1번 대한민국 육국 신체 측정 데이터 [몸무게->허리둘레예측]

In [250]:

```
import numpy as np
import matplotlib.pyplot as plt
import torch
import torch.nn as nn
import torch.optim as optim
import torch.nn.init as init
import torchvision.datasets as dset
import torchvision.transforms as transforms
from torch.utils.data import DataLoader
```

In [251]:

```
f = open('./armybody.csv', "r", newline='₩r')
data = f.readline()

lines = data.split('₩n')
header = lines[0].split(',')
print(header)

data = []
while 1:
    line = f.readline()
    data.append(line)
    if not line: break
f.close()
```

```
['순번', '측정 일자', '가슴 둘레 센티미터', '소매길이 센티미터', '신장 센티미터',
'허리 둘레 센티미터', '샅높이 센티미터', '머리 둘레 센티미터', '발 길이 센티미터',
'몸무게 킬로그램₩r']
```

In [252]:

```
data = np.array(data)
print(data.shape)
```

```
(135672,)
```

In [253]:

```
print(data[108400])
sample = data[108400].strip('₩n').split(',')
print(sample)
print(len(sample))
```

```
108401,20160307,,85.9,171.3,91.7,79,57.1,25.2,69.5
['108401', '20160307', '', '85.9', '171.3', '91.7', '79', '57.1', '25.2', '69.5
₩r']
10
```

In [254]:

```
new_data = []
for i in range(0, len(data)):
    seq = data[i].strip().split(',')
    if not len(seq)==10:
        print(i)
    if i==108400:
        continue
    if len(seq)==10:
        new_data.append(seq)
df = np.array(new_data, 'float')
```

```
135670
135671
```

In [255]:

```
print(data[135670])
```

1-1 데이터 세트의 차원 형태(dimension shape)를 출력해 보세요.

In [348]:

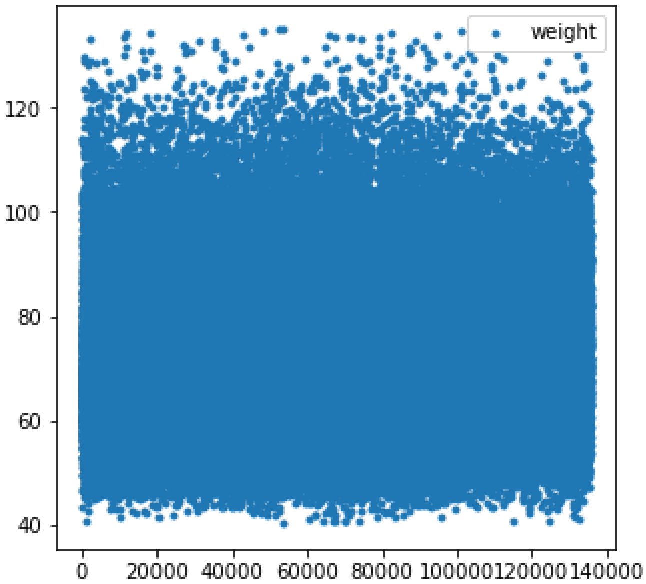
```
print(df.shape)
print('결측치가 있는 108400데이터와, 읽어지지 않는 135670두개의 데이터를 제외한 결과입니다.')
```

```
(135669, 10)
결측치가 있는 108400데이터와, 읽어지지 않는 135670두개의 데이터를 제외한 결과입니
다.
```

1-2 2차원 평면에 몸무게와 허리둘레 데이터 포인트들을 가시화 해보세요.

In [257]:

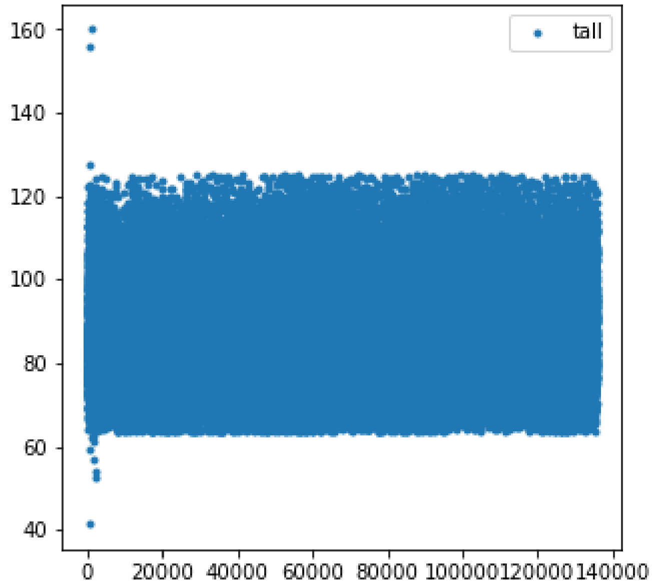
```
plt.plot(df[:,-1], '.')
plt.legend(['weight'])
plt.figure(figsize=(10,15))
plt.show()
```



<Figure size 720x1080 with 0 Axes>

In [258]:

```
plt.plot(df[:,5], '.')
plt.legend(['tall'])
plt.figure(figsize=(10,15))
plt.show()
```




```
<Figure size 720x1080 with 0 Axes>
```

1-3 데이터 세트 중 100000개를 학습 세트로 하고 나머지를 테스트 세트로 나누고 각 세트의 마지막 데이터를 출력해 보세요.

In [259]:

```
trainX = df[:100000, -1].reshape(-1,1)
trainY = df[:100000, 5].reshape(-1,1)
testX = df[100000:, -1].reshape(-1,1)
testY = df[100000:, 5].reshape(-1,1)
print(trainX.shape)
print(trainY.shape)
print(testX.shape)
print(testY.shape)
```

```
(100000, 1)
(100000, 1)
(35669, 1)
(35669, 1)
```

In [260]:

```
print(trainX[-1], trainY[-1])
print(testX[-1], testY[-1])
```

```
[65.9] [79.5]
[90.6] [105.9]
```

1-4 선형회귀(linear regression) 모델을 설계하고 학습 모델의 구성하고 각 계층별 요약과 파라미터 수를 출력해 보세요.

In [261]:

```
model = nn.Linear(1,1)

loss_func = nn.L1Loss()
optimizer = optim.SGD(model.parameters(),lr=0.0002)
```

In [262]:

```
print(model)
print(list(model.parameters()))
```

```
Linear(in_features=1, out_features=1, bias=True)
[Parameter containing:
tensor([[-0.9989]], requires_grad=True), Parameter containing:
tensor([0.0727], requires_grad=True)]
```

1-5 에포크를 1000, 학습률 0.001로 튜닝하고 테스트 데이터로 에포크별 MAE(mean absolute error) 손실을 평가하여 그래프로 그려보세요.

In [263]:

```
num_epoch = 1000
```

In [264]:

```
trainX_tensor = torch.FloatTensor(trainX)
trainY_tensor = torch.FloatTensor(trainY)
testX_tensor = torch.FloatTensor(testX)
testY_tensor = torch.FloatTensor(testY)
```

In [266]:

```
print(trainX_tensor.shape)
print(trainY_tensor.shape)
```

```
torch.Size([100000, 1])
torch.Size([100000, 1])
```

In [267]:

```
loss_arr =[]

for i in range(num_epoch):
    optimizer.zero_grad()
    output = model(trainX_tensor)
    loss = loss_func(output,trainY_tensor)
    loss.backward()

    optimizer.step()

    loss_arr.append(loss.detach().numpy())
```

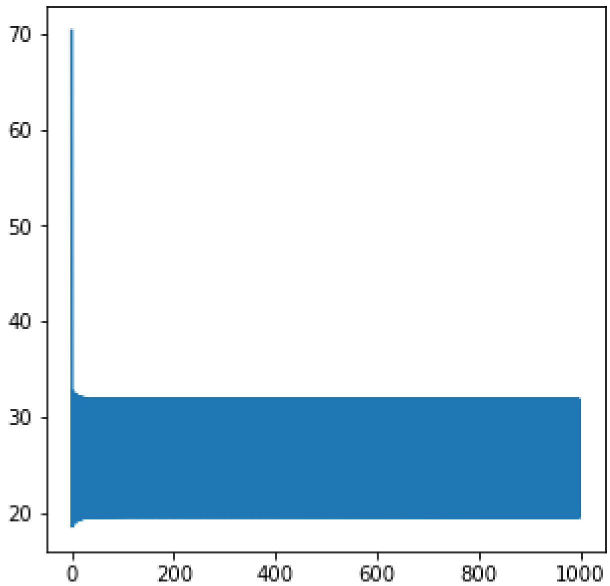
In [172]:

```
print('lr = 0.01')
plt.plot(loss_arr)
```

lr = 0.01

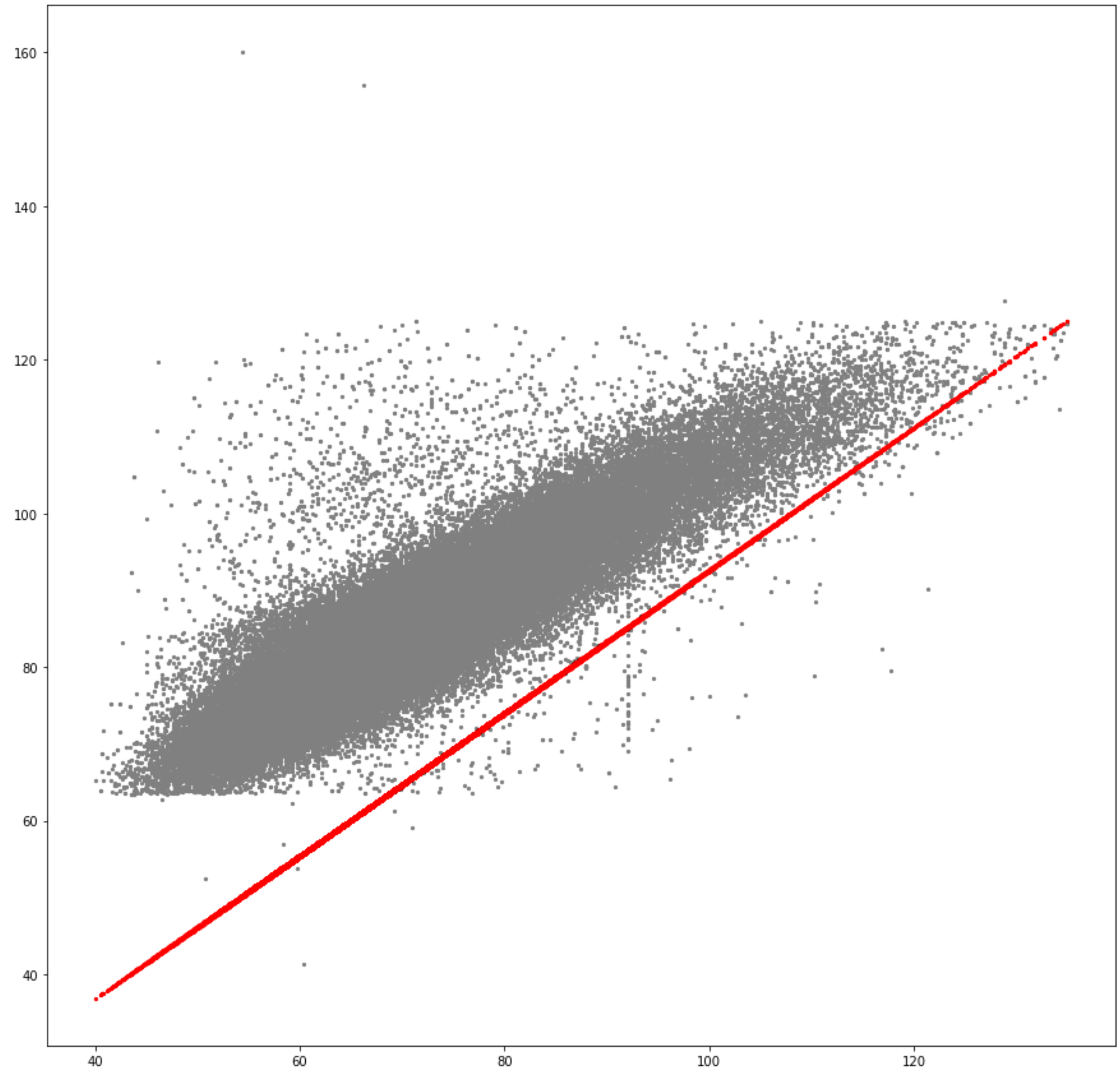
Out[172]:

[<matplotlib.lines.Line2D at 0x26a327667c8>]



In [173]:

```
plt.figure(figsize=(15,15))
plt.scatter(trainX_tensor.numpy(),trainY_tensor.numpy(),s=5,c="gray")
plt.scatter(trainX_tensor.detach().numpy(),output.detach().numpy(),s=5,c="red")
plt.show()
print('lr = 0.01')
```




```
lr = 0.01
```

1-6 손실함수로 MSE(mean squared error)를 사용해도 성능이 잘 나오도록 튜닝해 보세요.

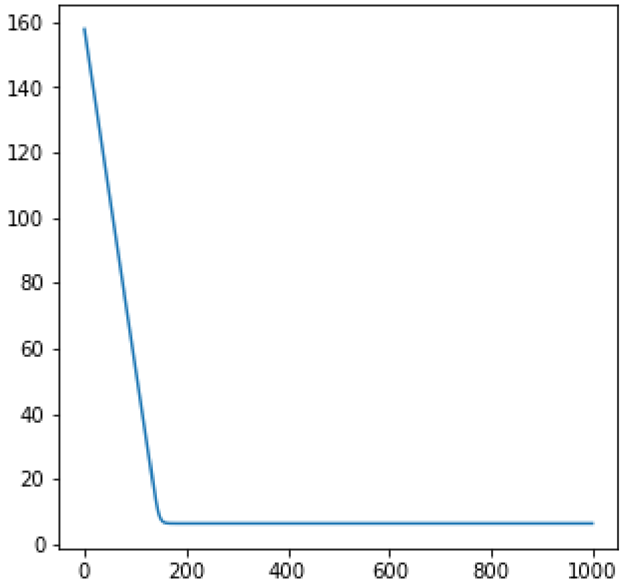
In [268]:

```
print('lr = 0.0002')
plt.plot(loss_arr)
```

```
lr = 0.0002
```

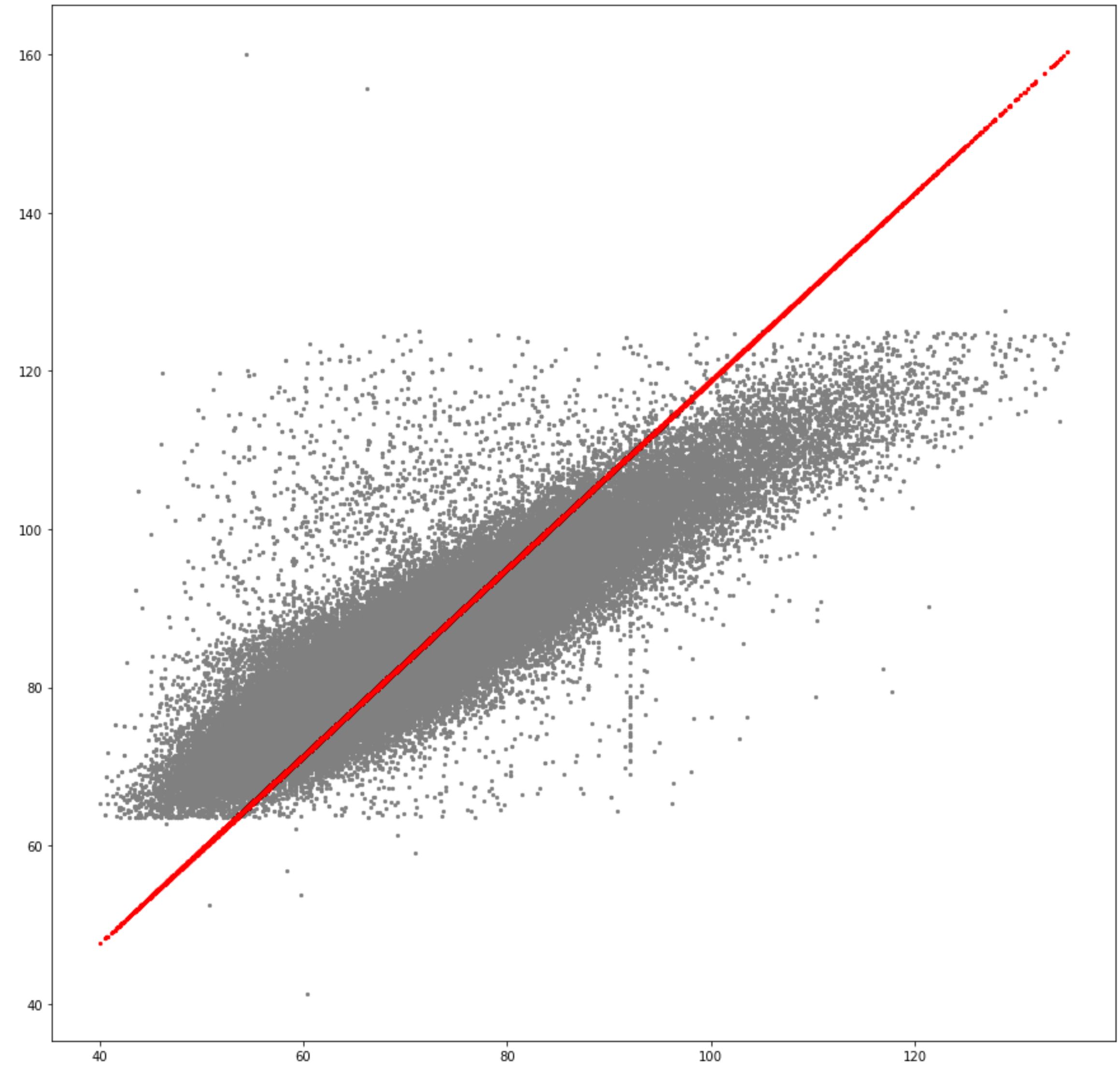
Out[268]:

```
[<matplotlib.lines.Line2D at 0x26a32325308>]
```



In [269]:

```
plt.figure(figsize=(15,15))
plt.scatter(trainX_tensor.numpy(),trainY_tensor.numpy(),s=5,c="gray")
plt.scatter(trainX_tensor.detach().numpy(),output.detach().numpy(),s=5,c="red")
plt.show()
print('lr = 0.0002')
```



lr = 0.0002

2번 인공신경망 설계

In [271]:

```
num_data =1000
```

In [272]:

```
noise = init.normal_(torch.FloatTensor(num_data,1),std=1)
x = init.uniform_(torch.Tensor(num_data,1),-15,15)
y = (x+noise)**3
y_noise = y + noise
```

In [273]:

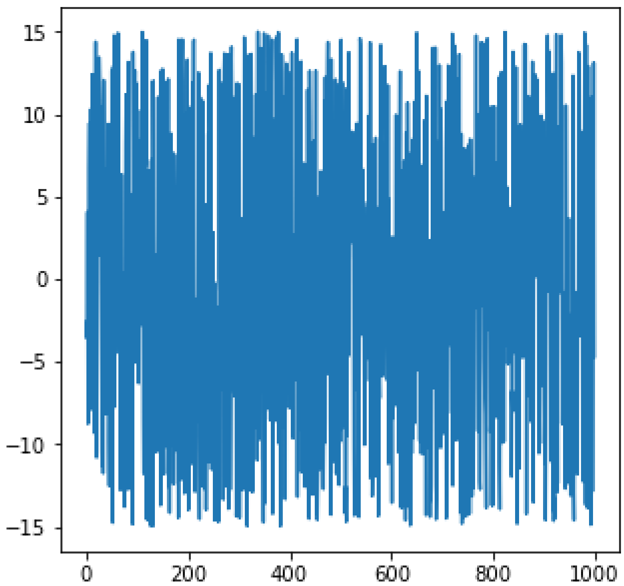
```
print(x.shape)
print(y.shape)
```

```
torch.Size([1000, 1])
torch.Size([1000, 1])
```

2-1 2차원 평면에 x, y 포인트들을 가시화 해보세요.

In [274]:

```
plt.plot(x)
plt.rcParams['figure.figsize'] = [5, 5]
```

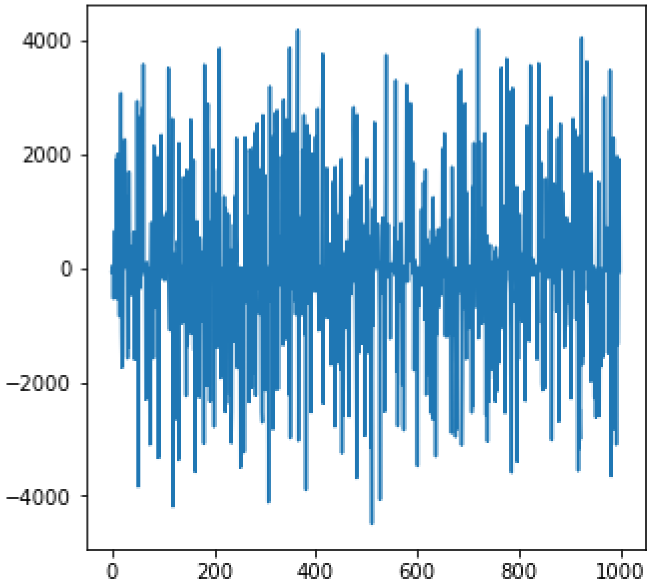


In [275]:

```
plt.plot(y)
```

Out[275]:

```
[<matplotlib.lines.Line2D at 0x26a3236b9c8>]
```

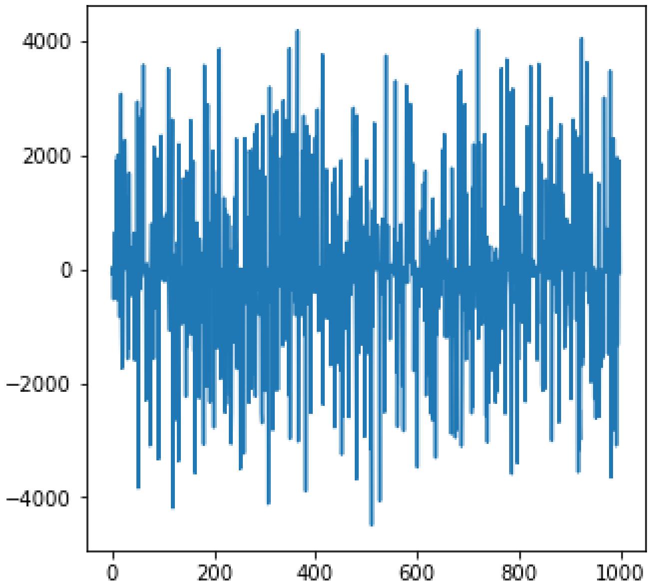


In [276]:

```
plt.plot(y_noise)
```

Out[276]:

```
[<matplotlib.lines.Line2D at 0x26a3270dd08>]
```



2-2 특성의 개수가 1 -> 50 -> 100 -> 1개로 변하는 완전연결 신경망(fully connected neural network) 모델을 설계하고 학습 모델의 구성과 각 계층별 요약과 파라미터 수를 출력해 보세요.

In [279]:

```
model = nn.Sequential(
          nn.Linear(1,50),
          nn.ReLU(),
          nn.Linear(50,100),
          nn.ReLU(),
          nn.Linear(100,1)
      )

loss_func = nn.L1Loss()
optimizer = optim.SGD(model.parameters(),lr=0.0002)
```

In [280]:

```
print(model)
print(list(model.parameters()))
```

```
Sequential(
  (0): Linear(in_features=1, out_features=50, bias=True)
  (1): ReLU()
  (2): Linear(in_features=50, out_features=100, bias=True)
  (3): ReLU()
  (4): Linear(in_features=100, out_features=1, bias=True)
)
[Parameter containing:
tensor([[ 0.6889],
        [ 0.7615],
        [ 0.6350],
        [-0.4935],
        [-0.4293],
        [ 0.3529],
        [ 0.7595],
        [-0.2271],
        [ 0.9399],
        [ 0.7234],
        [ 0.0991],
        [-0.5423],
        [ 0.6210],
        [-0.4160],
        [ 0.9601],
        [-0.9942],
        [-0.3650],
        [-0.0538],
        [-0.8180],
        [-0.9769],
        [ 0.0070],
        [-0.8975],
        [ 0.3065],
        [ 0.3240],
        [ 0.3079],
        [-0.6589],
        [ 0.9711],
        [-0.0983],
        [-0.9970],
        [ 0.9710],
        [-0.5667],
        [-0.9331],
        [ 0.0765],
        [ 0.1807],
        [ 0.3450],
        [-0.0554],
        [-0.0644],
        [-0.8512],
        [ 0.3380],
        [-0.1693],
        [-0.2905],
        [ 0.9146],
        [ 0.3973],
        [-0.6453],
        [ 0.6901],
        [-0.3293],
        [ 0.8313],
        [ 0.1344],
        [ 0.6190],
        [ 0.9309]], requires_grad=True), Parameter containing:
tensor([-0.5251,  0.5015,  0.0624,  0.3049, -0.2317, -0.9087,  0.7586, -0.8024,
         0.4438, -0.1884,  0.4242, -0.4967,  0.5658,  0.4770,  0.7975,  0.4401,
        -0.1686,  0.1154,  0.6465, -0.7017, -0.8131,  0.3066,  0.0422,  0.3200,
```

```
        -0.6791,  0.8217, -0.8211,  0.9654, -0.4926, -0.2379, -0.5888, -0.0942,
         0.6315, -0.9432,  0.6416,  0.6962, -0.3162,  0.4853, -0.5199,  0.8079,
         0.9897,  0.6902, -0.1436,  0.4817,  0.7120,  0.1835, -0.6940,  0.2788,
         0.8105,  0.0650], requires_grad=True), Parameter containing:
tensor([[-0.0787, -0.1330,  0.1355,  ...,  0.1087,  0.0908, -0.1005],
        [-0.0002,  0.0918,  0.1127,  ...,  0.0937,  0.0131, -0.1303],
        [ 0.0391,  0.0369, -0.0379,  ...,  0.1108, -0.0324,  0.0049],
        ...,
        [-0.0035,  0.0577,  0.0776,  ...,  0.1057, -0.1378, -0.0365],
        [-0.0633,  0.0309,  0.0526,  ...,  0.1073,  0.0420,  0.0232],
        [-0.0422, -0.0585, -0.0055,  ...,  0.0775,  0.0400,  0.0221]],
       requires_grad=True), Parameter containing:
tensor([-0.0006,  0.1402,  0.1066,  0.1241,  0.0185,  0.0186, -0.0959,  0.0081,
         0.1276, -0.0492,  0.0037, -0.0925,  0.0648, -0.1283, -0.1132, -0.1107,
        -0.1375, -0.0645,  0.0507, -0.0688, -0.1127, -0.0920,  0.0525, -0.0829,
         0.0938,  0.0929,  0.0968,  0.0782, -0.0266,  0.0435, -0.0250, -0.0797,
         0.1342, -0.0077, -0.0668,  0.0484, -0.0262, -0.0460, -0.0217,  0.0424,
         0.1130, -0.0662, -0.0635,  0.0642,  0.0562,  0.0482,  0.0562, -0.0126,
        -0.1313, -0.0214,  0.0938, -0.0639, -0.1047, -0.0366, -0.0028,  0.0750,
         0.0008, -0.1065,  0.0093, -0.1281, -0.1195, -0.1030,  0.0008,  0.0054,
         0.0262, -0.0561, -0.0947, -0.0783, -0.1224,  0.0658,  0.1200, -0.0677,
         0.0799,  0.0406,  0.0684, -0.0686, -0.0627, -0.1217, -0.0102,  0.1378,
        -0.0376,  0.1311,  0.0383, -0.0797, -0.1366, -0.0459, -0.0757, -0.0447,
         0.0384,  0.1312, -0.0326, -0.0437,  0.1333,  0.0060,  0.1073, -0.0215,
         0.1342, -0.0313,  0.1167,  0.0182], requires_grad=True), Parameter contai
ning:
tensor([[-0.0158,  0.0154,  0.0988,  0.0563, -0.0839,  0.0272, -0.0675, -0.0724,
          0.0723,  0.0676,  0.0457,  0.0771, -0.0267,  0.0652,  0.0566,  0.0068,
         -0.0017, -0.0977, -0.0699,  0.0293,  0.0519, -0.0682, -0.0801,  0.0866,
          0.0755,  0.0634, -0.0221,  0.0875,  0.0704, -0.0089, -0.0407, -0.0885,
          0.0287, -0.0595,  0.0826,  0.0079, -0.0215,  0.0990,  0.0532,  0.0780,
          0.0069, -0.0544, -0.0448,  0.0913, -0.0042, -0.0306, -0.0640,  0.0784,
          0.0686,  0.0259, -0.0096, -0.0479, -0.0552, -0.0730, -0.0385,  0.0438,
          0.0951, -0.0057, -0.0530,  0.0919,  0.0312, -0.0967, -0.0854, -0.0077,
         -0.0077, -0.0765, -0.0798, -0.0568, -0.0083, -0.0715, -0.0411,  0.0969,
          0.0260, -0.0073, -0.0907, -0.0317,  0.0275, -0.0427, -0.0265, -0.0021,
          0.0217,  0.0978,  0.0782,  0.0309, -0.0017, -0.0021, -0.0633,  0.0401,
          0.0056,  0.0760, -0.0089, -0.0556, -0.0041,  0.0086,  0.0156,  0.0504,
          0.0676,  0.0634, -0.0724,  0.0301]], requires_grad=True), Parameter cont
aining:
tensor([-0.0422], requires_grad=True)]
```

2-3 에포크 10000, 학습률 0.0002로 설정하고 에포크별 MAE(mean absolute error) 손실을 평가하여 그래프로 그려보세요.

In [281]:

```
num_epoch = 10000
```

In [282]:

```
loss_array = []
for i in range(num_epoch):
    optimizer.zero_grad()
    output = model(x)

    loss = loss_func(output,y_noise)
    loss.backward()
    optimizer.step()

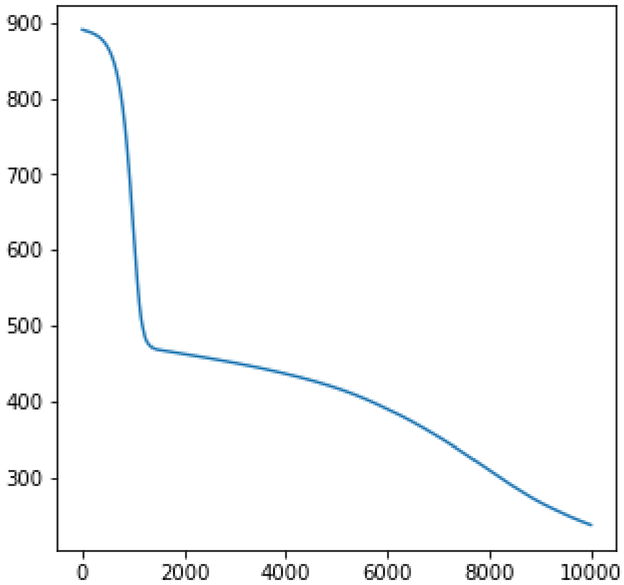
    loss_array.append(loss)
```

In [285]:

```
plt.plot(loss_array)
print('lr=0.0002')
```

```
---------------------------------------------------------------------------
TypeError                                 Traceback (most recent call last)
<ipython-input-285-cb3031b1efda> in <module>
      1 plt.plot(loss_array)
----> 2 print(lr=0.0002)

TypeError: 'lr' is an invalid keyword argument for print()
```



2-4 손실함수로 MSE(mean squared error)를 사용해도 성능이 잘 나오도록 튜닝해 보세요.

In [294]:

```
loss_func = nn.L1Loss()
optimizer = optim.Adam(model.parameters(),lr=0.005)
loss_array = []
for i in range(num_epoch):
    optimizer.zero_grad()
    output = model(x)

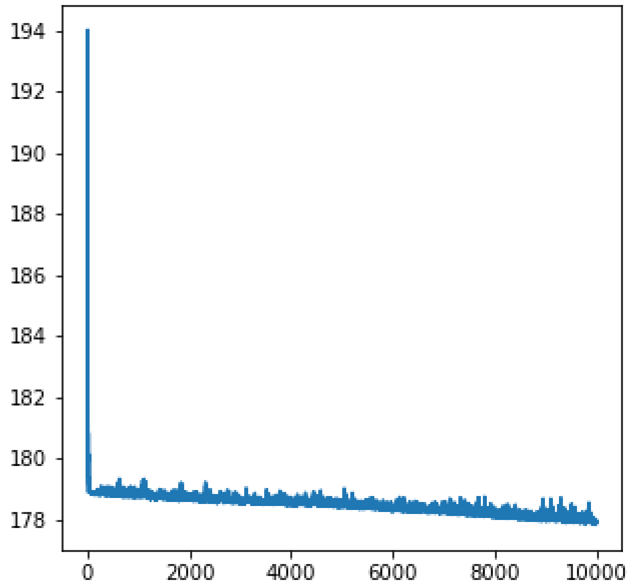
    loss = loss_func(output,y_noise)
    loss.backward()
    optimizer.step()

    loss_array.append(loss)
```

In [295]:

```
plt.plot(loss_array)
print('Adam,lr=0.0001')
```

Adam,lr=0.0001



3번 보너스

In [284]:

```
mnist_train = dset.FashionMNIST(root="../", train=True, transform=transforms.ToTensor(), target
_transform=None, download=True)
mnist_test = dset.FashionMNIST(root="../", train=False, transform=transforms.ToTensor(), target
_transform=None, download=True)
```

3-1 학습 세트의 마지막 데이터를 이미지로 출력해 보세요.

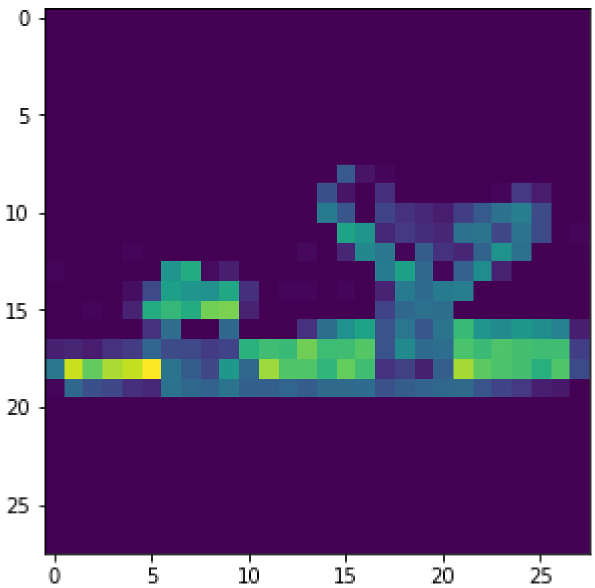
In [310]:

```
print(mnist_train.__getitem__(0)[0].size(), mnist_train.__len__())
print(mnist_test.__getitem__(0)[0].size(), mnist_test.__len__())
print(len(mnist_train),len(mnist_test))
```

```
torch.Size([1, 28, 28]) 60000
torch.Size([1, 28, 28]) 10000
60000 10000
```

In [311]:

```
plt.imshow(mnist_train.__getitem__(59999)[0].reshape(28,28))
plt.show()
```



3-2 학습 세트의 마지막 데이터에 대하여 1개의 채널을 입력으로 받아서 3개의 채널이 나오는 컨볼루션 연산을 적용해서 출력해 보세요.

In [326]:

```
model = nn.Sequential(
            nn.Conv2d(in_channels=1,out_channels=3,kernel_size=1)
      )

output = model(mnist_train.__getitem__(59999)[0].reshape(-1,1,28,28))
print(output.shape)
print(output)
```

```
torch.Size([1, 3, 28, 28])
tensor([[[[-0.7178, -0.7178, -0.7178,  ..., -0.7178, -0.7178, -0.7178],
          [-0.7178, -0.7178, -0.7178,  ..., -0.7178, -0.7178, -0.7178],
          [-0.7178, -0.7178, -0.7178,  ..., -0.7178, -0.7178, -0.7178],
          ...,
          [-0.7178, -0.7178, -0.7178,  ..., -0.7178, -0.7178, -0.7178],
          [-0.7178, -0.7178, -0.7178,  ..., -0.7178, -0.7178, -0.7178],
          [-0.7178, -0.7178, -0.7178,  ..., -0.7178, -0.7178, -0.7178]],

         [[-0.4956, -0.4956, -0.4956,  ..., -0.4956, -0.4956, -0.4956],
          [-0.4956, -0.4956, -0.4956,  ..., -0.4956, -0.4956, -0.4956],
          [-0.4956, -0.4956, -0.4956,  ..., -0.4956, -0.4956, -0.4956],
          ...,
          [-0.4956, -0.4956, -0.4956,  ..., -0.4956, -0.4956, -0.4956],
          [-0.4956, -0.4956, -0.4956,  ..., -0.4956, -0.4956, -0.4956],
          [-0.4956, -0.4956, -0.4956,  ..., -0.4956, -0.4956, -0.4956]],

         [[ 0.1318,  0.1318,  0.1318,  ...,  0.1318,  0.1318,  0.1318],
          [ 0.1318,  0.1318,  0.1318,  ...,  0.1318,  0.1318,  0.1318],
          [ 0.1318,  0.1318,  0.1318,  ...,  0.1318,  0.1318,  0.1318],
          ...,
          [ 0.1318,  0.1318,  0.1318,  ...,  0.1318,  0.1318,  0.1318],
          [ 0.1318,  0.1318,  0.1318,  ...,  0.1318,  0.1318,  0.1318],
          [ 0.1318,  0.1318,  0.1318,  ...,  0.1318,  0.1318,  0.1318]]]],
       grad_fn=<MkldnnConvolutionBackward>)
```

3-3 학습 세트의 마지막 데이터에 대하여 커널 사이즈 3인 컨볼루션 연산을 적용해서 출력해 보세요.

In [327]:

```
model = nn.Sequential(
            nn.Conv2d(in_channels=1,out_channels=1,kernel_size=3)
      )
output = model(mnist_train.__getitem__(59999)[0].reshape(-1,1,28,28))
print(output.shape)
print(output)
```

```
torch.Size([1, 1, 26, 26])
tensor([[[[-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2963, -0.2962, -0.2974, -0.3420,
           -0.3447, -0.3897, -0.3133, -0.3004, -0.2963, -0.2962, -0.2968,
           -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2970, -0.2965, -0.3374, -0.3947,
           -0.4132, -0.3293, -0.3139, -0.3353, -0.2964, -0.2960, -0.2954,
           -0.2982, -0.3250, -0.3360, -0.3560, -0.3182],
          [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
           -0.2956, -0.2956, -0.2956, -0.2961, -0.2972, -0.4112, -0.3618,
           -0.4875, -0.4166, -0.3594, -0.3879, -0.3664, -0.3704, -0.3905,
           -0.4559, -0.5388, -0.5372, -0.4580, -0.3625],
          [-0.2963, -0.2962, -0.2968, -0.2963, -0.2968, -0.2974, -0.2968,
           -0.2963, -0.2968, -0.2974, -0.2966, -0.2967, -0.3158, -0.5138,
           -0.4619, -0.5546, -0.5679, -0.3904, -0.4006, -0.4499, -0.5144,
           -0.5866, -0.5755, -0.5312, -0.4466, -0.3495],
          [-0.2982, -0.2965, -0.2992, -0.2986, -0.3015, -0.2958, -0.2954,
           -0.2964, -0.2968, -0.2965, -0.2950, -0.3014, -0.1963, -0.4414,
           -0.5621, -0.4352, -0.5160, -0.4852, -0.3818, -0.4593, -0.4704,
           -0.4620, -0.5409, -0.5621, -0.4192, -0.2707],
          [-0.2994, -0.2979, -0.2983, -0.2961, -0.3805, -0.4714, -0.5451,
           -0.4984, -0.3160, -0.3223, -0.2969, -0.3002, -0.2979, -0.1701,
           -0.3706, -0.5017, -0.4061, -0.5892, -0.5578, -0.3900, -0.4527,
           -0.5890, -0.4772, -0.3332, -0.2891, -0.2756],
          [-0.2942, -0.2961, -0.2972, -0.3395, -0.5337, -0.7015, -0.6664,
           -0.6172, -0.5634, -0.4920, -0.3384, -0.2930, -0.3050, -0.2726,
           -0.1988, -0.3723, -0.5585, -0.4414, -0.5614, -0.5551, -0.5339,
           -0.3976, -0.2565, -0.3164, -0.2674, -0.2964],
          [-0.2990, -0.2982, -0.3224, -0.4583, -0.5242, -0.7647, -0.9021,
           -0.8073, -0.7382, -0.5332, -0.3217, -0.2991, -0.2962, -0.2975,
           -0.2967, -0.2425, -0.4008, -0.5521, -0.6175, -0.4655, -0.3606,
           -0.3136, -0.2740, -0.2886, -0.2968, -0.2958],
          [-0.2982, -0.2966, -0.3059, -0.4033, -0.4576, -0.5026, -0.5123,
           -0.4580, -0.4386, -0.3489, -0.2779, -0.3180, -0.3762, -0.4689,
           -0.5742, -0.5892, -0.5735, -0.5480, -0.5354, -0.4983, -0.6216,
           -0.6196, -0.6092, -0.5971, -0.5997, -0.5226],
```

```
     [-0.3464, -0.3639, -0.3416, -0.3094, -0.4509, -0.4050, -0.2682,
      -0.3765, -0.5684, -0.5003, -0.6914, -0.7594, -0.8117, -0.8752,
      -0.8740, -0.6890, -0.6637, -0.5304, -0.5828, -0.7663, -0.7436,
      -0.8464, -0.8521, -0.8604, -0.8353, -0.6722],
     [-0.6930, -0.8582, -0.8451, -0.8932, -0.7825, -0.8049, -0.5067,
      -0.4655, -0.6895, -0.8101, -0.8135, -0.9355, -0.8476, -0.8333,
      -0.8177, -0.7397, -0.5476, -0.4669, -0.4193, -0.5471, -0.7816,
      -0.8805, -0.8314, -0.8232, -0.8292, -0.7171],
     [-0.6055, -0.6447, -0.6316, -0.5846, -0.5330, -0.4506, -0.5389,
      -0.5841, -0.4664, -0.6082, -0.5997, -0.5289, -0.5747, -0.5608,
      -0.5733, -0.5632, -0.3737, -0.4697, -0.4788, -0.5509, -0.6361,
      -0.5296, -0.5043, -0.4485, -0.4370, -0.4395],
     [-0.3158, -0.1881, -0.1973, -0.1609, -0.3822, -0.3083, -0.3439,
      -0.2688, -0.3738, -0.1708, -0.3178, -0.2502, -0.2841, -0.2513,
      -0.2920, -0.3889, -0.2864, -0.3770, -0.3056, -0.2125, -0.3069,
      -0.2286, -0.2263, -0.2290, -0.1818, -0.3212],
     [-0.2928, -0.2584, -0.2800, -0.2746, -0.2108, -0.2678, -0.2455,
      -0.2282, -0.2612, -0.2430, -0.2427, -0.2550, -0.2348, -0.2463,
      -0.2412, -0.2675, -0.2374, -0.2480, -0.2434, -0.2430, -0.2645,
      -0.2634, -0.2688, -0.2880, -0.2792, -0.3015],
     [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
     [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
     [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
     [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
     [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956],
     [-0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956, -0.2956,
      -0.2956, -0.2956, -0.2956, -0.2956, -0.2956]]]],
   grad_fn=<MkldnnConvolutionBackward>)
```

3-4 학습 세트의 마지막 데이터에 대하여 커널 사이즈 3, 스트라이드 3인 컨볼루션 연산을 적용해서 출력해 보세요.

In [328]:

```
model = nn.Sequential(
            nn.Conv2d(in_channels=1,out_channels=1,kernel_size=3, stride=3)
      )
output = model(mnist_train.__getitem__(59999)[0].reshape(-1,1,28,28))
print(output.shape)
print(output)
```

```
torch.Size([1, 1, 9, 9])
tensor([[[[0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219,
           0.2219],
          [0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219,
           0.2219],
          [0.2219, 0.2219, 0.2219, 0.2219, 0.2217, 0.1906, 0.2221, 0.2219,
           0.2219],
          [0.2221, 0.2221, 0.2215, 0.2211, 0.2846, 0.2454, 0.2724, 0.3250,
           0.3735],
          [0.2264, 0.2336, 0.3747, 0.1772, 0.2251, 0.4004, 0.4442, 0.3838,
           0.2942],
          [0.2073, 0.1903, 0.4867, 0.4669, 0.2072, 0.3469, 0.5069, 0.4970,
           0.4372],
          [0.5155, 0.5952, 0.5634, 0.5239, 0.6676, 0.7166, 0.4423, 0.6638,
           0.4990],
          [0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219,
           0.2219],
          [0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219, 0.2219,
           0.2219]]]], grad_fn=<MkldnnConvolutionBackward>)
```

3-5 학습 세트를 자신이 설계한 CNN 모델로 학습하고 테스트 세트로 정확도를 평가해 보세요.

In [338]:

```
batch_size = 64
learning_rate = 0.0002
num_epoch = 10
```

In [339]:

```
train_loader = DataLoader(mnist_train,batch_size=batch_size, shuffle=True,num_workers=2,drop_last=True)
test_loader = DataLoader(mnist_test,batch_size=batch_size, shuffle=False,num_workers=2,drop_last=True)
```

In [340]:

```
class CNN(nn.Module):
    def __init__(self):
        super(CNN,self).__init__()
        self.layer = nn.Sequential(
            nn.Conv2d(in_channels=1,out_channels=16,kernel_size=5),          # [batch_size,1,28,28] -> [batch_size,16,24,24]
            nn.ReLU(),                                                        # 필터의 개수는 1개(흑백이미지)에서 16개로 늘어나도록 임의로 설정했습니다.
            nn.Conv2d(in_channels=16,out_channels=32,kernel_size=5),         # [batch_size,16,24,24] -> [batch_size,32,20,20]
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2,stride=2),                             # [batch_size,32,20,20] -> [batch_size,32,10,10]
            nn.Conv2d(in_channels=32, out_channels=64, kernel_size=5),       # [batch_size,32,10,10] -> [batch_size,64,6,6]
            nn.ReLU(),
            nn.MaxPool2d(kernel_size=2,stride=2)                              # [batch_size,64,6,6] -> [batch_size,64,3,3]
        )
        self.fc_layer = nn.Sequential(
            nn.Linear(64*3*3,100),                                            # [batch_size,64*3*3] -> [batch_size,100]
            nn.ReLU(),
            nn.Linear(100,10)                                                 # [batch_size,100] -> [batch_size,10]
        )

    def forward(self,x):
        out = self.layer(x)                                                   # self.layer에 정의한 Sequential의 연산을 차례대로 다 실행합니다.
        out = out.view(batch_size,-1)                                         # view 함수를 이용해 텐서의 형태를 [batch_size,나머지]로 바꿔줍니다.
                                                                              # ex) 2x3 형태였던 텐서를 .view(1,-1) 해주면 1x6의 형태로 바뀝니다. .view(3,-1)이면 3x2로 바뀜.
                                                                              # 만약 전체 텐서의 크기가 batch_size로 나누어 떨어지지 않으면 오류가 납니다.
        out = self.fc_layer(out)
        return out
```

In [341]:

```
device = torch.device("cuda:0" if torch.cuda.is_available() else "cpu")
print(device)

model = CNN().to(device)

loss_func = nn.CrossEntropyLoss()

optimizer = torch.optim.Adam(model.parameters(), lr=0.002)
```

```
cuda:0
```

In [342]:

```
loss_arr =[]
for i in range(num_epoch):
    for j,[image,label] in enumerate(train_loader):

        x = image.to(device)
        y_= label.to(device)

        optimizer.zero_grad()
        output = model.forward(x)
        loss = loss_func(output,y_)
        loss.backward()
        optimizer.step()

        if j % 1000 == 0:
            print(j)
            print(image.size)
            print(label.size)
            print(loss)
            loss_arr.append(loss.cpu().detach().numpy())
```

```
0
<built-in method size of Tensor object at 0x0000026A360D9CC8>
<built-in method size of Tensor object at 0x0000026A328FFE08>
tensor(2.3081, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A35F01098>
<built-in method size of Tensor object at 0x0000026A35F01458>
tensor(0.2424, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A3612CD68>
<built-in method size of Tensor object at 0x0000026A35F018B8>
tensor(0.2617, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A35F011D8>
<built-in method size of Tensor object at 0x0000026A328FFB38>
tensor(0.1833, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A366CB278>
<built-in method size of Tensor object at 0x0000026A366CBEF8>
tensor(0.2101, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A328F4EF8>
<built-in method size of Tensor object at 0x0000026A328F4368>
tensor(0.2012, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A36702048>
<built-in method size of Tensor object at 0x0000026A36702EA8>
tensor(0.0992, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A35F01098>
<built-in method size of Tensor object at 0x0000026A35F01C78>
tensor(0.2520, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A3612C318>
<built-in method size of Tensor object at 0x0000026A32D8AB88>
tensor(0.2400, device='cuda:0', grad_fn=<NllLossBackward>)
0
<built-in method size of Tensor object at 0x0000026A32D85868>
<built-in method size of Tensor object at 0x0000026A32D8A9A8>
tensor(0.1388, device='cuda:0', grad_fn=<NllLossBackward>)
```

In [344]:

```
correct = 0
total = 0

with torch.no_grad():
    for image,label in test_loader:
        print(image.shape)
        print(label.shape)

        x = image.to(device)
        y_= label.to(device)


        output = model.forward(x)
        _,output_index = torch.max(output,1)

        total += label.size(0)
        correct += (output_index == y_).sum().float()

    print("Accuracy of Test Data: {}%".format(100*correct/total))
```

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Accuracy of Test Data: 90.63501739501953%
```

3-6 학습 모델의 각 계층별 요약과 파라미터 수를 출력해 보세요.

In [346]:

```
print(model)
print(list(model.parameters()))
```

```
CNN(
  (layer): Sequential(
    (0): Conv2d(1, 16, kernel_size=(5, 5), stride=(1, 1))
    (1): ReLU()
    (2): Conv2d(16, 32, kernel_size=(5, 5), stride=(1, 1))
    (3): ReLU()
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=Fals
e)
    (5): Conv2d(32, 64, kernel_size=(5, 5), stride=(1, 1))
    (6): ReLU()
    (7): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ceil_mode=Fals
e)
  )
  (fc_layer): Sequential(
    (0): Linear(in_features=576, out_features=100, bias=True)
    (1): ReLU()
    (2): Linear(in_features=100, out_features=10, bias=True)
  )
)
[Parameter containing:
tensor([[[[-1.4531e-01,  3.4147e-02,  2.9623e-01, -8.6458e-02, -3.8937e-01],
          [ 5.7209e-02, -1.9056e-01,  4.0041e-02,  1.5629e-01, -4.4271e-02],
          [-7.6948e-02,  2.2185e-01, -2.0429e-01,  4.4132e-02,  1.4092e-01],
          [-3.9637e-01, -1.3540e-01, -1.6280e-01,  2.7554e-01,  2.3662e-01],
          [-1.9212e-01,  1.2840e-01, -3.2989e-01, -6.9444e-02,  1.8193e-01]]],


        [[[ 2.7294e-02, -4.7589e-01, -5.7900e-01,  2.6975e-01, -2.5075e-01],
          [ 1.7635e-01, -2.0237e-01,  5.5234e-02,  1.0652e-01,  2.4122e-01],
          [-1.7315e-01,  2.7480e-01,  1.5789e-01,  1.0703e-01,  3.6340e-01],
          [ 3.2224e-01,  3.2744e-01, -1.2951e-01, -2.3798e-01, -5.9665e-02],
          [-7.8105e-02,  1.5422e-02, -1.1216e-01, -3.6502e-01, -6.7292e-02]]],


        [[[-1.1751e-01,  1.8176e-01, -2.4766e-01, -3.8583e-01, -5.2116e-02],
          [ 2.8013e-01,  3.1039e-01,  3.3151e-02,  1.4126e-01, -1.8540e-01],
          [ 3.5809e-02, -1.4447e-01, -2.5168e-01, -2.3377e-02, -2.1330e-01],
          [-1.2505e-01, -3.1857e-02,  3.4292e-02, -1.3837e-03, -1.8092e-01],
          [ 2.4279e-01,  6.9753e-02, -2.0538e-01,  2.6049e-01,  3.2178e-01]]],


        [[[ 9.0685e-02, -8.9343e-02,  3.6107e-01,  5.3057e-02, -7.6093e-02],
          [-7.0896e-02, -4.5746e-02,  1.5421e-01, -1.3317e-01,  1.0715e-01],
          [-1.7953e-01, -6.5211e-01, -1.7452e-01, -5.5006e-03, -5.1708e-02],
          [ 2.9165e-01, -4.8929e-01, -1.9312e-01,  2.6000e-01,  1.9523e-01],
          [-4.1313e-01, -1.0204e+00, -1.9221e-01, -1.1093e-01, -2.1604e-01]]],


        [[[-1.6108e+00, -1.9704e+00, -6.6881e-02, -1.7168e-02, -1.9123e-01],
          [-1.0149e+00, -2.0719e+00, -5.2867e-01,  1.6332e-03,  2.7052e-01],
          [ 1.0951e-01, -1.0360e-01, -4.7971e-02,  2.9696e-01,  7.8843e-02],
          [ 2.9057e-01, -1.8351e-01,  1.4093e-01,  1.3832e-01, -1.8857e-01],
          [-2.2420e-02,  8.5482e-02, -7.9006e-02,  1.6286e-01, -1.5581e-01]]],


        [[[ 2.7356e-01, -2.1939e-01, -4.4195e-01, -5.4984e-01, -1.4873e-01],
          [ 9.1493e-02, -4.7583e-01, -9.8391e-01, -7.0799e-01, -6.0486e-01],
          [-1.8775e-01,  1.6412e-01, -3.2287e-01, -4.8917e-01, -7.1528e-02],
          [-2.5060e-01,  2.2946e-01, -2.1939e-01,  3.1417e-02, -9.0405e-02],
          [ 9.4968e-02,  1.9434e-01, -1.4728e-01, -1.3437e-01, -1.6256e-01]]],
```

```
[[[ 3.2813e-01,  3.4610e-01, -3.4063e-01, -7.5113e-02, -1.9286e-01],
  [ 2.9235e-02,  6.3908e-02, -3.1199e-01,  1.0557e-01,  1.2317e-01],
  [ 3.4519e-01,  2.2062e-01, -1.2183e-01,  2.4522e-01,  8.8298e-02],
  [-8.4096e-02,  9.2599e-02, -2.5342e-01, -1.3058e-02,  1.4023e-01],
  [-3.3636e-01, -2.8383e-01, -2.2163e-01,  1.9980e-01,  9.2521e-02]]],


[[[ 3.5433e-01,  1.1173e-01, -2.4608e-01, -2.4843e-01,  4.4725e-01],
  [ 2.9631e-01, -1.6360e-01, -2.8739e-01, -2.4491e-01, -7.1777e-02],
  [ 1.4632e-01,  1.9429e-01,  1.6442e-01, -4.9659e-01, -3.8563e-01],
  [-2.3028e-01,  1.3101e-01,  2.5257e-01,  2.0970e-01, -8.1484e-02],
  [ 1.1585e-02, -1.1310e-01, -5.9741e-02, -1.0757e-01,  8.5389e-03]]],


[[[ 2.5859e-01,  6.9984e-03,  4.7666e-01,  3.1789e-01, -9.1624e-02],
  [-1.4078e-01, -2.8714e-01,  9.3490e-02,  3.3990e-01,  2.5606e-01],
  [-1.8003e-01, -2.5264e-02, -1.8540e-01, -2.2347e-01, -7.4464e-02],
  [-4.2390e-02,  3.1273e-01,  2.4786e-01, -2.3436e-01,  1.8449e-01],
  [-3.5500e-02,  1.8784e-01, -3.8592e-01, -4.2744e-01, -7.6374e-02]]],


[[[-3.2243e-01, -8.3613e-02,  3.4216e-02, -2.1899e-01,  6.6986e-02],
  [-3.5930e-01,  2.0227e-01,  5.8903e-02, -9.9545e-02, -1.4667e-02],
  [-1.6249e-01,  2.7105e-01,  1.0258e-01,  7.8456e-02,  1.3377e-01],
  [-2.2144e-01, -1.0188e-01, -1.0036e-01,  2.8555e-01,  1.9500e-01],
  [ 7.4076e-02, -5.6583e-02, -4.9288e-02,  6.7177e-02,  1.9942e-01]]],


[[[-3.6011e-01,  1.3861e-01, -3.4993e-01, -3.6471e-02, -1.4442e-01],
  [-2.6183e-03,  8.8383e-02, -2.3785e-01, -4.1887e-02,  4.8942e-02],
  [-3.7141e-01,  2.5996e-01, -5.1651e-02, -2.1772e-01, -2.4998e-01],
  [ 6.3949e-02,  1.4543e-01,  6.4821e-02,  5.8345e-02,  9.4667e-02],
  [ 4.5410e-02,  2.0171e-01, -3.3624e-02, -3.1360e-01, -3.3569e-02]]],


[[[ 2.6537e-01, -1.8158e-01, -4.1210e-01, -2.6115e-01, -1.0537e-02],
  [ 4.1576e-01, -1.3749e-01, -2.1062e-01, -1.6261e-01,  3.5245e-01],
  [-1.1299e-02, -8.0467e-03,  1.1839e-01, -1.6215e-01, -2.1016e-01],
  [ 1.3118e-01,  4.3101e-02, -4.6419e-03, -1.9834e-01, -4.7616e-02],
  [ 3.4119e-01,  2.0780e-02,  2.1124e-01,  2.0622e-01, -1.3309e-02]]],


[[[ 2.0844e-01, -3.6117e-01, -1.4049e+00, -1.9061e+00, -3.1223e-01],
  [ 4.7640e-02,  1.4241e-01, -1.5562e-01, -4.3921e-01,  2.4755e-01],
  [ 8.8767e-02,  7.6085e-03,  1.1717e-01,  2.7461e-02, -2.8275e-02],
  [ 1.5724e-01, -1.4564e-02, -5.9751e-02, -4.9184e-03, -4.4215e-02],
  [ 4.4611e-02, -9.1736e-02, -8.0361e-02,  1.0041e-01,  9.4391e-02]]],


[[[ 3.3611e-01, -6.7562e-02, -1.3252e-01, -1.9158e-01, -3.1174e-01],
  [ 2.3869e-01, -3.5523e-02,  2.9678e-01,  1.9904e-02, -2.5108e-02],
  [ 3.6405e-01, -3.9163e-01, -6.8804e-02, -2.6310e-02,  1.8177e-01],
  [ 1.1384e-02, -4.1825e-01,  7.9084e-02,  1.8581e-01,  1.3766e-02],
  [ 2.6131e-01, -2.3130e-01, -1.2950e-01,  6.5088e-02, -3.3412e-02]]],


[[[-5.6683e-01, -2.8870e-01, -3.0342e-01,  4.4500e-03, -8.6476e-02],
  [-1.5840e-01,  2.3334e-01,  2.5644e-01,  1.6673e-02, -6.9473e-02],
  [-8.3825e-02,  5.2112e-02, -9.9952e-02, -1.3713e-01,  3.4042e-02],
  [-4.6784e-02, -6.3275e-02,  2.2482e-01, -1.0167e-01, -1.7375e-01],
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          [-1.2079e-01,  1.6458e-02,  1.2365e-01,  1.4317e-01, -2.6381e-01]]],


         [[[ 1.4256e-02,  1.3537e-01, -2.0107e-01, -6.5872e-03,  2.0957e-01],
           [ 1.3585e-01, -7.8220e-02, -1.7565e-02, -2.3473e-01, -6.9731e-02],
           [ 4.8532e-03, -2.2437e-01,  1.1118e-01, -1.5984e-01, -1.1862e-01],
           [-7.9847e-02, -1.4142e-01,  1.8507e-01,  1.7620e-01,  1.2232e-03],
           [ 1.4163e-01, -1.3468e-01, -2.5267e-01,  7.0737e-02, -1.1688e-01]]]],
        device='cuda:0', requires_grad=True), Parameter containing:
tensor([ 0.0533,  0.0098, -0.0970,  0.2878,  0.2335,  0.2209,  0.0689, -0.0745,
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         0.1728,  0.0249,  0.0048, -0.1001,  0.3206, -0.1632,  0.1593,  0.0332],
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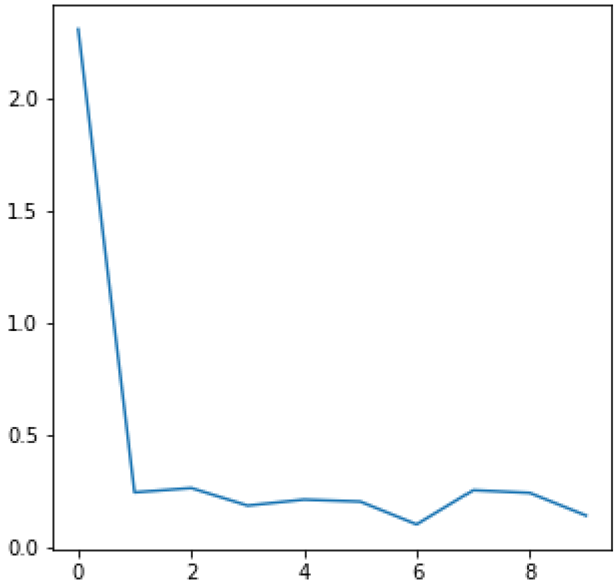
```

3-7 에포크를 5 이상으로 설정하고 에포크별 손실(loss) 그래프를 그려보세요.

In [343]:

```
plt.plot(loss_arr)
plt.show()
```



In [ ]: