Feedforward neural network (FNN)

CSE 472

Offline-3

Submitted by

Lara Khanom

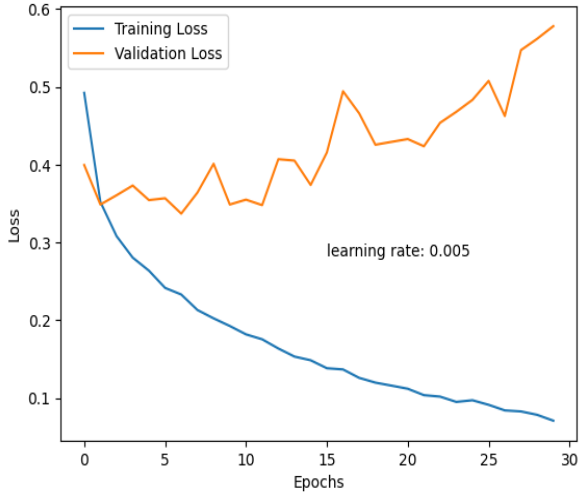
1905062

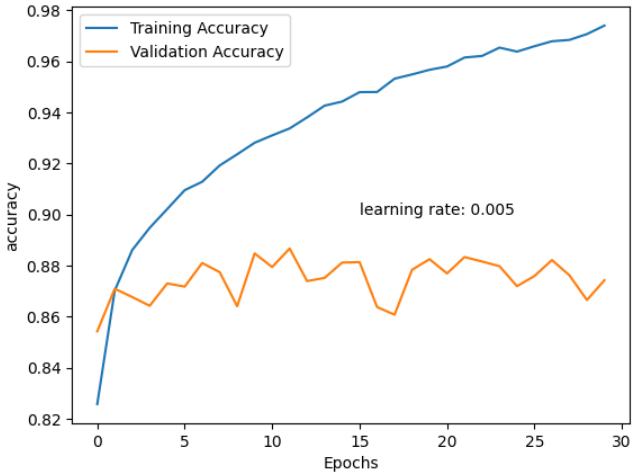
B1

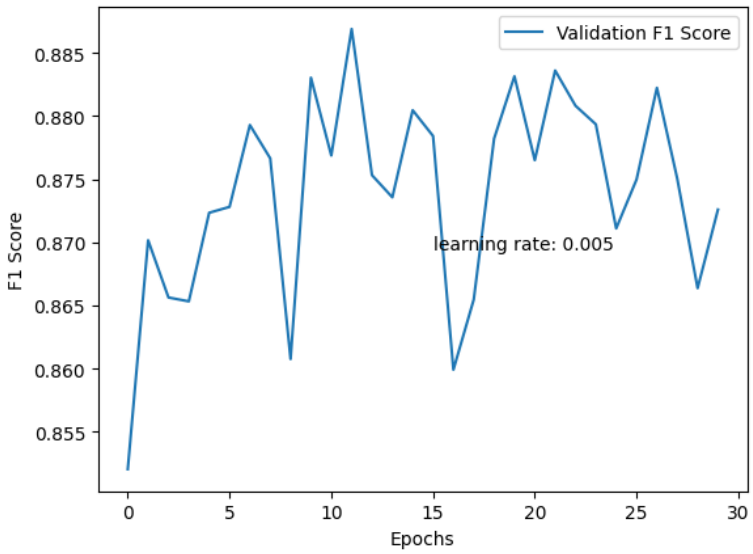
Model -1:

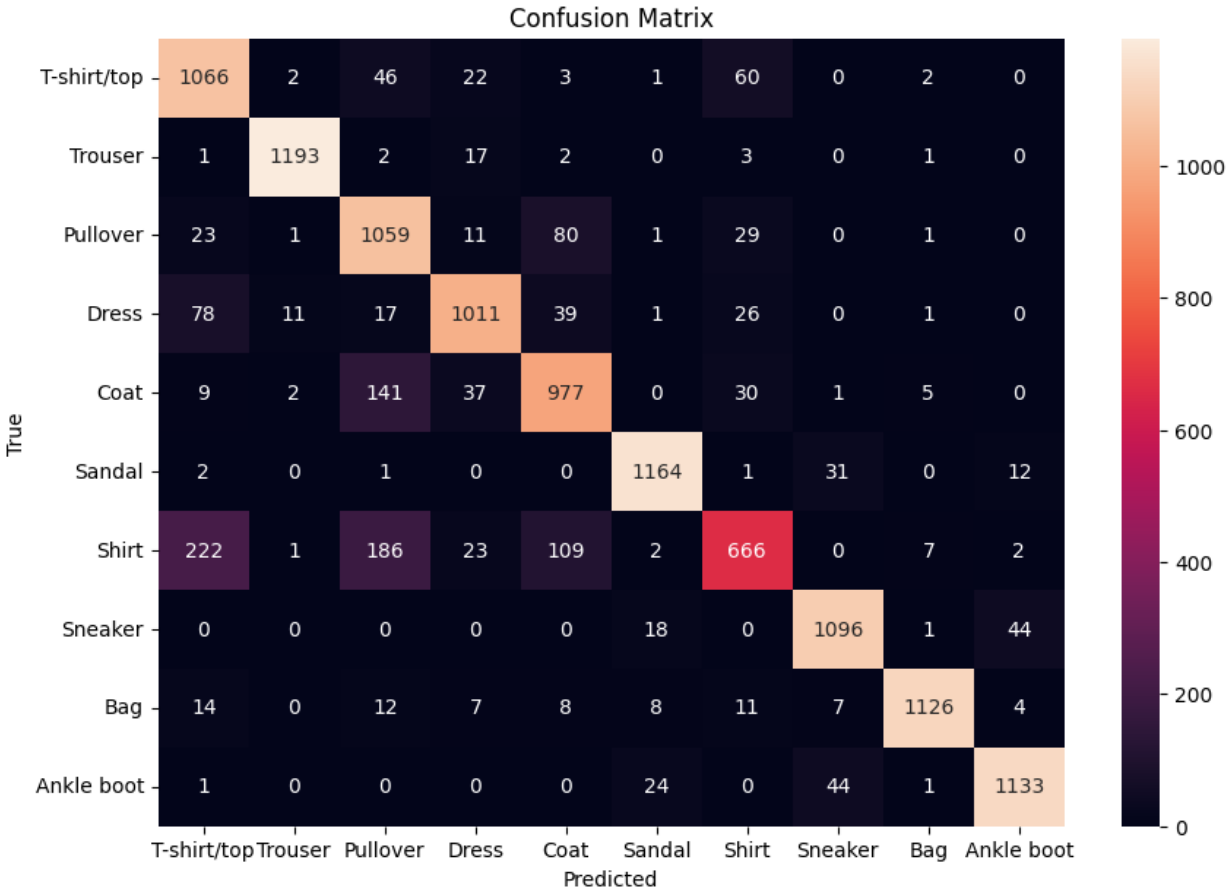
```
model.append(dense(784,128))
model.append(batchNormalization(128))
model.append(ReLU())
model.append(dense(128,64))
model.append(batchNormalization(64))
model.append(ReLU())
model.append(dense(64,10))
model.append(SoftMax())
```

Learning rate: 0.005

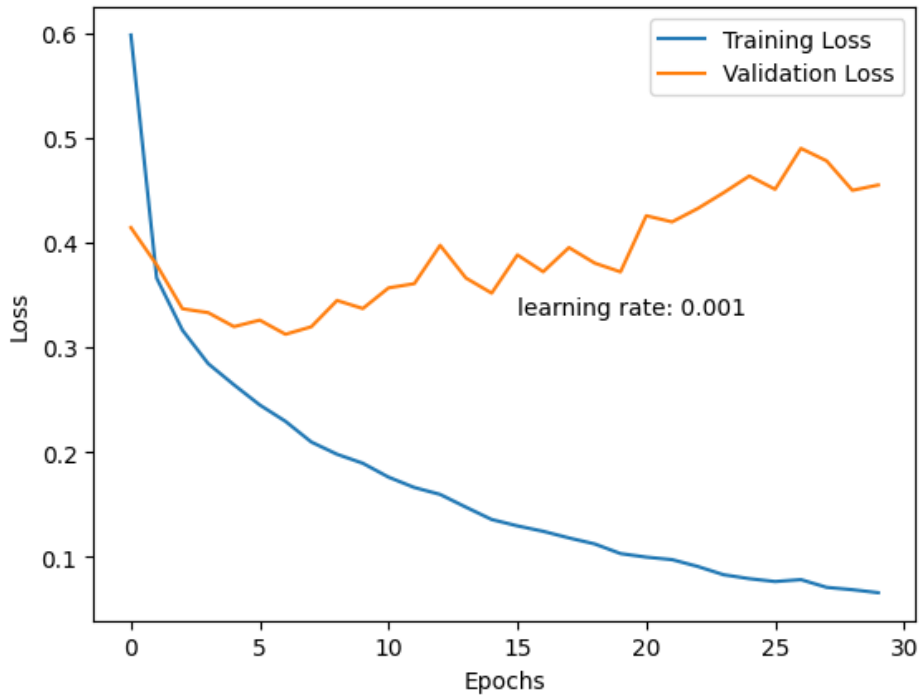


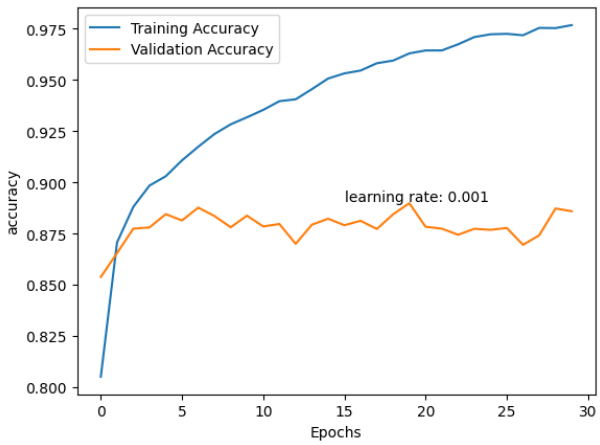


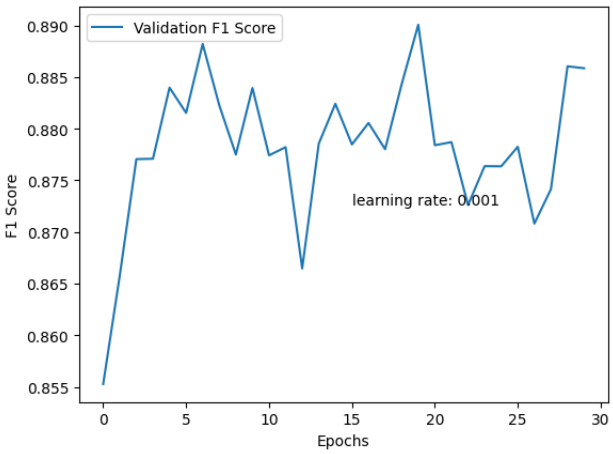


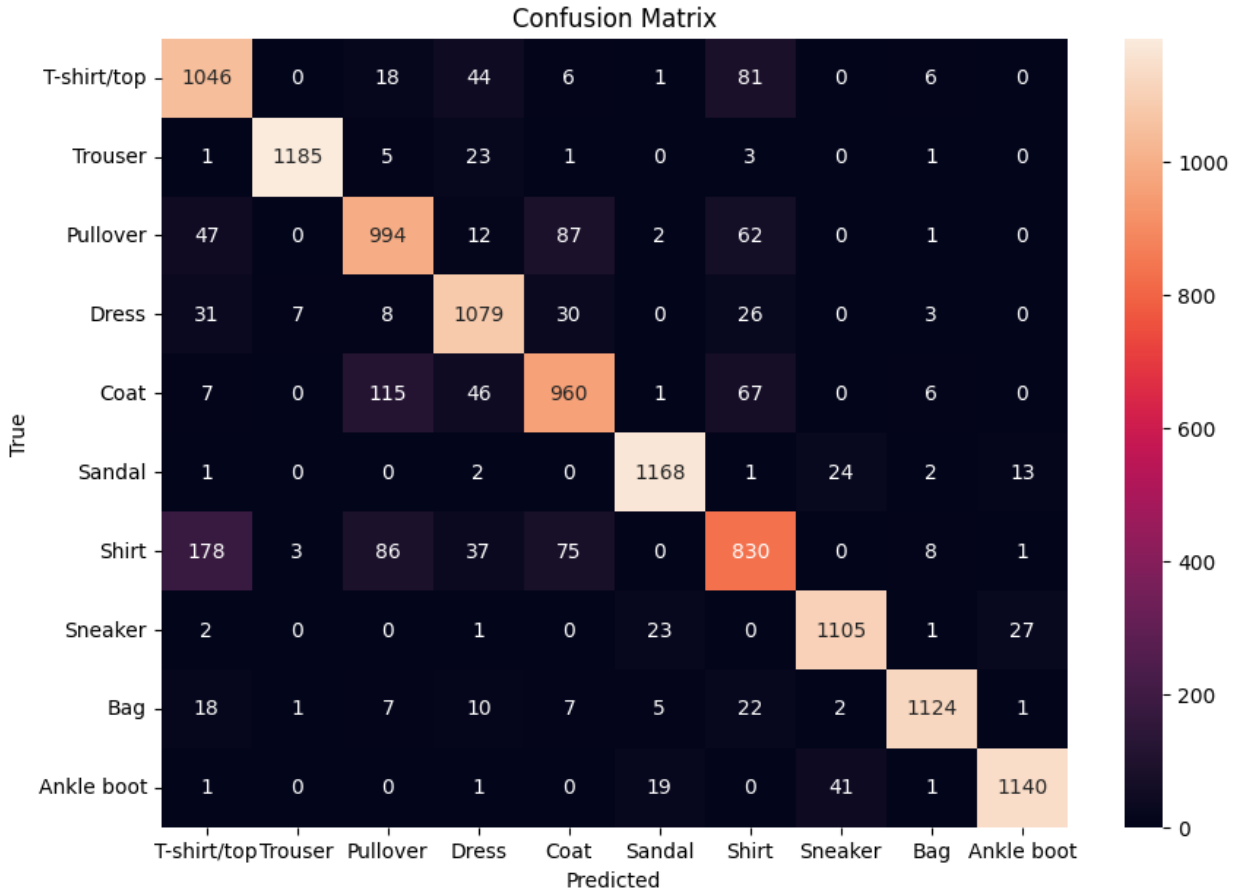


Learning rate: 0.001

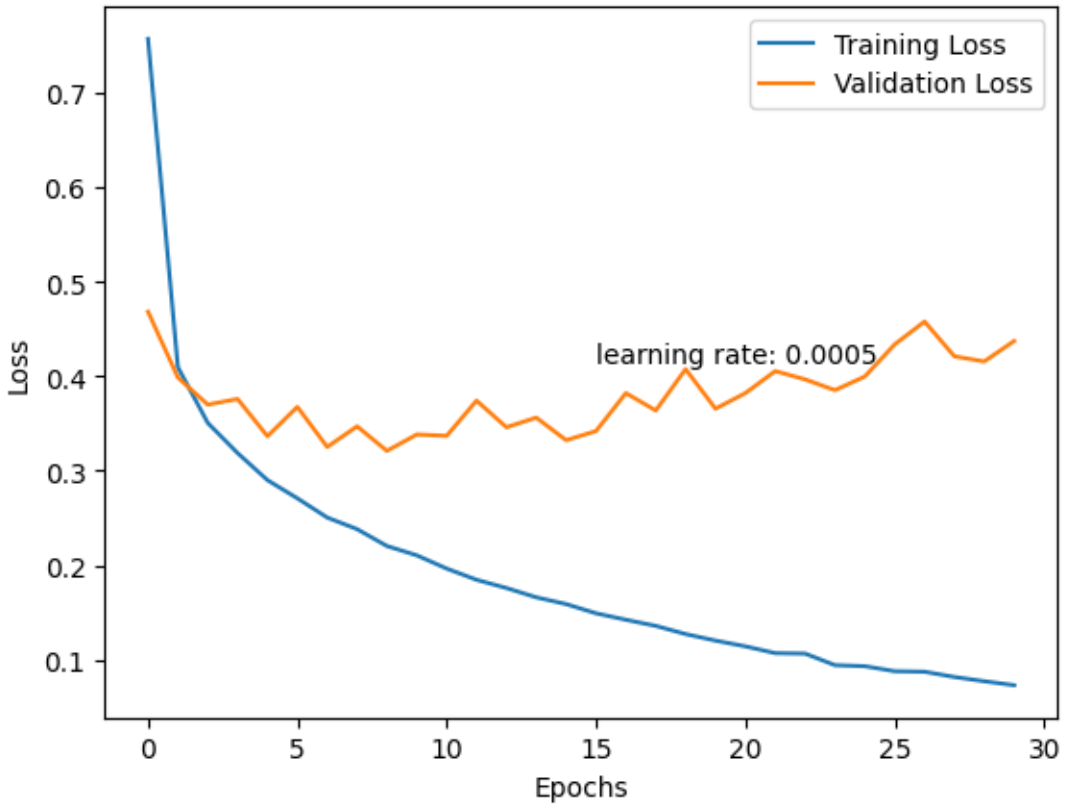


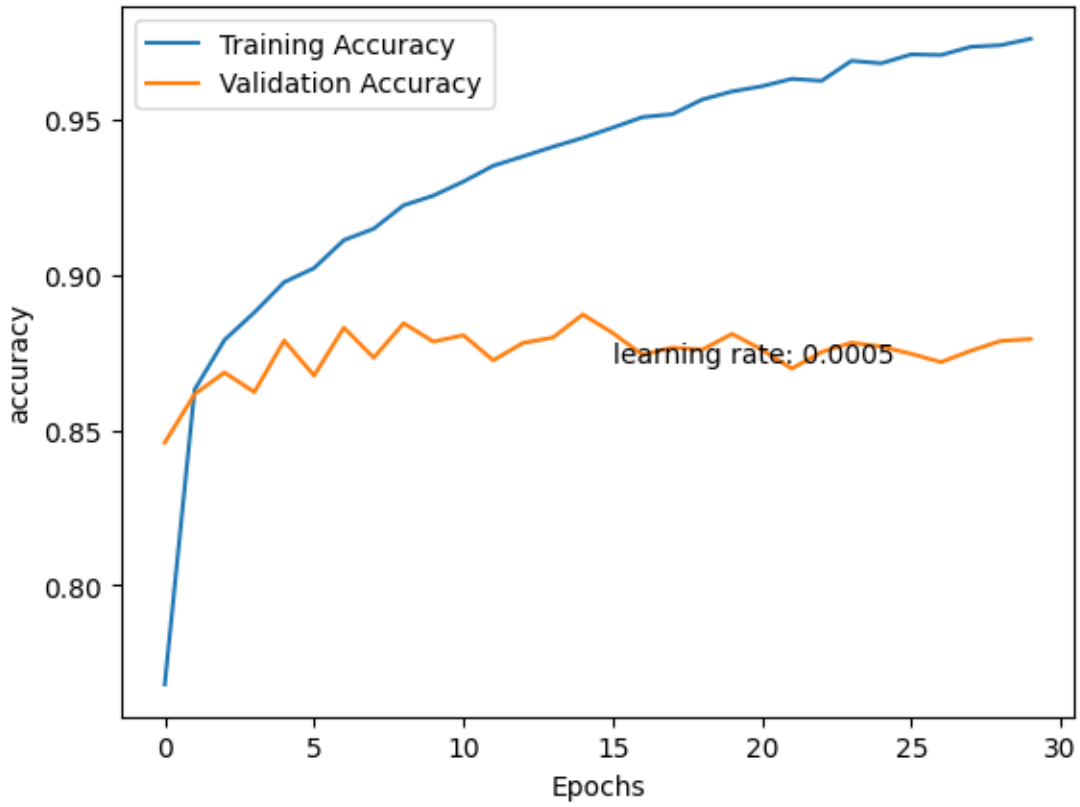


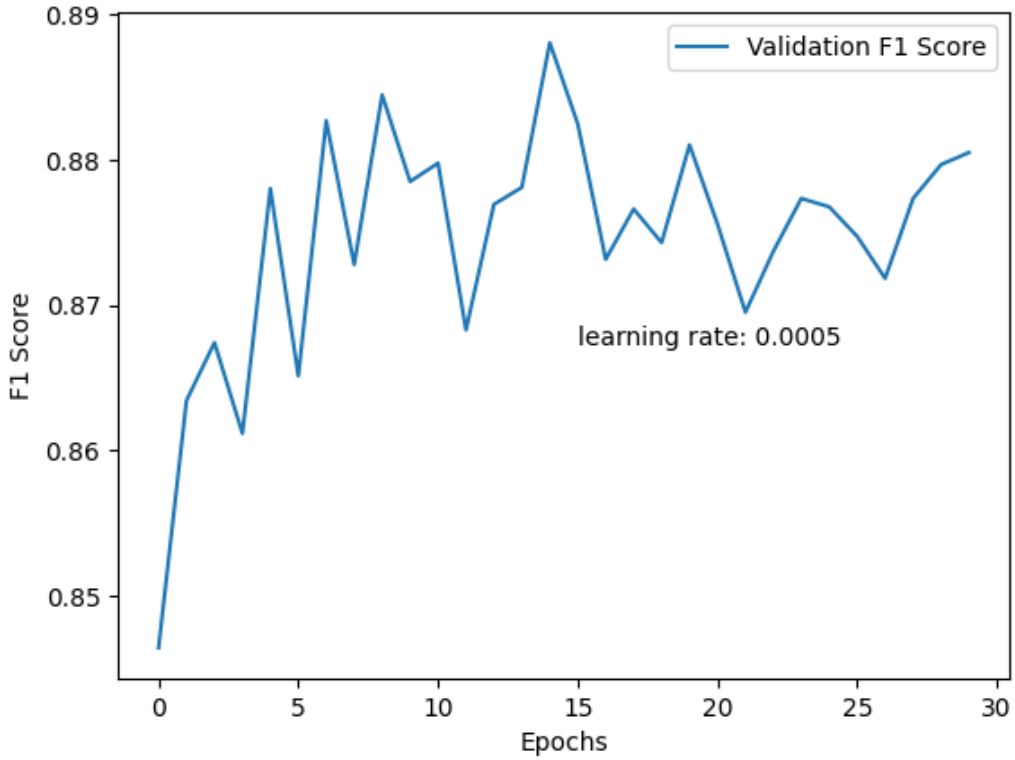


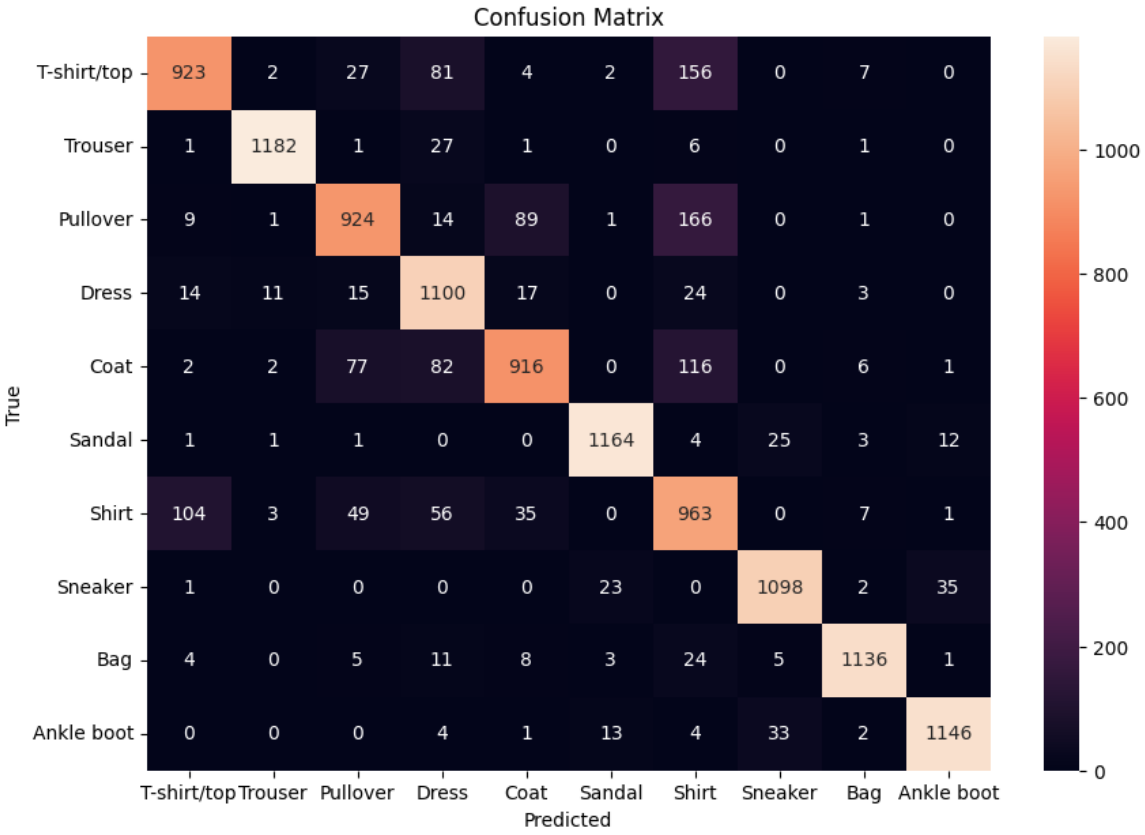


Learning rate: 0.0005

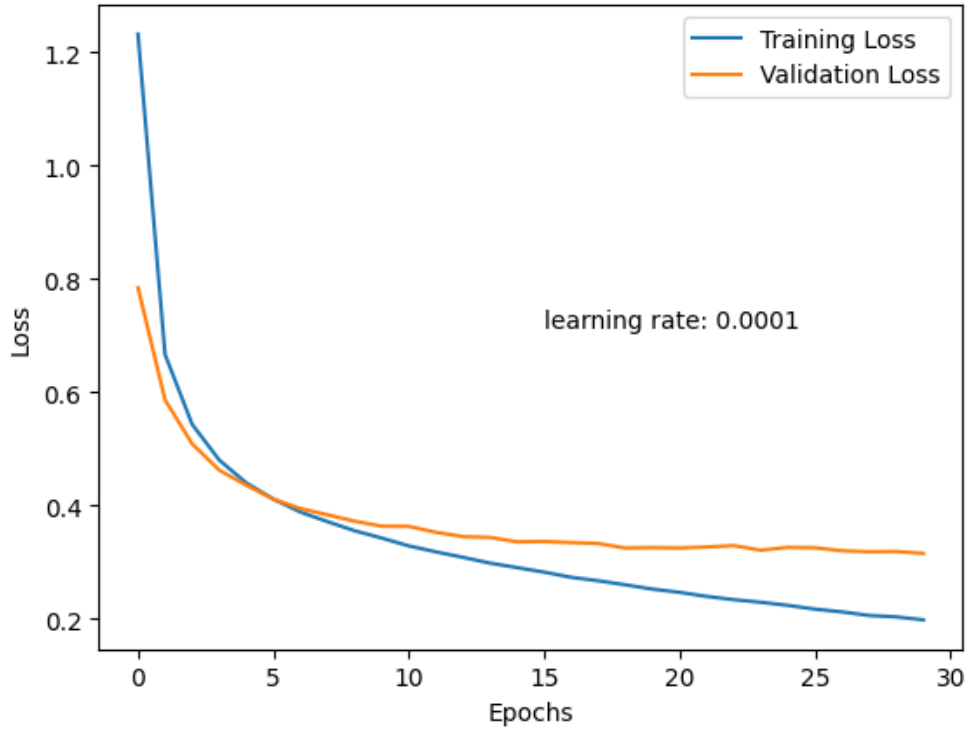

Training Loss
Validation Loss
learning rate: 0.0005
Loss
Epochs
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
5
10
15
20
25
30

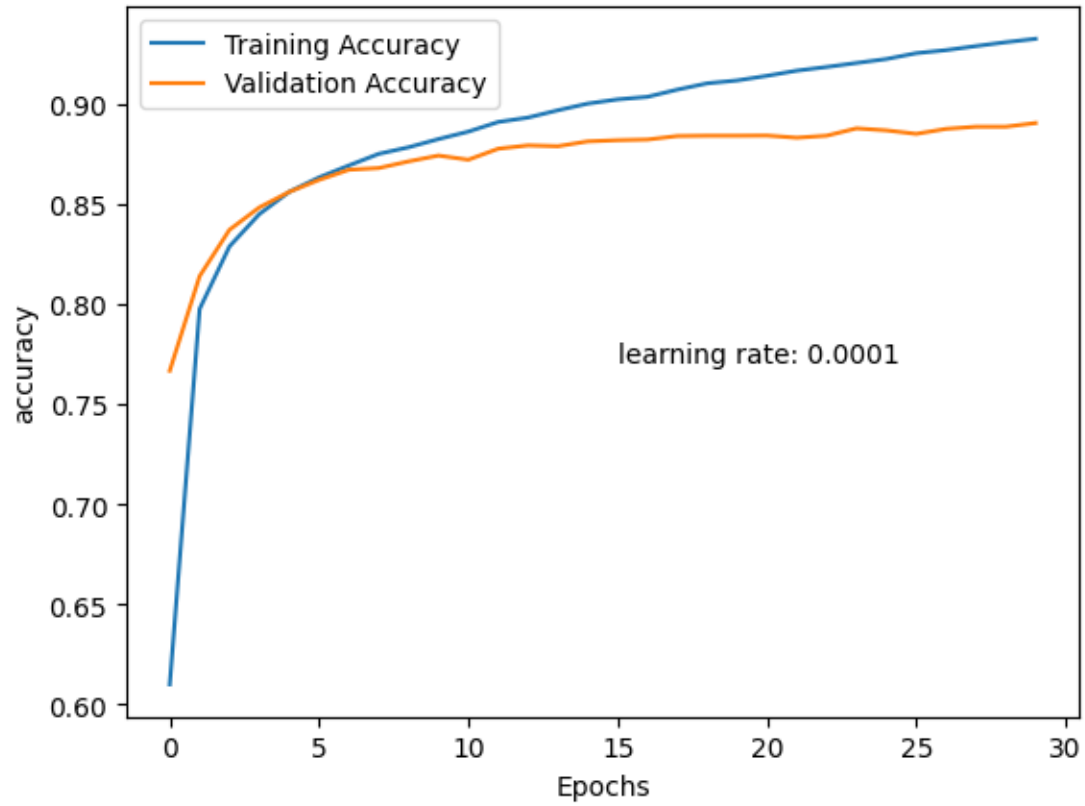

Training Accuracy
Validation Accuracy
learning rate: 0.0005
accuracy
Epochs
0.95
0.90
0.85
0.80
0
5
10
15
20
25
30

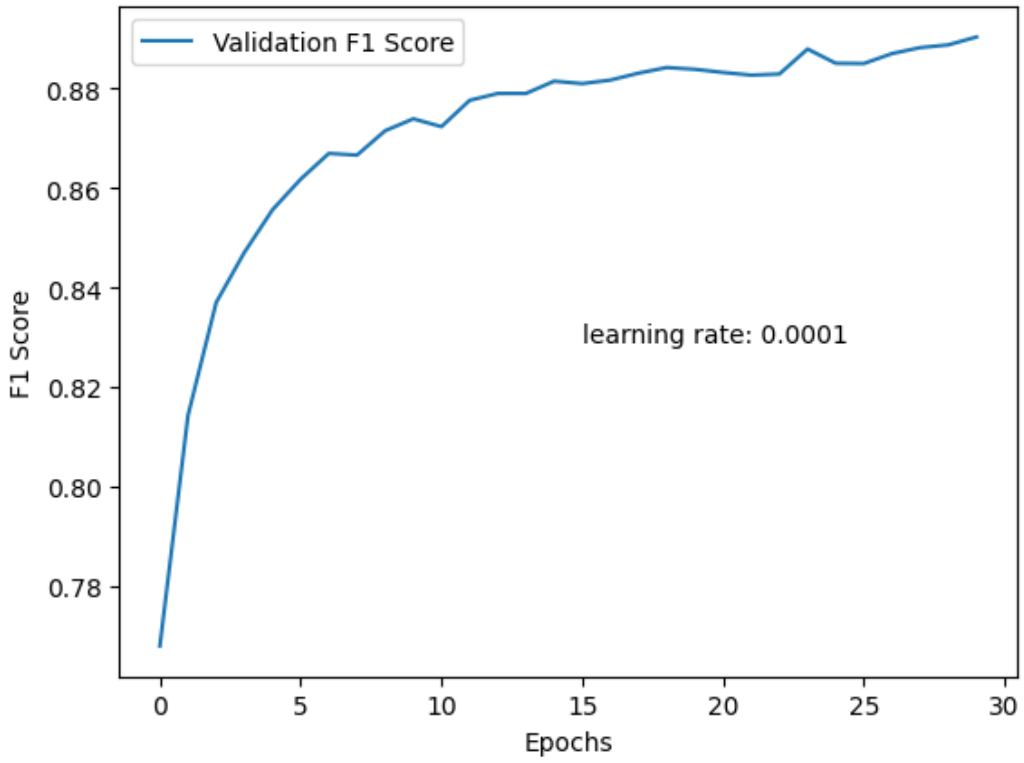

Validation F1 Score
learning rate: 0.0005
F1 Score
Epochs
0.89
0.88
0.87
0.86
0.85
0
5
10
15
20
25
30

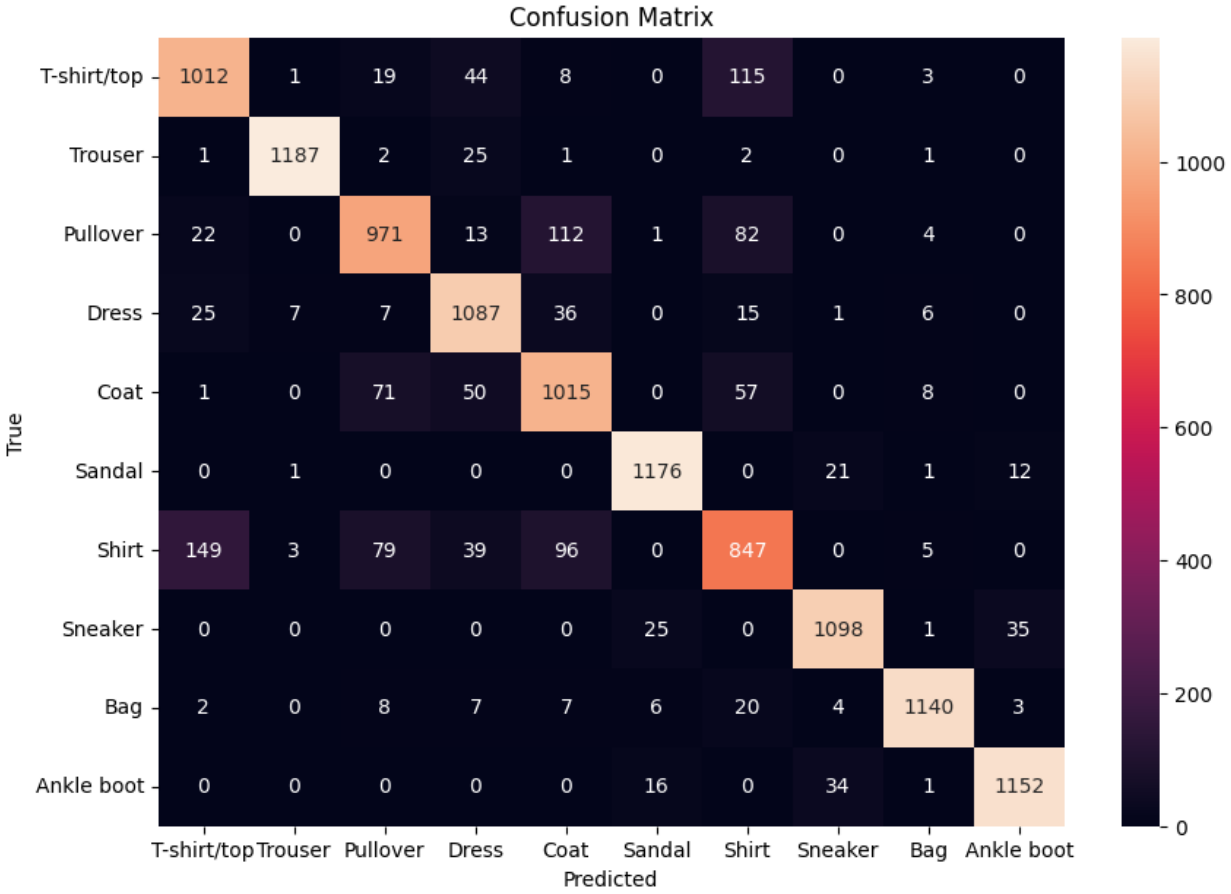

Confusion Matrix
True
Predicted
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
923 2 27 81 4 2 156 0 7 0
1 1182 1 27 1 0 6 0 1 0
9 1 924 14 89 1 166 0 1 0
14 11 15 1100 17 0 24 0 3 0
2 2 77 82 916 0 116 0 6 1
1 1 1 0 0 1164 4 25 3 12
104 3 49 56 35 0 963 0 7 1
1 0 0 0 0 23 0 1098 2 35
4 0 5 11 8 3 24 5 1136 1
0 0 0 4 1 13 4 33 2 1146
1000
800
600
400
200
0

Learning rate: 0.001





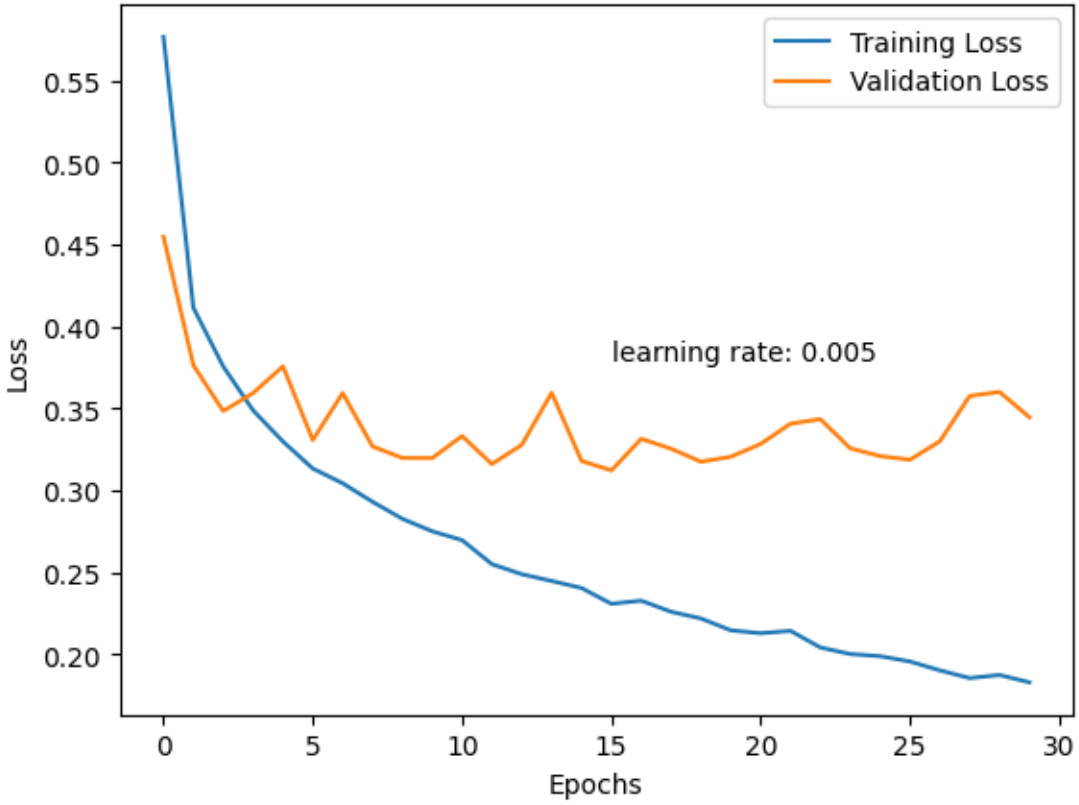

Validation F1 Score
learning rate: 0.0001
F1 Score
Epochs
0.88
0.86
0.84
0.82
0.80
0.78
0
5
10
15
20
25
30

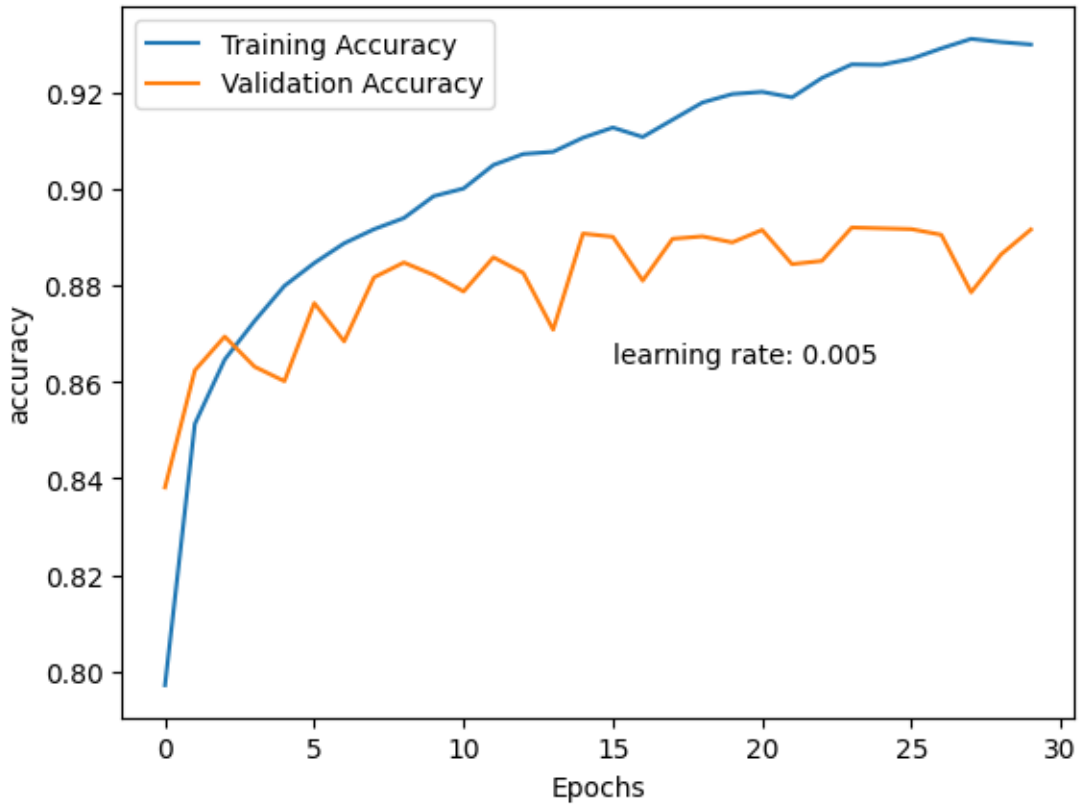

Confusion Matrix
T-shirt/top 1012 1 19 44 8 0 115 0 3 0
Trouser 1 1187 2 25 1 0 2 0 1 0
Pullover 22 0 971 13 112 1 82 0 4 0
Dress 25 7 7 1087 36 0 15 1 6 0
Coat 1 0 71 50 1015 0 57 0 8 0
Sandal 0 1 0 0 0 1176 0 21 1 12
Shirt 149 3 79 39 96 0 847 0 5 0
Sneaker 0 0 0 0 0 25 0 1098 1 35
Bag 2 0 8 7 7 6 20 4 1140 3
Ankle boot 0 0 0 0 0 16 0 34 1 1152
T-shirt/top Trouser Pullover Dress Coat Sandal Shirt Sneaker Bag Ankle boot
True
Predicted
1000
800
600
400
200
0

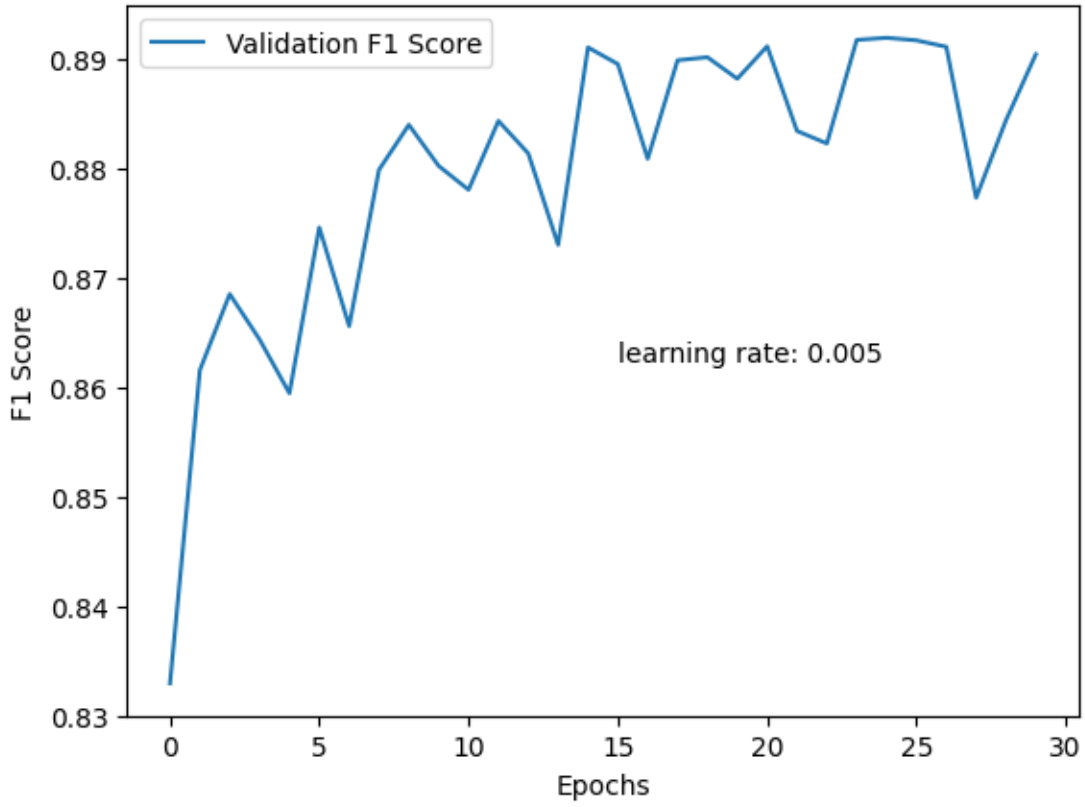
Model-2:

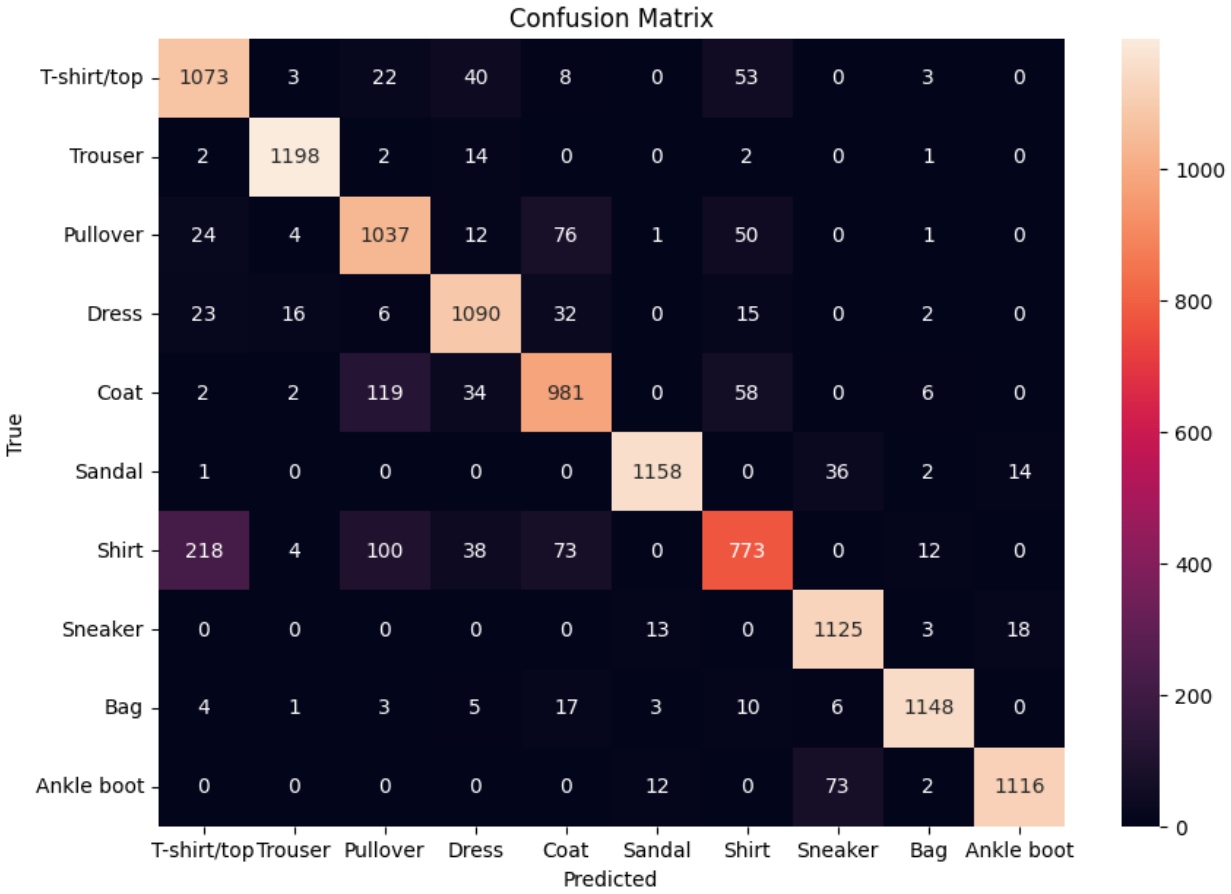
```
model.append(dense(784,128))
model.append(batchNormalization(128))
model.append(ReLU())
model.append(Dropout(0.2))
model.append(dense(128,64))
model.append(batchNormalization(64))
model.append(ReLU())
model.append(Dropout(0.2))
model.append(dense(64,10))
model.append(SoftMax())
```

Learning rate:0.005

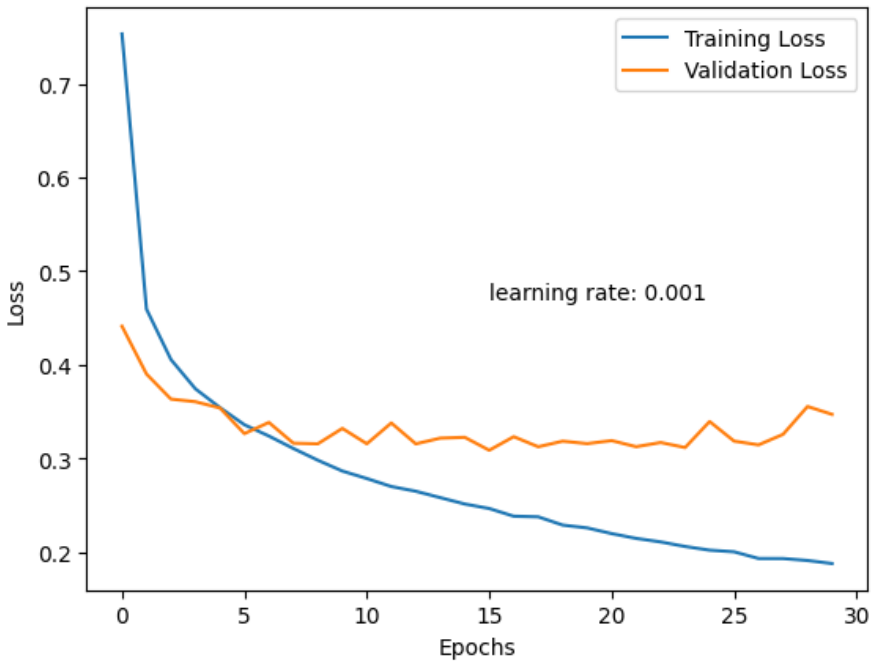


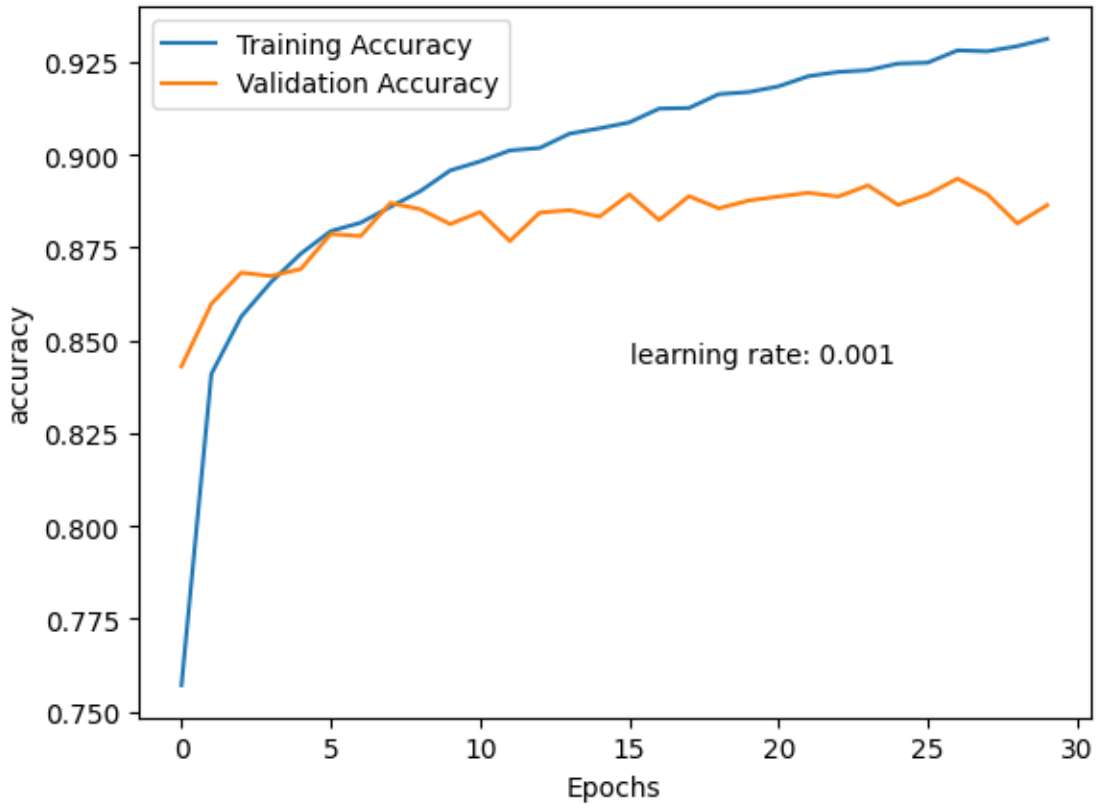

Training Accuracy
Validation Accuracy
learning rate: 0.005
accuracy
Epochs
0.80
0.82
0.84
0.86
0.88
0.90
0.92
0
5
10
15
20
25
30

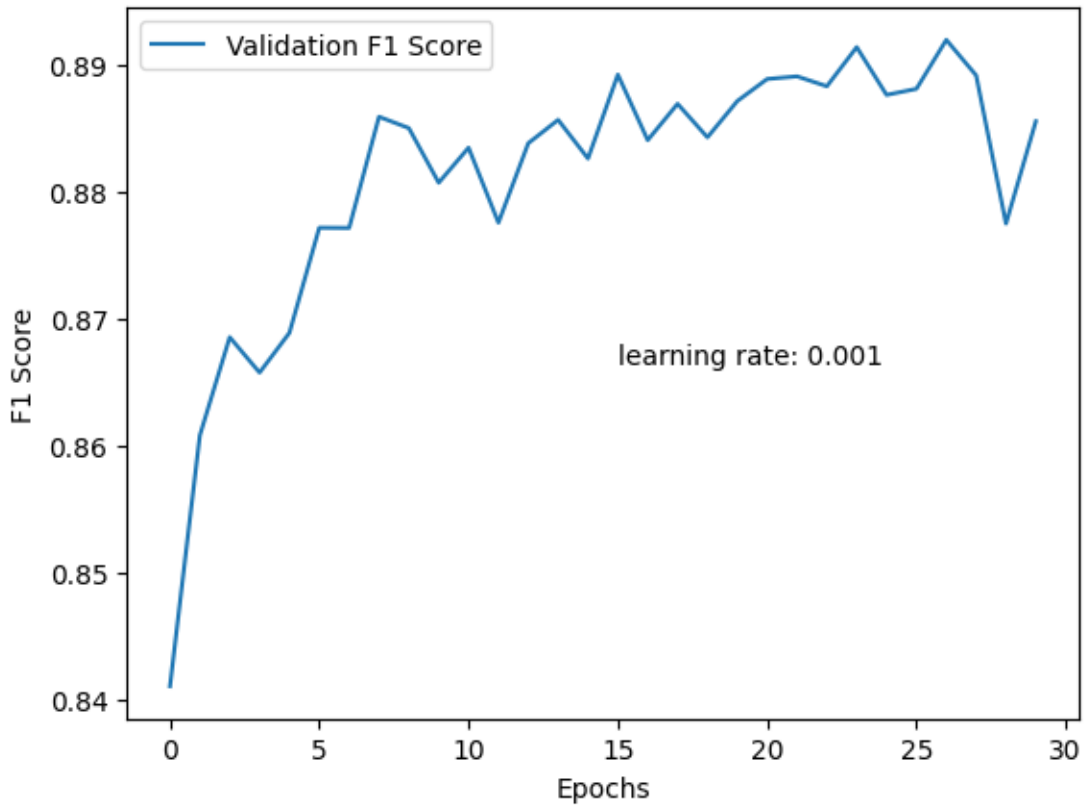

Validation F1 Score
learning rate: 0.005
F1 Score
Epochs
0.83
0.84
0.85
0.86
0.87
0.88
0.89
0
5
10
15
20
25
30

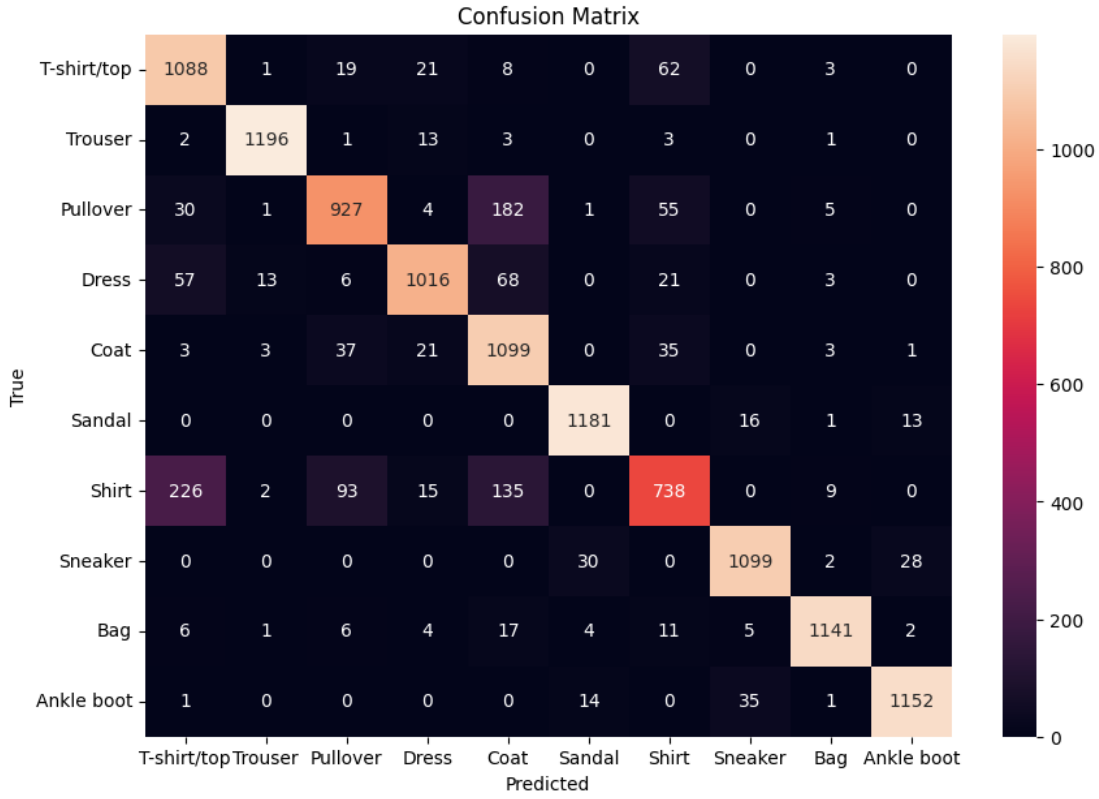


Learning rate: 0.001

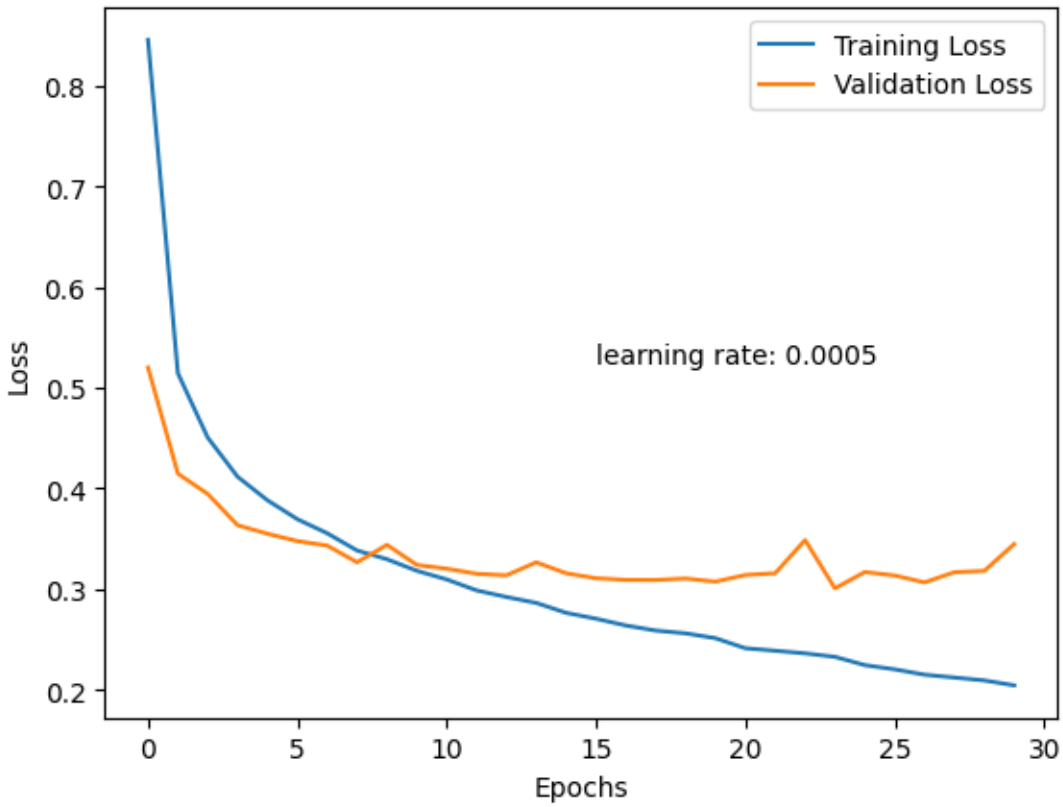


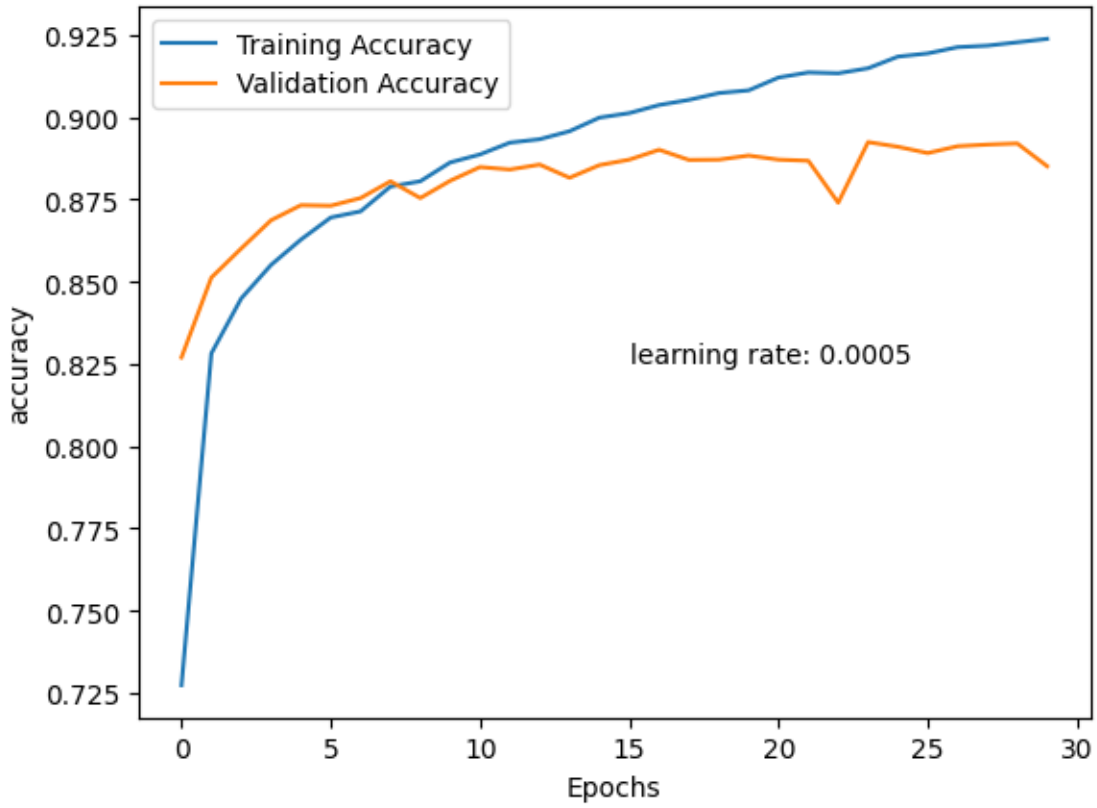

Training Accuracy
Validation Accuracy
learning rate: 0.001
accuracy
Epochs
0.925
0.900
0.875
0.850
0.825
0.800
0.775
0.750
0
5
10
15
20
25
30

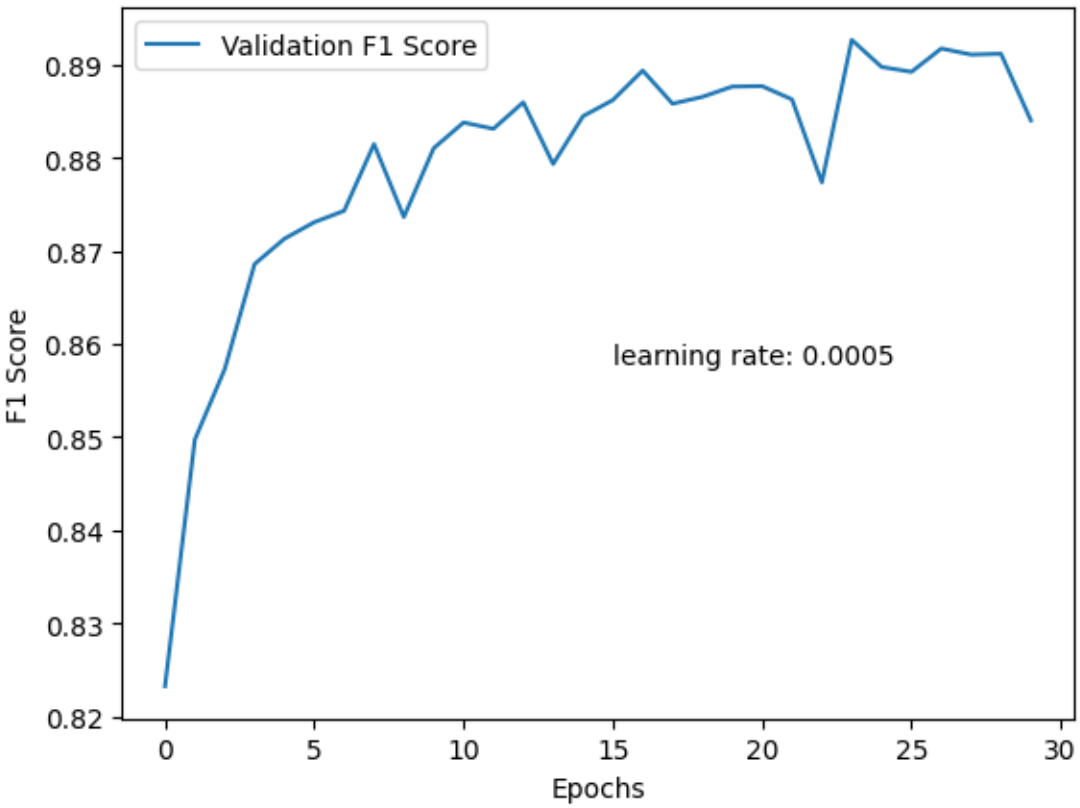

Validation F1 Score
learning rate: 0.001
F1 Score
Epochs
0.89
0.88
0.87
0.86
0.85
0.84
0
5
10
15
20
25
30

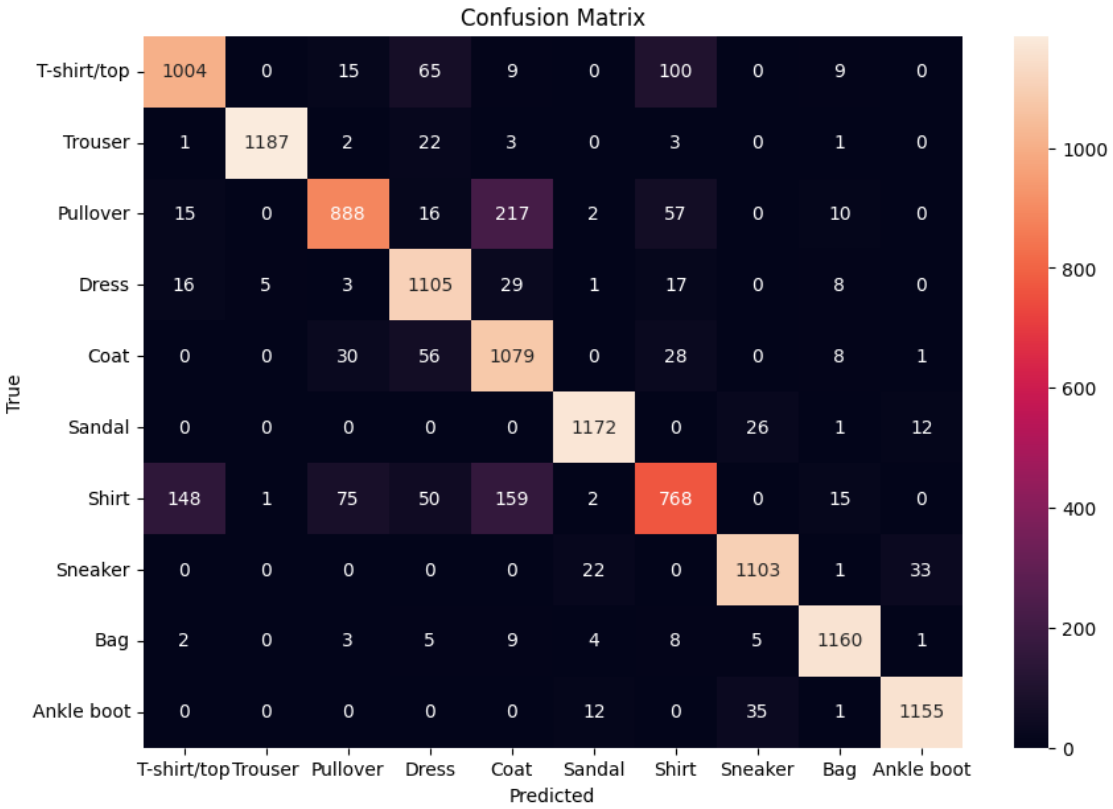


Learning rate: 0.0005

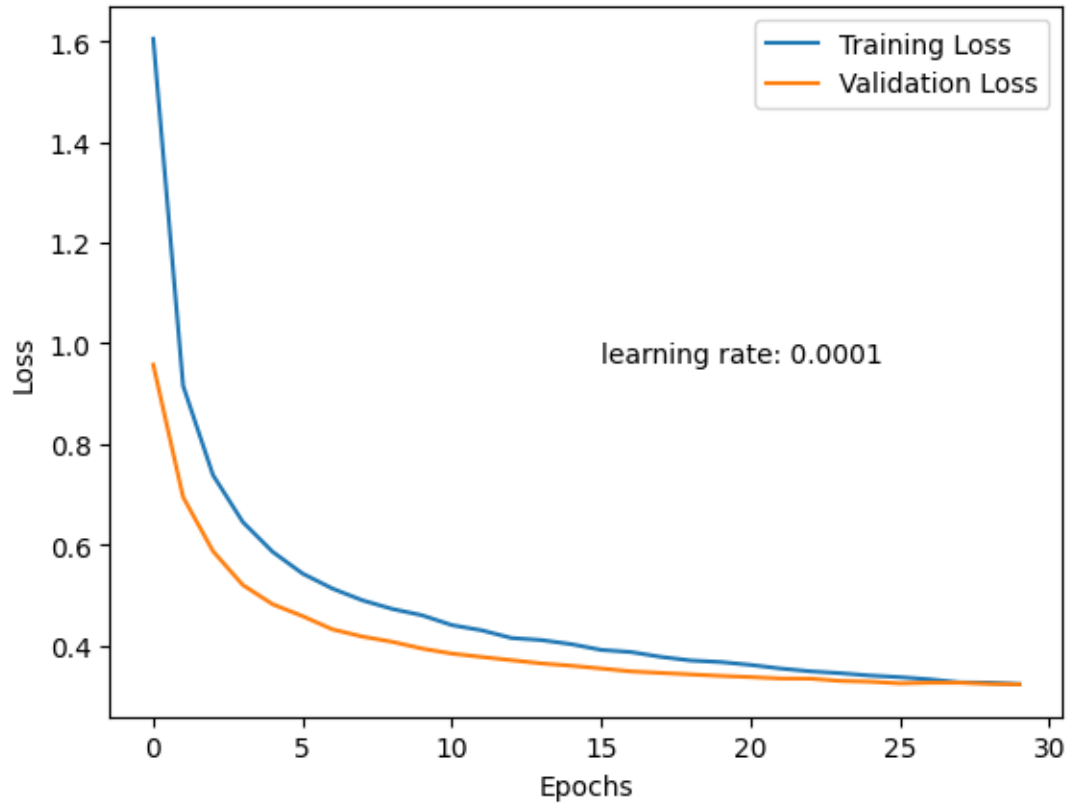


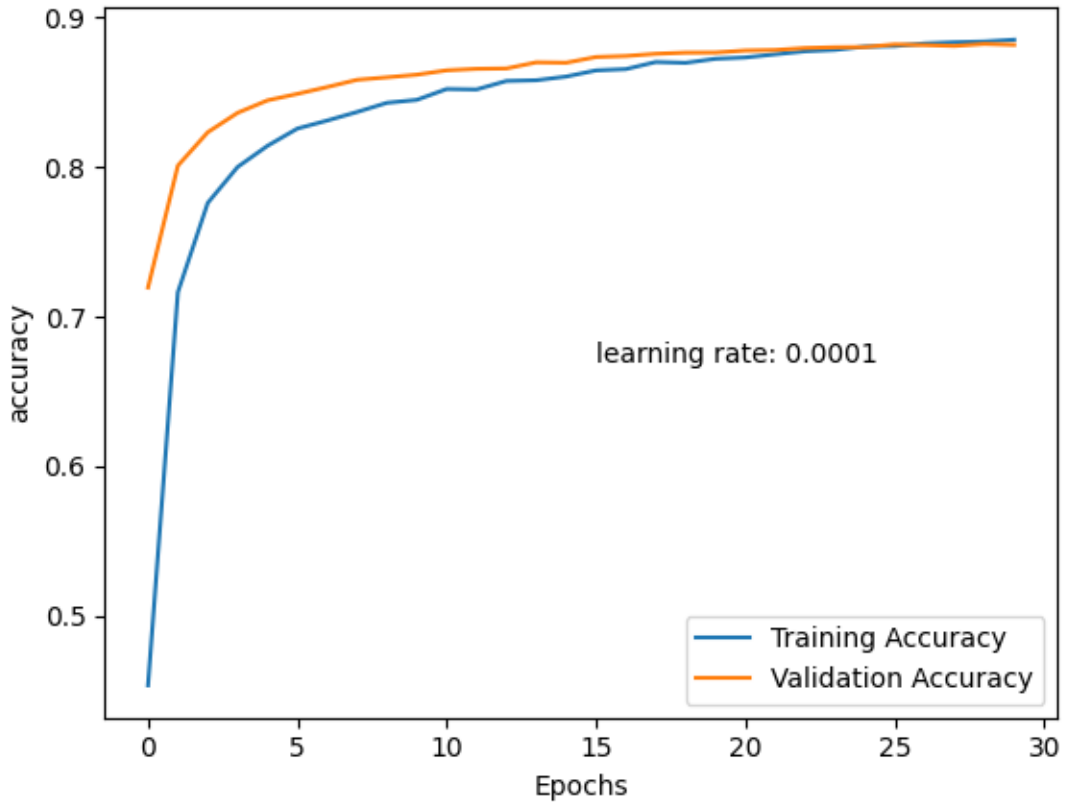

Training Accuracy
Validation Accuracy
learning rate: 0.0005
accuracy
Epochs
0.925
0.900
0.875
0.850
0.825
0.800
0.775
0.750
0.725
0
5
10
15
20
25
30

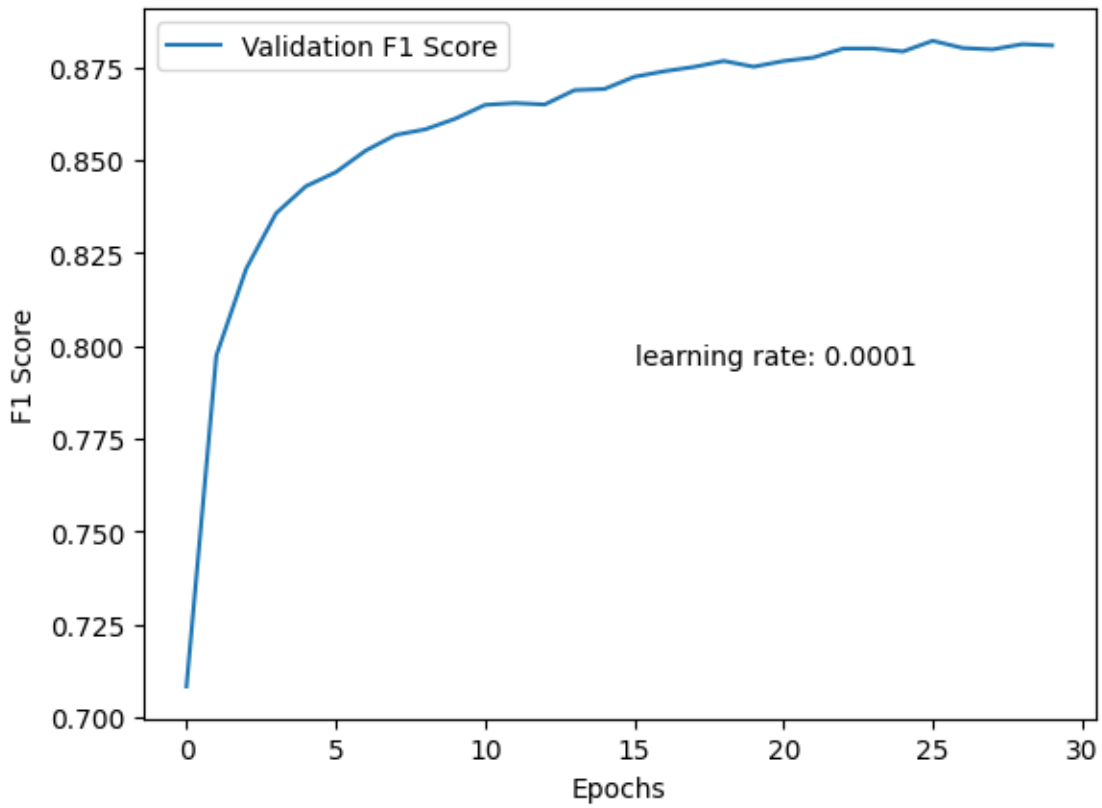

Validation F1 Score
learning rate: 0.0005
F1 Score
Epochs
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0
5
10
15
20
25
30

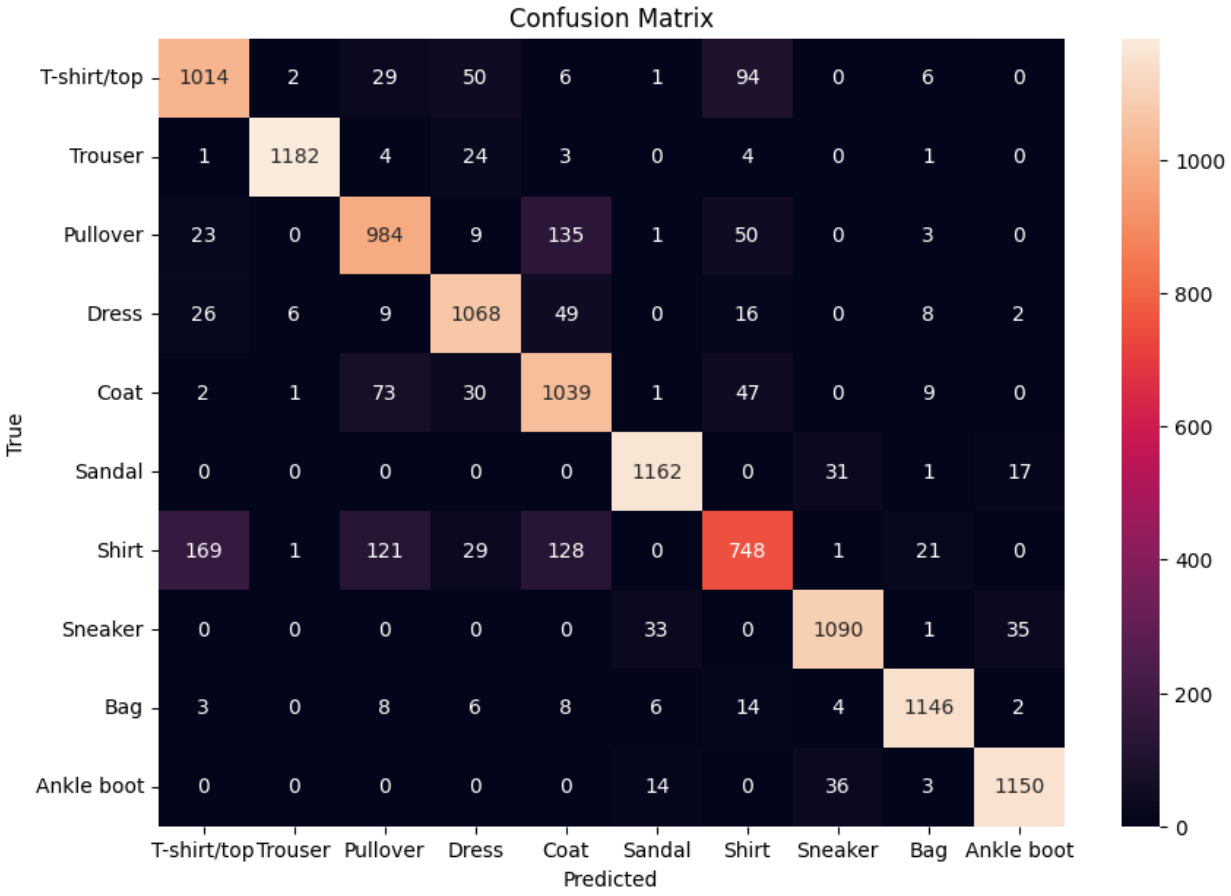


Learning rate:0.0001




0.9
0.8
0.7
0.6
0.5
accuracy
learning rate: 0.0001
Training Accuracy
Validation Accuracy
0
5
10
15
20
25
30
Epochs

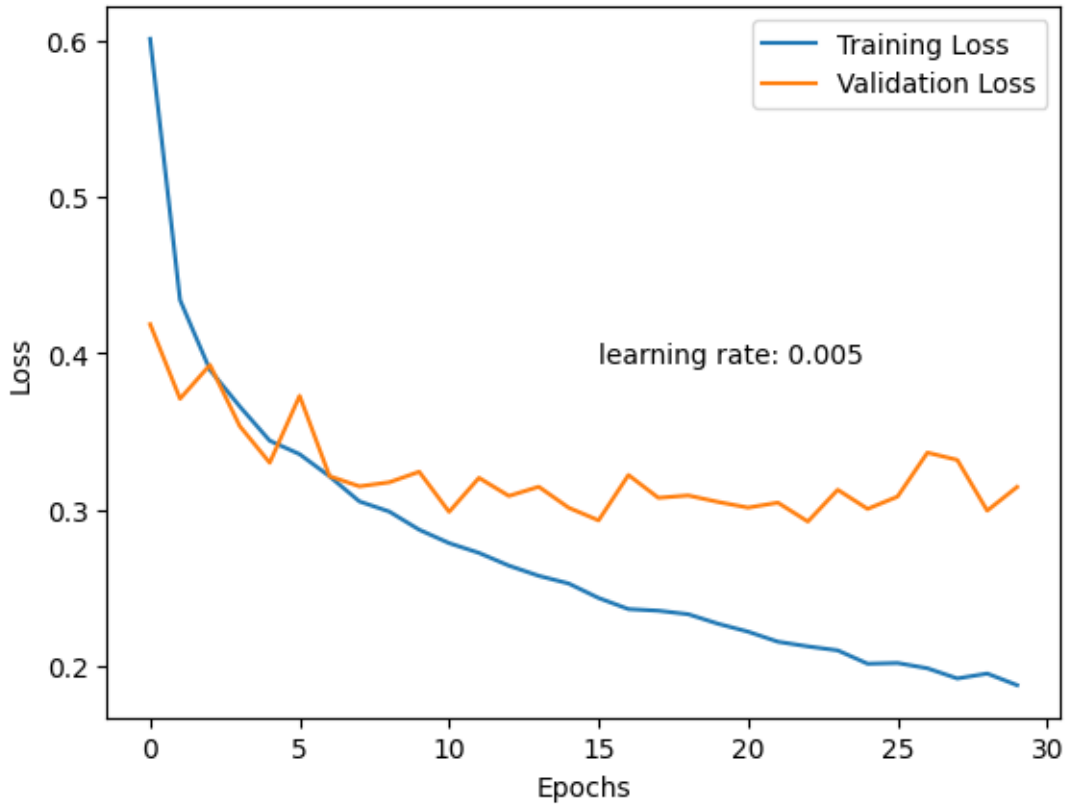

Validation F1 Score
0.875
0.850
0.825
0.800
0.775
0.750
0.725
0.700
F1 Score
learning rate: 0.0001
0
5
10
15
20
25
30
Epochs

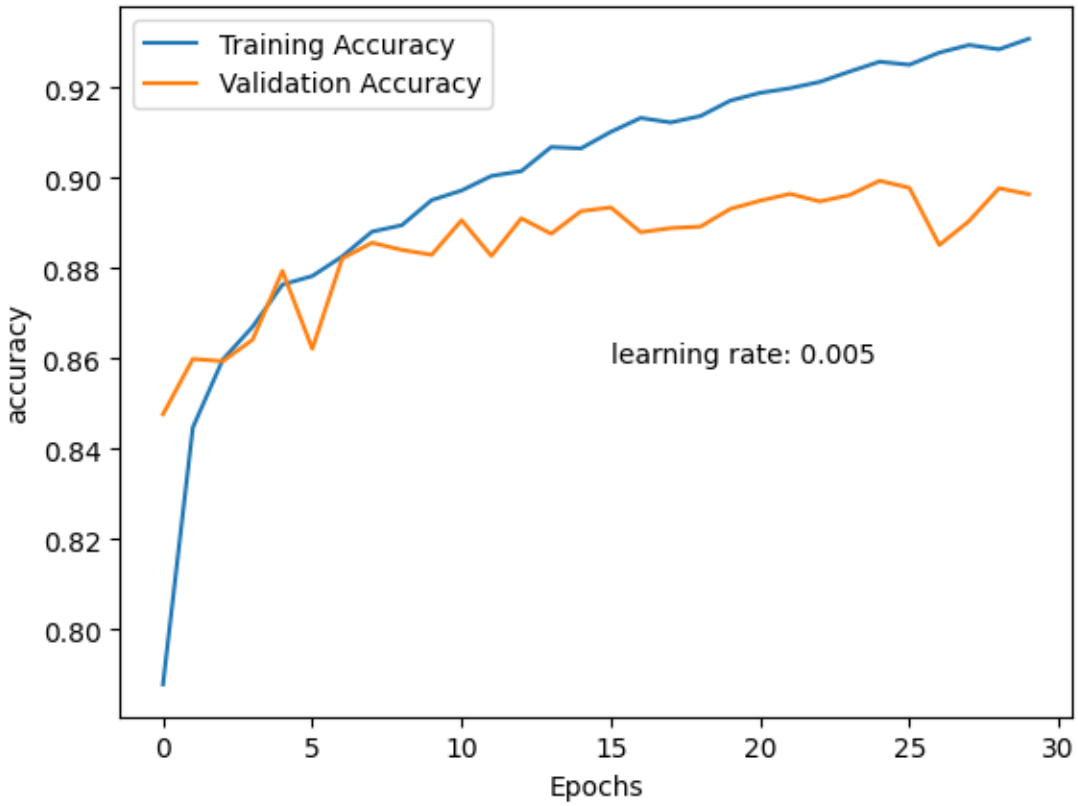


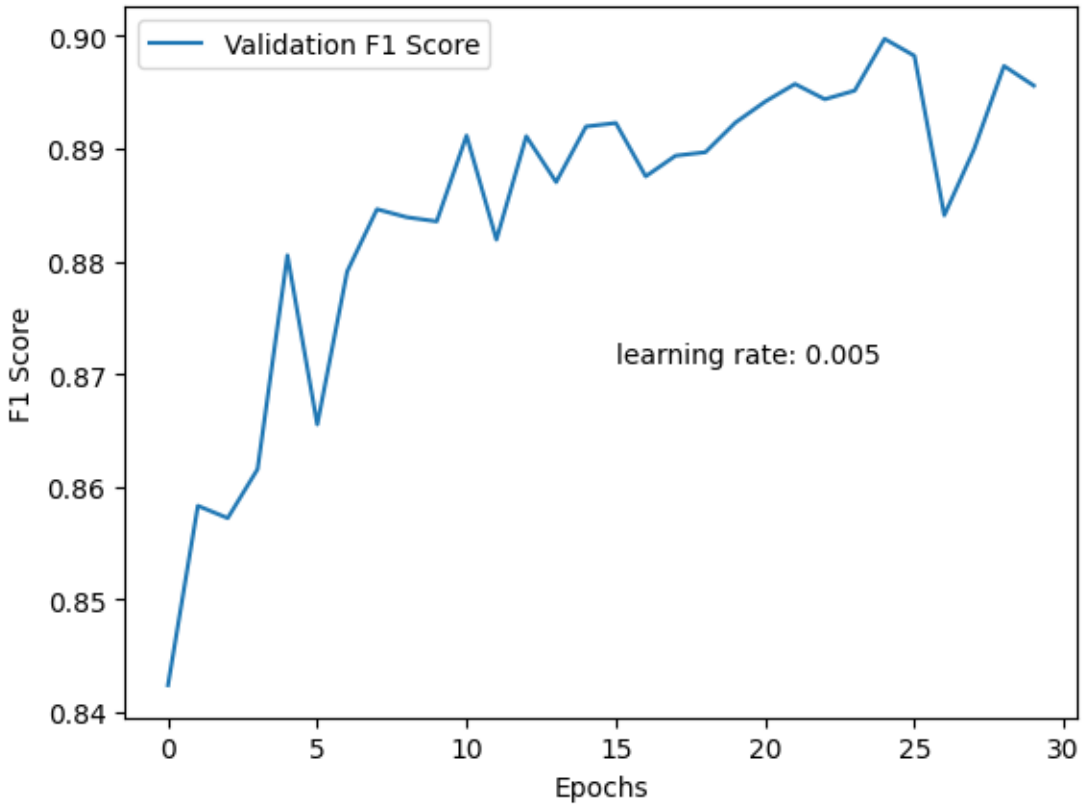
Model-3:

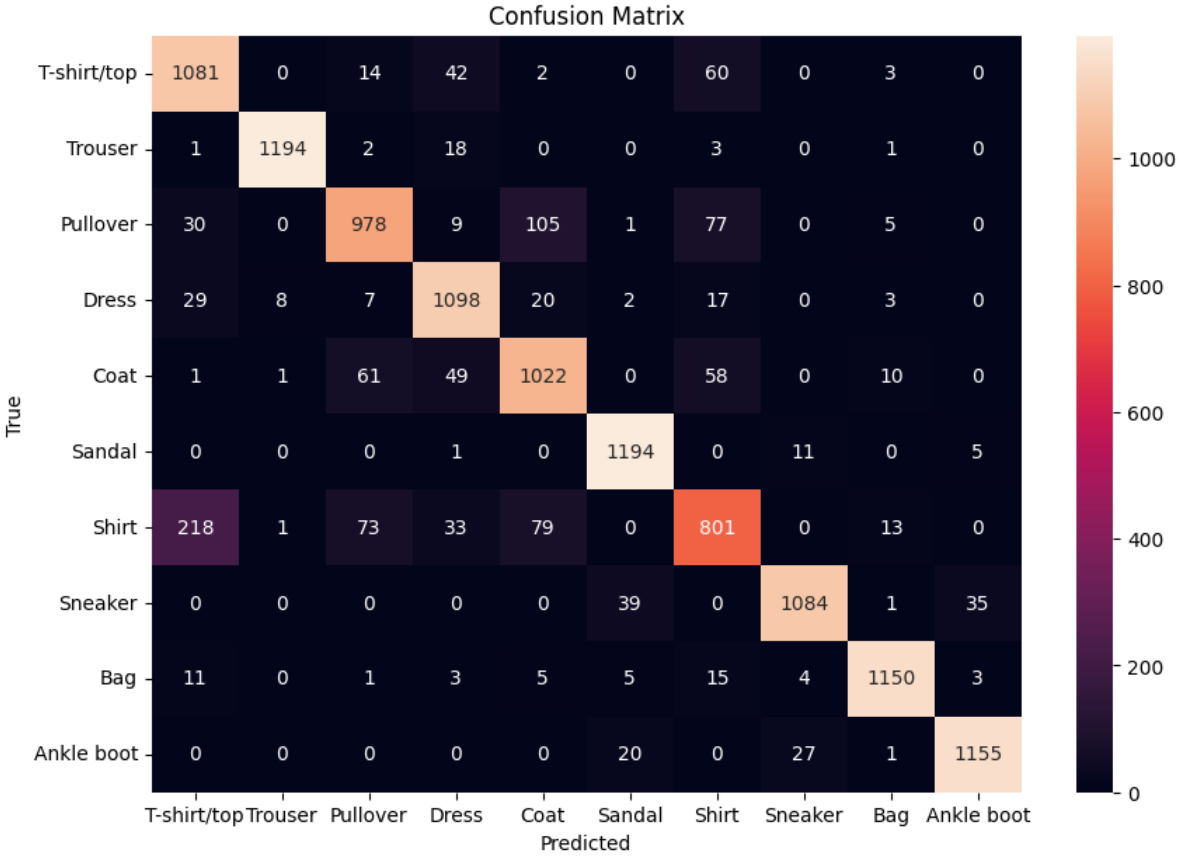
```
model.append(dense(784,256))
model.append(batchNormalization(256))
model.append(ReLU())
model.append(Dropout(0.3))
model.append(dense(256,128))
model.append(batchNormalization(128))
model.append(ReLU())
model.append(Dropout(0.2))
model.append(dense(128,64))
model.append(batchNormalization(64))
model.append(ReLU())
model.append(Dropout(0.2))
model.append(dense(64,10))
model.append(SoftMax())
```

Learing rate:0.005

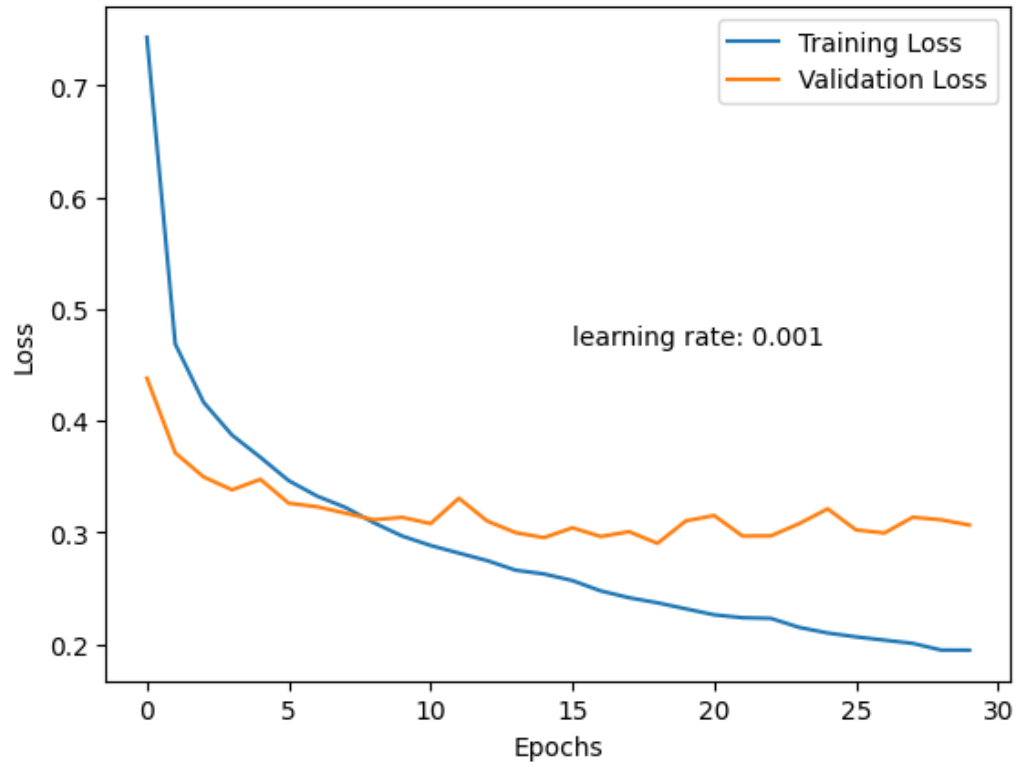

Training Loss
Validation Loss
learning rate: 0.005
Loss
Epochs
0.6
0.5
0.4
0.3
0.2
0
5
10
15
20
25
30

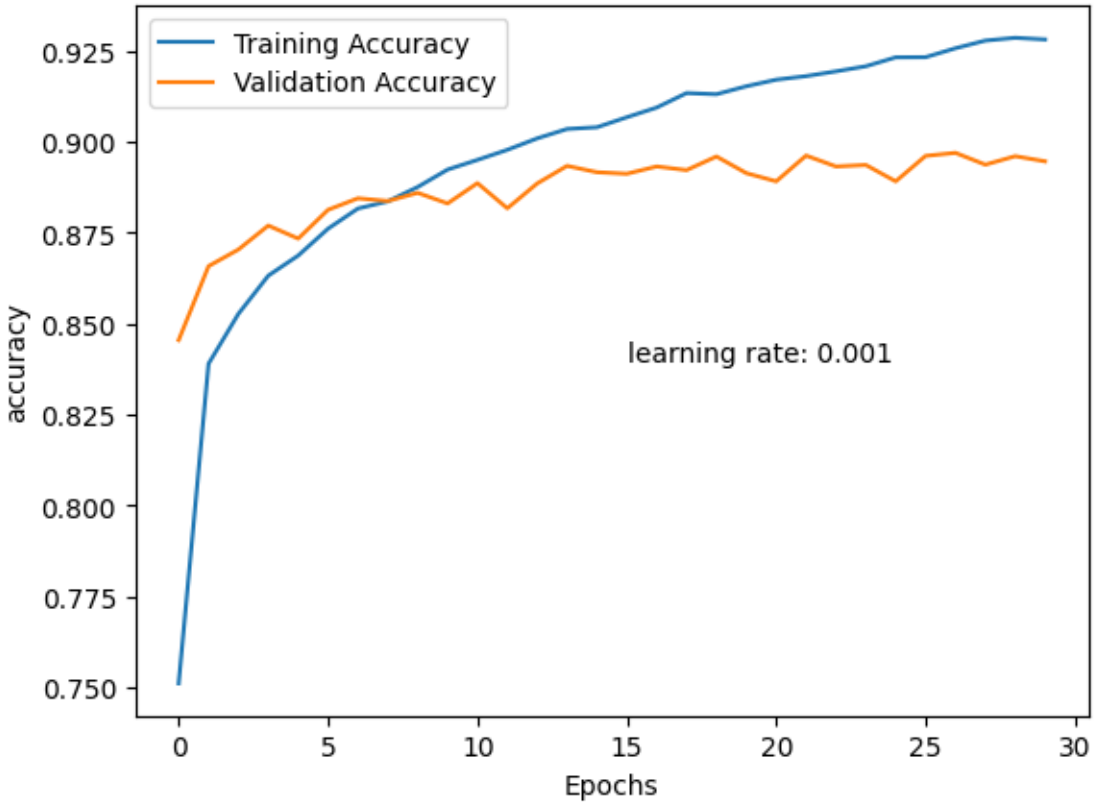

Training Accuracy
Validation Accuracy
learning rate: 0.005
accuracy
Epochs
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0
5
10
15
20
25
30

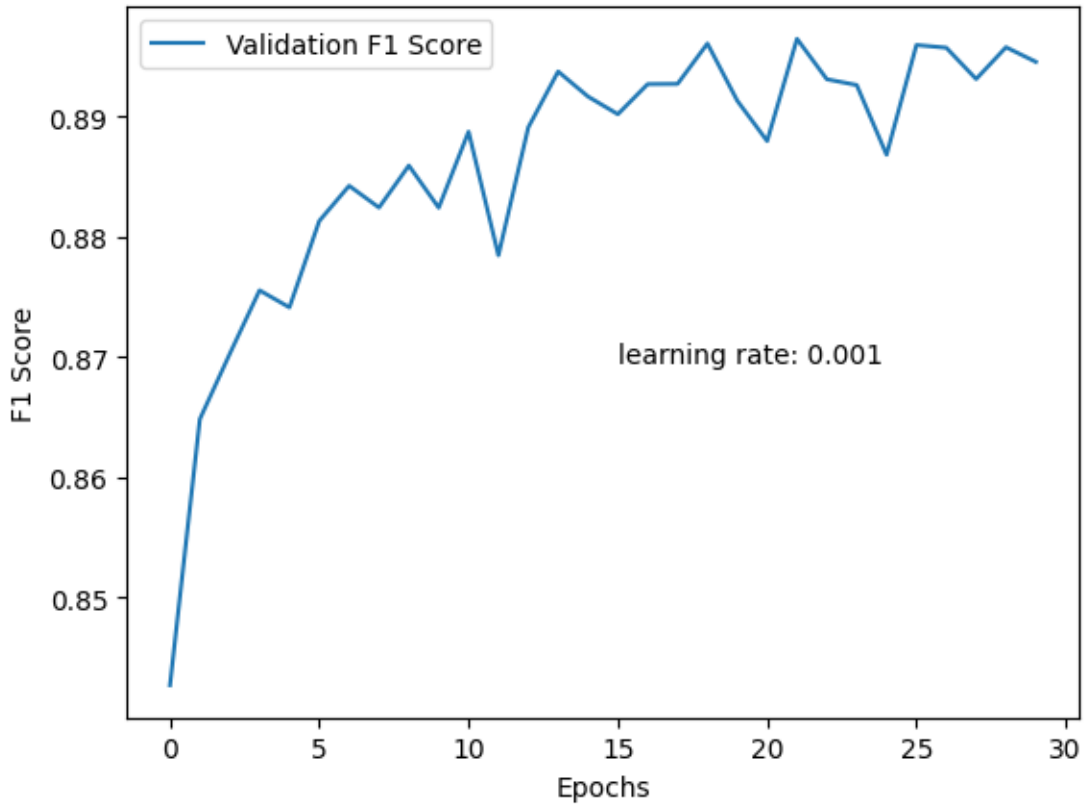

Validation F1 Score
learning rate: 0.005
F1 Score
Epochs
0.90
0.89
0.88
0.87
0.86
0.85
0.84
0
5
10
15
20
25
30

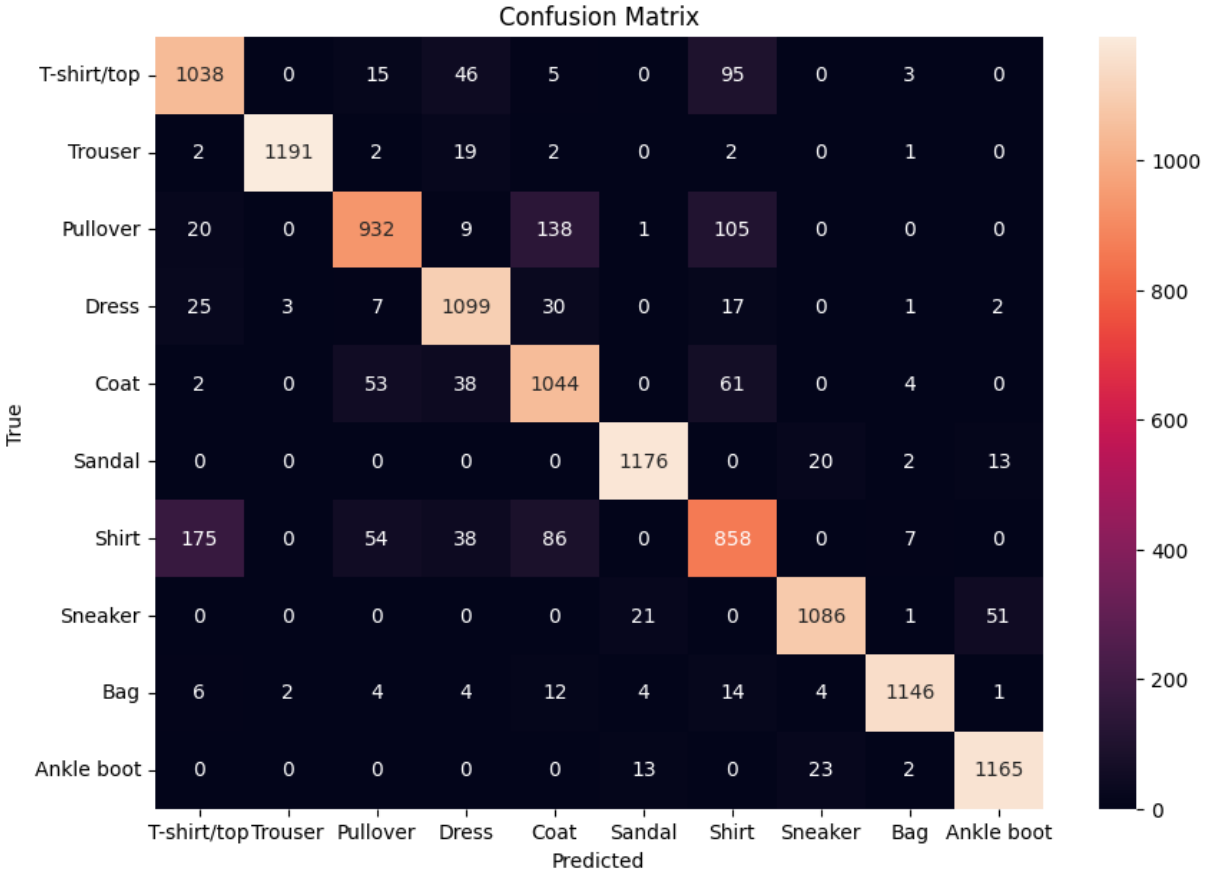

Confusion Matrix
True
Predicted
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
1081 0 14 42 2 0 60 0 3 0
1 1194 2 18 0 0 3 0 1 0
30 0 978 9 105 1 77 0 5 0
29 8 7 1098 20 2 17 0 3 0
1 1 61 49 1022 0 58 0 10 0
0 0 0 1 0 1194 0 11 0 5
218 1 73 33 79 0 801 0 13 0
0 0 0 0 0 39 0 1084 1 35
11 0 1 3 5 5 15 4 1150 3
0 0 0 0 0 20 0 27 1 1155
1000
800
600
400
200
0

Learning rate: 0.001

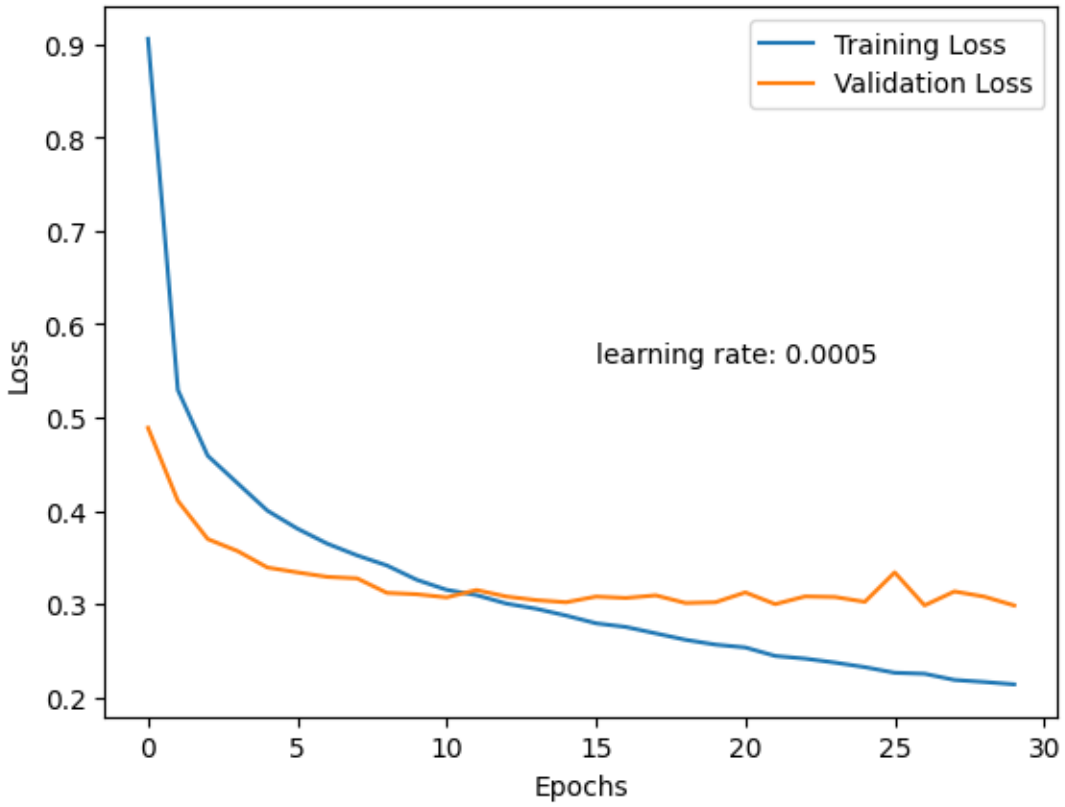


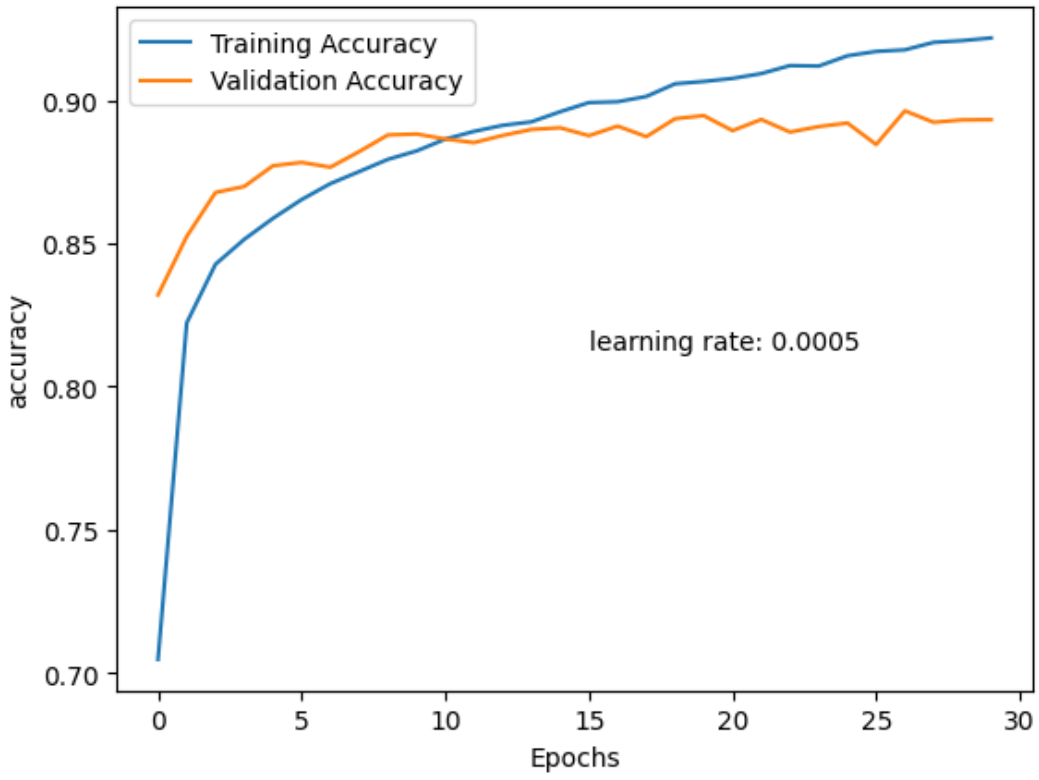


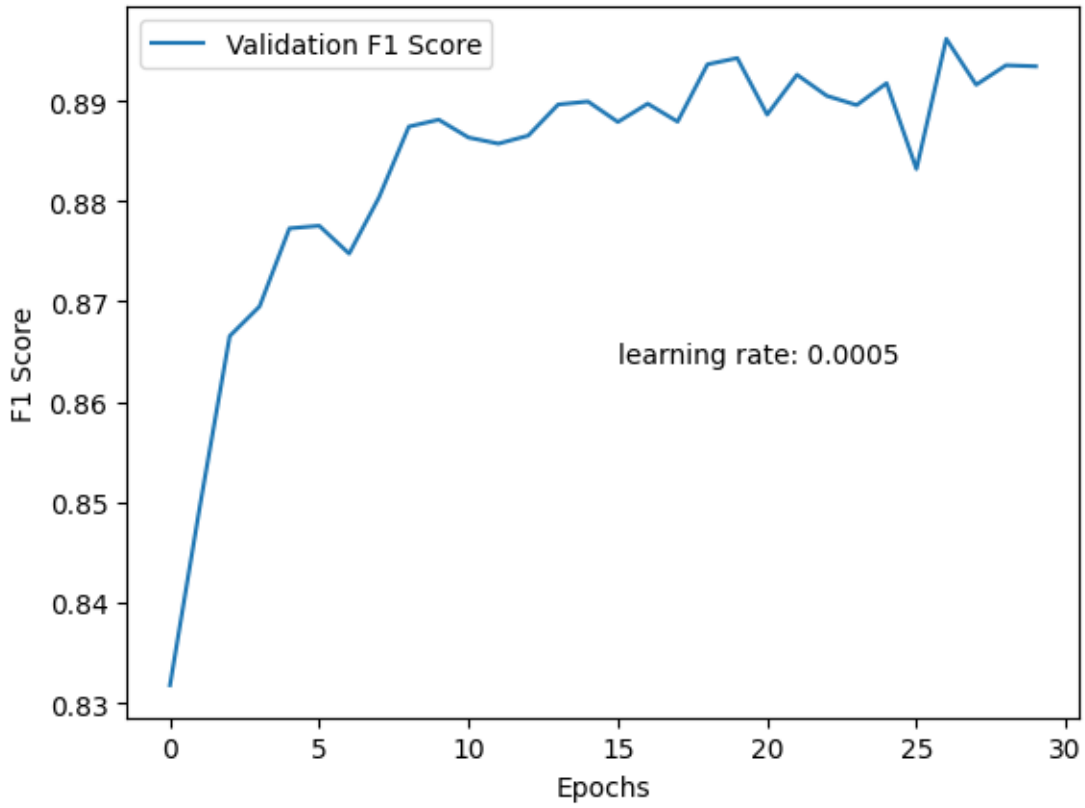

Validation F1 Score
learning rate: 0.001
F1 Score
Epochs
0.85
0.86
0.87
0.88
0.89
0
5
10
15
20
25
30

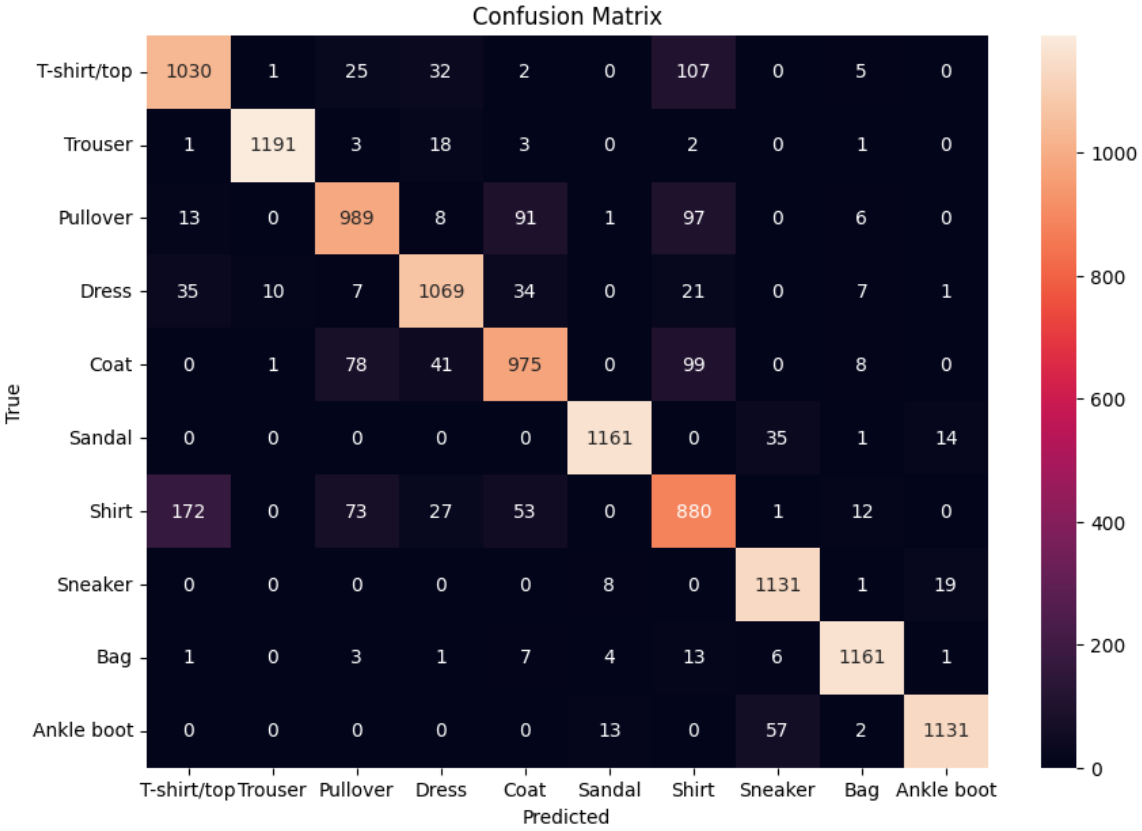

Confusion Matrix
True
Predicted
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
1038 0 15 46 5 0 95 0 3 0
2 1191 2 19 2 0 2 0 1 0
20 0 932 9 138 1 105 0 0 0
25 3 7 1099 30 0 17 0 1 2
2 0 53 38 1044 0 61 0 4 0
0 0 0 0 0 1176 0 20 2 13
175 0 54 38 86 0 858 0 7 0
0 0 0 0 0 21 0 1086 1 51
6 2 4 4 12 4 14 4 1146 1
0 0 0 0 0 13 0 23 2 1165
1000
800
600
400
200
0

Learning rate:0.0005

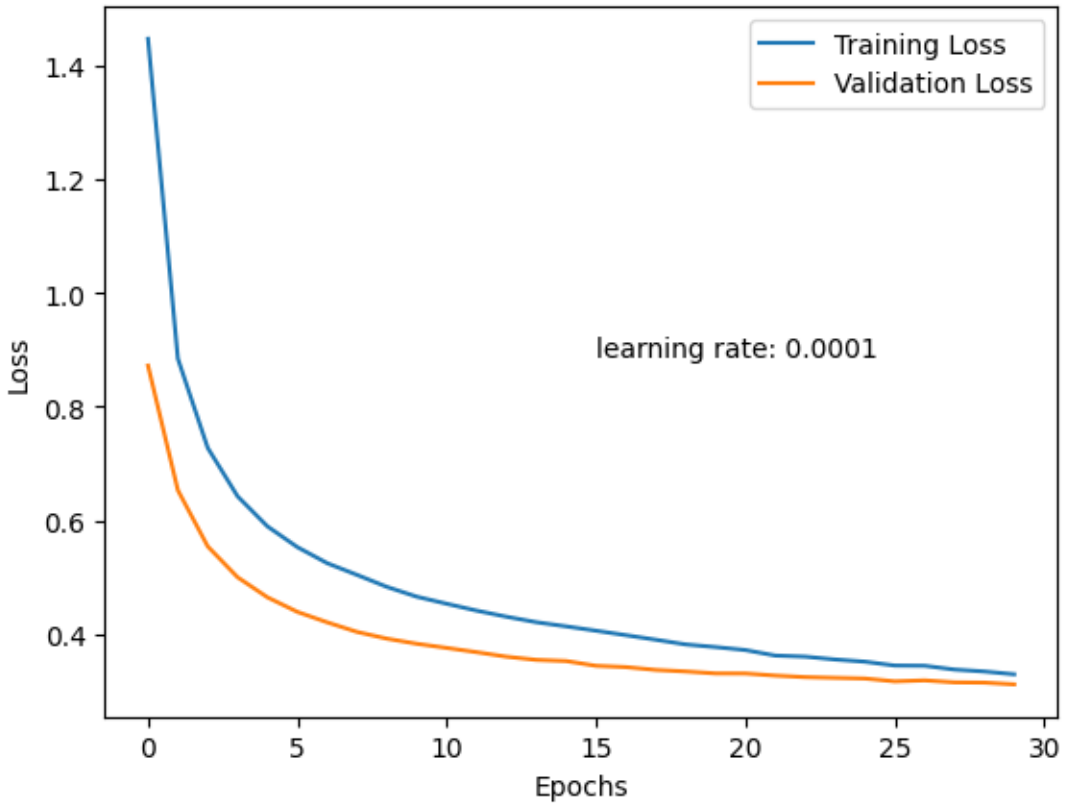


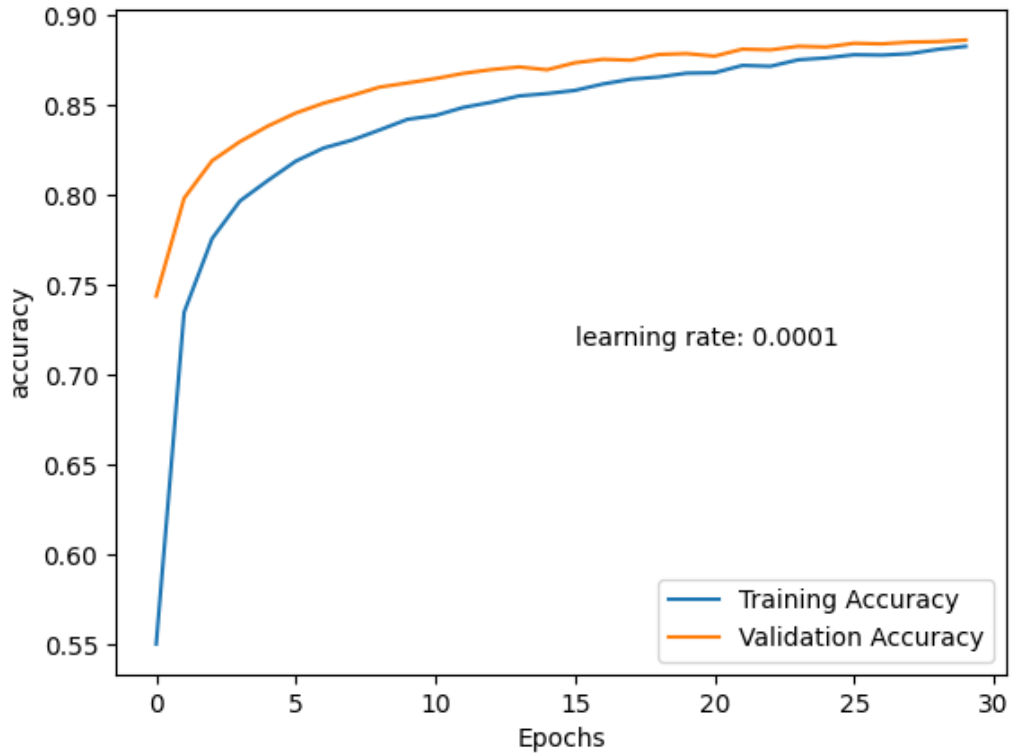


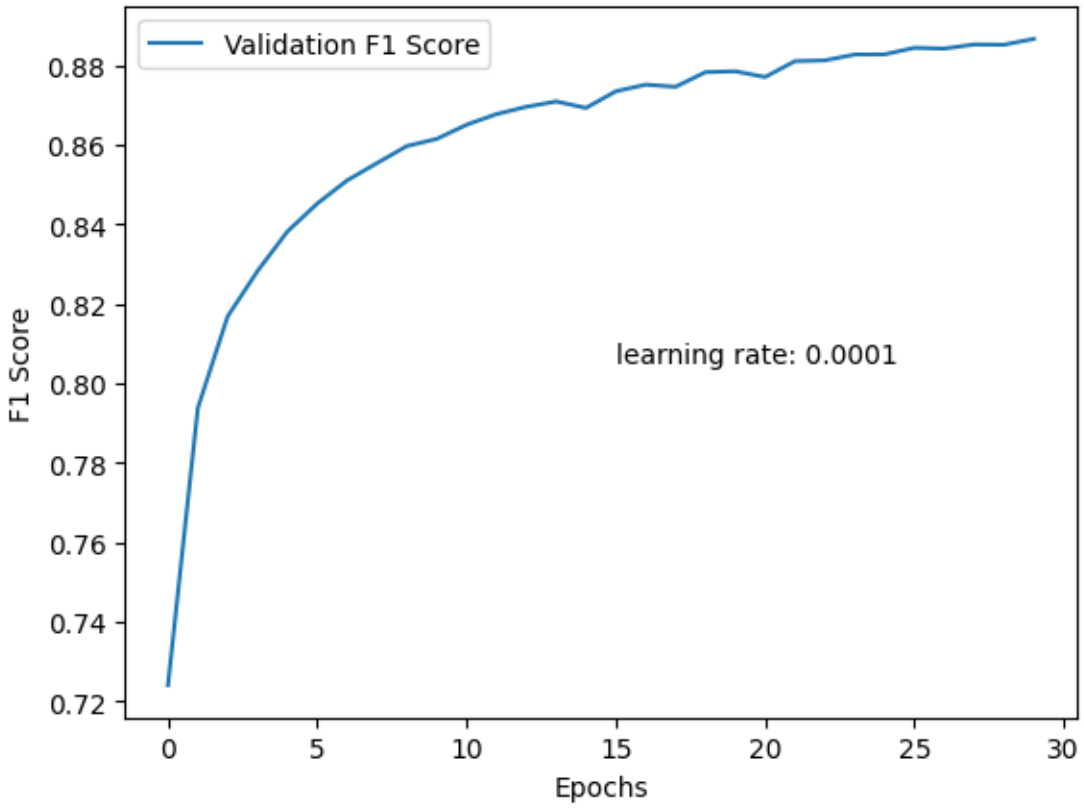

Validation F1 Score
learning rate: 0.0005
F1 Score
Epochs
0.83
0.84
0.85
0.86
0.87
0.88
0.89
0
5
10
15
20
25
30

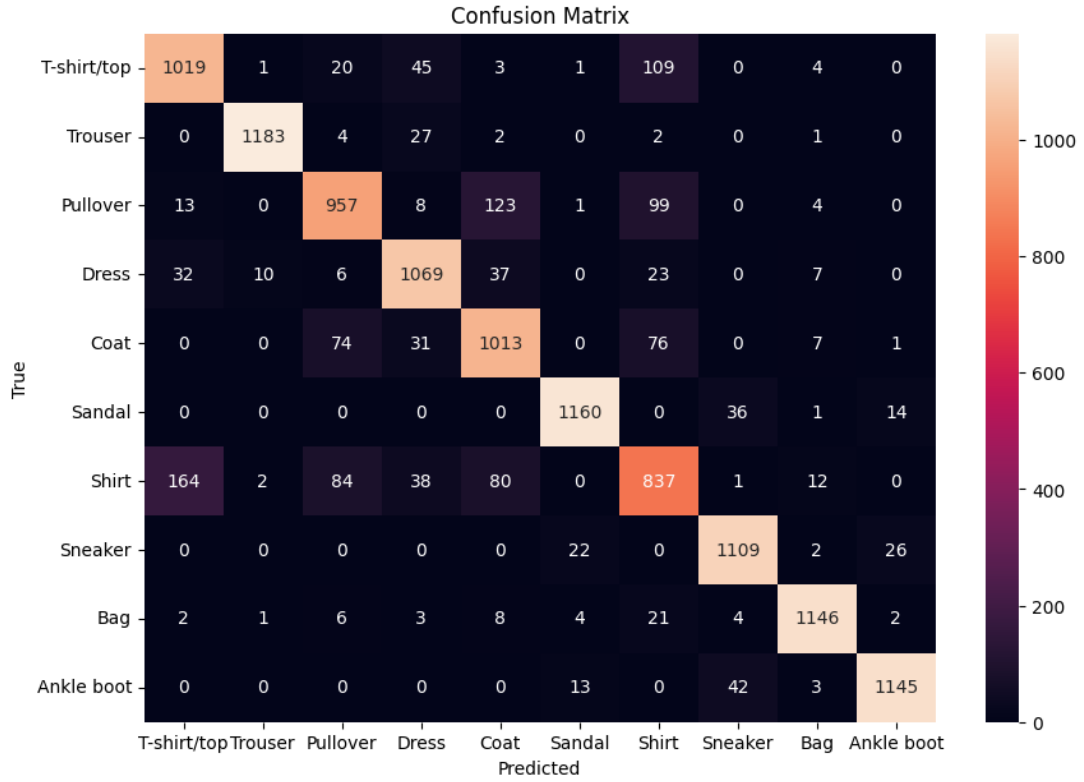

Confusion Matrix
True
Predicted
T-shirt/top
Trouser
Pullover
Dress
Coat
Sandal
Shirt
Sneaker
Bag
Ankle boot
1030 1 25 32 2 0 107 0 5 0
1 1191 3 18 3 0 2 0 1 0
13 0 989 8 91 1 97 0 6 0
35 10 7 1069 34 0 21 0 7 1
0 1 78 41 975 0 99 0 8 0
0 0 0 0 0 1161 0 35 1 14
172 0 73 27 53 0 880 1 12 0
0 0 0 0 0 8 0 1131 1 19
1 0 3 1 7 4 13 6 1161 1
0 0 0 0 0 13 0 57 2 1131
1000
800
600
400
200
0

Learning rate: 0.0001



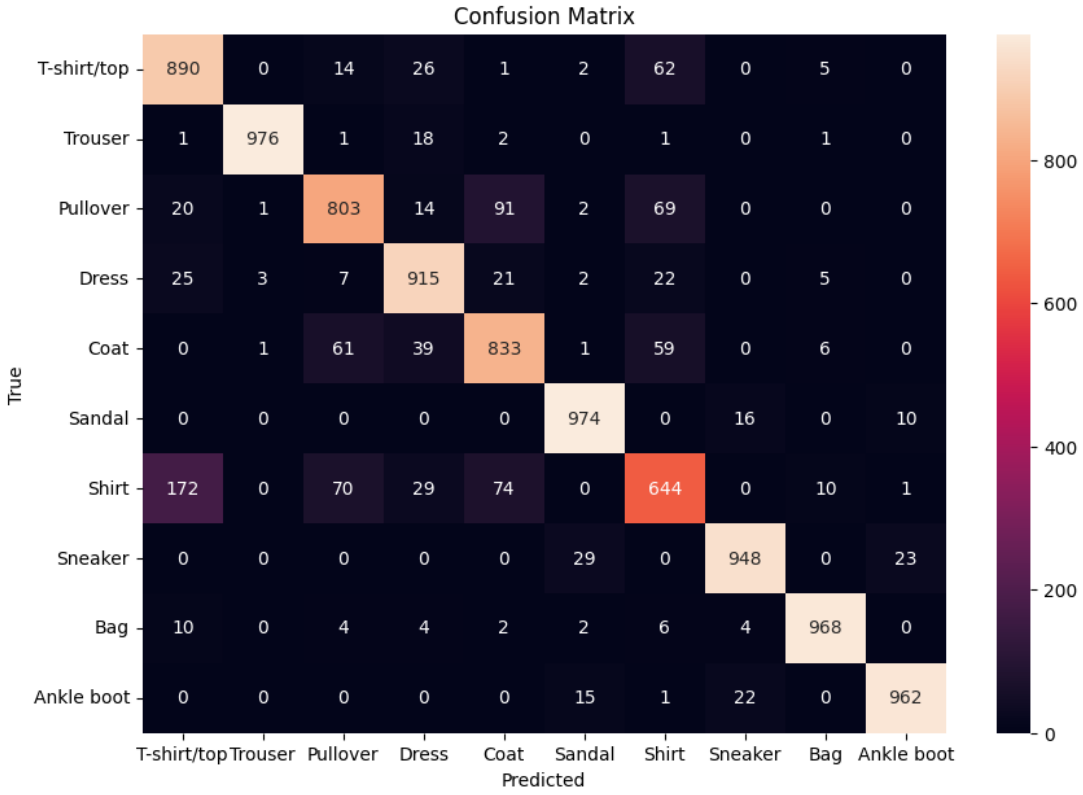



Validation F1 Score
learning rate: 0.0001
F1 Score
Epochs
0.88
0.86
0.84
0.82
0.80
0.78
0.76
0.74
0.72
0
5
10
15
20
25
30


Confusion Matrix
T-shirt/top 1019 1 20 45 3 1 109 0 4 0
Trouser 0 1183 4 27 2 0 2 0 1 0
Pullover 13 0 957 8 123 1 99 0 4 0
Dress 32 10 6 1069 37 0 23 0 7 0
Coat 0 0 74 31 1013 0 76 0 7 1
Sandal 0 0 0 0 0 1160 0 36 1 14
Shirt 164 2 84 38 80 0 837 1 12 0
Sneaker 0 0 0 0 0 22 0 1109 2 26
Bag 2 1 6 3 8 4 21 4 1146 2
Ankle boot 0 0 0 0 0 13 0 42 3 1145
True
T-shirt/top Trouser Pullover Dress Coat Sandal Shirt Sneaker Bag Ankle boot
Predicted
1000
800
600
400
200
0

For the selected best model:

- Testing Accuracy: 0.8913
- Testing_f1_Score: 0.8902283236998967
- Confusion matrix:



********** for all models **batch size 256 and epoch 30** are used **********

Running file:

1. For training model uncomment last 8-9 line (which is commented out) in code block 15 under training markdown
2. For testing uncomment 16 number code block under markdown testing