APMA 2822B: Home Assignment No 1

Due by September 29, 2025.

The goals of this assignment are:

1. Practicing writing a [simple] code, compiling it and executing.
2. Estimating the bounds on a theoretically achievable performance using the Roof Line model.
3. Practicing different memory allocation methods and measuring performance as a function of different memory allocation strategies.
4. Optimizing Matrix – Vector multiplication for CPUs.

Assignment:

Write a code for matrix-vector multiplication: y=A*x. Make sure your code produces correct answers.
Measure the time required for multiplying a matrix of N rows and M columns by a vector of M elements, vary M and N from around O(10) to O(10000). Using the time measurement and counting the required flops compute the achieved flop-rate (in Teraflops/s).
Generate a roof line model by estimating bytes-to-flop ratio (Arithmetic Intensity) and drawing the roofline according to the spec of the CPU you are using. If you are not familiar with the method of obtaining the CPU spec, then assume your CPU has a peak memory bandwidth of 160 GB/s and peak flop rate of 1 TFLOP/s.

Use different strategies for allocating memory for the matrix – use contiguous storage and separate memory allocation for each matrix row and measure the impact on performance.
Try to optimize the matrix-vector multiplication using the following strategies: loop unrolling, compiler optimization options (g++ -O2 …. g++ -O3, etc.)

If you feel that the exercise was easy, then implement row-major and column-major storage for the matrix.

Submission: write a report reflecting all the tasks in the Assignment and provide me with your code.

You may work in pairs (submit one report + code with both names on the report and in the code), you can also work individually.

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You can use the *gettimeofday* function as a timer.
A simple example of measuring elapsed time in a C++ code using the *gettimeofday* function can be found in: *https://people.cs.rutgers.edu/~pxk/416/notes/c-tutorials/times.html* , scroll to the end of that document.