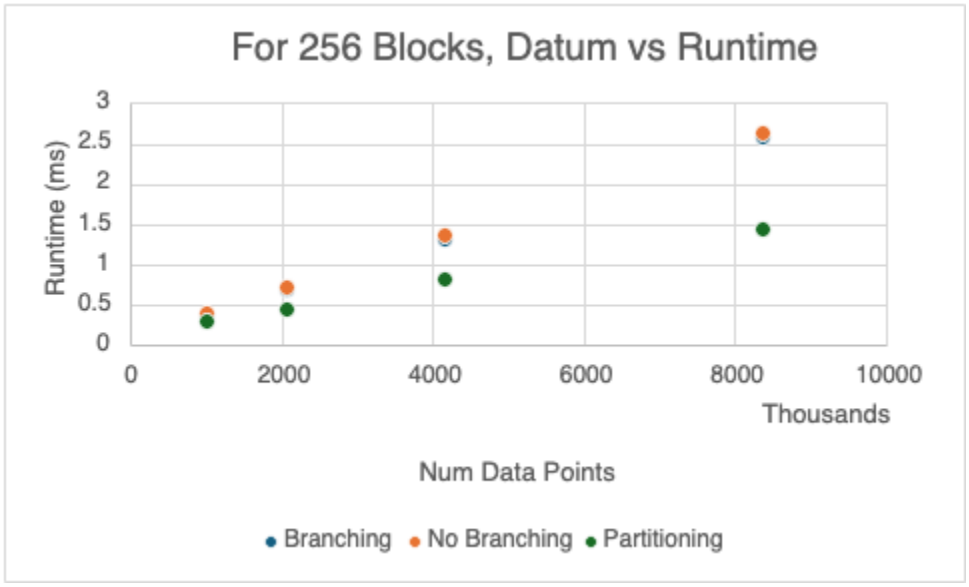
Table Results on runtime experiments:

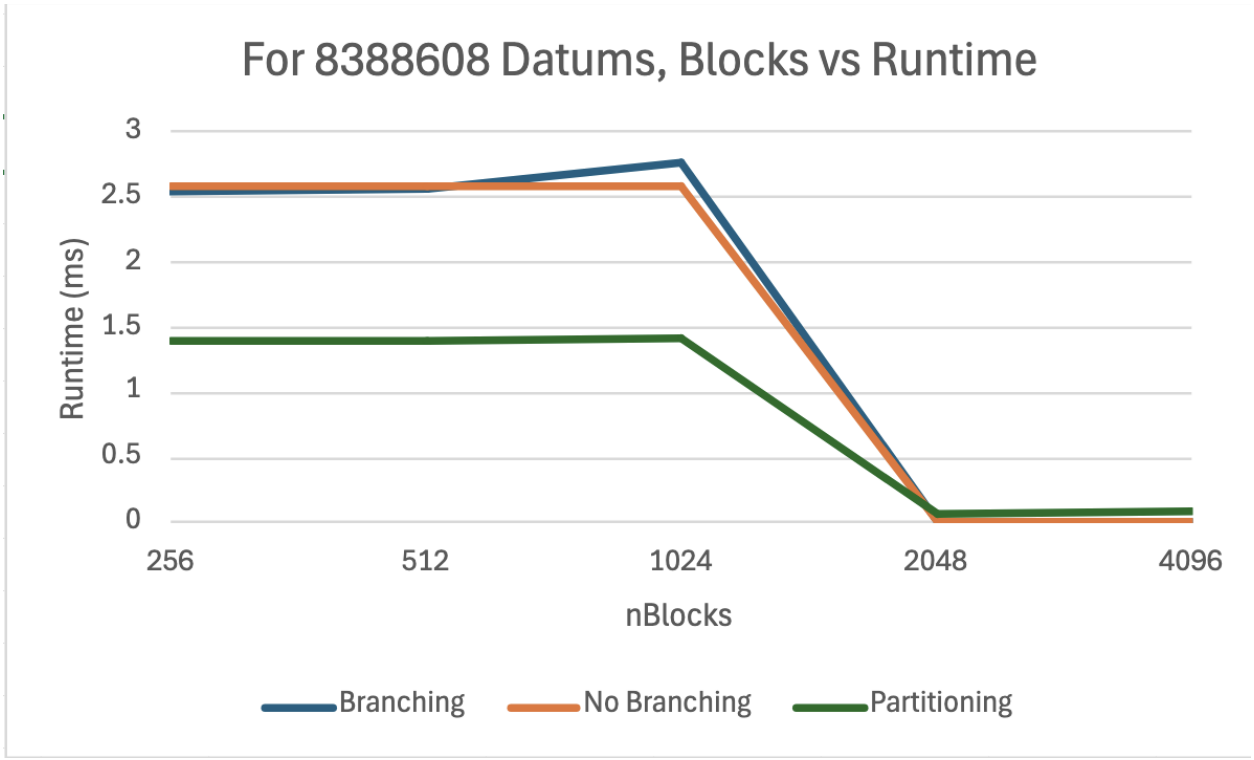
nThreads	nBlocks	Branching	No Branching	Partitioning
1048576	256	0.34	0.358	0.253
2097152	256	0.658	0.681	0.421
4194304	256	1.284	1.321	0.786
8388608	256	2.551	2.596	1.405
1048576	512	0.342	0.36	0.261
2097152	512	0.66	0.674	0.428
4194304	512	1.287	1.315	0.745
8388608	512	2.561	2.586	1.394
1048576	1024	0.368	0.349	0.266
2097152	1024	0.704	0.663	0.437
4194304	1024	1.37	1.294	0.779
8388608	1024	2.76	2.578	1.425
1048576	2048	0.002	0.003	0.055
2097152	2048	0.002	0.003	0.061
4194304	2048	0.002	0.004	0.063
8388608	2048	0.002	0.003	0.072
1048576	4096	0.002	0.003	0.051
2097152	4096	0.002	0.004	0.062
4194304	4096	0.002	0.003	0.069
8388608	4096	0.008	0.005	0.082

```
root@8f7b57b32738:~/IntroGPU/module3# ./assignment.exe 1073741824 16384
Running with 1073741824 total threads (65536 blocks of 16384)

Sample results (first 5):
i=0 | arr1=0 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.008 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.104 ms
```

1073741824	32768	0.008	0.003	0.104

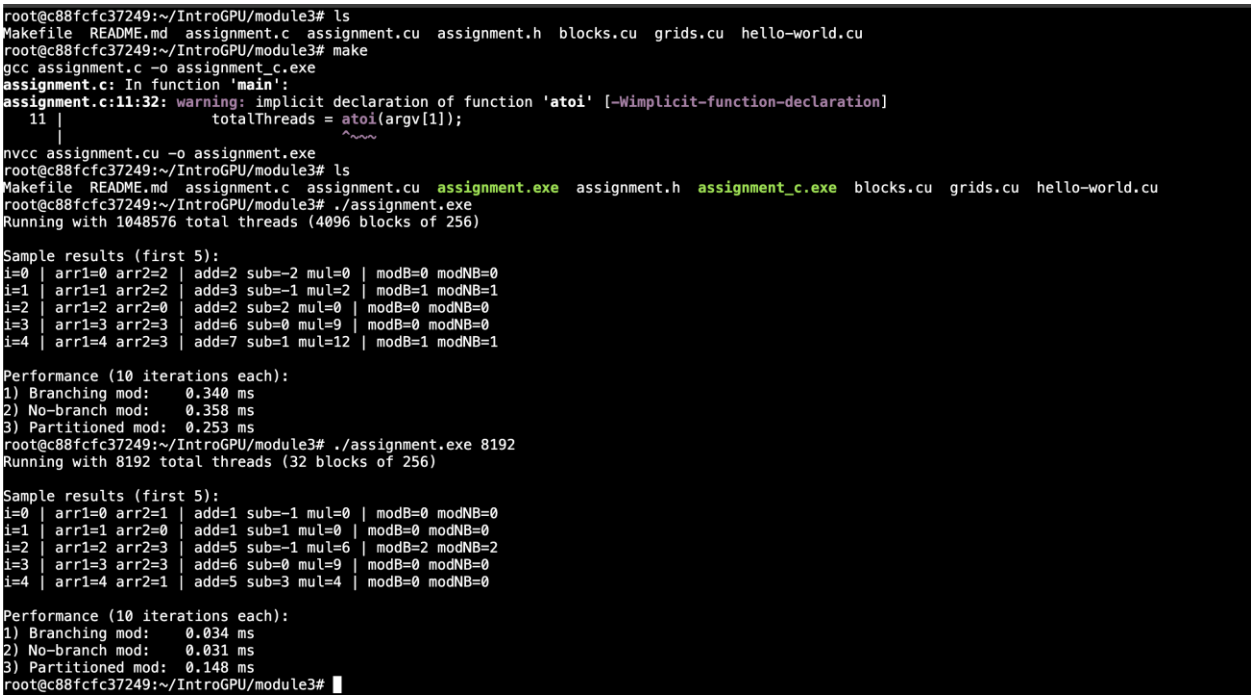
Charts on runtime:





As one can notice from the table and the charts (especially the chart where we fix block size to 256), as the number of threads increase then the runtime takes longer. This is expected as we are increasing the total amount of data to be processed.
More interestingly, as we increase the block size it initially doesn't make much of a difference, however, once it reaches past 2048 the GPU seems to get enough parallelization to fully utilize its hardware on the RTX A4000. Below that block size, it seems like we are under-utilizing the GPU. Crossing the threshold, we get performance jumps as the kernels are hitting higher occupancy and throughput. It's even fast for the monster last run I gave it to.

Run Screenshots with different threads:



```
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 2097152
Running with 2097152 total threads (8192 blocks of 256)

Sample results (first 5):
i=0 | arr1=0 arr2=1 | add=1 sub=-1 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=0 | add=1 sub=1 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=3 | add=5 sub=-1 mul=6 | modB=2 modNB=2
i=3 | arr1=3 arr2=2 | add=5 sub=1 mul=6 | modB=1 modNB=1
i=4 | arr1=4 arr2=0 | add=4 sub=4 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.658 ms
2) No-branch mod:    0.681 ms
3) Partitioned mod:  0.421 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 4194304
Running with 4194304 total threads (16384 blocks of 256)

Sample results (first 5):
i=0 | arr1=0 arr2=2 | add=2 sub=-2 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=1 | add=2 sub=0 mul=1 | modB=0 modNB=0
i=2 | arr1=2 arr2=3 | add=5 sub=-1 mul=6 | modB=2 modNB=2
i=3 | arr1=3 arr2=2 | add=5 sub=1 mul=6 | modB=1 modNB=1
i=4 | arr1=4 arr2=0 | add=4 sub=4 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    1.284 ms
2) No-branch mod:    1.321 ms
3) Partitioned mod:  0.786 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 8388608
Running with 8388608 total threads (32768 blocks of 256)

Sample results (first 5):
i=0 | arr1=0 arr2=1 | add=1 sub=-1 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=3 | add=4 sub=-2 mul=3 | modB=1 modNB=1
i=2 | arr1=2 arr2=1 | add=3 sub=1 mul=2 | modB=0 modNB=0
i=3 | arr1=3 arr2=1 | add=4 sub=2 mul=3 | modB=0 modNB=0
i=4 | arr1=4 arr2=1 | add=5 sub=3 mul=4 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    2.551 ms
2) No-branch mod:    2.596 ms
3) Partitioned mod:  1.405 ms
```

Run screenshots with different threads and different block sizes:

```
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 1048576 512
Running with 1048576 total threads (2048 blocks of 512)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=0 | add=1 sub=1 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=1 | add=3 sub=1 mul=2 | modB=0 modNB=0
i=3 | arr1=3 arr2=3 | add=6 sub=0 mul=9 | modB=0 modNB=0
i=4 | arr1=4 arr2=2 | add=6 sub=2 mul=8 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.342 ms
2) No-branch mod:    0.360 ms
3) Partitioned mod:  0.261 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 2097152 512
Running with 2097152 total threads (4096 blocks of 512)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=0 | add=1 sub=1 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=3 | add=5 sub=-1 mul=6 | modB=2 modNB=2
i=3 | arr1=3 arr2=2 | add=5 sub=1 mul=6 | modB=1 modNB=1
i=4 | arr1=4 arr2=2 | add=6 sub=2 mul=8 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.660 ms
2) No-branch mod:    0.674 ms
3) Partitioned mod:  0.428 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 4194304 512
Running with 4194304 total threads (8192 blocks of 512)

Sample results (first 5):
i=0 | arr1=0 arr2=1 | add=1 sub=-1 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=0 | add=1 sub=1 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=2 | add=4 sub=0 mul=4 | modB=0 modNB=0
i=3 | arr1=3 arr2=2 | add=5 sub=1 mul=6 | modB=1 modNB=1
i=4 | arr1=4 arr2=1 | add=5 sub=3 mul=4 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    1.287 ms
2) No-branch mod:    1.315 ms
3) Partitioned mod:  0.745 ms
root@c88fcfc37249:~/IntroGPU/module3#
```

```
1) Branching mod:    0.368 ms
2) No-branch mod:    0.349 ms
3) Partitioned mod:  0.266 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 2097152 1024
Running with 2097152 total threads (2048 blocks of 1024)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=3 | add=4 sub=-2 mul=3 | modB=1 modNB=1
i=2 | arr1=2 arr2=0 | add=2 sub=2 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=2 | add=5 sub=1 mul=6 | modB=1 modNB=1
i=4 | arr1=4 arr2=0 | add=4 sub=4 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.704 ms
2) No-branch mod:    0.663 ms
3) Partitioned mod:  0.437 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 4194304 1024
Running with 4194304 total threads (4096 blocks of 1024)

Sample results (first 5):
i=0 | arr1=0 arr2=1 | add=1 sub=-1 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=2 | add=3 sub=-1 mul=2 | modB=1 modNB=1
i=2 | arr1=2 arr2=0 | add=2 sub=2 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=0 | add=3 sub=3 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=1 | add=5 sub=3 mul=4 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    1.370 ms
2) No-branch mod:    1.294 ms
3) Partitioned mod:  0.779 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 8388608 1024
Running with 8388608 total threads (8192 blocks of 1024)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=2 | add=3 sub=-1 mul=2 | modB=1 modNB=1
i=2 | arr1=2 arr2=2 | add=4 sub=0 mul=4 | modB=0 modNB=0
i=3 | arr1=3 arr2=1 | add=4 sub=2 mul=3 | modB=0 modNB=0
i=4 | arr1=4 arr2=0 | add=4 sub=4 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    2.760 ms
2) No-branch mod:    2.578 ms
3) Partitioned mod:  1.425 ms
root@c88fcfc37249:~/IntroGPU/module3#
```

```
1) Branching mod:    0.002 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.055 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 2097152 2048
Running with 2097152 total threads (1024 blocks of 2048)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.002 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.061 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 4194304 2048
Running with 4194304 total threads (2048 blocks of 2048)

Sample results (first 5):
i=0 | arr1=0 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.002 ms
2) No-branch mod:    0.004 ms
3) Partitioned mod:  0.063 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 8388608 2048
Running with 8388608 total threads (4096 blocks of 2048)

Sample results (first 5):
i=0 | arr1=0 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.002 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.072 ms
root@c88fcfc37249:~/IntroGPU/module3#
```

```
1) Branching mod:    0.002 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.051 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 2097152 4096
Running with 2097152 total threads (512 blocks of 4096)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.002 ms
2) No-branch mod:    0.004 ms
3) Partitioned mod:  0.062 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 4194304 4096
Running with 4194304 total threads (1024 blocks of 4096)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.002 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.069 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 8388608 4096
Running with 8388608 total threads (2048 blocks of 4096)

Sample results (first 5):
i=0 | arr1=0 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.008 ms
2) No-branch mod:    0.005 ms
3) Partitioned mod:  0.082 ms
root@c88fcfc37249:~/IntroGPU/module3#
```

```
1) Branching mod:    0.002 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.051 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 2097152 4096
Running with 2097152 total threads (512 blocks of 4096)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.002 ms
2) No-branch mod:    0.004 ms
3) Partitioned mod:  0.062 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 4194304 4096
Running with 4194304 total threads (1024 blocks of 4096)

Sample results (first 5):
i=0 | arr1=0 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=0 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.002 ms
2) No-branch mod:    0.003 ms
3) Partitioned mod:  0.069 ms
root@c88fcfc37249:~/IntroGPU/module3# ./assignment.exe 8388608 4096
Running with 8388608 total threads (2048 blocks of 4096)

Sample results (first 5):
i=0 | arr1=0 arr2=2 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=1 | arr1=1 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=2 | arr1=2 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=3 | arr1=3 arr2=1 | add=0 sub=0 mul=0 | modB=0 modNB=0
i=4 | arr1=4 arr2=3 | add=0 sub=0 mul=0 | modB=0 modNB=0

Performance (10 iterations each):
1) Branching mod:    0.008 ms
2) No-branch mod:    0.005 ms
3) Partitioned mod:  0.082 ms
root@c88fcfc37249:~/IntroGPU/module3#
```