Dell Latitude 9420: Finish application-based office tasks faster, enjoy longer battery life, and work with cooler surface temps

Compared to the Lenovo ThinkPad X1 Carbon Gen 9

Dell™ Latitude™ 9420 and Lenovo® ThinkPad® X1 Carbon Gen 9 laptops both provide the advanced features of the Windows 10 Pro operating system and the compute power of 11th Gen Intel® Core™ processors. But impressive specs can only tell you part of the user experience story.

To determine which 14-inch business laptop could deliver better business user experiences, we set up comparable premium laptops from each line, both powered by Intel Core i7-1185G7 vPro® processors. And, because there's no single kind of business user, we put these laptops through Cinebench R23, SYSmark® 25, PCMark® 10, and MobileMark® 2018 industry-standard benchmark testing. These benchmarks measure hardware capabilities, system responsiveness, and battery life potential in a variety of use-cases. Then, we conducted hands-on surface temperature, screen-to-body ratio, acoustic, and camera evaluations so you have the information you need to make an informed decision.

Read on to learn how choosing the Dell Latitude 9420 instead of the Lenovo ThinkPad X1 Carbon Gen 9 can result in a better business user experience.

Dell Latitude 9420

Experience better day-to-day system responsiveness
based on higher SYSmark 25 overall performance rating scores

Work unplugged an hour longer without sacrificing performance
based on higher MobileMark 2018 battery life and performance qualification scores

Get comfortable with a cooler laptop
based on cooler surface temps while plugged in and under a PCMark 10 load

What we tested

The Dell Latitude 9420 and Lenovo ThinkPad X1 Carbon Gen 9 laptops we tested were powered by identical Intel Core i7-1185G7 vPro processors and equipped with 16 GB of memory and 512 GB of PCIe® SSD storage. The Dell Latitude 9420 came equipped with a 60Whr battery and the Lenovo ThinkPad X1 Carbon Gen 9 came equipped with a 57whr battery—the closest batteries we could find.

For the plugged in tests, we set the Windows power mode sliders on both laptops to "Best performance" as best practices for benchmarks that run on AC power. For MobileMark 2018—a battery life benchmark that runs on DC power, we left these power mode sliders in the default "Better performance"position. These are Windows-specific settings which are separate from the Dell- and Lenovo-specific thermal management settings we discuss in this report.

The Lenovo ThinkPad Xi Carbon Gen 9 default thermal management setting while plugged in is *Maximize Performance* and *Balanced* when the laptop is unplugged. The Dell Latitude 9420 default thermal management setting is always *Optimized Mode.* In all head-to-head test scenarios, we left the laptops in their default thermal management settings.

In addition to head-to-head laptop testing, we also explored the adaptive thermal management modes available on the Dell Latitude 9420. Next to each head-to-head test result on the following pages, we also show how switching to different Latitude 9420 adaptive thermal management modes affected its performance, temperature, and noise balance. We talk more about adaptive thermal management on page 3.

Small conveniences make big differences

- 16:10 aspect ratio with ComfortView+, designed to reduce blue-light emissions[1]

- SafeShutter, which automatically syncs with your video-conferencing apps if you give it permission to do so[2]

- Dell Optimizer 2.0, which includes ExpressConnect, Intelligent Audio, ExpressResponse, ExpressCharge, and Express Sign-In.[3]

- HD Camera with IPU 6 for clearer video quality

- Wi-Fi 6E, Bluetooth 5.2, and optional Qualcomm 5G modem connectivity

- HDMI 2.0, 1 USB-A port, 2 Thunderbolt 4 ports, and a MicroSD slot

- Optional fingerprint reader integrated into the power button

For more information on the Dell Latitude 9420, visit: https://www.dell.com/en-us/work/shop/2-in-1-laptops-tablets/latitude-9420-laptop-or-2-in-1/spd/latitude-14-9420-2-in-1-laptop.

Bigger is not always better

Both laptops we tested have 14-inch displays with 1,920 x 1,200 resolution, but the Dell Latitude 9420 laptop body is smaller, resulting in a smaller bezel. The larger bezels on the Lenovo ThinkPad X1 Carbon Gen 9 mean a bulkier-looking and potentially more distracting display. To see all the measurements we used to come to this figure, check out the science behind the report.
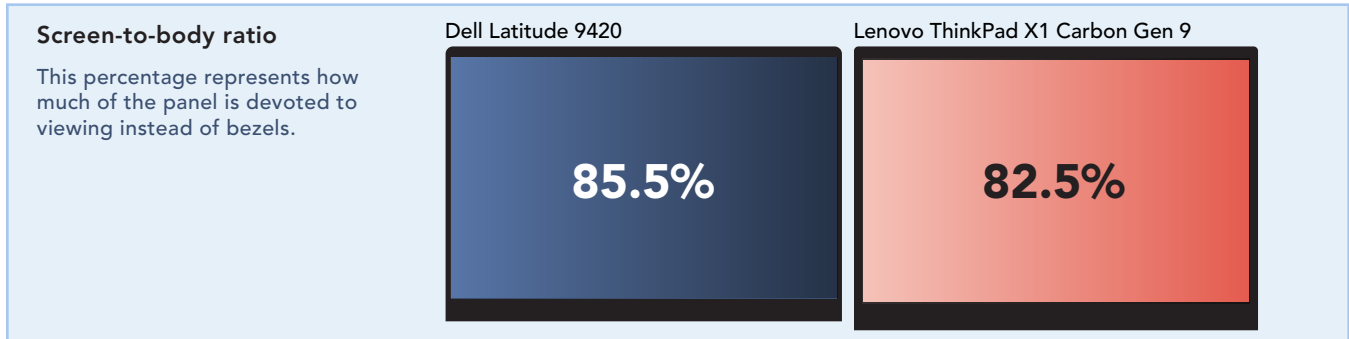
Screen-to-body ratio

This percentage represents how much of the panel is devoted to viewing instead of bezels.

Dell Latitude 9420

85.5%

Lenovo ThinkPad X1 Carbon Gen 9

82.5%

Figure 1: Screen-to-body ratios. Source: Principled Technologies.

Dialing in thermal management preferences

As mentioned on page 2, we set the Windows power mode slider on both Windows 10 Pro business laptops to best performance. However, Dell Latitude 9420 users can also dial in the performance, noise, and temperature balance that best suits their specific use preferences. The default thermal management setting is *Optimized Mode*, but you can configure these thermal settings (like we did in performance, temperature, and sound comparisons) using the Dell Power Manager application or in the BIOS.

Optimized Mode
is the default setting.
It balances performance,
noise, and temperature.

Cool Mode
prioritizes lower temperatures over
performance and noise. It is a good
option for people who work with
their computers on their laps.

Quiet Mode
is designed for spaces
where noise is a concern.

Ultra Performance Mode
prioritizes high performance over
temperature and noise. It is ideal for
multi-taskers or anyone using
graphics-intensive programs.[4]

At the time of testing, the Lenovo ThinkPad X1 Carbon Gen 9 used Adaptive Thermal Management to automatically switch between *Maximize Performance* (reduces CPU throttling) and *Balanced* (balances performance, noise, and temperature). The default plugged in thermal management setting was *Maximize Performance*. The default unplugged thermal management setting was *Balanced*.[5]

We note in each graph and caption which Dell- and Lenovo-specific thermal management setting was enabled on each laptop during that particular test.

Unlock productivity

There is no single advantage that can guarantee productivity. However, one near-universal factor in productivity is system responsiveness. The faster a system pulls up the website you're looking at or loads the apps you use every day, the more time you have to focus on the tasks in front of you. We found that the Dell Latitude 9420 handled SYSmark 25 application-based scenarios better than the similarly configured Lenovo ThinkPad X1 Carbon Gen 9.

Experience better day-to-day system responsiveness

SYSmark 25 overall performance rating
Higher is better

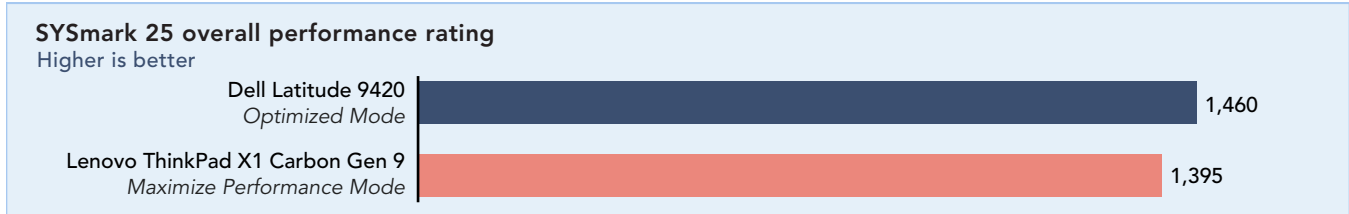|	
Dell Latitude 9420 *Optimized Mode*	1,460
Lenovo ThinkPad X1 Carbon Gen 9 *Maximize Performance Mode*	1,395

Figure 2: SYSmark 25 overall performance ratings with Windows power modes set to best performance and Dell and Lenovo thermal management settings left in default modes. Both devices were plugged in for these tests. Higher is better. Source: Principled Technologies.

But most of us don't work in a bubble—we need to meet with teammates and present our ideas to clients. So, the faster you can start a video-conferencing call or edit a spreadsheet before sending it off for approval, the more seamless your brainstorming sessions can be. We found that the Dell Latitude 9420 ranked slightly better in PCMark 10 overall ratings than the Lenovo ThinkPad X1 Carbon Gen 9.

Facilitate collaboration efforts

PCMark 10 overall rating
Higher is better

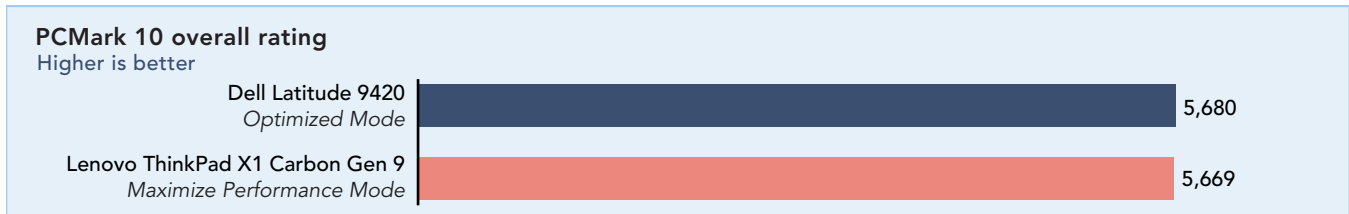|	
Dell Latitude 9420 *Optimized Mode*	5,680
Lenovo ThinkPad X1 Carbon Gen 9 *Maximize Performance Mode*	5,669

Figure 3: PCMark 10 overall ratings with Windows power modes set to best performance and Dell and Lenovo thermal management settings left in default modes. Both devices were plugged in for these tests. Higher is better. Source: Principled Technologies.

For users who don't want to be tied to an outlet or are constantly on the move from one meeting to another, an extra hour of battery life that doesn't negatively impact system responsiveness can also be a productivity lifesaver. We found that the Dell Latitude 9420 delivered over thirteen hours of strong, unplugged performance.

Work unplugged for an hour longer without sacrificing performance

MobileMark 2018 benchmark results

Overall performance qualification and corresponding battery life. Higher scores and more time is better.

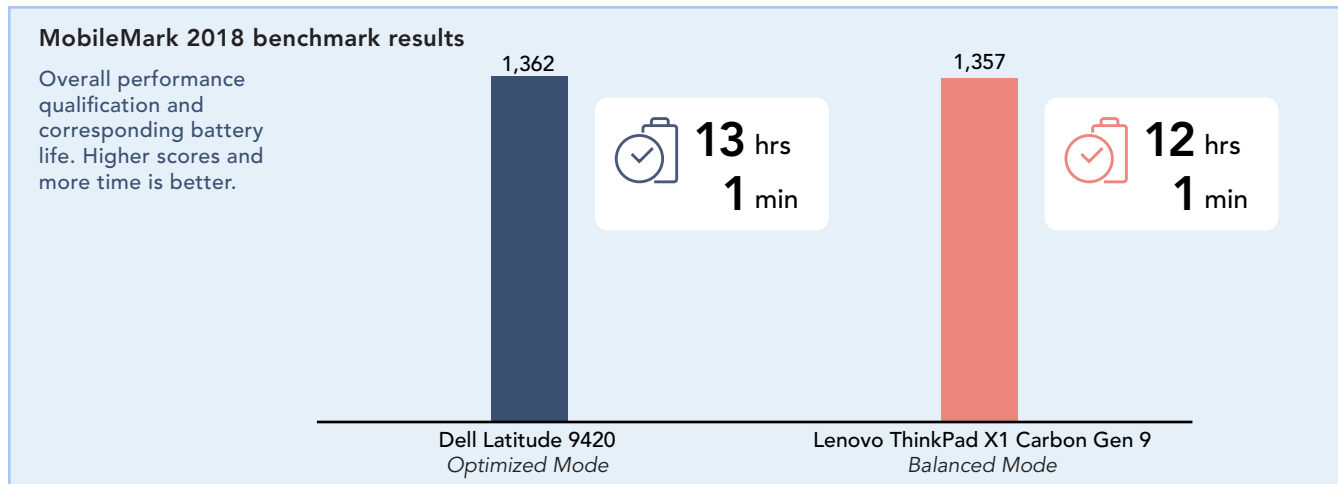|	Dell Latitude 9420 *Optimized Mode*	Lenovo ThinkPad X1 Carbon Gen 9 *Balanced Mode*
Score	1,362	1,357
Time	13 hrs 1 min	12 hrs 1 min

Figure 4: MobileMark 2018 benchmark results with Windows power modes set to better performance and Dell and Lenovo thermal management settings left in default modes. Both devices were unplugged for these tests. Time (hh:mm). More time and higher overall performance qualification scores are better. Source: Principled Technologies.

Unlock capability

While you may not render 3D images on your business computer, knowing your system can handle something as complex and resource-intensive as 3D rendering might make you feel confident about whatever your inbox will bring your way. For this comparison, we used Cinebench R23, a benchmark that measures both single-core and multi-core hardware capabilities. Complex spreadsheets, photo and video editing apps, scientific simulation software, graphics-intensive games, and 3D modeling and rendering programs rely on multi-core performance.[6] In our tests, both laptops performed comparably in single-core and multi-core scenarios. For context, CGDirector claims that gamers need a device that scores above 1,000 Cinebench R23 single-core points.[7] We also dialed in the *Ultra Performance Mode* option under thermal management preferences on the Dell Latitude 9420 and ran the benchmark again.

Cinebench R23 scores
Higher is better

Single-core

Dell Latitude 9420 *Optimized Mode*	1,489
Lenovo ThinkPad X1 Carbon Gen 9 *Maximize Performance Mode*	1,441

Multi-core

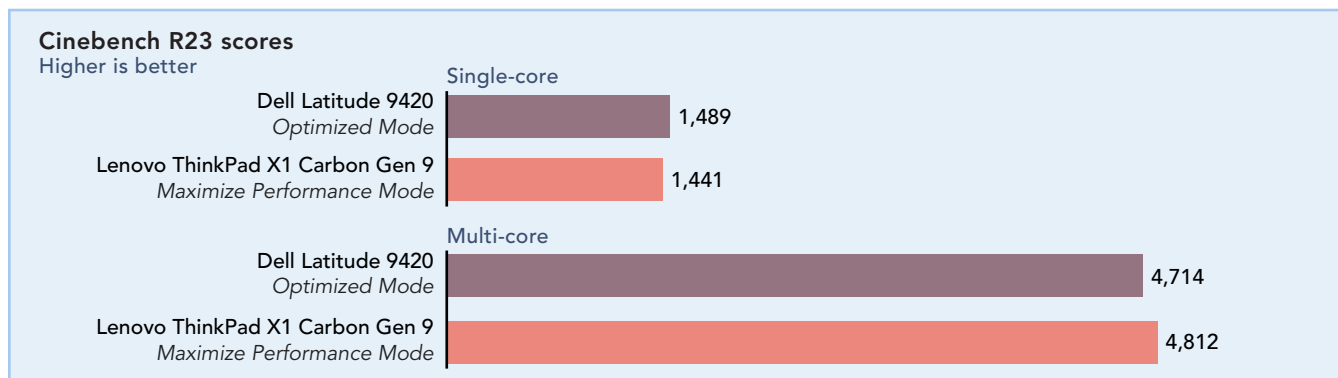|	
Dell Latitude 9420 *Optimized Mode*	4,714
Lenovo ThinkPad X1 Carbon Gen 9 *Maximize Performance Mode*	4,812

Figure 5: Single-core and multi-core Cinebench 23 scores with Windows power modes set to best performance and Dell and Lenovo thermal management settings left in default modes. Both devices were plugged in for these tests. Higher is better. Source: Principled Technologies.

Cinebench R23 scores
Higher is better

Single-core

Dell Latitude 9420
Ultra Performance Mode — 1,516

Dell Latitude 9420
Optimized Mode — 1,489

Multi-core

Dell Latitude 9420
Ultra Performance Mode — 5,316

Dell Latitude 9420
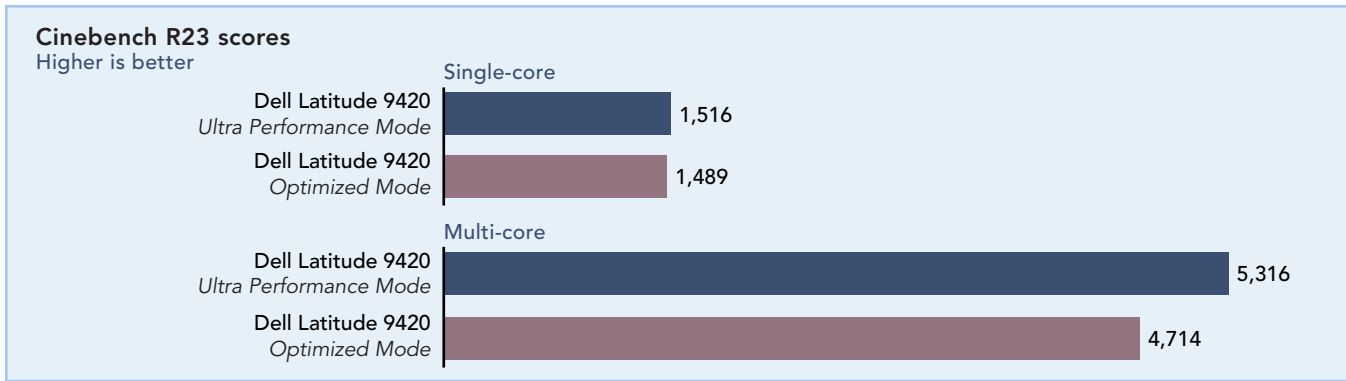*Optimized Mode* — 4,714

Figure 6: Single-core and multi-core Cinebench 23 scores with the Windows power mode set to best performance and Dell thermal management settings labeled. The Dell Latitude 9420 was plugged in during these tests. Source: Principled Technologies.

Get comfortable with a cooler laptop

Configuring your laptop with a high-performing processor, such as the Intel Core i7-1185G7 vPro processor in both business laptops we tested, can result in more noticeable heat on the surface of the device during resource-intensive tasks. To measure the difference Latitude 9420 thermal settings make, we also ran the resource-intensive PCMark 10 benchmark on the Latitude 9420 and took its temperatures twice: once when we left the Latitude 9420 thermal preference in *Optimized Mode* and once when we set it to *Cool Mode*.

Thermal performance during PCMark 10

Hot spot degrees (F) above room temperature while plugged in and running PCMark 10. Lower temperatures are better.

Top
22.1°F
12.3°C

Bottom
24.0°F
13.3°C

Top
29.3°F
16.3°C

Bottom
27.6°F
15.3°C

Dell Latitude 9420
Optimized Mode

Lenovo ThinkPad X1 Carbon Gen 9
Maximize Performance Mode
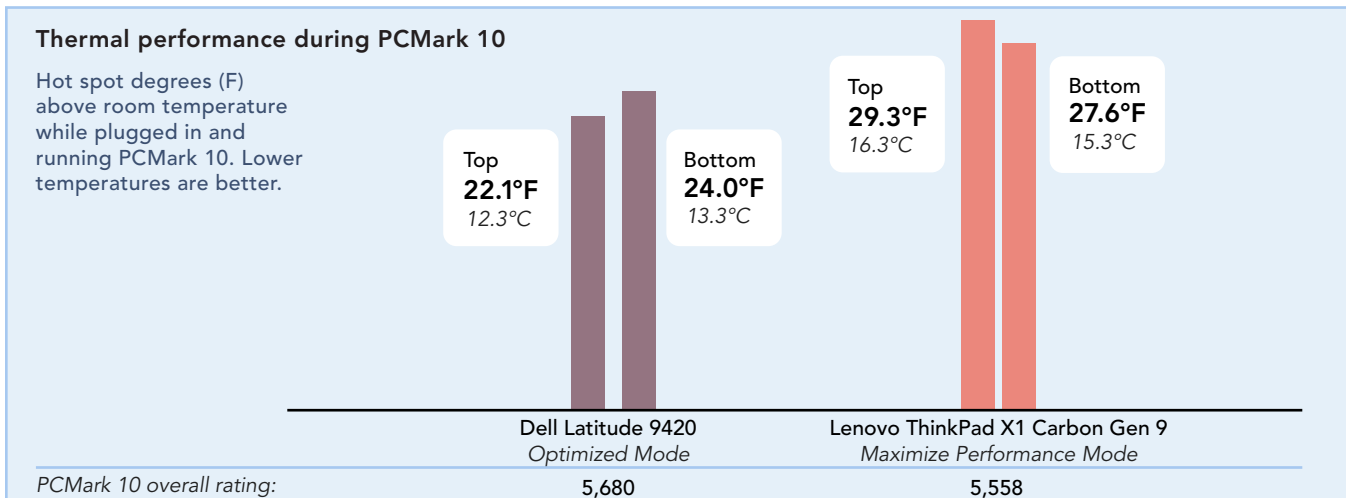
PCMark 10 overall rating:　　　　5,680　　　　　　　　5,558

Figure 7: Hot spot temperatures (F) above room temperature (lower is better) and corresponding PCMark 10 overall ratings (higher is better) with Windows power modes set to best performance and Dell and Lenovo thermal management settings left in default modes. Both devices were plugged in for these tests. Source: Principled Technologies.
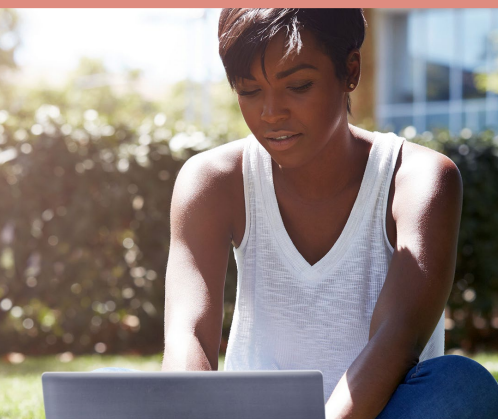
Comparing hardware capabilities, system responsiveness, acoustics, and battery life with benchmarks

Cinebench R23, SYSmark 25, PCMark 10, and MobileMark 2018 benchmarks put devices through real-world workloads based on activities business users encounter on a daily basis.[8,9,10,11] The battery life and benchmark scores we report reflect the specific configurations we tested. Any difference in the configurations you test, as well as screen brightness, network traffic, or software additions, can affect these results. For a deeper dive into our testing parameters and procedures, read the science behind the report.
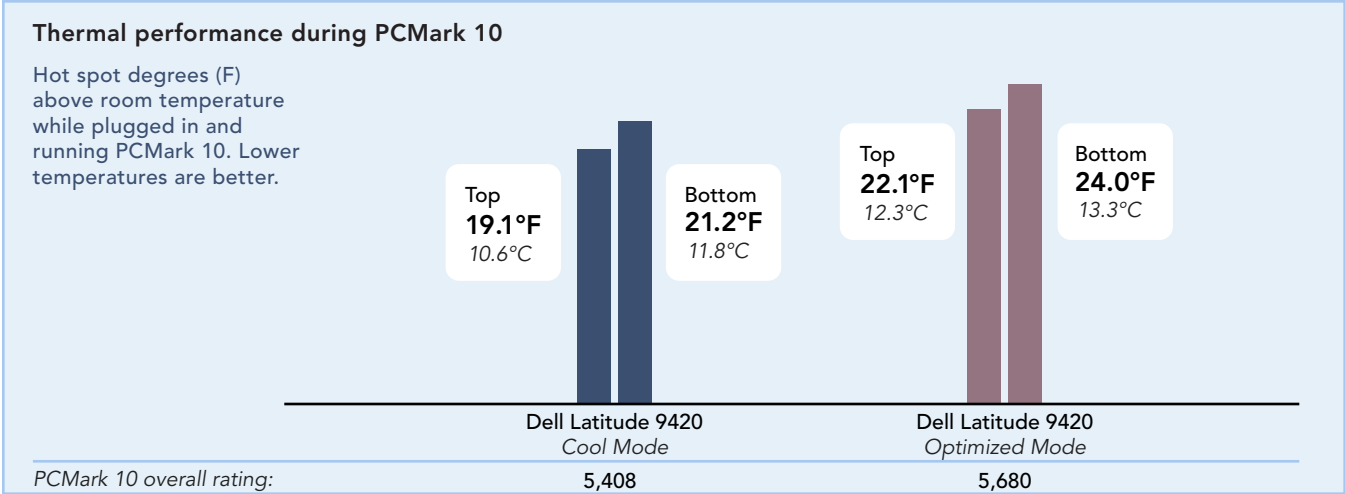
Thermal performance during PCMark 10

Hot spot degrees (F) above room temperature while plugged in and running PCMark 10. Lower temperatures are better.

Top **19.1°F** *10.6°C*

Bottom **21.2°F** *11.8°C*

Top **22.1°F** *12.3°C*

Bottom **24.0°F** *13.3°C*

Dell Latitude 9420
Cool Mode

Dell Latitude 9420
Optimized Mode

PCMark 10 overall rating: 5,408   5,680

Figure 8: Hot spot temperatures (F) above room temperature (lower is better) and corresponding PCMark 10 overall ratings (Higher is better) during these tests. Windows power mode set to best performance and Dell thermal management settings labeled. The Latitude 9420 was plugged in during these tests. Source: Principled Technologies.

Not a fan of laptop noise?

Being able to manage your laptop's processor and cooling fan settings to suit your personal preferences can have a positive impact on the time you spend in front of your laptop. As an example, rustling leaves or a whisper deliver noise levels of 20 dB and a library registers at 40 dB.[12] We also dialed in the *Quiet Mode* option under thermal management preferences on the Dell Latitude 9420 and ran the benchmark again.

Acoustic output while plugged in during PCMark 10
Lower is better

Extech SDL600 Sound Level Meter measurements (decibels)

PCMark 10 overall rating:

Dell Latitude 9420
Optimized Mode   24.4   5,680

Lenovo ThinkPad X1 Carbon Gen 9
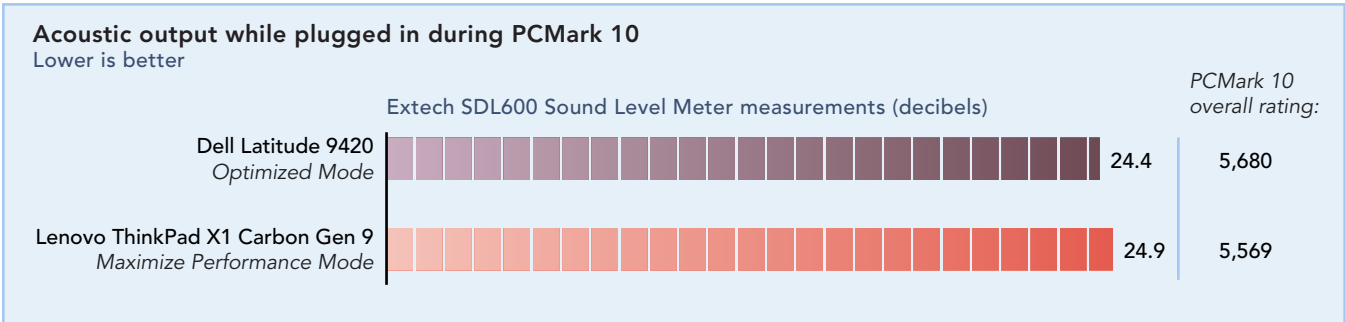*Maximize Performance Mode*   24.9   5,569

Figure 9: Extech SDL600 Sound Level Meter measurements (decibels, lower is better) and corresponding PCMark10 overall ratings (higher is better) during these tests. Windows power modes set to best performance and Dell and Lenovo thermal management settings left in default modes. Both devices were plugged in during these tests. Source: Principled Technologies.
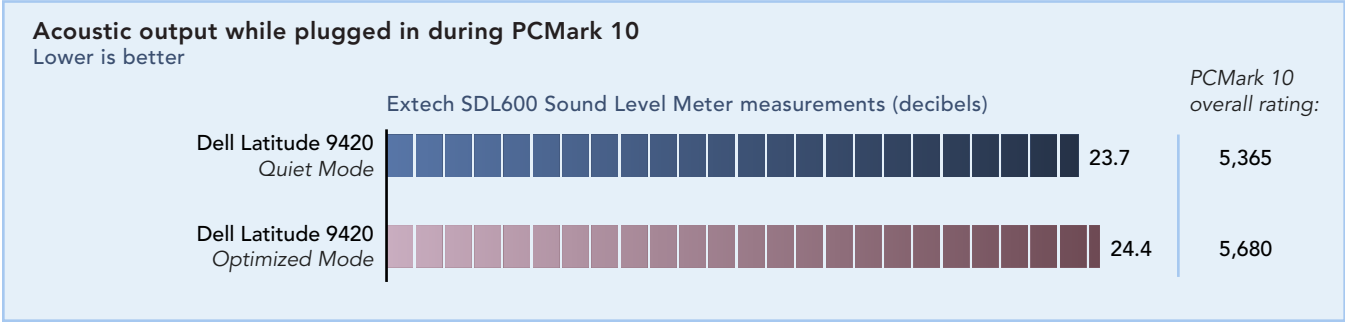
Acoustic output while plugged in during PCMark 10
Lower is better

Extech SDL600 Sound Level Meter measurements (decibels)

PCMark 10 overall rating:

Dell Latitude 9420
Quiet Mode   23.7   5,365

Dell Latitude 9420
Optimized Mode   24.4   5,680

Figure 10: Extech SDL600 Sound Level Meter measurements (decibels, lower is better) and corresponding PCMark 10 overall ratings (higher is better) during these tests. Windows power mode set to best performance and Dell thermal management settings labeled. The Latitude 9420 was plugged in during these tests. Source: Principled Technologies.

Are you ready for your closeup?

Picture quality assessment is subjective. So, here are two selfies, taken by a PT engineer, using the IR webcams pre-installed on both the Dell Latitude 9420 and the Lenovo ThinkPad X1 Carbon Gen 9. Note: The Latitude 9420 came equipped with Intel IPU 6 (Image Processing Unit) camera technology, which means users can adjust picture settings like brightness, HDR (High Dynamic Range), ISO, and shutter speed.[13] At the time of testing, the Lenovo ThinkPad X1 Carbon Gen 9 did not have Intel IPU 6 camera technology.[14]

You be the judge—which IR webcam delivers a better-quality image?

Figure 11: Unedited selfie taken in a well lit room (~785 lux) on the Dell Latitude 9420. Source: Principled Technologies.

Figure 12: Unedited selfie taken in a well lit room (~785 lux) on the Lenovo ThinkPad X1 Carbon Gen 9. Source: Principled Technologies.

Conclusion

No matter where you're working from, the computer you're working on can help or hinder you. In our hands-on comparison of a Dell Latitude 9420 laptop and a similarly configured Lenovo ThinkPad X1 Carbon Gen 9 laptop, we found that the Dell Latitude 9420 has the potential to provide a better day-to-day experience. In our tests, the Dell Latitude 9420 laptop ran longer unplugged; received higher hardware capability and system responsiveness benchmarks scores; and ran cooler under a resource-intensive load than the Lenovo ThinkPad X1 Carbon Gen 9. These wins make the Dell Latitude 9420 a sound choice when shopping for your next business laptop.

1   Dell Technologies, "Latitude 9420 Laptop or 2-in-1," accessed August 26, 2021, https://www.dell.com/en-us/work/shop/2-in-1-laptops-tablets/latitude-9420-laptop-or-2-in-1/spd/latitude-14-9420-2-in-1-laptop.

2   Dell Technologies, "How the Dell SafeShutter Webcam Balances Convenience and Privacy," accessed August 26, 2021, https://www.delltechnologies.com/en-us/blog/how-the-dell-safeshutter-webcam-balances-convenience-and-privacy/.

3   Dell Technologies, "Dell Optimizer." Accessed August 26, 2021, https://www.delltechnologies.com/en-us/work-at-full-speed/optimizer.htm.

4   Dell, "Dell Power Manager User's Guide: Thermal management," accessed August 20, 2021, https://www.dell.com/support/manuals/en-us/power-manager/dpm_ug/thermal-management?guid=guid-d6b7de5c-0b5c-4594-83e6-063ec77ed108&lang=en-us.

5   Lenovo, "ThinkPad X1 Carbon User Guide," accessed August 20, 2021, https://download.lenovo.com/pccbbs/mobiles_pdf/x1_carbon_5th_ug_en.pdf.

6   Spiceworks, "When do more processor cores mean better PC performance?" accessed September 23, 2021, https://community.spiceworks.com/topic/1980594-when-do-more-processor-cores-mean-better-pc-performance

7   CGDirector, "Cinebench R23 Scores [Updated Results]," accessed August 20, 2021, https://www.cgdirector.com/cinebench-r23-scores-updated-results/.

8   Maxon, "Cinebench: Evaluate your computer's hardware capabilities," accessed August 20, 2021, https://www.maxon.net/en/cinebench.

9   BAPCo, "SYSmark 25," accessed August 26, 2021, https://bapco.com/products/sysmark-25/.

10 UL, "PCMark 10," accessed August 20, 2021, https://benchmarks.ul.com/pcmark10.

11 BAPCo, "MobileMark 2018," accessed August 26, 2021, https://bapco.com/products/mobilemark-2018/.

12 IAC Acoustics, "Comparative Examples of Noise Levels," accessed August 26, 2021, https://www.iacacoustics.com/blog-full/comparative-examples-of-noise-levels.html.

13 Dell Technologies, "A snapshot of knowledge: Laptop camera technology," accessed September 16, 2021, https://www.delltechnologies.com/asset/en-us/products/laptops-and-2-in-1s/industry-market/dell-laptop-cameras-whitepaper.pdf.

14 Lenovo, "ThinkPad X1 Carbon Gen 9 (14", Intel)," accessed September 16, 2021, https://www.lenovo.com/us/en/p/laptops/thinkpad/thinkpadx1/x1-carbon-gen9/22tp2x1x1c9.

We concluded our hands-on testing on July 13, 2021. During testing, we determined the appropriate hardware and software configurations and applied updates as they became available. The results in this report reflect configurations that we finalized on May 10, 2021 or earlier. Unavoidably, these configurations may not represent the latest versions available when this report appears.

Our results

To learn more about how we have calculated the wins in this report, go to http://facts.pt/calculating-and-highlighting-wins.
Unless we state otherwise, we have followed the rules and principles we outline in that document.

Table 1: Results of our testing. Benchmark scores are the median of three runs.

	Dell Latitude 9420 laptop		Lenovo ThinkPad X1 Carbon Gen 9
Screen-to-body ratio dimensional analysis			
Display dimensions: width x height (mm)	303 x 188		303 x 191
Lid dimensions: width x height (mm)	310 x 215		316 x 222
Display area (sq. mm)	56,964		57,873
Lid area (sq. mm)	66,650		70,152
Display percentage of lid (%)	85.5		82.5
Cinebench R23			
Single-core	*Optimized Mode*	*Ultra Performance Mode*	*Maximize Performance Mode*
	1,489	1,516	1,441
Multi-core	4,714	5,316	4,812
SYSmark 25			
Overall performance rating	*Optimized Mode*		*Maximize Performance Mode*
	1,460		**1,395**
Productivity	1,478		1,386
Creativity	1,503		1,446
Responsiveness	1,290		1,273
PCMark 10			
Overall performance rating	*Optimized Mode*		*Maximize Performance Mode*
	5,680		**5,669**
Essentials overall rating	10,410		10,550
Apps start-up	14,261		15,749
Video conferencing	8,174		7,830
Web browsing	9,678		9,525
Productivity rating	**8,641**		**8,591**
Spreadsheets	9,597		9,584
Writing	7,781		7,701

	Dell Latitude 9420 laptop			Lenovo ThinkPad X1 Carbon Gen 9	
PCMark 10 (cont'd)					
Digital content creation rating	*Optimized Mode*			*Maximize Performance Mode*	
	5,530			5,456	
Photo editing	9,738			9,237	
Rendering and visualization	3,372			3,540	
Video editing	5,151			4,967	
MobileMark 2018					
Overall performance qualification	*Optimized Mode*			*Balanced Mode*	
	1,362			1,357	
Productivity	1,294			1,283	
Creativity	1,555			1,538	
Web browsing	1,257			1,266	
Battery life (hh:mm)	**13:01**			**12:01**	
Thermal testing					
PCMark 10 overall performance rating	*Optimized Mode*		*Cool Mode*	*Maximize Performance Mode*	
	5,680		5,408	5,558	
Average top hot-spot temperature (delta from room temperature)	12.3°C	22.1°F	10.6°C	19.1°F	16.3°C	29.3°F
Average bottom hot-spot temperature (delta from room temperature)	13.3°C	24.0°F	11.8°C	21.2°F	15.3°C	27.6°F
Acoustic testing					
PCMark 10 overall performance rating	*Optimized Mode*		*Quiet Mode*	*Maximize Performance Mode*	
	5,680		5,365	5,569	
Noise level (decibels)	24.4		23.7	24.9	

System configuration information

Table 2: Detailed information on the systems we tested.

System configuration information	Dell Latitude 9420 laptop	Lenovo ThinkPad X1 Carbon Gen 9
Processor		
Vendor	Intel	Intel
Name	Core i7	Core i7
Model number	1185G7	1185G7
Core frequency (GHz)	3.0-4.8	3.0-4.8
Number of cores	4	4
Cache	12 MB Intel Smart Cache	12 MB Intel Smart Cache
Memory		
Amount (GB)	16	16
Type	LPDDR4x	LPDDR4x
Speed (MHz)	4266	4266
Graphics		
Vendor	Intel	Intel
Model number	Iris Xe Graphics	Iris Xe Graphics
Storage		
Vendor	Western Digital	Toshiba
Model Number	SN530	KXG6AZNV512G
Amount	512 GB	512 GB
Type	M.2 PCIe NVMe	M.2 PCIe NVMe
Connectivity/expansion		
Wireless internet	Intel Wi-Fi 6E AX210	Intel AX201 Wi-Fi 6
Bluetooth	5.2	5.2
Ports	1 x USB 3.2 Gen 1 port with PowerShare 2 x Thunderbolt 4 ports with DisplayPort Alt Mode/USB4/Power Delivery	2 x USB 4 Type-C with Thunderbolt 4 (DisplayPort / Data Transfer / Power Delivery) 2 x USB-A 3.2 Gen 1
Video	HDMI 2.0	HDMI 2.0
Camera		
Specifications	720p at 30 fps, HD RGB IR camera, Dual-array microphones	720p HD with webcam privacy shutter
Battery		
Type	Lithium-ion	Lithium-ion
Rated capacity (Wh)	60	57

System configuration information	Dell Latitude 9420 laptop	Lenovo ThinkPad X1 Carbon Gen 9
Display		
Size (in.)	14.0	14.0
Type	FHD+	FHD+
Resolution	1,920 x 1,200	1,920 x 1,200
Touchscreen	No	No
Operating system		
Vendor	Microsoft	Microsoft
Name	Windows 10 Pro	Windows 10 Pro
Build number or version	19043.1081	19043.1081
BIOS		
BIOS name and version	Dell 1.4.1 06/04/2021	Lenovo N32ET63W (1.39) 05/14/2021
Dimensions		
Height (in)	0.33-0.54	0.59
Width (in)	12.22	12.38
Depth (in)	8.47	8.72
Weight (lbs.)	3.2	2.49

How we tested

Setting up the laptops

Creating and updating the OEM Windows 10 Pro Image

1. Boot the laptop.
2. To complete installation, follow the on-screen instructions using the default selections when appropriate.
3. In the bottom right corner, click the battery icon, and adjust the Windows Power mode (plugged in) to Best Performance.
4. Set DPI scaling to 100 percent, and set Screen and Sleep options to Never.

   - On the desktop, right-click, and select Display settings.
   - Under the Scale and layout section, select 100 percent for the Change the size of text, apps, and other items option.
   - From the left column, select Power & Sleep.
   - For all power options listed under Screen and Sleep, select Never.

5. Disable User Account Control notifications.

   - Select Windows Start, type UAC, and click Enter.
   - Move the slider control to Never notify, and click OK.

6. Run Windows Update, and install all updates available.
7. Launch the Windows Store app, and install all Store app updates.
8. Launch each vendor proprietary utility app installed on each laptop, and update any drivers or BIOS files.

   - For Dell, run the Dell Command Update utility.
   - For Lenovo, run the Lenovo Vantage utility.
   - To install the latest chipset and graphics drivers available, go to https://www.intel.com/content/www/us/en/support.html.

9. Verify the date and time are correct, and synchronize the laptop clock with the time server.
10. Install Intel CPU Runtime for OpenCL Applications 18.1 for Windows OS (64bit or 32bit) from https://registrationcenter.intel.com/en/forms/?productid=3207&pass=yes.
11. Disable Automatic Windows Update.

    - Right-click Windows Start.
    - Select Computer Management.
    - Select Services and Applications.
    - Select Services.
    - Scroll down, and double-click Windows Update.
    - Click Stop.
    - From the Startup type drop-down menu, select Disabled.

Capturing an image

1. Connect an external HDD to the laptop.
2. Right-click the desktop, and select Personalize→Home→Update & security→Backup→More options→See advanced settings→System Image Backup→Create a system image.
3. Verify that the external HDD is selected as the save drive, and click Next.
4. Verify that all drives are selected to back up, and click Next.
5. Click Start backup.
6. At Do you want to create a system repair disc, select No, and close the dialogs.

Restoring an image

1. Connect an external HDD to the laptop.
2. Press and hold the Shift key while Restarting the laptop.
3. Select Troubleshoot.
4. Select Advanced options.
5. Select System image recovery.
6. Select the User account.
7. Enter the laptop password, and click Continue.
8. Verify that the external HDD is selected, and click Next.
9. Once the recovery has completed, click Finish.

Measuring screen-to-body ratio

1. Measure the display width in mm.
2. Measure the display height in mm.
3. Calculate the display area (width x height) in mm.
4. Measure the width of the lid in mm.
5. Measure the height of the lid in mm.
6. Calculate the area (width x height) of the lid in mm.
7. Calculate the percentage of the lid area that the display area covers.

Measuring performance

Cinebench 23

Setting up the test

1. From the Microsoft Store, download and install Cinebench 23.

Running the test

1. Boot the laptop.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks.`
    - Do not interact with the laptop until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Launch Cinebench 23.
7. Select either CPU (multi-core) or CPU (single core), and click Start.
8. When the test completes, record the result.
9. Wait 15 minutes before re-running.
10. Repeat steps 7 through 9 twice more, and record the median results.

SYSmark 25

Avoiding antivirus software conflicts

SYSmark 25 is not compatible with any virus-scanning software, so we uninstalled any such software present on the laptops before we installed the benchmark.

Avoiding pre-installed software conflicts

SYSmark 25 installs the following applications, which its test scripts employ:

Productivity

- Adobe® Acrobat® Pro DC
- Audacity 2.3.2
- AutoIT 3.3.15.2
- Corel WinZip 24 Enterprise
- Google® Chrome®
- Microsoft Excel 2019
- Microsoft Outlook 2019
- Microsoft PowerPoint 2019
- Microsoft Word 2019
- Shotcut v19.09.14

Creativity

- Adobe Lightroom® Classic CC 2019
- Adobe Premiere® Pro CC 2019 v20.0.6
- Adobe Photoshop® CC 2019 v13.1.5

Responsiveness

- Adobe Acrobat Pro DC
- Adobe Lightroom Classic CC 2019
- Adobe Premiere Pro CC 2019
- Adobe Photoshop CC 2019
- Google Chrome
- Microsoft Excel 2019
- Microsoft Outlook 2019
- Microsoft PowerPoint 2019
- Microsoft Word 2019

If any of these applications already exist on the laptop under test, they could cause problems with the benchmark due to software conflicts. To avoid any such issues, we uninstalled all conflicting pre-installed software applications—including different versions of any of the programs SYSmark 25 uses—before we installed the benchmark.

Using the SYSmark built-in configuration tool

This tool supports three levels of configuration:

1. Only makes changes that are REQUIRED for the benchmark to run.
2. Additionally, makes changes that are RECOMMENDED for repeatable results.
3. Additionally, makes OPTIONAL changes that help ensure best results.

The configuration tool makes the following configuration changes at each of the three levels:

Level 1 - Required

- Disables User Account Control (UAC)
- Set DPI Scaling to 100%
- Disables Low Battery Actions
- Disables Network Proxies
- Disables System Sleep and Hibernate
- Disables Windows Update
- Disables the WinSAT service

Level 2 - Recommended

- Disables User Account Control
- Set DPI Scaling to 100%
- Disables Low Battery Actions
- Disables Network Proxies
- Disables System Sleep and Hibernate
- Disables Windows Update
- Create BAPCo power scheme
- Set Power Plan Type to High Performance
- Set CPU High Performance
- Disables Disk Defrag
- Disables Windows Error Reporting
- Disables Windows Lock Screen
- Disables Windows Pop-ups
- Disables Screen Saver and Monitor Timeout
- Disables Windows Sidebar/Gadgets
- Disables Desktop Slideshow
- Disables Windows Defender
- Disables Windows Firewall
- Set Font Smoothing

Level 3 - Optional

- Disables Hard Disk Timeout
- Disables System Restore
- Ignores Laptop Lid Close
- Enables Dark Mode

We chose the official BAPCo "Run Benchmark" default as outlined in the BAPCo SYSmark2018 User Guide (https://bapco.com/wp-content/uploads/2020/09/BAPCo_SYSmark25_user_guide_v1.4.pdf), which runs the benchmark using the Required and Recommended options.

Setting up the test

1. Install SYSmark 25 with the default options.

Running the test

1. Boot the laptop.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks.`
   - Do not interact with the laptop until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Launch SYSmark 25.
7. Click the Settings Gear icon.
8. Verify that the iterations are set to the default 1.
9. Verify that Conditioning Run is enabled.
10. Enter a name for the benchmark run.
11. To return to the main menu, click Back.
12. Click Run Benchmark.
13. When the benchmark finishes, record the SYSmark 25 benchmark results.
14. Repeat steps 1 through 13 twice more, and record the median results.

MobileMark 2018

Avoiding antivirus software conflicts

MobileMark 2018 is not compatible with any virus-scanning software, so we uninstalled any such software present on the laptops before we installed the benchmark.

Avoiding pre-installed software conflicts

MobileMark 2018 installs the following applications, which its test scripts employ:

Productivity

- Adobe Acrobat Pro DC
- AutoIT 3.3.14.2
- Google Chrome
- Microsoft Excel 2016
- Microsoft OneNote 2016
- Microsoft Outlook 2016
- Microsoft PowerPoint 2016
- Microsoft Word 2016
- Windows Zip

Creativity

- Adobe Photoshop CC
- Adobe Lightroom Classic CC
- CyberLink PowerDirector® 2015

Web Browsing

- Google Chrome
- Microsoft Movies & TV

If any of these applications already exist on the laptop under test, they could cause problems with the benchmark due to software conflicts. To avoid any such issues, we uninstalled all conflicting pre-installed software applications—including different versions of any of the programs MobileMark 2018 uses—before we installed the benchmark.

Adjusting display brightness and power settings

The brightness of a laptop's display affects its battery life. Therefore, BAPCo requires that, before you test with MobileMark 2018, you ensure the brightness of the laptop's monitor is greater than or equal to 200 nits in the center of a completely white screen while the laptop is unplugged and running on battery power. The measurement follows the standards from the Video Electronics Standards Association (www.vesa.org).

We complied with this standard for all our tests by setting each laptop's brightness as close to 200 nits as we could without going below that level. We used the following procedure before we started each test. Note: This procedure assumes we began with the laptop plugged into the power supply.

1. To create a completely blank, white screen, open Microsoft Paint by clicking Start→All Programs→Accessories→Paint.
2. To open the Resize and Skew dialog, press Ctrl+W.
3. Under Horizontal and Vertical, enter `200`, and click OK.
4. Click the View tab.
5. To view a white screen, click Full screen.
6. To allow the screen to warm, wait 45 minutes.
7. Unplug the laptop from the power supply, and measure the display's brightness using a luminance meter in the center of the screen. (We used a Gossen Mavolux5032C luxmeter.)
8. If the reading is below or significantly greater than 200 nits, adjust the screen brightness to as close to 200 nits as you can without going under, and retest:
   a. Click Windows Start.
   b. In the Windows Start search box, type `display settings`
   c. Adjust the slider to change the Display brightness to the correct percentage that produces no less than 200 nits.
9. Allow the laptop to run on battery power for 10 minutes, re-measure the display, and adjust the brightness up or down as necessary.
10. Verify that the laptop saved the brightness setting by plugging in the system, unplugging it, and taking another reading.

Using the MobileMark built-in configuration tool

This tool supports three levels of configuration:

1. Only makes changes that are REQUIRED for the benchmark to run.
2. Additionally, makes changes that are RECOMMENDED for repeatable results.
3. Additionally, makes OPTIONAL changes that help ensure best results.

The configuration tool makes the following configuration changes at each of the three levels:

Level 1 - Required

- Disables User Account Control (UAC)
- Set DPI Scaling to 100%
- Disables Low Battery Actions
- Disables Network Proxies
- Disables System Sleep and Hibernate
- Disables Windows Update
- Enables Windows Search

Level 2 - Recommended

- Create BAPCo power scheme
- Set Power Plan Type to Balanced
- Set CPU Adaptive Mode
- Disables Battery Saver Dimming
- Verifies Battery Saver Threshold
- Disables Disk Defrag
- Disables Windows Error Reporting
- Disables Windows Lock Screen
- Disables Windows Pop-ups
- Disables Screen Saver and Monitor Timeout
- Disables Windows Sidebar/Gadgets
- Disables Desktop Slideshow
- Disables Windows Defender
- Disables Windows Firewall
- Set Font Smoothing

Level 3 - Optional

- Disables Hard Disk Timeout
- Disables System Restore
- Ignores Laptop Lid Close

We chose the official BAPCo "Run Benchmark" default as outlined in the BAPCo MobileMark2018 User Guide (http://bapco.com/wp-content/uploads/2019/03/BAPCo_MobileMark2018_user_guide_v1.3.pdf), which runs the benchmark using the Required and Recommended options.

Setting up the performance-qualified battery life test

1. Verify that the wireless adapter is enabled and connected to a wireless router that is not connected to the internet.
2. Verify that the screen brightness is set to no less than 200 nits.
3. Install MobileMark 2018 with the default options.

Running the performance-qualified battery life test

1. Boot the laptop.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks.`
   - Do not interact with the laptop until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Launch MobileMark 2018.
7. Click the Settings Gear icon.
8. Verify that Conditioning Run is enabled.
9. Enter a name for the benchmark run.
10. To return to the main menu, click Back.
11. Click Run Benchmark.
12. When prompted, unplug the AC power adapter. The test will begin immediately.

When the laptop has fully depleted its battery and is no longer operational when running on battery power, the benchmark is complete.

We executed the MobileMark 2018 benchmark three times on the laptop and took the median performance score run as the representative battery life result for that test.

PCMark 10

Setting up the test

1. Purchase and download the PCMark 10 benchmark from https://benchmarks.ul.com/pcmark10.
2. Install PCMark 10.
3. Launch PCMark 10.
4. Enter the license key.
5. Exit PCMark.

Running the test

1. Boot the laptop.
2. Select Windows Start.
3. Type `cmd`, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks.`
   - Do not interact with the laptop until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Launch PCMark 10.
7. Click Run to begin the test.
8. When the test completes, record the results.
9. Repeat steps 1 through 8 twice more, and record the median results.

Measuring acoustics

These tests requires the following items:

- Extech SDL600 Sound Level Meter/Datalogger with SD card
- PCMark 10

Setting up the test

1. Place the laptop under test in a sound-proofed professional sound booth.
2. Set the Extech SDL600 on a tripod so that it is 30 centimeters in front of and 40 centimeters above the laptop under test.

Measuring acoustics while idle

Running the test

1. Boot the laptop.
2. Select Windows Start.
3. Type cmd, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`
    - Do not interact with the laptop until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Start the Extech SDL600 Sound Level Meter/Datalogger and allow the laptop to run at idle for 20 minutes.
7. At the end of the 20 minutes, stop the Extech SDL600 and record the average Idle (dB).
8. Shut down the laptop.
9. Repeat steps 1-8 two more times.

Measuring acoustics while running PCMark 10

Setting up the test

1. Purchase and download the PCMark 10 benchmark from https://benchmarks.ul.com/pcmark10.
2. Install PCMark 10.
3. Launch PCMark 10.
4. Enter the license key.
5. Exit PCMark.

Running the test

1. Boot the laptop.
2. Select Windows Start.
3. Type cmd, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`
    - Do not interact with the laptop until the command completes.
5. After the command completes, wait five minutes before running the test.
6. Launch PCMark 10.
7. In PCMark 10, simultaneously start the Extech SDL600 Sound Level Meter/Datalogger and click Run.
8. At the end of the PCMark 10 run, stop the Extech SDL600, and record the average sound level (dB) while running PCMark 10.
9. Shut down the laptop for 20 minutes and let it return to room temperature.
10. Repeat steps 1 through 9 two more times.

Measuring surface temperatures of the laptop while running PCMark 10

This test requires the following items:

- • FLIR i7 Thermal Imaging Camera
- • Fluke NetDAQ 2680A Data Acquisition System
- • PCMark 10

Measuring the thermal profile of the laptops as they run a performance benchmark requires two specialized tools: a FLIR® i7 thermal imaging camera with FLIR Tools and a Fluke® NetDAQ® 2680A Data Acquisition System with Type-T thermocouples, which includes both a hardware device and software that runs on a controller PC.

A thermocouple is a junction between two different metals that produces a voltage related to a temperature difference. We used Type-T thermocouples, which are suited for measurements in the −200° to 350°C range. We used the FLIR I7 to Identify the hot spot areas to place the Type T thermocouples.

Data acquisition (DAQ) is the process of sampling signals that measure real-world physical conditions, in this case, temperature. For our testing, we installed the Fluke DAQ software on a controller PC connected via Ethernet to the NetDAQ device. Five Type T thermocouples connect to the NetDAQ through a 20-channel input module, and attach to a test point on each laptop under test, and an extra probe measured the ambient air temperature. Each of these five channels are configured and controlled using the Fluke DAQ software installed on the controller PC. As each benchmark runs, the NetDAQ logs, in real time, the temperature of each of the five test points. After each run, the NetDAQ log is exported to Excel.

We reviewed the output from the NetDAQ and learned how much the surface temperature rises above ambient temperature when the laptop runs performance benchmarks.

Setting up the laptop

1. Place the laptop in a climate-controlled room.
2. In order to determine where to place the type-t thermocouple probes run Cinebench R23 for 1 hour and use the FLIR i7 thermal imaging camera to identify the monitored locations.
3. Attach a type-t thermocouple to each laptop in the locations that is being monitored.
4. Configure the Fluke NetDAQ 2680A Data Acquisition System to take measurements from the four surface temperature probes and one ambient temperature probe using the Fluke DAQ software.
5. Connect the five type-t thermocouples to five channels in the Fluke Fast Analog Input module (FAI).
6. In the Fluke DAQ software, click each surface temperature channel, select Thermocouple from the list of Functions, and choose T from the list of ranges.
7. Label each channel with the laptop associated with each thermocouple.
8. In the Fluke DAQ software, click the ambient temperature channel, select Thermocouple from the list of Functions, and choose T from the list of ranges.
9. Label this channel Ambient.
10. While running each test, use a Fluke 2680A Data Acquisition System to monitor ambient and surface temperature.

Setting up the test

1. Purchase and download the PCMark 10 benchmark from https://benchmarks.ul.com/pcmark10.
2. Install PCMark 10.
3. Launch PCMark 10.
4. Enter the license key.
5. Exit PCMark.

Running the test

1. Boot the laptop.
2. Select Windows Start.
3. Type cmd, and press Ctrl+Shift+Enter.
4. Type `Cmd.exe /c start /wait Rundll32.exe advapi32.dll,ProcessIdleTasks`

    • Do not interact with the laptop until the command completes.

5. After the command completes, wait five minutes before running the test.
6. Start the Fluke 2680A data logger using the Fluke DAQ software.
7. Launch PCMark 10.
8. Click Run.
9. When PCMark 10 has finished, stop the Fluke 2680A data logger using the Fluke DAQ software.
10. Save the thermal measurement data to a CSV file.
11. To find and report the average temperature measured at each location during the test, Use the thermal measurement CSV file.
12. Shutdown the laptop under test for 20 minutes before starting the next run.
13. Repeat steps 1 through 12 twice more.

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