

Import the necessary packages

In [10]:

```
import matplotlib.pyplot as plt
from keras.utils import np_utils
from tensorflow.keras.datasets import mnist
```

Load the data

In [2]:

```
(X_train, y_train), (X_test, y_test) = mnist.load_data()
```

Data Analysis

In [3]:

```
print(X_train.shape)
print(X_test.shape)
```

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

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

In [4]:

```
X_train[0]
```

Out[4]:

```
array([[ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
        18, 18, 18, 126, 136, 175, 26, 166, 255, 247, 127,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0, 30, 36, 94, 154, 170,
        253, 253, 253, 253, 253, 225, 172, 253, 242, 195, 64,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0, 49, 238, 253, 253, 253, 253,
        253, 253, 253, 253, 251, 93, 82, 82, 56, 39,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0, 18, 219, 253, 253, 253, 253,
        253, 198, 182, 247, 241,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0, 80, 156, 107, 253, 253,
        205, 11,  0, 43, 154,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0, 14,  1, 154, 253,
         90,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
         0,  0],
       [ 0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0, 139, 253,
        190, 2,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,  0,
```

```

0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 11, 190,
253, 70, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 35,
241, 225, 160, 108, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
81, 240, 253, 253, 119, 25, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 45, 186, 253, 253, 150, 27, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 16, 93, 252, 253, 187, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 249, 253, 249, 64, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 46, 130, 183, 253, 253, 207, 2, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 39,
148, 229, 253, 253, 253, 250, 182, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 24, 114, 221,
253, 253, 253, 253, 201, 78, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 23, 66, 213, 253, 253,
253, 253, 198, 81, 2, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 18, 171, 219, 253, 253, 253, 253,
195, 80, 9, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 55, 172, 226, 253, 253, 253, 253, 244, 133,
11, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 136, 253, 253, 253, 212, 135, 132, 16, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0],
[ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0,
0, 0]], dtype=uint8)

```

In [5]:

```
y_train[0]
```

Out[5]:

5

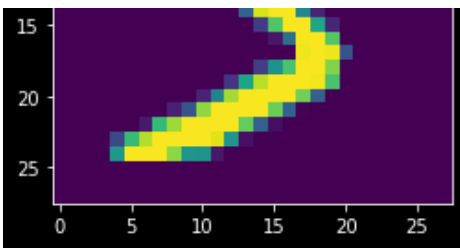
In [7]:

```
plt.imshow(X_train[0])
```

Out[7]:

<matplotlib.image.AxesImage at 0x299039b90f0>





Data Pre-Processing

In [8]:

```
X_train = X_train.reshape(60000, 28, 28, 1).astype('float32')
X_test = X_test.reshape(10000, 28, 28, 1).astype('float32')
```

In [11]:

```
number_of_classes = 10
Y_train = np_utils.to_categorical(y_train, number_of_classes)
Y_test = np_utils.to_categorical(y_test, number_of_classes)
```

In [12]:

```
Y_train[0]
```

Out[12]:

```
array([0., 0., 0., 0., 0., 1., 0., 0., 0., 0.], dtype=float32)
```