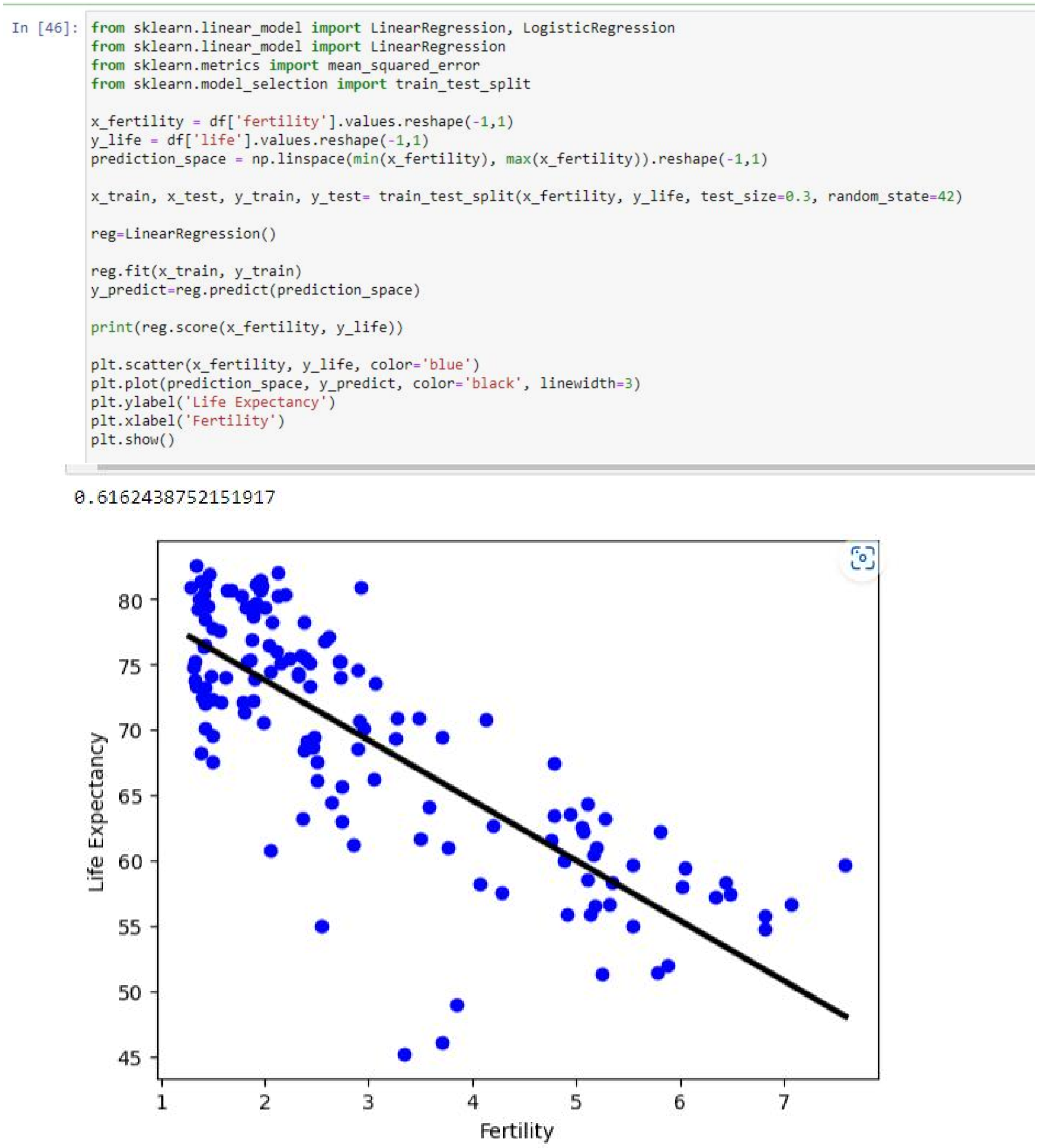
```
Correct out of 10000 9224
Percentage accuracy 92.24
```



```
In [43]: # LINEAR REGRESSION
```

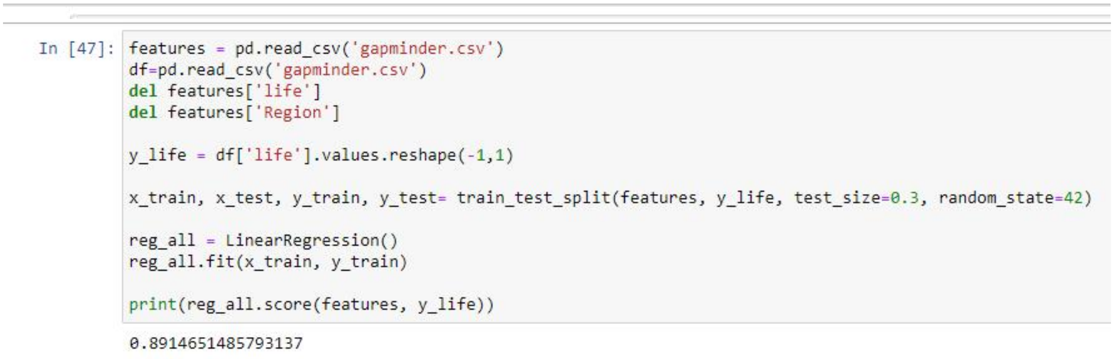
```
In [48]: import numpy as np
         import pandas as pd
         import seaborn as sns
         import matplotlib.pyplot as plt
         %matplotlib inline

         df=pd.read_csv('gapminder.csv')
```

```
In [45]: ax=sns.heatmap(df.corr(), square=True, cmap='RdYlGn')
         plt.show()
```



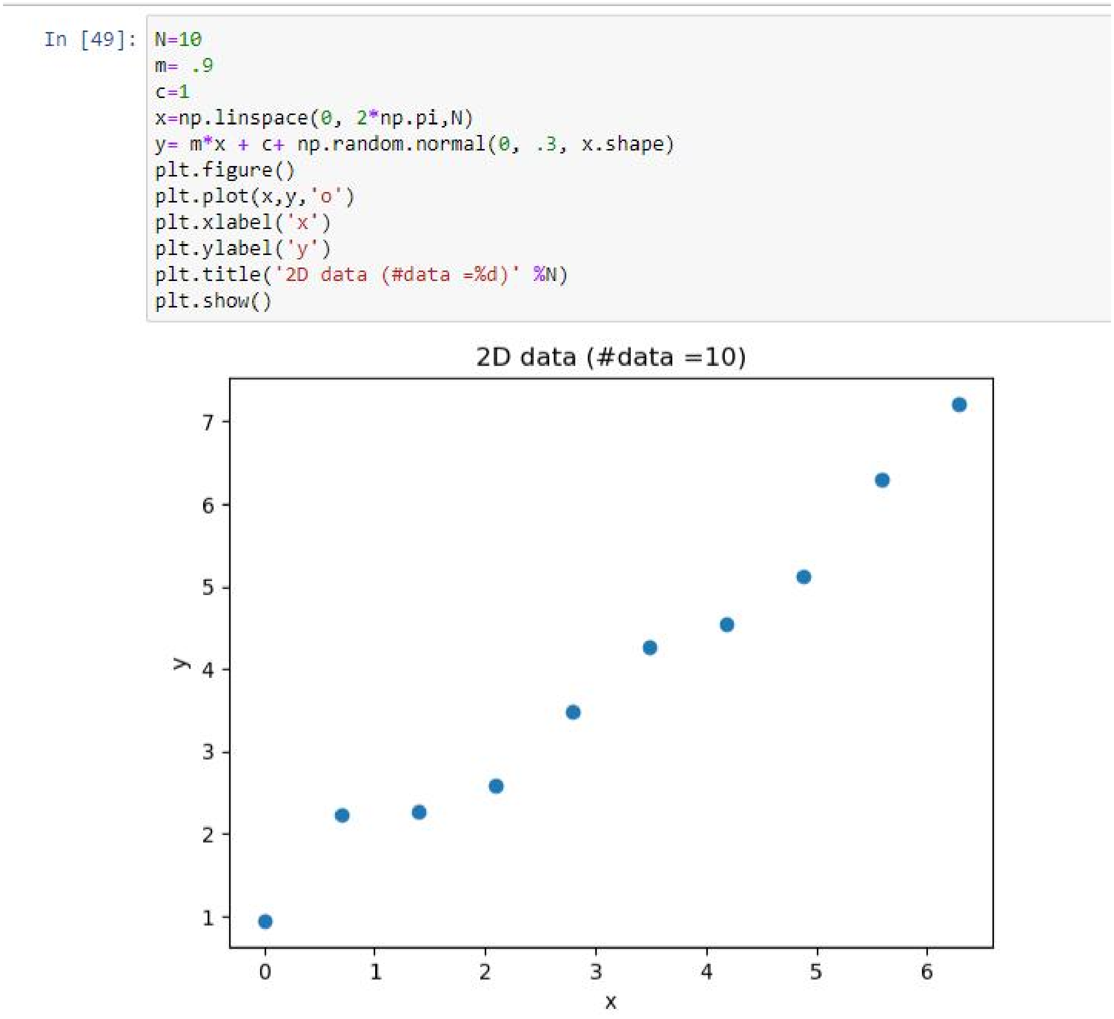
In [46]:
```
from sklearn.linear_model import LinearRegression, LogisticRegression
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error
from sklearn.model_selection import train_test_split

x_fertility = df['fertility'].values.reshape(-1,1)
y_life = df['life'].values.reshape(-1,1)
prediction_space = np.linspace(min(x_fertility), max(x_fertility)).reshape(-1,1)

x_train, x_test, y_train, y_test= train_test_split(x_fertility, y_life, test_size=0.3, random_state=42)

reg=LinearRegression()

reg.fit(x_train, y_train)
y_predict=reg.predict(prediction_space)

print(reg.score(x_fertility, y_life))

plt.scatter(x_fertility, y_life, color='blue')
plt.plot(prediction_space, y_predict, color='black', linewidth=3)
plt.ylabel('Life Expectancy')
plt.xlabel('Fertility')
plt.show()
```

```
0.6162438752151917
```



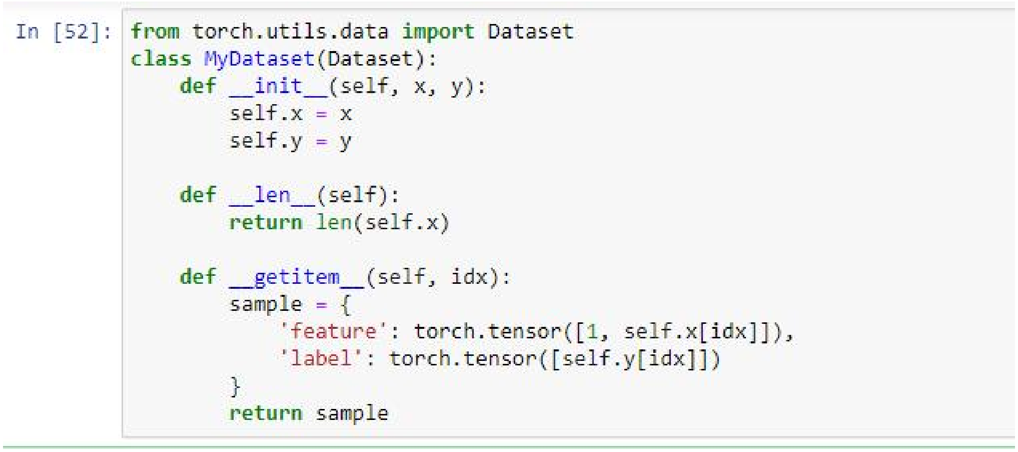
In [47]:
```
features = pd.read_csv('gapminder.csv')
df=pd.read_csv('gapminder.csv')
del features['life']
del features['Region']

y_life = df['life'].values.reshape(-1,1)

x_train, x_test, y_train, y_test= train_test_split(features, y_life, test_size=0.3, random_state=42)

reg_all = LinearRegression()
reg_all.fit(x_train, y_train)

print(reg_all.score(features, y_life))
```

```
0.8914651485793137
```

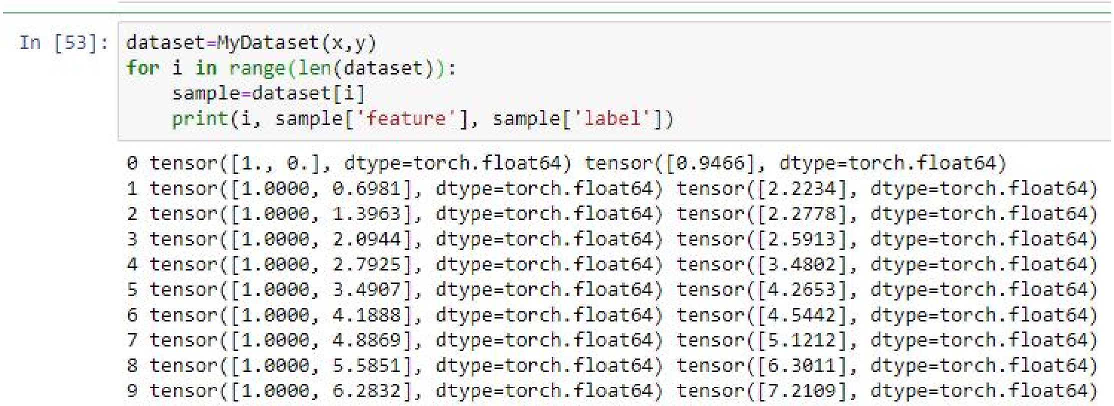


```
In [49]: N=10
         m= .9
         c=1
         x=np.linspace(0, 2*np.pi,N)
         y= m*x + c+ np.random.normal(0, .3, x.shape)
         plt.figure()
         plt.plot(x,y,'o')
         plt.xlabel('x')
         plt.ylabel('y')
         plt.title('2D data (#data =%d)' %N)
         plt.show()
```

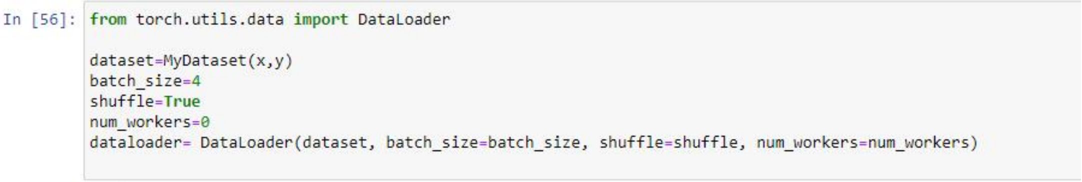
2D data (#data =10)



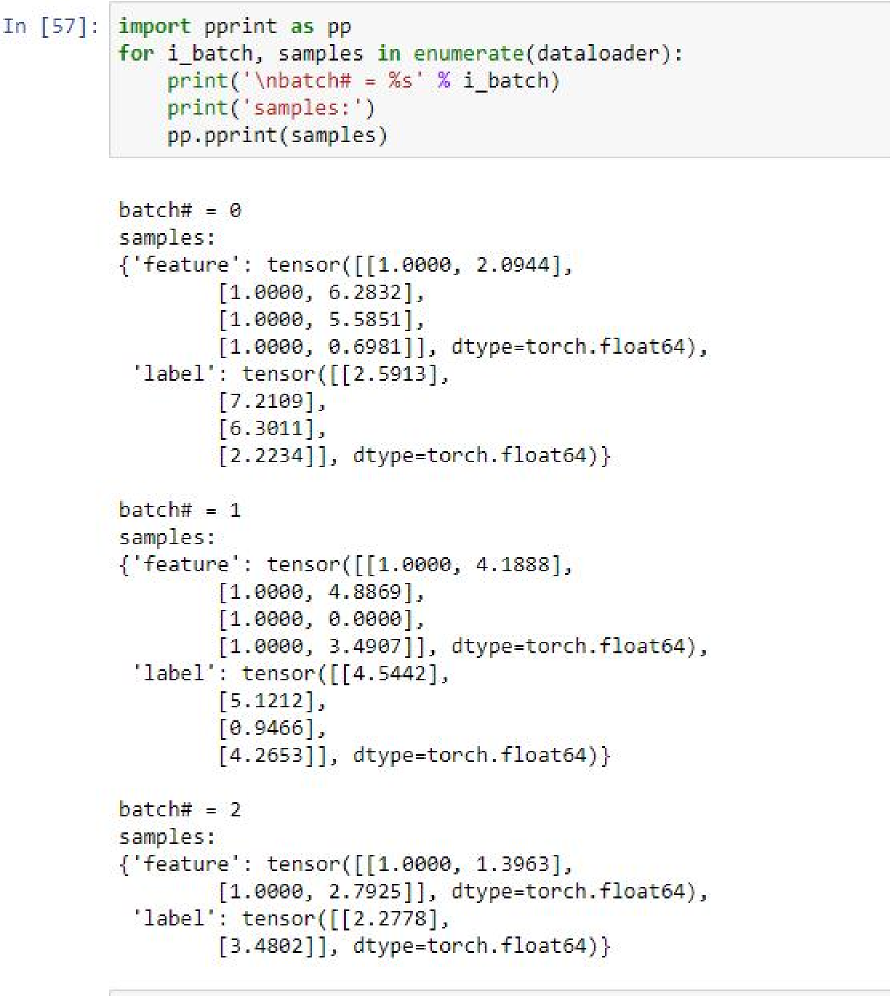
```
In [52]: from torch.utils.data import Dataset
         class MyDataset(Dataset):
             def __init__(self, x, y):
                 self.x = x
                 self.y = y

             def __len__(self):
                 return len(self.x)

             def __getitem__(self, idx):
                 sample = {
                     'feature': torch.tensor([1, self.x[idx]]),
                     'label': torch.tensor([self.y[idx]])
                 }
                 return sample
```



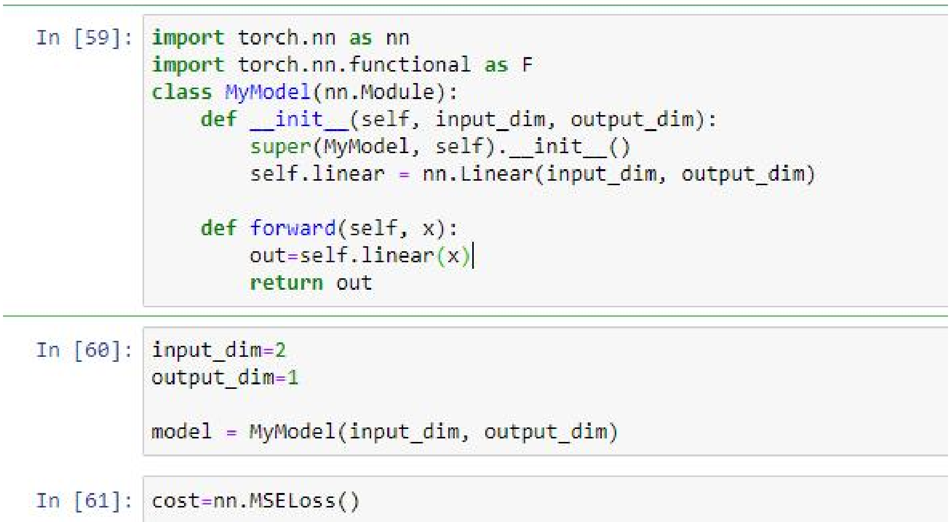
```
In [53]: dataset=MyDataset(x,y)
         for i in range(len(dataset)):
             sample=dataset[i]
             print(i, sample['feature'], sample['label'])

         0 tensor([1., 0.], dtype=torch.float64) tensor([0.9466], dtype=torch.float64)
         1 tensor([1.0000, 0.6981], dtype=torch.float64) tensor([2.2234], dtype=torch.float64)
         2 tensor([1.0000, 1.3963], dtype=torch.float64) tensor([2.2778], dtype=torch.float64)
         3 tensor([1.0000, 2.0944], dtype=torch.float64) tensor([2.5913], dtype=torch.float64)
         4 tensor([1.0000, 2.7925], dtype=torch.float64) tensor([3.4802], dtype=torch.float64)
         5 tensor([1.0000, 3.4907], dtype=torch.float64) tensor([4.2653], dtype=torch.float64)
         6 tensor([1.0000, 4.1888], dtype=torch.float64) tensor([4.5442], dtype=torch.float64)
         7 tensor([1.0000, 4.8869], dtype=torch.float64) tensor([5.1212], dtype=torch.float64)
         8 tensor([1.0000, 5.5851], dtype=torch.float64) tensor([6.3011], dtype=torch.float64)
         9 tensor([1.0000, 6.2832], dtype=torch.float64) tensor([7.2109], dtype=torch.float64)
```



```
In [56]: from torch.utils.data import DataLoader

         dataset=MyDataset(x,y)
         batch_size=4
         shuffle=True
         num_workers=0
         dataloader= DataLoader(dataset, batch_size=batch_size, shuffle=shuffle, num_workers=num_workers)
```



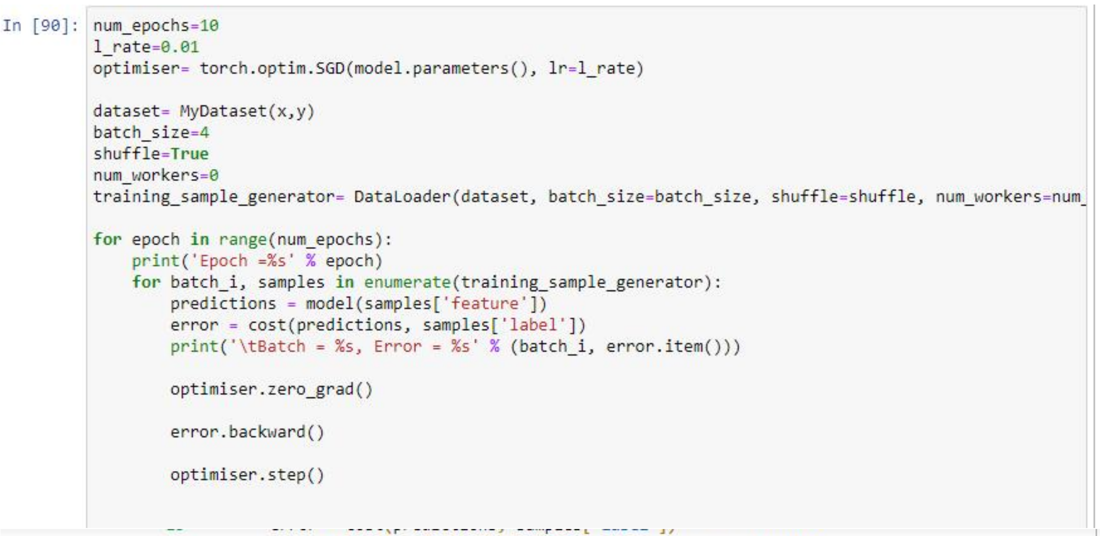
```
In [57]: import pprint as pp
         for i_batch, samples in enumerate(dataloader):
             print('\nbatch# = %s' % i_batch)
             print('samples:')
             pp.pprint(samples)


         batch# = 0
         samples:
         {'feature': tensor([[1.0000, 2.0944],
                 [1.0000, 6.2832],
                 [1.0000, 5.5851],
                 [1.0000, 0.6981]], dtype=torch.float64),
          'label': tensor([[2.5913],
                 [7.2109],
                 [6.3011],
                 [2.2234]], dtype=torch.float64)}

         batch# = 1
         samples:
         {'feature': tensor([[1.0000, 4.1888],
                 [1.0000, 4.8869],
                 [1.0000, 0.0000],
                 [1.0000, 3.4907]], dtype=torch.float64),
          'label': tensor([[4.5442],
                 [5.1212],
                 [0.9466],
                 [4.2653]], dtype=torch.float64)}

         batch# = 2
         samples:
         {'feature': tensor([[1.0000, 1.3963],
                 [1.0000, 2.7925]], dtype=torch.float64),
          'label': tensor([[2.2778],
                 [3.4802]], dtype=torch.float64)}
```



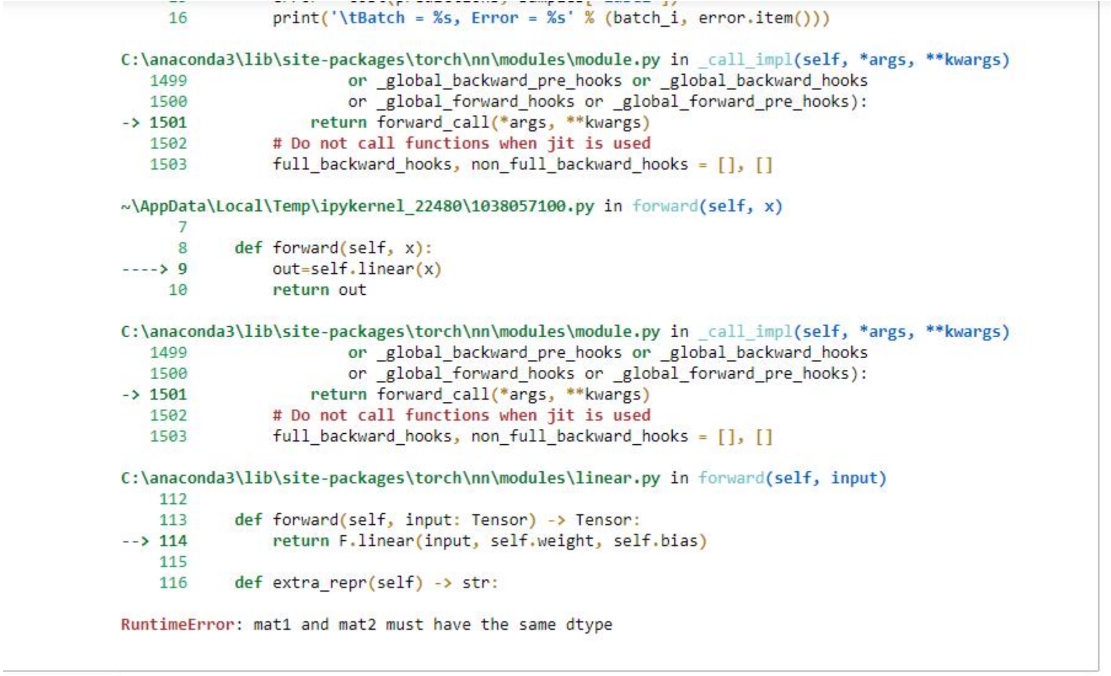
```
In [59]: import torch.nn as nn
         import torch.nn.functional as F
         class MyModel(nn.Module):
             def __init__(self, input_dim, output_dim):
                 super(MyModel, self).__init__()
                 self.linear = nn.Linear(input_dim, output_dim)

             def forward(self, x):
                 out=self.linear(x)
                 return out
```

```
In [60]: input_dim=2
         output_dim=1

         model = MyModel(input_dim, output_dim)
```

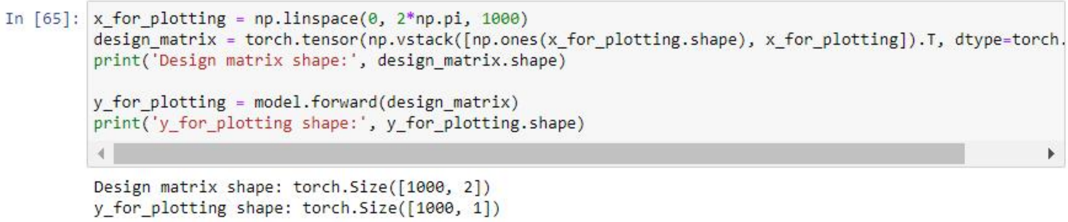
```
In [61]: cost=nn.MSELoss()
```



```
In [90]: num_epochs=10
         l_rate=0.01
         optimiser= torch.optim.SGD(model.parameters(), lr=l_rate)

         dataset= MyDataset(x,y)
         batch_size=4
         shuffle=True
         num_workers=0
         training_sample_generator= DataLoader(dataset, batch_size=batch_size, shuffle=shuffle, num_workers=num_

         for epoch in range(num_epochs):
             print('Epoch =%s' % epoch)
             for batch_i, samples in enumerate(training_sample_generator):
                 predictions = model(samples['feature'])
                 error = cost(predictions, samples['label'])
                 print('\tBatch = %s, Error = %s' % (batch_i, error.item()))

                 optimiser.zero_grad()

                 error.backward()

                 optimiser.step()
```

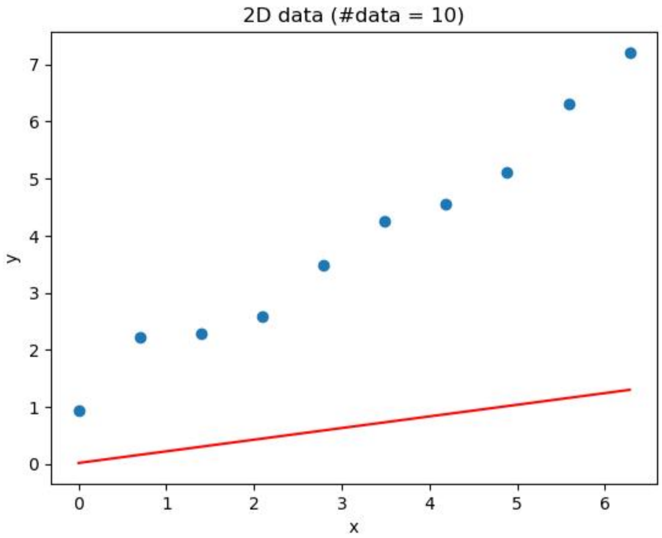


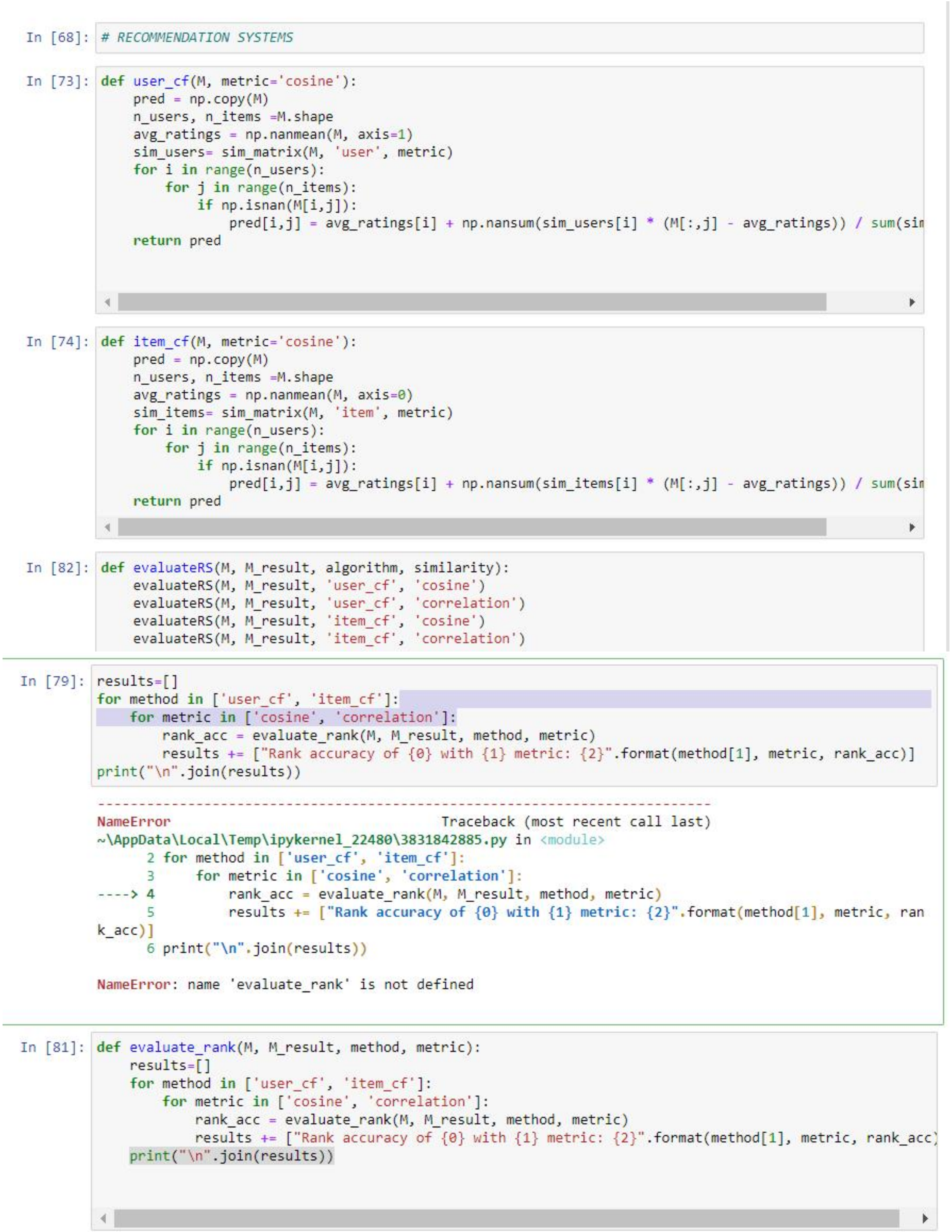
```
     16         print('\tBatch = %s, Error = %s' % (batch_i, error.item()))

C:\anaconda3\lib\site-packages\torch\nn\modules\module.py in _call_impl(self, *args, **kwargs)
   1499                 or _global_backward_pre_hooks or _global_backward_hooks
   1500                 or _global_forward_hooks or _global_forward_pre_hooks):
-> 1501             return forward_call(*args, **kwargs)
   1502         # Do not call functions when jit is used
   1503         full_backward_hooks, non_full_backward_hooks = [], []

~\AppData\Local\Temp\ipykernel_22480\1038057100.py in forward(self, x)
      7
      8     def forward(self, x):
----> 9         out=self.linear(x)
     10         return out

C:\anaconda3\lib\site-packages\torch\nn\modules\module.py in _call_impl(self, *args, **kwargs)
   1499                 or _global_backward_pre_hooks or _global_backward_hooks
   1500                 or _global_forward_hooks or _global_forward_pre_hooks):
-> 1501             return forward_call(*args, **kwargs)
   1502         # Do not call functions when jit is used
   1503         full_backward_hooks, non_full_backward_hooks = [], []

C:\anaconda3\lib\site-packages\torch\nn\modules\linear.py in forward(self, input)
    112
    113     def forward(self, input: Tensor) -> Tensor:
--> 114         return F.linear(input, self.weight, self.bias)
    115
    116     def extra_repr(self) -> str:

RuntimeError: mat1 and mat2 must have the same dtype
```



```
In [65]: x_for_plotting = np.linspace(0, 2*np.pi, 1000)
         design_matrix = torch.tensor(np.vstack([np.ones(x_for_plotting.shape), x_for_plotting]).T, dtype=torch.
         print('Design matrix shape:', design_matrix.shape)

         y_for_plotting = model.forward(design_matrix)
         print('y_for_plotting shape:', y_for_plotting.shape)

         Design matrix shape: torch.Size([1000, 2])
         y_for_plotting shape: torch.Size([1000, 1])
```

In [66]:
```
plt.figure()
plt.plot(x,y,'o')
plt.plot(x_for_plotting, y_for_plotting.data.numpy(), 'r-')
plt.xlabel('x')
plt.ylabel('y')
plt.title('2D data (#data = %d)' % N)
plt.show()
```





```
In [68]: # RECOMMENDATION SYSTEMS
```

```
In [73]: def user_cf(M, metric='cosine'):
             pred = np.copy(M)
             n_users, n_items =M.shape
             avg_ratings = np.nanmean(M, axis=1)
             sim_users= sim_matrix(M, 'user', metric)
             for i in range(n_users):
                 for j in range(n_items):
                     if np.isnan(M[i,j]):
                         pred[i,j] = avg_ratings[i] + np.nansum(sim_users[i] * (M[:,j] - avg_ratings)) / sum(sim
             return pred
```

```
In [74]: def item_cf(M, metric='cosine'):
             pred = np.copy(M)
             n_users, n_items =M.shape
             avg_ratings = np.nanmean(M, axis=0)
             sim_items= sim_matrix(M, 'item', metric)
             for i in range(n_users):
                 for j in range(n_items):
                     if np.isnan(M[i,j]):
                         pred[i,j] = avg_ratings[i] + np.nansum(sim_items[i] * (M[:,j] - avg_ratings)) / sum(sim
             return pred
```

```
In [82]: def evaluateRS(M, M_result, algorithm, similarity):
             evaluateRS(M, M_result, 'user_cf', 'cosine')
             evaluateRS(M, M_result, 'user_cf', 'correlation')
             evaluateRS(M, M_result, 'item_cf', 'cosine')
             evaluateRS(M, M_result, 'item_cf', 'correlation')
```

```
In [79]: results=[]
         for method in ['user_cf', 'item_cf']:
             for metric in ['cosine', 'correlation']:
                 rank_acc = evaluate_rank(M, M_result, method, metric)
                 results += ["Rank accuracy of {0} with {1} metric: {2}".format(method[1], metric, rank_acc)]
         print("\n".join(results))

         ---------------------------------------------------------------------------
         NameError                                 Traceback (most recent call last)
         ~\AppData\Local\Temp\ipykernel_22480\3831842885.py in <module>
               2 for method in ['user_cf', 'item_cf']:
               3     for metric in ['cosine', 'correlation']:
         ----> 4         rank_acc = evaluate_rank(M, M_result, method, metric)
               5         results += ["Rank accuracy of {0} with {1} metric: {2}".format(method[1], metric, ran
         k_acc)]
               6 print("\n".join(results))

         NameError: name 'evaluate_rank' is not defined
```

```
In [81]: def evaluate_rank(M, M_result, method, metric):
             results=[]
             for method in ['user_cf', 'item_cf']:
                 for metric in ['cosine', 'correlation']:
                     rank_acc = evaluate_rank(M, M_result, method, metric)
                     results += ["Rank accuracy of {0} with {1} metric: {2}".format(method[1], metric, rank_acc)
             print("\n".join(results))
```