HIGH PERFORMANCE MACHINE LEARNING
ECE-GY-9143
LAB – 2

Nagharjun Mathi Mariappan
nm4074

Question C2

```
#!/bin/bash
#SBATCH --account=ece-gy-9143-2022fa
#SBATCH --partition=n1s8-v100-1
#SBATCH --job-name=C222222
#SBATCH --nodes=1
#SBATCH --cpus-per-task=8
#SBATCH --output=C222222.out
#SBATCH --mem=2GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:v100:1
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision

srun python C2.py --cuda y --dataloaders 2 --opt sgd --datapath ./data
~
~
"submit_job_lab2.sh" 18L, 433C                          1,1          All
```

Output:


```
Files already downloaded and verified
Files already downloaded and verified
----------------------------------------------------------------------------------------------------
Epoch: 1

Loss: 1.881451, Accuracy: 32.584000

Data Loading Time: 0.759291, Training Time: 8.532162, Dataloading + Training time = 9.291453, Total Time: 22.557150

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 2

Loss: 1.357787, Accuracy: 50.190000

Data Loading Time: 0.721116, Training Time: 3.138121, Dataloading + Training time = 3.859237, Total Time: 16.820552

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 3

Loss: 1.085082, Accuracy: 61.040000

Data Loading Time: 0.711392, Training Time: 2.760595, Dataloading + Training time = 3.471987, Total Time: 16.767476

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 4

Loss: 0.882391, Accuracy: 68.390000

Data Loading Time: 0.726751, Training Time: 2.764242, Dataloading + Training time = 3.490993, Total Time: 16.754345

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 5

Loss: 0.728303, Accuracy: 74.602000

Data Loading Time: 0.690628, Training Time: 2.757506, Dataloading + Training time = 3.448134, Total Time: 16.726775

----------------------------------------------------------------------------------------------------
~
~
```

Question C3

0 Workers


```
#!/bin/bash
#SBATCH --job-name=C3_0
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C3.py --cuda y --dataloaders 0 --opt sgd --datapath ./data
~
~
~
~
~
"submit_job_lab2_0.sh" 15L, 353C                                          1,1          All
```

Output:

```
Files already downloaded and verified
Files already downloaded and verified
----------------------------------------------------------------------------------------------------
Epoch: 1
Loss: 2.127166, Accuracy: 26.182000
Data Loading Time: 14.430848, Training Time: 8.333195, Dataloading + Training Time: 22.764042, Total Time: 36.147460
----------------------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.565087, Accuracy: 42.014000
Data Loading Time: 14.405235, Training Time: 2.763377, Dataloading + Training Time: 17.168612, Total Time: 30.369579
----------------------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.279415, Accuracy: 53.556000
Data Loading Time: 14.401534, Training Time: 2.757137, Dataloading + Training Time: 17.158671, Total Time: 30.368081
----------------------------------------------------------------------------------------------------
Epoch: 4
Loss: 1.056271, Accuracy: 62.124000
Data Loading Time: 14.384500, Training Time: 2.743560, Dataloading + Training Time: 17.128060, Total Time: 30.368712
----------------------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.908237, Accuracy: 67.826000
Data Loading Time: 14.389561, Training Time: 2.742648, Dataloading + Training Time: 17.132209, Total Time: 30.377811
----------------------------------------------------------------------------------------------------
 For 0 Workers
Total Data Loading Time: 72.011678, Total Training Time: 19.339917, Final Total Time: 157.631644
~
~
~
"C3_0.out" 51L, 2060C                                          Calendar
```

4 Workers

```bash
#!/bin/bash
#SBATCH --job-name=C3_4
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C3.py --cuda y --dataloaders 4 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
~
"submit_job_lab2_4.sh" 15L, 353C                        1,1            All
```

Output:

```
Files already downloaded and verified
Files already downloaded and verified
----------------------------------------------------------------------------------------
Epoch: 1
Loss: 1.932654, Accuracy: 30.770000
Data Loading Time: 1.029289, Training Time: 5.193285, Dataloading + Training Time: 6.222574, Total Time: 18.076054
----------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.449043, Accuracy: 46.670000
Data Loading Time: 0.992040, Training Time: 4.239782, Dataloading + Training Time: 5.231821, Total Time: 17.182871
----------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.179214, Accuracy: 57.476000
Data Loading Time: 0.954112, Training Time: 4.243808, Dataloading + Training Time: 5.197921, Total Time: 17.206993
----------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------
Epoch: 4
Loss: 1.005200, Accuracy: 64.388000
Data Loading Time: 1.013517, Training Time: 4.259894, Dataloading + Training Time: 5.273411, Total Time: 17.270802
----------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.855999, Accuracy: 69.490000
Data Loading Time: 1.000116, Training Time: 4.254215, Dataloading + Training Time: 5.254331, Total Time: 17.242693
----------------------------------------------------------------------------------------
 For 4 Workers
Total Data Loading Time: 4.989074, Total Training Time: 22.190984, Final Total Time: 86.979414
~
~
~
"C3_4.out" 51L, 2048C
```

8 Workers

```bash
#!/bin/bash
#SBATCH --job-name=C3_8
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C3.py --cuda y --dataloaders 8 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
~
"submit_job_lab2_8.sh" 15L, 353C                              1,1          All
```

Output:


```
Files already downloaded and verified
Files already downloaded and verified
-------------------------------------------------------------------------------
Epoch: 1
Loss: 1.994279, Accuracy: 28.880000
Data Loading Time: 1.339623, Training Time: 5.166684, Dataloading + Training Time: 6.506307, Total Time: 18.352231
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Epoch: 2
Loss: 1.524654, Accuracy: 43.800000
Data Loading Time: 1.289399, Training Time: 4.294507, Dataloading + Training Time: 5.583906, Total Time: 17.526697
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Epoch: 3
Loss: 1.250322, Accuracy: 54.818000
Data Loading Time: 1.295826, Training Time: 4.273381, Dataloading + Training Time: 5.569206, Total Time: 17.564771
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Epoch: 4
Loss: 1.040158, Accuracy: 63.074000
Data Loading Time: 1.301577, Training Time: 4.252391, Dataloading + Training Time: 5.553968, Total Time: 17.577784
-------------------------------------------------------------------------------
-------------------------------------------------------------------------------
Epoch: 5
Loss: 0.889878, Accuracy: 68.676000
Data Loading Time: 1.301488, Training Time: 4.301344, Dataloading + Training Time: 5.602832, Total Time: 17.568652
-------------------------------------------------------------------------------
 For 8 Workers
Total Data Loading Time: 6.527913, Total Training Time: 22.288306, Final Total Time: 88.590136
~
~
~
~
"C3_8.out" 51L, 2048C
```

12 Workers


```bash
#!/bin/bash
#SBATCH --job-name=C3_12
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C3.py --cuda y --dataloaders 12 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_12.sh" 15L, 355C                          1,1          All
```

Output:


```
Files already downloaded and verified
Files already downloaded and verified
---------------------------------------------------------------------------------------------------
Epoch: 1
/home/nm4074/.local/lib/python3.8/site-packages/torch/utils/data/dataloader.py:563: UserWarning: This DataLoader will create 12 worker proce
is 10, which is smaller than what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoader ru
l slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(

Loss: 1.920384, Accuracy: 30.848000

Data Loading Time: 1.489052, Training Time: 8.656873, Dataloading + Training Time: 10.145925, Total Time: 23.801044

---------------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.472469, Accuracy: 46.012000

Data Loading Time: 1.470722, Training Time: 2.763532, Dataloading + Training Time: 4.234254, Total Time: 17.521764

---------------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.224550, Accuracy: 55.802000

Data Loading Time: 1.469140, Training Time: 2.749247, Dataloading + Training Time: 4.218386, Total Time: 17.512732

---------------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------------
Epoch: 4
Loss: 1.010647, Accuracy: 64.062000

Data Loading Time: 1.489399, Training Time: 2.735402, Dataloading + Training Time: 4.224801, Total Time: 17.532259

---------------------------------------------------------------------------------------------------

---------------------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.850490, Accuracy: 70.084000

Data Loading Time: 1.479252, Training Time: 2.756167, Dataloading + Training Time: 4.235419, Total Time: 17.524539

---------------------------------------------------------------------------------------------------

 For 12 Workers

Total Data Loading Time: 7.397564, Total Training Time: 19.661221, Final Total Time: 93.892338
"C3_12.out" 53L, 2535C
```

16 Workers


```bash
#!/bin/bash
#SBATCH --job-name=C3_16
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C3.py --cuda y --dataloaders 16 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_16.sh" 15L, 355C                              1,1              All
```

Output:


```
Files already downloaded and verified
Files already downloaded and verified

-----------------------------------------------------------------------------------------------------------------
Epoch: 1
/home/nm4074/.local/lib/python3.8/site-packages/torch/utils/data/dataloader.py:563: UserWarning: This DataLoader will create 16 worker proc
is 10, which is smaller than what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoader r
l slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(

Loss: 1.897020, Accuracy: 31.378000

Data Loading Time: 1.838260, Training Time: 6.216824, Dataloading + Training Time: 8.055084, Total Time: 21.878159

-----------------------------------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.395938, Accuracy: 48.490000

Data Loading Time: 1.861479, Training Time: 2.899351, Dataloading + Training Time: 4.760830, Total Time: 18.459837

-----------------------------------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.146426, Accuracy: 58.798000

Data Loading Time: 1.826175, Training Time: 2.930982, Dataloading + Training Time: 4.757157, Total Time: 18.437965

-----------------------------------------------------------------------------------------------------------------
Epoch: 4
Loss: 0.970623, Accuracy: 65.192000

Data Loading Time: 1.888839, Training Time: 2.920110, Dataloading + Training Time: 4.808949, Total Time: 18.494061

-----------------------------------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.836521, Accuracy: 70.538000

Data Loading Time: 1.795191, Training Time: 2.826157, Dataloading + Training Time: 4.621348, Total Time: 18.363080

-----------------------------------------------------------------------------------------------------------------
 For 16 Workers

Total Data Loading Time: 9.209943, Total Training Time: 17.793425, Final Total Time: 95.633101
"C3_16.out" 53L, 2534C
```

20 Workers


```
#!/bin/bash
#SBATCH --job-name=C3_20
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C3.py --cuda y --dataloaders 20 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_20.sh" 15L, 355C                                    1,1        All
```

Output:


```
Files already downloaded and verified
Files already downloaded and verified

-------------------------------------------------------------------------------------------------
Epoch: 1
/home/nm4074/.local/lib/python3.8/site-packages/torch/utils/data/dataloader.py:563: UserWarning: This DataLoader will create 20 worker proc
is 10, which is smaller than what this DataLoader is going to create. Please be aware that excessive worker creation might get DataLoader r
1 slowness/freeze if necessary.
  warnings.warn(_create_warning_msg(

Loss: 2.144719, Accuracy: 25.222000

Data Loading Time: 2.178160, Training Time: 13.448373, Dataloading + Training Time: 15.626534, Total Time: 27.956700

-------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.559243, Accuracy: 42.352000

Data Loading Time: 2.249210, Training Time: 4.216558, Dataloading + Training Time: 6.465768, Total Time: 18.429033

-------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.286485, Accuracy: 53.092000

Data Loading Time: 2.271620, Training Time: 4.253950, Dataloading + Training Time: 6.525569, Total Time: 18.491224

-------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------
Epoch: 4
Loss: 1.039924, Accuracy: 62.720000

Data Loading Time: 2.179353, Training Time: 4.232007, Dataloading + Training Time: 6.411360, Total Time: 18.460440

-------------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.853286, Accuracy: 69.912000

Data Loading Time: 2.161334, Training Time: 4.195379, Dataloading + Training Time: 6.356712, Total Time: 18.481929

-------------------------------------------------------------------------------------------------
 For 20 Workers

Total Data Loading Time: 11.039677, Total Training Time: 30.346266, Final Total Time: 101.819326
"C3_20.out" 53L, 2538C
```

Inference: 4 workers are needed for optimal performance

Question C4

1 Worker


```
#!/bin/bash
#SBATCH --job-name=C4_1
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C4.py --cuda y --dataloaders 1 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
~
"submit_job_lab2_C4_1.sh" 15L, 353C                              1,1          All
```

Output:

```
Files already downloaded and verified
Files already downloaded and verified
-------------------------------------------------------------------------------------------
Epoch: 1
Loss: 2.021689, Accuracy: 29.232000
Data Loading Time: 0.677419, Training Time: 6.634655, Dataloading + Training Time: 7.312074, Total Time: 21.183691
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.487198, Accuracy: 45.042000
Data Loading Time: 0.676466, Training Time: 2.780609, Dataloading + Training Time: 3.457075, Total Time: 16.693135
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.239478, Accuracy: 55.024000
Data Loading Time: 0.674014, Training Time: 2.772398, Dataloading + Training Time: 3.446411, Total Time: 16.703429
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
Epoch: 4
Loss: 1.037386, Accuracy: 62.924000
Data Loading Time: 0.665432, Training Time: 2.774311, Dataloading + Training Time: 3.439744, Total Time: 16.691338
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.879116, Accuracy: 68.698000
Data Loading Time: 0.657241, Training Time: 2.767372, Dataloading + Training Time: 3.424613, Total Time: 16.686903
-------------------------------------------------------------------------------------------
 For 1 Workers
Total Data Loading Time: 3.350571, Total Training Time: 17.729346, Total Training + dataloading time = 21.079917, Final Total Time: 87.958496
~
~
~
~
"C4_1.out" 51L, 2095C
```

4 Workers

```bash
#!/bin/bash
#SBATCH --job-name=C4_4
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C4.py --cuda y --dataloaders 4 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_C4_2.sh" 15L, 353C                              1,1            All
```

Output:

Question C5

CPU

Output:

```
                                          arjun17 — nm4074@log-1:~ — ssh nm4074@gw.hpc.nyu.edu — 208×56
Files already downloaded and verified
Files already downloaded and verified
----------------------------------------------------------------------------------------------------
Epoch: 1
Loss: 1.922236, Accuracy: 31.666000
Data Loading Time: 1.000288, Training Time: 249.890459, Dataloading + Training Time: 250.890747, Total Time: 251.081424

----------------------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.451488, Accuracy: 46.588000
Data Loading Time: 0.838411, Training Time: 248.292668, Dataloading + Training Time: 249.131079, Total Time: 249.273468

----------------------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.191168, Accuracy: 57.256000
Data Loading Time: 0.847229, Training Time: 249.248548, Dataloading + Training Time: 250.095777, Total Time: 250.222515

----------------------------------------------------------------------------------------------------
Epoch: 4
Loss: 0.986688, Accuracy: 64.614000
Data Loading Time: 0.886870, Training Time: 249.509733, Dataloading + Training Time: 250.396603, Total Time: 250.513681

----------------------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.848952, Accuracy: 70.000000
Data Loading Time: 0.863877, Training Time: 248.784109, Dataloading + Training Time: 249.647986, Total Time: 249.766862
----------------------------------------------------------------------------------------------------
 For 4 Workers
Total Data Loading Time: 4.436675, Total Training Time: 1245.725517, Total Training + dataloading time = 1250.162192, Final Total Time: 1250.857950
Average Training + dataloading time over 5 epochs = 250.032438, Average Running Time over 5 eopchs: 250.171590
~
~
"C5_cpu.out" 53L, 2238C
```

GPU

```
                    arjun17 — nm4074@log-1:~ — ssh nm4074@greene.hpc.nyu.edu — 80×24
#!/bin/bash
#SBATCH --job-name=C5_gpu
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C5.py --cuda y --dataloaders 4 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
~
"submit_job_lab2_C5_1.sh" 15L, 355C                              1,1            All
```

Output:

```
                                                    arjun17 — nm4074@log-1:~ — ssh nm4074@gw.hpc.nyu.edu — 208×56
Files already downloaded and verified
Files already downloaded and verified

----------------------------------------------------------------------------------------------------
Epoch: 1

Loss: 1.912569, Accuracy: 31.108000

Data Loading Time: 0.906229, Training Time: 3.617638, Dataloading + Training Time: 4.523868, Total Time: 17.779190

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 2

Loss: 1.452662, Accuracy: 46.364000

Data Loading Time: 0.870805, Training Time: 2.807515, Dataloading + Training Time: 3.678320, Total Time: 16.899243

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 3

Loss: 1.180536, Accuracy: 57.194000

Data Loading Time: 0.883144, Training Time: 2.783385, Dataloading + Training Time: 3.666529, Total Time: 16.897940

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 4

Loss: 1.005695, Accuracy: 64.060000

Data Loading Time: 0.846285, Training Time: 2.796815, Dataloading + Training Time: 3.643100, Total Time: 16.885395

----------------------------------------------------------------------------------------------------

----------------------------------------------------------------------------------------------------
Epoch: 5

Loss: 0.868388, Accuracy: 69.264000

Data Loading Time: 0.872448, Training Time: 2.773811, Dataloading + Training Time: 3.646259, Total Time: 16.903017

----------------------------------------------------------------------------------------------------

 For 4 Workers

Total Data Loading Time: 4.378911, Total Training Time: 14.779165, Total Training + dataloading time = 19.158076, Final Total Time: 85.364785

Average Training + dataloading time over 5 epochs = 3.831615, Average Running Time over 5 eopchs: 17.072957
~
"C5_gpu.out" 53L, 2204C
```

Question C6

Sgd

```
                    arjun17 — nm4074@log-1:~ — ssh nm4074@greene.hpc.nyu.edu — 80×24
#!/bin/bash
#SBATCH --job-name=C6_sgd
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C6.py --cuda y --dataloaders 4 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
~
"submit_job_lab2_C6_sgd.sh" 15L, 355C                          1,1              All
```

Output:


```
HERE sgd OPTIMIZER IS USED
Files already downloaded and verified
Files already downloaded and verified
-----------------------------------------------------------------------------------------
Epoch: 1
Loss: 2.056218, Accuracy: 26.316000
Data Loading Time: 0.934733, Training Time: 3.645197, Dataloading + Training Time: 4.579930, Total Time: 17.784543
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.464886, Accuracy: 45.820000
Data Loading Time: 0.928020, Training Time: 2.849547, Dataloading + Training Time: 3.777567, Total Time: 17.006980
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.187279, Accuracy: 57.262000
Data Loading Time: 0.917129, Training Time: 2.858217, Dataloading + Training Time: 3.775346, Total Time: 16.989703
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
Epoch: 4
Loss: 0.998617, Accuracy: 64.628000
Data Loading Time: 0.946181, Training Time: 2.833721, Dataloading + Training Time: 3.779902, Total Time: 17.015581
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.867932, Accuracy: 69.442000
Data Loading Time: 0.942500, Training Time: 3.036115, Dataloading + Training Time: 3.978614, Total Time: 17.017943
-----------------------------------------------------------------------------------------
 For 4 Workers
Total Data Loading Time: 4.668563, Total Training Time: 15.222797, Total Training + dataloading time = 19.891359, Final Total Time: 85.814751
~
~
~
"C6_sgd.out" 52L, 2122C
```

Sgdnesterov


```
#!/bin/bash
#SBATCH --job-name=C6_sgdnesterov
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C6.py --cuda y --dataloaders 4 --opt sgdnesterov --datapath ./data
~
~
~
~
~
~
~
~
~
"submit_job_lab2_C6_sgdnesterov.sh" 15L, 371C                    1,1              All
```

Output:

```
HERE sgdnesterov OPTIMIZER IS USED
Files already downloaded and verified
Files already downloaded and verified
----------------------------------------------------------------------------------
Epoch: 1

Loss: 2.035512, Accuracy: 26.510000

Data Loading Time: 1.046257, Training Time: 6.019464, Dataloading + Training Time: 7.065721, Total Time: 18.750428
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Epoch: 2

Loss: 1.424194, Accuracy: 47.588000

Data Loading Time: 1.060095, Training Time: 4.505036, Dataloading + Training Time: 5.565130, Total Time: 17.300855
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Epoch: 3

Loss: 1.127429, Accuracy: 59.084000

Data Loading Time: 1.102669, Training Time: 4.526691, Dataloading + Training Time: 5.629360, Total Time: 17.353031
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Epoch: 4

Loss: 0.943649, Accuracy: 66.620000

Data Loading Time: 1.063306, Training Time: 4.523616, Dataloading + Training Time: 5.586923, Total Time: 17.314921
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
Epoch: 5

Loss: 0.825601, Accuracy: 70.926000

Data Loading Time: 1.064192, Training Time: 4.473196, Dataloading + Training Time: 5.537388, Total Time: 17.296982
----------------------------------------------------------------------------------
 For 4 Workers

Total Data Loading Time: 5.336519, Total Training Time: 24.048003, Total Training + dataloading time = 29.384522, Final Total Time: 88.016217
~
~
~
"C6_sgdnesterov.out" 52L, 2130C
```

Adadelta

```bash
#!/bin/bash
#SBATCH --job-name=C6_adadelta
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C6.py --cuda y --dataloaders 4 --opt adadelta --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_C6_adadelta.sh" 15L, 365C                    1,1          All
```

Output:

```
HERE adadelta OPTIMIZER IS USED
Files already downloaded and verified
Files already downloaded and verified
-------------------------------------------------------------------------------------------
Epoch: 1

Loss: 1.387872, Accuracy: 49.094000

Data Loading Time: 0.952286, Training Time: 5.140140, Dataloading + Training Time: 6.092427, Total Time: 18.701006
-------------------------------------------------------------------------------------------

-------------------------------------------------------------------------------------------
Epoch: 2

Loss: 0.887783, Accuracy: 68.472000

Data Loading Time: 0.918600, Training Time: 5.365153, Dataloading + Training Time: 6.283753, Total Time: 18.029061
-------------------------------------------------------------------------------------------

-------------------------------------------------------------------------------------------
Epoch: 3

Loss: 0.689228, Accuracy: 75.938000

Data Loading Time: 0.916692, Training Time: 4.347992, Dataloading + Training Time: 5.264683, Total Time: 17.993747
-------------------------------------------------------------------------------------------

-------------------------------------------------------------------------------------------
Epoch: 4

Loss: 0.580467, Accuracy: 79.804000

Data Loading Time: 0.923176, Training Time: 4.350711, Dataloading + Training Time: 5.273887, Total Time: 18.001856
-------------------------------------------------------------------------------------------

-------------------------------------------------------------------------------------------
Epoch: 5

Loss: 0.507765, Accuracy: 82.266000

Data Loading Time: 0.882167, Training Time: 4.348468, Dataloading + Training Time: 5.230635, Total Time: 17.962396
-------------------------------------------------------------------------------------------

 For 4 Workers

Total Data Loading Time: 4.592920, Total Training Time: 23.552463, Total Training + dataloading time = 28.145384, Final Total Time: 90.688066
~
~
~
"C6_adadelta.out" 52L, 2127C
```

Adagrad

```bash
#!/bin/bash
#SBATCH --job-name=C6_adagrad
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C6.py --cuda y --dataloaders 4 --opt adagrad --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_C6_adagrad.sh" 15L, 363C                    1,1          All
```

Output:

```
arjun17 — nm4074@log-1:~ — ssh nm4074@gw.hpc.nyu.edu — 208×56
HERE adagrad OPTIMIZER IS USED
Files already downloaded and verified
Files already downloaded and verified
-------------------------------------------------------------------------------------
Epoch: 1
Loss: 2.170890, Accuracy: 26.312000
Data Loading Time: 1.110152, Training Time: 5.707742, Dataloading + Training Time: 6.817894, Total Time: 18.201986
-------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------
Epoch: 2
Loss: 1.643369, Accuracy: 38.866000
Data Loading Time: 1.059453, Training Time: 4.860693, Dataloading + Training Time: 5.920146, Total Time: 17.269872
-------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------
Epoch: 3
Loss: 1.377111, Accuracy: 49.688000
Data Loading Time: 1.056571, Training Time: 4.825147, Dataloading + Training Time: 5.881718, Total Time: 17.266926
-------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------
Epoch: 4
Loss: 1.141265, Accuracy: 59.046000
Data Loading Time: 1.046545, Training Time: 4.809437, Dataloading + Training Time: 5.855982, Total Time: 17.257288
-------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------
Epoch: 5
Loss: 0.978039, Accuracy: 65.068000
Data Loading Time: 1.054336, Training Time: 4.838416, Dataloading + Training Time: 5.892752, Total Time: 17.280047
-------------------------------------------------------------------------------------
 For 4 Workers
Total Data Loading Time: 5.327057, Total Training Time: 25.041435, Total Training + dataloading time = 30.368492, Final Total Time: 87.276119
~
~
~
"C6_adagrad.out" 52L, 2126C
```

Adam

```
arjun17 — nm4074@log-1:~ — ssh nm4074@greene.hpc.nyu.edu — 80×24
#!/bin/bash
#SBATCH --job-name=C6_adam
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2

#pip3 install torch
#pip3 install torchvision
python C6.py --cuda y --dataloaders 4 --opt adam --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_C6_adam.sh" 15L, 357C                          1,1          All
```

Output:

```
arjun17 — nm4074@log-1:~ — ssh nm4074@gw.hpc.nyu.edu — 208×56
HERE adam OPTIMIZER IS USED
Files already downloaded and verified
Files already downloaded and verified
--------------------------------------------------------------------------------------------------------
Epoch: 1

Loss: 2.236613, Accuracy: 22.234000

Data Loading Time: 0.891450, Training Time: 5.493833, Dataloading + Training Time: 6.385284, Total Time: 19.011824

--------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------------
Epoch: 2

Loss: 1.856090, Accuracy: 28.780000

Data Loading Time: 0.892062, Training Time: 3.938709, Dataloading + Training Time: 4.830771, Total Time: 17.509146

--------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------------
Epoch: 3

Loss: 1.825711, Accuracy: 29.910000

Data Loading Time: 0.876408, Training Time: 3.939026, Dataloading + Training Time: 4.815434, Total Time: 17.505885

--------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------------
Epoch: 4

Loss: 1.832697, Accuracy: 29.348000

Data Loading Time: 0.876455, Training Time: 3.927690, Dataloading + Training Time: 4.804145, Total Time: 17.519145

--------------------------------------------------------------------------------------------------------
--------------------------------------------------------------------------------------------------------
Epoch: 5

Loss: 1.819754, Accuracy: 30.214000

Data Loading Time: 0.892791, Training Time: 3.950985, Dataloading + Training Time: 4.843776, Total Time: 17.537230

--------------------------------------------------------------------------------------------------------
 For 4 Workers

Total Data Loading Time: 4.429167, Total Training Time: 21.250242, Total Training + dataloading time = 25.679409, Final Total Time: 89.083230
~
~
~
"C6_adam.out" 52L, 2123C
```

Question C7

```
arjun17 — nm4074@log-1:~ — ssh nm4074@greene.hpc.nyu.edu — 80×24
#!/bin/bash
#SBATCH --job-name=C7
#SBATCH --nodes=1
#SBATCH --cpus-per-task=10
#SBATCH --output=%x.out
#SBATCH --mem=64GB
#SBATCH --time=02:00:00
#SBATCH --ntasks-per-node=1
#SBATCH --gres=gpu:rtx8000
module purge
cd /scratch/nm4074/lab2


#pip3 install torch
#pip3 install torchvision
python C7.py --cuda y --dataloaders 4 --opt sgd --datapath ./data
~
~
~
~
~
~
~
~
"submit_job_lab2_C7.sh" 15L, 351C                           1,1            All
```

Output:

arjun17 — nm4074@log-1:~ — ssh nm4074@gw.hpc.nyu.edu — 208×56

Files already downloaded and verified
Files already downloaded and verified

Epoch: 1

Loss: 1.974142, Accuracy: 29.594000

Data Loading Time: 0.990183, Training Time: 7.064182, Dataloading + Training Time: 8.054364, Total Time: 21.340184

Epoch: 2

Loss: 1.480416, Accuracy: 45.632000

Data Loading Time: 0.959991, Training Time: 2.868290, Dataloading + Training Time: 3.828281, Total Time: 16.837974

Epoch: 3

Loss: 1.190029, Accuracy: 56.998000

Data Loading Time: 1.002573, Training Time: 2.863352, Dataloading + Training Time: 3.865925, Total Time: 16.937849

Epoch: 4

Loss: 0.981544, Accuracy: 65.168000

Data Loading Time: 0.979780, Training Time: 2.865110, Dataloading + Training Time: 3.844890, Total Time: 16.967298

Epoch: 5

Loss: 0.808178, Accuracy: 71.324000

Data Loading Time: 0.987047, Training Time: 2.866579, Dataloading + Training Time: 3.853626, Total Time: 16.983506

 For 4 Workers

Total Data Loading Time: 4.919574, Total Training Time: 18.527512, Total Training + dataloading time = 23.447086, Final Total Time: 89.066811
~
~
~
"C7.out" 51L, 2095C

Q1:
  How many convolutional layers are in the ResNet-18 model?
   A) 18

Q2:
  What is the input dimension of the last linear layer?
   A) It is (512 * 1)

Q3:
How many trainable parameters and how many gradients are in the ResNet-18 model that you build (please show both the answer and the code that you use to count them) when using the SGD optimizer?

Code:

```
summary(net,(3,32,32))
```
Where net is where the model is loaded and (3, 32, 32) are the inputs

Number of trainable parameters = 11173962
Number of gradients = 11173962

```
● ● ●          arjun17 — nm4074@log-1:~ — -zsh — 80×24
        Conv2d-37              [-1, 512, 4, 4]        1,179,648
    BatchNorm2d-38             [-1, 512, 4, 4]            1,024
        Conv2d-39              [-1, 512, 4, 4]        2,359,296
    BatchNorm2d-40             [-1, 512, 4, 4]            1,024
        Conv2d-41              [-1, 512, 4, 4]          131,072
    BatchNorm2d-42             [-1, 512, 4, 4]            1,024
     BasicBlock-43             [-1, 512, 4, 4]                0
        Conv2d-44              [-1, 512, 4, 4]        2,359,296
    BatchNorm2d-45             [-1, 512, 4, 4]            1,024
        Conv2d-46              [-1, 512, 4, 4]        2,359,296
    BatchNorm2d-47             [-1, 512, 4, 4]            1,024
     BasicBlock-48             [-1, 512, 4, 4]                0
        Linear-49                    [-1, 10]            5,130
================================================================
Total params: 11,173,962
Trainable params: 11,173,962
Non-trainable params: 0
----------------------------------------------------------------
Input size (MB): 0.01
```

Q4:
The same question as Q3, except now use Adam (only the answer is required, not the code).

Number of trainable parameters = 11173962
Number of gradients = 11173962

```
● ● ●     arjun17 — nm4074@log-3:~ — ssh nm4074@gw.hpc.nyu.edu — 80×24
        Conv2d-37              [-1, 512, 4, 4]        1,179,648
    BatchNorm2d-38             [-1, 512, 4, 4]            1,024
        Conv2d-39              [-1, 512, 4, 4]        2,359,296
    BatchNorm2d-40             [-1, 512, 4, 4]            1,024
        Conv2d-41              [-1, 512, 4, 4]          131,072
    BatchNorm2d-42             [-1, 512, 4, 4]            1,024
     BasicBlock-43             [-1, 512, 4, 4]                0
        Conv2d-44              [-1, 512, 4, 4]        2,359,296
    BatchNorm2d-45             [-1, 512, 4, 4]            1,024
        Conv2d-46              [-1, 512, 4, 4]        2,359,296
    BatchNorm2d-47             [-1, 512, 4, 4]            1,024
     BasicBlock-48             [-1, 512, 4, 4]                0
        Linear-49                    [-1, 10]            5,130
================================================================
Total params: 11,173,962
Trainable params: 11,173,962
Non-trainable params: 0
----------------------------------------------------------------
Input size (MB): 0.01
Forward/backward pass size (MB): 11.25
Params size (MB): 42.63
Estimated Total Size (MB): 53.89
----------------------------------------------------------------
"Q3.out" 64L, 3902C                                64,1           Bot
```