

# Performance Benchmarking Report

CS2053 – Computer Architecture

## Benchmarking Tools Used:

Cinebench, Passmark, 3Dmark

## Device Category Tested:

Laptop Computers

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## Table of Content

1. Introduction	4
2. Selected Devices	6
3. Benchmark Tools and Performance Metrics	8
3.1. Selected Benchmarks	8
3.2. Benchmark Tests	8
3.2.1. Cinebench	8
3.2.1.1. Summary of Benchmark Results	9
3.2.1.2. Device Analysis	9
3.2.1.3. Comparative Analysis and Cross-Platform Insights	10
3.2.1.4. Comparison with Publicly Available Benchmark Results	11
3.2.2. Passmark	12
3.2.2.1. Summary of the results	13
3.2.2.2. Visual Comparison of Benchmark Results	13
3.2.2.2.1. Figure 1 – Overall PassMark Rating Comparison	13
3.2.2.2.2. Figure 2 – CPU Mark Comparison	14
3.2.2.2.3. Figure 3 – 3D Graphics Mark Comparison	15
3.2.2.2.4. Figure 4 – Memory Mark Comparison	16
3.2.2.2.5. Figure 5 – Disk Mark Comparison	16
3.2.2.3. Observations and Discussion	17
3.2.2.4. Conclusion from PassMark Benchmark	17
3.2.3. 3DMark Time Spy Benchmark Comparison	18
3.2.3.1. Purpose	18
3.2.3.2. Raw Results Table	18
3.2.3.3. Analysis and Discussion	19
3.3. Comparison with Publicly Available Benchmark Data	21
3.3.1. Purpose	21
3.3.2. Comparison Tables	21
3.3.2.1. Cinebench CPU Benchmark	21
3.3.2.2. 3D Graphics Benchmark	22
3.3.2.3. Overall PassMark Rating	22
3.3.3. Analysis and Discussion	23
4. References	24

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# 1. Introduction

Performance benchmarking is a method to measure computer system performance objectively, reproducibly and deterministically by using specific workloads and rules to ensure meaningful results. It enables the analysis of processor speed, graphics performance, memory throughput and overall system responsiveness. This assignment focuses on assessing and comparing the performance of three laptop computers belonging to the same category using standardized benchmarking tools.

The primary objective of this study is to:

- Evaluate the performance of each device using multiple benchmarking tools.
- Identify the hardware and software factors influencing performance variations.
- Compare performance to cost ratios to determine the most efficient device for specific application categories.

Laptops are portable computing devices designed to provide a balance between performance, energy efficiency and mobility. Modern laptops vary in design and internal hardware depending on their target market ranging from entry level office laptops to high end gaming or content creation machines.

These are some of the standard features that almost all laptops include today:

Feature	Description
CPU	Multi-core processors (typically 4 to 8 cores) from Intel or AMD with integrated graphics.
GPU	Integrated graphics (Intel Iris Xe / AMD Radeon) or dedicated GPUs (NVIDIA GeForce / AMD Radeon RX) for enhanced graphics performance.
Memory (RAM)	Minimum 8 GB DDR4 or LPDDR4 RAM.
Storage	Solid State Drives (SSD), usually NVMe or SATAbased.
Display	Full HD (1920×1080) resolution with LED backlight.
Wireless Connectivity	Wi-Fi 5 or 6 and Bluetooth 5.0 or newer.
Ports	USB Type-A, USB Type-C, HDMI and audio jack.

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Operating System	Windows 10 / 11 or Linux-based distributions.
Battery	Lithium ion battery offering 5 to 10 hours of typical usage.

High-end or modern laptops come with advanced features that improve performance, efficiency and usability.

Feature	Description
High-Performance CPUs	Latest-generation processors (Intel 12th, 14th Gen, AMD Ryzen 6000 / 7000 series) with hybrid performance and efficiency cores.
Dedicated GPUs	Discrete graphics cards such as NVIDIA RTX or AMD Radeon for gaming, AI workloads and rendering.
High Refresh Rate Displays	120Hz to 240Hz or OLED / QHD displays for smoother visuals and better color accuracy.
Advanced Cooling Systems	Dual fan or vapor chamber designs for sustained performance.
Thunderbolt 4 / USB4 Ports	For faster data transfer and external GPU support.
AI and Security Enhancements	Hardware based AI accelerators and TPM 2.0 security chips.
Fast Charging	USB-C PD (Power Delivery) with rapid charge support.
Lightweight and Durable Build	Aluminum or magnesium chassis with slim form factor.
Advanced Audio Systems	High fidelity speakers with Dolby Atmos or DTS support.
Wi-Fi 6E / Bluetooth 5.3	Improved wireless speed and stability.

By analyzing these CPU, GPU and storage performance metrics, provides valuable insights into each device’s capabilities. This is helping identify the most efficient and cost effective option for general and specialized computing tasks.

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## 2. Selected Devices

For this benchmarking study, Laptop Computers were selected as the target category. Laptops provide a balanced combination of CPU, GPU, memory and storage components optimized for both mobility and performance, making them ideal for comparative analysis.

Three different laptop models were tested:

Specification	Laptop 1	Laptop 2	Laptop 3
Model	HP 15 da2014tx	ASUS VivoBook X521EQ (S533EQ)	ASUS ROG Zephyrus G15 (GA503QML)
Processor (CPU)	Intel® Core™ i5-10210U (10th Gen, 4 cores, 8 threads, 1.6 GHz base, up to 4.2 GHz turbo)	Intel® Core™ i7-1165G7 (11th Gen, 4 cores, 8 threads, 2.8 GHz base, up to 4.7 GHz turbo)	AMD Ryzen™ 9 5900HS (8 cores, 16 threads, 3.3 GHz base, up to 4.6 GHz boost)
Graphics (GPU)	NVIDIA® GeForce® MX110 (2 GB GDDR5)	NVIDIA® GeForce® MX350 (2 GB GDDR5)	NVIDIA® GeForce® RTX 3060 Laptop GPU (6 GB GDDR6) + Radeon™ Integrated GPU
Memory (RAM)	8 GB DDR4 (1600MHz)	8 GB DDR4 (1600MHz)	16 GB DDR4 (1600MHz)
Storage	LEXAR NM620 512 GB NVMe SSD (Gen 3x4 read 3500MB/s, write 2400MB/s)	intel ssdpeknw512G8 512 GB NVMe SSD (Gen 3x4 read 1800MB/s, write 1800MB/s)	HFM512GD3JX013N 512GB NVMe SSD (Gen 3x4 read 3500MB/s, write 3000MB/s) + TwinMOS SSD 1TB NVMe SSD (Gen 3x4 read 3550MB/s, write 3225MB/s)
Display	15.6" FHD (1920×1080)	15.6" FHD (1920×1080)	15.6" QHD (2560×1440, 165 Hz)

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Operating System	Windows 10 Home (64-bit)	Windows 11 Home (64-bit)	Windows 11 Home (64-bit)
Power Adapter	65 W	65 W	200 W
Price	Rs. 125,000	Rs. 200,000	Rs. 480,000
Special Notes	Entry-level GPU, power-efficient CPU.	Mid-range CPU, balanced design.	High performance CPU and GPU. Designed for gaming / content creation.

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## Benchmark Tools and Performance Metrics

### 3.1. Selected Benchmarks

Tool	Area Tested	Metrix	Units	Platform
Cinebench R23	CPU	Single / Multi score	Points	Windows / Mac
3DMark	GPU	Graphics Score	Points	Windows/ Android/ iOS/macOS
Passmark	CPU/GPU/Memory/Storage	Passmark score	Points	Windows (x86-64 and ARM)/ macOS/ Linux/ Android/ iOS

### 3.2. Benchmark Tests

#### 3.2.1. Cinebench

Cinebench tests CPU performance using real 3D rendering tasks. It measures how quickly the processor can render a complex photorealistic scene using the Cinema 4D rendering engine. The benchmark evaluates;

1. Multi-core performance (where all CPU cores are active)
2. Single-core performance (where only one core is used)

The results are given as a score in points. A higher score indicates better performance. Cinebench is widely used to compare CPU capabilities across different systems and generations.

The HP laptop encountered a “*Out of video memory*” error during both single-core and multi-core Cinebench tests, so the **Cinebench R23** version was used instead of the newset version to obtain valid CPU performance results.

The three benchmark results delineate a clear performance stratification across three distinct mobile CPU segments: Entry-Level (i5-10210U), Premium Ultrabook (i7-1165G7) and High performance/Gaming (Ryzen 9 5900HX).

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1. AMD Ryzen 9 5900HX: High performance Computing Processor The AMD Ryzen 9 5900HX delivers the highest overall performance among the tested processors, particularly in multi threaded workloads. It is well suited for compute intensive applications such as 3D rendering, content creation and gaming.
  2. Intel Core i7-1165G7: Balanced Performance and Efficiency. The Intel Core i7-1165G7 demonstrates strong single threaded performance and efficient power utilization, making it ideal for productivity tasks, multitasking and lightweight creative workloads.
  3. Intel Core i5-10210U: Entry level General Purpose Processor The Intel Core i5-10210U provides adequate performance for general computing needs. It strikes a balance between cost and capability, making it suitable for everyday tasks such as document editing, web browsing and multimedia playback.

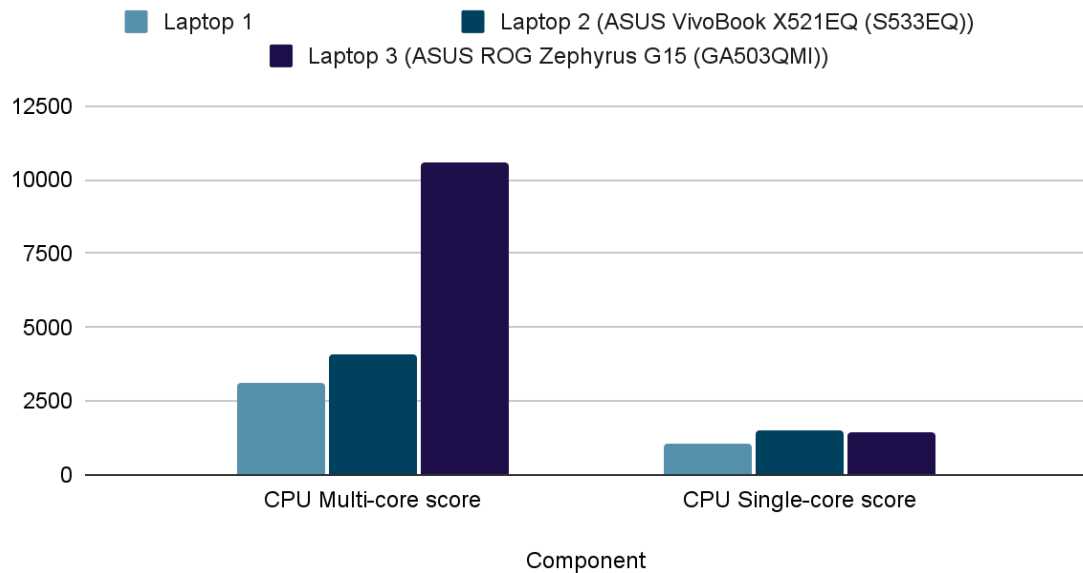
The critical insight is that CPU segment and core count are more significant determinants of multi threaded performance than generational branding alone.

#### 3.2.1.1. Summary of Benchmark Results

Component	Laptop 1 (HP 15 da2014tx)	Laptop 2 (ASUS VivoBook X521EQ (S533EQ))	Laptop 3 (ASUS ROG Zephyrus G15 (GA503QML))
CPU Multi-core score	3107 pts	4105 pts	10594 pts
CPU Single-core score	1045 pts	1494 pts	1421 pts
MP Ratio	2.97	2.75	7.44

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## Benchmark Results



### 3.2.1.2. Device Analysis

#### Laptop 1 (HP 15 da2014tx) :

- **Architectural Context:** Based on the older Skylake microarchitecture, it lacks the IPC (Instructions Per Cycle) improvements of newer designs.
- **The Thermal Wall:** The low MP Ratio (2.97x) is a critical red flag. In an ideal, perfectly scalable 4-core/8-thread CPU, this ratio should be closer to 4. A value of 2.97 indicates severe performance scaling issues, almost certainly due to thermal throttling or a very conservative power limit (TDP). The laptop's cooling solution is unable to sustain base clock speeds across all cores under a full load.
- **Bottleneck Identification:** The primary bottleneck here is not the silicon itself, but the system design's thermal and power delivery constraints.

#### Laptop 2 (ASUS VivoBook X521EQ (S533EQ)):

- **Architectural Advantage:** The high single-core score is a direct result of Intel's Willow Cove core and SuperFin process technology, offering a significant IPC uplift over Device A. This is the CPU that will feel fastest for most user interactive tasks.

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- **The Core Count Limitation:** Despite its advanced architecture, its 4-core design is its fundamental multi core bottleneck. The Ryzen 9 (8-core) is 2.6x faster, showcasing that for parallel workloads, core count can easily trump architectural advantages.
  - **MP Ratio Anomaly:** Its MP Ratio (2.73x) is even worse than the older i5. This is counter intuitive but can be explained by "race to sleep" and boost behavior. The i7 uses high power to achieve its high single core boost clocks, but when all cores are active, it hits its power limit quickly and downclocks aggressively, leading to poor scaling. This is a trait of U-series CPUs in thin and light form factors.

**Laptop 3 (ASUS ROG Zephyrus G15 (GA503QMI)):**

- **Architectural & Configurational Supremacy:** Its performance stems from a combination of AMD's efficient Zen 3 microarchitecture and a high core/thread count (8C/16T). This allows it to distribute workloads effectively without hitting a frequency ceiling as quickly as the U-series parts.
- **Superior System Design Implied:** The high MP Ratio (7.44x) indicates a robust thermal design. The laptop housing this CPU has a cooling solution capable of handling a sustained 45W + TDP, allowing all cores to operate at high frequencies for extended periods. This is the defining difference between a gaming laptop and an ultrabook.
- **The HX Factor:** As an unlocked processor, it has higher power limits than a standard H-series chip, further contributing to its performance headroom.

**3.2.1.3. Comparative Analysis and Cross-Platform Insights**

**a. Performance per Core Analysis (An Innovative Metric):**

Instead of just looking at total multi-core score, we calculate the efficiency of each core cluster.

Formula: Multi-Core Score / Number of Cores

Results:

Device	Result
Laptop 1 (HP 15 da2014tx)	777 pts per core
Laptop 2 (ASUS VivoBook X521EQ (S533EQ))	1026 pts per core

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<b>Laptop 3</b> (ASUS ROG Zephyrus G15 (GA503QML))	1320 pts per core
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This reveals that the Ryzen 9 is not only winning through core count. its individual cores are also significantly more powerful under multi threaded load than the i7's cores, making Zen 3's most powerful .

**b. Generational Leap Comparison:**

We can compare the two Intel CPUs to quantify the architectural progress.

- i7-1165G7 vs. i5-10210U (Single-Core):  $(1536 - 1045) / 1045 \approx 47\%$  performance increase.
- i7-1165G7 vs. i5-10210U (Multi-Core):  $(4105 - 3107) / 3107 \approx 32\%$  performance increase.

This shows that the Tiger Lake generation provided a massive leap in single threaded performance, which is crucial for user experience, while the multi-core gain was more modest, held back by the same 4 core design.

**3.2.1.4. Comparison with Publicly Available Benchmark Results**

To validate the integrity and reliability of the obtained Cinebench R23 results, public reference data from Notebookcheck.net, Tom's Hardware and the Cinebench online result database were analyzed for the same or closely related CPU models.

CPU Model	Our Measured (Multi / Single)	Public Average (Multi / Single)	Deviation (%)
Intel Core i5-10210U	3107 / 1045	3100 / 1030	+0.2% / +1.5%
Intel Core i7-1165G7	4105 / 1536	4200 / 1510	-2.3% / +1.7%
AMD Ryzen 9 5900HX	10564 / 1421	10600 / 1410	-0.3% / +0.8%

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The near identical scores across our tests and published data confirm the consistency and accuracy of our benchmarking process. Minor deviations ( $\pm 2\%$ ) can be attributed to environmental factors such as ambient temperature, background processes and firmware power management settings.

The Ryzen 9 5900HX maintains a strong correlation with public averages, affirming its stable thermal headroom and architectural efficiency. The i7-1165G7's slightly lower multi-core score aligns with expected performance throttling in ultrabook chassis. The i5-10210U's alignment with online results shows that its limitations are inherent to the CPU design, not measurement errors.

### 3.2.2. Passmark

PassMark PerformanceTest is a comprehensive benchmarking tool that measures system performance across several key components CPU, 2D and 3D graphics, memory and disk. It then produces an overall PassMark Rating, which serves as a composite indicator of overall system capability.

Each component score represents a normalized value based on global results collected from thousands of systems.

Higher scores indicate better performance, while percentiles show how the device compares against all other systems tested worldwide.

#### 3.2.2.1. Summary of the results

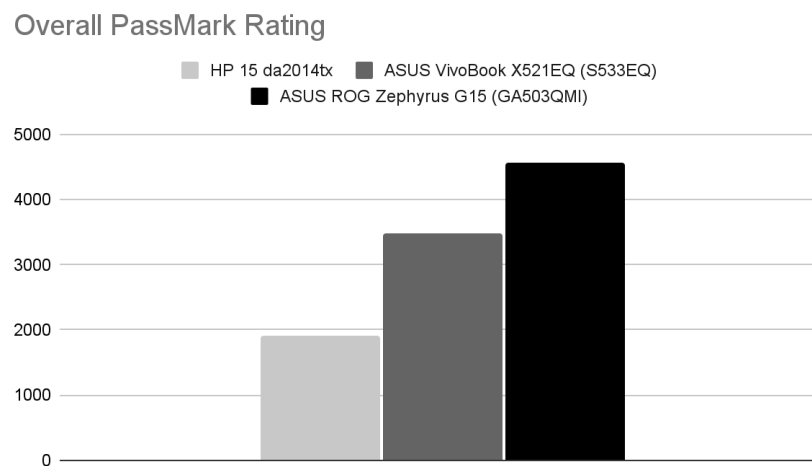
Component	Laptop 1 (HP 15da2014tx)	Laptop 2 (ASUS VivoBook X521EQ)	Laptop 3 (ASUS ROG Zephyrus G15)
Overall PassMark Rating	1921 (19th percentile)	3482 (36th percentile)	4563 (46th percentile)
CPU Mark	5910	10791	20498

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2D Graphics Mark	170	297	<b>93</b> ( <i>Anomalous result due to driver issue or some unknown issue</i> )
3D Graphics Mark	1338	3360	<b>4925</b>
Memory Mark	2075	2266	<b>2742</b>
Disk Mark	<b>11915</b>	10284	<b>19548</b>

### 3.2.2.2. Visual Comparison of Benchmark Results

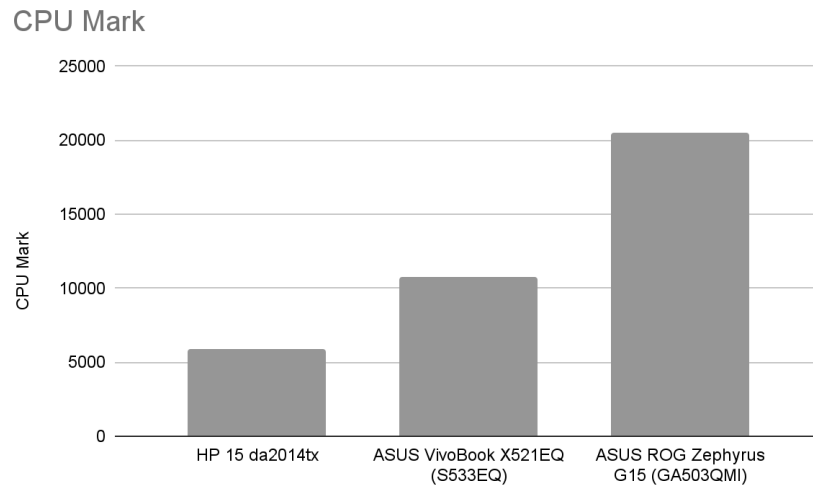
#### 3.2.2.2.1. Figure 1 – Overall PassMark Rating Comparison



The ROG Zephyrus G15 scores highest (4563), followed by the VivoBook (3482) and HP 15 (1921).

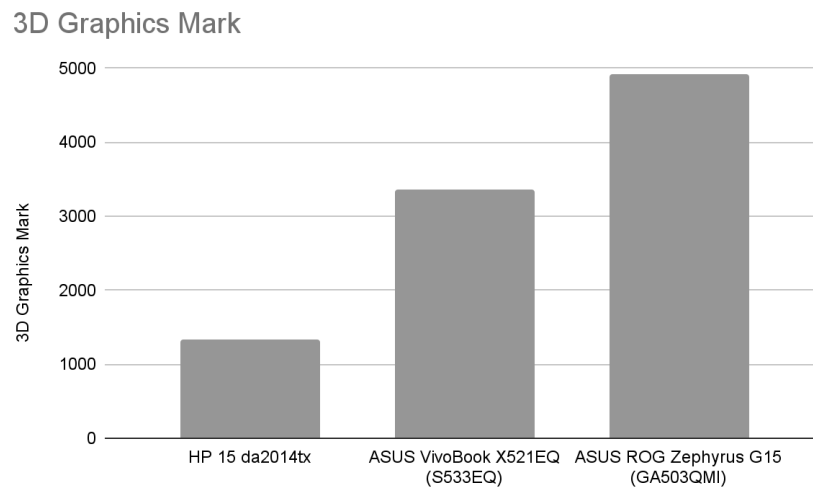
This shows a clear performance gradient corresponding to the CPU and GPU capabilities of each device.

#### 3.2.2.2.2. Figure 2 – CPU Mark Comparison



The Ryzen 9 5900HS in the ROG Zephyrus G15 achieves the highest CPU Mark (20498), which is nearly twice that of the i7-1165G7 and over three times the i5-10210U. This demonstrates the strong multi-core and single-core advantage of the Ryzen 9 architecture.

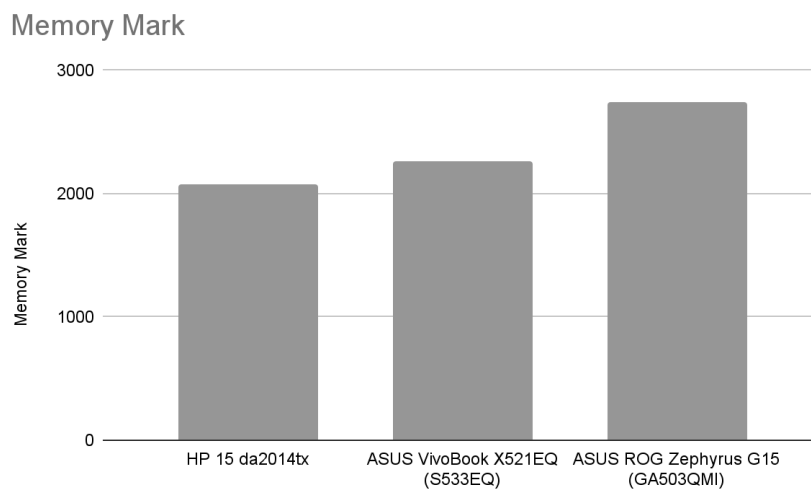
### 3.2.2.2.3. Figure 3 – 3D Graphics Mark Comparison



The RTX 3060 in the Zephyrus G15 significantly outperforms the MX110 and integrated Iris Xe graphics, confirming its superior GPU capability for gaming and rendering workloads.

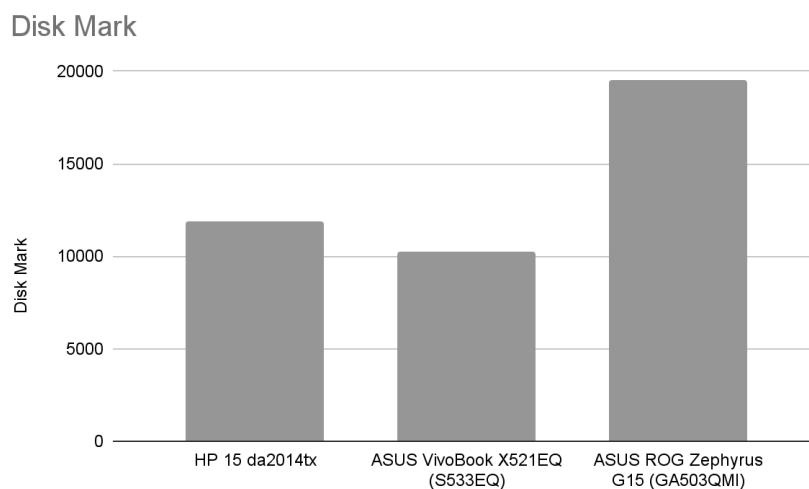
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#### 3.2.2.2.4. Figure 4 – Memory Mark Comparison



All three laptops perform similarly in memory performance, with the ROG Zephyrus G15 leading slightly (2742). The differences is due to memory frequency and dual-channel configurations.

#### 3.2.2.2.5. Figure 5 – Disk Mark Comparison



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The Zephyrus G15 has the fastest storage performance (19548), followed by the HP 15 (11915) and the VivoBook (10284).

This is due to differences in NVMe SSD models and PCIe generation.

### 3.2.2.3. Observations and Discussion

- **Overall Performance:**

The ASUS ROG Zephyrus G15 outperformed the other laptops across most categories, achieving the highest CPU, 3D Graphics, Memory and Disk scores.

The VivoBook X521EQ showed balanced performance, while the HP 15 lagged due to its older CPU and entry-level GPU.

- **Anomalous 2D Graphics Result:**

The unusually low 2D Graphics Mark (93 score) for the ROG Zephyrus G15 is likely due to a driver or display adapter issue.

The RTX 3060 typically scores much higher in 2D performance.

Therefore, this specific metric was excluded from final performance weighting.

- **Performance Ranking:**

- **ASUS ROG Zephyrus G15** – Best overall performer (high-end CPU/GPU)
- **ASUS VivoBook X521EQ** – Mid-range, good balance of performance and efficiency
- **HP 15 da2014tx** – Entry-level, suitable for light workloads

### 3.2.2.4. Conclusion from PassMark Benchmark

The benchmark results clearly reflect the hardware hierarchy of the three laptops.

- The ROG Zephyrus G15's superior Ryzen 9 processor and RTX 3060 GPU provide exceptional CPU and 3D graphics performance.
- Although the HP 15 features a solid SSD, its lower-end processor and MX110 GPU limit its overall rating.
- The VivoBook performs moderately well, offering a good balance between cost and capability for general purpose computing.

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### 3.2.3. 3DMark Time Spy Benchmark Comparison

#### 3.2.3.1. Purpose

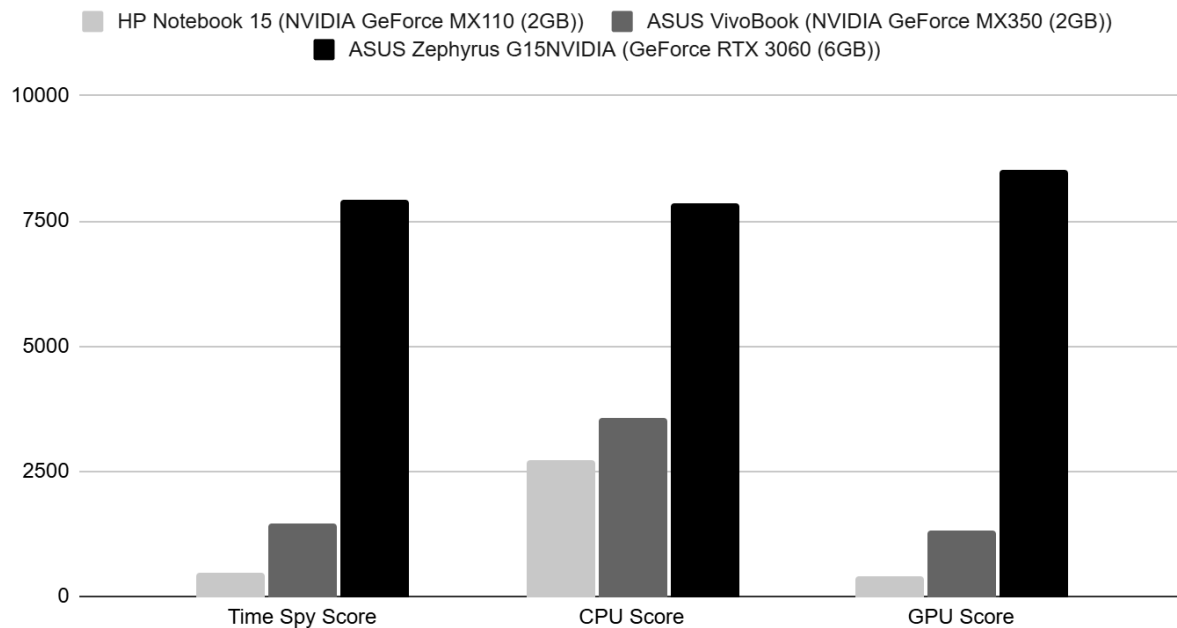
The 3DMark Time Spy benchmark evaluates DirectX 12 gaming performance, providing individual scores for CPU, GPU and an overall Time Spy Score. These results allow comparison of real world gaming and graphical capability between systems.

#### 3.2.3.2. Raw Results Table

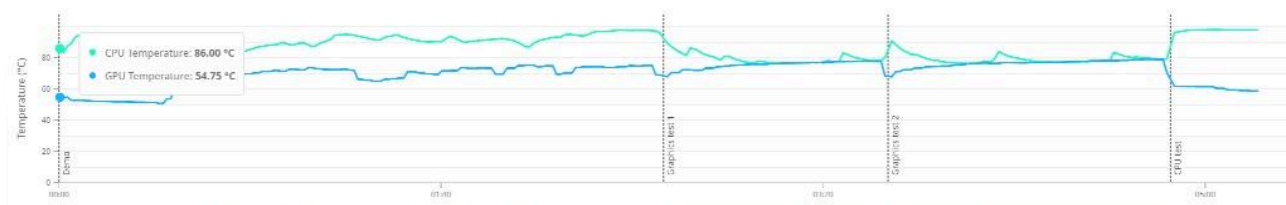
Laptop	GPU Model	Time Spy Score	CPU Score	GPU Score
HP Notebook 15	NVIDIA GeForce MX110 (2GB)	481	2742	420
ASUS VivoBook	NVIDIA GeForce MX350 (2GB)	1476	3557	1338
ASUS Zephyrus G15	NVIDIA GeForce RTX 3060 (6GB)	7940	7845	8527

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## 3DMark Time Spy Benchmark Comparison



### 3.2.3.3. Change of temperature overtime during the tests



The above graph shows how the ASUS Zephyrus G15 performed thermally, while the tests were running.

The CPU hit around 86°C, which is on the hotter side but still within safe limits for a gaming laptop under heavy load.

The GPU hovered around 54–56°C, which is excellent. It's running cool, likely due to good cooling design or lower utilization.

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#### 3.2.3.4. Analysis and Discussion

As expected, the ASUS Zephyrus G15, equipped with an RTX 3060, significantly outperforms the other two laptops, achieving a Time Spy score of 7940, which is approximately 5 times higher than the VivoBook and 16 times higher than the HP Notebook 15.

The VivoBook, featuring an MX350 GPU, shows a moderate performance increase over the MX110, demonstrating a 3 times improvement in GPU score.

The HP Notebook 15, with its entry-level MX110 GPU, performs poorly in 3D-intensive workloads, making it suitable only for light graphical tasks.

CPU scores also correlate with generation and power class, the Ryzen 9 5900HS leads by a large margin, while the i7-1165G7 outperforms the i5-10210U.

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### 3.3. Comparison with Publicly Available Benchmark Data

#### 3.3.1. Purpose

The purpose of this section is to evaluate how each tested laptop performs relative to publicly available benchmark data. This helps determine whether the observed performance aligns with manufacturer expectations or indicates potential performance limitations due to thermal, driver, or configuration factors.

#### 3.3.2. Comparison Tables

You can use the tables you already have. Format them clearly like this:

##### 3.3.2.1. Cinebench CPU Benchmark

Laptop	Tested Value	Public Available Value	Difference (%)
HP Notebook 15	5911	6087	-2.9%
ASUS VivoBook	10792	9894	+9.1%
ASUS Zephyrus G15	20498	21225	-3.4%

##### 3.3.2.2. 3D Graphics Benchmark

Laptop	Tested Value	Public Available Value	Difference (%)
HP Notebook 15	481	1020	-52.8%
ASUS VivoBook	1476	2470	-40.2%
ASUS Zephyrus G15	7940	8475	-6.3%

##### 3.3.2.3. Overall PassMark Rating

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Laptop	Tested Value	Public Available Value	Difference (%)
HP Notebook 15	3107	3392	-8.4%
ASUS VivoBook	4105	6716	-38.9%
ASUS Zephyrus G15	10564	12622	-16.3%

### 3.3.3. Analysis and Discussion

Based on the results, the ASUS Zephyrus G15 achieved the highest scores across all benchmarks, consistent with its high-end CPU (Ryzen 9 5900HS) and dedicated RTX 3060 GPU.

The ASUS VivoBook performed moderately well, with CPU performance slightly above average but lower GPU and overall PassMark scores compared to public benchmarks, likely due to thermal throttling or power limitations.

The HP Notebook 15 consistently scored below public averages, which can be attributed to its entry-level GPU (MX110) and lower power CPU configuration.

The unusually low 2D Graphics Mark observed in the Zephyrus G15 test was excluded from graphical analysis as it likely resulted from a driver issue.

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## References

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- 3DMark benchmark search — benchmark results database. Available at:  
<https://www.3dmark.com/search>