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## FACULTY OF COMPUTING

### SEMESTER 2 2023/2024

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**SECR1033 COMPUTER ORGANIZATION AND ARCHITECTURE**

**SECTION 02**

**PROJECT**

**LECTURER: DR. FARKHANA BINTI MUCHTAR**

<b>Student Name</b>	<b>Matric No.</b>
GOE JIE YING	A23CS0224
POH LOK YEE	A23CS0262
TEH RU QIAN	A23CS0191
WOO CHENG SHUAN	A23CS0283

Demo for Benchmarking of CPU: <https://youtu.be/vqxDLZQwk7s>

Demo for Assembly Code: <https://www.youtube.com/watch?v=3zhElhMeJ4M>

Video Presentation: [https://youtu.be/tP13-s\\_ugRM](https://youtu.be/tP13-s_ugRM)

## Table of Contents

<b>1.0 Introduction</b>	<b>3</b>
1.1 Problem Background	3
1.2 Aim	3
1.3 Objective	4
1.4 Scopes (Computer Specification & Benchmarking Tools Features)	4
<b>2.0 Project - Part 1</b>	<b>6</b>
2.1 Overview	6
2.2 Flowchart of Projects	6
2.3 Benchmarking Results	7
2.4 Analysis, Comparison, Discussion	13
<b>3.0 Project - Part 2</b>	<b>23</b>
3.1 Overview	23
3.2 Flowchart of Execution	24
3.3 Coding and Implementation	25
3.4 Execution and Results	29
3.5 Analysis, Comparison, Discussion	33
<b>4.0 Conclusion and Reflection</b>	<b>37</b>
4.1 Conclusion	37
4.2 Reflection	38
<b>References</b>	<b>39</b>
<b>Appendices</b>	<b>39</b>

# **1.0 Introduction**

## **1.1 Problem Background**

Benchmarking in computing is the process of evaluating and comparing the performance of different systems, particularly central processing units (CPUs), by running a series of standardized tests and experiments. These tests evaluate the processing speed, efficiency, and capabilities then produce a result that gives a standardized reference for users to compare different processors, allowing them to make informed decisions on the hardware best suited for their needs.

CPU benchmarks are divided into three types: synthetic, real-world, and application benchmarks. Synthetic benchmarks analyze a processor's performance using theoretical workloads generated to stress-test specific components. This targeted testing encourages a deeper understanding and optimization in specialized aspects such as arithmetic operations, graphics rendering, or memory read/write speeds. Real-world benchmarks simulate everyday scenarios and tasks that actual users frequently encounter, providing a more relatable performance baseline that accurately reflects end-user experiences. Application benchmarks measure performance using actual software applications that users run, such as web browsers, office suites, or video editing programs. It provides performance metrics based on the use of real applications, reflecting how well a CPU can handle specific tasks or software.

This project consists of two parts: Part 1 involves students investigating benchmark tools and Part 2 involves using an undefined assembly to measure mathematical equations. We have selected four compatible benchmark tools, and choose four different Windows OS-running computers to run benchmarking tests on each. All the data will be summarized for comparison as to improve the understanding of performance differences between the systems.

## **1.2 Aim**

The main purpose of this group project is to compare the results of benchmarking four different PCs using various benchmarking programs. We'll also run a basic Assembly program on four separate computers and utilize functions to determine the difference in CPU running time between them.

## 1.3 Objective

- CPU-Z, Geekbench, Task Manager and MiniTool Partition Wizard are used as benchmarking tools to compare four different computers.
- Analyze and compare the benchmarking results to learn about CPU's strengths and weaknesses in various computing tasks.
- Run the same assembly programme on four different computers and examine its efficiency in terms of CPU time to obtain and CPU elapsed time.

## 1.4 Scopes (Computer Specification & Benchmarking Tools Features)

The computers being benchmarked include the HP Pavilion, Asus Vivobook, Lenovo Ideapad Slim3 and DELL Inspiron 3505.

Specifications	Computer Type			
	HP Pavilion	Asus Vivobook	Lenovo Ideapad Slim3	DELL Inspiron 3505
Processor Type	Intel Core i5	Intel Core i5 1035G1	Intel Core i5 1235U	AMD Ryzen 5 Mobile 3500U
RAM Size	8 GBytes	12 GBytes	16 GBytes	8 GBytes
Cache Type	L1 ×8, L2 ×4, L3 ×1	L1 ×8, L2 ×4, L3 ×1	L1 ×12, L2 ×1, L3 ×1	L1 ×8, L2 ×4, L3 ×1
Memory Type	DDR4	DDR4	DDR4	DDR4
Motherboard	HP-8987	ASUSTeK COMPUTER INC.-X509JP	LENOVO-LNVN B161216	Dell Inc.
Single-Core Score	1797	1178	2021	547
Multi-Core Score	5124	2710	6057	2432

In this project, we use CPU-Z, Geekbench, MiniTool Partition Wizard and Task Manager to benchmark the computers.

1. **CPU-Z:** This is a widely-used utility software that provides comprehensive information about a computer system's hardware components. While it primarily focuses on the

CPU(Central Processing Unit), it also offers insights into other system elements, including:

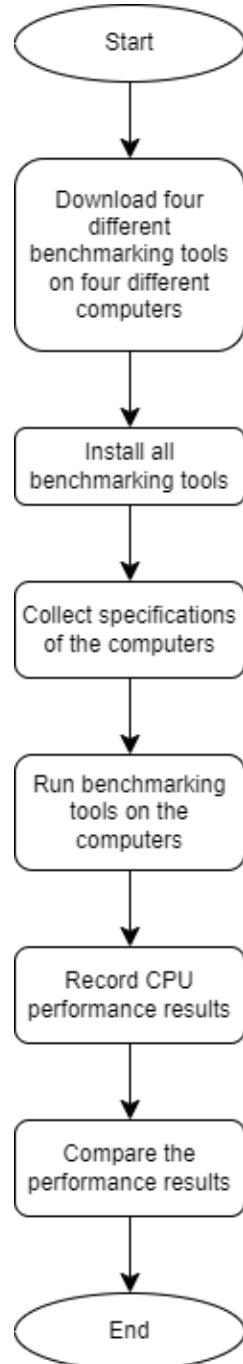
- Processor name and number, codename, manufacturing process, package and cache levels.
  - Mainboard and chipset details.
  - Memory type, size, timings and module specifications (SPD).
  - Real-time measurements of each core's internal frequency and memory frequency.
  - CPU-Z is fully supported on Windows® 11.
2. **Geekbench**: This is a cross-platform benchmarking tool designed to measure a computer's performance. It provides a detailed performance analysis by:
- Evaluating both single-core and multi-core performance.
  - Running a variety of tests that simulate real-world tasks and applications to measure processing power.
  - Offering insights into both CPU and GPU performance.
  - Providing scores that can be compared across different devices and operating systems.
3. **Task Manager**: This built-in Windows utility is used to monitor and manage computer performance and system resources. It offers features such as:
- Displaying real-time data on CPU, memory, disk and network usage.
  - Providing insights into running processes and applications, allowing users to identify resource-intensive tasks.
  - Offering detailed performance graphs for each component.
  - Allowing users to manage startup programs and services to optimize performance.
4. **MiniTool Partition Wizard**: It is a user-friendly tool for managing disk partitions on computers, helping users organize and optimize their storage effectively. It offers features such as:
- Handling tasks like creating, resizing and deleting partitions, converting disk types and recovering lost partitions.
  - Copying disks, aligning partitions for SSDs and checking file system integrity.
  - Optimizing disk space usage and managing startup programs and services.
  - Providing visual disk usage representation and real-time disk activity monitoring.

## 2.0 Project - Part 1

### 2.1 Overview

To investigate the performance of four CPUs and make an analysis to the performance data and make a comparison to the four CPUs.

### 2.2 Flowchart of Projects



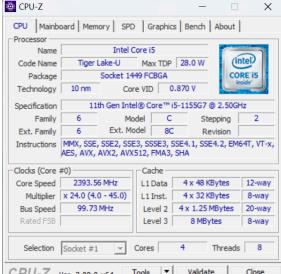
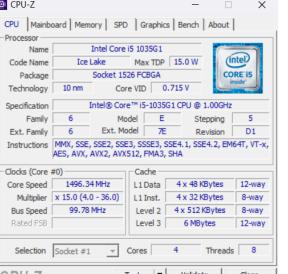
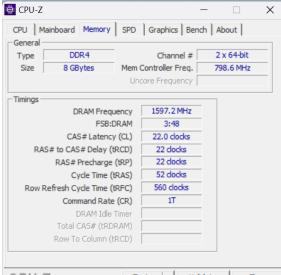
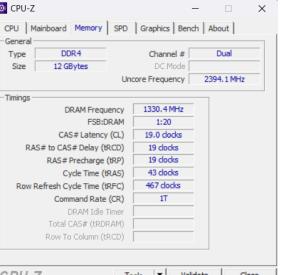
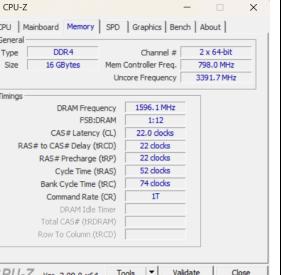
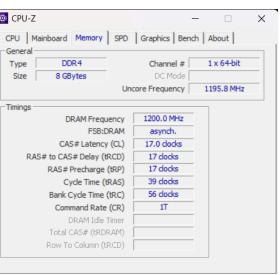
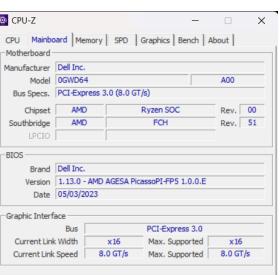
## 2.3 Benchmarking Results

Here is the computer specification collected by **CPU-Z**, **Geekbeech**, **Task Manager** and **MiniTool Partition Wizard**.

Specifications	Computer Type			
	HP Pavilion	Asus Vivobook	Lenovo Ideapad Slim3	DELL Inspiron 3505
<b>CPU</b>				
CPU model	Intel Core i5	Intel Core i5 1035G1	Intel Core i5 1235U	AMD Ryzen 5 Mobile 3500U
Single core speed (Clock Frequency)	2393.56 MHz	1496.34 MHz	3790.73 MHz	1394.79 MHz
Number of core	4	4	2P + 8E	4
Number of threads	8	8	12	8
Thermal Design Power (TDP)	28.0W	15.0W	15.0W	15.0W
<b>Motherboard</b>				
Bus Specification	PCI-Express 3.0	PCI-Express 3.0	PCI-Express 4.0	PCI-Express 3.0
Transfer Rate	8.0 GT/s	8.0 GT/s	16.0 GT/s	8.0 GT/s
<b>Cache</b>				
L1 Data	48.0 KB x 4	48.0 KB x 4	48.0 KB x 6	64.0 KB x 4
L1 Instruction	32.0 KB x 4	32.0KB x 4	32.0 KB x 6	32.0 KB x 4
L2	1.25 MB x 4	512 KB x 4	6.50 MB x 1	512 KB x 4
L3	8.00 MB x 1	6.00 MB x 1	12.0 MB x 1	4.00 MB x 1

Memory				
Type	DDR4	DDR4	DDR4	DDR4
Maximum Bandwidth	1597.2 MHz	1330.4 MHz	1596.1 MHz	1200.0 MHz
Size	8 GB	12 GB	16 GB	8 GB
Transfer rate	3192 MT/s	2128 MT/s	3192 MT/s	2400 MT/s
Sequential Read (MB/s)				
4KB	513.776MB/s	591.085MB/s	521.682MB/s	676.34MB/s
8KB	468.815MB/s	640.066MB/s	431.861MB/s	580.443MB/s
16KB	584.987MB/s	1361.07MB/s	474.966MB/s	585.583MB/s
32KB	711.241MB/s	1273.69MB/s	743.8MB/s	872.585MB/s
Sequential Write (MB/s)				
4KB	408.688MB/s	500.778MB/s	386.407MB/s	474.573MB/s
8KB	742.935MB/s	925.145MB/s	625.527MB/s	221.739MB/s
16KB	603.28MB/s	1217.92MB/s	1066.25MB/s	254.455MB/s
32KB	1050.86MB/s	1350.3MB/s	1063.79MB/s	240.206MB/s
Random Read (MB/s)				
4KB	529.763MB/s	598.296MB/s	488.898MB/s	616.058MB/s
8KB	387.08MB/s	932.316MB/s	374.888MB/s	553.815MB/s
16KB	431.207MB/s	1309.43MB/s	427.725MB/s	770.086MB/s
32KB	642.757MB/s	1412.11MB/s	636.938MB/s	1137.67MB/s
Random Write (MB/s)				
4KB	370.979MB/s	406.565MB/s	306.185MB/s	472.737MB/s
8KB	629.669MB/s	889.453MB/s	558.519MB/s	236.685MB/s
16KB	1121.8MB/s	1336.06MB/s	1013.85MB/s	638.949MB/s
32KB	413.687MB/s	1384.74MB/s	843.877MB/s	751.254MB/s

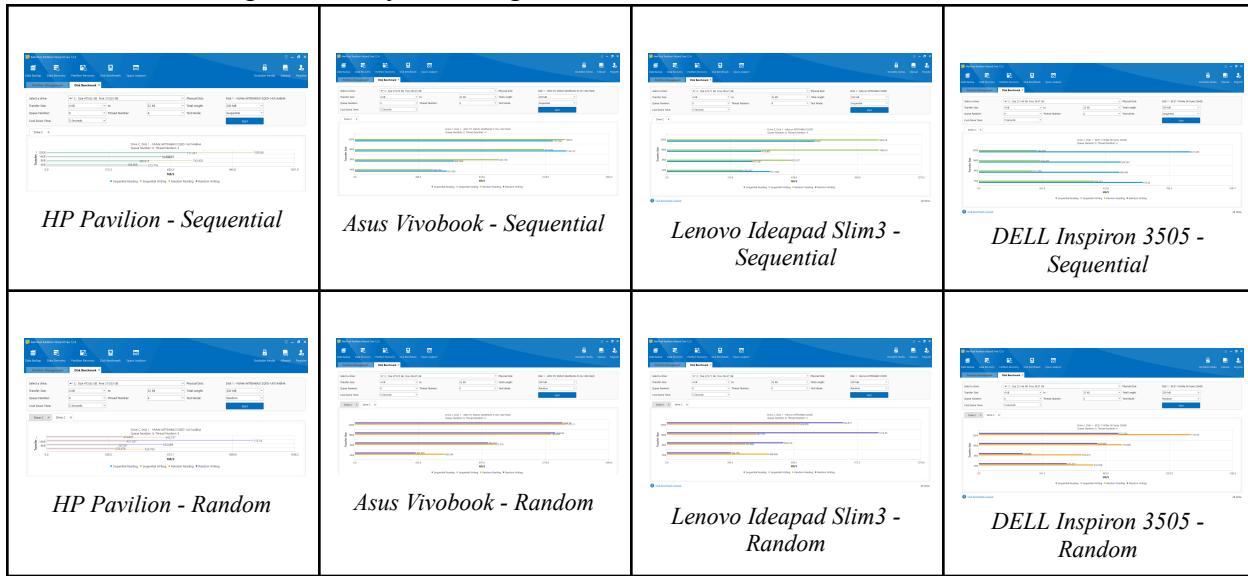
Below are the computers analyzed using CPU-Z

 <p><b>HP Pavilion - CPU</b></p>	 <p><b>Asus Vivobook - CPU</b></p>	 <p><b>Lenovo Ideapad Slim3 - CPU</b></p>	 <p><b>DELL Inspiron 3505 - CPU</b></p>
 <p><b>HP Pavilion - Memory</b></p>	 <p><b>Asus Vivobook - Memory</b></p>	 <p><b>Lenovo Ideapad Slim3 - Memory</b></p>	 <p><b>DELL Inspiron 3505 - Memory</b></p>
 <p><b>HP Pavilion - Mainboard</b></p>	 <p><b>Asus Vivobook - Mainboard</b></p>	 <p><b>Lenovo Ideapad Slim3 - Mainboard</b></p>	 <p><b>DELL Inspiron 3505 - Mainboard</b></p>

## Below are the computers analyzed using Geekbench

<p><b>CPU Information</b></p> <table border="1"> <tbody> <tr><td>Name</td><td>Intel Core i5-11500T</td></tr> <tr><td>Topology</td><td>1 Processor, 4 Cores, 8 Threads</td></tr> <tr><td>Identifier</td><td>GenuineIntel Family 6 Model 140 Stepping 2</td></tr> <tr><td>Base Frequency</td><td>2.50 GHz</td></tr> <tr><td>Cluster 1</td><td>4 Cores</td></tr> <tr><td>Maximum Frequency</td><td>4692 MHz</td></tr> <tr><td>Package</td><td>Socket 1440 FCBGA</td></tr> <tr><td>Codename</td><td>Tiger Lake-U</td></tr> <tr><td>L1 Instruction Cache</td><td>32.0 KB x 4</td></tr> <tr><td>L1 Data Cache</td><td>48.0 KB x 4</td></tr> <tr><td>L2 Cache</td><td>1.25 MB x 4</td></tr> <tr><td>L3 Cache</td><td>8.00 MB x 1</td></tr> </tbody> </table>	Name	Intel Core i5-11500T	Topology	1 Processor, 4 Cores, 8 Threads	Identifier	GenuineIntel Family 6 Model 140 Stepping 2	Base Frequency	2.50 GHz	Cluster 1	4 Cores	Maximum Frequency	4692 MHz	Package	Socket 1440 FCBGA	Codename	Tiger Lake-U	L1 Instruction Cache	32.0 KB x 4	L1 Data Cache	48.0 KB x 4	L2 Cache	1.25 MB x 4	L3 Cache	8.00 MB x 1	<p><b>CPU Information</b></p> <table border="1"> <tbody> <tr><td>Name</td><td>Intel Core i5-10501</td></tr> <tr><td>Topology</td><td>1 Processor, 4 Cores, 8 Threads</td></tr> <tr><td>Identifier</td><td>GenuineIntel Family 6 Model 126 Stepping 5</td></tr> <tr><td>Base Frequency</td><td>1.20 GHz</td></tr> <tr><td>Cluster 1</td><td>4 Cores</td></tr> <tr><td>Maximum Frequency</td><td>3592 MHz</td></tr> <tr><td>Package</td><td>Socket 1208 FCBGA</td></tr> <tr><td>Codename</td><td>Ice Lake</td></tr> <tr><td>L1 Instruction Cache</td><td>32.0 KB x 4</td></tr> <tr><td>L1 Data Cache</td><td>48.0 KB x 4</td></tr> <tr><td>L2 Cache</td><td>912 KB x 4</td></tr> <tr><td>L3 Cache</td><td>6.00 MB x 1</td></tr> </tbody> </table>	Name	Intel Core i5-10501	Topology	1 Processor, 4 Cores, 8 Threads	Identifier	GenuineIntel Family 6 Model 126 Stepping 5	Base Frequency	1.20 GHz	Cluster 1	4 Cores	Maximum Frequency	3592 MHz	Package	Socket 1208 FCBGA	Codename	Ice Lake	L1 Instruction Cache	32.0 KB x 4	L1 Data Cache	48.0 KB x 4	L2 Cache	912 KB x 4	L3 Cache	6.00 MB x 1	<p><b>CPU Information</b></p> <table border="1"> <tbody> <tr><td>Name</td><td>Intel Core i5-1239U</td></tr> <tr><td>Topology</td><td>1 Processor, 10 Cores, 12 Threads</td></tr> <tr><td>Identifier</td><td>GenuineIntel Family 6 Model 154 Stepping 4</td></tr> <tr><td>Base Frequency</td><td>2.49 GHz</td></tr> <tr><td>Cluster 1</td><td>2 Cores</td></tr> <tr><td>Cluster 2</td><td>8 Cores</td></tr> <tr><td>Maximum Frequency</td><td>4399 MHz</td></tr> <tr><td>Package</td><td>Socket T744 FCBGA</td></tr> <tr><td>Codename</td><td>Alder Lake</td></tr> <tr><td>L1 Instruction Cache</td><td>32.0 KB x 6</td></tr> <tr><td>L1 Data Cache</td><td>48.0 KB x 6</td></tr> <tr><td>L2 Cache</td><td>1.25 MB x 1</td></tr> <tr><td>L3 Cache</td><td>12.0 MB x 1</td></tr> </tbody> </table>	Name	Intel Core i5-1239U	Topology	1 Processor, 10 Cores, 12 Threads	Identifier	GenuineIntel Family 6 Model 154 Stepping 4	Base Frequency	2.49 GHz	Cluster 1	2 Cores	Cluster 2	8 Cores	Maximum Frequency	4399 MHz	Package	Socket T744 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	<p><b>CPU Information</b></p> <table border="1"> <tbody> <tr><td>Name</td><td>AMD Ryzen 5 3600U</td></tr> <tr><td>Topology</td><td>1 Processor, 4 Cores, 8 Threads</td></tr> <tr><td>Identifier</td><td>AuthentM&amp;D Family 23 Model 24 Stepping 1</td></tr> <tr><td>Base Frequency</td><td>2.10 GHz</td></tr> <tr><td>Cluster 1</td><td>4 Cores</td></tr> <tr><td>Maximum Frequency</td><td>3802 MHz</td></tr> <tr><td>Package</td><td>Socket EFS</td></tr> <tr><td>Codename</td><td>Pisces</td></tr> <tr><td>L1 Instruction Cache</td><td>64.0 KB x 4</td></tr> <tr><td>L1 Data Cache</td><td>32.0 KB x 4</td></tr> <tr><td>L2 Cache</td><td>512 KB x 4</td></tr> <tr><td>L3 Cache</td><td>4.00 MB x 1</td></tr> </tbody> </table>	Name	AMD Ryzen 5 3600U	Topology	1 Processor, 4 Cores, 8 Threads	Identifier	AuthentM&D Family 23 Model 24 Stepping 1	Base Frequency	2.10 GHz	Cluster 1	4 Cores	Maximum Frequency	3802 MHz	Package	Socket EFS	Codename	Pisces	L1 Instruction Cache	64.0 KB x 4	L1 Data Cache	32.0 KB x 4	L2 Cache	512 KB x 4	L3 Cache	4.00 MB x 1																																														
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Below are the computers analyzed using **MiniTool Partition Wizard**



Here is the computer specification collected by the **Task Manager**.

Specifications	Load Level	Computer Type			
		HP Pavilion	Asus Vivobook	Lenovo Ideapad Slim3	DELL Inspiron 3505
Avg CPU Usage (%)	Low	16%	24%	12%	28%
	Middle	8%	10%	11%	72%
	High	15%	22%	27%	28%
Memory Usage (%)	Low	74%	50%	47%	68%
	Middle	80%	65%	58%	68%
	High	92%	84%	70%	82%
Disk Usage(%)	Low	1%	4%	3%	21%
	Middle	1%	1%	2%	3%
	High	2%	4%	4%	2%
Network Usage (%)	Low	0%	0%	0%	0%
	Middle	0%	0%	0%	1%
	High	0%	0%	0%	2%

Processes Running	Low	117	81	106	93
	Middle	124	84	107	109
	High	132	100	124	112

Below are the computers analyzed using Task Manager

 <b>HP Pavilion - Low load</b>	 <b>Asus Vivobook - Low load</b>	 <b>Lenovo Ideapad Slim3 - Low load</b>	 <b>DELL Inspiron 3505 - Low load</b>
 <b>HP Pavilion - Middle load</b>	 <b>Asus Vivobook - Middle load</b>	 <b>Lenovo Ideapad Slim3 - Middle load</b>	 <b>DELL Inspiron 3505 - Middle load</b>
 <b>HP Pavilion - High load</b>	 <b>Asus Vivobook - High load</b>	 <b>Lenovo Ideapad Slim3 - High load</b>	 <b>DELL Inspiron 3505 - High load</b>

## 2.4 Analysis, Comparison, Discussion

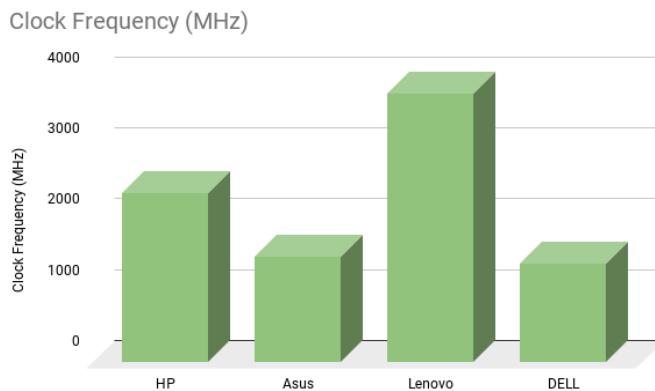
After running the benchmark test on four CPUs, we get the required performance data. Using obtained data, we can obtain detailed information about CPU performance.

### **CPU-Z**

#### **1. CPU Processor (Clock Speed)**

The clock speed, measured in megahertz (MHz), indicates how swiftly the processor can execute instructions. Generally, a higher clock speed suggests better performance in handling tasks. The HP Pavilion operates at 2393.56 MHz, the Asus Vivobook at 1496.34 MHz, the Lenovo Ideapad Slim3 at 3790.73 MHz, and the DELL Inspiron 3505 at 1394.79 MHz. From these specifications, we can see that the Lenovo Ideapad Slim3 has the highest clock speed among the four models.

Higher clock speeds typically correlate with faster task execution and enhanced overall performance. The Lenovo Ideapad Slim3's notable speed suggests it may have an advantage over the HP Pavilion, Asus Vivobook, and DELL Inspiron 3505 in raw processing power. However, it's important to note that clock speed alone doesn't fully reflect a computer's performance.



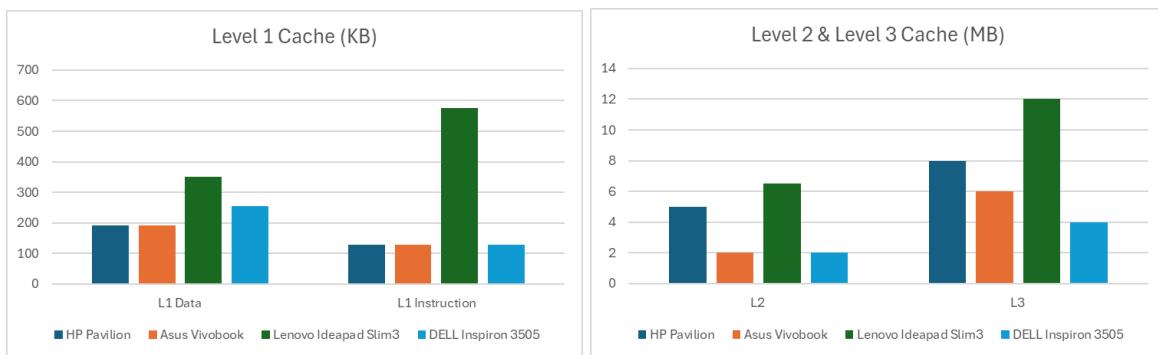
When comparing the number of cores and threads, the HP Pavilion, Asus Vivobook, and DELL Inspiron 3505 each feature 4 cores and 8 threads, providing a balanced setup for multitasking and parallel processing. In contrast, the Lenovo Ideapad Slim3 distinguishes itself with a hybrid architecture of 2 performance cores (P-cores) and 8 efficiency cores (E-cores), totaling 10 cores and 12 threads. This unique configuration enables the Lenovo Ideapad Slim3 to handle a variety of workloads more efficiently, optimizing performance for both single-threaded and multi-threaded applications.

Additionally, considering thermal design power (TDP), the HP Pavilion has a TDP of 28W, notably higher than the 15W TDP of the Asus Vivobook, Lenovo Ideapad Slim3,

and DELL Inspiron 3505. This higher TDP suggests that the HP Pavilion can manage more power, potentially offering better performance for demanding tasks but with increased energy consumption and heat output. Conversely, the lower TDP of the other laptops indicates better energy efficiency and potentially longer battery life, making them suitable for everyday tasks with lower power demands.

## 2. Cache

Cache memory is crucial in modern computer systems, acting as a high-speed buffer between the CPU and main memory. There are three levels of cache: Level 1 (L1), Level 2 (L2), and Level 3 (L3). L1 cache includes L1 Data Cache and L1 Instruction Cache, with L1 being the smallest and L3 the largest in size. From the bar chart below, we can clearly see that Lenovo Ideapad Slim3 leads significantly in all cache levels.



HP Pavilion and Asus Vivobook have identical L1 cache configurations (192 KB for data and 128 KB for instructions), while Lenovo Ideapad Slim3 features larger L1 caches at 352 KB for data and 576 KB for instructions. The DELL Inspiron 3505 has an L1 cache configuration of 256 KB for data and 128 KB for instructions, placing it between the HP Pavilion, Asus Vivobook and the Lenovo Ideapad Slim3 in terms of L1 cache size.

Lenovo Ideapad Slim3 have 6.5 MB total L2 cache, whereas HP Pavilion have 5 MB, Asus Vivobook and DELL Inspiron 3505 have 2 MB. A larger L2 cache size can provide advantages in handling larger datasets and more complex applications, potentially improving overall system performance.

Lenovo Ideapad Slim3 boasts the largest L3 Cache at 12 MB, compared to 8 MB in HP Pavilion, 6 MB in Asus Vivobook, and 4 MB in DELL Inspiron 3505. This larger L3 cache can further enhance performance in managing larger datasets and executing complex applications efficiently.

Overall, Lenovo Ideapad Slim3's superior cache configuration, including larger L1, L2, and L3 cache sizes compared to HP Pavilion, Asus Vivobook, and DELL Inspiron 3505,

ensures enhanced responsiveness, faster data processing, and superior performance across various computing tasks.

### **3. Memory**

Memory is a crucial component in laptops, impacting performance, especially in multitasking and running intensive applications. It includes parameters such as size, speed, channels, and CAS latency, which measures the delay before data transfer begins.

In terms of memory size, the Lenovo Ideapad Slim3 has the largest memory at 16 GB, followed by the Asus Vivobook with 12 GB, and the HP Pavilion and DELL Inspiron 3505 both with 8 GB. Larger memory sizes generally improve multitasking and the ability to run memory-intensive applications smoothly.

The HP Pavilion and Lenovo Ideapad Slim3 have similar DRAM frequencies (1597.2 MHz and 1596.1 MHz, respectively), which are higher than the DRAM frequency of the Asus Vivobook (1330.4 MHz) and the DELL Inspiron 3505 (1200 MHz). Higher DRAM frequencies can lead to better data transfer rates and overall performance.

The Asus Vivobook has a lower CAS latency (19 clocks) compared to the HP Pavilion and Lenovo Ideapad Slim3 (22 clocks), while the DELL Inspiron 3505 has the lowest CAS latency at 17 clocks. Lower CAS latency indicates faster access to memory data, potentially improving performance in latency-sensitive applications.

Overall, the Lenovo Ideapad Slim3 offers the best memory configuration with its larger size and higher frequencies for enhanced performance. The Asus Vivobook benefits from lower CAS latency and dual-channel configuration, while the DELL Inspiron 3505 offers the lowest CAS latency, and the HP Pavilion offers solid performance with a high DRAM frequency.

### **4. Motherboard**

The motherboard serves as the central hub connecting all internal components such as the memory, processor, graphics card, and other hardware, while also facilitating power distribution and enabling communication between these components.

Lenovo Ideapad Slim3 distinguishes itself with support for PCI-Express 4.0, boasting a theoretical data transfer rate of 16.0 GT/s, which surpasses the PCI-Express 3.0 (8.0 GT/s) utilized by HP Pavilion, Asus Vivobook, and DELL Inspiron 3505. This adoption of PCI-Express 4.0 not only offers higher bandwidth but also potential future-proofing for enhanced data transfer speeds.

The chipset selection in each laptop—Intel Tiger Lake for HP Pavilion, Ice Lake for Asus Vivobook, Alder Lake for Lenovo Ideapad Slim3, and AMD Ryzen SOC for DELL Inspiron 3505—significantly influences overall performance, system stability, compatibility, and feature support. These distinctions are tailored to meet various computing requirements, with Lenovo Ideapad Slim3 particularly notable for its advanced PCI-Express capability and chipset configuration, ensuring future-proofing and optimal performance.

## **GeekBench**

### **1. Add system info as complement /conformation to CPU-Z**

To understand each laptop's hardware configuration thoroughly, it's essential to merge system information with specific details from CPU-Z. Each laptop includes crucial components such as the processor (CPU), memory (RAM), cache memory, and chipset codename, all influencing performance and functionality.

For instance, the HP Pavilion is powered by an 11th Gen Intel Core i5-1155G7 processor with 8 GB of DDR4 RAM. This setup ensures strong performance for everyday computing and moderate multimedia tasks. CPU-Z verifies details about cache memory sizes tailored for the Tiger Lake chipset, optimizing data handling and processing efficiency.

In contrast, the ASUS Vivobook features an Intel Core i5-1035G1 processor and 12 GB of DDR4 RAM, enhancing multitasking capabilities and supporting smoother operation for resource-demanding applications. CPU-Z confirms cache configurations and system architecture specific to the Ice Lake platform, optimizing overall performance.

Meanwhile, the Lenovo Ideapad Slim3 is equipped with a 12th Gen Intel Core i5-1235U processor and 16 GB of DDR4 RAM, leveraging advancements in Alder Lake architecture for superior gaming and content creation performance. CPU-Z validation focuses on critical metrics like cache sizes, memory timings, and PCI-Express support, highlighting the laptop's advanced features and future-proofing potential.

The DELL Inspiron 3505 is powered by an AMD Ryzen 5 3500U processor with 8 GB of DDR4 RAM. This configuration provides a balanced performance for a range of tasks, from daily computing to more intensive applications. CPU-Z details reveal cache memory sizes and system architecture optimized for the AMD Ryzen SOC, ensuring efficient data handling and robust performance.

In summary, integrating system information with CPU-Z details provides a comprehensive overview of each laptop's hardware composition, including cache memory sizes, memory configurations, and chipset codenames (Tiger Lake, Ice Lake, Alder Lake, and AMD Ryzen SOC). This approach ensures precise comparisons and supports informed decisions based on individual computing requirements.

## 2. CPU test with variation of technique or method used, either single-core or multi-core performance

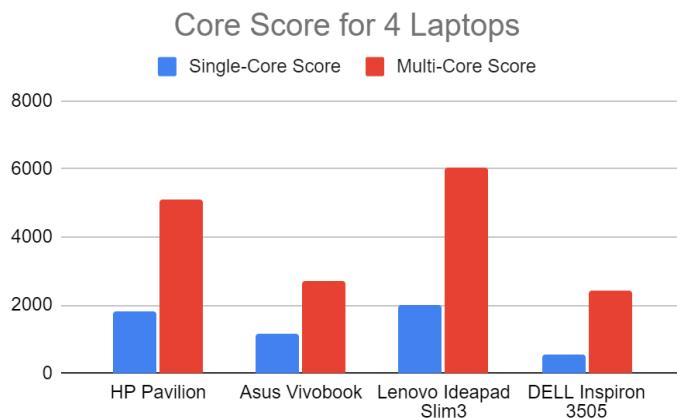
The Single-Core Score indicates how quickly a processor can execute instructions on a single core, which is essential for tasks that don't utilize multiple cores simultaneously. Higher scores indicate better performance in applications like web browsing and basic productivity software.

Conversely, the Multi-Core Score measures a processor's ability to handle multiple tasks across all its cores at the same time. Higher Multi-Core Scores indicate superior performance in tasks that can benefit from parallel processing, such as video editing and running multiple applications simultaneously.

The Lenovo Ideapad Slim3 leads with a Single-Core Score of 2021, followed by the HP Pavilion (1797), ASUS Vivobook (1176), and DELL Inspiron 3505 (547). This shows that Lenovo Ideapad Slim3 excels in tasks that heavily rely on single-core processing power.

For Multi-Core Score, the Lenovo Ideapad Slim3 also outperforms with a score of 6057, surpassing the HP Pavilion's 5124, ASUS Vivobook's 2710, and DELL Inspiron 3505's 2432. This highlights its capability in handling multi-threaded applications and tasks that benefit from parallel processing.

The bar chart below provides a clearer overview of the single-core and multi-core scores for the four laptops.

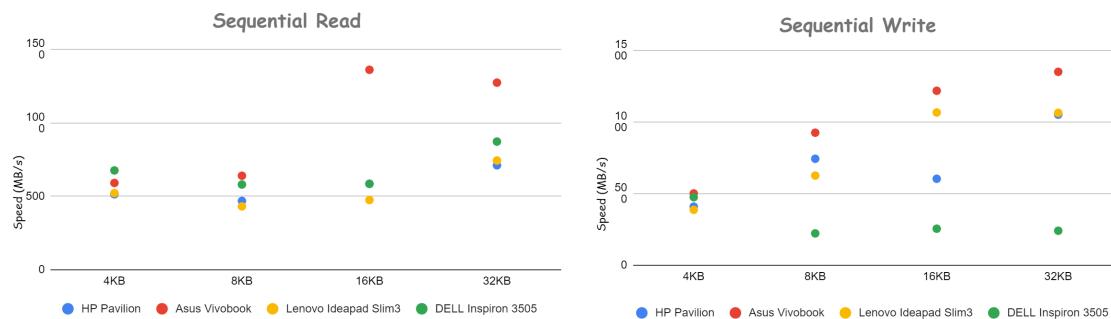


In summary, while the HP Pavilion, ASUS Vivobook, and DELL Inspiron 3505 offer competitive performance in their respective categories, the Lenovo Ideapad Slim3 stands out with superior single-core and multi-core performance, supported by its advanced hardware specifications and chipset design.

## **MiniTool Partition Wizard**

### **1. Sequential mode stress test**

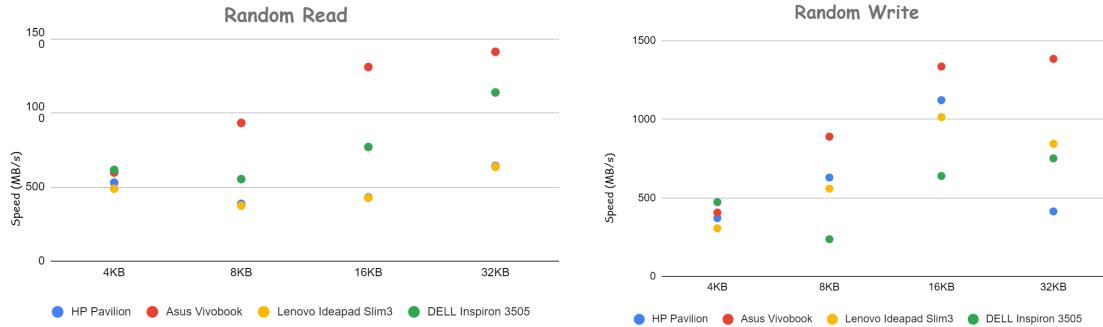
Based on the disk benchmarking results using MiniTool Partition Wizard, the HP Pavilion, ASUS Vivobook, Lenovo Ideapad Slim3 and Dell Inspiron 3505 show varying performance in sequential read and write operations. For sequential read speeds, the Dell Inspiron consistently outperformed the others across all block sizes, peaking at 1,273.69MB/s for 32KB. The ASUS Vivobook also showed strong performance, particularly at 16KB and 32KB block sizes, with speeds of 1,361.07MB/s and 1,273.69MB/s, respectively. The HP Pavilion and Lenovo Ideapad had lower but respectable read speeds. For sequential write speeds, the ASUS Vivobook again showed exceptional performance, especially at larger block sizes, with a peak of 1,350.3MB/s for 32KB. The HP Pavilion and Lenovo Ideapad had moderate write speeds, while the Dell Inspiron showed variable performance, particularly low at 16KB and 32KB block sizes. Overall, the ASUS Vivobook demonstrated the best sequential read and write performance, making it highly suitable for tasks requiring large continuous data transfers.



### **2. Random mode stress test**

In random read and write operations, the performance disparities among the HP Pavilion, ASUS Vivobook, Lenovo Ideapad Slim3 and Dell Inspiron 3505 are evident. For random reads speeds, the Dell Inspiron excelled, particularly at larger block sizes, reaching up to 1,412.11MB/s for 32KB. The ASUS Vivobook also performed well, especially at 16KB and 32KB, achieving 1,309.43MB/s and 1,412.11MB/s, respectively. The HP Pavilion and Lenovo Ideapad showed lower but consistent random read speeds. For random write speeds, the ASUS Vivobook and Dell Inspiron were the top performers. The Vivobook achieved its highest speed at 16KB with 1,336.06MB/s, while the Inspiron excelled at 32KB with 1,384.74MB/s. The HP Pavilion and Lenovo Ideapad had lower random write

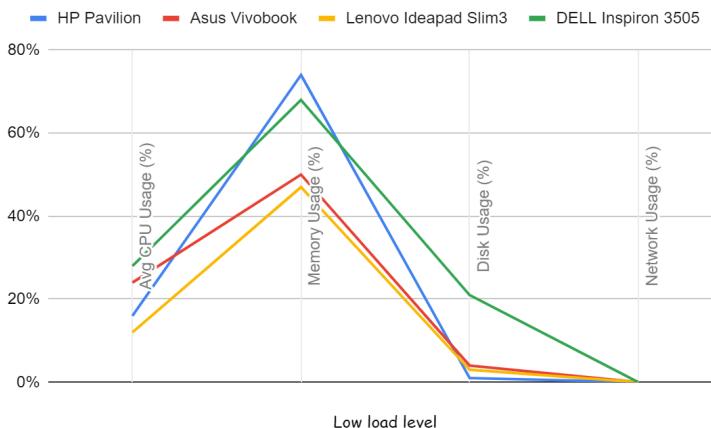
speeds, with the Pavilion showing a notable peak at 16KB. Overall, the ASUS Vivobook and Dell Inspiron demonstrated superior random read and write capabilities, making them ideal for tasks involving frequent small data transactions.



## Task Manager

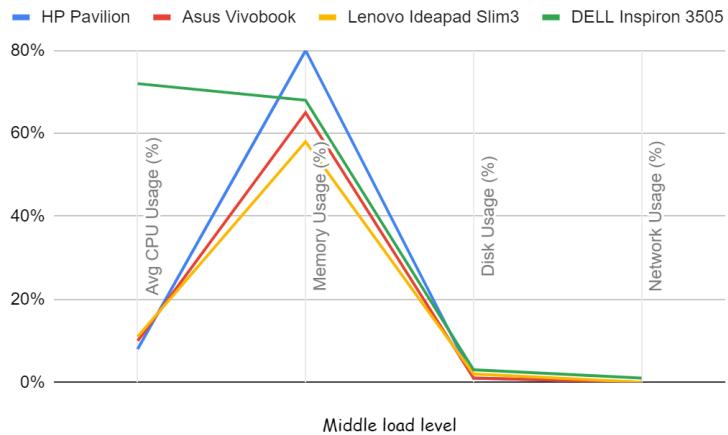
### 1. Low load testing

For low load conditions, which typically involve minimal system strain, we opened lightweight applications, including Microsoft Word for text editing, aiming for memory consumption between 30% to 50%. The HP Pavilion operated efficiently with a CPU usage of 16%, memory usage of 74%, disk usage of 1%, and no network usage. Similarly, the ASUS VivoBook showed a higher CPU usage of 24% but maintained a lower memory usage at 50%, with disk usage at 4% and network usage at 0%. The Lenovo IdeaPad Slim 3 demonstrated a balanced performance with 12% CPU usage, 47% memory usage, 3% disk usage, and no network activity. In contrast, the Dell Inspiron 3505 exhibited the highest CPU usage at 28%, with 68% memory usage, a notable 21% disk usage, and no network usage. Overall, all laptops managed the low load conditions without significant strain, but the Dell Inspiron 3505's high disk usage indicates it may be less efficient at handling background processes.



## 2. Middle load testing

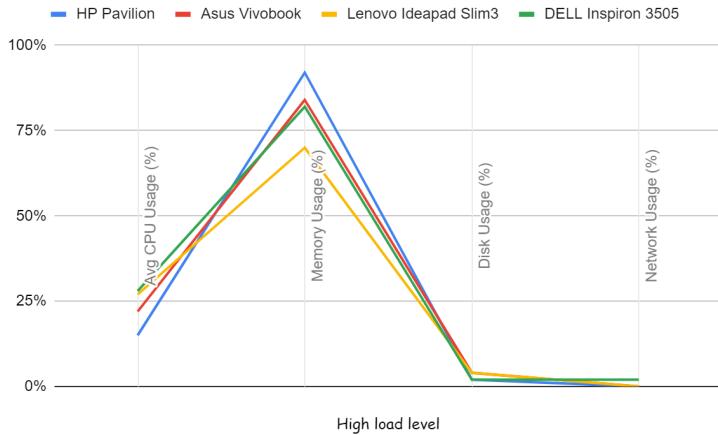
In the middle load scenario, designed to consume around 50% to 60% of memory, we opened multiple applications to increase the system demand. The HP Pavilion's performance showed a drop in CPU usage to 8%, with memory usage at 70%, disk usage remaining at 1%, and no network usage. The ASUS VivoBook had a CPU usage of 10%, with memory usage increasing to 65%, disk usage dropping to 1%, and no network usage. The Lenovo IdeaPad Slim 3 exhibited stable performance with 11% CPU usage, 58% memory usage, 2% disk usage, and no network activity. The Dell Inspiron 3505 displayed an unusual spike in CPU usage at 72%, with memory usage constant at 68%, disk usage at 3%, and 1% network usage. This indicates that while most laptops handled the middle load efficiently, the Dell Inspiron 3505 experienced a significant increase in CPU usage, suggesting potential optimization issues or hardware limitations.



## 3. High load testing

High load conditions were simulated by opening several resource-intensive applications, including development tools like Microsoft Visual Studio, CapCut and Google Chrome, aiming for memory usage above 70%. The HP Pavilion showed a rise in CPU usage to 15% and a substantial increase in memory usage to 92%, with disk usage at 2% and no network activity, indicating it struggled to manage the high load efficiently. The ASUS VivoBook displayed a balanced performance with 22% CPU usage, 84% memory usage, 4% disk usage, and no network usage, demonstrating its capability to handle heavy tasks. The Lenovo IdeaPad Slim 3 maintained a consistent performance with 27% CPU usage, 70% memory usage, 4% disk usage, and no network activity, showing it could manage high loads effectively. The Dell Inspiron 3505, when tested under high load with twelve applications, returned to a CPU usage of 28%, memory usage at 82%, 2% disk usage, and 2% network usage, indicating it managed to distribute resources better under higher loads. Overall, while all laptops exhibited increased resource usage under high load, the ASUS VivoBook and Lenovo IdeaPad Slim 3 showed balanced and efficient handling,

whereas the HP Pavilion and Dell Inspiron 3505 had more pronounced fluctuations in performance.



#### 4. Monitoring and analysis

Throughout these tests, the process and performance monitoring were conducted using Task Manager to record CPU, memory usage, disk usage and network usage.

For the low load testing phase, all laptops managed low-load conditions without significant strain. The HP Pavilion, ASUS VivoBook, and Lenovo IdeaPad Slim 3 maintained balanced CPU and memory usage, indicating their efficiency in handling basic tasks. However, the Dell Inspiron 3505 exhibited higher CPU and disk usage, suggesting it might be less efficient at managing background processes even under minimal load while under the middle load testing phase, the HP Pavilion and Lenovo IdeaPad Slim 3 continued to show stable performance with moderate increases in resource usage. The ASUS VivoBook also performed well, demonstrating an efficient balance between CPU and memory usage. In contrast, the Dell Inspiron 3505 experienced a significant spike in CPU usage, indicating potential optimization issues or hardware limitations that affect its ability to handle mid-range tasks efficiently. Lastly, the ASUS VivoBook and Lenovo IdeaPad Slim 3 showcased robust performance, handling multiple applications with efficient resource distribution in the high-load testing phase. The HP Pavilion struggled with high memory usage, indicating a limitation in handling heavy loads effectively. The Dell Inspiron 3505, despite its earlier spike in CPU usage under middle load, managed to distribute resources better under high load, but still showed signs of strain with increased memory and disk usage.

In conclusion, the benchmarking and performance analysis across these three systems highlighted their strengths and weaknesses under different load conditions. The ASUS VivoBook and Lenovo IdeaPad Slim 3 emerged as the most capable laptops across all load conditions, efficiently managing resources and maintaining balanced performance.

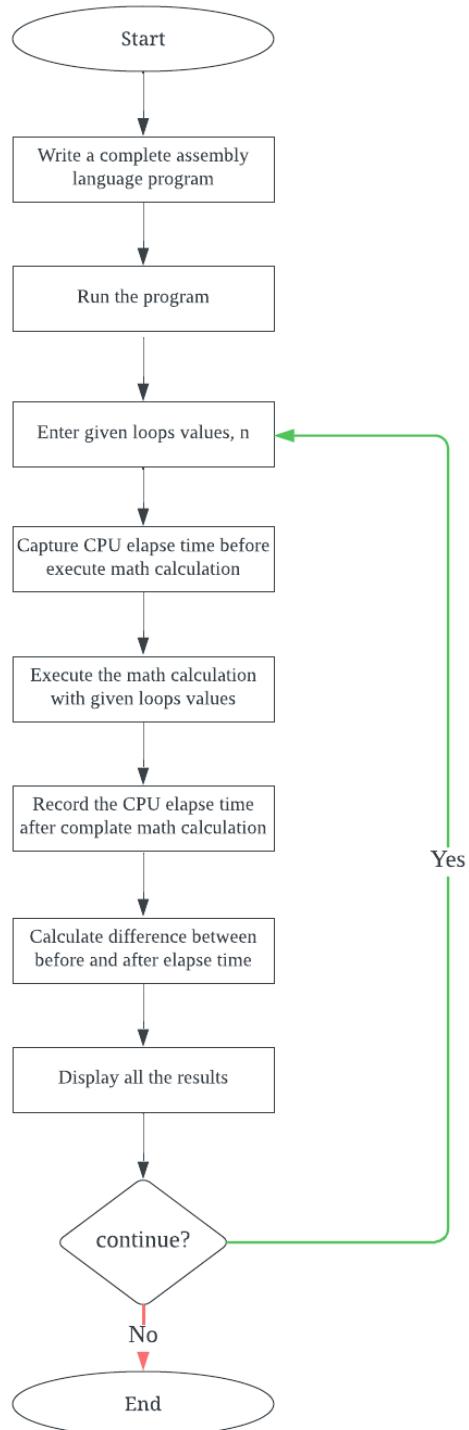
The HP Pavilion, while performing well under low and middle loads, showed limitations under high loads due to high memory usage. The Dell Inspiron 3505 demonstrated inconsistent performance, with significant CPU spikes under middle load but better resource management under high load. These findings highlight the importance of selecting laptops based on their ability to handle varying workloads, with the ASUS VivoBook and Lenovo IdeaPad Slim 3 being reliable choices for both light and intensive tasks.

## **3.0 Project - Part 2**

### 3.1 Overview

The second part of this project involves a detailed investigation of the CPU elapsed time of four different computer systems. The task requires writing an assembly language program to measure and compare the running times on each system. Initially, the program's running time is calculated theoretically using a polynomial equation. Afterward, the program is executed, and the actual elapsed time is recorded. This data is then used to evaluate the efficiency, speed, and capability of the CPUs in each system.

### 3.2 Flowchart of Execution



### 3.3 Coding and Implementation

```
TITLE Project COA
; Group member:
; 1. Goe Jie Ying
; 2. Poh Lok Yee
; 3. Teh Ru Qian
; 4. Woo Cheng Shuan
; Date: 23 June 2024

include Irvine32.inc
.data
    msgWelcome BYTE "Welcome to CPU Benchmark Program", 0dh, 0ah, 0
    msgAlgorithm BYTE "Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) +
(21*x) + 23", 0ah, 0dh
        BYTE "(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)", 0
    msgEnterN BYTE "Enter Number of Looping (N) = ", 0
    msgProgress BYTE "CPU time Stress Test in progress...", 0dh, 0ah, 0
    msgResult BYTE "Result: ", 0dh, 0ah, 0
    msgFirstCapture BYTE "First Capture Execution time in millisecond: ", 0
    msgSecondCapture BYTE "Second Capture Execution time in millisecond: ", 0
    msgDiffTime BYTE "Different Execution time in millisecond: ", 0
    msgSum BYTE "Value of Sum from the Stress Test (polynomial) = ", 0
    msgPrompt BYTE "Press 'y' to continue or 'n' to exit the benchmark: ", 0
    msgBye BYTE "Thank you ... BYE!!", 0dh, 0ah, 0

    coef1 DWORD 17; a = 17
    coef2 DWORD 22; b = 22
    coef3 DWORD 21; c = 21
    coef4 DWORD 23; d = 23

    max_loop DWORD ?
    sum WORD ?
    capture_msec_before DWORD ?
    capture_msec_after DWORD ?
    elapsed_time DWORD ?

.code
main PROC
; Display welcome message
```

```
call clrscr
mov edx, offset msgWelcome
call WriteString
call crlf

; Display the algorithm
mov edx, offset msgAlgorithm
call WriteString
call crlf

; Prompt for max loop value
mov edx, offset msgEnterN
call WriteString
call ReadDec
mov max_loop, eax

; Display progress message
mov edx, offset msgProgress
call WriteString
call crlf

; Capture time before starting the loop
call GetMseconds
mov capture_msec_before, eax

; Initialize sum to 0
mov sum, 0

; Set loop counter
mov ecx, max_loop
mov ebx, 1

calc_loop:
; Calculate y = (coef1 * x ^ 3) + (coef2 * x ^ 2) + (coef3 * x) + coef4
; coef1* x ^ 3
mov eax, coef1
call Delay
mul bx
mul bx
mul bx
```

```
mov dx, ax      ; Store in dx for adding later

; coef2* x ^ 2
mov eax, coef2
call Delay
mul bx
mul bx
add dx, ax      ; add previous result

; coef3* x
mov eax, coef3
call Delay
mul bx
add dx, ax      ; add previous result

;coef4
mov eax, coef4
call Delay
add dx, ax      ; add coef4

; Add y to sum
add sum, dx

; Increment loop counter
inc ebx
loop calc_loop

; Capture time after completing the loop
call GetMseconds
mov capture_msec_after, eax

; Calculate elapsed time
mov eax, capture_msec_after
sub eax, capture_msec_before
mov elapsed_time, eax

; Display results
mov edx, offset msgResult
call WriteString
call crlf
```

```
mov edx, offset msgFirstCapture
call WriteString
mov eax, capture_msec_before
call WriteDec
call crlf

mov edx, offset msgSecondCapture
call WriteString
mov eax, capture_msec_after
call WriteDec
call crlf

mov edx, offset msgDiffTime
call WriteString
mov eax, elapsed_time
call WriteDec
call crlf

mov edx, offset msgSum
call WriteString
mov ax, sum
call WriteDec
call crlf

; Prompt to continue pr exit
mov edx, offset msgPrompt
call WriteString
call ReadChar

cmp al, 'y'
je main

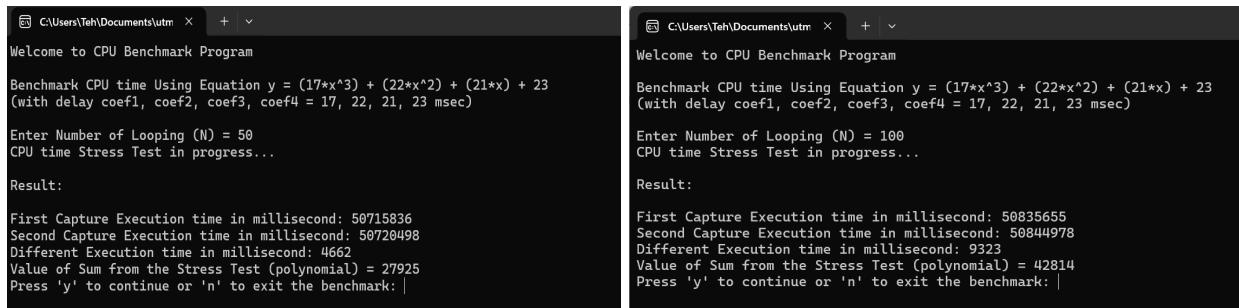
call crlf
mov edx, offset msgBye
call WriteString

;Exit program
exit
main ENDP
END main
```

## 3.4 Execution and Results

HP Pavilion

No of Loop (N)	Capture_msec (before)	Capture_msec (after)	Capture_msec (different)
50	50715836	50720498	4662
100	50835655	50844978	9323
200	50879619	50898262	18643
500	50930212	50976859	46647
700	51024410	51089661	65251
1000	51365056	51458702	93646



```

C:\Users\Teh\Documents\utm x + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 50
CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 50715836
Second Capture Execution time in millisecond: 50720498
Different Execution time in millisecond: 4662
Value of Sum from the Stress Test (polynomial) = 27925
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Teh\Documents\utm x + v
Welcome to CPU Benchmark Program

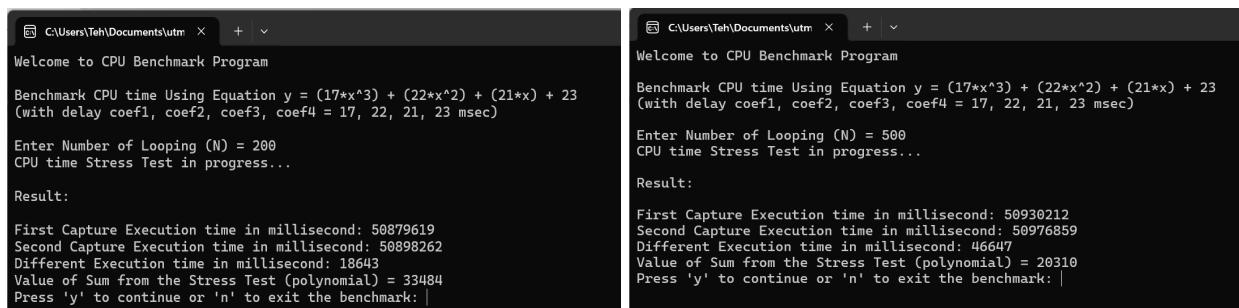
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 100
CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 50835655
Second Capture Execution time in millisecond: 50844978
Different Execution time in millisecond: 9323
Value of Sum from the Stress Test (polynomial) = 42814
Press 'y' to continue or 'n' to exit the benchmark: |

```



```

C:\Users\Teh\Documents\utm x + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 200
CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 50879619
Second Capture Execution time in millisecond: 50898262
Different Execution time in millisecond: 18643
Value of Sum from the Stress Test (polynomial) = 33484
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Teh\Documents\utm x + v
Welcome to CPU Benchmark Program

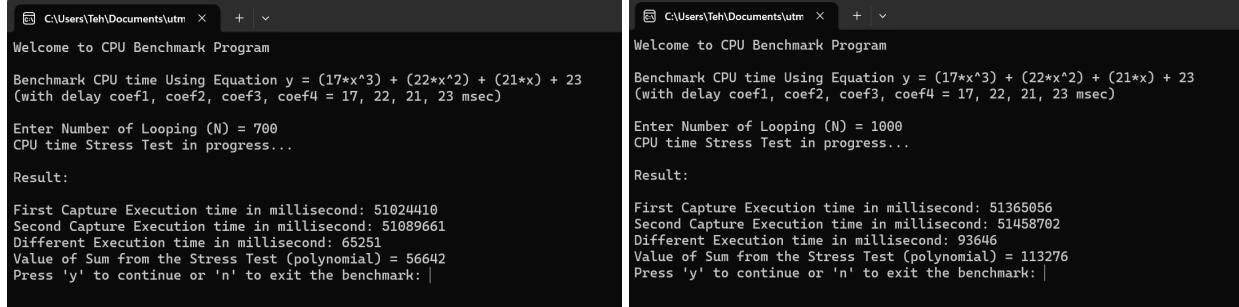
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 500
CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 50930212
Second Capture Execution time in millisecond: 50976859
Different Execution time in millisecond: 46647
Value of Sum from the Stress Test (polynomial) = 20310
Press 'y' to continue or 'n' to exit the benchmark: |

```



```

C:\Users\Teh\Documents\utm x + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 500
CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 50930212
Second Capture Execution time in millisecond: 50976859
Different Execution time in millisecond: 46647
Value of Sum from the Stress Test (polynomial) = 20310
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Teh\Documents\utm x + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 700
CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 51024410
Second Capture Execution time in millisecond: 51089661
Different Execution time in millisecond: 65251
Value of Sum from the Stress Test (polynomial) = 56642
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Teh\Documents\utm x + v
Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 1000
CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 51365056
Second Capture Execution time in millisecond: 51458702
Different Execution time in millisecond: 93646
Value of Sum from the Stress Test (polynomial) = 113276
Press 'y' to continue or 'n' to exit the benchmark: |

```

## Asus Vivobook

No of Loop (N)	Capture_msec (before)	Capture_msec (after)	Capture_msec (different)
50	70482913	70487606	4693
100	70873095	70881894	8799
200	71088645	71107391	18746
500	71004995	71049616	44621
700	71569739	71635380	65641
1000	71716019	71809633	93614

The image shows four side-by-side terminal windows, each displaying the output of a CPU benchmark program. The program performs a stress test on a polynomial equation  $y = (17*x^3) + (22*x^2) + (21*x) + 23$  for a specified number of loops (N). It captures execution times before and after the stress test and calculates the sum of the results.

**Loop Count 200:**

```
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 200
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 71088645
Second Capture Execution time in millisecond: 71107391
Different Execution time in millisecond: 18746
Value of Sum from the Stress Test (polynomial) = 33484
Press 'y' to continue or 'n' to exit the benchmark:
```

**Loop Count 500:**

```
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 500
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 71004995
Second Capture Execution time in millisecond: 71049616
Different Execution time in millisecond: 44621
Value of Sum from the Stress Test (polynomial) = 42814
Press 'y' to continue or 'n' to exit the benchmark:
```

**Loop Count 700:**

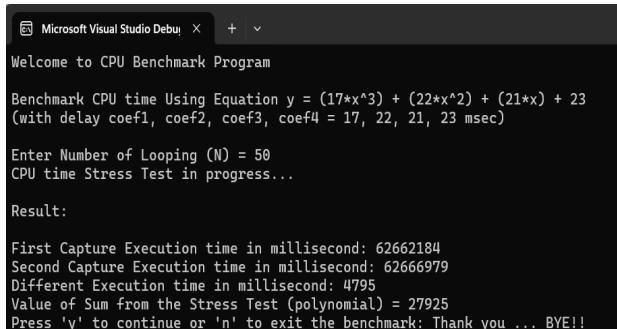
```
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 700
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 71569739
Second Capture Execution time in millisecond: 71635380
Different Execution time in millisecond: 65641
Value of Sum from the Stress Test (polynomial) = 122178
Press 'y' to continue or 'n' to exit the benchmark:
```

**Loop Count 1000:**

```
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 1000
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 71716019
Second Capture Execution time in millisecond: 71809633
Different Execution time in millisecond: 93614
Value of Sum from the Stress Test (polynomial) = 113276
Press 'y' to continue or 'n' to exit the benchmark:
```

## Lenovo Ideapad Slim3

No of Loop (N)	Capture_msec (before)	Capture_msec (after)	Capture_msec (different)
50	62662184	62666979	4795
100	62698519	62788084	9565
200	62738059	62757209	19150
500	62866382	62908373	41991
700	62782399	62842314	59915
1000	62938136	63022154	84018



Microsoft Visual Studio Debug

Welcome to CPU Benchmark Program

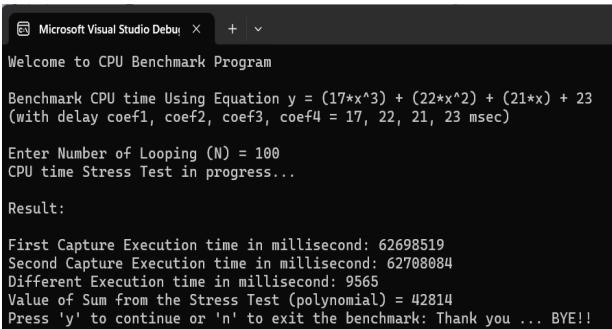
Benchmark CPU time Using Equation  $y = (17*x^3) + (22*x^2) + (21*x) + 23$  (with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 50

CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 62662184  
 Second Capture Execution time in millisecond: 62666979  
 Different Execution time in millisecond: 4795  
 Value of Sum from the Stress Test (polynomial) = 27925  
 Press 'y' to continue or 'n' to exit the benchmark: Thank you ... BYE!!



Microsoft Visual Studio Debug

Welcome to CPU Benchmark Program

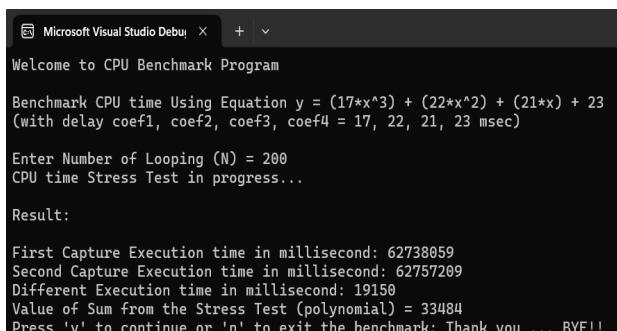
Benchmark CPU time Using Equation  $y = (17*x^3) + (22*x^2) + (21*x) + 23$  (with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 100

CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 62698519  
 Second Capture Execution time in millisecond: 62788084  
 Different Execution time in millisecond: 9565  
 Value of Sum from the Stress Test (polynomial) = 42814  
 Press 'y' to continue or 'n' to exit the benchmark: Thank you ... BYE!!



Microsoft Visual Studio Debug

Welcome to CPU Benchmark Program

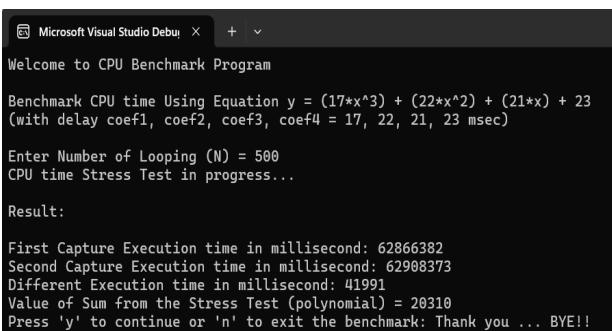
Benchmark CPU time Using Equation  $y = (17*x^3) + (22*x^2) + (21*x) + 23$  (with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 200

CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 62738059  
 Second Capture Execution time in millisecond: 62757209  
 Different Execution time in millisecond: 19150  
 Value of Sum from the Stress Test (polynomial) = 33484  
 Press 'y' to continue or 'n' to exit the benchmark: Thank you ... BYE!!



Microsoft Visual Studio Debug

Welcome to CPU Benchmark Program

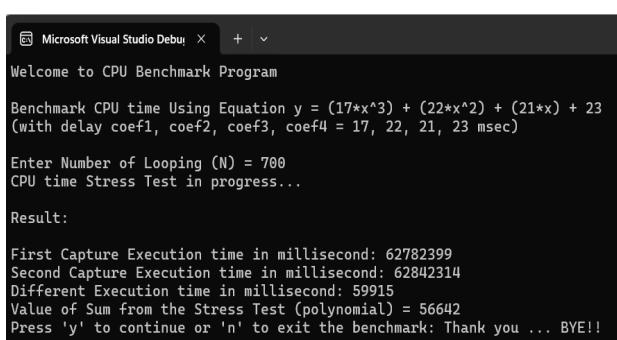
Benchmark CPU time Using Equation  $y = (17*x^3) + (22*x^2) + (21*x) + 23$  (with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 500

CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 62866382  
 Second Capture Execution time in millisecond: 62908373  
 Different Execution time in millisecond: 41991  
 Value of Sum from the Stress Test (polynomial) = 20310  
 Press 'y' to continue or 'n' to exit the benchmark: Thank you ... BYE!!



Microsoft Visual Studio Debug

Welcome to CPU Benchmark Program

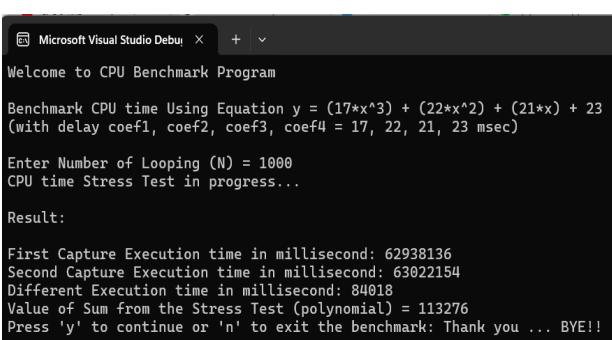
Benchmark CPU time Using Equation  $y = (17*x^3) + (22*x^2) + (21*x) + 23$  (with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 700

CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 62782399  
 Second Capture Execution time in millisecond: 62842314  
 Different Execution time in millisecond: 59915  
 Value of Sum from the Stress Test (polynomial) = 56642  
 Press 'y' to continue or 'n' to exit the benchmark: Thank you ... BYE!!



Microsoft Visual Studio Debug

Welcome to CPU Benchmark Program

Benchmark CPU time Using Equation  $y = (17*x^3) + (22*x^2) + (21*x) + 23$  (with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)

Enter Number of Looping (N) = 1000

CPU time Stress Test in progress...

Result:

First Capture Execution time in millisecond: 62938136  
 Second Capture Execution time in millisecond: 63022154  
 Different Execution time in millisecond: 84018  
 Value of Sum from the Stress Test (polynomial) = 113276  
 Press 'y' to continue or 'n' to exit the benchmark: Thank you ... BYE!!

## DELL Inspiron 3505

No of Loop (N)	Capture_msec (before)	Capture_msec (after)	Capture_msec (different)
50	9221504	9227717	6213
100	9301157	9313591	12434
200	9333870	9358843	24973
500	9377887	9440122	62235
700	9465263	9552594	87331
1000	9575262	9699838	124576

```

C:\Users\Polok\source\repos\ x + v
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 50
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 9221504
Second Capture Execution time in millisecond: 9227717
Different Execution time in millisecond: 6213
Value of Sum from the Stress Test (polynomial) = 27925
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Polok\source\repos\ x + v
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 100
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 9301157
Second Capture Execution time in millisecond: 9313591
Different Execution time in millisecond: 12434
Value of Sum from the Stress Test (polynomial) = 42814
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Polok\source\repos\ x + v
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 200
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 9333870
Second Capture Execution time in millisecond: 9358843
Different Execution time in millisecond: 24973
Value of Sum from the Stress Test (polynomial) = 33484
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Polok\source\repos\ x + v
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 500
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 9377887
Second Capture Execution time in millisecond: 9440122
Different Execution time in millisecond: 62235
Value of Sum from the Stress Test (polynomial) = 20310
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Polok\source\repos\ x + v
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 700
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 9465263
Second Capture Execution time in millisecond: 9552594
Different Execution time in millisecond: 87331
Value of Sum from the Stress Test (polynomial) = 122178
Press 'y' to continue or 'n' to exit the benchmark: |

C:\Users\Polok\source\repos\ x + v
Welcome to CPU Benchmark Program
Benchmark CPU time Using Equation y = (17*x^3) + (22*x^2) + (21*x) + 23
(with delay coef1, coef2, coef3, coef4 = 17, 22, 21, 23 msec)
Enter Number of Looping (N) = 1000
CPU time Stress Test in progress...
Result:
First Capture Execution time in millisecond: 9575262
Second Capture Execution time in millisecond: 9699838
Different Execution time in millisecond: 124576
Value of Sum from the Stress Test (polynomial) = 113276
Press 'y' to continue or 'n' to exit the benchmark: |

```

### 3.5 Analysis, Comparison, Discussion

CPU elapsed time is a critical metric for understanding the efficiency and speed of a system in executing tasks. The analysis of CPU elapsed time for the HP Pavilion, ASUS Vivobook, Lenovo Ideapad Slim3 and DELL Inspiron 3505 involves evaluating their performance under different computational loads. In this project, the elapsed time was measured using a polynomial function as the benchmarking algorithm.

The polynomial equation used as the benchmarking algorithm is defined as:

$$f(x) = (a * x^3) + (b * x^2) + c * x + d$$

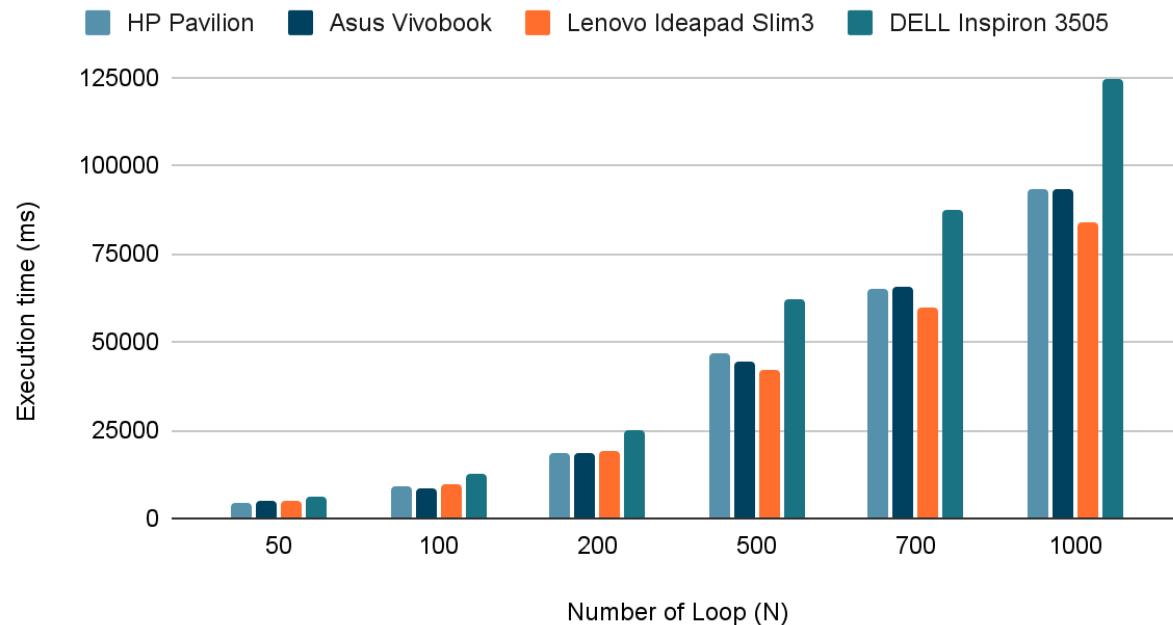
where a, b, c, and d are coefficients representing delay values, and x is an input integer value. The program is executed with varying maximum loop values (N) to compare performance differences. The chosen loop values for this comparison are 50, 100, 200, 500, 700, and 1000.

By recording the start and end times of the program's execution for each loop value, the elapsed time is calculated. This data is then analyzed using the polynomial equation to model the performance and measure the efficiency, speed, and capability of each CPU. The results provide a basis for comparing the performance of the four systems, offering insights into their relative effectiveness under different computational loads. After analyzing the collected data, the execution times for running a mathematical equation on four different computers have been compiled in a new table.

No of Loop (N)	Total Execution Time(ms)			
	HP Pavilion	Asus Vivobook	Lenovo Ideapad Slim3	DELL Inspiron 3505
50	4662	4693	4795	6213
100	9323	8799	9565	12434
200	18643	18746	19150	24973
500	46647	44621	41991	62235
700	65251	65641	59915	87331
1000	93646	93614	84018	124576

In each loop iteration, the highlighted box indicates lowest execution time. To offer a clearer and more intuitive visual representation of the data, the total execution time table has been converted into a bar chart below.

## Total Execution Time by 4 Computers



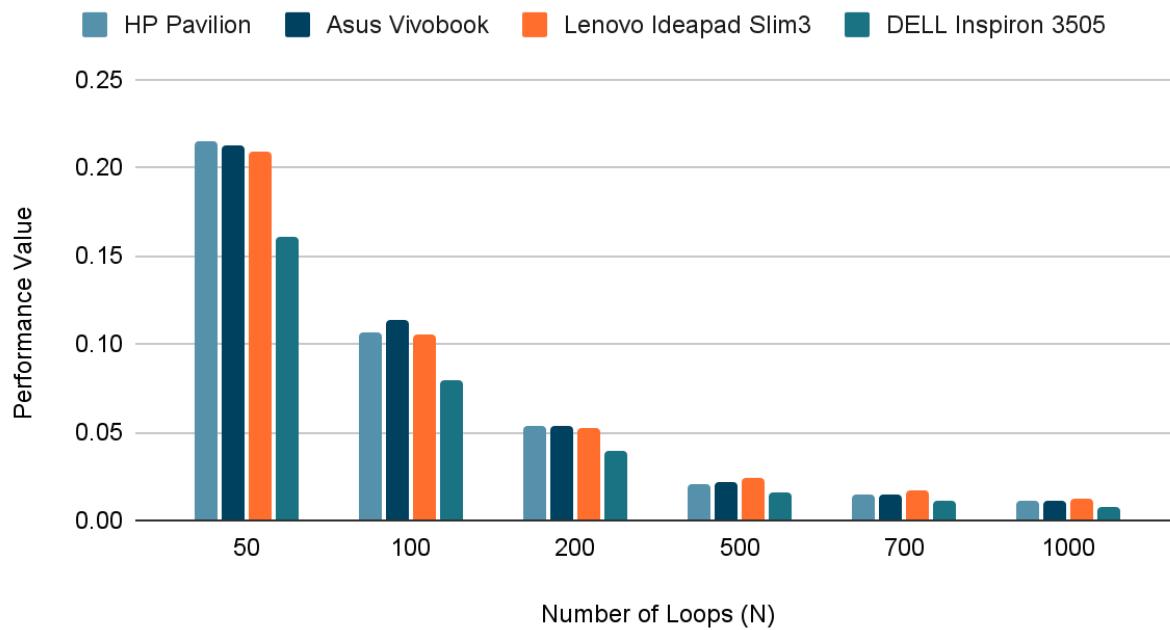
From the bar chart, we can observe DELL Inspiron 3505 consistently has the highest execution times, while Lenovo Ideapad Slim3 generally performs better, particularly as the number of loops increases. These values will be used to analyze performance by calculating the reciprocal of the execution time ( $1/\text{execution time}$ ) to facilitate a standardized comparison of each system's efficiency.

No of Loop (N)	Performance			
	HP Pavilion	Asus Vivobook	Lenovo Ideapad Slim3	DELL Inspiron 3505
50	0.215	0.213	0.209	0.161
100	0.107	0.114	0.105	0.080
200	0.054	0.053	0.052	0.040

500	0.021	0.022	0.024	0.016
700	0.015	0.015	0.017	0.011
1000	0.011	0.011	0.012	0.008

In each loop iteration, the highlighted box indicates the highest performance and better efficiency. To provide a clearer visual representation of the data, a bar chart has been created from the performance table.

## Performance Comparison of 4 Computers



The data reveals that HP Pavilion and Asus Vivobook generally perform well, with similar efficiency across most loop counts. Both systems exhibit high performance, particularly in the lower loop counts, indicating that they are well-optimized for smaller tasks. However, as the loop count increases, Lenovo Ideapad Slim3 begins to show better efficiency. It consistently maintains higher performance values for larger loop counts, demonstrating its superior capability in handling more extensive computational tasks. It may have a more powerful processor or advanced architecture, allowing it to perform calculations more efficiently.

Conversely, DELL Inspiron 3505 shows lower performance values across all loop counts compared to the other systems. It has higher execution times compared to other computers in each loop count and may not be as efficient in processing tasks, especially as the loop count increases. The significant drop in performance for DELL Inspiron 3505 at higher loop counts

indicates potential inefficiencies in its processing capabilities. This could be attributed to hardware limitations such as a less powerful processor, lower clock speed, smaller cache size, or inefficient memory management.

No of Loop (N)	Performance		$N = H/L$
	Highest(H)	Lowest(L)	
50	0.215	0.161	1.3
100	0.114	0.080	1.4
200	0.054	0.040	1.3
500	0.024	0.016	1.5
700	0.017	0.011	1.5
1000	0.012	0.008	1.5

To determine the relative efficiency between the best and worst-performing computer, the highest and lowest performance values for each loop count were compared using  $n=H/L$ , where H is the highest performance value and L is the lowest performance value.

The ratio n demonstrates how many times faster the highest performing computer is compared to the lowest performing one:

- **For 50 loops:** HP Pavilion is 1.3 times faster than DELL Inspiron 3505.
- **For 100 loops:** Asus Vivobook is 1.4 times faster than DELL Inspiron 3505.
- **For 200 loops:** HP Pavilion is 1.3 times faster than the DELL Inspiron 3505.
- **For 500, 700 and 1000 loops:** Lenovo Ideapad Slim3 is 1.5 times faster than DELL Inspiron 3505.

In summary, the performance levels of the four computers that are arranged in descending order are Lenovo Ideapad Slim3, followed by HP Pavilion and Asus Vivobook, with DELL Inspiron 3505 ranking last. This conclusion is based on the analysis of performance values calculated as the reciprocal of execution times, where Lenovo Ideapad Slim3 consistently demonstrates superior efficiency, particularly for larger computational tasks. HP Pavilion and Asus Vivobook exhibit comparable performance, while DELL Inspiron 3505 consistently shows the lowest performance, indicating higher execution times and potential inefficiencies.

## 4.0 Conclusion and Reflection

### 4.1 Conclusion

The analysis of the CPU elapsed times for our four laptops—HP Pavilion, Asus Vivobook, Lenovo Ideapad Slim3, and Dell Inspiron 3505—reveals that their overall performance is quite similar, with some differences in specific areas.

The **Lenovo Ideapad Slim3** generally performed well, showing strong overall performance in both single-core and multi-core tasks according to its Geekbench scores. It also had the highest disk performance in MiniTool Partition Wizard's benchmarks, indicating efficient disk operations. However, some variability in its CPU elapsed times was observed across different loop counts.

The **HP Pavilion** demonstrated solid and reliable performance, making it well-suited for everyday use and moderate tasks. Its Geekbench scores and disk performance were decent, with notable sequential read speeds. Its moderate CPU elapsed times compared to the other laptops indicate good data transfer rates for various tasks.

The **Asus Vivobook** demonstrated a balance of performance, being capable of handling everyday tasks and some multitasking efficiently. Although its disk performance metrics were slightly lower compared to the others, it still offers adequate performance for basic use and standard applications.

The **Dell Inspiron 3505** showed balanced performance for daily computing and more intensive tasks. It showcased competitive disk performance with notable sequential read speeds and write speeds. Despite having longer CPU elapsed times compared to other laptops, it still performs well across various workloads, highlighting its capability for handling demanding applications effectively.

This comparison highlights the importance of hardware specifications, including processor speed, cache size, memory, and disk performance, in overall computer performance. Additionally, system optimization and background processes can significantly affect CPU and disk performance.

#### **Summary:**

- **Lenovo Ideapad Slim3:** Best choice for high performance, quick task completion, and efficient disk operations. Ideal for demanding applications and multitasking.
- **HP Pavilion:** Reliable for everyday use and moderate tasks, with good disk performance metrics indicating strong data transfer capabilities.

- **Asus Vivobook:** Balanced performance suitable for basic use and standard applications, though slightly lower disk performance compared to others.
- **Dell Inspiron 3505:** Adequate for everyday computing and more intensive tasks, showcasing competitive disk performance metrics despite lower Geekbench scores.

Overall, while the **Lenovo Ideapad Slim3** leads slightly in both CPU and disk performance, the **HP Pavilion, Asus Vivobook, and Dell Inspiron 3505** provide comparable performance, making them all viable options depending on the user's specific needs.

## 4.2 Reflection

Goe Jie Ying

Completing this benchmark project taught me how hardware specs like processor speed, memory size, and cache impact laptop performance. Using benchmark tools, I learned to identify the differences between laptops and understand the importance of selecting the right hardware for specific needs. This experience underscored the value of benchmarking for accurate performance assessment and helped me gain skills in analyzing and interpreting hardware data.

Poh Lok Yee

Looking back at this project, I feel satisfied with the work and the insights gained. This experience has deepened my understanding of performance analysis and the factors influencing computational efficiency. It showed me how important it is to test hardware thoroughly to understand its strengths and weaknesses. These skills will help me make better choices about hardware selection and optimization in future projects.

Teh Ru Qian

Through this project, I gained experience comparing the performance of several PCs using benchmarking software such as CPU-Z, Geekbench, MiniTools Partition Wizard and Task Manager. I gained a deeper understanding of the advantages and disadvantages of the Lenovo Ideapad Slim3, Asus Vivobook, DELL Inspiron 3505 and HP Pavilion by putting them through several tests. During this experience, I became more adept at assessing hardware and selecting the appropriate computer for different kinds of work.

Woo Cheng Shuan

Reflecting on this project, I learned how to assess computer performance under different load conditions by running various applications and monitoring CPU and memory usage. For example, we tested disk read and write speeds, gaining insights into how different devices handle data by using tools like MiniTool Partition Wizard. This experience highlighted the importance of managing system resources effectively, particularly by closing unnecessary processes to improve performance. Overall, the project provided practical knowledge on maintaining and optimizing computer efficiency in real-world scenarios.

## References

DevX. (2023, October 18). *Central Processing Unit Benchmark - Glossary*.

<https://www.devx.com/terms/central-processing-unit-benchmark/>

Techquickie. (2014, November 17). *Benchmarks as fast as possible* [Video]. YouTube.

<https://www.youtube.com/watch?v=cHtNJngtS1I>

## Appendices

### Task Division

Task	Person in Charge
Introduction	Lok Yee & Ru Qian & Cheng Shuan
Project - Part 1	Jie Ying & Ru Qian & Cheng Shuan
Benchmarking Using Free Tools	All Members
Project - Part 2	Ru Qian & Lok Yee
Benchmarking Using ASM Code Program	All Members
Conclusion	Jie Ying
Reflection	All Members
Slides	Jie Ying & Ru Qian

### Meeting

