

# HW 4

## Problem1

Running main() from ./googletest-main/googletest/src/gtest\_main.cc

[=====] Running 7 tests from 3 test suites.

[-----] Global test environment set-up.

[-----] 1 test from testWarmup

[ RUN ] testWarmup.deviceWarmup

[ OK ] testWarmup.deviceWarmup (0 ms)

[-----] 1 test from testWarmup (0 ms total)

[-----] 3 tests from basicGEMMRowMajor

[ RUN ] basicGEMMRowMajor.small

Testing row major basicGEMM

GEMM: M = 37; N = 41; K = 43

Relative Inf error = 0

Average of 10 runs for cublas: 1.22176e-05 seconds

Average of 10 runs for myGEMM: 1.9936e-05 seconds

Reference GEMM is 1.63174 times faster

[ OK ] basicGEMMRowMajor.small (2034 ms)

[ RUN ] basicGEMMRowMajor.medium

Testing row major basicGEMM

GEMM: M = 599; N = 433; K = 751

Relative Inf error = 0

Average of 10 runs for cublas: 5.69152e-05 seconds

Average of 10 runs for myGEMM: 0.00117668 seconds

Reference GEMM is 20.6742 times faster

[ OK ] basicGEMMRowMajor.medium (29 ms)

[ RUN ] basicGEMMRowMajor.large

Testing row major basicGEMM

GEMM: M = 7817; N = 7919; K = 6869

Relative Inf error = 0

Average of 10 runs for cublas: 0.0556991 seconds

Average of 10 runs for myGEMM: 1.82414 seconds

Reference GEMM is 32.7499 times faster

[ OK ] basicGEMMRowMajor.large (22286 ms)

[-----] 3 tests from basicGEMMRowMajor (24350 ms total)

[-----] 3 tests from basicGEMMColumnMajor

[ RUN ] basicGEMMColumnMajor.small

Testing column major basicGEMM

GEMM: M = 37; N = 41; K = 43

Relative Inf error = 0

Average of 10 runs for cublas: 1.01952e-05 seconds

Average of 10 runs for myGEMM: 1.6544e-05 seconds

Reference GEMM is 1.62272 times faster

[ OK ] basicGEMMColumnMajor.small (1 ms)

[ RUN ] basicGEMMColumnMajor.medium

Testing column major basicGEMM

GEMM: M = 599; N = 433; K = 751

Relative Inf error = 0

Average of 10 runs for cublas: 4.28672e-05 seconds

Average of 10 runs for myGEMM: 0.000986576 seconds

Reference GEMM is 23.0147 times faster

[ OK ] basicGEMMColumnMajor.medium (34 ms)

[ RUN ] basicGEMMColumnMajor.large

Testing column major basicGEMM

GEMM: M = 7817; N = 7919; K = 6869

Relative Inf error = 0

Average of 10 runs for cublas: 0.0554989 seconds

Average of 10 runs for myGEMM: 5.40035 seconds

Reference GEMM is 97.3055 times faster

[ OK ] basicGEMMColumnMajor.large (61606 ms)

[-----] 3 tests from basicGEMMColumnMajor (61642 ms total)

[-----] Global test environment tear-down

[=====] 7 tests from 3 test suites ran. (85993 ms total)

[ PASSED ] 7 tests.

Analysis:

Input	Row Major (seconds)	Column Major (seconds)	Ratio
M = 37; N = 41; K = 43	1.99E-05	1.65E-05	1.21
M = 599; N = 433; K = 751	0.00117668	0.000986576	1.19

M = 7817; N = 7919; K = 6869	1.82414	5.40035	0.34
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For the 3 input cases, on small problem sizes, row-major and column-major largely the same. On the biggest input, row-major outperforms column-major.

For bigger input sizes, the execution time is longer, and the ratio also changes with respect to input sizes.

In terms of memory access pattern, the row-major access pattern is more friendly to load and store because the consecutive threads are accessing the consecutive elements in the B and C matrix (global memory coalescing).

## Problem 2

```
[=====] Running 4 tests from 1 test suite.
[-----] Global test environment set-up.
[-----] 4 tests from SharedGEMMTest
[ RUN    ] SharedGEMMTest.deviceWarmup
[   OK   ] SharedGEMMTest.deviceWarmup (0 ms)
[ RUN    ] SharedGEMMTest.small
```

```
GEMM: M = 37; N = 41; K = 43
Relative Inf error = 0
Average of 10 runs for cublas: 1.27232e-05 seconds
Average of 10 runs for myGEMM: 1.97056e-05 seconds
Reference GEMM is          1.54879 times faster
[   OK   ] SharedGEMMTest.small (2028 ms)
[ RUN    ] SharedGEMMTest.medium
```

```
GEMM: M = 599; N = 433; K = 751
Relative Inf error = 0
Average of 10 runs for cublas: 5.63552e-05 seconds
Average of 10 runs for myGEMM: 0.000436563 seconds
Reference GEMM is          7.74664 times faster
[   OK   ] SharedGEMMTest.medium (20 ms)
[ RUN    ] SharedGEMMTest.large
```

```
GEMM: M = 7817; N = 7919; K = 6869
Relative Inf error = 0
Average of 10 runs for cublas: 0.0545129 seconds
Average of 10 runs for myGEMM: 0.623188 seconds
Reference GEMM is          11.4319 times faster
```

```
[    OK ] SharedGEMMTest.large (9081 ms)
[-----] 4 tests from SharedGEMMTest (11131 ms total)

[-----] Global test environment tear-down
[=====] 4 tests from 1 test suite ran. (11131 ms total)
[ PASSED ] 4 tests.
```