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Assignment: 4
Course: CPSC 424/524

Modules:
[ff242@grace1 PS4]$ module list

Currently Loaded Modules:
  1) StdEnv (S)   2) Langs/Intel/15   3) GPU/Cuda/8.0

  Where:
   S: Module is Sticky, requires --force to unload or purge

Environment:
[ff242@grace1 PS4]$ which icc
/gpfs/apps/hpc/Langs/Intel/2015_update2/composer_xe_2015.2.164/bin/intel64/icc
[ff242@grace1 PS4]$ icc --version
icc (ICC) 15.0.2 20150121
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Commands:
srun --pty -c 5 --mem-per-cpu=6100 -p cpsc424_gpu --gres-flags=enforce-binding -t 2:00:00 --gres=gpu:1 bash

module load Langs/Intel/15 GPU/Cuda/8.0

make matmul
./matmul <n> <B> <G>

Output:
See appendix at the end of this report.

Task 1:
The serial CPU code of the kij variant of matrix multiplication is in

void cpu_matrixmult_kij(FP* a, FP* b, FP* c, int n, int p, int m);

a.

	Run 1	Run 2	Run 3	Run 4	Run 5
Block Dims.	(32, 32)	(32, 32)	(32, 32)	(32, 32)	(32, 32)
Grid Dims.	(32, 32)	(256, 256)	(32, 32)	(256, 256)	(32, 256)
GPU Time	26.92	13803.76	217.47	1759.16	1750.13
CPU Time	421.64	314220.59	3835.46	39269.21	36774.54

b.

	n = 8192, p = 8192, m = 8192
Block Dims.	(16, 16)
Grid Dims.	(512, 512)
GPU Time	20417.34

Using n = p = m = 8192, the best block dimension changes from (32, 32) to (16, 16), and grid dimension from (256, 256) to (512, 512). GPU time increases from 13803.76 ms to 20417.34 ms.

c.

K80 has 12GB of memory. The size of float is 4 bytes. There are 3 matrices A, B and C.

(12 * 1024 * 1024 * 1024 Bytes) / (4 Bytes) / 3 = 2^{30}

The largest matrix size is 2^{15} = 32768. Although in practice it's not entirely possible to achieve exactly n = p = m = 32768, because not 100% of all memory can be allocated for A, B, C.

By binary search, the largest possible matrix size approximately 31500.

	n = 31500, p = 31500, m = 31500
Block Dims.	(32, 32)

Grid Dims.	(985, 985)
GPU Time	866857.75

Task 2:

a.

	Run 1	Run 2	Run 3	Run 4	Run 5
Block Dims.	(32, 32)	(32, 32)	(32, 32)	(32, 32)	(32, 32)
Grid Dims.	(32, 32)	(256, 256)	(32, 32)	(256, 256)	(32, 256)
GPU Time	13.24	4578.05	95.76	700.92	679.18
CPU Time	424.44	313989.06	3807.13	39248.34	38766.97

Note that the GPU performance is much better than that in Task 1A.

b.

	n = 8192, p = 8192, m = 8192
Block Dims.	(32, 32)
Grid Dims.	(256, 256)
GPU Time	5635.93

Note that unlick Task 1B, switching from single precision to double precision FP doesn't change the best block dimension nor grid dimension. They remain to be (32, 32) and (256, 256), respectively.

GPU time increased from 4547.59 ms to 5635.93 ms. Note also that GPU performance is much better than that in Task 1B.

c.
Same as Task 1C.

	n = 31500, p = 31500, m = 31500
Block Dims.	(32, 32)
Grid Dims.	(985, 985)

GPU Time	260790.78

Note that the GPU performance is much better than that in Task 1C.

Task 3:

n = p = m = 8192
Block Dims. = (32, 32)

NTB	2	3	4	5	6
Block Dims.	(32, 32)	(32, 32)	(32, 32)	(32, 32)	(32, 32)
Grid Dims.	(128, 256)	(86, 256)	(64, 256)	(52, 256)	(43, 256)
GPU Time	3483.10	3014.58	2729.72	2554.12	2474.44

NTB	7	8	9	10	11
Block Dims.	(32, 32)	(32, 32)	(32, 32)	(32, 32)	(32, 32)
Grid Dims.	(37, 256)	(32, 256)	(29, 256)	(26, 256)	(24, 256)
GPU Time	2339.08	2359.39	2421.09	2313.91	2377.77

After NTB = 7, GPU time converges.

Optimal NTB = 10.

From NTB = 12, runs are not successful.

Task 4:
TODO: Matrix dimensions are not multiples of the tile width (e.g., n = p = 8000, TW = 16).

Appendix:

Task 1A

Run 1

[ff242@c22n05 PS4]$ ./matmul-1a 1024 1024 1024 2
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (2, 2), Grid_Dim = (512, 512)
Time to calculate results on GPU: 736.315247 ms.
Time to calculate results on CPU (kij variant): 419.288391 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 1024 1024 4
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (4, 4), Grid_Dim = (256, 256)
Time to calculate results on GPU: 169.190018 ms.
Time to calculate results on CPU (kij variant): 419.009705 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 1024 1024 8
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (8, 8), Grid_Dim = (128, 128)
Time to calculate results on GPU: 49.896191 ms.
Time to calculate results on CPU (kij variant): 418.788971 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 1024 1024 16
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (16, 16), Grid_Dim = (64, 64)
Time to calculate results on GPU: 29.224960 ms.
Time to calculate results on CPU (kij variant): 418.705566 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 1024 1024 32
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (32, 32), Grid_Dim = (32, 32)
Time to calculate results on GPU: 26.927263 ms.
Time to calculate results on CPU (kij variant): 421.640991 ms.

Scaled error between GPU and CPU: 3.880910e-11

Run 2
[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 8192 2
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (2, 2), Grid_Dim = (4096, 4096)
Time to calculate results on GPU: 312921.250000 ms.
Time to calculate results on CPU (kij variant): 309188.937500 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 8192 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (4, 4), Grid_Dim = (2048, 2048)
Time to calculate results on GPU: 86468.898438 ms.
Time to calculate results on CPU (kij variant): 315561.000000 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 8192 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (8, 8), Grid_Dim = (1024, 1024)
Time to calculate results on GPU: 26997.009766 ms.
Time to calculate results on CPU (kij variant): 313154.968750 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 8192 16
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (16, 16), Grid_Dim = (512, 512)
Time to calculate results on GPU: 15937.527344 ms.
Time to calculate results on CPU (kij variant): 313849.656250 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)

Block_Dim = (32, 32), Grid_Dim = (256, 256)
Time to calculate results on GPU: 13803.760742 ms.
Time to calculate results on CPU (kij variant): 314220.593750 ms.
Scaled error between GPU and CPU: 4.850336e-12

Run 3
[ff242@c22n05 PS4]$ ./matmul-1a 1024 8192 1024 2
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (2, 2), Grid_Dim = (512, 512)
Time to calculate results on GPU: 4964.122070 ms.
Time to calculate results on CPU (kij variant): 3783.324463 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 8192 1024 4
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (4, 4), Grid_Dim = (256, 256)
Time to calculate results on GPU: 1489.536133 ms.
Time to calculate results on CPU (kij variant): 3794.133789 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 8192 1024 8
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (8, 8), Grid_Dim = (128, 128)
Time to calculate results on GPU: 418.386139 ms.
Time to calculate results on CPU (kij variant): 3768.614502 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 8192 1024 16
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (16, 16), Grid_Dim = (64, 64)
Time to calculate results on GPU: 246.332703 ms.
Time to calculate results on CPU (kij variant): 3809.836670 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-1a 1024 8192 1024 32
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (32, 32), Grid_Dim = (32, 32)
Time to calculate results on GPU: 217.475494 ms.
Time to calculate results on CPU (kij variant): 3835.466064 ms.
Scaled error between GPU and CPU: 3.873685e-11

Run 4
[ff242@c22n05 PS4]$ ./matmul-1a 8192 1024 8192 2
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (2, 2), Grid_Dim = (4096, 4096)
Time to calculate results on GPU: 39035.558594 ms.
Time to calculate results on CPU (kij variant): 39214.242188 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 1024 8192 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (4, 4), Grid_Dim = (2048, 2048)
Time to calculate results on GPU: 10887.140625 ms.
Time to calculate results on CPU (kij variant): 39219.339844 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 1024 8192 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (8, 8), Grid_Dim = (1024, 1024)
Time to calculate results on GPU: 3498.343506 ms.
Time to calculate results on CPU (kij variant): 39345.484375 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 1024 8192 16
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (16, 16), Grid_Dim = (512, 512)
Time to calculate results on GPU: 2098.453369 ms.

Time to calculate results on CPU (kij variant): 39263.152344 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 1024 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (256, 256)
Time to calculate results on GPU: 1759.165771 ms.
Time to calculate results on CPU (kij variant): 39269.210938 ms.
Scaled error between GPU and CPU: 4.862468e-12

Run 5
[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 1024 2
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (2, 2), Grid_Dim = (512, 4096)
Time to calculate results on GPU: 38917.230469 ms.
Time to calculate results on CPU (kij variant): 37930.332031 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 1024 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (4, 4), Grid_Dim = (256, 2048)
Time to calculate results on GPU: 10875.866211 ms.
Time to calculate results on CPU (kij variant): 37326.464844 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 1024 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (8, 8), Grid_Dim = (128, 1024)
Time to calculate results on GPU: 3468.807617 ms.
Time to calculate results on CPU (kij variant): 37306.355469 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 1024 16
Device count = 1
Using device 0

Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (16, 16), Grid_Dim = (64, 512)
Time to calculate results on GPU: 2119.412109 ms.
Time to calculate results on CPU (kij variant): 36763.351562 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-1a 8192 8192 1024 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (32, 32), Grid_Dim = (32, 256)
Time to calculate results on GPU: 1750.133179 ms.
Time to calculate results on CPU (kij variant): 36774.542969 ms.
Scaled error between GPU and CPU: 4.847350e-12

Task 1B

[ff242@c22n05 PS4]$ ./matmul-1b 8192 8192 8192 2
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (2, 2), Grid_Dim = (4096, 4096)
Time to calculate results on GPU: 293995.625000 ms.

[ff242@c22n05 PS4]$ ./matmul-1b 8192 8192 8192 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (4, 4), Grid_Dim = (2048, 2048)
Time to calculate results on GPU: 89318.078125 ms.

[ff242@c22n05 PS4]$ ./matmul-1b 8192 8192 8192 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (8, 8), Grid_Dim = (1024, 1024)
Time to calculate results on GPU: 32606.392578 ms.

[ff242@c22n05 PS4]$ ./matmul-1b 8192 8192 8192 16
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)

Block_Dim = (16, 16), Grid_Dim = (512, 512)
Time to calculate results on GPU: 20417.341797 ms.

[ff242@c22n05 PS4]$ ./matmul-1b 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (256, 256)
Time to calculate results on GPU: 20738.224609 ms.

Task 1C

[ff242@c22n05 PS4]$ ./matmul-1c 31500 31500 31500 32
Device count = 1
Using device 0
Matrix Dimension = A (31500, 31500), B (31500, 31500), C (31500, 31500)
Block_Dim = (32, 32), Grid_Dim = (985, 985)
Time to calculate results on GPU: 866857.750000 ms.

Task 2A

Run 1
[ff242@c22n05 PS4]$ ./matmul-2a 1024 1024 1024 2
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (2, 2), Grid_Dim = (512, 512)
Time to calculate results on GPU: 699.273071 ms.
Time to calculate results on CPU (kij variant): 426.138245 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 1024 1024 4
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (4, 4), Grid_Dim = (256, 256)
Time to calculate results on GPU: 88.427170 ms.
Time to calculate results on CPU (kij variant): 424.662781 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 1024 1024 8
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (8, 8), Grid_Dim = (128, 128)
Time to calculate results on GPU: 18.709120 ms.
Time to calculate results on CPU (kij variant): 424.430573 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 1024 1024 16
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (16, 16), Grid_Dim = (64, 64)
Time to calculate results on GPU: 15.288000 ms.
Time to calculate results on CPU (kij variant): 423.960632 ms.
Scaled error between GPU and CPU: 3.880910e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 1024 1024 32
Device count = 1
Using device 0
Matrix Dimension = A (1024, 1024), B (1024, 1024), C (1024, 1024)
Block_Dim = (32, 32), Grid_Dim = (32, 32)
Time to calculate results on GPU: 13.248928 ms.
Time to calculate results on CPU (kij variant): 424.440948 ms.
Scaled error between GPU and CPU: 3.880910e-11

Run 2
[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 8192 2
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (2, 2), Grid_Dim = (4096, 4096)
Time to calculate results on GPU: 290320.687500 ms.
Time to calculate results on CPU (kij variant): 313918.500000 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 8192 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (4, 4), Grid_Dim = (2048, 2048)
Time to calculate results on GPU: 44305.812500 ms.

Time to calculate results on CPU (kij variant): 311889.093750 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 8192 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (8, 8), Grid_Dim = (1024, 1024)
Time to calculate results on GPU: 8965.449219 ms.
Time to calculate results on CPU (kij variant): 316047.312500 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 8192 16
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (16, 16), Grid_Dim = (512, 512)
Time to calculate results on GPU: 5301.091309 ms.
Time to calculate results on CPU (kij variant): 315647.937500 ms.
Scaled error between GPU and CPU: 4.850336e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (256, 256)
Time to calculate results on GPU: 4578.053711 ms.
Time to calculate results on CPU (kij variant): 313989.062500 ms.
Scaled error between GPU and CPU: 4.850336e-12

Run 3
[ff242@c22n05 PS4]$ ./matmul-2a 1024 8192 1024 2
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (2, 2), Grid_Dim = (512, 512)
Time to calculate results on GPU: 4663.170898 ms.
Time to calculate results on CPU (kij variant): 3815.829834 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 8192 1024 4
Device count = 1
Using device 0

Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (4, 4), Grid_Dim = (256, 256)
Time to calculate results on GPU: 854.713989 ms.
Time to calculate results on CPU (kij variant): 3800.458008 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 8192 1024 8
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (8, 8), Grid_Dim = (128, 128)
Time to calculate results on GPU: 209.582947 ms.
Time to calculate results on CPU (kij variant): 3825.282471 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 8192 1024 16
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (16, 16), Grid_Dim = (64, 64)
Time to calculate results on GPU: 109.165634 ms.
Time to calculate results on CPU (kij variant): 3828.928711 ms.
Scaled error between GPU and CPU: 3.873685e-11

[ff242@c22n05 PS4]$ ./matmul-2a 1024 8192 1024 32
Device count = 1
Using device 0
Matrix Dimension = A (1024, 8192), B (8192, 1024), C (1024, 1024)
Block_Dim = (32, 32), Grid_Dim = (32, 32)
Time to calculate results on GPU: 95.763008 ms.
Time to calculate results on CPU (kij variant): 3807.138184 ms.
Scaled error between GPU and CPU: 3.873685e-11

Run 4
[ff242@c22n05 PS4]$ ./matmul-2a 8192 1024 8192 2
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (2, 2), Grid_Dim = (4096, 4096)
Time to calculate results on GPU: 36297.171875 ms.
Time to calculate results on CPU (kij variant): 39284.027344 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 1024 8192 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (4, 4), Grid_Dim = (2048, 2048)
Time to calculate results on GPU: 5656.812012 ms.
Time to calculate results on CPU (kij variant): 39255.808594 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 1024 8192 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (8, 8), Grid_Dim = (1024, 1024)
Time to calculate results on GPU: 1271.829712 ms.
Time to calculate results on CPU (kij variant): 39251.195312 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 1024 8192 16
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (16, 16), Grid_Dim = (512, 512)
Time to calculate results on GPU: 782.968628 ms.
Time to calculate results on CPU (kij variant): 39135.000000 ms.
Scaled error between GPU and CPU: 4.862468e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 1024 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 1024), B (1024, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (256, 256)
Time to calculate results on GPU: 700.922546 ms.
Time to calculate results on CPU (kij variant): 39248.343750 ms.
Scaled error between GPU and CPU: 4.862468e-12

Run 5
[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 1024 2
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (2, 2), Grid_Dim = (512, 4096)
Time to calculate results on GPU: 36391.000000 ms.

Time to calculate results on CPU (kij variant): 38422.750000 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 1024 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (4, 4), Grid_Dim = (256, 2048)
Time to calculate results on GPU: 5657.747070 ms.
Time to calculate results on CPU (kij variant): 38733.101562 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 1024 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (8, 8), Grid_Dim = (128, 1024)
Time to calculate results on GPU: 1275.061035 ms.
Time to calculate results on CPU (kij variant): 38664.855469 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 1024 16
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (16, 16), Grid_Dim = (64, 512)
Time to calculate results on GPU: 781.981873 ms.
Time to calculate results on CPU (kij variant): 38653.050781 ms.
Scaled error between GPU and CPU: 4.847350e-12

[ff242@c22n05 PS4]$ ./matmul-2a 8192 8192 1024 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 1024), C (8192, 1024)
Block_Dim = (32, 32), Grid_Dim = (32, 256)
Time to calculate results on GPU: 679.181519 ms.
Time to calculate results on CPU (kij variant): 38766.972656 ms.
Scaled error between GPU and CPU: 4.847350e-12

Task 2B

[ff242@c22n05 PS4]$ ./matmul-2b 8192 8192 8192 2

Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (2, 2), Grid_Dim = (4096, 4096)
Time to calculate results on GPU: 294123.562500 ms.

[ff242@c22n05 PS4]$ ./matmul-2b 8192 8192 8192 4
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (4, 4), Grid_Dim = (2048, 2048)
Time to calculate results on GPU: 45651.042969 ms.

[ff242@c22n05 PS4]$ ./matmul-2b 8192 8192 8192 8
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (8, 8), Grid_Dim = (1024, 1024)
Time to calculate results on GPU: 9525.722656 ms.

[ff242@c22n05 PS4]$ ./matmul-2b 8192 8192 8192 16
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (16, 16), Grid_Dim = (512, 512)
Time to calculate results on GPU: 6078.923340 ms.

[ff242@c22n05 PS4]$ ./matmul-2b 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (256, 256)
Time to calculate results on GPU: 5635.937988 ms.

Task 2C

[ff242@c22n06 PS4]$ ./matmul-2c 31500 31500 31500 32
Device count = 1
Using device 0
Matrix Dimension = A (31500, 31500), B (31500, 31500), C (31500, 31500)
Block_Dim = (32, 32), Grid_Dim = (985, 985)
Time to calculate results on GPU: 260790.781250 ms.

Task 3

NTB = 2
[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (128, 256)
Time to calculate results on GPU: 3483.108887 ms.

NTB = 3
[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (86, 256)
Time to calculate results on GPU: 3014.583496 ms.

NTB = 4
[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (64, 256)
Time to calculate results on GPU: 2729.725830 ms.

NTB = 5
[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (52, 256)
Time to calculate results on GPU: 2554.125244 ms.

NTB = 6
[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (43, 256)
Time to calculate results on GPU: 2474.440430 ms.

NTB = 7

[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (37, 256)
Time to calculate results on GPU: 2339.084473 ms.

NTB = 8

[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (32, 256)
Time to calculate results on GPU: 2359.397217 ms.

NTB = 9

[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (29, 256)
Time to calculate results on GPU: 2421.096924 ms.

NTB = 10

[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (26, 256)
Time to calculate results on GPU: 2313.911133 ms.

NTB = 11

[ff242@c22n06 PS4]$ ./matmul-3 8192 8192 8192 32
Device count = 1
Using device 0
Matrix Dimension = A (8192, 8192), B (8192, 8192), C (8192, 8192)
Block_Dim = (32, 32), Grid_Dim = (24, 256)
Time to calculate results on GPU: 2377.772461 ms.