



FACULTY OF COMPUTING

SEMESTER 2

2023/2024

SECR 1033 – COMPUTER ORGANIZATION AND ARCHITECTURE

SECTION 03

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Group Project Link Video: [Project](#)

TABLE OF CONTENTS

PART 1 : CPU Benchmarking and Performance Analysis Using Free Tools	2
1. Introduction	2
1.1 Problem Background	2
1.2 Aim	3
1.3 Objective	3
1.4 Scope (Computer Specification & Benchmarking Tools Feature)	3
2. The Flowchart of The Project	6
2.1 CPU-Z	6
2.2 Geekbench	7
2.3 Window Task Manager	8
2.4 MiniTool Partition Wizard	9
3. Benchmarking Results	10
CPUZ (System info)	10
Geekbench (CPU stress test)	18
Task Manager (Active Program and Resource Adjustment)	24
MiniTools (Disk benchmark)	33
4. Analysis, Comparison, Discussion	36
PART 2 : Writing ASM code program for Benchmarking Software	47
5. Conclusion	51
6. Reflection	51

PART 1 : CPU Benchmarking and Performance Analysis Using Free Tools

1. Introduction

Most processes that happen inside of the computer happen in the Central Processing Unit (CPU) which is often referred to as the “brain” of the computer. Every execution of instructions from a program and operation of other hardware components happens via instruction from the CPU.

1.1 Problem Background

CPU benchmarking is the process of evaluating the performance of a CPU by running various tests and simulations designed to measure its speed, efficiency and overall capabilities. Therefore, comparison between multiple CPUs can be easily done through the usage of the benchmarking tools by reading the score performance of the CPUs. There are three types of CPU benchmarks which are synthetic benchmarks, real-world benchmarks and application benchmarks.

Synthetic benchmark entails creating data and a workload using programmes/applications in order to stimulate a near real-world scenario, (Holt, 2023). This benchmark is also easy to set up and the test is repeatable and controllable. However, this benchmark is produced intentionally by us, the result produced might not be accurate as the result might not be unrealistic.

Real-world benchmark is basically tested how fast it can complete the task by giving a real workload, (*Real-World Benchmark With Nero Software--Nero Score. Get Better!*, 2023). Examples of workload are file compression and 3D rendering. This benchmarking test will give us a consistent and precise way of assessing hardware performance, (*Real-World Benchmark With Nero Software--Nero Score. Get Better!*, 2023). However, the result produced might be influenced by other system components.

Application benchmarks evaluate the performance and capabilities of software applications under various conditions where they focus on measuring the efficiency, responsiveness and overall functionality of an application, (*Benchmark Testing Explained: Boost Your Software's Performance*, 2024). This benchmarking is relevant for users of specific applications. Therefore, it is only limited to specific applications and may not provide a full overview of CPU performance.

1.2 Aim

Our aim in working on this project is to gain a deeper understanding of the principles of CPU benchmarking, as well as learn how to use the available free benchmarking tools and interpret the results.

1.3 Objective

Our objectives for this project are :

1. To understand the principles of CPU benchmarking.
2. To compare the performance of different CPUs.
3. To analyze the impact of different workloads on CPU performance.
4. To learn to use free benchmarking tools and interpret their results.

1.4 Scope (Computer Specification & Benchmarking Tools Feature)

In this project, four different laptops with four different specifications have been used to complete this project. Each specification of four different laptops will be shown through the table below.

Model Name	Cache Memory	Motherboard	Random Access Memory (RAM)	Central Processing Unit (CPU)
Asus TUF Gaming A15	L1 Data: 8x32 KB (8-way) L1 Inst. : 8x32 KB (8-way) L2: 8x512 KB (8-way) L3: 16 MB (16-way)	Manufacturer: ASUSTeK Computer Inc. Model: FA507RC Chipset: AMD Ryzen SOC	Type: DDR5 Size: 8 GB	Specification: AMD Ryzen 7 6800H with Radeon Graphics Core: 8 Threads: 16
HP Laptop 15s-eq1xxx	L1 Data: 2x32 KB (8-way) L1 Inst. : 2x32 KB (4-way) L2: 2x512 KB (8-way) L3: 4 MB (16-way)	Manufacturer: HP Model: 8706 Chipset: AMD Ryzen SOC	Type: DDR4 Size: 4 GB	Specification: AMD Athlon Silver 3050U with Radeon Graphics Core: 2 Threads: 2

HP Elitebook 840 G4	L1 Data: 2x32 KB (8-way) L1 Inst. : 2x32 KB (8-way) L2: 2x256 KB (4-way) L3: 3 MB (12-way)	Manufacturer: HP Model: 828C Chipset: Intel Kaby Lake	Type: DDR4 Size: 8 GB Core: 2 Threads: 4	Specification: Intel Core i5-7300U CPU @ 2.60GHz
Lenovo IdeaPad Slim 5 16IAH8	L1 Data: 4x48 KB + 4x32 KB L1 Inst. : 4x32 KB + 4x64 KB L2: 4 x 1.25 MB + 2 MB L3: 12 MB	Manufacturer: LENOVO Model: LNVNB 161216 Chipset: Intel Alder Lake	Type: DDR5 Size: 16 GB Core: 4P + 4E Threads: 12	Specification: 12th Gen Intel Core i5-12450H

Table 1 : All 4 laptop's specifications

Benchmark Tools	Feature
CPU-Z	Gathers information on some of the main devices of computer system : <ul style="list-style-type: none"> - Processor name and number, codename, process, package, cache levels - Mainboard and chipset - Memory type, size, timings and module specifications. - Real time measurement of each core's internal frequency, memory frequency.
Geekbench	CPU Benchmark Function : <ul style="list-style-type: none"> - Measures the processor's single core and multi-core power, for everything.
Monitor Task Manager (Windows OS tools)	Allow users to monitor and manage the processes and applications running on their computer. <ul style="list-style-type: none"> - Provide real-time data on the usage of system resources such as CPU, memory, and disk. - Displays graphs that show the utilization of these resources over time.

	<ul style="list-style-type: none"> - View more detailed information about each resource by clicking on the corresponding section of the graph.
MiniTool Partition Wizard (Windows)	<p>Disk Benchmark Function :</p> <ul style="list-style-type: none"> - Measure the transfer (read & write) speed under various disk access scenarios like sequential and random.

Table 2 : Benchmark Tools Feature

2. The Flowchart of The Project

2.1 CPU-Z

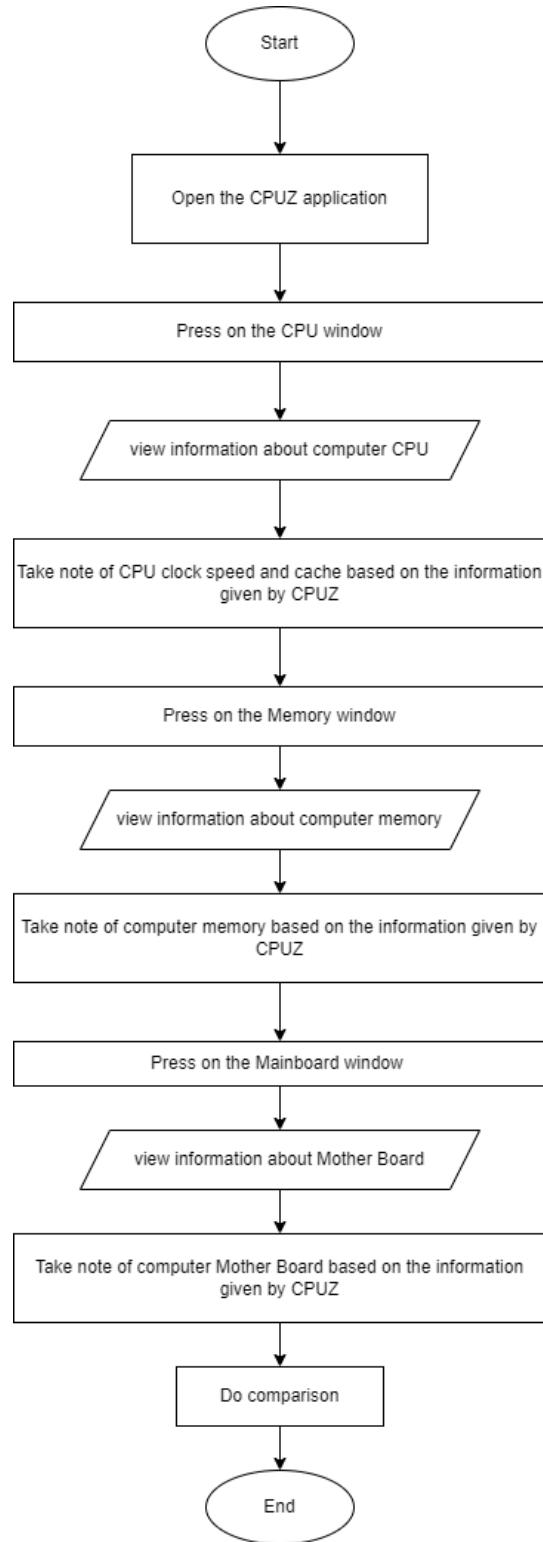


Figure 1: Steps of benchmarking using CPU-Z

2.2 Geekbench

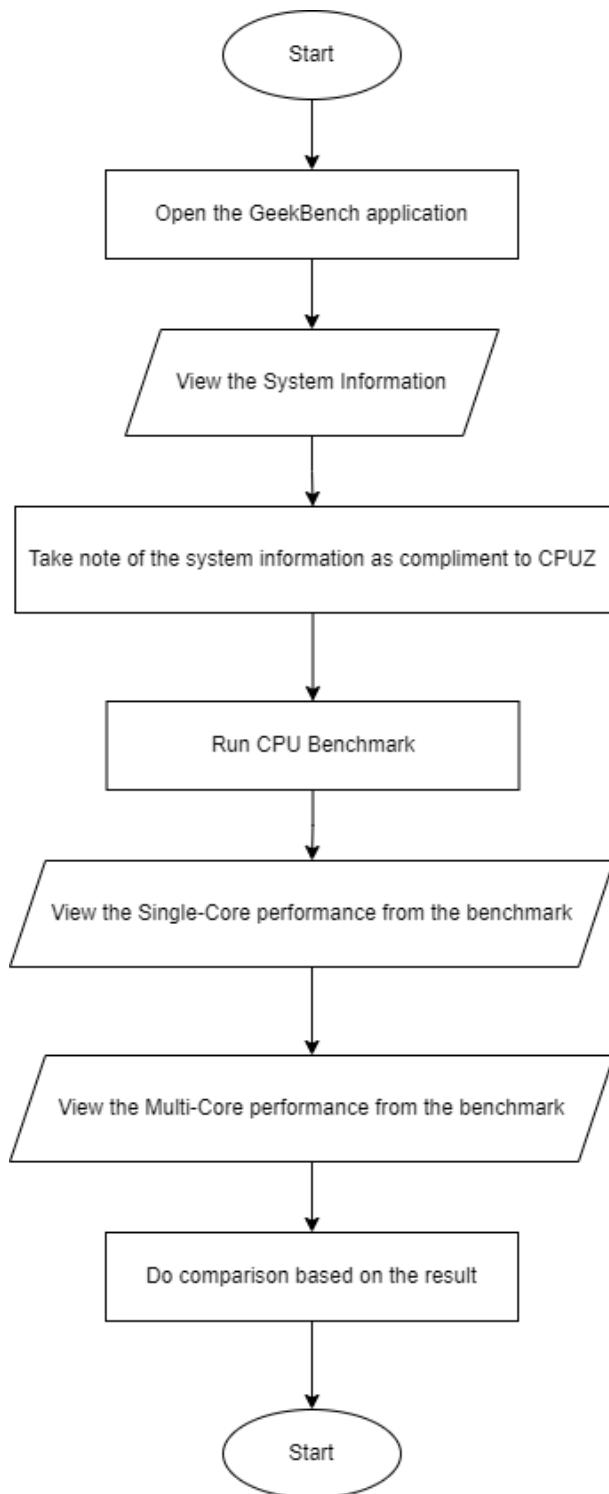


Figure 2: Steps of benchmarking using Geekbench

2.3 Window Task Manager

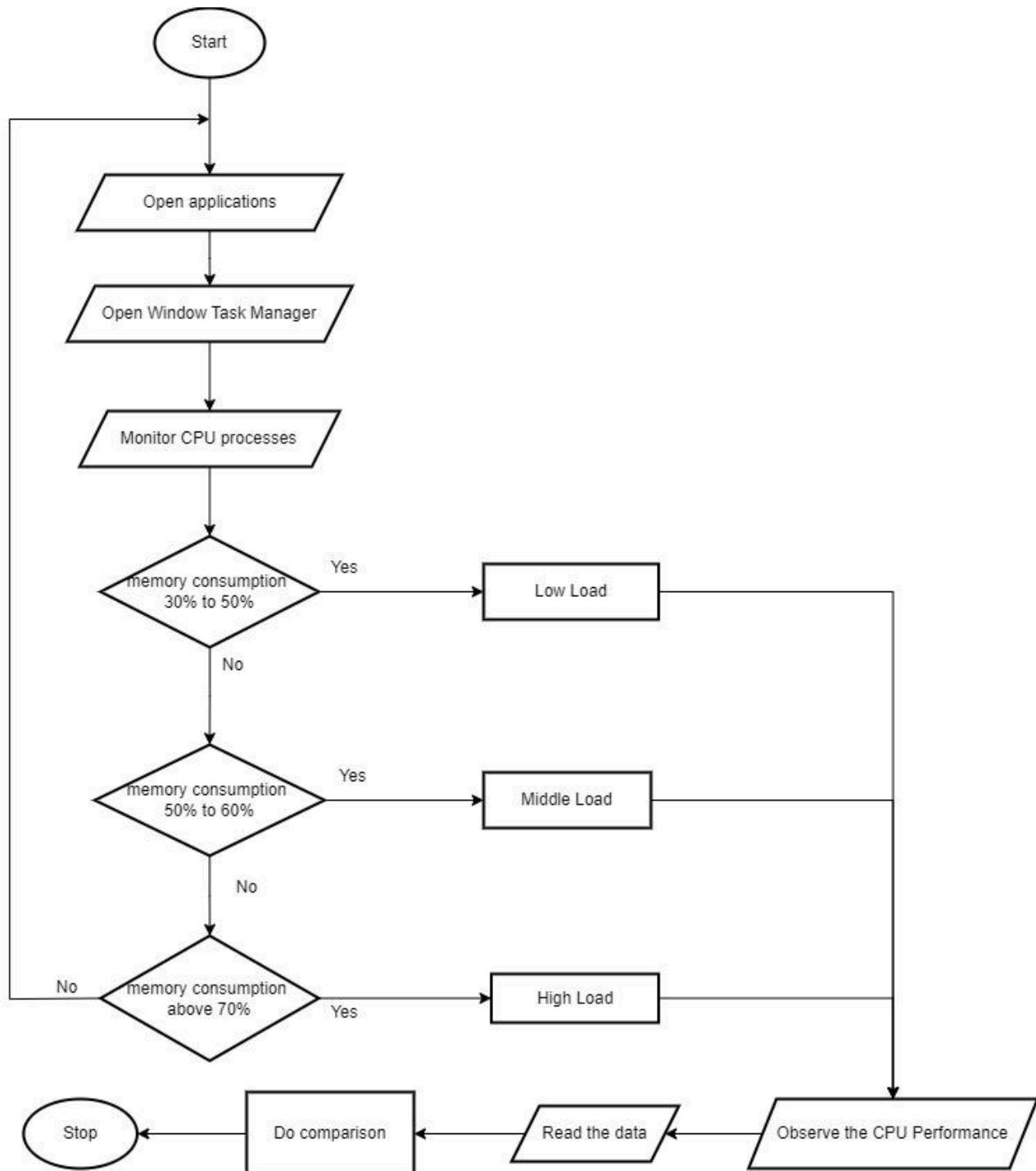


Figure 3: Steps of benchmarking using Window Task Manager

2.4 MiniTool Partition Wizard

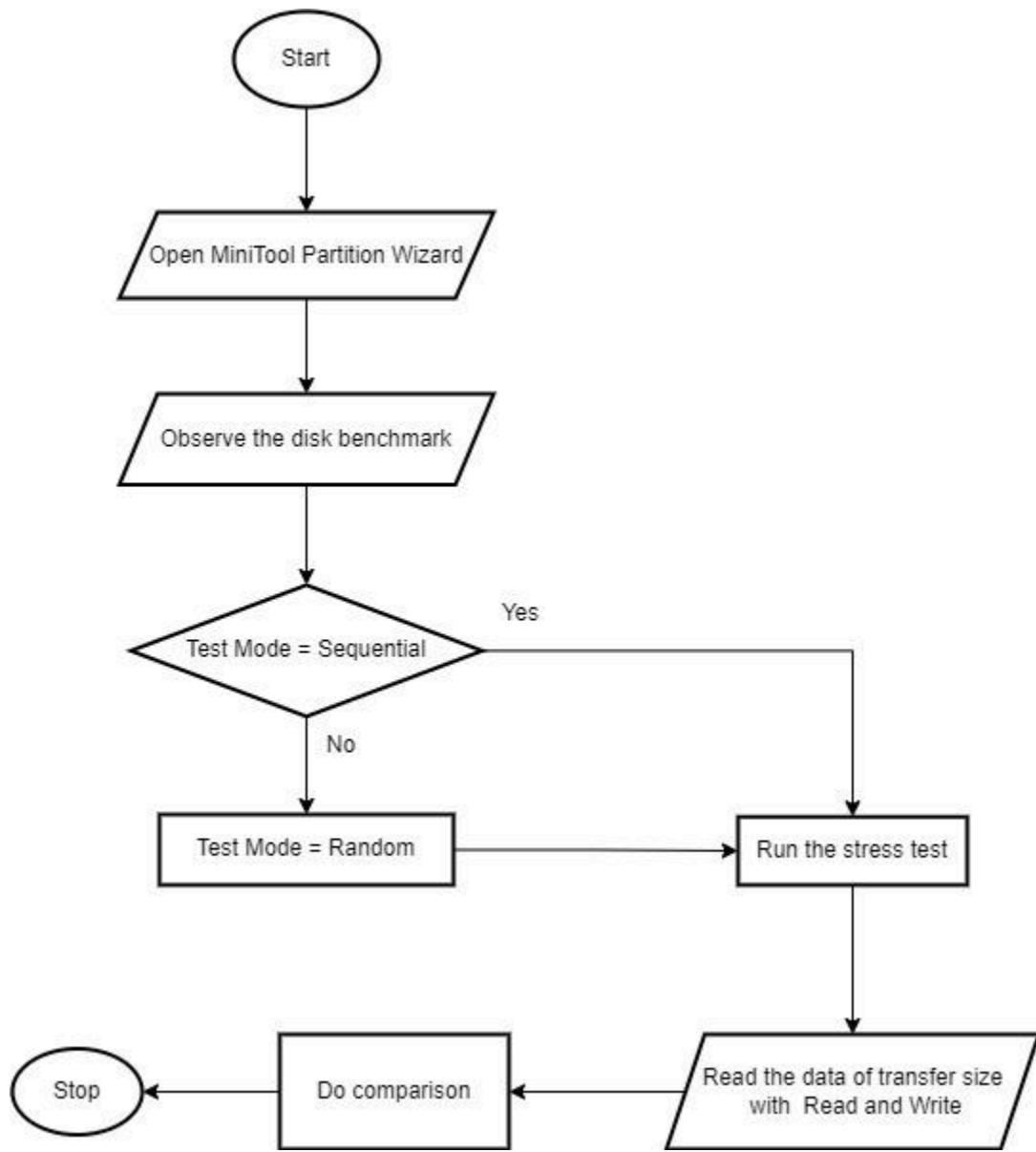
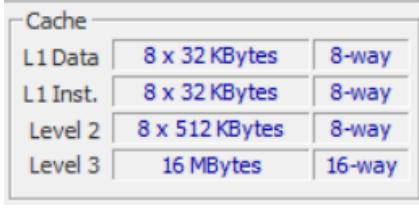
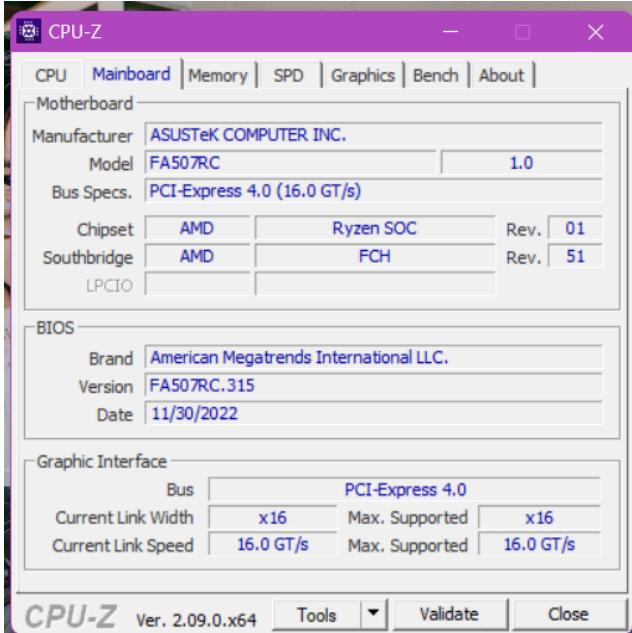
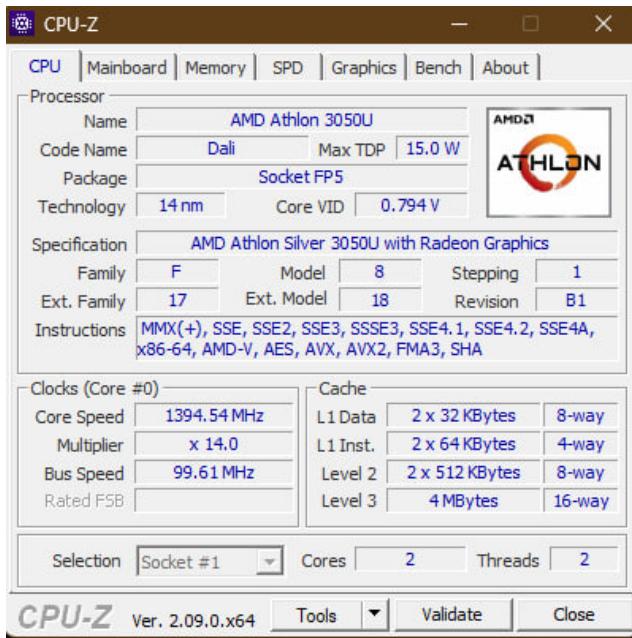


Figure 4: Steps of benchmarking using Minitool Partition Wizard

3. Benchmarking Results

Computer	CPUZ (System info)												
Asus TUF Gaming A15	<p>CPU:</p>  <p>The screenshot shows the CPU-Z application interface. The main tab selected is 'CPU'. Key information displayed includes:</p> <ul style="list-style-type: none"> Processor: Name: AMD Ryzen 7 6800H, Code Name: Rembrandt, Max TDP: 45.0 W, Package: Socket FP7, Technology: 6 nm, Core VID: 0.681 V. Specification: Family: F, Model: 4, Stepping: 1, Ext. Family: 19, Ext. Model: 44, Revision: RMB-B1. Instructions: MMX(+), SSE, SSE2, SSE3, SSSE3, SSE4.1, SSE4.2, SSE4A, x86-64, AES, AVX, AVX2, FMA3, SHA. Clocks (Core #0): Core Speed: 1235.51 MHz, Multiplier: x 12.38, Bus Speed: 99.84 MHz, Rated FSB. Cache: L1 Data: 8 x 32 KBytes, 8-way, L1 Inst.: 8 x 32 KBytes, 8-way, Level 2: 8 x 512 KBytes, 8-way, Level 3: 16 MBytes, 16-way. Selection: Socket #1, Cores: 8, Threads: 16. <p>CPU-Z Ver. 2.09.0.x64 Tools Validate Close</p> <p>Cache:</p>  <p>The screenshot shows the 'Cache' section of the CPU-Z application. It displays the following cache configuration:</p> <table border="1"> <tr> <td>L1 Data</td> <td>8 x 32 KBytes</td> <td>8-way</td> </tr> <tr> <td>L1 Inst.</td> <td>8 x 32 KBytes</td> <td>8-way</td> </tr> <tr> <td>Level 2</td> <td>8 x 512 KBytes</td> <td>8-way</td> </tr> <tr> <td>Level 3</td> <td>16 MBytes</td> <td>16-way</td> </tr> </table> <p>Memory:</p>	L1 Data	8 x 32 KBytes	8-way	L1 Inst.	8 x 32 KBytes	8-way	Level 2	8 x 512 KBytes	8-way	Level 3	16 MBytes	16-way
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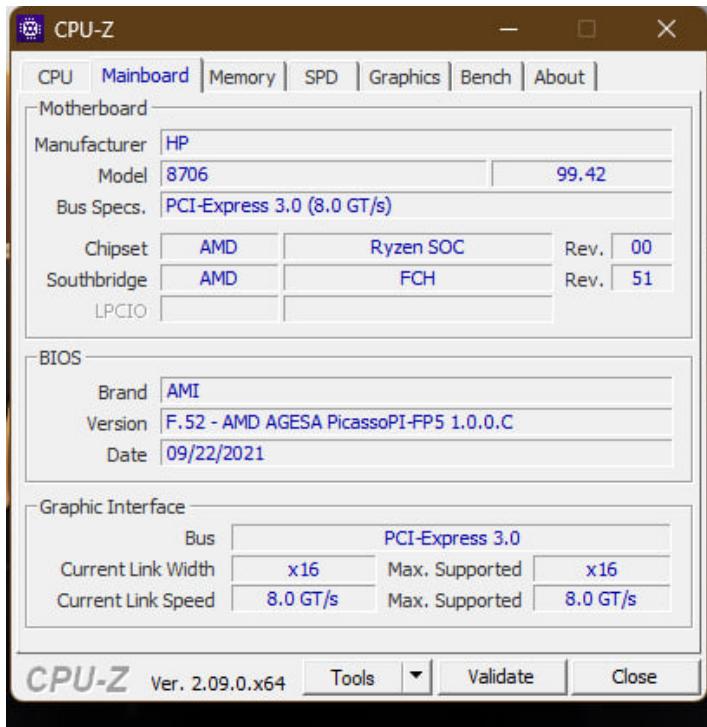
	 <p>CPU-Z Ver. 2.09.0.x64 Tools Validate Close</p> <p>Mainboard</p> <table border="1"> <tr><td>Manufacturer</td><td>ASUSTeK COMPUTER INC.</td></tr> <tr><td>Model</td><td>FA507RC</td><td>1.0</td></tr> <tr><td>Bus Specs.</td><td>PCI-Express 4.0 (16.0 GT/s)</td></tr> <tr><td>Chipset</td><td>AMD</td><td>Ryzen SOC</td><td>Rev. 01</td></tr> <tr><td>Southbridge</td><td>AMD</td><td>FCH</td><td>Rev. 51</td></tr> <tr><td>LPCIO</td><td></td><td></td><td></td></tr> </table> <p>BIOS</p> <table border="1"> <tr><td>Brand</td><td>American Megatrends International LLC.</td></tr> <tr><td>Version</td><td>FA507RC.315</td></tr> <tr><td>Date</td><td>11/30/2022</td></tr> </table> <p>Graphic Interface</p> <table border="1"> <tr><td>Bus</td><td>PCI-Express 4.0</td></tr> <tr><td>Current Link Width</td><td>x16</td><td>Max. Supported</td><td>x16</td></tr> <tr><td>Current Link Speed</td><td>16.0 GT/s</td><td>Max. Supported</td><td>16.0 GT/s</td></tr> </table>	Manufacturer	ASUSTeK COMPUTER INC.	Model	FA507RC	1.0	Bus Specs.	PCI-Express 4.0 (16.0 GT/s)	Chipset	AMD	Ryzen SOC	Rev. 01	Southbridge	AMD	FCH	Rev. 51	LPCIO				Brand	American Megatrends International LLC.	Version	FA507RC.315	Date	11/30/2022	Bus	PCI-Express 4.0	Current Link Width	x16	Max. Supported	x16	Current Link Speed	16.0 GT/s	Max. Supported	16.0 GT/s
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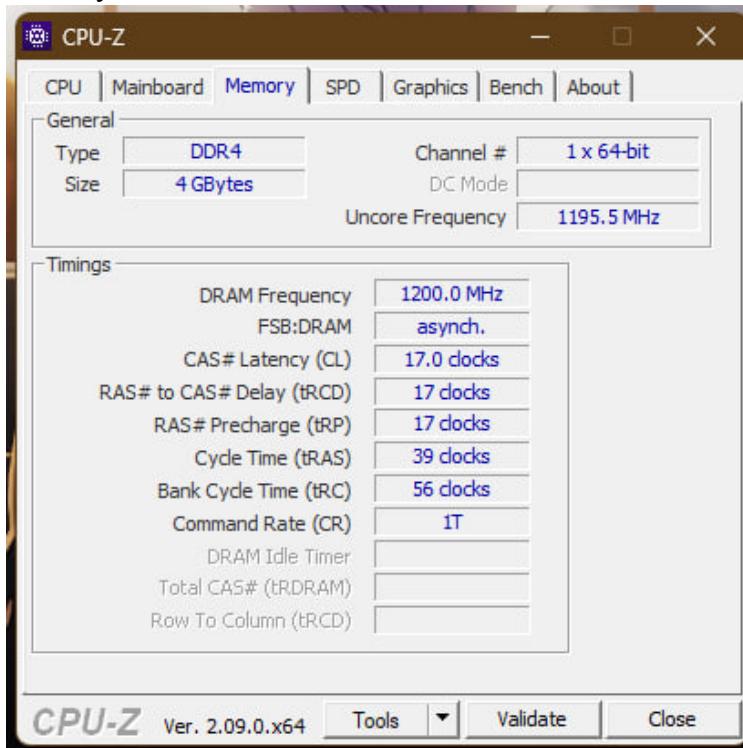
Cache:

Cache		
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Motherboard:

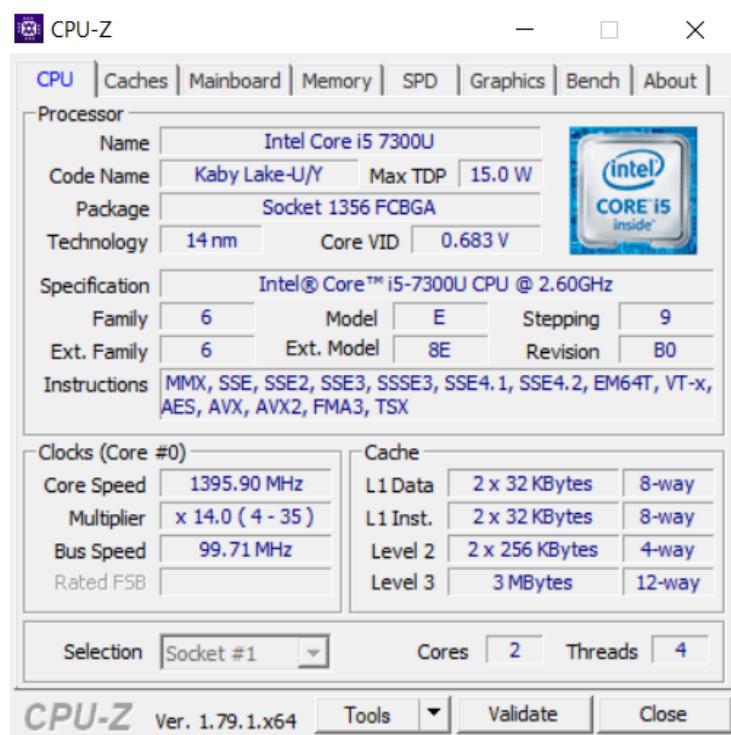


Memory:

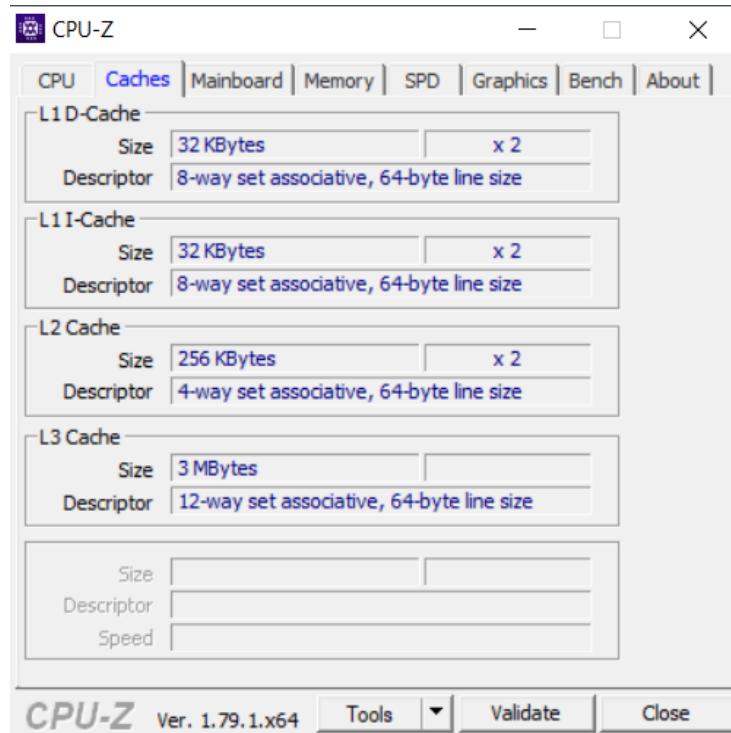


HP Elitebook 840 G4

CPU:



Cache:



Memory:

CPU-Z Ver. 1.79.1.x64

General

Type	DDR4	Channel #	Single
Size	8 GBytes	DC Mode	
NB Frequency 698.1 MHz			

Timings

DRAM Frequency	1063.9 MHz
FSB:DRAM	1:16
CAS# Latency (CL)	15.0 clocks
RAS# to CAS# Delay (tRCD)	15 clocks
RAS# Precharge (tRP)	15 clocks
Cycle Time (tRAS)	35 clocks
Row Refresh Cycle Time (tRFC)	374 clocks
Command Rate (CR)	2T
DRAM Idle Timer	
Total CAS# (tRDRAM)	
Row To Column (tRCD)	

Tools Validate Close

Motherboard:

CPU-Z Ver. 1.79.1.x64

Motherboard

Manufacturer	HP			
Model	828C	KBC Version	45.4C	
Chipset	Intel	Kaby Lake	Rev.	02
Southbridge	Intel	ID9D4E	Rev.	21
LPCIO				

BIOS

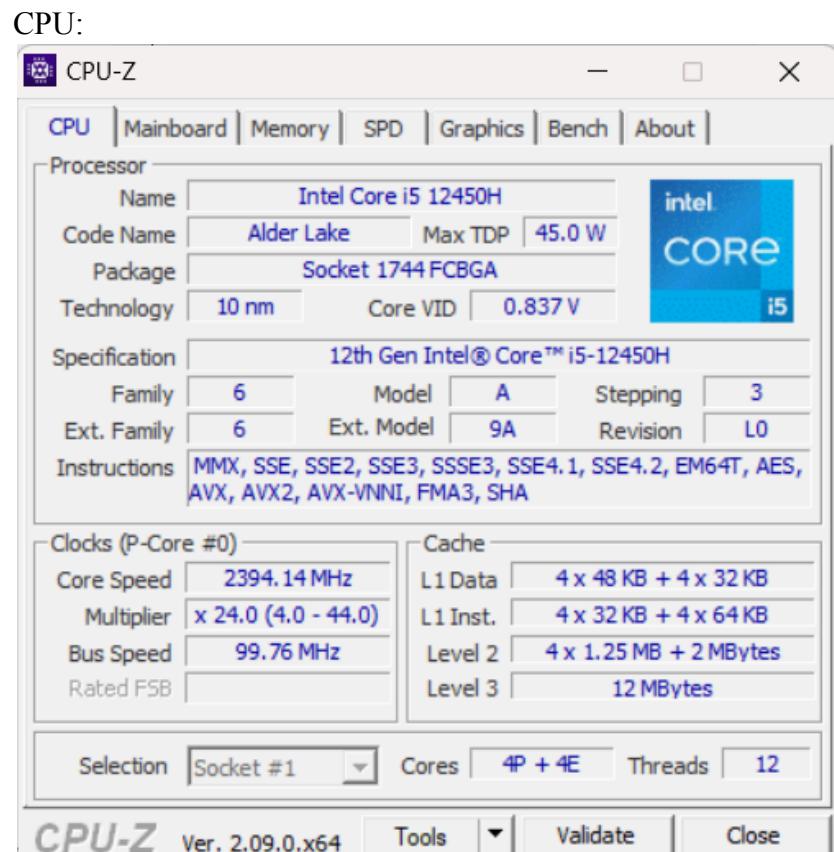
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Version	P78 Ver. 01.31
Date	10/16/2019

Graphic Interface

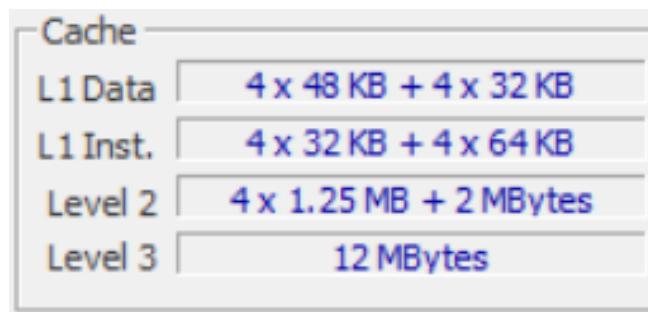
Version	PCI-Express		
Link Width	x0	Max. Supported	x0
Side Band Addressing			

Tools Validate Close

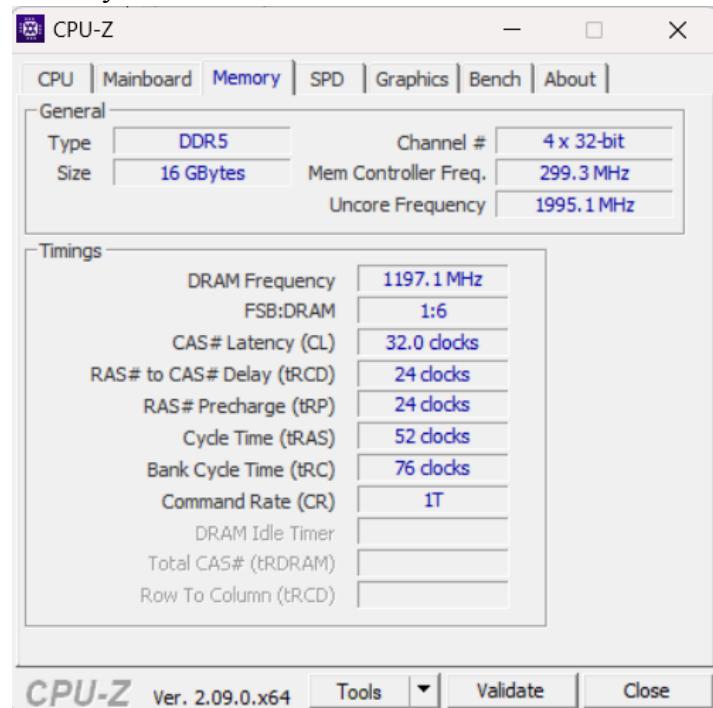
Lenovo IdeaPad Slim 5
16IAH8



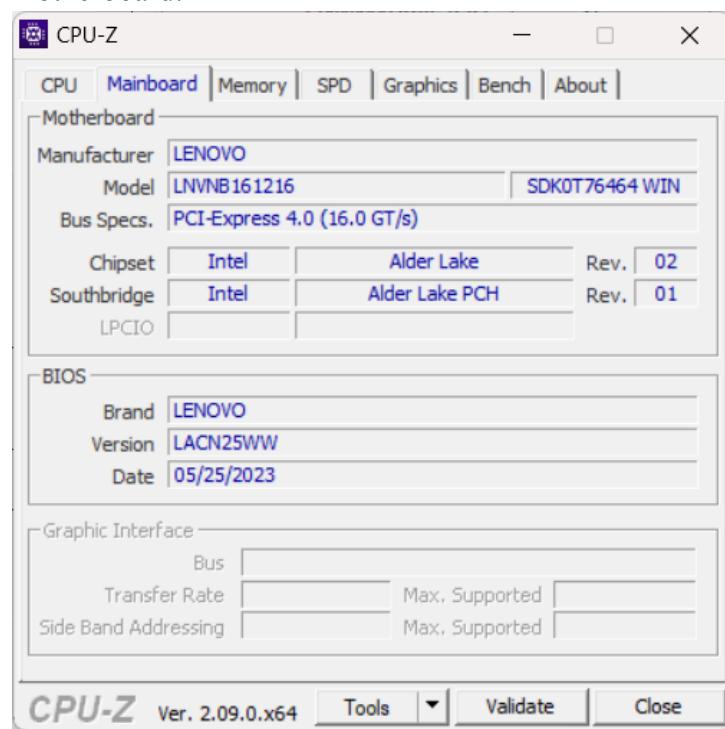
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Photo Filter	2213	22.0 images/sec																																																					
Ray Tracer	10894	10.5 Mpixels/sec																																																					
Structure from Motion	4031	127.6 Kpixels/sec																																																					
HP Laptop 15s-eq1xxx	<p>CPU Information</p> <table border="1"> <thead> <tr> <th></th><th></th></tr> </thead> <tbody> <tr> <td>Name</td><td>AMD Athlon Silver 3050U</td></tr> <tr> <td>Topology</td><td>1 Processor, 2 Cores</td></tr> <tr> <td>Identifier</td><td>AuthenticAMD Family 23 Model 24 Stepping 1</td></tr> <tr> <td>Base Frequency</td><td>2.30 GHz</td></tr> <tr> <td>Cluster 1</td><td>2 Cores</td></tr> <tr> <td>Maximum Frequency</td><td>3015 MHz</td></tr> <tr> <td>Package</td><td>Socket FP5</td></tr> <tr> <td>Codename</td><td>Dali</td></tr> <tr> <td>L1 Instruction Cache</td><td>64.0 KB x 2</td></tr> <tr> <td>L1 Data Cache</td><td>32.0 KB x 2</td></tr> <tr> <td>L2 Cache</td><td>512 KB x 2</td></tr> <tr> <td>L3 Cache</td><td>4.00 MB x 1</td></tr> </tbody> </table>			Name	AMD Athlon Silver 3050U	Topology	1 Processor, 2 Cores	Identifier	AuthenticAMD Family 23 Model 24 Stepping 1	Base Frequency	2.30 GHz	Cluster 1	2 Cores	Maximum Frequency	3015 MHz	Package	Socket FP5	Codename	Dali	L1 Instruction Cache	64.0 KB x 2	L1 Data Cache	32.0 KB x 2	L2 Cache	512 KB x 2	L3 Cache	4.00 MB x 1																												
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Single-Core Performance

Single-Core Score	
File Compression	880 126.3 MB/sec
Navigation	846 5.10 routes/sec
HTML5 Browser	564 11.3 pages/sec
PDF Renderer	814 18.8 Mpixels/sec
Photo Library	550 7.46 images/sec
Clang	711 3.50 Klines/sec
Text Processing	606 48.5 pages/sec
Asset Compression	784 24.3 MB/sec
Object Detection	228 6.63 images/sec
Background Blur	632 2.61 images/sec
Horizon Detection	871 27.1 Mpixels/sec
Object Remover	615 47.3 Mpixels/sec
HDR	798 23.4 Mpixels/sec
Photo Filter	371 3.68 Images/sec
RayTracer	825 604.7 Kpixels/sec
Structure from Motion	744 23.5 Kpixels/sec

Multi-Core Performance

Multi-Core Score	
File Compression	853 122.6 MB/sec
Navigation	1337 8.06 routes/sec
HTML5 Browser	588 12.0 pages/sec
PDF Renderer	1035 23.9 Mpixels/sec
Photo Library	798 10.8 Images/sec
Clang	1185 5.84 Klines/sec
Text Processing	708 56.5 pages/sec
Asset Compression	1386 42.9 MB/sec
Object Detection	240 7.17 Images/sec
Background Blur	889 3.68 Images/sec
Horizon Detection	1300 40.5 Mpixels/sec
Object Remover	973 74.8 Mpixels/sec
HDR	1133 33.2 Mpixels/sec
Photo Filter	287 2.65 Images/sec
RayTracer	1145 1.11 Mpixels/sec
Structure from Motion	708 22.4 Kpixels/sec

HP Elitebook 840 G4

CPU Information	
Name	Intel Core i5-7300U
Topology	1 Processor, 2 Cores, 4 Threads
Identifier	GenuineIntel Family 6 Model 142 Stepping 9
Base Frequency	2.69 GHz
Cluster 1	2 Cores
Maximum Frequency	3492 MHz
Package	Socket 1515 FCBGA
Codename	Kaby Lake-R
L1 Instruction Cache	32.0 KB x 2
L1 Data Cache	32.0 KB x 2
L2 Cache	256 KB x 2
L3 Cache	3.00 MB x 1
Single-Core Performance	
Single-Core Score	659
File Compression	589 84.6 MB/sec 
Navigation	723 4.36 routes/sec 
HTML5 Browser	660 13.5 pages/sec 
PDF Renderer	671 15.5 Mpixels/sec 
Photo Library	666 9.04 images/sec 
Clang	716 3.53 Klines/sec 
Text Processing	635 50.8 pages/sec 
Asset Compression	648 20.1 MB/sec 
Object Detection	328 9.81 images/sec 
Background Blur	1014 4.20 images/sec 
Horizon Detection	917 28.5 Mpixels/sec 
Object Remover	511 39.3 Mpixels/sec 
HDR	657 19.3 Mpixels/sec 
Photo Filter	961 9.54 images/sec 
Ray Tracer	684 661.6 Kpixels/sec 
Structure from Motion	671 21.2 Kpixels/sec 

Multi-Core Performance	
Multi-Core Score	1814
File Compression	954 136.9 MB/sec
Navigation	1522 9.17 routes/sec
HTML5 Browser	1666 34.1 pages/sec
PDF Renderer	2647 61.0 Mpixels/sec
Photo Library	2098 28.5 images/sec
Clang	2730 13.4 Klines/sec
Text Processing	719 57.6 pages/sec
Asset Compression	3218 99.7 MB/sec
Object Detection	919 27.5 images/sec
Background Blur	2915 12.1 images/sec
Horizon Detection	2591 80.6 Mpixels/sec
Object Remover	1416 108.9 Mpixels/sec
HDR	2247 65.9 Mpixels/sec
Photo Filter	1621 16.1 images/sec
Ray Tracer	2846 2.75 Mpixels/sec
Structure from Motion	2483 78.6 Kpixels/sec

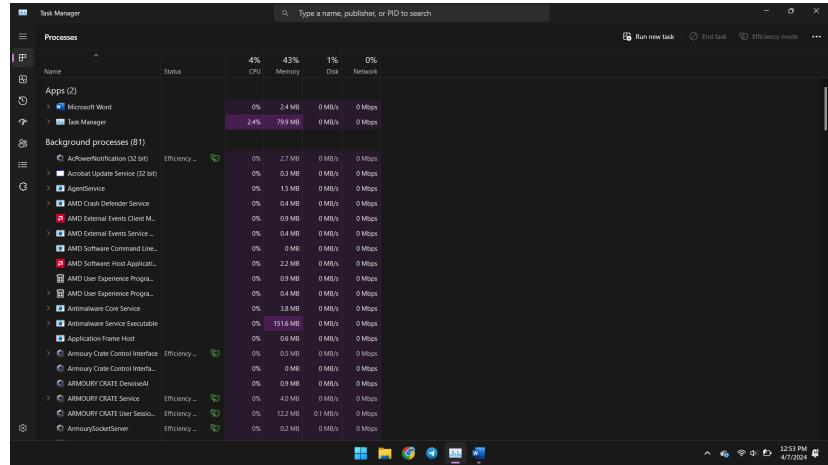
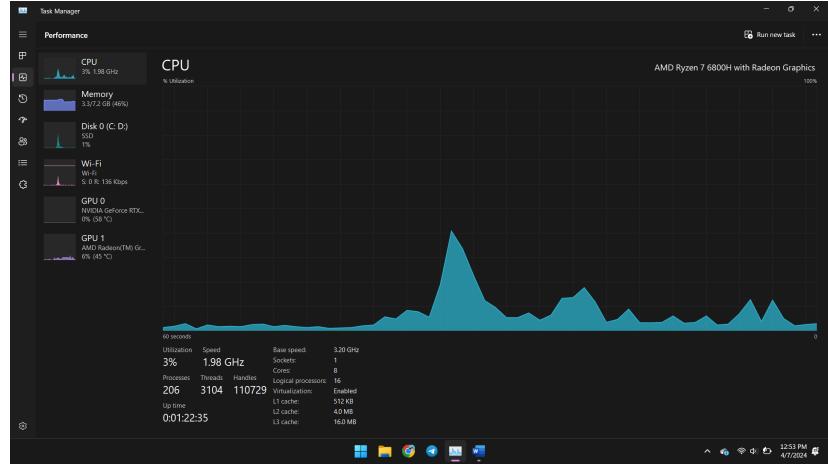
Lenovo IdeaPad Slim 5 16IAH8	CPU Information
Name	Intel Core i5-12450H
Topology	1 Processor, 8 Cores, 12 Threads
Identifier	GenuineIntel Family 6 Model 154 Stepping 3
Base Frequency	2.00 GHz
Cluster 1	4 Cores
Cluster 2	4 Cores
Maximum Frequency	4389 MHz
Package	Socket 1744 FCBGA
Codename	Alder Lake
L1 Instruction Cache	32.0 KB x 6
L1 Data Cache	48.0 KB x 6
L2 Cache	1.25 MB x 1
L3 Cache	12.0 MB x 1

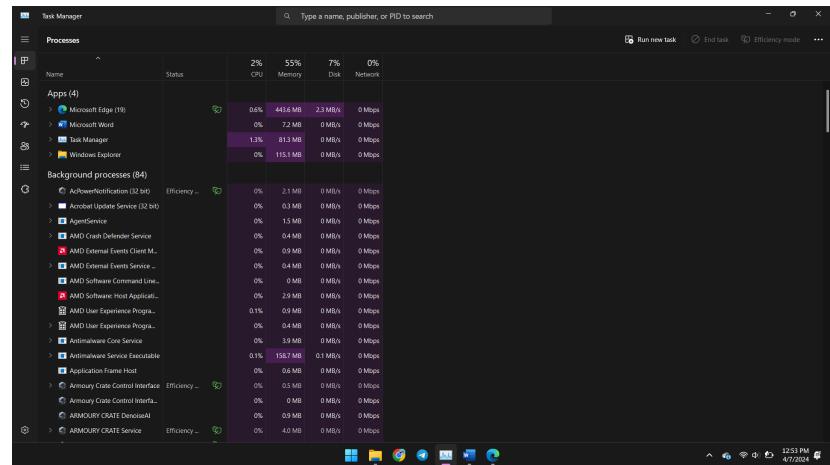
Single-Core Performance

Single-Core Score	1091
File Compression	1091 156.6 MB/sec
Navigation	1049 6.32 routes/sec
HTML5 Browser	1044 21.4 pages/sec
PDF Renderer	1049 24.2 Mpixels/sec
Photo Library	1093 14.8 images/sec
Clang	991 4.88 Klines/sec
Text Processing	1031 82.6 pages/sec
Asset Compression	1048 32.5 MB/sec
Object Detection	977 29.2 images/sec
Background Blur	1475 6.10 images/sec
Horizon Detection	1292 40.2 Mpixels/sec
Object Remover	920 70.7 Mpixels/sec
HDR	1211 35.5 Mpixels/sec
Photo Filter	1238 12.3 images/sec
Ray Tracer	1110 1.07 Mpixels/sec
Structure from Motion	1155 36.6 Kpixels/sec

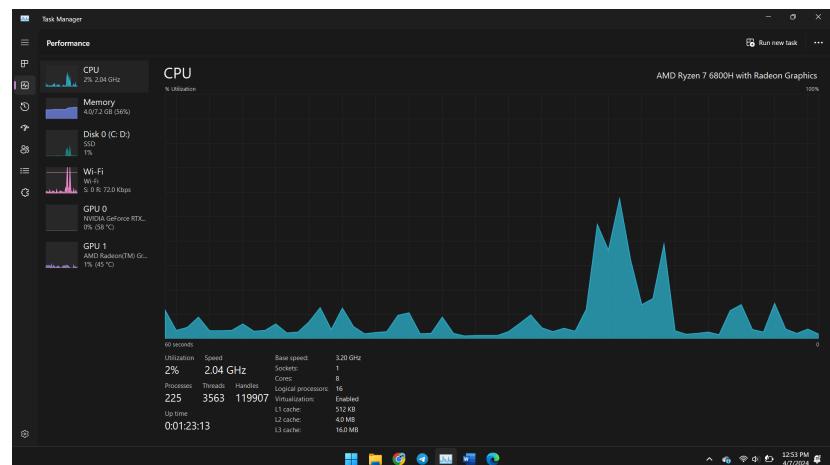
Multi-Core Performance

Multi-Core Score	5396
File Compression	3791 544.4 MB/sec
Navigation	6310 38.0 routes/sec
HTML5 Browser	5548 113.6 pages/sec
PDF Renderer	5845 134.8 Mpixels/sec
Photo Library	6608 89.7 images/sec
Clang	7339 36.1 Klines/sec
Text Processing	1441 115.4 pages/sec
Asset Compression	8393 260.1 MB/sec
Object Detection	3864 115.6 images/sec
Background Blur	5544 22.9 images/sec
Horizon Detection	7374 229.5 Mpixels/sec
Object Remover	5112 393.1 Mpixels/sec
HDR	5747 168.6 Mpixels/sec
Photo Filter	6139 60.9 images/sec
Ray Tracer	7772 7.52 Mpixels/sec
Structure from Motion	7278 230.4 Kpixels/sec

Computer	Task Manager (Active Program and Resource Adjustment)
Asus TUF Gaming A15	<p>Low Load</p> <p>Process:</p>  <p>The screenshot shows the Windows Task Manager in the Processes tab. It lists two active programs: Microsoft Word (CPU usage 4%, Memory 24 MB) and Task Manager (CPU usage 24%, Memory 79.9 MB). The rest of the processes listed are background services, all with very low CPU and memory usage.</p> <p>Performance:</p>  <p>The screenshot shows the Windows Task Manager in the Performance tab. It displays real-time monitoring for CPU, Memory, Disk, WiFi, and GPU. The CPU usage is shown as a blue area graph. Below the graph, detailed CPU statistics are provided: Utilization 3%, Speed 1.98 GHz, Base speed 3.20 GHz, Cores 8, Logical processors 16, and Virtualization Enabled. Other metrics shown include Processes (206), Threads (3104), Handles (110729), Up time (0:01:22:35), and system temperatures (GPU 0: 6% (58 °C), GPU 1: 6% (45 °C)).</p>
	<p>Middle Load</p> <p>Process:</p>

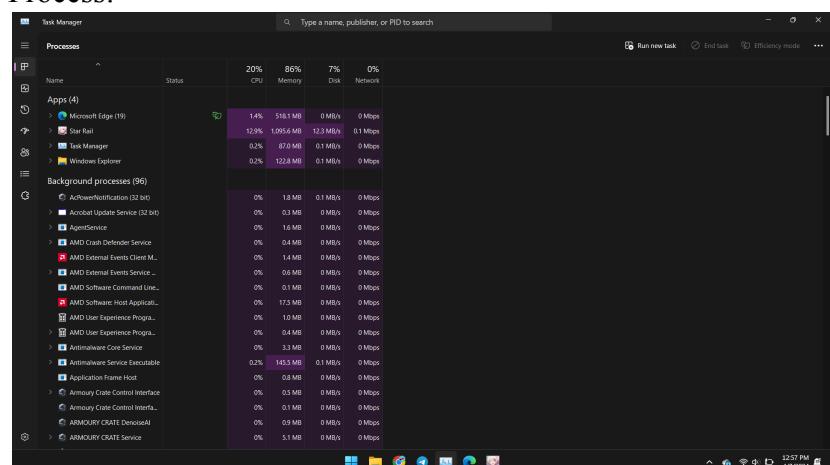


Performance:

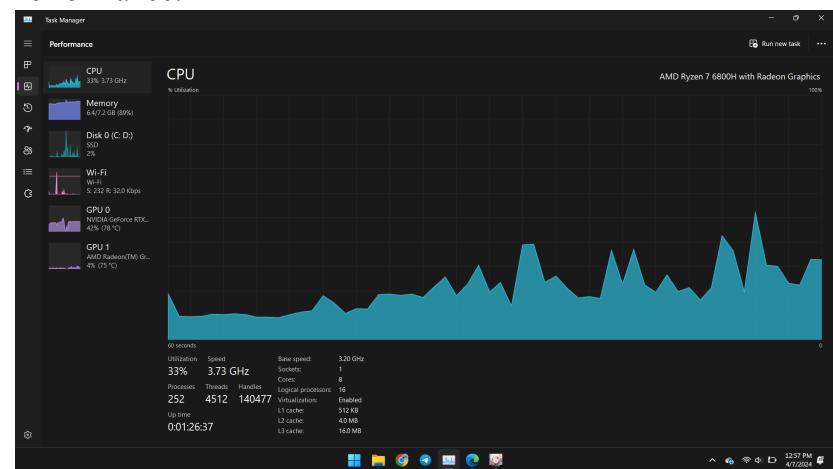


High Load

Process:



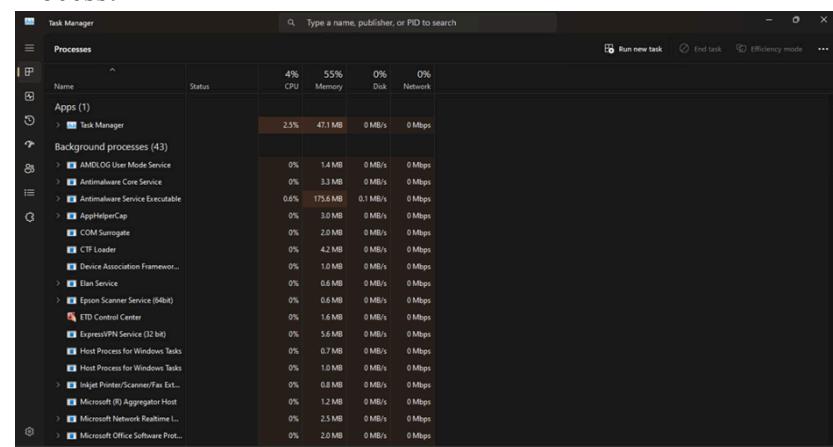
Performance:



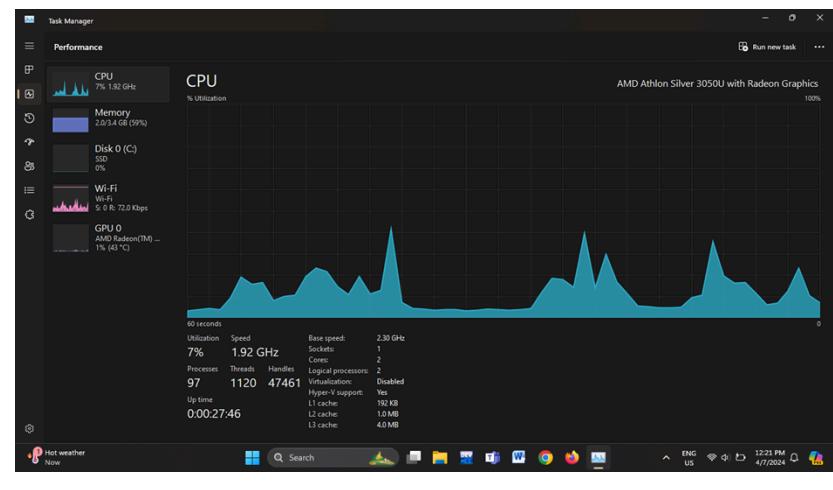
HP Laptop 15s-eq1xxx

Low Load

Process:

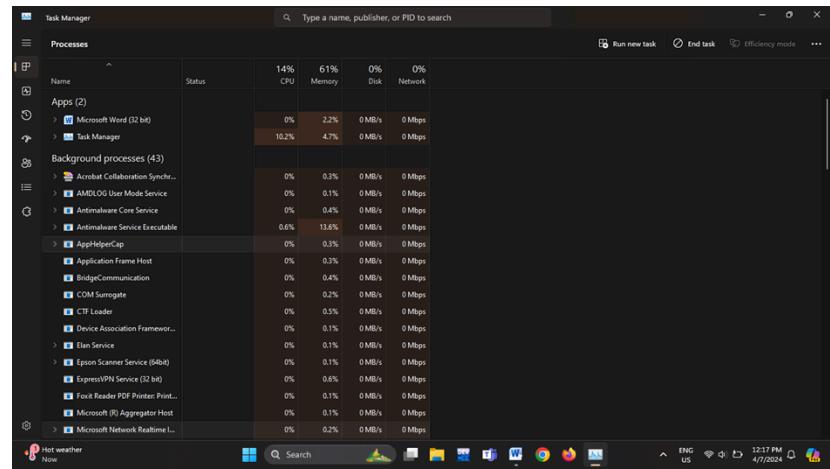


Performance:

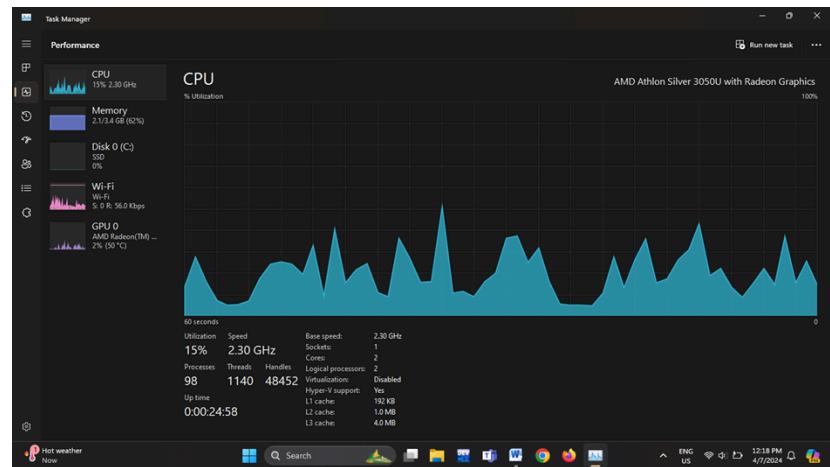


Middle Load:

Process:

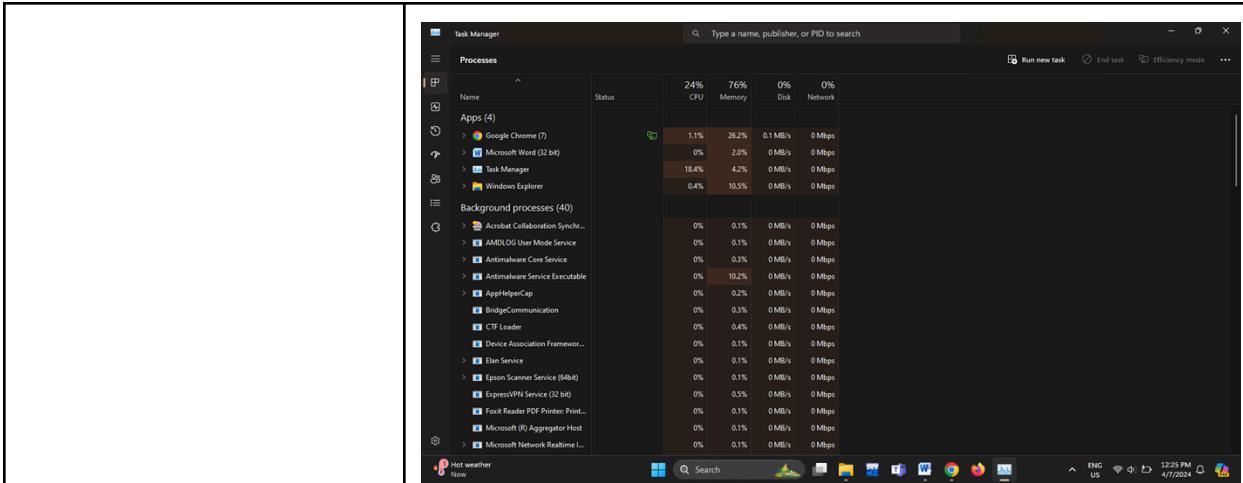


Performance:

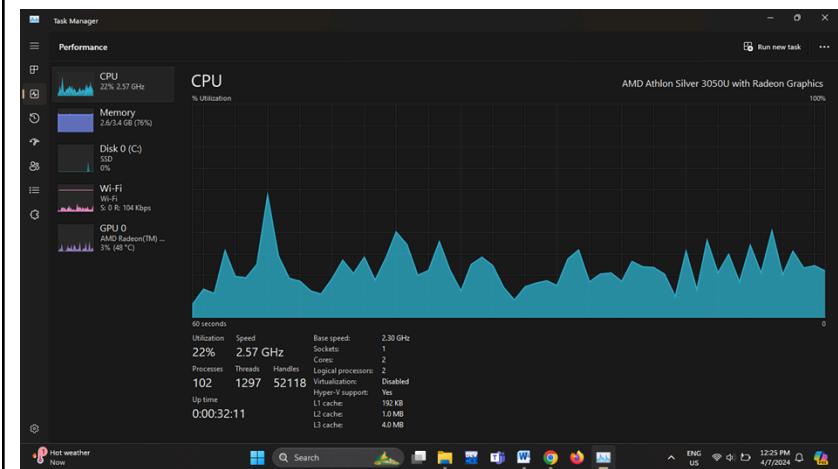


High Load:

Process:



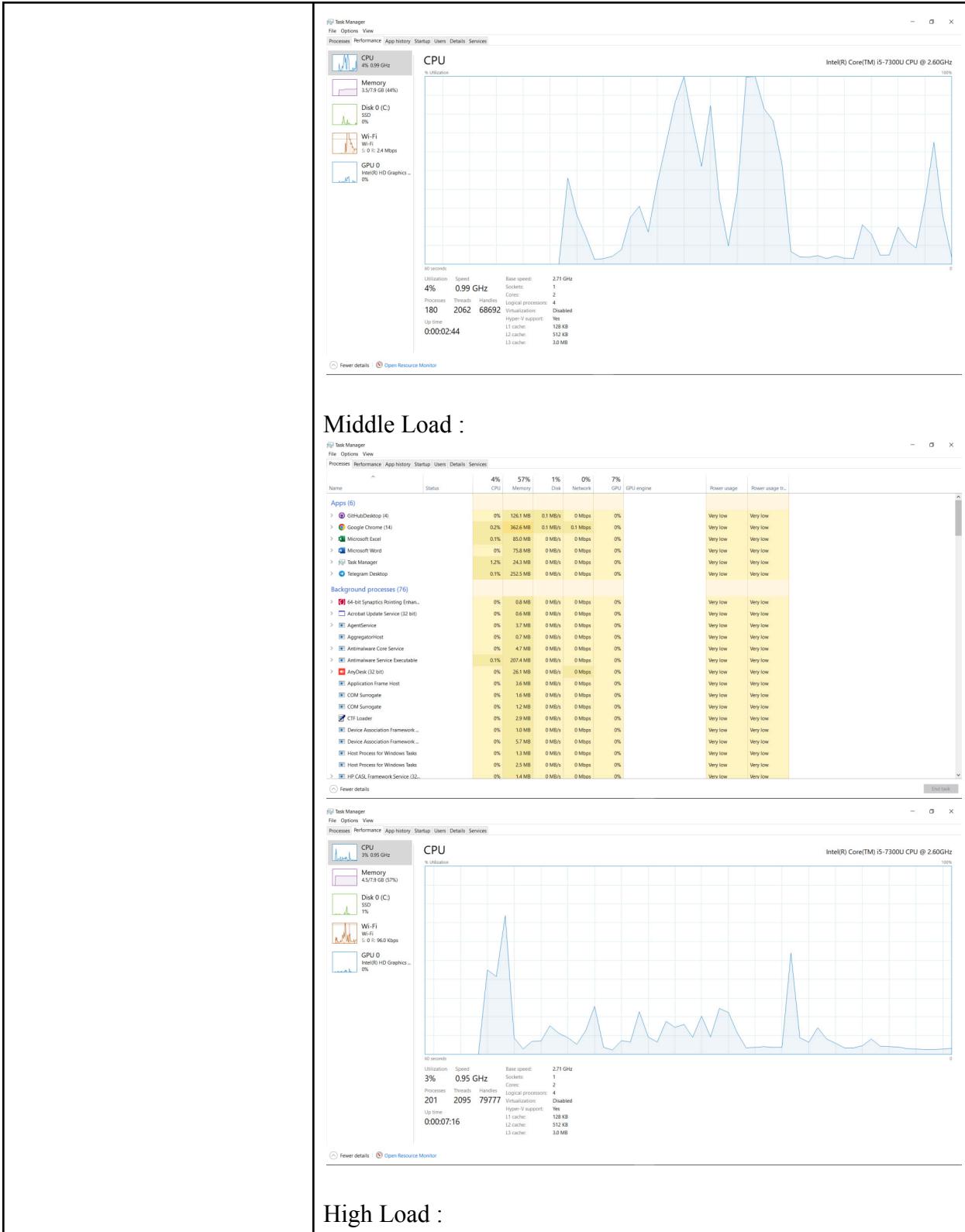
Performance:

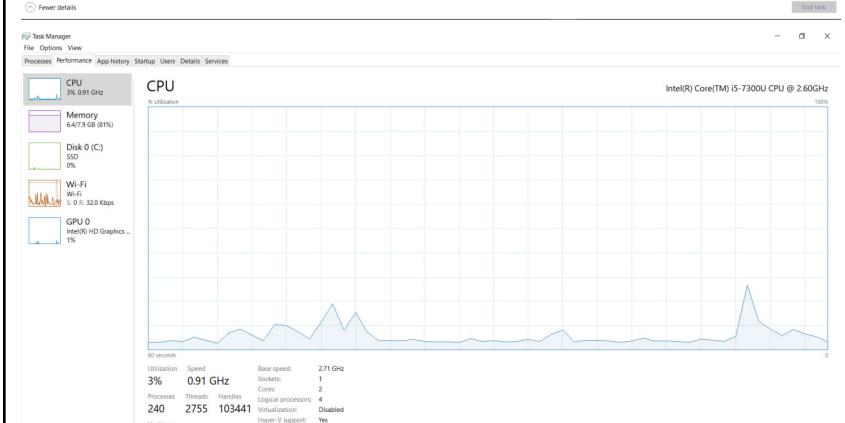
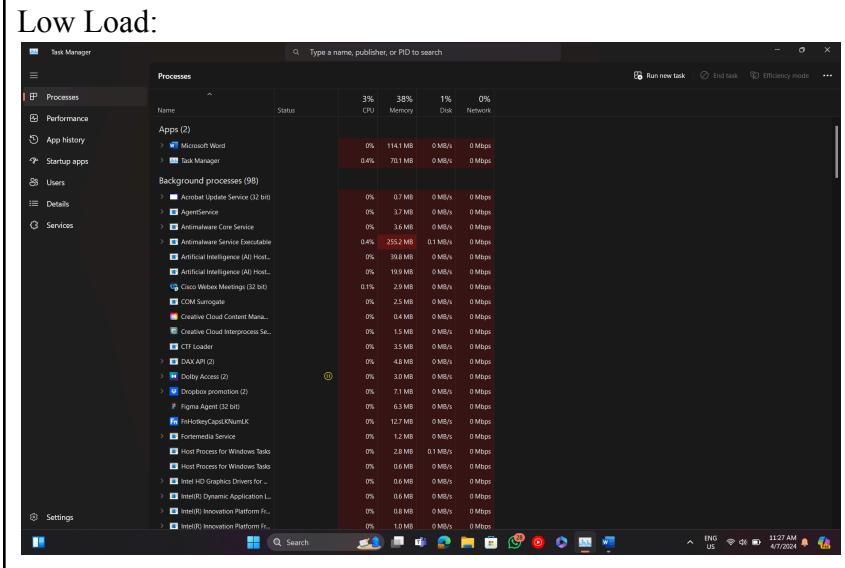


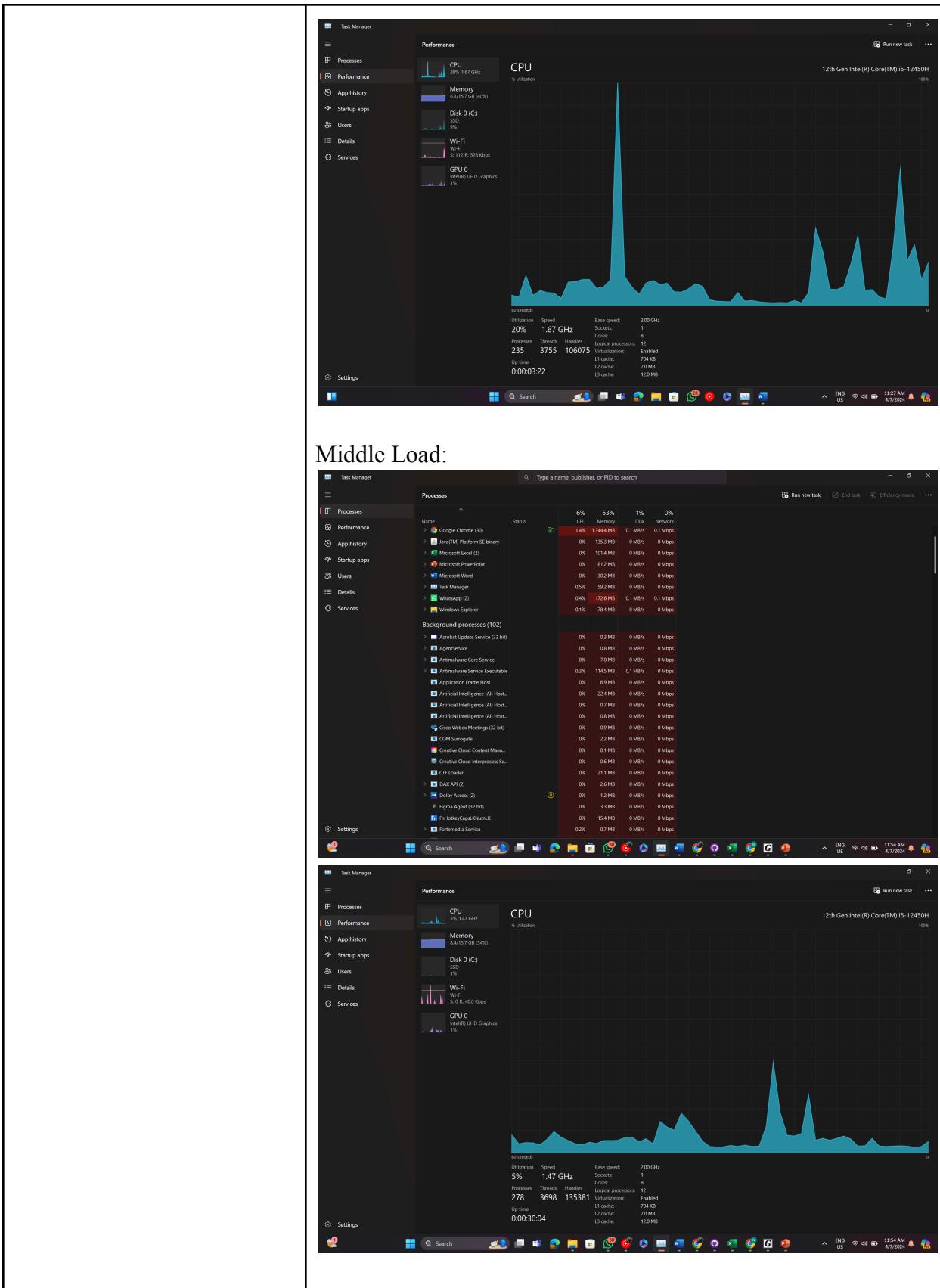
HP Elitebook 840 G4

Low Load :

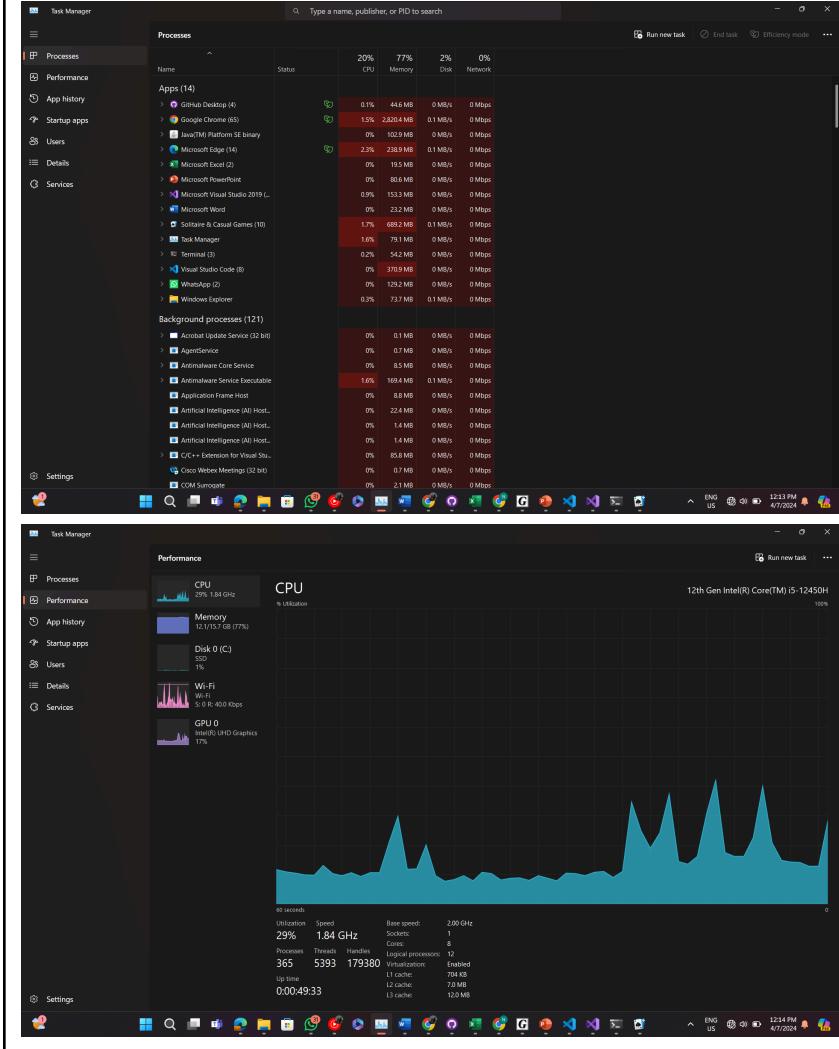
Name	Status	15% CPU	37% CPU	1% Disk	0% Network	0% GPU	Power usage	Power usage tr.
Apps (2)								
> Microsoft Word		0%	73.2 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Task Manager		4.7%	21.0 MB	0 MB/s	0 Mbps	0%	Low	Very low
Background processes (71)								
> 64-bit Synaptics Pointing Estab...		0%	0.8 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Acrobat Update Service (32 bit)		0%	0.7 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Agentrace		0%	0.8 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> AggregatorHost		0%	0.8 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Antimalware Core Service		0%	4.6 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Antimalware Service Executable		0.4%	207.2 MB	0.1 MB/s	0 Mbps	0%	Very low	Very low
> AnyDesk (32 bit)		0%	26.2 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> COM Surrogate		0%	12 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> COM Surrogate		0%	13 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> CTI Loader		0%	2.8 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Device Association Framework...		0%	1.1 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Device Association Framework...		0%	6.0 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Host Process for Windows Tasks		0%	1.3 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> Host Process for Windows Tasks		0.1%	2.2 MB	0.1 MB/s	0 Mbps	0%	Very low	Very low
> HP CASL Framework Service (32...		0%	14 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> HP Hotkey UWP Service		0%	14 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> HP Hotkey UWP Service		0%	19 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> HP LAN/WLAN/WWW Switchin...		0%	1.6 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> HP Smart Background Task Host...		0%	1.7 MB	0 MB/s	0 Mbps	0%	Very low	Very low
> HP Smart-Install Service		0%	0.5 MB	0 MB/s	0 Mbps	0%	Very low	Very low

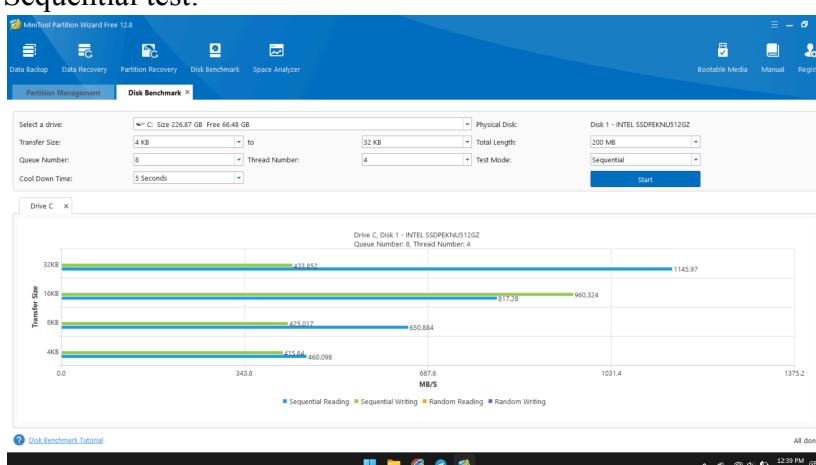
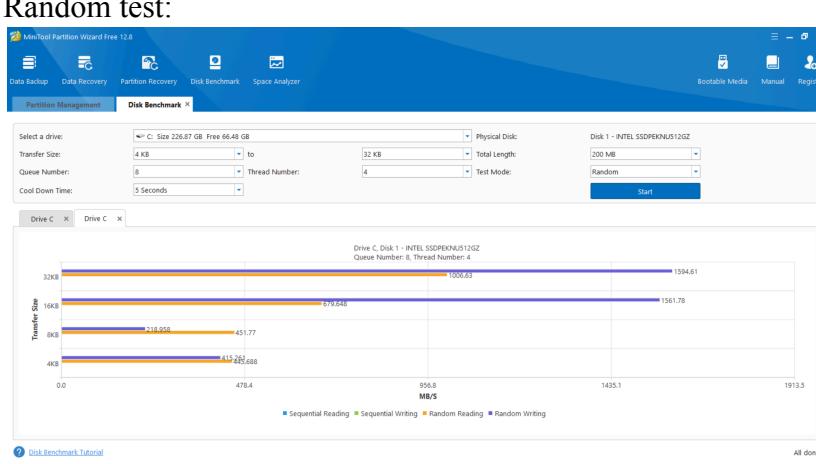
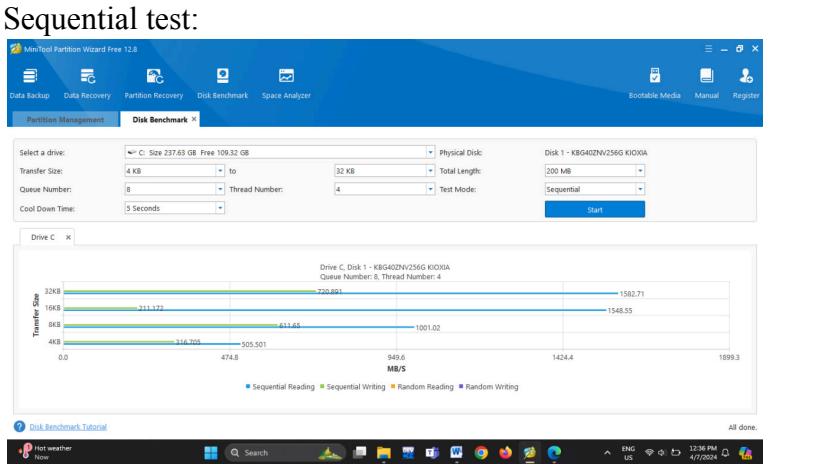


 <p>Task Manager</p> <p>File Options View</p> <p>Processes Performance App history Startup Users Details Services</p> <p>Apps (11)</p> <ul style="list-style-type: none"> > Adobe Acrobat 0% 86.5 MB 0 MB/s 0 Mbps 0% Very low Very low > Discord 0.7% 320.9 MB 0.1 MB/s 0 Mbps 0% Very low Very low > GitHubDesktop (4) 0.1% 182.2 MB 0 MB/s 0 Mbps 0% Very low Very low > Google Chrome 0.3% 321.6 MB 0.1 MB/s 0 Mbps 0% Very low Very low > Microsoft Excel 0% 47.4 MB 0 MB/s 0 Mbps 0% Very low Very low > Microsoft Visual Studio 2019 (3...) 0% 321.2 MB 0 MB/s 0 Mbps 0% Very low Very low > Microsoft Word 0% 73.2 MB 0 MB/s 0 Mbps 0% Very low Very low > Task Manager 0.6% 25.7 MB 0 MB/s 0 Mbps 0% Very low Very low > Telegram Desktop 0% 299.0 MB 0 MB/s 0 Mbps 0% Very low Very low > TexPad 0% 12.5 MB 0 MB/s 0 Mbps 0% Very low Very low > Visual Studio Code (13) 0% 599.3 MB 0 MB/s 0 Mbps 0% Very low Very low <p>Background processes (85)</p> <ul style="list-style-type: none"> > 64-bit Spravics Rounding Erran... 0% 0.3 MB 0 MB/s 0 Mbps 0% Very low Very low > Acrobat Collaboration Syncron... 0.1% 43 MB 0 MB/s 0 Mbps 0% Very low Very low > Acrobat Collaboration Syncron... 0.1% 24.6 MB 0 MB/s 0 Mbps 0% Very low Very low > Acrobat Update Service (32 bit) 0% 0.3 MB 0 MB/s 0 Mbps 0% Very low Very low > Adobe Acrobat 0% 40.8 MB 0 MB/s 0 Mbps 0% Very low Very low > Adobe Acrobat 0% 4.7 MB 0 MB/s 0 Mbps 0% Very low Very low > Adobe Acrobat 0% 26.5 MB 0 MB/s 0 Mbps 0% Very low Very low > Adobe Acrobat 0% 31.7 MB 0 MB/s 0 Mbps 0% Very low Very low > Adobe Acrobat 0% 3.5 MB 0 MB/s 0 Mbps 0% Very low Very low > Adobe Acrobat 0% 28.1 MB 0 MB/s 0 Mbps 0% Very low Very low > Adobe Acrobat 0% 22.5 MB 0 MB/s 0 Mbps 0% Very low Very low <p>(Fewer details End task)</p>	 <p>Task Manager</p> <p>File Options View</p> <p>Processes Performance App history Startup Users Details Services</p> <p>CPU</p> <p>Intel(R) Core(TM) i5-7300U CPU @ 2.60GHz</p> <p>% Utilization</p> <p>Utilization Speed Base speed: 2.7 GHz</p> <p>3% 0.91 GHz Sockets: 1</p> <p>Processes Threads Handles Logical processors: 4</p> <p>240 2755 103441 Virtualization: Disabled</p> <p>Up time Hyper-V support: Yes</p> <p>0:00:21:11 L1 cache: 312 KB</p> <p>L2 cache: 512 KB</p> <p>L3 cache: 3.0 MB</p> <p>(Fewer details Open Resource Monitor)</p>																		
<h2>Lenovo IdeaPad Slim 5 16IAH8</h2>	<h3>Low Load:</h3>  <p>Task Manager</p> <p>Type a name, publisher, or PID to search</p> <p>Run new task End task Efficiency mode</p> <p>Processes</p> <table border="1"> <thead> <tr> <th>Name</th> <th>Status</th> <th>3% CPU</th> <th>38% Memory</th> <th>1% Disk</th> <th>0% Network</th> </tr> </thead> <tbody> <tr> <td>Apps (2)</td> <td></td> <td>0%</td> <td>114.1 MB</td> <td>0 MB/s</td> <td>0 Mbps</td> </tr> <tr> <td>Background processes (98)</td> <td></td> <td>0%</td> <td>70.1 MB</td> <td>0 MB/s</td> <td>0 Mbps</td> </tr> </tbody> </table> <p>Performance App history Startup apps Users Details Services Settings</p> <p>Run new task End task Efficiency mode</p>	Name	Status	3% CPU	38% Memory	1% Disk	0% Network	Apps (2)		0%	114.1 MB	0 MB/s	0 Mbps	Background processes (98)		0%	70.1 MB	0 MB/s	0 Mbps
Name	Status	3% CPU	38% Memory	1% Disk	0% Network														
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Background processes (98)		0%	70.1 MB	0 MB/s	0 Mbps														

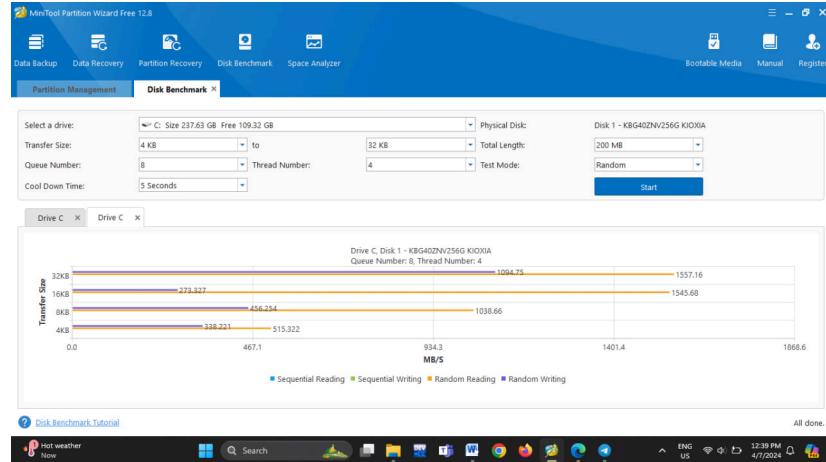


High Load:



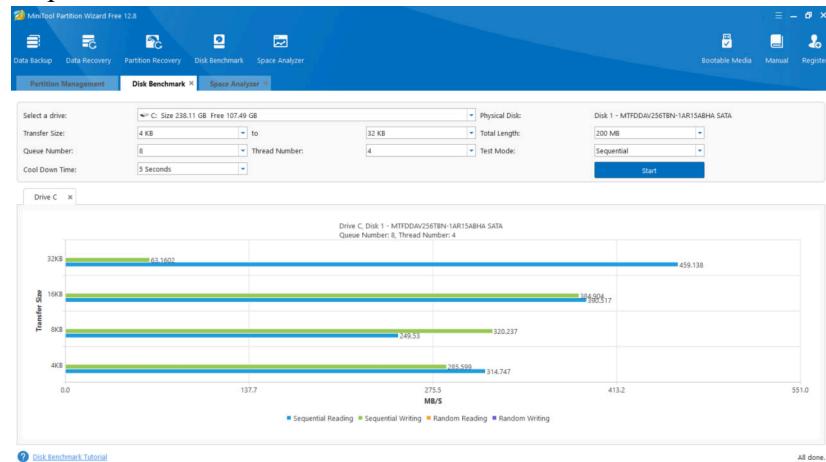
Computer	MiniTools (Disk benchmark)																																																
Asus TUF Gaming A15	<p>Sequential test:</p>  <table border="1"> <caption>Sequential Test Results (Drive C)</caption> <thead> <tr> <th>Transfer Size</th> <th>Sequential Reading (MB/S)</th> <th>Sequential Writing (MB/S)</th> <th>Total Length (MB)</th> </tr> </thead> <tbody> <tr> <td>32 KB</td> <td>1145.97</td> <td>1113.852</td> <td>200 MB</td> </tr> <tr> <td>16 KB</td> <td>960.324</td> <td>817.28</td> <td>200 MB</td> </tr> <tr> <td>8 KB</td> <td>650.884</td> <td>475.017</td> <td>200 MB</td> </tr> <tr> <td>4 KB</td> <td>460.098</td> <td>415.68</td> <td>200 MB</td> </tr> <tr> <td>2 KB</td> <td>1375.2</td> <td>1031.4</td> <td>200 MB</td> </tr> </tbody> </table> <p>Random test:</p>  <table border="1"> <caption>Random Test Results (Drive C)</caption> <thead> <tr> <th>Transfer Size</th> <th>Random Reading (MB/S)</th> <th>Random Writing (MB/S)</th> <th>Total Length (MB)</th> </tr> </thead> <tbody> <tr> <td>32 KB</td> <td>1594.61</td> <td>1006.63</td> <td>200 MB</td> </tr> <tr> <td>16 KB</td> <td>1561.78</td> <td>1599.648</td> <td>200 MB</td> </tr> <tr> <td>8 KB</td> <td>451.77</td> <td>218.958</td> <td>200 MB</td> </tr> <tr> <td>4 KB</td> <td>1913.5</td> <td>1152.688</td> <td>200 MB</td> </tr> <tr> <td>2 KB</td> <td>1425.1</td> <td>956.8</td> <td>200 MB</td> </tr> </tbody> </table>	Transfer Size	Sequential Reading (MB/S)	Sequential Writing (MB/S)	Total Length (MB)	32 KB	1145.97	1113.852	200 MB	16 KB	960.324	817.28	200 MB	8 KB	650.884	475.017	200 MB	4 KB	460.098	415.68	200 MB	2 KB	1375.2	1031.4	200 MB	Transfer Size	Random Reading (MB/S)	Random Writing (MB/S)	Total Length (MB)	32 KB	1594.61	1006.63	200 MB	16 KB	1561.78	1599.648	200 MB	8 KB	451.77	218.958	200 MB	4 KB	1913.5	1152.688	200 MB	2 KB	1425.1	956.8	200 MB
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HP Laptop 15s-eq1xxx	<p>Sequential test:</p>  <table border="1"> <caption>Sequential Test Results (Drive C)</caption> <thead> <tr> <th>Transfer Size</th> <th>Sequential Reading (MB/S)</th> <th>Sequential Writing (MB/S)</th> <th>Total Length (MB)</th> </tr> </thead> <tbody> <tr> <td>32 KB</td> <td>1582.71</td> <td>720.891</td> <td>200 MB</td> </tr> <tr> <td>16 KB</td> <td>1548.55</td> <td>611.145</td> <td>200 MB</td> </tr> <tr> <td>8 KB</td> <td>1001.02</td> <td>511.172</td> <td>200 MB</td> </tr> <tr> <td>4 KB</td> <td>1899.3</td> <td>516.705</td> <td>200 MB</td> </tr> <tr> <td>2 KB</td> <td>1424.4</td> <td>949.6</td> <td>200 MB</td> </tr> </tbody> </table>	Transfer Size	Sequential Reading (MB/S)	Sequential Writing (MB/S)	Total Length (MB)	32 KB	1582.71	720.891	200 MB	16 KB	1548.55	611.145	200 MB	8 KB	1001.02	511.172	200 MB	4 KB	1899.3	516.705	200 MB	2 KB	1424.4	949.6	200 MB																								
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Random test:

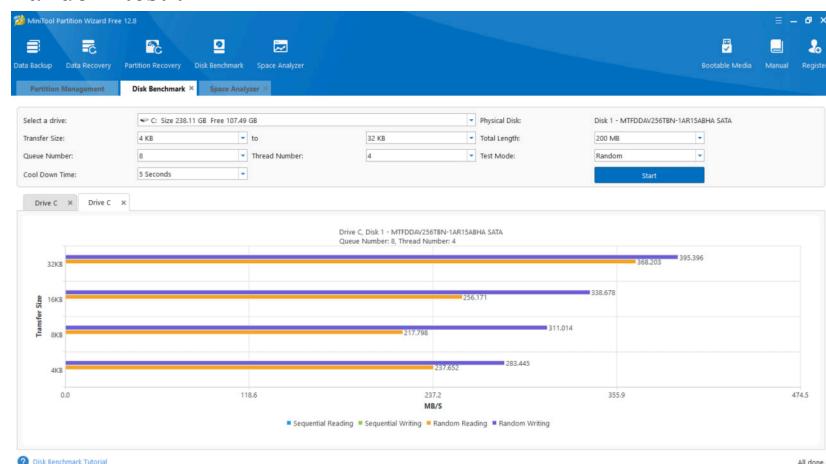


HP Elitebook 840 G4

Sequential test :

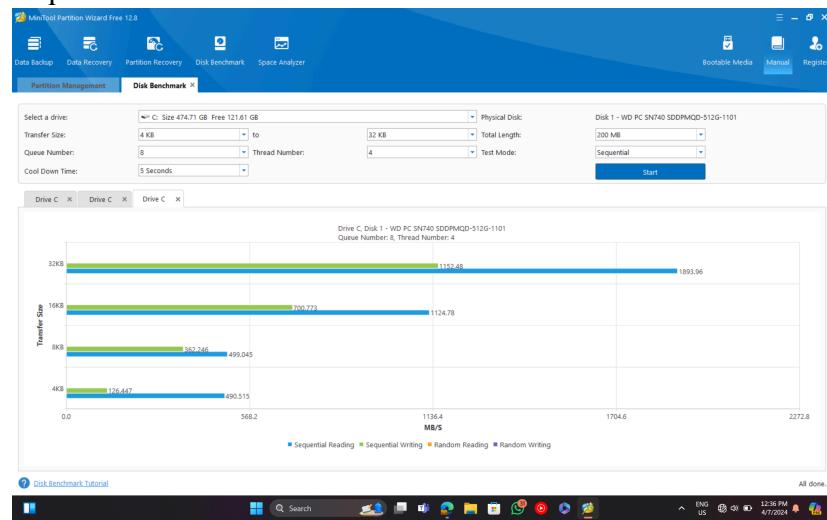


Random test :



Lenovo IdeaPad Slim 5 16IAH8

Sequential Test:



Random Test:

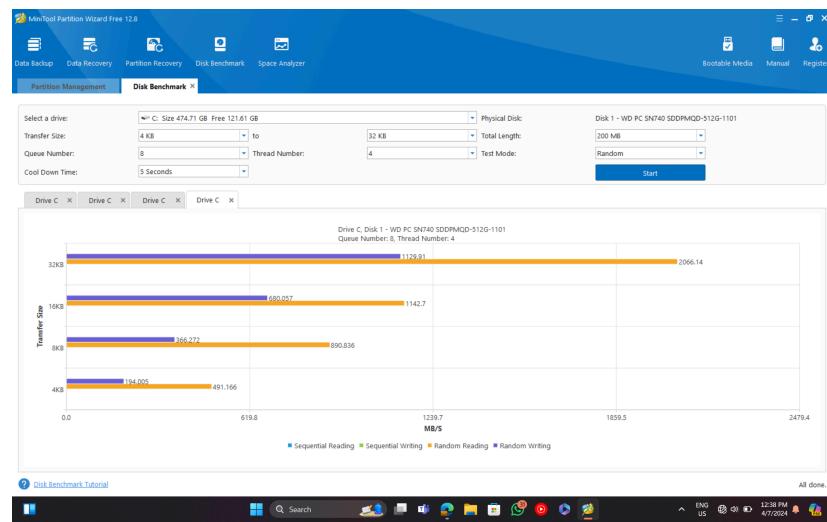


Table 3 : Benchmarking Result

4. Analysis, Comparison, Discussion

Computer	CPUZ (System Info)	Geekbench (CPU stress test)	Task Manager (Active Program and Resource Adjustment)	MiniTools (Disk benchmark)
Asus TUF Gaming A15	<p>The CPU performance for this laptop is 1235.51 MHz for core speed with multiplier of 12.38 and bus speed of 99.84MHz.</p> <p>Moving on to cache, the associativity of L1 data and instruction cache and L2 cache is 8-way while L3 cache is an 16-way associative cache. For each cache size, the total size for L1 data and instruction cache is 32 KBytes. L2 cache has a total size of 512 KBytes and L3 cache has a total size of 16 MBytes.</p> <p>The memory type for this laptop is DDR5 with total size of 8GBytes and Uncore frequency of 1197.5 MHz. The frequency of DRAM is 2390.8 MHz.</p> <p>Next, the motherboard's model is FA507RC manufactured by</p>	<p>From Geekbench, the laptop's processor is named AMD Ryzen 7 6800H and it has 1 processor with 8 cores and 16 threads. The maximum frequency is 2448 MHz with base frequency of 3.2 GHz.</p> <p>About the core performance, the overall score for single-core is 1017 and for multi-core is 4109. From the overall score, it shows that this laptop performs tasks that utilize single and multi core at respective scores. Since the multi-core is higher, this laptop is better at multitasking rather than performing tasks that rely heavily on single-threaded performance.</p> <p>Information about specialized tasks for single-core, the highest score is background blur (1466) and the lowest score is object detection (533) indicates that background blur tasks are better</p>	<p>Using the task manager application, the CPU performance for this laptop is observed under three conditions of load which are low, middle and high.</p> <p>Under low load with 43% of total memory used, the CPU utilization is 3% indicating that the CPU is mostly idle during the low load test and operating speed is 1.98GHz which is low compared to the base speed (3.2GHz) indicates the laptop is currently on power-saving mode.</p> <p>Under the middle load test, total memory used is 55%. The CPU utilization is only 2% which is lower than low load test may indicate that the CPU is more idle during middle test than low test. It can also indicate that the applications</p>	<p>This tool is used to test the SSD performance on this laptop. From the test, the result is varied from 4KB to 32 KB for both sequential and random tests.</p> <p>For sequential tests, the highest sequential read speed is 1145.97 MB/s at 32 KB transfer size and sequential write speed is 960.324 MB/s at 16 KB transfer size. This shows that higher transfer size shows better performance in sequential tests.</p> <p>For random tests, the highest random read speed is 1561.78 MB/s at 32 KB transfer size and highest random write speed is 1594.61 MB/s at 32 KB transfer size. This shows that this SSD can perform</p>

	<p>ASUSTeK COMPUTER INC.</p> <p>The bus spec of the motherboard is PCI-Express 4.0 with 16 Gigatransfers per second and it is equipped with AMD Ryzen SOC chipset. The BIOS's brand is American Megatrends International LLC. version FA507RC.315.</p>	<p>with processing 6.07 images/second while this laptop is slow at object detection with 15.9 images/second within the constraints of a single CPU core for this laptop. For the multi-core, the highest score is ray tracer (10894) and the lowest score is text processing (1319) indicates that this laptop is good at graphics rendering with highest performance at 10.5 Mpixels/second and have difficulty at text processing with 105.6 pages/second within constraint of multi-core CPU for this laptop.</p>	<p>are less used than Microsoft Word that are opened during low load tests. The operating speed during the middle load test is still lower than the base speed, showing that the laptop is still on the power-saving mode.</p> <p>Moving on to the high load test, the total memory used is 86% with a game application (Star Rail) used a total of 1095.6 MB during the test resulted in 33% of CPU utilization indicates that the CPU is currently performing a heavy task since the GPU is also on 42% utilization compared to 0% GPU utilization in low and middle load test. The operating also shows that the CPU is currently utilizing the Turbo Boost that this laptop has since it is a gaming laptop, so it is boosting the gaming experience for the game application that is currently opened.</p>	<p>various transfer sizes but the highest transfer size shows better performance.</p> <p>From both tests, this laptop's SSD can perform various transfer sizes from 4KB to 32KB but it shows better performance in higher transfer sizes which is at 16KB and 32KB. However, to compare between sequential and random tests, sequential operations generally perform better in read operation but the speed in random operations are increasing as the transfer sizes increase in both read and write operations.</p>
HP Laptop 15s-eq1xxx	<p>For the clock speed, based on CPUZ benchmark, this laptop has 1394.54 MHz core speed with x 14.0 multiplier and bus</p>	<p>The CPU information I got for Geekbench read the name of the laptop processor as AMD Athlon Silver 3050U with 1 processor</p>	<p>The performance of this laptop will be viewed by observing the performance of the CPU where it will be viewed in three</p>	<p>Two different results for the disk benchmark are shown for sequential reading and random reading. The disk</p>

<p>speed, 99.61 MHz.</p> <p>For the laptop cache system, it has 3 levels of cache. L1 Data cache with 8-way set associative cache can store 2x32 KBytes. Meanwhile, for L1 Inst. with 4-way, it can store 2x64KBytes. For Level 2, it is equipped with the same set associative cache as L1 Data cache which is an 8-way that can store 2x512 KBytes. The last level, which is Level 3, has a 16-way set associative cache that can store 4MBytes.</p> <p>Moving to the memory part, this laptop has DDR4 memory type with the size of 4GBytes. The laptop's Uncore memory frequency is 1195.5MHz. It has dynamic RAM with a frequency of 1200.0 MHz.</p> <p>Next, the motherboard of this laptop is manufactured by HP using the 8706 model. The bus specs indicate that the motherboard supports PCI-Express 3.0, which has a maximum data transfer rate of 8.0 Gigatransfers per second (GT/s). Chipset used is AMD Ryzen SOC. Version: F.52 - AMD AGESA PicassoPI-FP5</p>	<p>and 2 cores. The rest of the CPU information is just the same as viewed in CPUZ benchmarking. The overall single-core score is 631, indicating the general efficiency of a single CPU core. Specific tasks like file compression, navigation, and object detection are measured, with file compression having a high score of 880 (123.1 MB/s) and navigation scoring 846 (5.10 routes/s), showing the CPU's strength in these areas. Other tasks, such as HTML5 browsing, PDF rendering, and text processing, are also evaluated, demonstrating varied performance levels across different applications. The scores reflect how well the CPU handles individual tasks, with higher numbers indicating better performance.</p> <p>The overall multi-core score is 819, reflecting the CPU's efficiency in multi-threaded operations. High-scoring tasks include navigation (1337, 8.06 routes/sec), asset compression (1388, 49.9 MB/sec), and PDF rendering (1035, 23.9 Mpixels/sec), indicating strong</p>	<p>different conditions which are low load, middle load and high load.</p> <p>In low load, 43% of total memory is used, the CPU utilization is 4%. The result showed that the usage is heavily utilized even though the laptop only opens Task Manager to view the CPU performance.</p> <p>While doing the middle load test, total memory used is 61%. The CPU utilization is 14% which is higher than low load. The result showed a higher result than low load even though only Microsoft Word.</p> <p>Next is a high load test, 76% of total memory is used, the CPU utilization is 24%. The performance showed that the computer is heavily utilized even though it only opens Microsoft Word, Windows Explorer and only performs simple web browsing.</p>	<p>benchmark performance shows strong performance across different transfer sizes in both sequential and random reads.</p> <p>For sequential reads, the drive achieved speeds from 316.705 MB/s at 4 KB to 720.890 MB/s at 32 KB.</p> <p>For random reads, it achieved speeds from 338.221 MB/s at 4 KB to 109475 MB/s at 32 KB.</p> <p>The results shown for different transfer sizes indicates the optimization is suitable for everyday usage.</p>
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	1.0.0.C is the version number of the BIOS, including the AGESA (AMD Generic Encapsulated Software Architecture) version used.	performance in these areas. The CPU also performs well in clang compilation (1185, 5.84 Klines/sec) and horizon detection (1300, 40.5 Mpixels/sec). Tasks like object detection (240, 7.17 images/sec) and photo filter application (267, 2.65 images/sec) have lower scores, suggesting these tasks are less optimized for multi-core performance on this CPU. Overall, the multi-core performance demonstrates the CPU's ability to handle more complex and parallelizable tasks efficiently compared to single-core performance.		
HP Elitebook 840 G4	The clock speed on this laptop is 1395.90 MHz core speed with x14.0 multiplier and the bus speed is 99.71 MHz. The cache system in this laptop has 3 levels of cache. L1 Data cache with 8-way, can store 2x32KBytes. For L1 Inst. cache with 8-way can store 2x32KBytes. For Level 2 cache, with 4-way that can store 2x256 KBytes. Next, Level 3 cache with 12-way can store 3	The CPU information for Geekbench read the name of the laptop processor as Intel Core i5-7300U with 1 processor, 2 cores and 4 threads. The rest of the CPU information is the same as CPU-Z benchmarking. The single-core performance chart shows an overall score of 659, with the highest performance in the Background Blur task (1014, 4.20 images/sec) and the lowest in Object Detection (328, 9.81 images/sec). Notable	Under the low load, the CPU memory at 37% has the CPU performance with 0.99GHz. For middle load, the CPU memory at 57% has the CPU performance with 0.95GHz. In high load, the CPU memory at 81% has the CPU performance with 0.91GHz.	The disk benchmark results show varying performance based on the transfer size, which is 4 KB to 32 KB. It has 4 thread numbers and the cool down time is 5 seconds. For the sequential test mode with total length is 200 MB, the sequential reading achieves the highest speed of 459.138 MB/s at 32 KB transfer size. Meanwhile

	<p>MBytes.</p> <p>The memory type is DDR4 with size 8GBytes. The NorthBridge memory frequency is 698.1MHz. It also has dynamic RAM with a frequency of 1063.9 MHz.</p> <p>Next, the motherboard of this laptop is manufactured by HP with model 828C. The BIOS version is P 78 ver. 01.31 dated 16/10/2019. The version of Graphic Interface used is PCI-Express.</p>	<p>performances include Navigation (723, 4.36 routes/sec) and Clang (716, 3.53 Klines/sec).</p> <p>In contrast, the multi-core performance chart reveals a significantly higher overall score of 1814. The highest performance is observed in Clang (2730, 13.4 Klines/sec), while the lowest is in Text Processing (719, 57.6 pages/sec). Other noteworthy performances include the PDF Renderer (2647, 61.0 Mpixels/sec) and the Ray Tracer (2846, 2.75 Mpixels/sec).</p>		<p>the sequential writing is the slowest, peaking at 63.1602 MB/s at 32 KB transfer size.</p> <p>For the random test mode with a total length of 200 MB, the random writing reaches the highest speed of 395.396 MB/s at 32 KB transfer size. The random reading is the slowest, peaking at 217.798 MB/s at 8 KB transfer size.</p>
Lenovo IdeaPad Slim 5 16IAH8	<p>The processor of the laptop has a maximum TDP of 45.0W, using the Socket 1744 FCBGA package. Clock speed showed that the laptop has 2394.14 MHz core speed with x 24.0 (4.0 - 44.0) multiplier and bus speed of 99.76MHz.</p> <p>The cache configuration includes L1 data of 4 x 48 KB + 3 x 32 KB, L1 instruction of 4 x 32 KB + 3 x 32 KB, L2 cache of 4 x 1.25 MB + 2 MB, and an L3 cache of 12 MB. It also has 8 cores with 4 performance</p>	<p>The CPU information shown in Geekbench is tally with the information shown in CPU-Z, where it uses 1 processor, has 8 cores and 12 threads. The rest of the is just the same as viewed in CPU-Z benchmarking.</p> <p>The overall single-core score is 1091, indicating the general efficiency of a single CPU core. Specific tasks like background blur, horizon detection, and photo filter are measured, with background blur having a high score of 1475 (6.10 images/s)</p>	<p>Under the low load, the CPU memory with 38% and CPU utilization at 20%, running at 1.67 GHz, with memory usage is 6.3 GB out of 15.7 GB. The disk, network, and GPU usage are minimal where they are not being heavily utilized.</p> <p>Under the middle load, the CPU memory with 53% and CPU utilization at 5%, running at 1.47 GHz, with memory usage is 8.4 GB out of 15.7 GB.</p> <p>Under the high load, the CPU</p>	

	<p>cores (P) and 4 efficiency cores (E).</p> <p>The memory type of this laptop is DDR5 with a total size of 16GB. The memory is operating at a DRAM frequency of 1197.1 MHz with timings of CAS Latency (CL) at 32 clocks, RAS to CAS Delay (tRCD) at 24 clocks, RAS Precharge (tRP) at 24 clocks, and Cycle Time (tRAS) at 52 clocks. The laptop also used an uncore frequency with operating speed of 1995.1MHz.</p> <p>Next, the laptop is manufactured by Lenovo with model number LNVNB161216 with BIOS version LACN25WW dated 05/25/2023. The chipset and southbridge are both Intel Alder Lake, with revisions 02 and 01, respectively. The bus specifications include PCI-Express 4.0 (16.0 GT/s).</p>	<p>and horizon detection 1292 (40.2 Mpixels/s), showing the CPU's strength in these areas. Other tasks, such as HTML5 browsing, PDF rendering, and text processing, are also evaluated, demonstrating varied performance levels across different applications. The scores reflect how well the CPU handles individual tasks, with higher numbers indicating better performance.</p> <p>The overall multi-core score is 5396, reflecting the CPU's efficiency in multi-threaded operations. High-scoring tasks include asset compression (8393, 260.1MB/sec), ray tracer (7772, 7.52 Mpixels/s), and also horizon detection (7374, 229.5 Mpixels/s), indicating strong performance in these areas. The CPU also performs well in clang compilation (1185, 5.84 Klines/sec) and horizon detection (1300, 40.5 Mpixels/sec). Tasks like object detection (240, 7.17 images/sec) and photo filter application (267, 2.65 images/sec) have lower scores, suggesting these tasks are less</p>	<p>memory with 77% and CPU utilization at 29%, running at 1.84 GHz, with memory usage is 12.1 GB out of 15.7 GB.</p>
--	--	---	--

		optimized for multi-core performance on this CPU. Overall, the multi-core performance demonstrates the CPU's ability to handle more complex and parallelizable tasks efficiently compared to single-core performance.		
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Table 4 : Benchmark Comparison

Computer Name	Code
Asus TUF Gaming A15	A
HP Laptop 15s-eq1xxx	B
HP Elitebook 840 G4	C
Lenovo IdeaPad Slim 5 16IAH8	D

Table 5 : Computer name type and its code

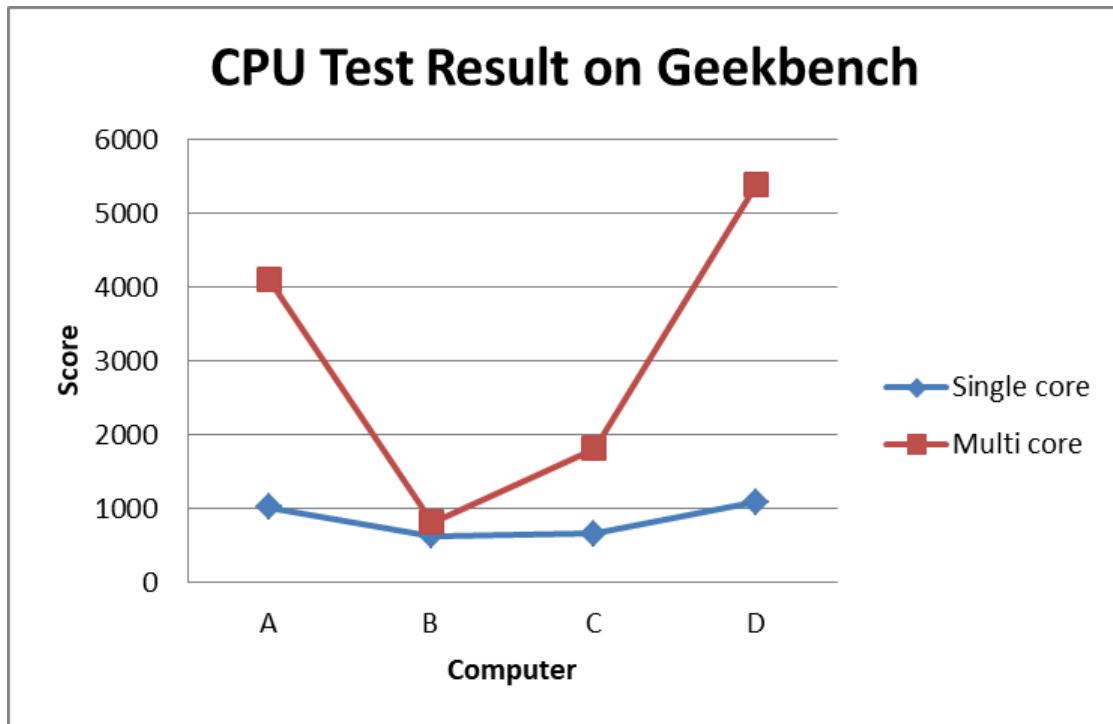


Diagram 1 : Comparison 4 computers in CPU Test using Geekbench Tool

The chart above displays Geekbench CPU test results for four computers which are Computer A, B, C and D, comparing single-core and multi-core scores by using the Geekbench tool. Computer A shows a single-core score around 1000 and multi-core above 4000. Computer B has the lowest multi-core score, dropping below 1000, while its single-core remains around 800. Computer C's scores are similar to Computer B, with both single-core and multi-core scores under 1000. However, Computer D demonstrates a significant performance boost, with a single-core just above 1000 and an impressive multi-core score reaching around 5500. This

indicates that Computer D beat in multi-core performance, while Computer B and C have relatively low scores in both categories.

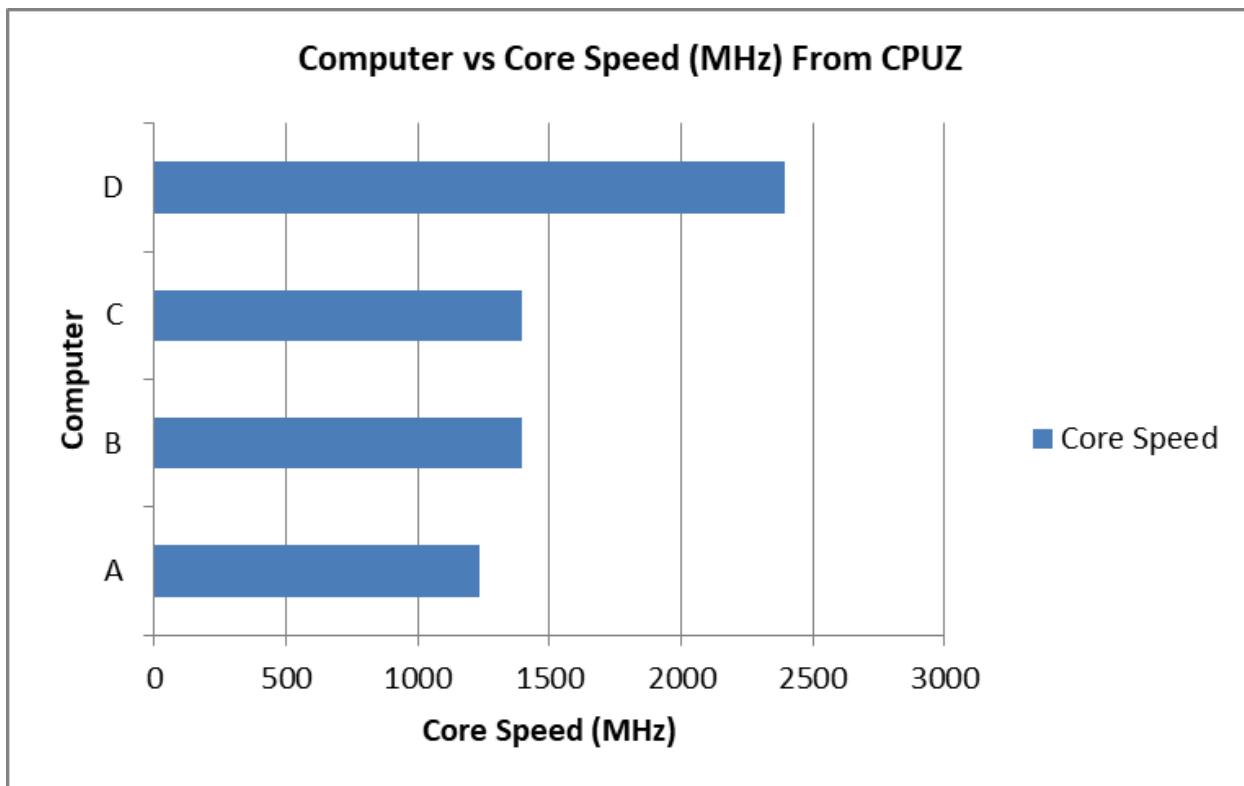


Diagram 2 : Comparison 4 computers in Core speed using CPU-Z

Based on the bar chart in Figure shown above, Computer D stands out with the highest core speed, reaching slightly over 2500 MHz, indicating superior performance in terms of processing speed. This shows that such speed can enhance performance in tasks that require intensive processing such as complex computational tasks. Moreover, both Computer B and C have similar core speeds, showing that the computers offer comparable levels of performance. It may not be as high as Computer D but the processing power is suitable for everyday computing tasks such as web browsing. While Computer A has the lowest core speed indicates that it was the least powerful among the 4 computers. As Computer A has the lowest core speed, indicates that Computer A is more suitable for basic tasks that are non-demanding such as word processing and simple web browsing.

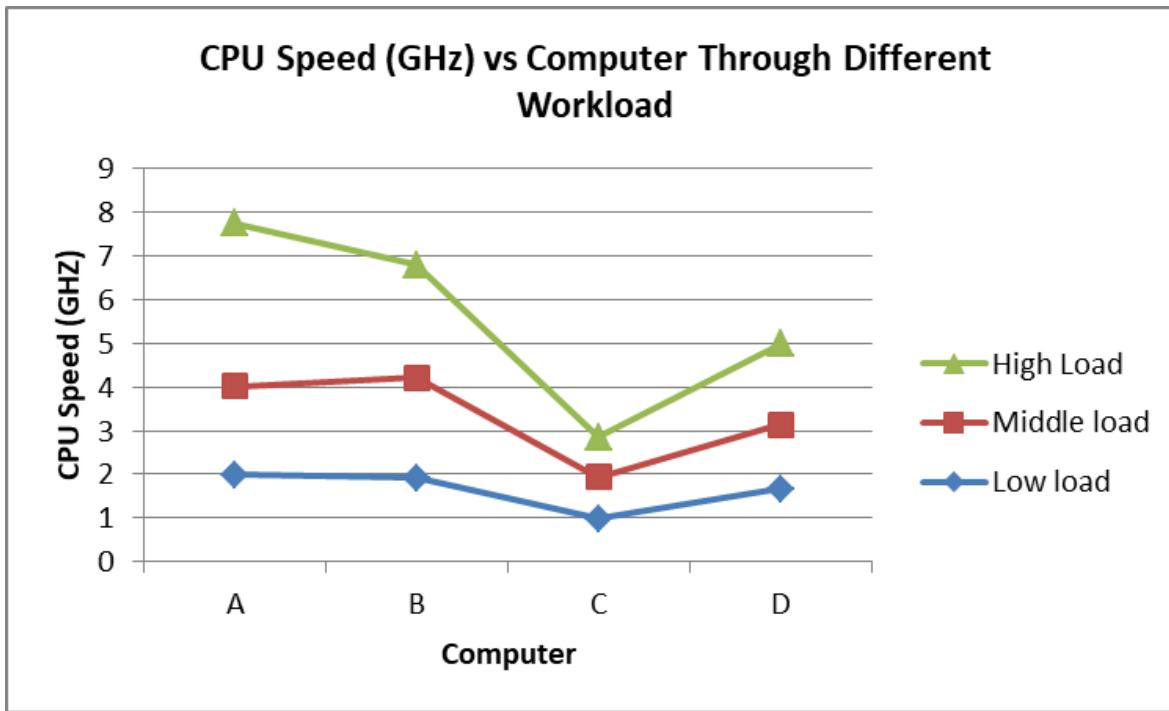


Diagram 3 : Comparison on 4 computers between CPU Speed among three Different Loads using Task Manager tool

The chart above shows the comparison between CPU speed in GHz across four computers which is computer A, B, C, D under different workloads by using Task Manager tool. Under low load, CPU speeds are consistently low, ranging from 2 to 2.5 GHz across all computers. For middle load, the speeds of the CPU are relatively stable, shifting between 3 and 4 GHz across all computers. Under the high load, CPU speeds start at around 7.5 GHz for Computer A and decrease to about 3 GHz for Computer C, then increase to 5 GHz for Computer D. This indicates that high workloads significantly affect CPU speed variations, while middle and low workloads show more consistent performance across different computers. This shows that as the stage of workload increases, the CPU's performance diminishes, likely due to resource constraints.

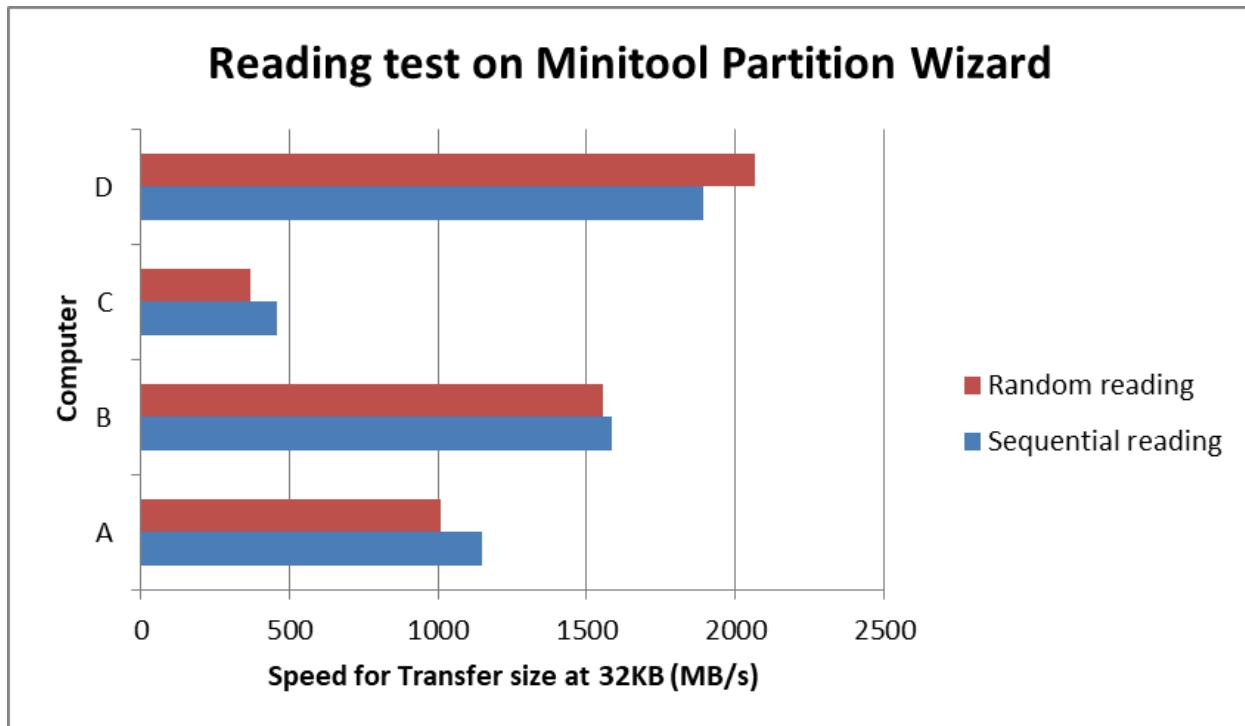


Diagram 4 : Comparison 4 computers in reading test transfer size using Minitool Partition Wizard

Based on the bar chart in Figure shown above, it is clear that Computer D leads in both random and sequential reading speeds where Computer D demonstrates the highest performance, with random reading speeds approaching 2000 MB/s and sequential reading speeds just under 2000 MB/s. As it is highly efficient at both types of reading operations, making it well-suited for tasks that require rapid data access and processing. While Computer B shows similar performance for both reading types, with speeds around 1500 MB/s. This shows that it can handle intensive data operations fairly well, though not quite as efficiently as Computer D. On the other hand, Computer A has moderate performance, with random reading around 500 MB/s and sequential reading at 750 MB/s. This makes Computer A less ideal for tasks that require high-speed data reading but acceptable for moderate use. Lastly, Computer C exhibits the lowest performance, with random reading around 500 MB/s and sequential reading slightly higher, near 750 MB/s. This shows that Computer C is least efficient at handling data read operations, making it suitable only for basic tasks that do not require high-speed data access.

PART 2 : Writing ASM code program for Benchmarking Software

Equation Y and loop:

```
mov ECX, N
mov EBX, N
mov sum, 0
math_loop : mov EAX, coef1 ; Calculate (9* x^3)
    call Delay
    mul EBX
    mul EBX
    mul EBX
    ADD sum, EAX

    mov EAX, coef2 ; Calculate (10* x^2)
    call Delay
    mul EBX
    mul EBX
    ADD sum, EAX

    mov EAX, coef3 ; Calculate (12* x)
    call Delay
    mul EBX
    ADD sum, EAX

    mov EAX, coef4 ; Calculate coef4
    ADD sum, EAX
LOOP math_LOOP
```

Diagram 5 : ASM code of algorithm y equation and loop used

Output from the program:

N = 50

```
C:\Users\Owner\Documents\l x + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = 9*x^3 + 10*x^2 + 12*x + 28
    (with delay coef1, coef2, coef3, coef4 = 12,9,10,28 msec)

Enter Number of looping (N) = 50

CPU time Stress Test in Progress...

Result:

First Capture Execution time in milisecond: 3146240
Second Capture Execution time in milisecond: 3148568
Different Execution time in milisecond: 2328
Value of Sum from the Stress Test (polynomial) = 57531400

Press 'y' to continue or 'n' to exit the benchmark : |
```

Diagram 6 : Output when N=50

N = 100

```
C:\Users\Owner\Documents\l + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = 9*x^3 + 10*x^2 + 12*x + 28
(with delay coef1, coef2, coef3, coef4 = 12,9,10,28 msec)

Enter Number of looping (N) = 100

CPU time Stress Test in Progress...

Result:

First Capture Execution time in milisecond: 3183845
Second Capture Execution time in milisecond: 3188498
Different Execution time in milisecond: 4653
Value of Sum from the Stress Test (polynomial) = 910122800

Press 'y' to continue or 'n' to exit the benchmark : |
```

Diagram 7 : Output when N=100

N = 200

```
C:\Users\Owner\Documents\l + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = 9*x^3 + 10*x^2 + 12*x + 28
(with delay coef1, coef2, coef3, coef4 = 12,9,10,28 msec)

Enter Number of looping (N) = 200

CPU time Stress Test in Progress...

Result:

First Capture Execution time in milisecond: 3214058
Second Capture Execution time in milisecond: 3223396
Different Execution time in milisecond: 9338
Value of Sum from the Stress Test (polynomial) = 1595583712

Press 'y' to continue or 'n' to exit the benchmark : |
```

Diagram 8 : Output when N=200

N = 500

```
C:\Users\Owner\Documents\ + ▾
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = 9*x^3 + 10*x^2 + 12*x + 28
                                (with delay coef1, coef2, coef3, coef4 = 12,9,10,28 msec)

Enter Number of looping (N) = 500

CPU time Stress Test in Progress...

Result:

First Capture Execution time in milisecond: 3244410
Second Capture Execution time in milisecond: 3267694
Different Execution time in milisecond: 23284
Value of Sum from the Stress Test (polynomial) = 1112298224

Press 'y' to continue or 'n' to exit the benchmark : |
```

Diagram 9 : Output when N=500

N = 700

```
C:\Users\Owner\Documents\ + ▾
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = 9*x^3 + 10*x^2 + 12*x + 28
                                (with delay coef1, coef2, coef3, coef4 = 12,9,10,28 msec)

Enter Number of looping (N) = 700

CPU time Stress Test in Progress...

Result:

First Capture Execution time in milisecond: 3330478
Second Capture Execution time in milisecond: 3363106
Different Execution time in milisecond: 32628
Value of Sum from the Stress Test (polynomial) = 3967349712

Press 'y' to continue or 'n' to exit the benchmark : |
```

Diagram 10 : Output when N=700

N = 1000

```
C:\Users\Owner\Documents\l + ~
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = 9*x^3 + 10*x^2 + 12*x + 28
(with delay coef1, coef2, coef3, coef4 = 12,9,10,28 msec)
Enter Number of looping (N) = 1000
CPU time Stress Test in Progress...
Result:
First Capture Execution time in milisecond: 3407707
Second Capture Execution time in milisecond: 3454304
Different Execution time in milisecond: 46597
Value of Sum from the Stress Test (polynomial) = 3465608288
Press 'y' to continue or 'n' to exit the benchmark : |
```

Diagram 11 : Output when N=1000

No of Loop (N)	Capture_msec (before)	Capture_msec (after)	CPU_msec (different)
50	3146240	3148568	2328
100	3183845	3188498	4653
200	3214058	3223396	9338
500	3244410	3267694	23284
700	3330478	3363106	32628
1000	3407707	3454304	46597

Table 6 : CPU Elapse Time Comparison Table

5. Conclusion

To conclude, this project aimed to deepen the understanding of CPU benchmarking principles and compare the performance between different CPUs by using different benchmarking tools. The analysis covered four laptops with different specifications which are Asus TUF Gaming A15, HP Laptop 15s-eq1xxx, HP Elitebook 840 G4 and Lenovo IdeaPad Slim 5 16IAH8. The benchmarking tools like CPU-Z, Geekbench, Task Manager and MiniTool Partition Wizard were used to analyze the performance of the CPUs under different workloads. The results highlighted the strengths and weaknesses of each CPU and also provided insights into their efficiency in single-core and multi-core tasks, as well as their performance under various load conditions. The study demonstrated that higher transfer sizes generally agree to state that the CPU has a better performance and multitasking capabilities were more prominent in CPUs with higher counts. Overall, this project provided a comprehensive evaluation of the CPU performance across different systems, emphasizing the importance of benchmarking in understanding and optimizing computer hardware performance.

6. Reflection

6.1 Nurul Ika Syafiny

From this project, in part one, the benchmarking test was done to my computer using multiple applications. I had learned multiple ways of benchmarking, the software we can use for it and how it was done. I can see how my computer works and its performance as well as comparing it with the others. Besides, I also learned how to read the results of benchmarking. I am sure these will help me in the future when it's time for me to buy a new computer since I can understand all the computer specifications better. In part 2, I gained more understanding of ASM code by making the code for getting the execution time with my teammates. This improves my skills in ASM language and introduces me to new functions available in this language. To conclude, this project has given me a lot of new information and knowledge about the computer world that will likely be needed in future.

6.2 Lubna Al Haani

During the execution of this project, I have learned many things about benchmarking, especially the principles of CPU benchmarking. I also understand and learn more about my computer's specifications through the benchmark results by learning to use the benchmark tools. When I compared our computer's specifications, I realized how different specifications with different limited workload capacity manage its system for stability and smoothness. In part 2 of the project, I have improved my ASM coding skills while coding for the CPU benchmark with my group members. I also understand ASM code more from the Irvine Library and from the real experience of running the CPU

benchmarking using our own ASM code. In conclusion, this project helps me gain new experience and more knowledge in the field of computer science, particularly in the technology benchmarking process that will be useful for my career in the future.

6.3 Nuraisyah

Throughout the completion of this project, I have learned a lot about internal computer components. I not only get to use new benchmarking tools but also get to know a deeper understanding on what and functionality of each benchmarking tool. I also got to learn how to read charts from the result produced by the benchmarking test. Besides, I not only get to know my laptop but also get to compare the functionality of my laptop with my group members where I get to see each specification that affects different performance of every laptop. I also get to learn new things through the completion of the ASM code where I get more understanding to write it using Irvine Library using Visual Studio 2019. To conclude, this new experience allow me getting deeper in Computer Science world where it never fail to amaze me with the new technology that keep on evolving.

6.4 Nur Firzana

In this project, I learnt how to do the benchmarking CPU by using different tools. Participating in this CPU benchmarking project has been enriching my experience that deepened my knowledge and understanding of evaluation and optimizing computer hardware performance. Working with various benchmarking tools also enhanced my practical skills and technical knowledge. I also learnt from ASM code using Irvine Library that we can do the CPU benchmarking. This hands-on experience bridges the gap between theoretical knowledge and real-world application which can make my studies more relevant. To sum up, the project has been extremely useful in equipping me with the skills and knowledge necessary for further exploration in the future.

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