In [1]:

```
import tensorflow as tf
tf.compat.v1.disable_eager_execution()

from keras.datasets import mnist
from tensorflow.python.keras.layers import *
from tensorflow.python.keras.layers.advanced_activations import LeakyReLU
from tensorflow.python.keras.models import Sequential,Model
from tensorflow.compat.v1.keras.optimizers import Adam

import numpy as np
import matplotlib.pyplot as plt
import math
```

```
Using TensorFlow backend.
```

In [2]:

```
(X_Train,_),(_,_) = mnist.load_data()
```

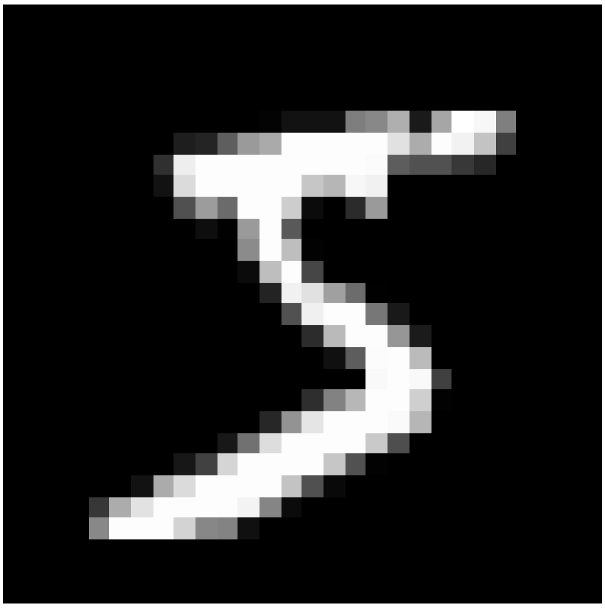
In [3]:

```
print(X_Train.shape)
```

```
(60000, 28, 28)
```

In [4]:

```
# Visualize
plt.style.use('seaborn')
plt.axis('off')
plt.imshow(X_Train[0],cmap='gray')
plt.show()
```



In [5]:

```
# Normalize this data - [-1,1]
#print(X_Train[0]) - btw 0-255 (int)

X_Train = (X_Train.astype('float32') - 127.5) / 127.5

print(np.min(X_Train))
print(np.max(X_Train))
```

```
-1.0
1.0
```

In [6]:

```
print(X_Train.shape)
```

```
(60000, 28, 28)
```

In [7]:

```
TOTAL_EPOCHS = 50
BATCH_SIZE = 256
NO_OF_BATCHES = int(X_Train.shape[0]/BATCH_SIZE) # 60000/256
HALF_BATCH = 128
NOISE_DIM = 100 # Upsample into 784 dim vector
adam = Adam(lr=2e-4,beta_1=0.5)
```

In [8]:

```
# Generator
# Input Noise (100 dim) and Outputs a vector (784 dim)

generator = Sequential()
generator.add(Dense(256,input_shape=(NOISE_DIM,)))
generator.add(LeakyReLU(0.2))
generator.add(Dense(512))
generator.add(LeakyReLU(0.2))
generator.add(Dense(1024))
generator.add(LeakyReLU(0.2))
generator.add(Dense(784, activation='tanh'))

generator.compile(loss='binary_crossentropy', optimizer=adam)
generator.summary()
```

```
WARNING:tensorflow:From c:\python\python38\lib\site-packages\tensorflow\python\ops\resource_variable_ops.py:16
able.__init__ (from tensorflow.python.ops.resource_variable_ops) with constraint is deprecated and will be rem
Instructions for updating:
If using Keras pass *_constraint arguments to layers.
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
dense (Dense)                (None, 256)               25856     
_________________________________________________________________
leaky_re_lu (LeakyReLU)      (None, 256)               0         
_________________________________________________________________
dense_1 (Dense)              (None, 512)               131584    
_________________________________________________________________
leaky_re_lu_1 (LeakyReLU)    (None, 512)               0         
_________________________________________________________________
dense_2 (Dense)              (None, 1024)              525312    
_________________________________________________________________
leaky_re_lu_2 (LeakyReLU)    (None, 1024)              0         
_________________________________________________________________
dense_3 (Dense)              (None, 784)               803600    
=================================================================
Total params: 1,486,352
Trainable params: 1,486,352
Non-trainable params: 0
_________________________________________________________________
```

In [9]:

```
# Discriminator
# Input Img (784 dim) and Outputs a probability num (1 dim) - Downsampling

discriminator = Sequential()
discriminator.add(Dense(512,input_shape=(784,)))
discriminator.add(LeakyReLU(0.2))
discriminator.add(Dense(256))
discriminator.add(LeakyReLU(0.2))
discriminator.add(Dense(1,activation='sigmoid'))

discriminator.compile(loss='binary_crossentropy',optimizer=adam)
discriminator.summary()
```

```
Model: "sequential_1"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
dense_4 (Dense)              (None, 512)               401920    
_________________________________________________________________
leaky_re_lu_3 (LeakyReLU)    (None, 512)               0         
_________________________________________________________________
dense_5 (Dense)              (None, 256)               131328    
_________________________________________________________________
leaky_re_lu_4 (LeakyReLU)    (None, 256)               0         
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 257       
=================================================================
Total params: 533,505
Trainable params: 533,505
Non-trainable params: 0
_________________________________________________________________
```

In [10]:

```
# GAN
discriminator.trainable = False
gan_input = Input(shape=(NOISE_DIM,))
generated_img = generator(gan_input)
gan_output = discriminator(generated_img)

# Functional API
model = Model(gan_input,gan_output)
model.compile(loss='binary_crossentropy',optimizer=adam)
```

In [11]:

```
X_Train = X_Train.reshape(-1,784)
print(X_Train.shape)
```

```
(60000, 784)
```

In [13]:

```
import os
os.mkdir('model')
os.mkdir('images')
os.listdir()
```

```
['.ipynb_checkpoints', 'images', 'MNIST_GAN.ipynb', 'model']
```

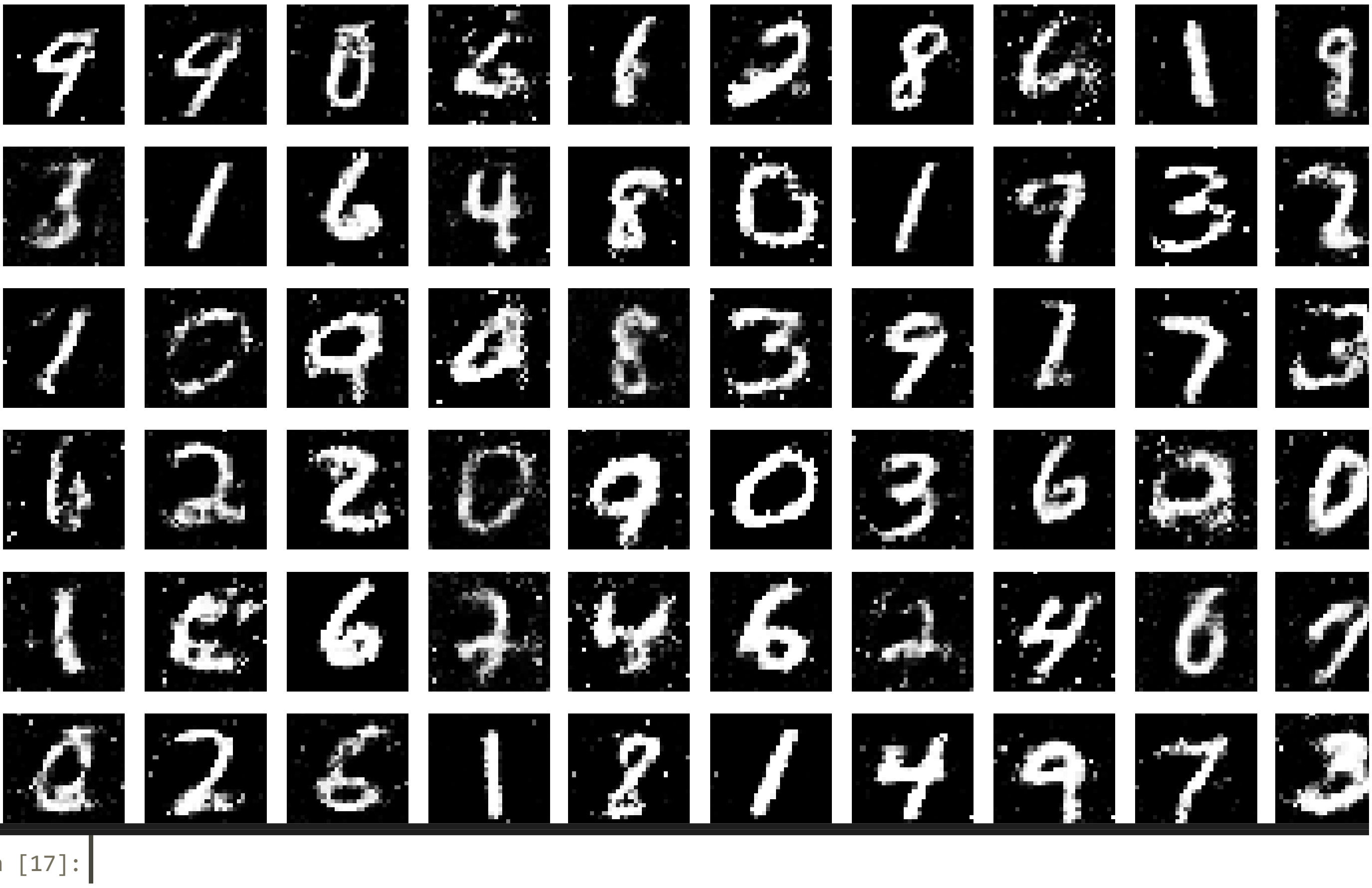
In [14]:

```
def save_images(epoch,samples=100):

  noise = np.random.normal(0,1,size=(samples,NOISE_DIM))
  generated_imgs = generator.predict(noise)
  generated_imgs = generated_imgs.reshape(samples,28,28)

  plt.figure(figsize=(10,10))

  for i in range(samples):
    plt.subplot(10,10,i+1)
    plt.imshow(generated_imgs[i],interpolation='nearest',cmap='gray')
    plt.axis('off')

  plt.tight_layout()
  plt.savefig('images/gan_output_epoch_{}.png'.format(epoch+1))
  plt.show()
```

In [15]:

```
# Training Loop

d_losses = []
g_losses = []

for epoch in range(TOTAL_EPOCHS):
  epoch_d_loss = 0.
  epoch_g_loss = 0.

  # Mini batch SGD
  for step in range(NO_OF_BATCHES):

    # Step-3 Discriminator Training, generator frozen
    # 50% Real Data + 50% Fake Data

    # Real Data X
    idx = np.random.randint(0,X_Train.shape[0],HALF_BATCH)
    real_imgs = X_Train[idx]

    # Fake Data X
    noise = np.random.normal(0,1,size=(HALF_BATCH,NOISE_DIM))
    fake_imgs = generator.predict(noise) # Forward Pass only, no training - updating w

    # Labels
    real_y = np.ones((HALF_BATCH,1)) * 0.9
    fake_y = np.zeros((HALF_BATCH,1))

    # Train our Discriminator
    d_loss_real = discriminator.train_on_batch(real_imgs,real_y)
    d_loss_fake = discriminator.train_on_batch(fake_imgs,fake_y)
    d_loss = 0.5*d_loss_real + 0.5*d_loss_fake

    epoch_d_loss += d_loss

    # Train Generator (Considering Frozen Discriminator)
    noise = np.random.normal(0,1,size=(BATCH_SIZE,NOISE_DIM))
    ground_truth_y = np.ones((BATCH_SIZE,1))
    g_loss = model.train_on_batch(noise,ground_truth_y)
    epoch_g_loss += g_loss

  print("Epoch= %d , Discriminator Loss= %.4f, Generator Loss= %.4f"%((epoch+1),epoch_
  d_losses.append(epoch_d_loss/NO_OF_BATCHES)
```

```
g_losses.append(epoch_g_loss/NO_OF_BATCHES)

if (epoch+1)%5==0:
  generator.save('model/mnist_gan_generator_{}.h5'.format(epoch+1))
  save_images(epoch)
```



In [17]:

```
ls
```

```
 Volume in drive C is Windows
 Volume Serial Number is E23E-D7E3

 Directory of C:\Users\sinha\Desktop\Luicifer\Study\ML CB\MNIST GAN

25-04-2020  15:15    <DIR>          .
25-04-2020  15:15    <DIR>          ..
25-04-2020  14:49    <DIR>          .ipynb_checkpoints
25-04-2020  15:15    <DIR>          images
25-04-2020  15:15         1,472,949 MNIST_GAN.ipynb
25-04-2020  15:15    <DIR>          model
               1 File(s)      1,472,949 bytes
               5 Dir(s)  249,069,076,480 bytes free
```

In [93]:

```
#!zip -r /content/images.zip /content/images
```

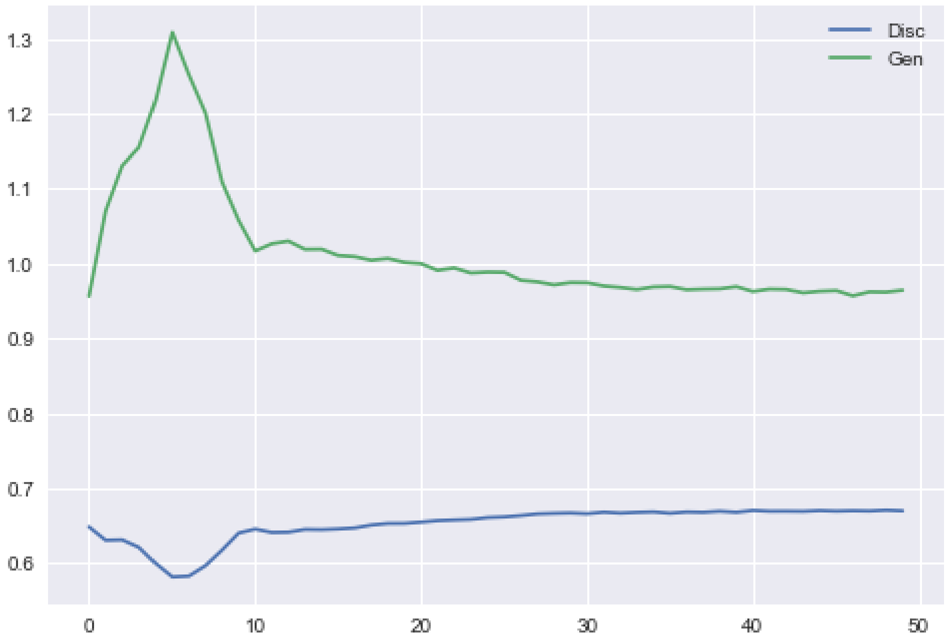
```
  adding: content/images/ (stored 0%)
  adding: content/images/gan_output_epoch_15.png (deflated 5%)
  adding: content/images/gan_output_epoch_50.png (deflated 6%)
  adding: content/images/gan_output_epoch_45.png (deflated 6%)
  adding: content/images/gan_output_epoch_10.png (deflated 4%)
  adding: content/images/gan_output_epoch_25.png (deflated 5%)
  adding: content/images/gan_output_epoch_35.png (deflated 6%)
  adding: content/images/gan_output_epoch_5.png (deflated 4%)
  adding: content/images/gan_output_epoch_40.png (deflated 6%)
  adding: content/images/gan_output_epoch_30.png (deflated 6%)
  adding: content/images/gan_output_epoch_20.png (deflated 5%)
```

In [0]:

```
#from google.colab import files
#files.download('images.zip')
```

In [19]:

```
plt.plot(d_losses,label="Disc")
plt.plot(g_losses,label="Gen")
plt.legend()
plt.show()
```



In [0]: