In [1]:

```
%matplotlib inline
from matplotlib import pyplot as plt
import numpy as np
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import Sequential, layers
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Flatten, Dense
from tensorflow.keras.utils import to_categorical
```

In [2]:

```
import glob
import os
import PIL
import time

from IPython import display
```

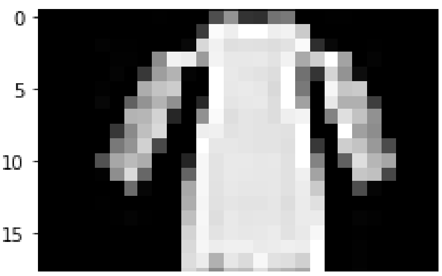
In [3]:

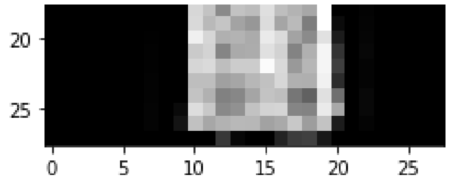
```
fashion_mnist = keras.datasets.fashion_mnist

(train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()

print(train_images.shape, train_labels.shape, '\n')

# set random seed
np.random.seed(42)
trainsize = 10000  # number of training images we use, selected randomly
randtrain = np.random.choice(train_images.shape[0], trainsize, replace=False)
train_images, train_labels = train_images[randtrain], train_labels[randtrain]

print(train_images.shape, train_labels.shape)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-l
abels-idx1-ubyte.gz
29515/29515 [==============================] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/train-i
mages-idx3-ubyte.gz
26421880/26421880 [==============================] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-la
bels-idx1-ubyte.gz
5148/5148 [==============================] - 0s 0us/step
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/t10k-im
ages-idx3-ubyte.gz
4422102/4422102 [==============================] - 0s 0us/step
(60000, 28, 28) (60000,)

(10000, 28, 28) (10000,)
```

In [4]:

```
# demonstrate an image
plt.figure()
plt.imshow(train_images[10])
plt.imshow(train_images[10], cmap='gray')
plt.show()
```





In [5]:

```
train_images = train_images.reshape(train_images.shape[0], 28, 28, 1).astype('float32')
train_images = (train_images - 127.5) / 127.5 # Normalize the images to [-1, 1]

BUFFER_SIZE = trainsize
BATCH_SIZE = 100
g_loss = []
d_loss = []

# Batch and shuffle the data
train_dataset = tf.data.Dataset.from_tensor_slices(train_images).shuffle(BUFFER_SIZE).ba
tch(BATCH_SIZE)
```

In [6]:

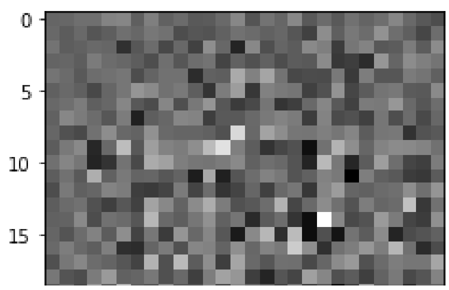
```
def make_generator_model():
    model = tf.keras.Sequential()
    model.add(layers.Dense(7*7*256, use_bias=False, input_shape=(100,)))
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Reshape((7, 7, 256)))
    assert model.output_shape == (None, 7, 7, 256) # Note: None is the batch size

    model.add(layers.Conv2DTranspose(128, (5, 5), strides=(1, 1), padding='same', use_bi
as=False))
    assert model.output_shape == (None, 7, 7, 128)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(64, (5, 5), strides=(2, 2), padding='same', use_bia
s=False))
    assert model.output_shape == (None, 14, 14, 64)
    model.add(layers.BatchNormalization())
    model.add(layers.LeakyReLU())

    model.add(layers.Conv2DTranspose(1, (5, 5), strides=(2, 2), padding='same', use_bias
=False, activation='tanh'))
    assert model.output_shape == (None, 28, 28, 1)

    return model
```

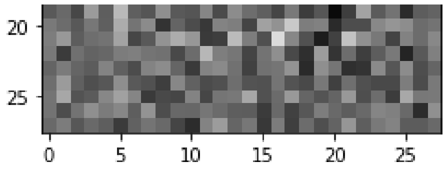
In [7]:

```
generator = make_generator_model()

noise = tf.random.normal([1, 100])
generated_image = generator(noise, training=False)

plt.imshow(generated_image[0, :, :, 0], cmap='gray')
```

Out[7]:

```
<matplotlib.image.AxesImage at 0x7ff5603ff550>
```





In [8]:

```
def make_discriminator_model():
    model = tf.keras.Sequential()
    model.add(layers.Conv2D(64, (5, 5), strides=(2, 2), padding='same',
                                     input_shape=[28, 28, 1]))
    model.add(layers.LeakyReLU())
    model.add(layers.Dropout(0.3))

    model.add(layers.Conv2D(128, (5, 5), strides=(2, 2), padding='same'))
    model.add(layers.LeakyReLU())
    model.add(layers.Dropout(0.3))

    model.add(layers.Flatten())
    model.add(layers.Dense(1))

    return model
```

In [9]:

```
discriminator = make_discriminator_model()
decision = discriminator(generated_image)
print (decision)
```

```
tf.Tensor([[-0.00055553]], shape=(1, 1), dtype=float32)
```

In [10]:

```
# This method returns a helper function to compute cross entropy loss
cross_entropy = tf.keras.losses.BinaryCrossentropy(from_logits=True)
```

In [11]:

```
def discriminator_loss(real_output, fake_output, d_loss):
    real_loss = cross_entropy(tf.ones_like(real_output), real_output)
    fake_loss = cross_entropy(tf.zeros_like(fake_output), fake_output)
    total_loss = real_loss + fake_loss
    d_loss.append(total_loss)
    return total_loss
```

In [12]:

```
def generator_loss(fake_output, g_loss):
    fake_loss = cross_entropy(tf.ones_like(fake_output), fake_output)
    g_loss.append(fake_loss)
    return fake_loss
```

In [13]:

```
generator_optimizer = tf.keras.optimizers.Adam(1e-4)
discriminator_optimizer = tf.keras.optimizers.Adam(1e-4)
```

In [14]:

```
checkpoint_dir = './training_checkpoints'
checkpoint_prefix = os.path.join(checkpoint_dir, "ckpt")
checkpoint = tf.train.Checkpoint(generator_optimizer=generator_optimizer,
                                 discriminator_optimizer=discriminator_optimizer,
                                 generator=generator,
                                 discriminator=discriminator)
```

In [28]:

```
EPOCHS = 100
```

```
noise_dim = 100
num_examples_to_generate = 4

# We will reuse this seed overtime (so it's easier)
# to visualize progress in the animated GIF)
seed = tf.random.normal([num_examples_to_generate, noise_dim])
```

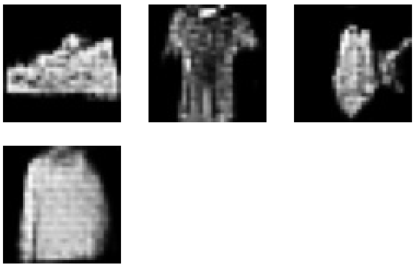
In [29]:

```
# Notice the use of `tf.function`
# This annotation causes the function to be "compiled".
# @tf.function
def train_step(images):
    noise = tf.random.normal([BATCH_SIZE, noise_dim])

    with tf.GradientTape() as gen_tape, tf.GradientTape() as disc_tape:
      generated_images = generator(noise, training=True)

      real_output = discriminator(images, training=True)
      fake_output = discriminator(generated_images, training=True)

      gen_loss = generator_loss(fake_output, g_loss)
      disc_loss = discriminator_loss(real_output, fake_output, d_loss)

    gradients_of_generator = gen_tape.gradient(gen_loss, generator.trainable_variables)
    gradients_of_discriminator = disc_tape.gradient(disc_loss, discriminator.trainable_va
riables)

    generator_optimizer.apply_gradients(zip(gradients_of_generator, generator.trainable_v
ariables))
    discriminator_optimizer.apply_gradients(zip(gradients_of_discriminator, discriminator
.trainable_variables))


def train(dataset, epochs):
  for epoch in range(epochs):
    start = time.time()

    for image_batch in dataset:
      train_step(image_batch)

    # Produce images for the GIF as we go
    display.clear_output(wait=True)
    generate_and_save_images(generator,
                             epoch + 1,
                             seed)

    # Save the model every 15 epochs
    if (epoch + 1) % 15 == 0:
      checkpoint.save(file_prefix = checkpoint_prefix)

    print ('Time for epoch {} is {} sec'.format(epoch + 1, time.time()-start))

  # Generate after the final epoch
  display.clear_output(wait=True)
  generate_and_save_images(generator,
                           epochs,
                           seed)


def generate_and_save_images(model, epoch, test_input):
  # Notice `training` is set to False.
  # This is so all layers run in inference mode (batchnorm).
  predictions = model(test_input, training=False)

  fig = plt.figure(figsize=(4,4))

  for i in range(predictions.shape[0]):
      plt.subplot(3, 3, i+1)
      plt.imshow(predictions[i, :, :, 0] * 127.5 + 127.5, cmap='gray')
      plt.axis('off')
```

```
  plt.savefig('image_at_epoch_{:04d}.png'.format(epoch))
  plt.show()
```

In [30]:

```
train(train_dataset, EPOCHS)
```



In [31]:

```
checkpoint.restore(tf.train.latest_checkpoint(checkpoint_dir))
```

Out[31]:

```
<tensorflow.python.training.tracking.util.CheckpointLoadStatus at 0x7ff4d0377a90>
```

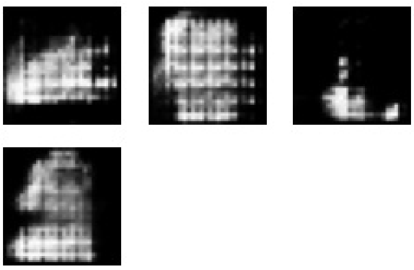
In [32]:

```
# Display a single image using the epoch number
def display_image(epoch_no):
  return PIL.Image.open('image_at_epoch_{:04d}.png'.format(epoch_no))
```

In [40]:

```
display_image(1)
```

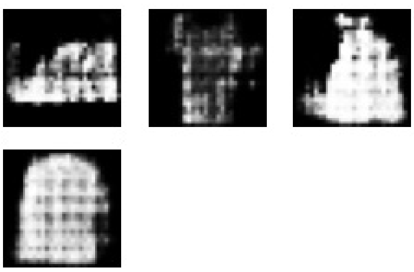
Out[40]:



In [38]:

```
display_image(20)
```

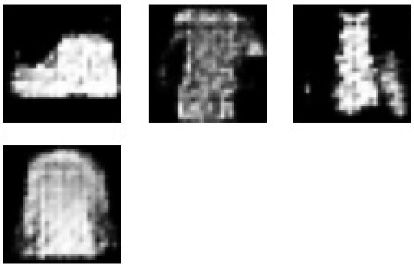
Out[38]:



In [34]:

```
display_image(40)
```

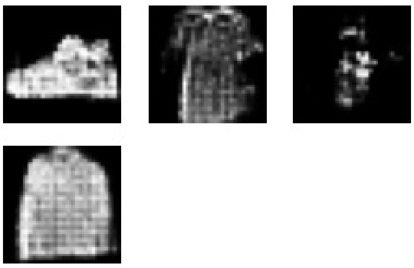
Out[34]:



In [35]:

```
display_image(60)
```

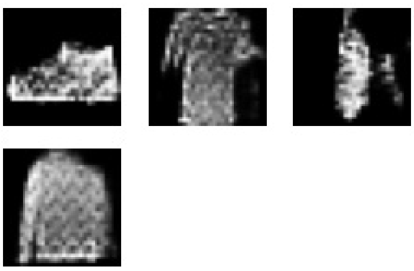
Out[35]:



In [36]:

```
display_image(80)
```

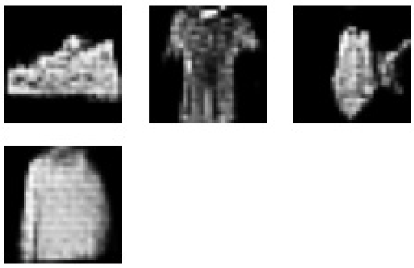
Out[36]:



In [37]:

```
display_image(100)
```

Out[37]:

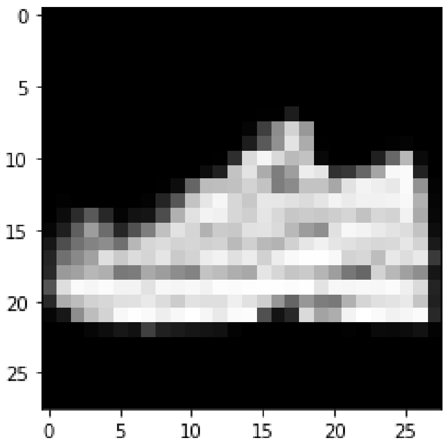


In [124]:

```
# generate a new image from the trained generator
noi = tf.random.normal([1, 100])
sample = checkpoint.generator(noi, training=False)
plt.imshow(sample[0, :, :, 0], cmap='gray')
```

Out[124]:

```
<matplotlib.image.AxesImage at 0x7ff4451507d0>
```



In [125]:

```
# detect the image using the trained discriminator
val = checkpoint.discriminator(sample)
print (val)
```

```
tf.Tensor([[-0.3878896]], shape=(1, 1), dtype=float32)
```