```
%matplotlib inline
import torch
import torch.nn as nn
import pandas as pd
import numpy as np
from torchvision import transforms
from torch.utils.data import Dataset, DataLoader
from PIL import Image
from torch import autograd
from torch.autograd import Variable
from torchvision.utils import make_grid
import matplotlib.pyplot as plt
from tensorflow.keras.datasets import fashion_mnist
```

```
device = 'cuda' if torch.cuda.is_available() else 'cpu'

print('torch version:',torch.__version__)
print('device:', device)
```

```
torch version: 2.1.0+cu121
device: cuda
```

```
train_data_path = 'fashion-mnist_train.csv'
valid_data_path = 'fashion-mnist_test.csv'
print('Train data path:', train_data_path)
print('Valid data path:', valid_data_path)

img_size = 28
batch_size = 64

z_size = 100
generator_layer_size = [256, 512, 1024]
discriminator_layer_size = [1024, 512, 256]

epochs = 30
learning_rate = 1e-4
```

```
Train data path: fashion-mnist_train.csv
Valid data path: fashion-mnist_test.csv
```

```
class_list = ['T-Shirt', 'Trouser', 'Pullover', 'Dress', 'Coat', 'Sandal', 'Shirt', 'Sneaker', 'Bag', 'Ankle boot']
class_num = len(class_list)
```

```
class FashionMNIST(Dataset):
    def __init__(self, path, img_size, transform=None):
        self.transform = transform
        fashion_df = pd.read_csv(path)
        self.images = fashion_df.iloc[:, 1:].values.astype('uint8').reshape(-1, img_size, img_size)
        self.labels = fashion_df.label.values
        print('Image size:', self.images.shape)
        print('--- Label ---')
        print(fashion_df.label.value_counts())

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

    def __getitem__(self, idx):
        label = self.labels[idx]
        img = self.images[idx]
        img = Image.fromarray(self.images[idx])

        if self.transform:
            img = self.transform(img)

        return img, label
```

```
dataset = FashionMNIST(train_data_path, img_size)
```

```
Image size: (54857, 28, 28)
--- Label ---
5    5509
6    5500
0    5497
8    5487
7    5481
3    5481
4    5479
2    5475
9    5474
1    5474
Name: label, dtype: int64
<ipython-input-29-d73abe5726c9>:5: RuntimeWarning: invalid value encountered in cast
  self.images = fashion_df.iloc[:, 1:].values.astype('uint8').reshape(-1, img_size, img_size)
```

```
transform = transforms.Compose([
        transforms.ToTensor(),
        transforms.Normalize(mean=(0.5,), std=(0.5,))
])
```

```
dataset = FashionMNIST(train_data_path, img_size, transform=transform)
data_loader = torch.utils.data.DataLoader(dataset, batch_size=batch_size, shuffle=True)
```

```
Image size: (54857, 28, 28)
--- Label ---
5    5509
6    5500
0    5497
8    5487
7    5481
3    5481
4    5479
2    5475
9    5474
1    5474
Name: label, dtype: int64
<ipython-input-29-d73abe5726c9>:5: RuntimeWarning: invalid value encountered in cast
  self.images = fashion_df.iloc[:, 1:].values.astype('uint8').reshape(-1, img_size, img_size)
```

```
for images, labels in data_loader:
    fig, ax = plt.subplots(figsize=(18,10))
    ax.set_xticks([])
    ax.set_yticks([])
    ax.imshow(make_grid(images, nrow=16).permute(1,2,0))
    break
```

```
WARNING:matplotlib.image:Clipping input data to the valid range for imshow with RGB data ([0..1] for floats or [0..255
```

```
# Generator
class Generator(nn.Module):
    def __init__(self, generator_layer_size, z_size, img_size, class_num):
        super().__init__()

        self.z_size = z_size
        self.img_size = img_size

        self.label_emb = nn.Embedding(class_num, class_num)

        self.model = nn.Sequential(
            nn.Linear(self.z_size + class_num, generator_layer_size[0]),
            nn.LeakyReLU(0.2, inplace=True),
            nn.Linear(generator_layer_size[0], generator_layer_size[1]),
            nn.LeakyReLU(0.2, inplace=True),
            nn.Linear(generator_layer_size[1], generator_layer_size[2]),
            nn.LeakyReLU(0.2, inplace=True),
            nn.Linear(generator_layer_size[2], self.img_size * self.img_size),
            nn.Tanh()
        )

    def forward(self, z, labels):

        z = z.view(-1, self.z_size)

        c = self.label_emb(labels)

        x = torch.cat([z, c], 1)

        out = self.model(x)

        return out.view(-1, self.img_size, self.img_size)
```

```
# Discriminator
class Discriminator(nn.Module):
    def __init__(self, discriminator_layer_size, img_size, class_num):
        super().__init__()

        self.label_emb = nn.Embedding(class_num, class_num)
        self.img_size = img_size

        self.model = nn.Sequential(
            nn.Linear(self.img_size * self.img_size + class_num, discriminator_layer_size[0]),
            nn.LeakyReLU(0.2, inplace=True),
            nn.Dropout(0.3),
            nn.Linear(discriminator_layer_size[0], discriminator_layer_size[1]),
            nn.LeakyReLU(0.2, inplace=True),
            nn.Dropout(0.3),
            nn.Linear(discriminator_layer_size[1], discriminator_layer_size[2]),
            nn.LeakyReLU(0.2, inplace=True),
            nn.Dropout(0.3),
            nn.Linear(discriminator_layer_size[2], 1),
            nn.Sigmoid()
        )

    def forward(self, x, labels):

        x = x.view(-1, self.img_size * self.img_size)

        c = self.label_emb(labels)

        x = torch.cat([x, c], 1)

        out = self.model(x)

        return out.squeeze()
```

```
generator = Generator(generator_layer_size, z_size, img_size, class_num).to(device)

discriminator = Discriminator(discriminator_layer_size, img_size, class_num).to(device)
```

```
criterion = nn.BCELoss()
```

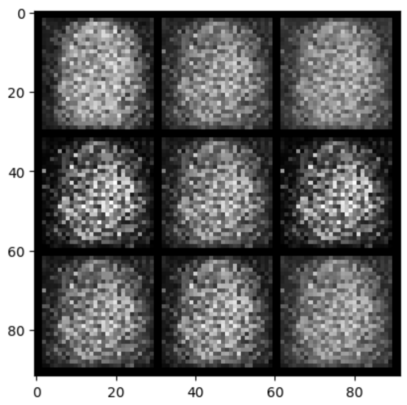
```
g_optimizer = torch.optim.Adam(generator.parameters(), lr=learning_rate)
d_optimizer = torch.optim.Adam(discriminator.parameters(), lr=learning_rate)
```

```python
def generator_train_step(batch_size, discriminator, generator, g_optimizer, criterion):

    g_optimizer.zero_grad()

    z = Variable(torch.randn(batch_size, z_size)).to(device)

    fake_labels = Variable(torch.LongTensor(np.random.randint(0, class_num, batch_size))).to(device)

    fake_images = generator(z, fake_labels)

    validity = discriminator(fake_images, fake_labels)

    g_loss = criterion(validity, Variable(torch.ones(batch_size)).to(device))

    g_loss.backward()

    g_optimizer.step()

    return g_loss.data
```

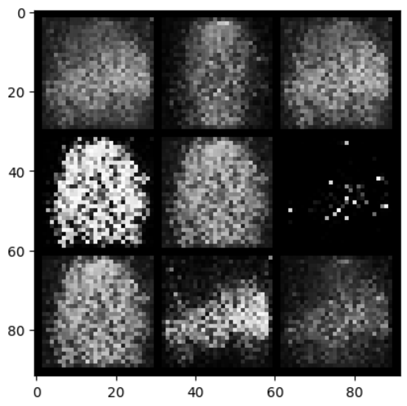
```python
def discriminator_train_step(batch_size, discriminator, generator, d_optimizer, criterion, real_images, labels):

    d_optimizer.zero_grad()

    real_validity = discriminator(real_images, labels)

    real_loss = criterion(real_validity, Variable(torch.ones(batch_size)).to(device))

    z = Variable(torch.randn(batch_size, z_size)).to(device)

    fake_labels = Variable(torch.LongTensor(np.random.randint(0, class_num, batch_size))).to(device)

    fake_images = generator(z, fake_labels)

    fake_validity = discriminator(fake_images, fake_labels)

    fake_loss = criterion(fake_validity, Variable(torch.zeros(batch_size)).to(device))

    d_loss = real_loss + fake_loss

    d_loss.backward()

    d_optimizer.step()

    return d_loss.data
```

```python
for epoch in range(epochs):

    print('Starting epoch {}...'.format(epoch+1))

    for i, (images, labels) in enumerate(data_loader):

        real_images = Variable(images).to(device)
        labels = Variable(labels).to(device)

        generator.train()

        d_loss = discriminator_train_step(len(real_images), discriminator,
                                          generator, d_optimizer, criterion,
                                          real_images, labels)

        g_loss = generator_train_step(batch_size, discriminator, generator, g_optimizer, criterion)

    generator.eval()

    print('g_loss: {}, d_loss: {}'.format(g_loss, d_loss))

    z = Variable(torch.randn(class_num-1, z_size)).to(device)

    labels = Variable(torch.LongTensor(np.arange(class_num-1))).to(device)

    sample_images = generator(z, labels).unsqueeze(1).data.cpu()

    grid = make_grid(sample_images, nrow=3, normalize=True).permute(1,2,0).numpy()
    plt.imshow(grid)
    plt.show()
```

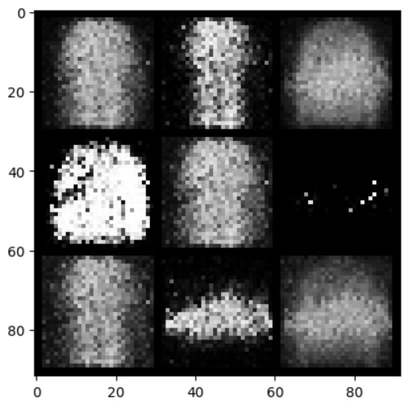
```
Starting epoch 1...
g_loss: 4.214088439941406, d_loss: 0.07327994704246521
```



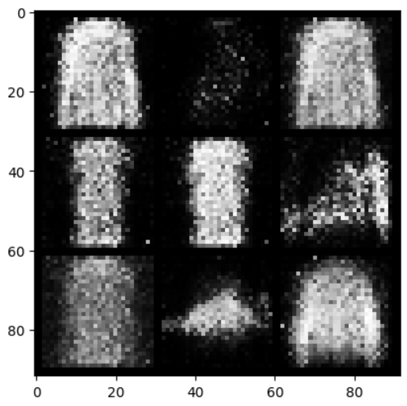
```
Starting epoch 2...
g_loss: 4.79979133605957, d_loss: 0.5232222676277161
```



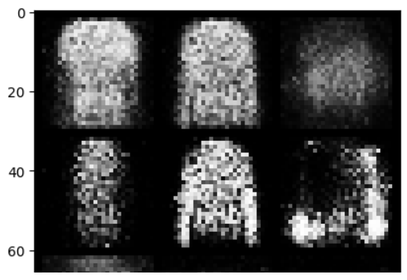
```
Starting epoch 3...
g_loss: 4.046194076538086, d_loss: 0.2724122405052185
```

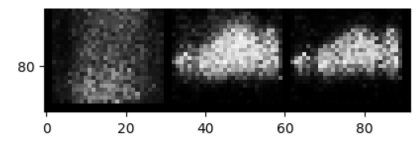


```
Starting epoch 4...
g_loss: 3.0581414699554443, d_loss: 0.6690121293067932
```

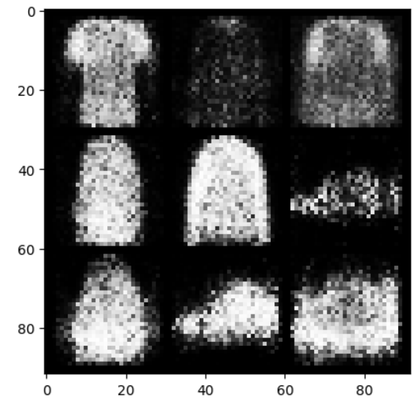


```
Starting epoch 5...
g_loss: 3.2966952323913574, d_loss: 0.8501036167144775
```

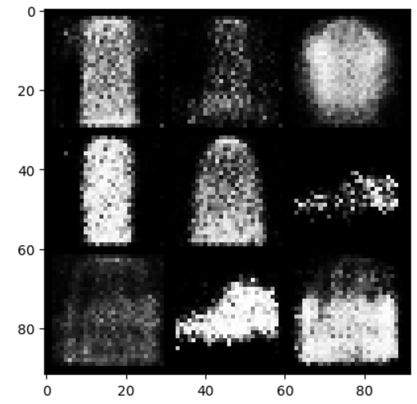




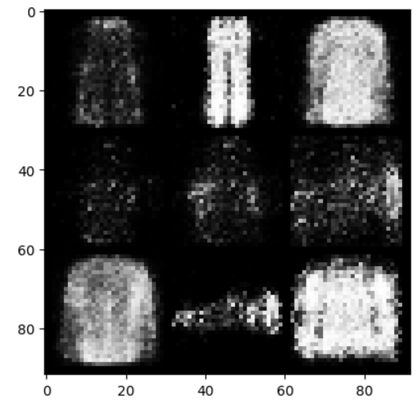
```
Starting epoch 6...
g_loss: 2.5073013305664062, d_loss: 0.14032147824764252
```



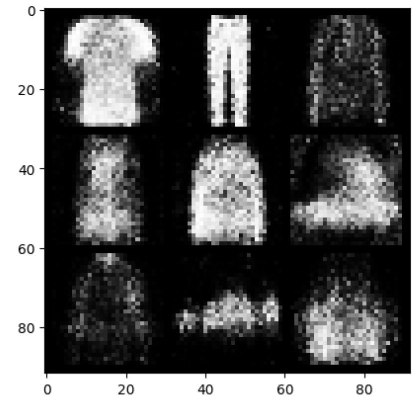
```
Starting epoch 7...
g_loss: 2.093390464782715, d_loss: 0.616520881652832
```



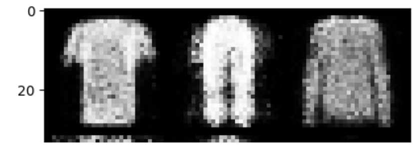
```
Starting epoch 8...
g_loss: 2.1092827320098877, d_loss: 0.7811322212219238
```

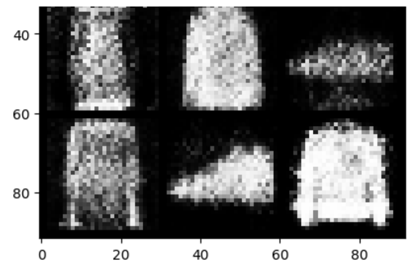


```
Starting epoch 9...
g_loss: 1.9661606550216675, d_loss: 0.4761162996292114
```

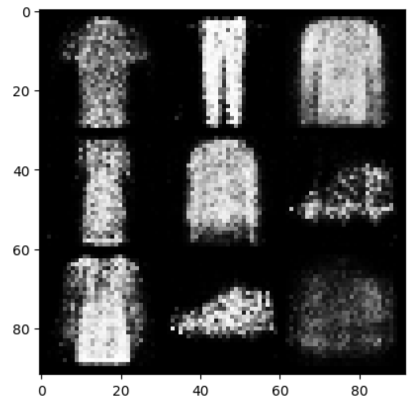


```
Starting epoch 10...
g_loss: 1.7368433475494385, d_loss: 0.7077469229698181
```

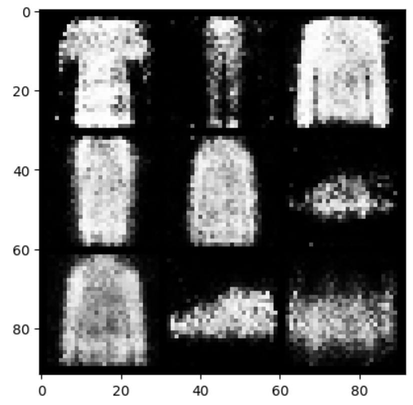




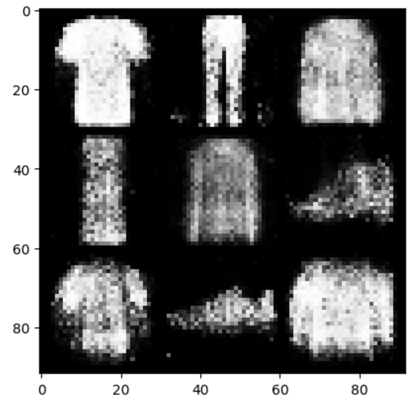
```
Starting epoch 11...
g_loss: 1.7700729370117188, d_loss: 0.8103394508361816
```



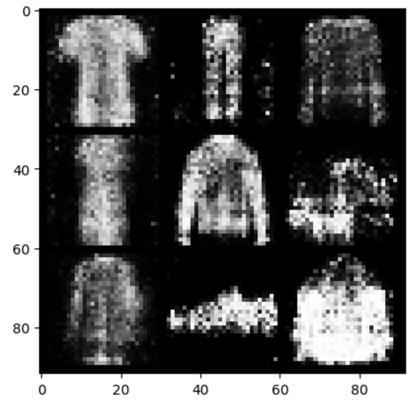
```
Starting epoch 12...
g_loss: 1.9872630834579468, d_loss: 1.2251219749450684
```



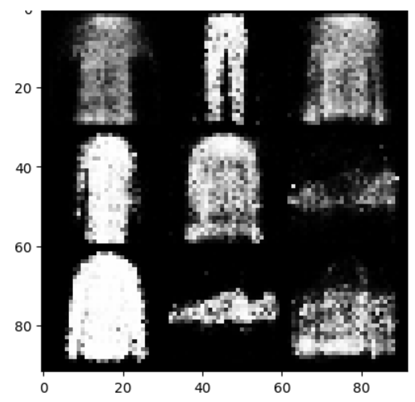
```
Starting epoch 13...
g_loss: 1.7247905731201172, d_loss: 0.6582655906677246
```



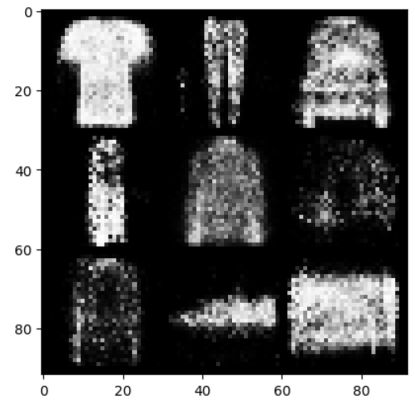
```
Starting epoch 14...
g_loss: 1.5843260288238525, d_loss: 0.7902719974517822
```



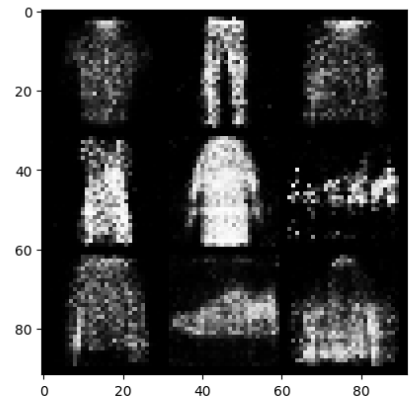
```
Starting epoch 15...
g_loss: 1.5800964832305908, d_loss: 0.904029369354248
```



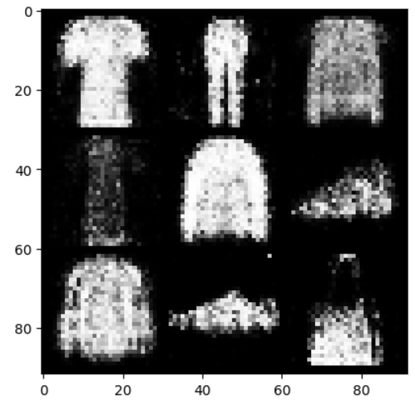
```
Starting epoch 16...
g_loss: 1.794431209564209, d_loss: 1.0457078218460083
```



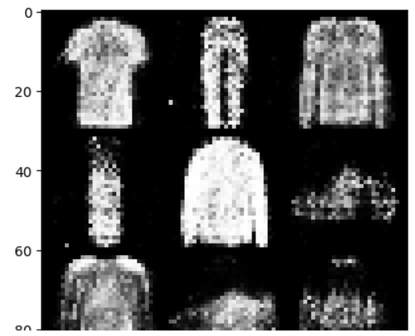
```
Starting epoch 17...
g_loss: 1.5139235258102417, d_loss: 0.36951225996017456
```

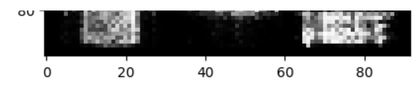


```
Starting epoch 18...
g_loss: 1.7507511377334595, d_loss: 1.118704915046692
```

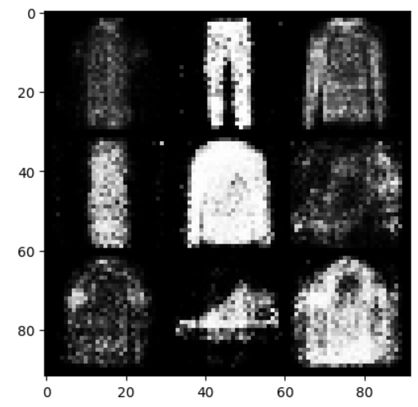


```
Starting epoch 19...
g_loss: 1.4980735778808594, d_loss: 0.6630492806434631
```

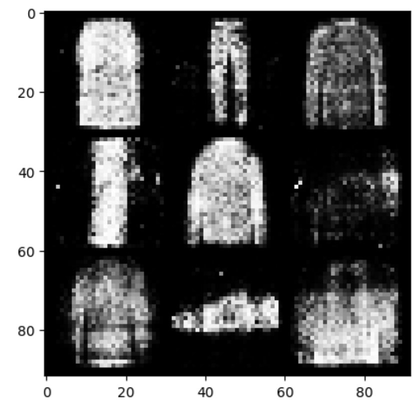




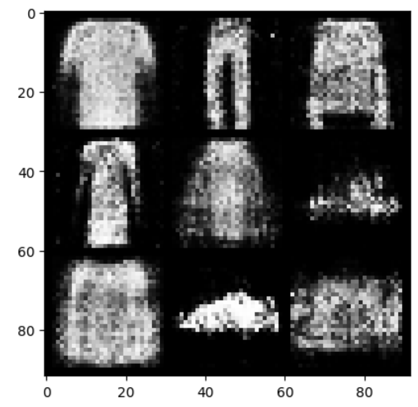
```
Starting epoch 20...
g_loss: 1.349402904510498, d_loss: 1.8251450061798096
```



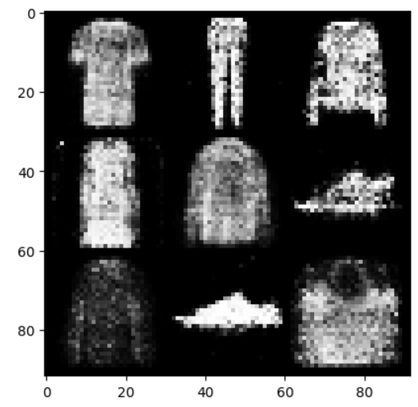
```
Starting epoch 21...
g_loss: 1.4814159870147705, d_loss: 0.8370993733406067
```



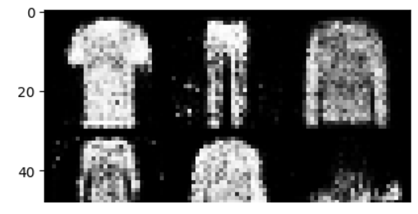
```
Starting epoch 22...
g_loss: 1.3773398399353027, d_loss: 0.714303731918335
```

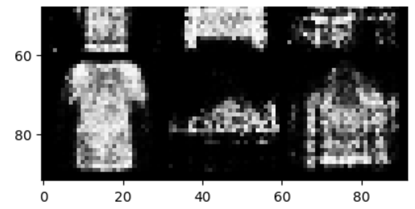


```
Starting epoch 23...
g_loss: 1.558439016342163, d_loss: 1.4103363752365112
```

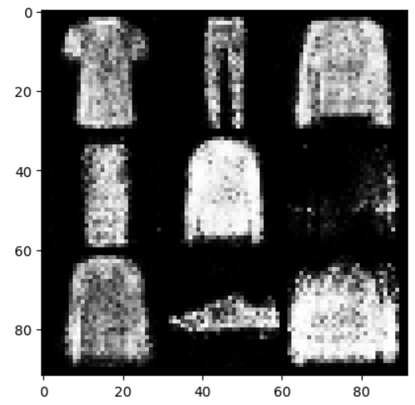


```
Starting epoch 24...
g_loss: 1.2184844017028809, d_loss: 1.0785242319107056
```

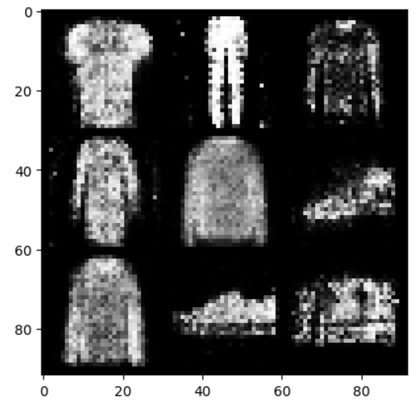




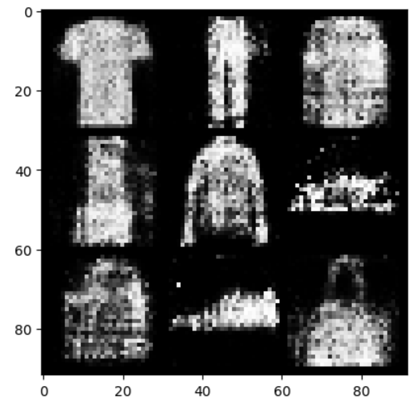
```
Starting epoch 25...
g_loss: 1.3112118244171143, d_loss: 0.5816022157669067
```



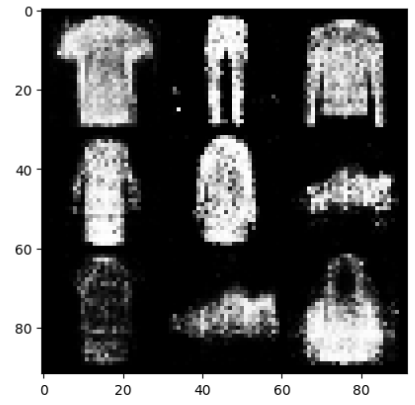
```
Starting epoch 26...
g_loss: 1.3857911825180054, d_loss: 0.7969949841499329
```



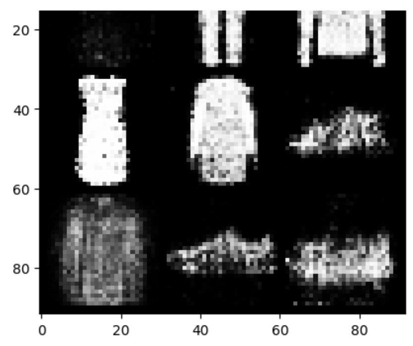
```
Starting epoch 27...
g_loss: 1.1504745483398438, d_loss: 1.2739052772521973
```



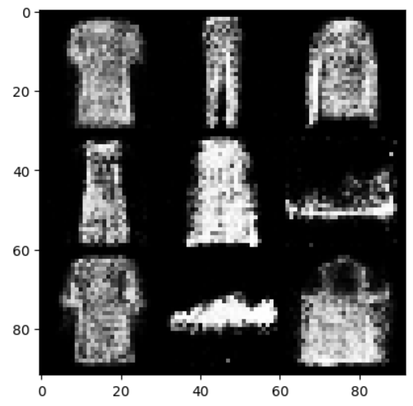
```
Starting epoch 28...
g_loss: 1.2947826385498047, d_loss: 1.0116496086120605
```



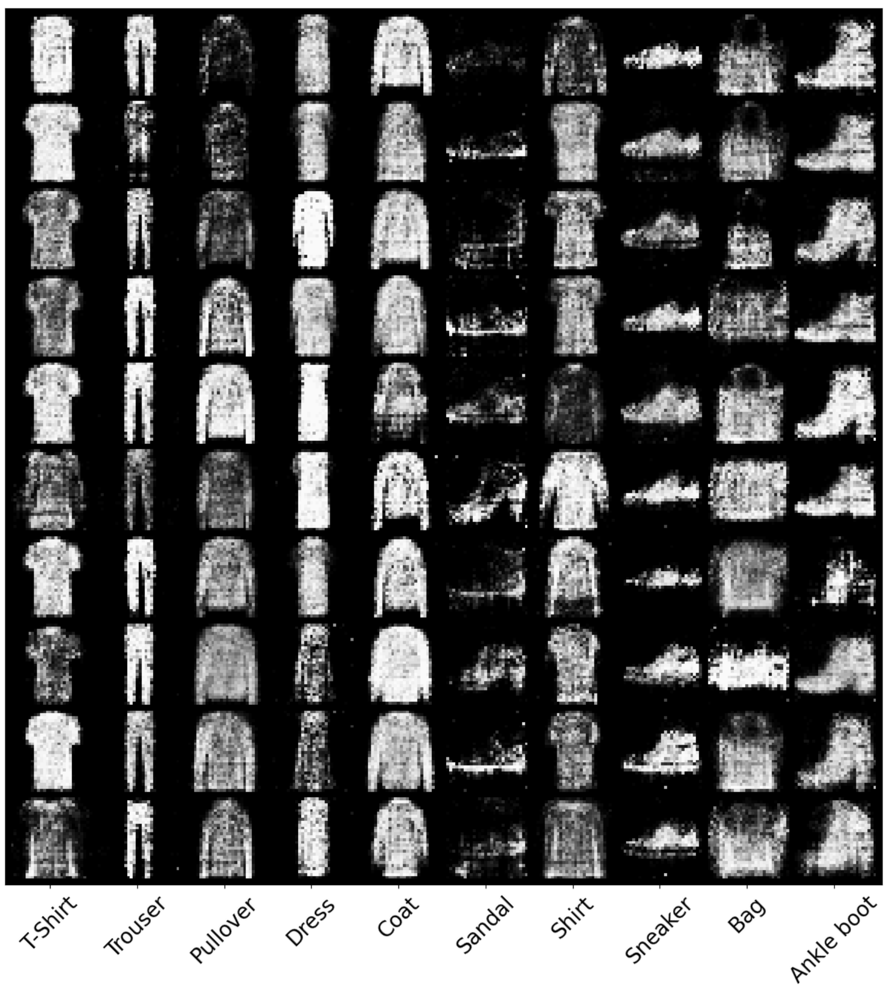
```
Starting epoch 29...
g_loss: 1.0083329677581787, d_loss: 1.3472275733947754
```



```
Starting epoch 30...
g_loss: 1.277076005935669, d_loss: 1.4603924751281738
```



```
# Generated Images Category wise
z = Variable(torch.randn(z_size, z_size)).to(device)

labels = Variable(torch.LongTensor([i for _ in range(class_num) for i in range(class_num)])).to(device)

sample_images = generator(z, labels).unsqueeze(1).data.cpu()

grid = make_grid(sample_images, nrow=class_num, normalize=True).permute(1,2,0).numpy()
fig, ax = plt.subplots(figsize=(15,15))
ax.imshow(grid)
_ = plt.yticks([])
_ = plt.xticks(np.arange(15, 300, 30), class_list, rotation=45, fontsize=20)
```


T-Shirt
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot