In [1]:

```python
import numpy as np
import torch
import torchvision
import torchvision.transforms as transforms
import torch.nn as nn
import torch.nn.functional as F
import torch.optim as optim

import matplotlib.pyplot as plt
%matplotlib inline
```

Load and normalize the MNIST dataset (images of hand written digits)

In [2]:

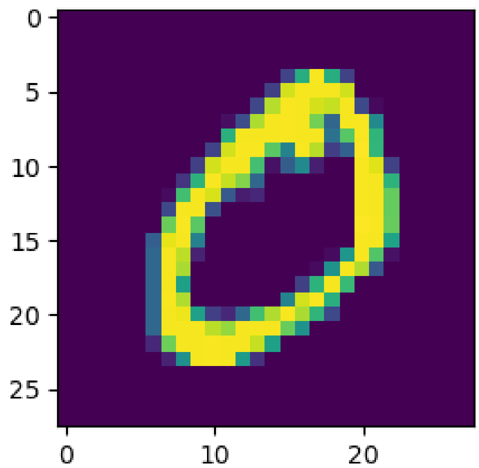
```python
trans = transforms.Compose([transforms.ToTensor(), transforms.Normalize((0.1307,), (0.3081,))])
# if not exist, download mnist dataset
train_set = torchvision.datasets.MNIST(root='./data', train=True, transform=trans, download=True)
test_set = torchvision.datasets.MNIST(root='./data', train=False, transform=trans, download=True)

print(train_set.data.shape)
print(test_set.data.shape)

batch_size = 60

train_loader = torch.utils.data.DataLoader(
                 dataset=train_set,
                 batch_size=batch_size,
                 shuffle=True)
test_loader = torch.utils.data.DataLoader(
                dataset=test_set,
                batch_size=batch_size,
                shuffle=False)
```

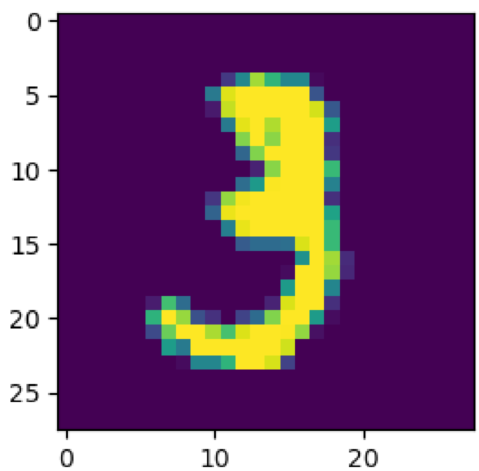
```
torch.Size([60000, 28, 28])
torch.Size([10000, 28, 28])
```

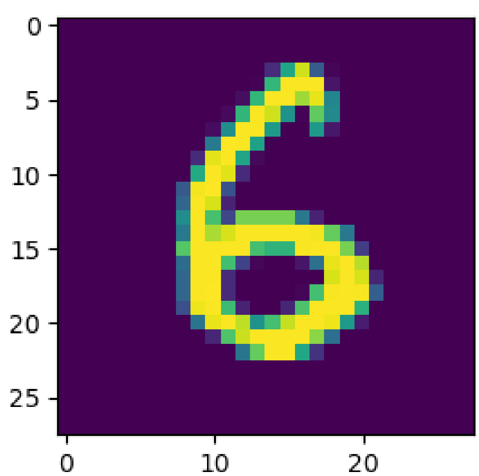
Visualizing sample images

In [3]:

```python
plt.figure(figsize=(3, 3))
plt.imshow(train_set.data[1,:,:])
plt.show()
plt.figure(figsize=(3, 3))
plt.imshow(train_set.data[10,:,:])
plt.show()
plt.figure(figsize=(3, 3))
plt.imshow(train_set.data[106,:,:])
plt.show()
```







Define the neural network

In [4]:
```
class Network(nn.Module):

    def __init__(self,input_size,hidden_size,output_size):
        super(Network, self).__init__()
        self.l1 = nn.Linear(input_size, hidden_size)
        self.l2 = nn.Linear(hidden_size, hidden_size)
        self.l3 = nn.Linear(hidden_size, output_size)

    def forward(self, x):
        x = self.l1(x)
        x = F.relu(x)
```

```python
        x = self.l2(x)
        x = F.relu(x)
        x = self.l3(x)
        return x
```

In [5]:

```python
input_size = 28*28
hidden_size = 200
output_size = 10

net = Network(input_size,hidden_size,output_size)
print(net)
```

```
Network(
  (l1): Linear(in_features=784, out_features=200, bias=True)
  (l2): Linear(in_features=200, out_features=200, bias=True)
  (l3): Linear(in_features=200, out_features=10, bias=True)
)
```

In [6]:

```python
for name, p in net.named_parameters():
    print(name,',',p.size(),type(p))
```

```
l1.weight , torch.Size([200, 784]) <class 'torch.nn.parameter.Parameter'>
l1.bias , torch.Size([200]) <class 'torch.nn.parameter.Parameter'>
l2.weight , torch.Size([200, 200]) <class 'torch.nn.parameter.Parameter'>
l2.bias , torch.Size([200]) <class 'torch.nn.parameter.Parameter'>
l3.weight , torch.Size([10, 200]) <class 'torch.nn.parameter.Parameter'>
l3.bias , torch.Size([10]) <class 'torch.nn.parameter.Parameter'>
```

Training

In [7]:

```python
learning_rate = 0.1

optimizer = optim.SGD(net.parameters(), lr=learning_rate, momentum=0.9)
criterion = nn.CrossEntropyLoss()
```

In [8]:

```python
epochs = 2
loss_log = []

for epoch in range(epochs):
    # trainning
    for batch_idx, (x, target) in enumerate(train_loader):
        optimizer.zero_grad()
        x = x.view(-1,28*28)
        out = net(x)
        loss = criterion(out, target)
        loss.backward()
        optimizer.step()

        if (batch_idx) % 100 == 0:
            print('==>>> epoch: {}, batch index: {}, train loss: {:.6f}'.format(
                epoch, batch_idx, loss.item()))
```

```
==>>> epoch: 0, batch index: 0, train loss: 2.298910
==>>> epoch: 0, batch index: 100, train loss: 0.565800
==>>> epoch: 0, batch index: 200, train loss: 0.210814
==>>> epoch: 0, batch index: 300, train loss: 0.199449
==>>> epoch: 0, batch index: 400, train loss: 0.044163
==>>> epoch: 0, batch index: 500, train loss: 0.278131
==>>> epoch: 0, batch index: 600, train loss: 0.257529
==>>> epoch: 0, batch index: 700, train loss: 0.140273
==>>> epoch: 0, batch index: 800, train loss: 0.261669
==>>> epoch: 0, batch index: 900, train loss: 0.291870
==>>> epoch: 1, batch index: 0, train loss: 0.473041
==>>> epoch: 1, batch index: 100, train loss: 0.190254
==>>> epoch: 1, batch index: 200, train loss: 0.178370
==>>> epoch: 1, batch index: 300, train loss: 0.198735
==>>> epoch: 1, batch index: 400, train loss: 0.263687
==>>> epoch: 1, batch index: 500, train loss: 0.160736
==>>> epoch: 1, batch index: 600, train loss: 0.149622
==>>> epoch: 1, batch index: 700, train loss: 0.036301
==>>> epoch: 1, batch index: 800, train loss: 0.278597
==>>> epoch: 1, batch index: 900, train loss: 0.190922
```

Testing

In [11]:

```python
with torch.no_grad():
    correct = 0
    total = 0
    for images, labels in test_loader:
        images = images.reshape(-1, 28*28)
        outputs = net(images)
        _, predicted = torch.max(outputs.data, 1)
        total += labels.size(0)
        correct += (predicted == labels).sum().item()

    print('Accuracy of the network on the 10000 test images: {} %'.format(100 * correct / total))
```

```
Accuracy of the network on the 10000 test images: 93.79 %
```

In [ ]: