```
1  # Using AlexNet Model for FashinMNIST
```

```
1  import torch
2  !pip install d2l==1.0.0a0
```

```
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.8/dist-packages (from requests->d2l==1.0.0a0) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.8/dist-packages (from requests->d2l==1.0.0a0) (2022.12.
Requirement already satisfied: chardet<5,>=3.0.2 in /usr/local/lib/python3.8/dist-packages (from requests->d2l==1.0.0a0) (4.0.0)
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.8/dist-packages (from importlib-metadata>=4.8.0->gym->d2l==1.0.0
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.8/dist-packages (from python-dateutil>=2.1->matplotlib->d2l==1.0.
Requirement already satisfied: jupyter-client in /usr/local/lib/python3.8/dist-packages (from ipykernel->jupyter->d2l==1.0.0a0) (6.
Requirement already satisfied: tornado>=4.2 in /usr/local/lib/python3.8/dist-packages (from ipykernel->jupyter->d2l==1.0.0a0) (6.2)
Requirement already satisfied: traitlets>=4.1.0 in /usr/local/lib/python3.8/dist-packages (from ipykernel->jupyter->d2l==1.0.0a0) (
Requirement already satisfied: ipython>=5.0.0 in /usr/local/lib/python3.8/dist-packages (from ipykernel->jupyter->d2l==1.0.0a0) (7.
Requirement already satisfied: widgetsnbextension~=3.6.0 in /usr/local/lib/python3.8/dist-packages (from ipywidgets->jupyter->d2l==
Requirement already satisfied: jupyterlab-widgets>=1.0.0 in /usr/local/lib/python3.8/dist-packages (from ipywidgets->jupyter->d2l==
Requirement already satisfied: ipython-genutils~=0.2.0 in /usr/local/lib/python3.8/dist-packages (from ipywidgets->jupyter->d2l==1.
Requirement already satisfied: pygments in /usr/local/lib/python3.8/dist-packages (from jupyter-console->jupyter->d2l==1.0.0a0) (2.
Requirement already satisfied: prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0 in /usr/local/lib/python3.8/dist-packages (from jupyter
Requirement already satisfied: testpath in /usr/local/lib/python3.8/dist-packages (from nbconvert->jupyter->d2l==1.0.0a0) (0.6.0)
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Requirement already satisfied: bleach in /usr/local/lib/python3.8/dist-packages (from nbconvert->jupyter->d2l==1.0.0a0) (6.0.0)
Requirement already satisfied: pandocfilters>=1.4.1 in /usr/local/lib/python3.8/dist-packages (from nbconvert->jupyter->d2l==1.0.0a
Requirement already satisfied: defusedxml in /usr/local/lib/python3.8/dist-packages (from nbconvert->jupyter->d2l==1.0.0a0) (0.7.1)
Requirement already satisfied: entrypoints>=0.2.2 in /usr/local/lib/python3.8/dist-packages (from nbconvert->jupyter->d2l==1.0.0a0)
Requirement already satisfied: nbformat>=4.4 in /usr/local/lib/python3.8/dist-packages (from nbconvert->jupyter->d2l==1.0.0a0) (5.7
Requirement already satisfied: jupyter-core in /usr/local/lib/python3.8/dist-packages (from nbconvert->jupyter->d2l==1.0.0a0) (5.2.
Requirement already satisfied: Send2Trash>=1.5.0 in /usr/local/lib/python3.8/dist-packages (from notebook->jupyter->d2l==1.0.0a0) (
Requirement already satisfied: terminado>=0.8.3 in /usr/local/lib/python3.8/dist-packages (from notebook->jupyter->d2l==1.0.0a0) (
Requirement already satisfied: argon2-cffi in /usr/local/lib/python3.8/dist-packages (from notebook->jupyter->d2l==1.0.0a0) (21.3.0
Requirement already satisfied: prometheus-client in /usr/local/lib/python3.8/dist-packages (from notebook->jupyter->d2l==1.0.0a0) (
Requirement already satisfied: pyzmq>=17 in /usr/local/lib/python3.8/dist-packages (from notebook->jupyter->d2l==1.0.0a0) (23.2.1)
Collecting qtpy>=2.0.1
  Downloading QtPy-2.3.0-py3-none-any.whl (83 kB)
     ──────────────────────────────────── 83.6/83.6 KB 6.1 MB/s eta 0:00:00
Requirement already satisfied: pickleshare in /usr/local/lib/python3.8/dist-packages (from ipython>=5.0.0->ipykernel->jupyter->d2l=
Collecting jedi>=0.10
  Downloading jedi-0.18.2-py2.py3-none-any.whl (1.6 MB)
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Requirement already satisfied: decorator in /usr/local/lib/python3.8/dist-packages (from ipython>=5.0.0->ipykernel->jupyter->d2l==1
Requirement already satisfied: backcall in /usr/local/lib/python3.8/dist-packages (from ipython>=5.0.0->ipykernel->jupyter->d2l==1.
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Requirement already satisfied: MarkupSafe>=0.23 in /usr/local/lib/python3.8/dist-packages (from jinja2>=2.4->nbconvert->jupyter->d2
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Requirement already satisfied: wcwidth in /usr/local/lib/python3.8/dist-packages (from prompt-toolkit!=3.0.0,!=3.0.1,<3.1.0,>=2.0.0
Requirement already satisfied: packaging in /usr/local/lib/python3.8/dist-packages (from qtpy>=2.0.1->qtconsole->jupyter->d2l==1.0.
Requirement already satisfied: ptyprocess in /usr/local/lib/python3.8/dist-packages (from terminado>=0.8.3->notebook->jupyter->d2l=
Requirement already satisfied: argon2-cffi-bindings in /usr/local/lib/python3.8/dist-packages (from argon2-cffi->notebook->jupyter-
Requirement already satisfied: webencodings in /usr/local/lib/python3.8/dist-packages (from bleach->nbconvert->jupyter->d2l==1.0.0a
Requirement already satisfied: parso<0.9.0,>=0.8.0 in /usr/local/lib/python3.8/dist-packages (from jedi>=0.10->ipython>=5.0.0->ipyk
Requirement already satisfied: attrs>=17.4.0 in /usr/local/lib/python3.8/dist-packages (from jsonschema>=2.6->nbformat>=4.4->nbconv
Requirement already satisfied: importlib-resources>=1.4.0 in /usr/local/lib/python3.8/dist-packages (from jsonschema>=2.6->nbformat
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Requirement already satisfied: cffi>=1.0.1 in /usr/local/lib/python3.8/dist-packages (from argon2-cffi-bindings->argon2-cffi->noteb
Requirement already satisfied: pycparser in /usr/local/lib/python3.8/dist-packages (from cffi>=1.0.1->argon2-cffi-bindings->argon2-
Installing collected packages: qtpy, jedi, qtconsole, jupyter, d2l
Successfully installed d2l-1.0.0a0 jedi-0.18.2 jupyter-1.0.0 qtconsole-5.4.0 qtpy-2.3.0
```

```
1 !pip install matplotlib
2 %matplotlib inline
3 !pip install matplotlib-inline
4 import sys
5 !{sys.executable} -m pip install matplotlib
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Requirement already satisfied: matplotlib in /usr/local/lib/python3.8/dist-packages (3.2.2)
Requirement already satisfied: numpy>=1.11 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (1.21.6)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (0.11.0)
Requirement already satisfied: pyparsing!=2.0.4,!=2.1.2,!=2.1.6,>=2.0.1 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (3.0
Requirement already satisfied: python-dateutil>=2.1 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (2.8.2)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (1.4.4)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.8/dist-packages (from python-dateutil>=2.1->matplotlib) (1.15.0)
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting matplotlib-inline
  Downloading matplotlib_inline-0.1.6-py3-none-any.whl (9.4 kB)
```

```
Requirement already satisfied: traitlets in /usr/local/lib/python3.8/dist-packages (from matplotlib-inline) (5.7.1)
Installing collected packages: matplotlib-inline
Successfully installed matplotlib-inline-0.1.6
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Requirement already satisfied: matplotlib in /usr/local/lib/python3.8/dist-packages (3.2.2)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (0.11.0)
Requirement already satisfied: python-dateutil>=2.1 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (2.8.2)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (1.4.4)
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Requirement already satisfied: numpy>=1.11 in /usr/local/lib/python3.8/dist-packages (from matplotlib) (1.21.6)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.8/dist-packages (from python-dateutil>=2.1->matplotlib) (1.15.0)
```

```python
1 import time
2 import numpy as np
3 import torch
4 import torchvision
5 from torchvision import transforms
6 from torch import nn
7 from d2l import torch as d2l
8 from torch.optim import lr_scheduler
```

```python
1 def AlexNet(num_classes=10):
2     net = nn.Sequential(
3             nn.LazyConv2d(6, kernel_size=5, padding=1),
4             nn.ReLU(),
5             nn.MaxPool2d(kernel_size=3, stride=2),
6             nn.LazyConv2d(16, kernel_size=5, padding=2),
7             nn.ReLU(),
8             nn.MaxPool2d(kernel_size=3, stride=2),
9             nn.LazyConv2d(25, kernel_size=3, padding=1),
10            nn.ReLU(),
11            nn.LazyConv2d(35, kernel_size=3, padding=1),
12            nn.ReLU(),
13            nn.LazyConv2d(25, kernel_size=5, padding=1),
14            nn.ReLU(),
15            nn.MaxPool2d(kernel_size=3, stride=2),
16            nn.Flatten(),
17            nn.LazyLinear(256),
18            nn.ReLU(),
19            nn.Dropout(p=0.1),
20            nn.LazyLinear(64),
21            nn.ReLU(),
22            nn.Dropout(p=0.1),
23            nn.LazyLinear(num_classes))
24     return net
```

```python
1 print(net)
```

```
(denselayer22): _DenseLayer(
  (norm1): BatchNorm2d(2064, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (relu1): ReLU(inplace=True)
  (conv1): Conv2d(2064, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
  (norm2): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (relu2): ReLU(inplace=True)
  (conv2): Conv2d(192, 48, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
)
(denselayer23): _DenseLayer(
  (norm1): BatchNorm2d(2112, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (relu1): ReLU(inplace=True)
  (conv1): Conv2d(2112, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
  (norm2): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (relu2): ReLU(inplace=True)
  (conv2): Conv2d(192, 48, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
)
(denselayer24): _DenseLayer(
  (norm1): BatchNorm2d(2160, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (relu1): ReLU(inplace=True)
  (conv1): Conv2d(2160, 192, kernel_size=(1, 1), stride=(1, 1), bias=False)
  (norm2): BatchNorm2d(192, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
  (relu2): ReLU(inplace=True)
  (conv2): Conv2d(192, 48, kernel_size=(3, 3), stride=(1, 1), padding=(1, 1), bias=False)
)
)
(norm5): BatchNorm2d(2208, eps=1e-05, momentum=0.1, affine=True, track_running_stats=True)
)
(classifier): Linear(in_features=2208, out_features=1000, bias=True)
)
```

```
1 def train(model, train_loader, test_loader, num_epochs, loss_fn, trainer):
2
3     animator = d2l.Animator(xlabel='epoch', xlim=[0, num_epochs], legend=['train loss', 'train accuracy', 'test accuracy'])
4     for epoch in range(num_epochs):
5         metric = d2l.Accumulator(3)
6         for i, (X, y) in enumerate(train_loader):
7             net.train()
8             trainer.zero_grad()
9             y_hat = net(X)
10            l = loss_fn(y_hat, y)
11            l.backward()
12            trainer.step()
13            with torch.no_grad():
14                metric.add(l * X.shape[0], d2l.accuracy(y_hat, y), X.shape[0])
15            train_loss = metric[0] / metric[2]
16            train_acc = metric[1] / metric[2]
17            if (i + 1) % 50 == 0:
18                animator.add(epoch + i / len(train_loader),
19                             (train_loss, train_acc, None))
20
21        test_acc = d2l.evaluate_accuracy_gpu(model, test_loader)
22        animator.add(epoch+1, (None, None, test_acc))
23
24    print(f'train loss {train_loss:.3f}, train accuracy {train_acc:.3f}, 'f'test accuracy {test_acc:.3f}')
```

```
1 loss = nn.CrossEntropyLoss()
2 batch_size = 256
3 num_epochs = 10
4 lr=0.01
```
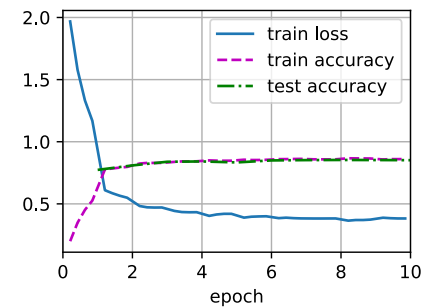
```
1 train_loader, test_loader = d2l.load_data_fashion_mnist(batch_size=batch_size)
2 net= AlexNet(num_classes=10)
3 trainer = torch.optim.Adam(net.parameters(), lr=lr)
```

```
1 train(net, train_loader, test_loader, num_epochs, loss, trainer)
```

train loss 0.381, train accuracy 0.861, test accuracy 0.852


```
1 # Measuring and comparing theoretical computation complexity (number of operations and parameters size)
```

```
1 pip install torchinfo
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting torchinfo
  Downloading torchinfo-1.7.2-py3-none-any.whl (22 kB)
Installing collected packages: torchinfo
Successfully installed torchinfo-1.7.2
```

```
1   from torchinfo import summary
2
3   model = AlexNet()
4   batch_size = 256
5   summary(model, input_size=(batch_size, 1, 28, 28))
```
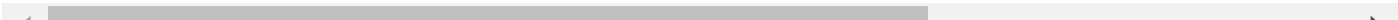
```
/usr/local/lib/python3.8/dist-packages/torch/nn/modules/lazy.py:180: UserWarning: Lazy modules are a new feature under heavy development
  warnings.warn('Lazy modules are a new feature under heavy development '
==========================================================================================
Layer (type:depth-idx)                   Output Shape              Param #
==========================================================================================
Sequential                               [256, 10]                 --
├─Conv2d: 1-1                            [256, 6, 26, 26]          156
├─ReLU: 1-2                             [256, 6, 26, 26]          --
├─MaxPool2d: 1-3                        [256, 6, 12, 12]          --
├─Conv2d: 1-4                           [256, 16, 12, 12]         2,416
├─ReLU: 1-5                             [256, 16, 12, 12]         --
├─MaxPool2d: 1-6                        [256, 16, 5, 5]           --
├─Conv2d: 1-7                           [256, 25, 5, 5]           3,625
├─ReLU: 1-8                             [256, 25, 5, 5]           --
├─Conv2d: 1-9                           [256, 35, 5, 5]           7,910
├─ReLU: 1-10                            [256, 35, 5, 5]           --
├─Conv2d: 1-11                          [256, 25, 3, 3]           21,900
├─ReLU: 1-12                            [256, 25, 3, 3]           --
├─MaxPool2d: 1-13                       [256, 25, 1, 1]           --
├─Flatten: 1-14                         [256, 25]                 --
├─Linear: 1-15                          [256, 256]                6,656
├─ReLU: 1-16                            [256, 256]                --
├─Dropout: 1-17                         [256, 256]                --
├─Linear: 1-18                          [256, 64]                 16,448
├─ReLU: 1-19                            [256, 64]                 --
├─Dropout: 1-20                         [256, 64]                 --
├─Linear: 1-21                          [256, 10]                 650
==========================================================================================
Total params: 59,761
Trainable params: 59,761
Non-trainable params: 0
Total mult-adds (M): 246.42
```

```
================================================================================
Input size (MB): 0.80
Forward/backward pass size (MB): 17.23
Params size (MB): 0.24
Estimated Total Size (MB): 18.28
================================================================================
```

1

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