

# DLOPs Assignment 1 Report

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*Roll Number: B23CS1037*

January 24, 2026

## Colab Notebook:

[https://colab.research.google.com/drive/1A6I5AuWTPN1Adlk6fiDcz\\_UhlifHuXEM?usp=sharing](https://colab.research.google.com/drive/1A6I5AuWTPN1Adlk6fiDcz_UhlifHuXEM?usp=sharing)

## Github Link:

<https://github.com/Laksh-Mendpara/MLOps-Laksh-B23CS1037/tree/Assignment-1>

## Best Performing Models:

<https://drive.google.com/drive/folders/1DkssK5Gm7j0-HUb0uw2z1hp4N-J6D6d3?usp=sharing>

## 1 Q1(a): ResNet Classification on MNIST and FashionMNIST

In this section, we trained ResNet-18 and ResNet-50 models on the MNIST and FashionMNIST datasets using various hyperparameters (Batch Size, Optimizer, Learning Rate).

### Results Analysis

- **Overall Performance:** The models performed exceptionally well on MNIST, achieving > 99% accuracy in most configurations.
- **FashionMNIST Challenge:** FashionMNIST proved more challenging, with accuracies hovering around 90-93%.
- **Optimizer Comparison:** Adam generally converged faster and achieved better stability compared to SGD, especially at lower learning rates. SGD with LR=0.0001 showed significantly poorer performance on FashionMNIST.

## Experimental Results

### Results for MNIST

Batch	Opt	LR	R50 (5e)	R50 (10e)	R18 (5e)	R18 (10e)
16	sgd	0.001	99.19	99.31	99.06	99.37
16	sgd	0.0001	97.05	98.56	97.97	98.75
16	adam	0.001	98.87	99.02	99.07	99.12
16	adam	0.0001	99.17	99.15	99.15	99.42
32	sgd	0.001	98.93	99.24	99.01	99.28
32	sgd	0.0001	93.83	96.20	96.41	97.76
32	adam	0.001	98.80	99.05	98.82	99.33
32	adam	0.0001	99.36	99.10	99.25	99.41

## Results for FASHION-MNIST

Batch	Opt	LR	R50 (5e)	R50 (10e)	R18 (5e)	R18 (10e)
16	sgd	0.001	88.64	91.74	90.03	90.90
16	sgd	0.0001	78.24	84.82	80.29	86.63
16	adam	0.001	90.05	89.85	90.42	92.99
16	adam	0.0001	89.24	91.76	91.17	92.43
32	sgd	0.001	86.95	90.13	87.33	90.52
32	sgd	0.0001	74.35	80.64	77.56	82.31
32	adam	0.001	89.74	91.09	90.80	92.00
32	adam	0.0001	91.21	91.91	90.12	90.66

## Performance Visualization

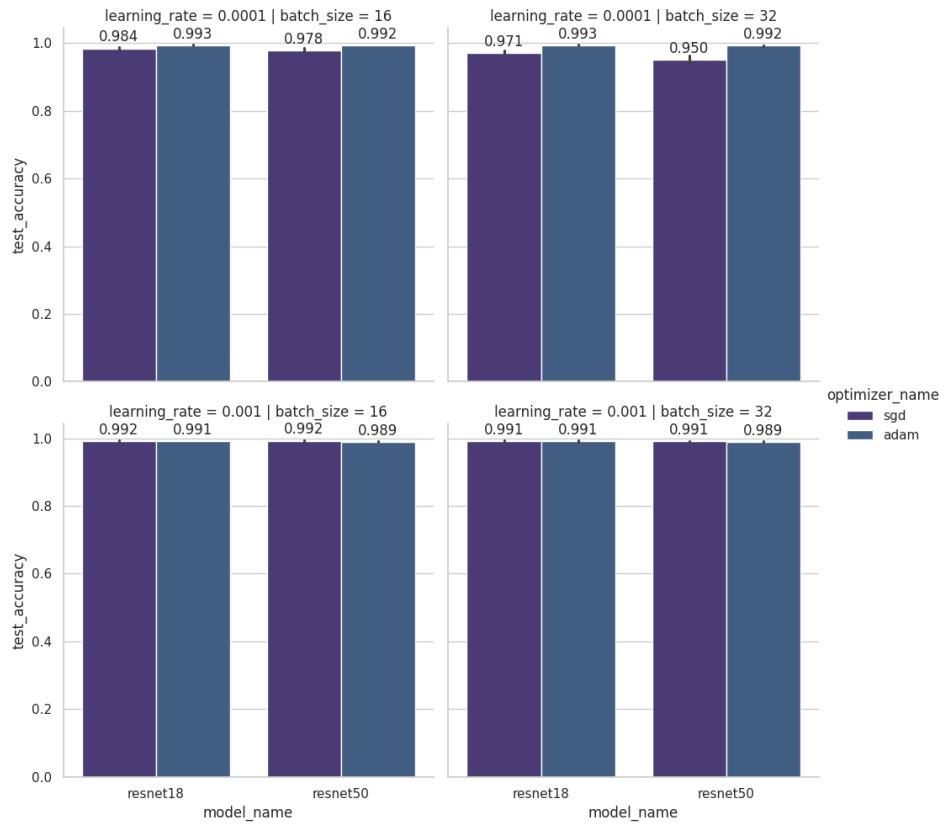


Figure 1: Parameter Grid Analysis

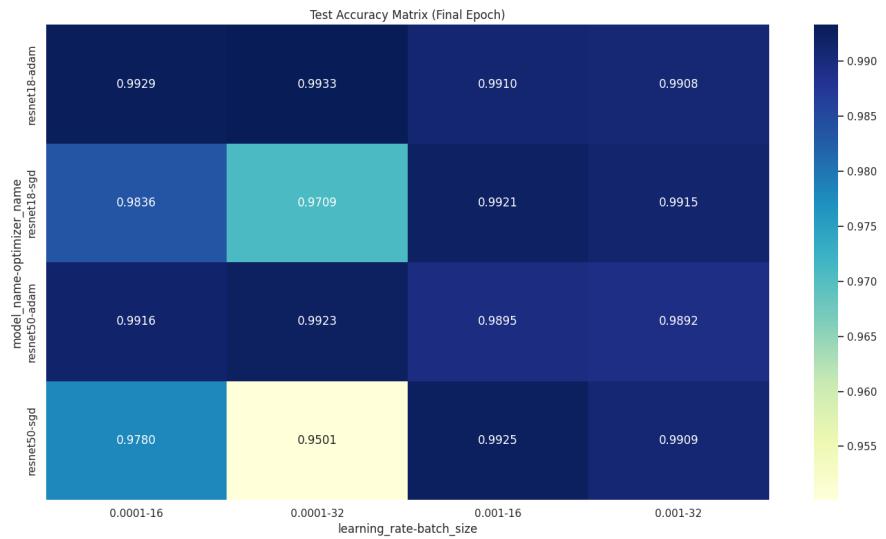


Figure 2: Accuracy Matrix

## 2 Q1(b): SVM Classification

We trained SVM classifiers with Polynomial and RBF kernels on both datasets. Kernel Performance: RBF kernels generally outperformed Polynomial kernels.

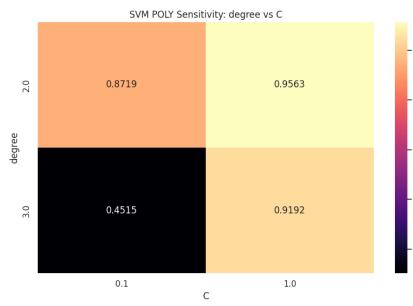
### SVM Results for MNIST

Kernel	Params	Acc (%)	Time (ms)
poly	{degree: 2, C: 0.1, gamma: scale}	87.37	4686
poly	{degree: 2, C: 0.1, gamma: auto}	87.01	4235
poly	{degree: 2, C: 1.0, gamma: scale}	95.65	3136
poly	{degree: 2, C: 1.0, gamma: auto}	95.61	3081
poly	{degree: 3, C: 0.1, gamma: scale}	45.98	5219
poly	{degree: 3, C: 0.1, gamma: auto}	44.33	5531
poly	{degree: 3, C: 1.0, gamma: scale}	92.04	3809
poly	{degree: 3, C: 1.0, gamma: auto}	91.80	3872
rbf	{C: 0.1, gamma: scale}	91.15	3859
rbf	{C: 0.1, gamma: auto}	91.15	3788
rbf	{C: 1.0, gamma: scale}	96.01	3276
rbf	{C: 1.0, gamma: auto}	95.99	2991

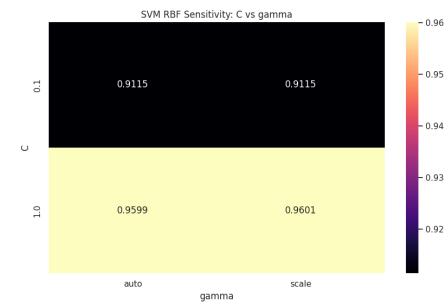
### SVM Results for FASHION-MNIST

Kernel	Params	Acc (%)	Time (ms)
poly	{degree: 2, C: 0.1, gamma: scale}	75.16	3586
poly	{degree: 2, C: 0.1, gamma: auto}	75.16	3542
poly	{degree: 2, C: 1.0, gamma: scale}	81.22	3055
poly	{degree: 2, C: 1.0, gamma: auto}	81.22	3015
poly	{degree: 3, C: 0.1, gamma: scale}	71.80	3738
poly	{degree: 3, C: 0.1, gamma: auto}	71.80	3724
poly	{degree: 3, C: 1.0, gamma: scale}	80.16	3085
poly	{degree: 3, C: 1.0, gamma: auto}	80.15	3058
rbf	{C: 0.1, gamma: scale}	77.23	3259
rbf	{C: 0.1, gamma: auto}	77.24	3183
rbf	{C: 1.0, gamma: scale}	82.44	3016
rbf	{C: 1.0, gamma: auto}	82.44	2847

### SVM Visualizations



(a) Poly Kernel Heatmap



(b) RBF Kernel Heatmap

### 3 Q2: Hardware Comparison (CPU vs GPU)

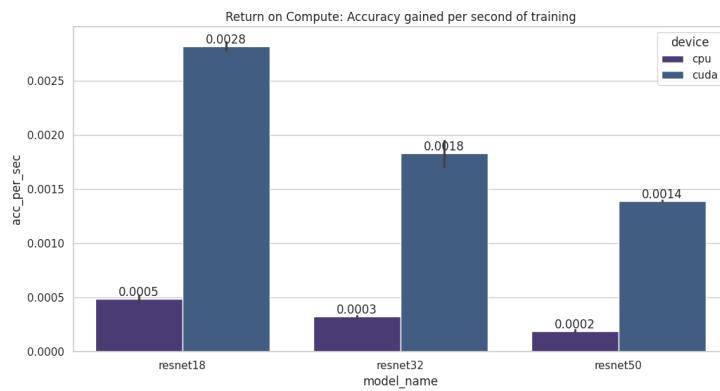
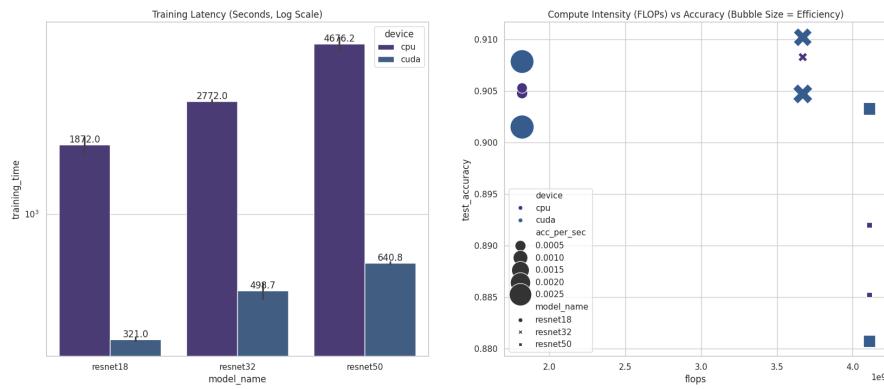
This section compares the training performance of ResNet models on CPU and GPU. GPU yielded a massive speedup ( 5.5x for ResNet-18).

#### Performance Comparison Table

Dev	Opt	LR	R18 Acc	R32 Acc	R50 Acc	R18 Time(ms)
CPU	SGD	0.001	90.48	90.83	88.52	1734187
CPU	ADAM	0.001	90.53	90.46	89.20	2009823
GPU	SGD	0.001	90.15	90.47	90.33	315674
GPU	ADAM	0.001	90.79	91.02	88.07	326356

Note: Table simplified for LaTeX fit. Full data in README.

#### Hardware Performance Dashboard



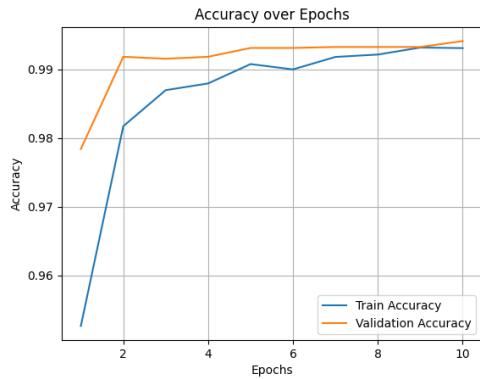


## Appendix: Training Curves

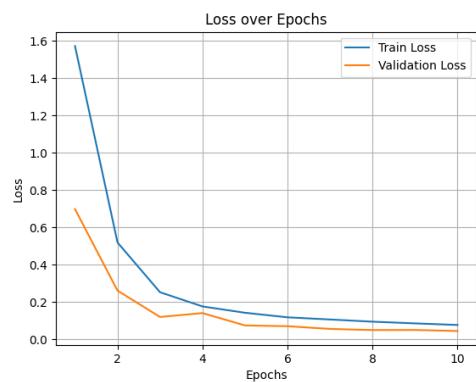
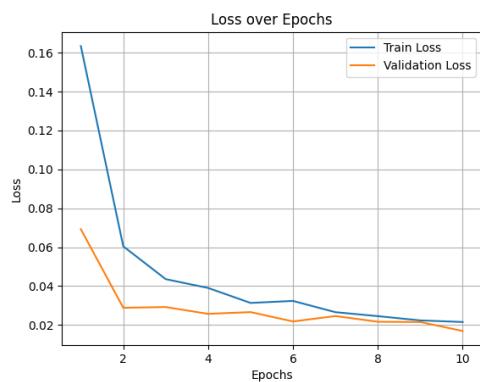
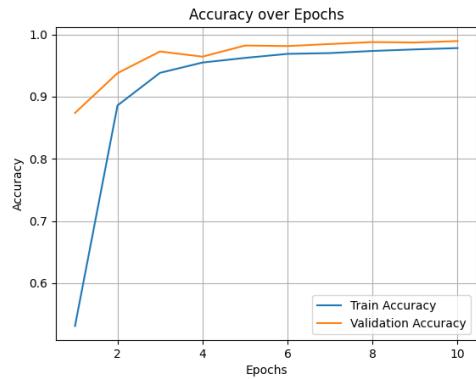
### Q1(a) Experiments (Max Epochs = 10)

MNIST

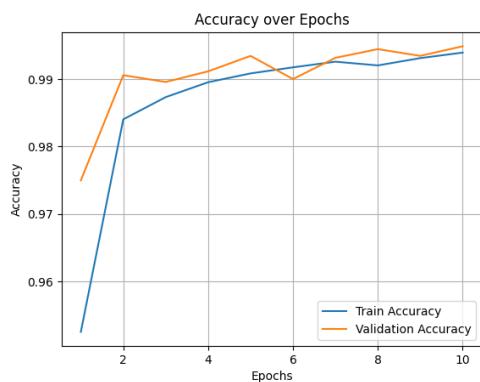
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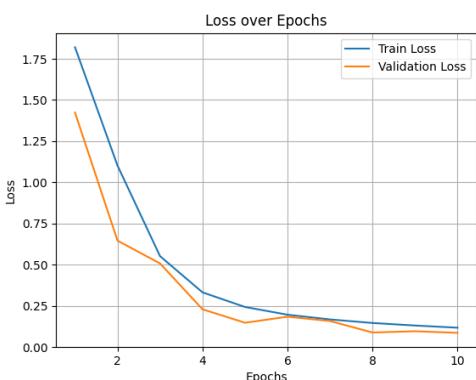
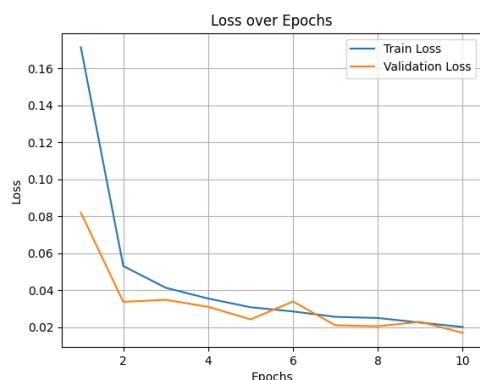
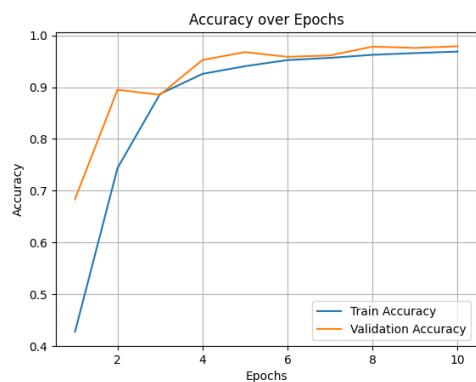
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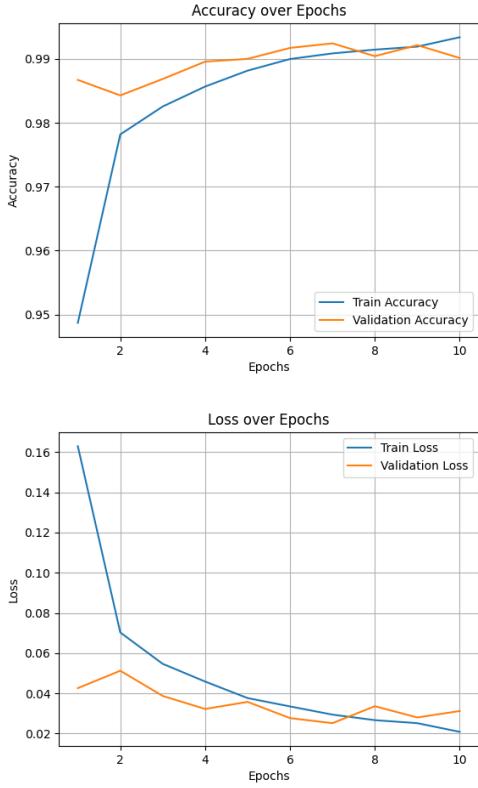
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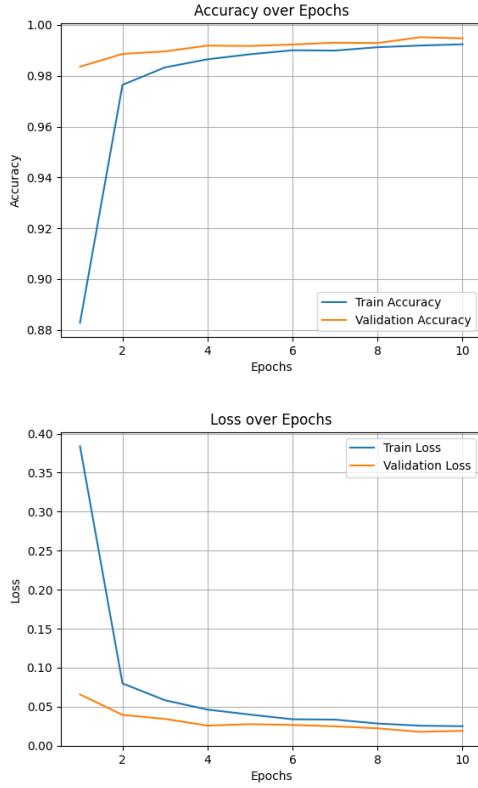
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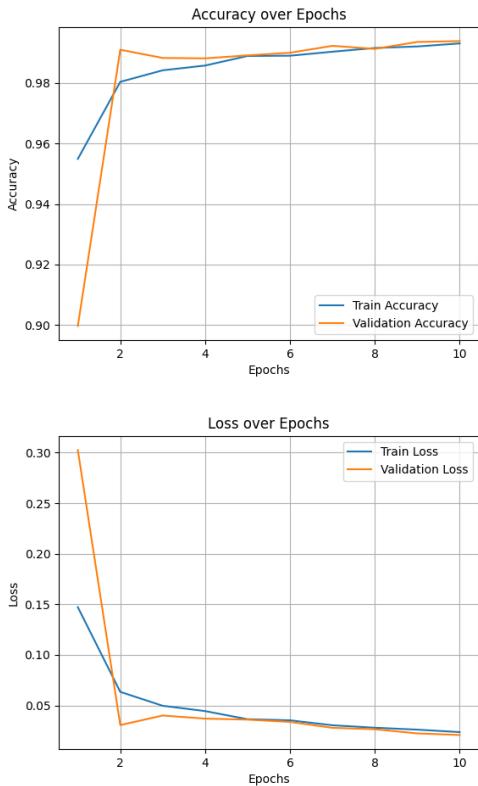
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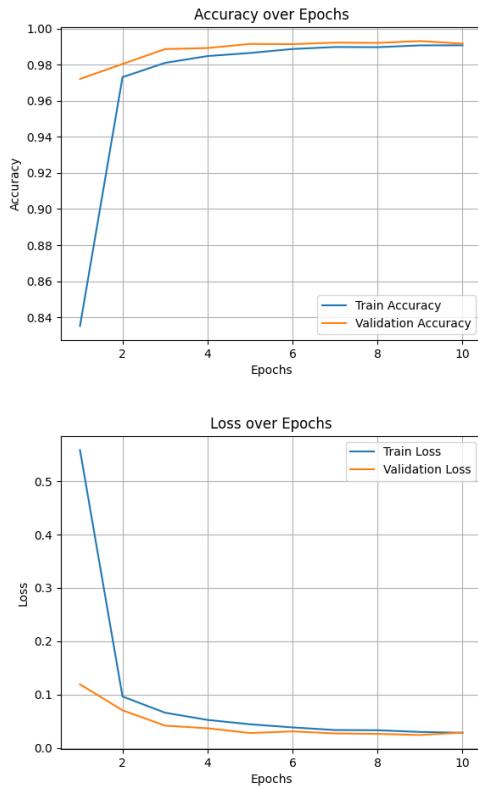
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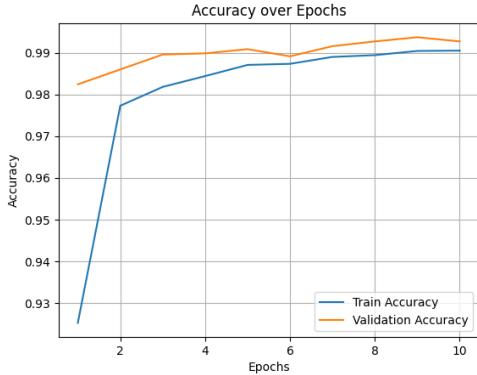
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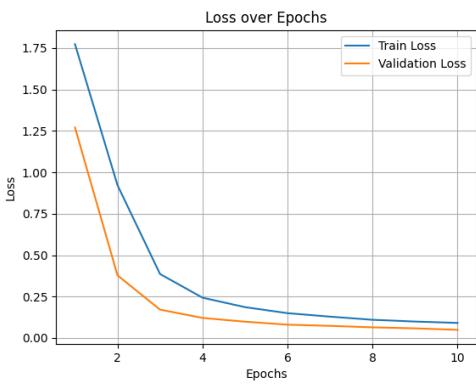
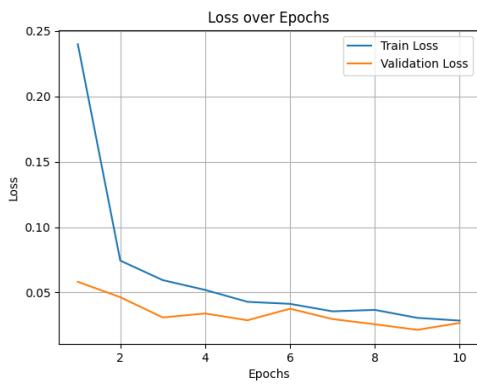
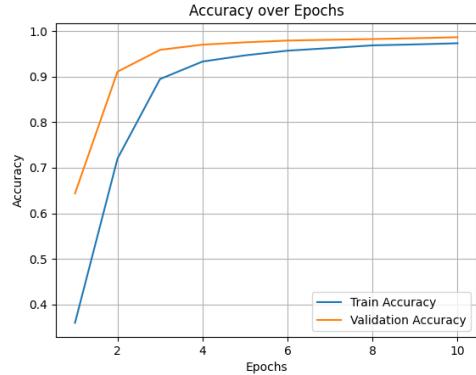
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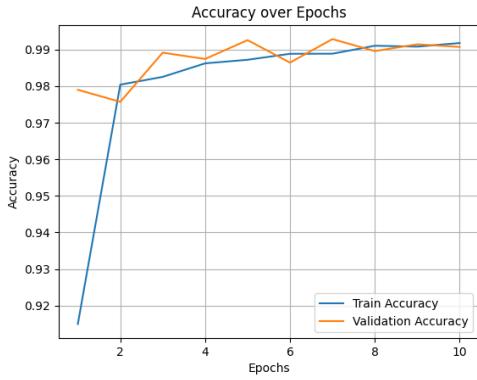
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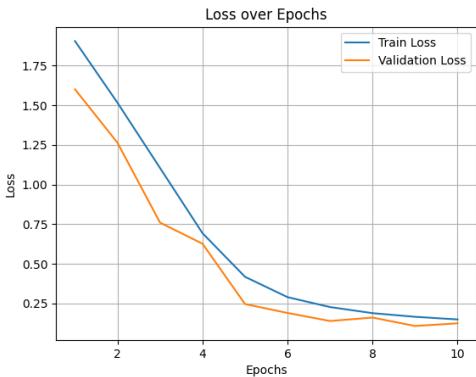
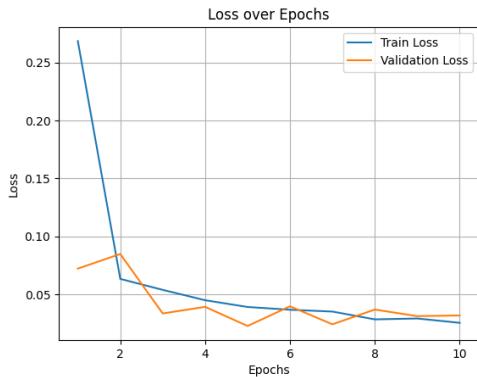
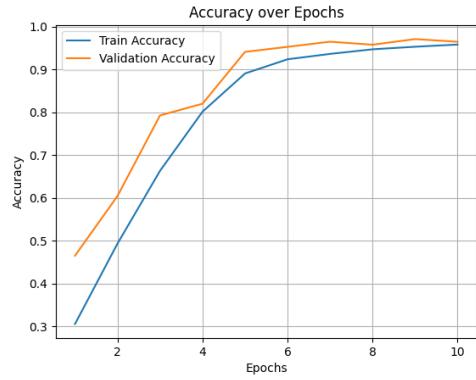
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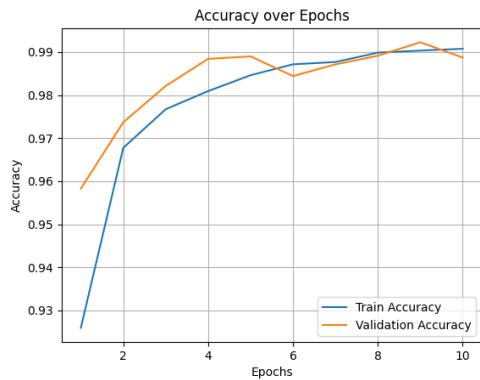
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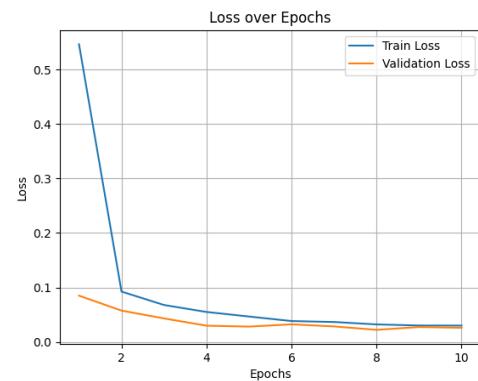
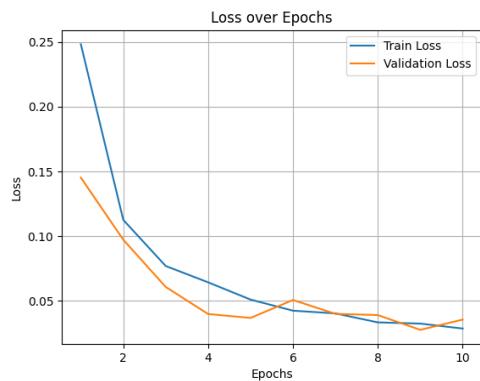
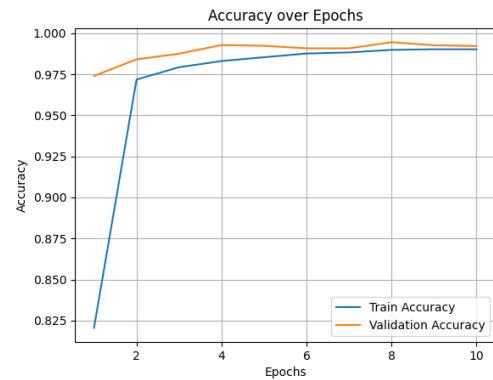
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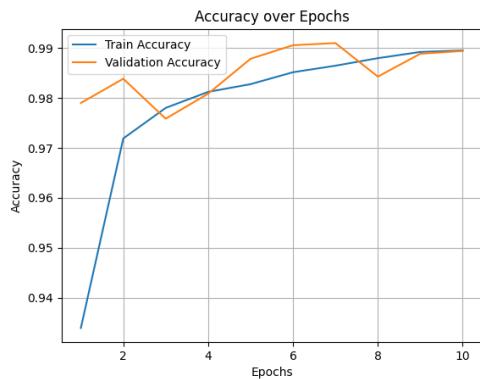
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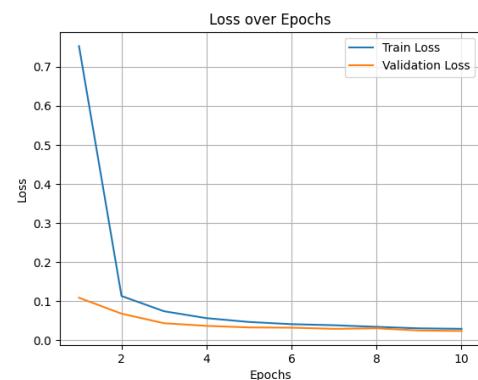
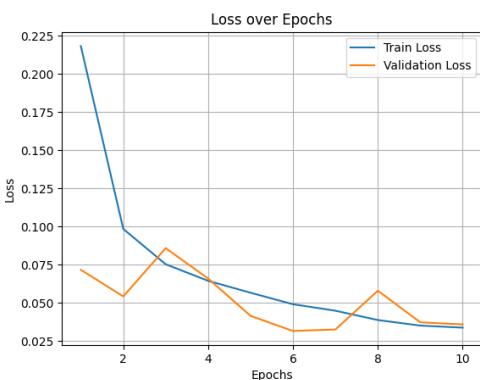
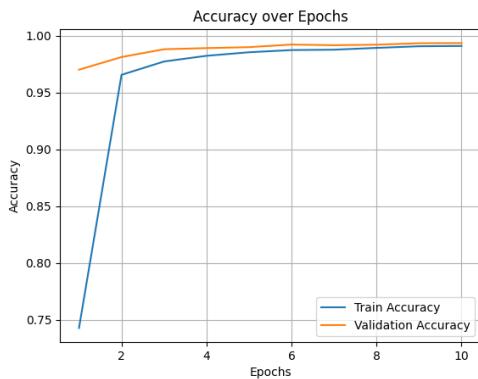
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**Resnet50 ADAM LR=0.001**

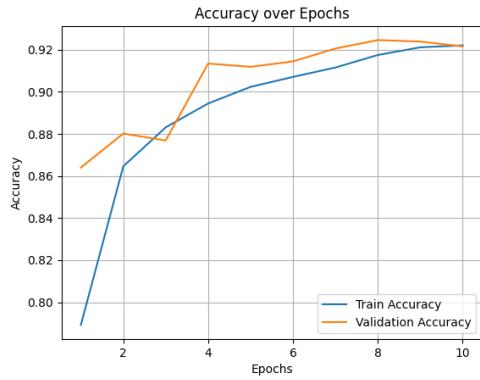


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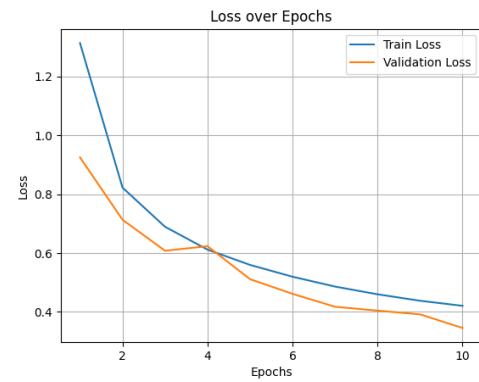
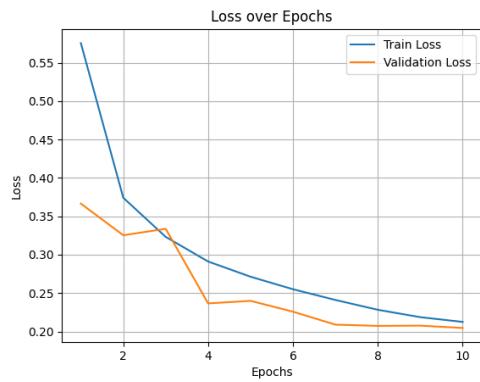
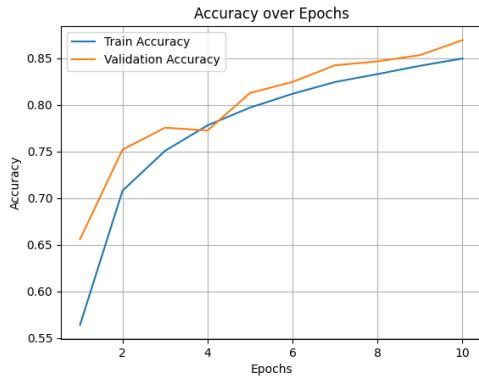


## FASHION\_MNIST

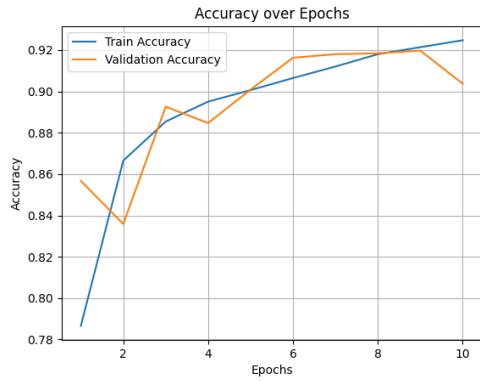
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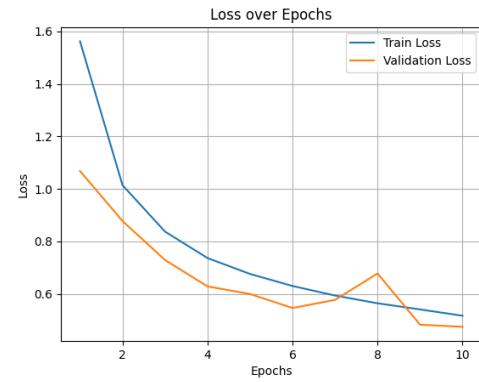
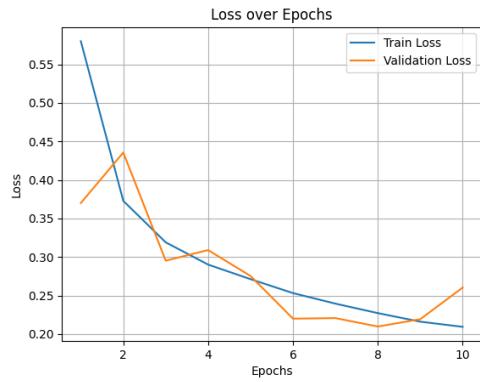
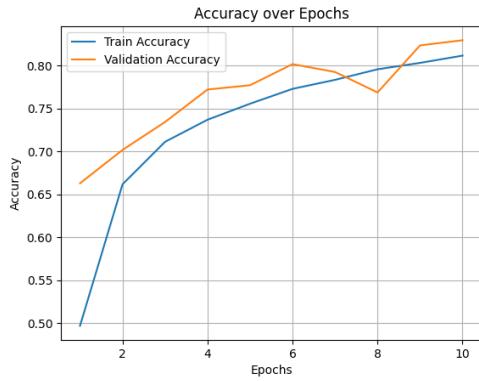
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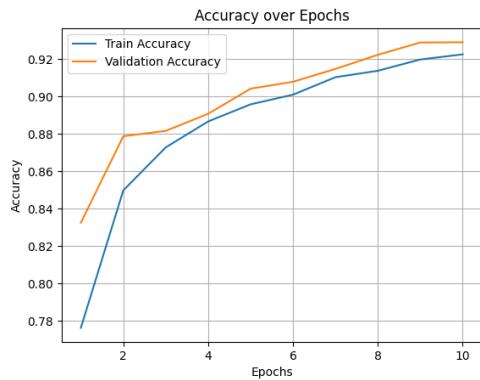
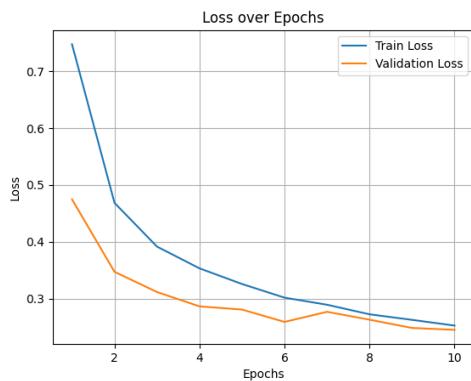
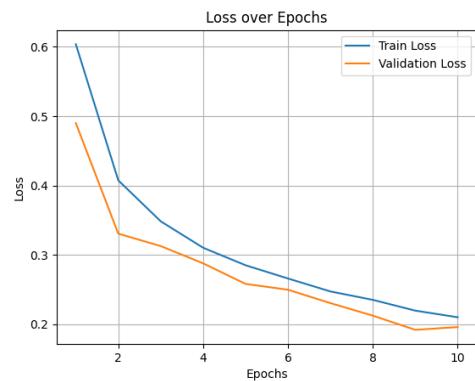
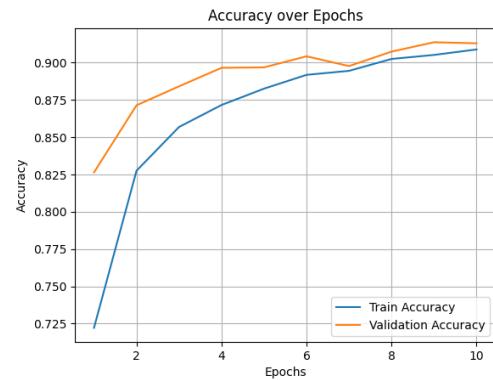
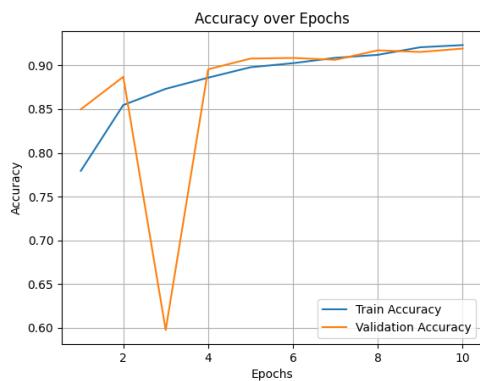
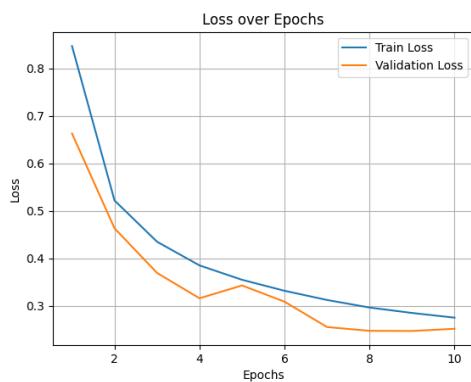
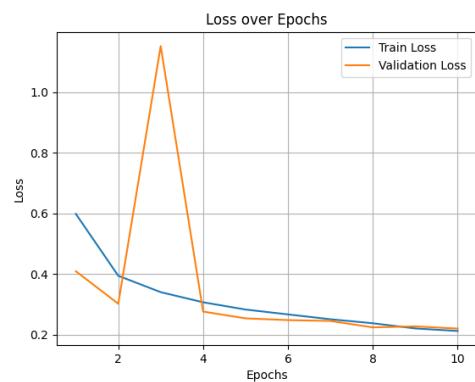
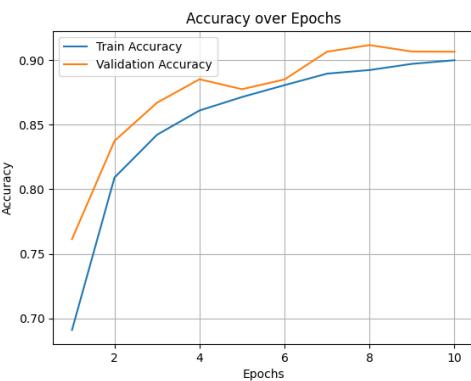


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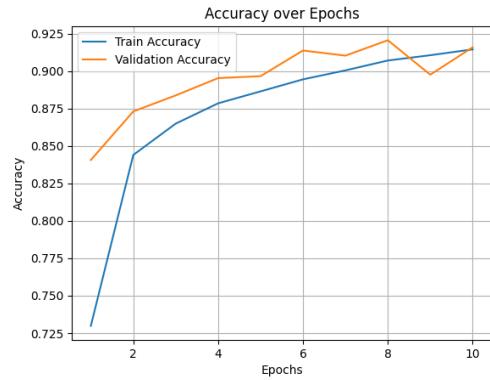


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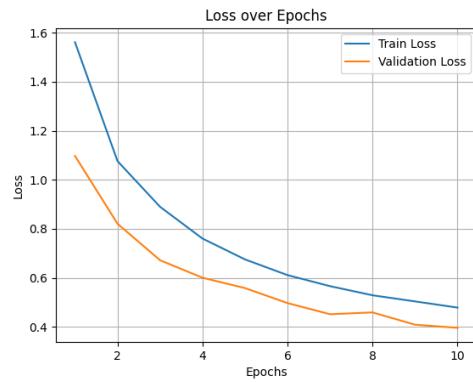
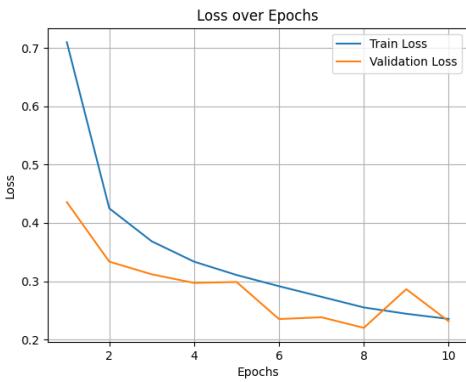
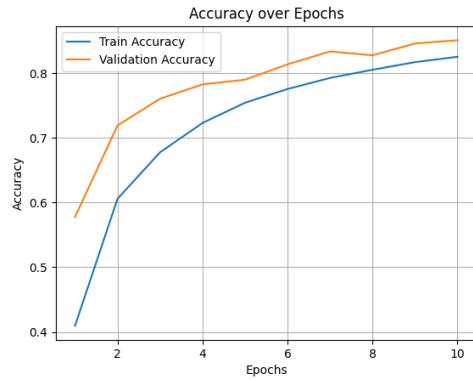


**Resnet18 ADAM LR=0.001****Resnet18 SGD LR=0.001****Resnet18 ADAM LR=0.001****Resnet18 SGD LR=0.001**

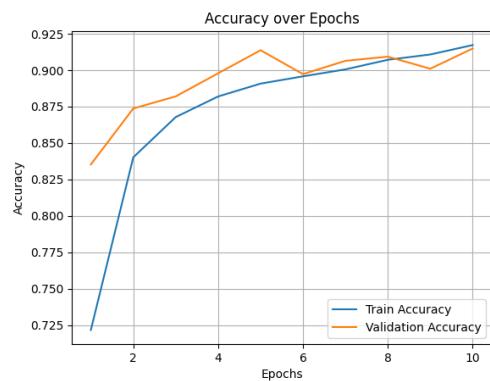
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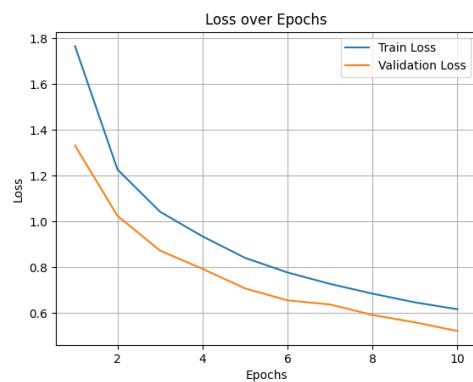
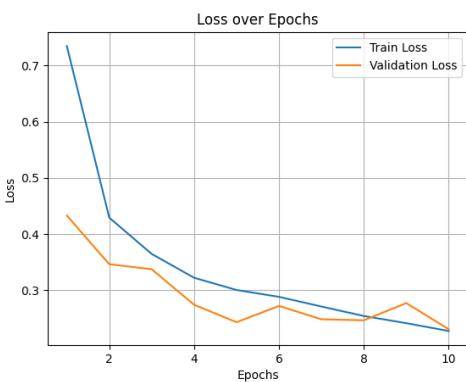
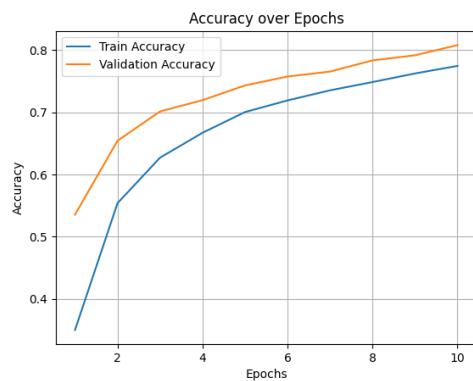
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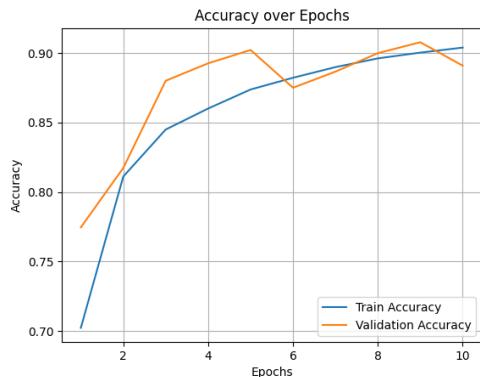
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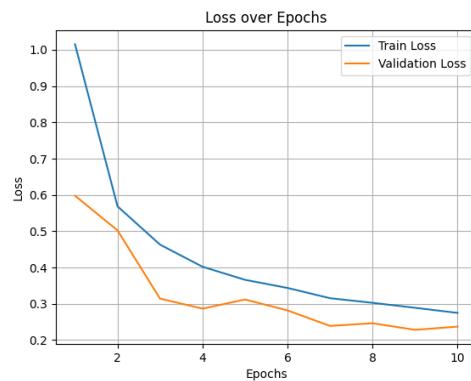
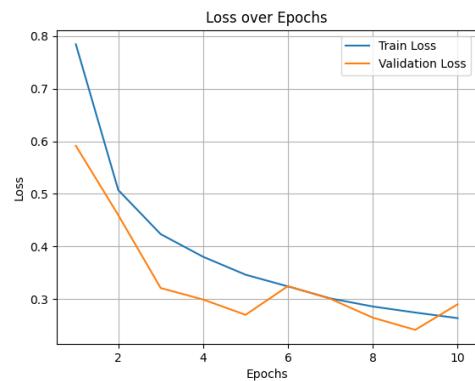
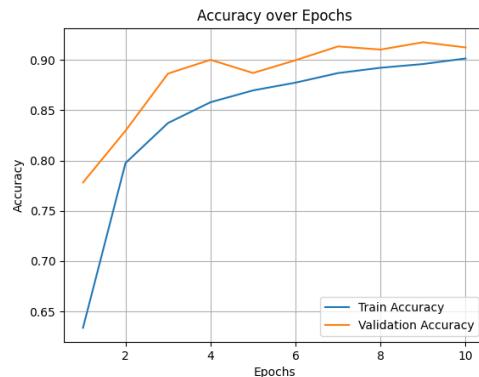
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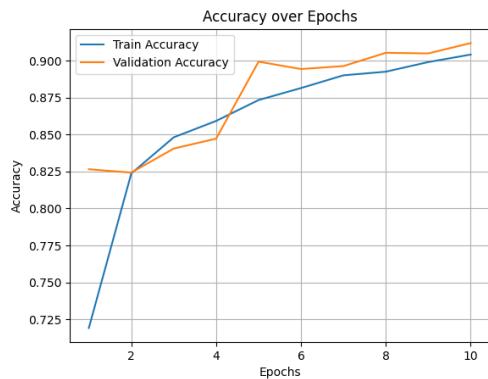
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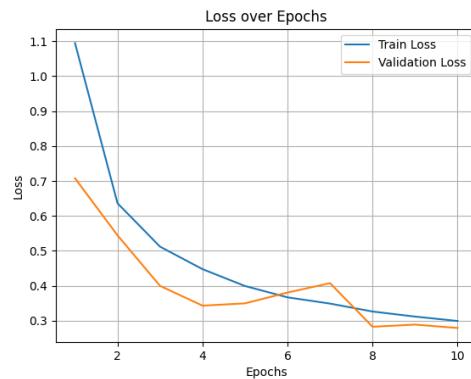
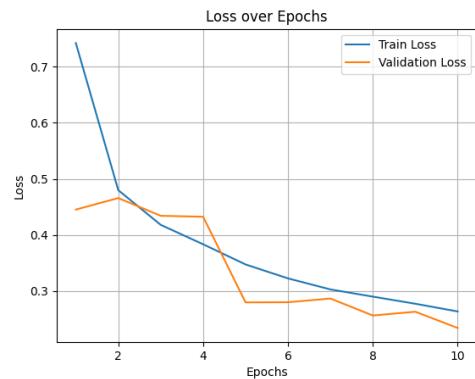
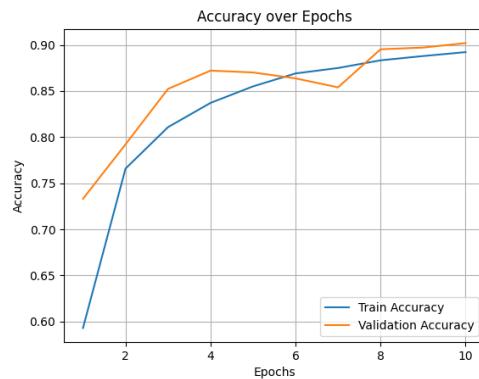
**Resnet50 SGD LR=0.001**



**Resnet50 ADAM LR=0.001**

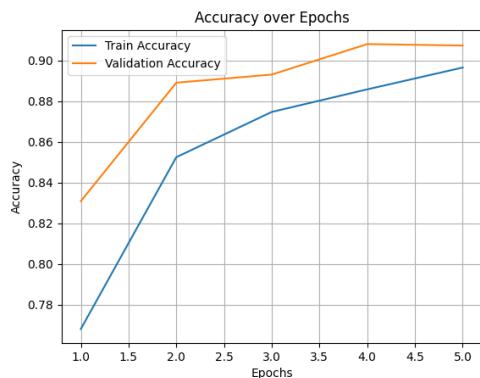


**Resnet50 SGD LR=0.001**

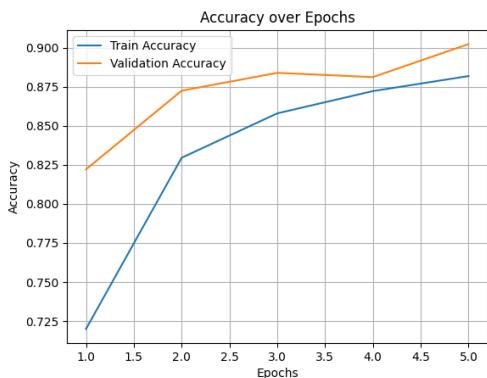


## Q2 Experiments (FashionMNIST, Max Epochs = 5)

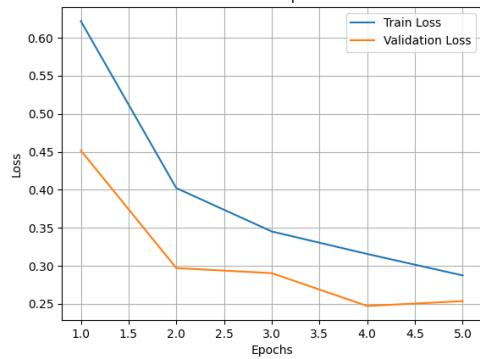
CPU Resnet18



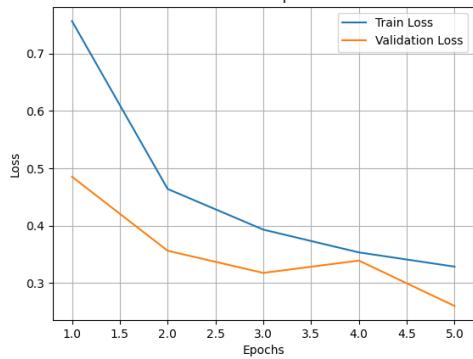
CPU Resnet18



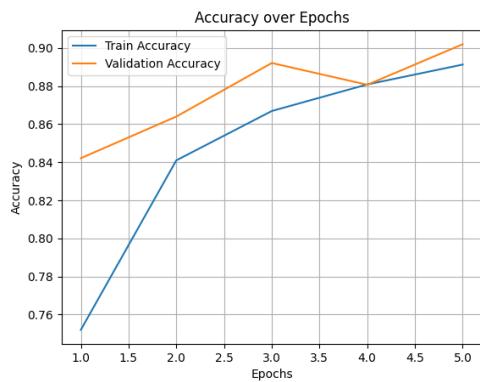
Loss over Epochs



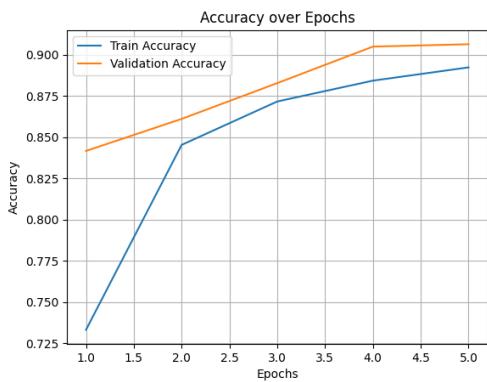
Loss over Epochs



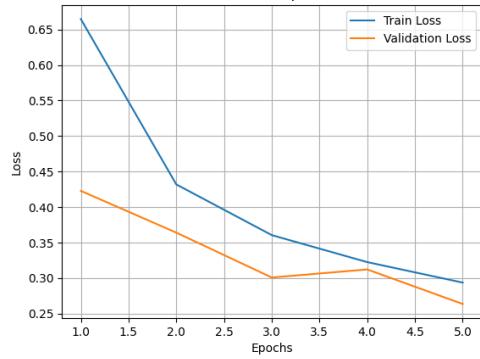
CPU Resnet32



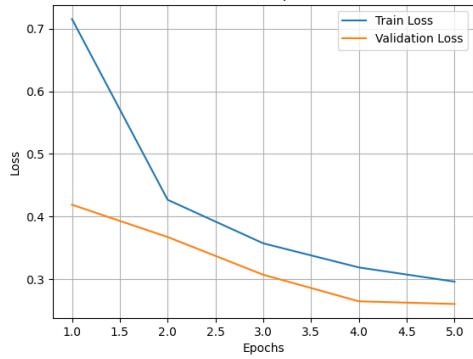
CPU Resnet32

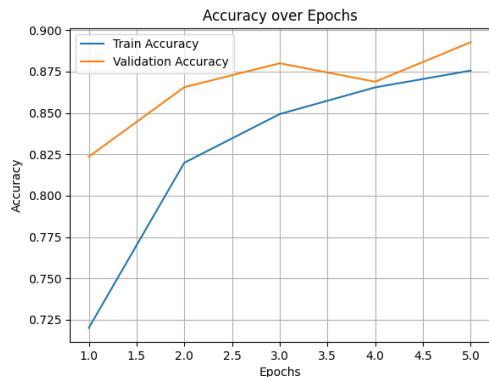
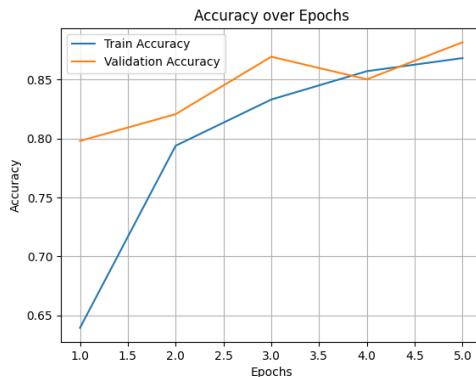


Loss over Epochs

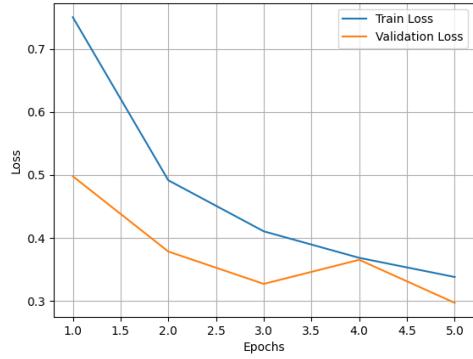


Loss over Epochs

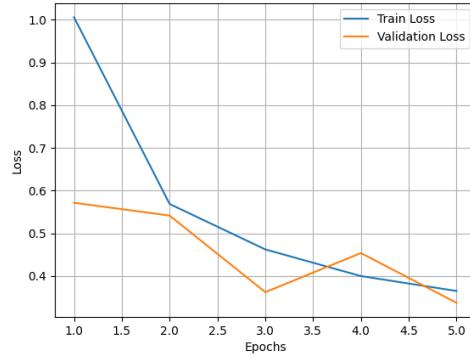
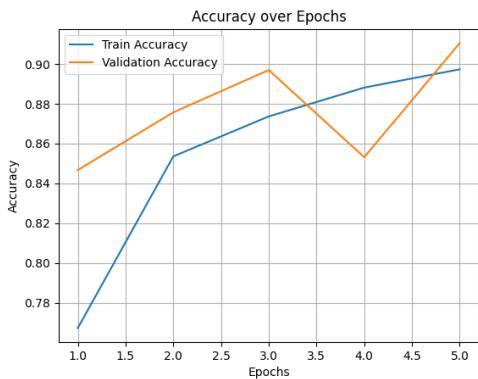
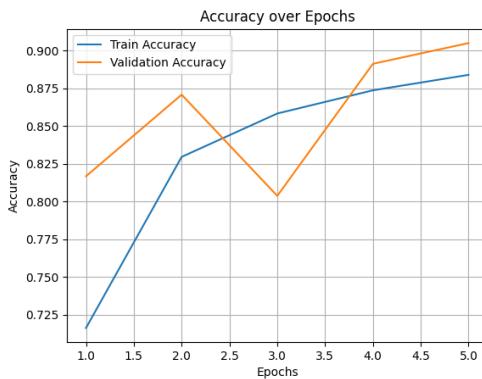


**CPU Resnet50****CPU Resnet50**

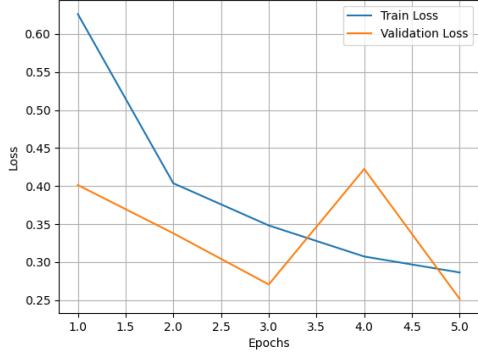
Loss over Epochs



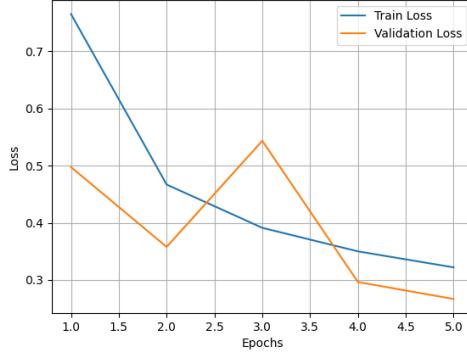
Loss over Epochs

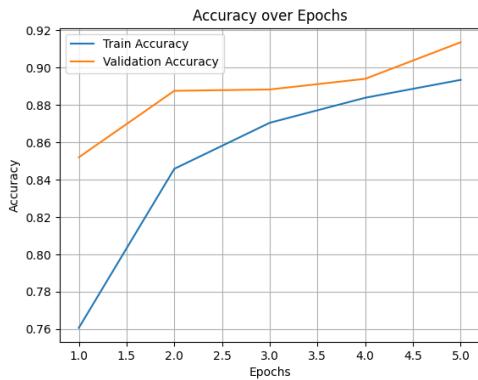
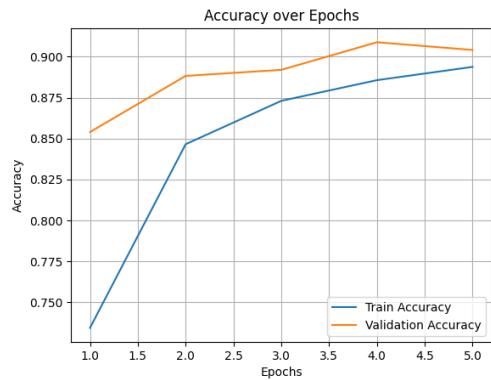
**GPU Resnet18****GPU Resnet18**

Loss over Epochs

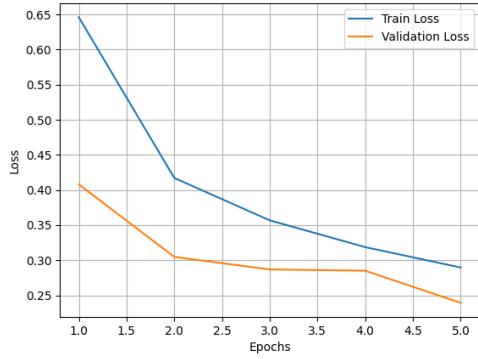


Loss over Epochs

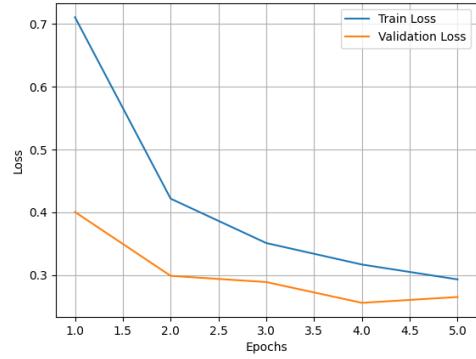
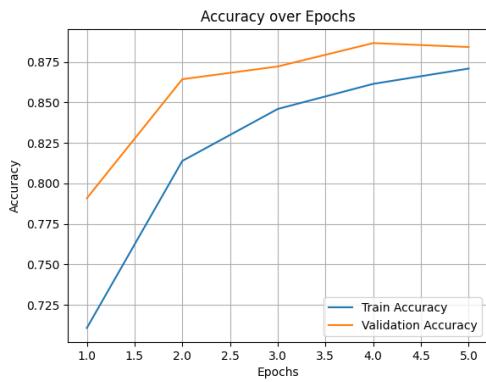
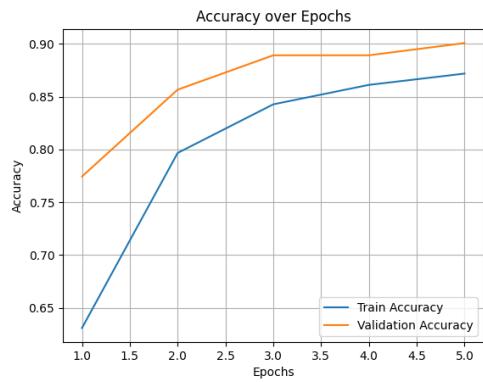


**GPU Resnet32****GPU Resnet32**

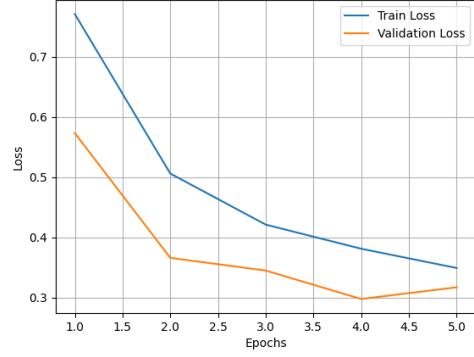
Loss over Epochs



Loss over Epochs

**GPU Resnet50****GPU Resnet50**

Loss over Epochs



Loss over Epochs

