Assignment 1

Quantitative Computer Architecture (CSE 5350)

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Contents

1 Device Under Test (DUT)

Details: MacBook Pro (14-inch, 2023), model ID `Mac14,9`; Apple M2 Pro (10 cores; 6 performance + 4 efficiency) at 3.45 GHz; 16 GB unified memory; macOS **15.6.1 (Build 24G90)**. Tests were run on wall power with background apps minimized.

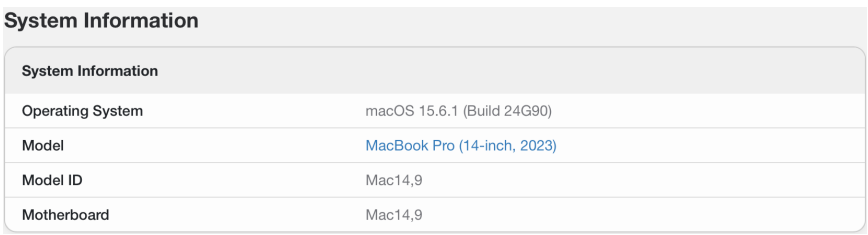

Figure 1: System information (OS & model).

CPU Information	
Name	Apple M2 Pro
Topology	1 Processor, 10 Cores
Identifier	Apple M2 Pro
Base Frequency	3.45 GHz
Cluster 1	6 Cores
Cluster 2	4 Cores
L1 Instruction Cache	128 KB x 1
L1 Data Cache	64.0 KB x 1
L2 Cache	4.00 MB x 1
Instruction Sets	neon aes sha1 sha2 neon-fp16 neon-dotprod i8mm

Figure 2: CPU information (Apple M2 Pro, core topology, caches).

2 Tools Used

Tool A: Geekbench 6.5.0 (CPU) — Cross-platform CPU benchmark running short, application-like subtests (compression, image processing, ML, crypto, compilers, web, ray tracing). Reports *Single-Core* and *Multi-Core* composite scores (higher is better).
Tool B: PassMark PerformanceTest 11.0.1003 (CPU & Memory suites) — CPU micro-benchmarks (integer, floating-point, primes, sorting, encryption, compression, physics, SIMD/extended instructions, single-thread) combined into *CPU Mark*; separate *Memory Mark* measures cached/uncached read, write bandwidth, latency, and threaded bandwidth.
Tool C: Blackmagic Disk Speed Test (macOS) — Free macOS utility from Blackmagic Design that measures sequential read and write throughput of a drive in MB/s. It writes and reads large test files, then reports speeds and shows which video formats (e.g., ProRes, H.265, RAW) the drive can sustain in real-time editing.

3 Results (screen-shots/tables) [Question 1(a)]

3.1 Geekbench 6 (CPU)

Summary scores from the run on my MacBook:

Single-Core	**2,708**
Multi-Core	**13,064**

The link for this benchmarking run (Geekbench 6 (CPU)) is in here.

3.2 Geekbench 6 Compute (OpenCL) (optional, GPU-compute)

Composite *OpenCL* score from my run on the MacBook:

OpenCL Composite	**47,566**

The link for my OpenCL score is in here.

Figure 3: Geekbench 6 Single-Core subtests (selected workloads such as Clang, photo filters, object remover, etc.).

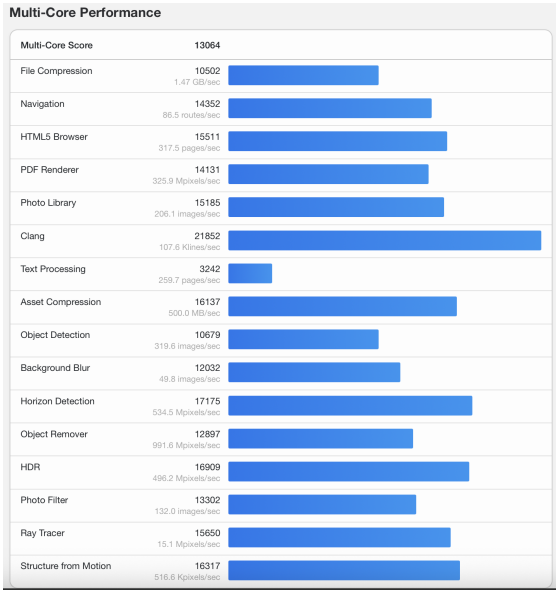

Figure 4: Geekbench 6 Multi-Core subtests.

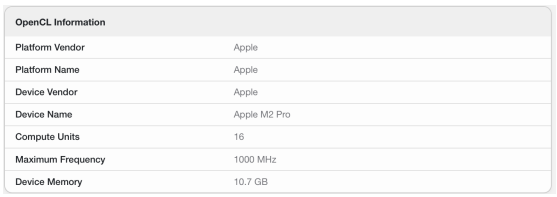

Figure 5: OpenCL device info (Apple M2 Pro, 16 compute units, ∼1,000 MHz, ∼10.7 GB device memory).

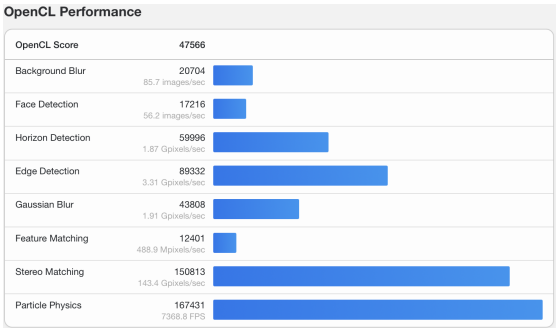

Figure 6: OpenCL subtests (e.g., edge detection, Gaussian blur, stereo matching, particle physics).

3.3 PassMark PerformanceTest 11 (CPU & Memory)

CPU Mark (composite)	**22,662**
Integer Math	45,279 MOps/s
Floating Point Math	56,034 MOps/s
Find Prime Numbers	245 Million primes/s
Random String Sorting	32,675 Thousand strings/s
Data Encryption	12,822 MB/s
Data Compression	273,724 KB/s
Physics	3,244 Frames/s
Extended Instructions	14,700 Million matrices/s
Single Thread	4,152 MOps/s

Table 1: PassMark CPU Mark subtests

Memory Mark (composite)	**3,682**
Database Operations	9,819 KOps/s
Read (Cached)	25,903 MB/s
Read (Uncached)	22,170 MB/s
Write	22,357 MB/s
Latency	27 ns
Threaded Bandwidth	120,827 MB/s
Available RAM at run	6,946 MB

Table 2: PassMark Memory Mark subtests

The full benchmark can be found here.

Benchmark Scores

- CPU Mark	22,662
Integer Math	45,279 MOps/Sec
Floating Point Math	56,034 MOps/Sec
Find Prime Numbers	245 Million Primes/Sec
Random String Sorting	32,675 Thousand Strings/Sec
Data Encryption	12,822 MBytes/Sec
Data Compression	273,724 KBytes/Sec
Physics	3,244 Frames/Sec
Extended Instructions	14,700 Million Matrices/Sec
Single Thread	4,152 MOps/Sec

Figure 7: PassMark CPU Mark subtests.

- Memory Mark	3,682
Database Operations	9,819 KOps/Sec
Memory Read Cached	25,903 MBytes/Sec
Memory Read Uncached	22,170 MBytes/Sec
Memory Write	22,357 MBytes/Sec
Available RAM	6,946 Megabytes
Memory Latency	27 ns (lower is better)
Memory Threaded	120,827 MBytes/Sec

Figure 8: PassMark Memory Mark subtests.

3.4 Blackmagic Disk Speed Test (Storage)

Sequential throughput (internal NVMe SSD): **Write 2,491 MB/s**, **Read 2,842 MB/s**. Figure 9 contains the output.

4 What do these results mean? How do the tools run? [Question 1(b)]

Both of them were run for a certain period of time. I've divided my outcome into different sections below.

Scope of what was evaluated

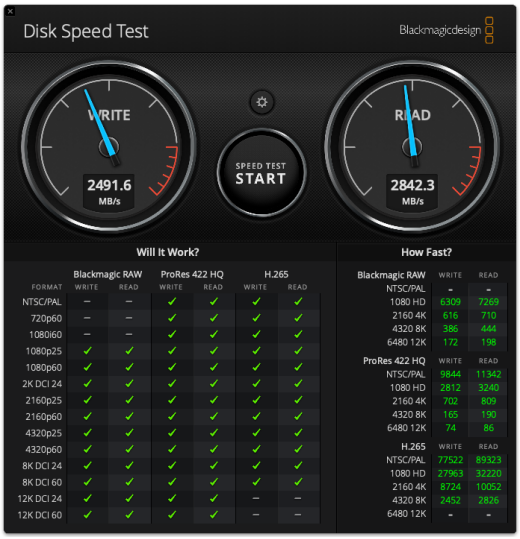

Figure 9: Blackmagic Disk Speed Test screenshot.

- **Geekbench 6 (CPU)** evaluates *CPU throughput* on a mix of short, real-world workloads (e.g., compression, image filters, ML inference, PDF rendering, Clang compile fragments, web page rendering, ray tracing). It does *not* test the disk. Output is a normalized *Single-Core* and *Multi-Core* score (higher is better) [2].
- **Geekbench 6 Compute (OpenCL)** evaluates *GPU compute* (not graphics FPS) by timing GPU kernels such as edge/feature detection, Gaussian blur, stereo matching, and particle physics. Output is a composite *OpenCL score* [1].
- **PassMark 11 (CPU/Memory suites)** evaluates *CPU micro-benchmarks* (integer/floating-point arithmetic, primes, sorting, encryption, compression, physics, SIMD) and separately *memory bandwidth/latency*. It does *not* include disk or graphics FPS in these particular runs [9].
- **Blackmagic Disk Speed Test**: Measures large-block *sequential* read/write throughput (MB/s) by writing/reading test files; representative of video/file-transfer workloads (not random I/O or latency). *Method:* choose target volume, run, record steady-state write/read.

How do they run?

- **Geekbench 6** runs one full pass of many short subtests. Each subtest is *timed* and converted into a normalized score; composite single-/multi-core scores are then produced from a weighted/geometric combination of those subtests. The default is one pass; multiple passes may be run for consistency.
- **PassMark 11** runs each micro-benchmark for a set duration/iterations and reports a *rate* (e.g., MOps/s, MB/s, FPS). A weighted combination forms the *CPU Mark* and *Memory Mark*.
- **Blackmagic** measures sequential read/write throughput by writing large files to disk and measuring the sustained MB/s. It does not measure small random I/O or latency, but it is representative of tasks like video editing and file transfers.

5 How does my system compare to others? [Question 2]

Using the public result browsers (Geekbench Browser and PassMark Baselines) as context:

- For the **MacBook Pro (14-inch, 2023) with M2 Pro (10-core)**, typical Geekbench 6 results cluster roughly around the low–2600s to high–2700s (single-core) and 12.000–13.200 (multi-core) [6]. Mine runs at **2,708/13,064** sits slightly *above* the middle of those clusters.
- Versus the prior-generation **M1 Pro (10-core)** model, single-core tends to be moderately higher on M2 Pro while multi-core is modestly higher; my results are consistent with that pattern [5].
- My **PassMark CPU Mark** of **22,662** aligns with other M2 Pro (10-core) entries and is slightly above the reference value shown alongside my baseline page [6].
- My **OpenCL compute** score of **47,566** is in the expected band for the M2 Pro iGPU and reflects solid GPU-compute throughput [4].

Interpretation: Being plugged in, a cool chassis, and minimal background load often yield slightly above-average scores; thermal saturation or background activity would push the numbers down.

Reference (avg)	Ref SC	My SC	ΔSC	Ref MC	ΔMC
MBP 14 (2023) **M2 Pro 10c**	2,649	2,708	**+2.23%**	12,317	**+6.06%**
MBP 14 (2021) **M1 Pro 10c**	2,384	2,708	**+13.59%**	12,326	**+5.99%**
MBP 14 (2023) **M2 Pro 12c**	2,656	2,708	**+1.96%**	14,436	**−9.50%**

6 Methodology and "CPU speed"

6.1 How is "CPU speed" determined here? [Question 3 (a)]

Neither tool reports raw clock speed as "the score." Instead, they measure *work done per unit time* on real or synthetic workloads:

- Effective performance ≈ **frequency** × **IPC (work per clock)** × **core count** ± **memory hierarchy effects** [8].
- **Geekbench 6** converts timed subtests into normalized scores and aggregates them into **Single-Core** (one core active) and **Multi-Core** (all cores active) composites. Thus, frequency, IPC, scheduler efficiency, and memory/LLC behavior all influence the result [3].
- **PassMark CPU Mark** combines throughput from several CPU micro-benchmarks (integer, FP, primes, sorting, encryption, compression, physics, SIMD, single-thread) into a weighted composite; it reflects practical compute throughput rather than frequency alone [7, 8].

6.2 What else is measured (disk I/O, graphics, memory, flash)? How? [Question 3(b)]

- **Disk/Flash: Yes** (Blackmagic) — sequential MB/s by writing/reading large files (good proxy for video/file workflows).
- **Graphics (FPS rendering):** *Not measured* here. Geekbench Compute uses the GPU for *compute kernels*, not frame rendering. A graphics-FPS benchmark (e.g., GFXBench/3DMark) would be used for that.
- **Memory:** *Yes*—PassMark **Memory Mark** reports cached/uncached read, write, latency, and threaded bandwidth (my values are in the table above). Some Geekbench CPU subtests are memory-sensitive, but Geekbench CPU is not a dedicated memory bandwidth test.

References

[1] Geekbench 6 Compute Result (OpenCL, Run ID 4795592). https://browser.geekbench.com/v6/compute/4795592. Accessed: 2025-09-15.

[2] Geekbench 6 CPU Result (Run ID 13820193). https://browser.geekbench.com/v6/cpu/13820193. Accessed: 2025-09-15.

[3] Geekbench 6 CPU Workloads. https://www.geekbench.com/doc/geekbench6-cpu-workloads.pdf. Accessed: 2025-09-15.

[4] Geekbench OpenCL Benchmarks Chart. https://browser.geekbench.com/opencl-benchmarks. Accessed: 2025-09-15.

[5] MacBook Pro (14-inch, 2021) — M1 Pro 10-core, Geekbench 6 Averages. https://browser.geekbench.com/macs/macbook-pro-14-inch-2021-apple-m1-pro-10-core-cpu. Accessed: 2025-09-15.

[6] MacBook Pro (14-inch, 2023) — M2 Pro 10-core, Geekbench 6 Averages. https://browser.geekbench.com/macs/macbook-pro-14-inch-2023-m2-pro-10c-cpu. Accessed: 2025-09-15.

[7] PassMark FAQ — Understanding your Results. https://www.passmark.com/support/performancetest_faq/understanding-results.php. Accessed: 2025-09-15.

[8] PassMark Forum: CPU Mark Calculation. https://forums.passmark.com/performancetest/3312-cpu-mark-calculation. Accessed: 2025-09-15.

[9] PassMark PerformanceTest V11 Baseline #5102903. https://www.passmark.com/baselines/V11/display.php?id=510290316767. Accessed: 2025-09-15.