In [5]:
```
import keras
from keras import layers

# This is the size of our encoded representations
encoding_dim = 32  # 32 floats -> compression of factor 24.5, assuming the

# This is our input image
input_img = keras.Input(shape=(784,))
# "encoded" is the encoded representation of the input
encoded = layers.Dense(encoding_dim, activation='relu')(input_img)
# "decoded" is the lossy reconstruction of the input
decoded = layers.Dense(784, activation='sigmoid')(encoded)

# This model maps an input to its reconstruction
autoencoder = keras.Model(input_img, decoded)
```

In [6]:
```
encoder = keras.Model(input_img, encoded)
```

In [7]:
```
# This is our encoded (32-dimensional) input
encoded_input = keras.Input(shape=(encoding_dim,))
# Retrieve the last layer of the autoencoder model
decoder_layer = autoencoder.layers[-1]
# Create the decoder model
decoder = keras.Model(encoded_input, decoder_layer(encoded_input))
```

In [8]:
```
autoencoder.compile(optimizer='adam', loss='binary_crossentropy')
```

In [9]:
```
from keras.datasets import mnist
import numpy as np
(x_train, _), (x_test, _) = mnist.load_data()
```

In [10]:
```
x_train = x_train.astype('float32') / 255.
x_test = x_test.astype('float32') / 255.
x_train = x_train.reshape((len(x_train), np.prod(x_train.shape[1:])))
x_test = x_test.reshape((len(x_test), np.prod(x_test.shape[1:])))
print(x_train.shape)
print(x_test.shape)
```

```
(60000, 784)
(10000, 784)
```

In [11]:
```
autoencoder.fit(x_train, x_train,
                epochs=50,
                batch_size=256,
                shuffle=True,
                validation_data=(x_test, x_test))
```

```
Epoch 1/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 5s 12ms/step - loss: 0.3858 - val_loss: 0.190
4
Epoch 2/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.1797 - val_loss: 0.153
5
Epoch 3/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.1495 - val_loss: 0.134
4
Epoch 4/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.1324 - val_loss: 0.122
4
Epoch 5/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 14ms/step - loss: 0.1217 - val_loss: 0.113
9
Epoch 6/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 13ms/step - loss: 0.1135 - val_loss: 0.107
5
Epoch 7/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.1073 - val_loss: 0.102
6
Epoch 8/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.1030 - val_loss: 0.099
2
Epoch 9/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0998 - val_loss: 0.097
0
Epoch 10/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0978 - val_loss: 0.095
6
Epoch 11/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0965 - val_loss: 0.094
7
Epoch 12/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0955 - val_loss: 0.094
1
Epoch 13/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0952 - val_loss: 0.093
6
Epoch 14/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0947 - val_loss: 0.093
3
Epoch 15/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0944 - val_loss: 0.093
1
Epoch 16/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0943 - val_loss: 0.092
9
Epoch 17/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0941 - val_loss: 0.092
8
Epoch 18/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0940 - val_loss: 0.092
6
Epoch 19/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0939 - val_loss: 0.092
5
Epoch 20/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0937 - val_loss: 0.092
4
Epoch 21/50
```

```
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0936 - val_loss: 0.092
4
Epoch 22/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.0936 - val_loss: 0.092
3
Epoch 23/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0935 - val_loss: 0.092
2
Epoch 24/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0933 - val_loss: 0.092
2
Epoch 25/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0931 - val_loss: 0.092
2
Epoch 26/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0933 - val_loss: 0.092
1
Epoch 27/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0932 - val_loss: 0.092
1
Epoch 28/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0933 - val_loss: 0.092
1
Epoch 29/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0930 - val_loss: 0.092
0
Epoch 30/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 5s 11ms/step - loss: 0.0931 - val_loss: 0.091
9
Epoch 31/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0930 - val_loss: 0.092
0
Epoch 32/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0929 - val_loss: 0.091
9
Epoch 33/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0929 - val_loss: 0.091
8
Epoch 34/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0931 - val_loss: 0.091
8
Epoch 35/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0930 - val_loss: 0.091
8
Epoch 36/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.0930 - val_loss: 0.091
8
Epoch 37/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0928 - val_loss: 0.091
8
Epoch 38/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0930 - val_loss: 0.091
8
Epoch 39/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0928 - val_loss: 0.091
8
Epoch 40/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0927 - val_loss: 0.091
7
Epoch 41/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0931 - val_loss: 0.091
```

```
7
Epoch 42/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0927 - val_loss: 0.091
7
Epoch 43/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0928 - val_loss: 0.091
6
Epoch 44/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0927 - val_loss: 0.091
7
Epoch 45/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0926 - val_loss: 0.091
7
Epoch 46/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0927 - val_loss: 0.091
8
Epoch 47/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0927 - val_loss: 0.091
6
Epoch 48/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0928 - val_loss: 0.091
7
Epoch 49/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0926 - val_loss: 0.091
6
Epoch 50/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.0927 - val_loss: 0.091
6
```

Out[11]:

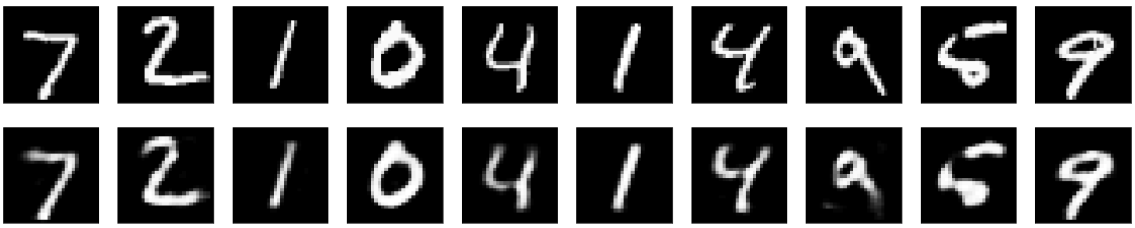
```
<keras.src.callbacks.history.History at 0x1e504a3ea60>
```

In [12]:

```
encoded_imgs = encoder.predict(x_test)
decoded_imgs = decoder.predict(encoded_imgs)
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
```

In [13]:
```
import matplotlib.pyplot as plt

n = 10  # How many digits we will display
plt.figure(figsize=(20, 4))
for i in range(n):
    # Display original
    ax = plt.subplot(2, n, i + 1)
    plt.imshow(x_test[i].reshape(28, 28))
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)

    # Display reconstruction
    ax = plt.subplot(2, n, i + 1 + n)
    plt.imshow(decoded_imgs[i].reshape(28, 28))
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)
plt.show()
```



In [14]:
```
from keras import regularizers

encoding_dim = 32

input_img = keras.Input(shape=(784,))
# Add a Dense layer with a L1 activity regularizer
encoded = layers.Dense(encoding_dim, activation='relu',
                activity_regularizer=regularizers.l1(10e-5))(input_img)
decoded = layers.Dense(784, activation='sigmoid')(encoded)

autoencoder = keras.Model(input_img, decoded)
```

In [15]:
```
autoencoder.compile(optimizer='adam', loss='binary_crossentropy')
```

In [16]:
```
autoencoder.fit(x_train, x_train, epochs=50, batch_size=256, shuffle=True,
```

```
Epoch 1/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 5s 11ms/step - loss: 0.6846 - val_loss: 0.615
5
Epoch 2/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.5987 - val_loss: 0.553
5
Epoch 3/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 9ms/step - loss: 0.5397 - val_loss: 0.5038
Epoch 4/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 9ms/step - loss: 0.4926 - val_loss: 0.4638
Epoch 5/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.4550 - val_loss: 0.431
4
Epoch 6/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 9ms/step - loss: 0.4235 - val_loss: 0.4050
Epoch 7/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3988 - val_loss: 0.383
4
Epoch 8/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3785 - val_loss: 0.365
6
Epoch 9/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3615 - val_loss: 0.350
8
Epoch 10/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.3470 - val_loss: 0.338
5
Epoch 11/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3357 - val_loss: 0.328
1
Epoch 12/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3253 - val_loss: 0.319
4
Epoch 13/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3171 - val_loss: 0.312
0
Epoch 14/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3105 - val_loss: 0.305
6
Epoch 15/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.3040 - val_loss: 0.300
2
Epoch 16/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2991 - val_loss: 0.295
5
Epoch 17/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2945 - val_loss: 0.291
5
Epoch 18/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 10ms/step - loss: 0.2907 - val_loss: 0.288
0
Epoch 19/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2869 - val_loss: 0.285
0
Epoch 20/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2843 - val_loss: 0.282
3
Epoch 21/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2815 - val_loss: 0.280
0
Epoch 22/50
```

```
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2795 - val_loss: 0.278
0
Epoch 23/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2775 - val_loss: 0.276
2
Epoch 24/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2756 - val_loss: 0.274
6
Epoch 25/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2747 - val_loss: 0.273
3
Epoch 26/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.2735 - val_loss: 0.272
1
Epoch 27/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.2718 - val_loss: 0.271
0
Epoch 28/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2708 - val_loss: 0.270
0
Epoch 29/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 13ms/step - loss: 0.2702 - val_loss: 0.269
2
Epoch 30/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.2692 - val_loss: 0.268
5
Epoch 31/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2685 - val_loss: 0.267
8
Epoch 32/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2679 - val_loss: 0.267
2
Epoch 33/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.2673 - val_loss: 0.266
7
Epoch 34/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.2667 - val_loss: 0.266
2
Epoch 35/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 10ms/step - loss: 0.2668 - val_loss: 0.265
8
Epoch 36/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2657 - val_loss: 0.265
5
Epoch 37/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2652 - val_loss: 0.265
2
Epoch 38/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 12ms/step - loss: 0.2654 - val_loss: 0.264
9
Epoch 39/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2648 - val_loss: 0.264
6
Epoch 40/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2649 - val_loss: 0.264
4
Epoch 41/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2650 - val_loss: 0.264
2
Epoch 42/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2642 - val_loss: 0.264
```

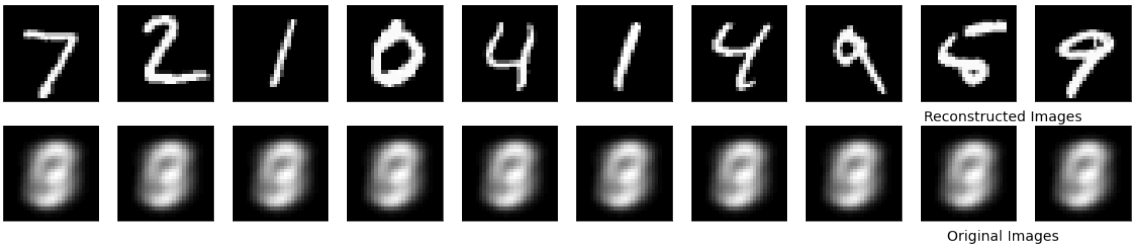
```
0
Epoch 43/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2643 - val_loss: 0.263
8
Epoch 44/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 11ms/step - loss: 0.2640 - val_loss: 0.263
7
Epoch 45/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2641 - val_loss: 0.263
6
Epoch 46/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2636 - val_loss: 0.263
5
Epoch 47/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2636 - val_loss: 0.263
4
Epoch 48/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 3s 10ms/step - loss: 0.2633 - val_loss: 0.263
3
Epoch 49/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2637 - val_loss: 0.263
2
Epoch 50/50
235/235 ━━━━━━━━━━━━━━━━━━━━ 2s 10ms/step - loss: 0.2634 - val_loss: 0.263
1
```

Out[16]:

```
<keras.src.callbacks.history.History at 0x1e5131d2f40>
```

In [18]:
```
decoded_imgs = autoencoder.predict(x_test)

# Set the number of images you want to display
n = 10
plt.figure(figsize=(20, 4))

for i in range(n):
    # Display original images
    ax = plt.subplot(2, n, i + 1)
    plt.imshow(x_test[i].reshape(28, 28))  # Assuming x_test is reshaped to
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)

    # Display reconstructed images
    ax = plt.subplot(2, n, i + 1 + n)
    plt.imshow(decoded_imgs[i].reshape(28, 28))  # Reshape decoded images t
    plt.gray()
    ax.get_xaxis().set_visible(False)
    ax.get_yaxis().set_visible(False)

# Adding labels for the two rows
plt.text(-10, 30, 'Original Images', fontsize=14, ha='center', va='top')
plt.text(-10, -5, 'Reconstructed Images', fontsize=14, ha='center', va='top

plt.show()
```

```
313/313 ━━━━━━━━━━━━━━━━━━━━ 1s 3ms/step
```



In [ ]: