



The science behind the report:

Dell Precision 5690: Accelerate AI workloads, speed creative workflows, and support sustainability goals

This document describes what we tested, how we tested, and what we found. To learn how these facts translate into real-world benefits, read the report [Dell Precision 5690: Accelerate AI workloads, speed creative workflows, and support sustainability goals](#).

We concluded our hands-on testing on July 16, 2024. 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 30, 2024 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 on the two systems.

	Dell™ Precision™ 5690	Apple® MacBook Pro® 16"
Geekbench ML - higher is better		
ONNX - DirectML (GPU) score	12,821	N/A
CoreML - GPU score	N/A	10,515
MLPerf ResNet50 Benchmark (TensorRT/Tensorflow) - higher is better		
Queries per second	8,417.88	124.70
Stable Diffusion - Generate Image From Text (txt2img) - lower is better		
Time to generate image (seconds)	542.6	1,027.2
Adobe Premiere Pro 24.5 - Enhance Speech - lower is better		
Time to process Enhance Speech on 1-minute .MOV (seconds)	4.4	15.2
Autodesk Maya 2025 - Render sequence test - lower is better		
Time to render sequence (h:mm:ss)	0:19:13.8	1:19:31.3

	Dell™ Precision™ 5690	Apple® MacBook Pro® 16"
WebXPRT - higher is better		
Benchmark score	340	318
Procyon AI Computer Vision		
Overall score - higher is better	809	587
MobileNetv3 - average inference time (ms) - lower is better	0.64	1.07
ResNet-50 - average inference time (ms) - lower is better	1.77	2.80
Inceptionv4 - average inference time (ms) - lower is better	5.47	8.93
DeepLabv3 - average inference time (ms) - lower is better	6.5	6.63
YOLOv3 - average inference time (ms) - lower is better	6.31	8.94
REAL-ESRGAN - average inference time (ms) - lower is better	218.07	240.07

Table 2: Results of our Copilot testing on the Dell Precision 5690. We did not test the Apple MacBook Pro 16".

	Time to execute prompts (seconds)
Workflow 1	
Reviewing weekly agenda	31.75
Summarizing email thread	22.62
Generating draft email	33.56
Total	87.93
Workflow 2	
Conducting market research	36.22
Drafting project proposal	27.25
Generating social media plan	25.07
Total	88.54
Workflow 3	
Generating presentation template	27.12
Adding a new slide	13.47
Adding animations to slides	7.6
Total	48.19

Table 3: Results of our serviceability testing. Lower is better.

	Dell Precision 5690	Apple MacBook Pro 16"	Percent Difference
Fan			
Removing and replacing fan - Median	07:34.8	56:27.4	86.57%
Number of steps required to remove and replace fan	14	79	82.28%
Battery			
Removing and replacing battery - Median	07:53.3	35:13.7	77.61%
Number of steps required to remove and replace battery	14	31	54.84%
Storage			
Removing and replacing storage - Median	06:32.2	N/A	-
Number of steps required to remove and replace storage	10	N/A	-
Heatsink			
Removing and replacing heatsink - Median	07:43.3	55:58.8	86.21%
Number of steps required to remove and replace heatsink	8	78	89.74%

System configuration information

Table 4: Detailed information on the systems we tested.

System configuration information	Dell Precision 5690	Apple MacBook Pro 16" (Nov 2023)
Processor		
Vendor	Intel®	Apple
Model number	Core™ Ultra 9 processor 185H	M3 Max
Core frequency (GHz)	E-cores: up to 3.80 P-cores: up to 5.10 Low Power Efficient-cores: up to 2.5	2.75 – 4.05 GHz
Number of cores	16	16
Logical processors	22	N/A
Memory		
Amount (GB)	32	48
Type	LPDDR5x	Unified
Graphics		
Vendor	NVIDIA®	Apple
Model number	RTX™ 3500 Ada	M3 Max 40-core GPU
Storage		
Amount (TB)	1	1
Type	SSD	SSD
Connectivity/expansion		
Wireless internet	Intel WiFi 7 BE200 (802.11be)	WiFi 6E (802.11ax)
Bluetooth	5.3	5.3
USB	1x SD card reader 1x USB 3.2 Gen 2 Type-C port 2x Thunderbolt™ 4 ports	1x SDXC card 3x Thunderbolt 4 ports
Battery		
Type	Integrated lithium-ion	Integrated lithium-polymer
Rated capacity (Whr)	100	100
Display		
Size (in.)	16	16.2
Resolution	1920 x 1200	3456 x 2234
Dimensions		
Height (in.)	0.87	0.66
Width (in.)	13.92	14.01
Depth (in.)	9.46	9.77
Weight (lb.)	4.46	4.8

How we tested

Setting up the system (Windows)

Setting up and updating the OEM image

1. Boot the system.
2. Follow the on-screen instructions to complete installation, using the default selections when appropriate.
3. Set the Windows (plugged in) Power Mode to Best Performance.
4. Set Screen and Sleep options to Never:
 - a. Right-click the desktop, and select Display settings.
 - b. Select System from the left column.
 - c. Click Power & Battery.
 - d. For all power options listed under Screen and Sleep, select Never.
5. Disable User Account Control notifications:
 - a. Select Windows Start, type UAC, and press the Enter key.
 - b. Move the slider control to Never notify, and click OK.
6. Run Windows Update, and install all updates available.
7. Run the Dell Command Update utility, and install all recommended BIOS/driver updates available.
8. Verify the date and time are correct, and synchronize the system clock with the time server.
9. Pause Automatic Windows Updates:
 - a. Click the Windows Start button.
 - b. Type Windows Update settings and press the Enter key.
 - c. From the Pause updates drop-down menu, select Pause for 5 weeks.

Capturing an image

1. Connect an external HDD to the system.
2. Click Windows Menu button, and type Control Panel in the search bar. Click Control Panel → System and Security → Backup and Restore (Windows 7) → 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. When you see the prompt to create a system repair disc, select No, and close the dialogs.

Restoring an image

1. Connect an external HDD to the system.
2. Press and hold the Shift key while restarting the system.
3. Select Troubleshoot.
4. Select Advanced options.
5. Select See more recovery options.
6. Select System image recovery.
7. Select the User account.
8. Enter the system password, and click Continue.
9. At the Restore system files and settings screen, select Next.
10. Verify that the external HDD is selected, and click Next.
11. Once the recovery has completed, click Finish.

Setting up the system (macOS)

Setting up and updating the OEM image

1. Boot the system.
2. Follow the on-screen instructions to complete installation, using the default selections when appropriate.
3. Set Screen and Sleep options to Never:
 - a. Select System Settings.
 - b. Select Lock Screen.
 - c. Change the following options to Never:
 - Start Screen Saver when inactive.
 - Turn display off on battery when inactive.
 - Turn display off on power adapter when inactive.
 - Require password after screen saver begins or display is turned off.
 - d. Return to System Settings, and select Battery.
 - e. Set On power adapter setting to High Power.
 - f. Click Options.
 - g. Disable the Slightly dim the display on battery option.
4. Disable automatically adjust brightness:
 - a. Select System Settings.
 - b. Select Display.
 - c. Disable Automatically adjust brightness.
5. Run Software Update, and install all updates available.
6. Verify the date and time are correct.
7. Enable Automatic log in:
 - a. Select System Settings.
 - b. Click Users & Groups.
 - c. Select the drop-down menu next to the Automatically log in as setting, and select the User account.
8. Disable Automatic Mac Updates:
 - a. Select System Settings.
 - b. Click General.
 - c. Click Software Update.
 - d. Click the information icon next to Automatic updates.
 - e. Disable Check for updates.

Capturing an image

1. Connect an external HDD to the system.
2. Click the Apple menu button, and select System Settings.
3. Select General, and select Time Machine.
4. Click Add Backup Disk, and select the drive. Wait for the initial backup to complete.
5. Click Options.
6. Set Backup Frequency to Manually.
7. Click Done.

Restoring an image

1. Connect an external HDD to the system.
2. Launch Finder ,and click Go → Utilities on the menu bar.
3. Click Migration Assistant.
4. Click Continue.
5. Ensure the backup HDD is selected, and click Continue.
6. Select the backup created previously, and click Continue.
7. Ensure all boxes are checked, and click Continue.
8. After the backup restore is completed, click Quit.

Testing with the WebXPRT 4 benchmark

Running the test (Windows & macOS)

1. Open the web browser under test (Edge for the Windows system, and Safari for the macOS system), and go to <https://www.principledtechnologies.com/benchmarkxprt/webxprt/>.
2. Click Run WebXPRT 4.
3. At the Ready to test your browser screen, click Continue.
4. Click Start.
5. When the test completes, record the results.
6. Click Run Again, and click Start to rerun WebXPRT. Record the results.
7. Repeat step 6 two more times.

Testing with ResNet-50 (Windows)

Setting up the test

1. Launch PowerShell as an administrator.
2. Enable WSL2 and reboot when prompted:

```
Enable-WindowsOptionalFeature -online -featurename Microsoft-Hyper-V-All,VirtualMachinePlatform,Microsoft-Windows-Subsystem-Linux
```

3. Update WSL2:

```
wsl --update
```

4. Update to pre-release (for us, this was 2.2.4):

```
wsl --update --pre-release
```

5. Install Ubuntu 22.04:

```
wsl -install Ubuntu-22.04
```

6. Enter `sudo nano /etc/profile` and add the following to the end of the file:

```
export PATH="/home/ptuser/.local/bin:$PATH"
```

7. Update apt:

```
sudo apt update && sudo apt upgrade -y
```

8. Exit, and start a new session.

9. Install packages:

```
sudo apt install python3 python3-pip python3-venv git wget curl zlib1g unzip -y
```

10. Install and test CM:

```
python3 -m pip install cmind  
cm test core
```

11. Remove any previous Docker packages:

```
for pkg in docker.io docker-doc docker-compose docker-compose-v2 podman-docker containerd runc; do  
sudo apt-get remove $pkg; done
```

12. Add Docker GPG key and install and test Docker:

```
sudo apt-get update

sudo apt-get install ca-certificates curl -y

sudo install -m 0755 -d /etc/apt/keyrings

sudo curl -fsSL https://download.docker.com/linux/ubuntu/gpg -o /etc/apt/keyrings/docker.asc

sudo chmod a+r /etc/apt/keyrings/docker.asc

echo "deb [arch=$(dpkg --print-architecture) signed-by=/etc/apt/keyrings/docker.asc] https://
download.docker.com/linux/ubuntu $(. /etc/os-release && echo "$VERSION_CODENAME") stable" | sudo tee
/etc/apt/sources.list.d/docker.list > /dev/null

sudo apt update && sudo apt install docker-ce docker-ce-cli containerd.io docker-buildx-plugin
docker-compose-plugin -y

sudo usermod -aG docker $USER

newgrp docker

docker run hello-world
```

13. Enable docker services:

```
sudo systemctl enable docker.service

sudo systemctl enable containerd.service
```

14. Pull MLPerf repo:

```
cm pull repo mlcommons@cm4mlops
```

Running the test

1. Build Docker container (this may take several hours), and run ResNet-50:

```
cm run script --tags=run-mlperf,inference,_performance-only,_full \
--division=open \
--category=edge \
--device=cuda \
--model=resnet50 \
--precision=float32 \
--implementation=nvidia \
--backend=tensorrt \
--scenario=Offline \
--execution_mode=valid \
--power=no \
--adr.python.version_min=3.8 \
--clean \
--compliance=no \
--quiet \
--time \
--docker \
--docker_cache=no
```

2. Repeat the command from step 1 two more times, waiting 15 minutes between each run.

ResNet-50 (macOS)

Setting up the test

1. Launch Terminal.
2. Install Homebrew and add it to path:

```
/bin/bash -c "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"  
  
(echo; echo 'eval "$(/opt/homebrew/bin/brew shellenv)'"') >> /Users/<USERNAME>/.zprofile  
  
eval "$(/opt/homebrew/bin/brew shellenv)"
```

3. Install prerequisites:

```
brew install python3 git wget curl gcc
```

4. Install CM:

```
python3 -m pip install cmind
```

5. Add to path:

```
nano ~/.zprofile  
  
Add the following to the last line of .zprofile and press Ctrl+X to save and exit:  
export PATH="$PATH:./Library/Python/3.9/bin"
```

6. Update path:

```
source ~/.zprofile
```

7. To ensure all environment variables are active, relaunch Terminal.

8. Upgrade pip:

```
/Library/Developer/CommandLineTools/usr/bin/python3.9 -m pip install --upgrade pip
```

9. Create and activate Python virtual environment:

```
/Library/Developer/CommandLineTools/usr/bin/python3.9 -m venv ~/venv-metal-python3.9 source ~/venv-metal-python3.9/bin/activate
```

10. Install Tensorflow for Metal packages:

```
python -m pip install tensorflow tensorflow-metal
```

11. Pull MLPerf environment:

```
cm pull repo mlcommons@cm4mlops
```

12. Get dataset for ResNet-50:

```
cm run script -tags=get,dataset,imagenet,validation -j
```

13. Get model for ResNet-50:

```
cm run script -tags=get,ml-model,resnet50,_tensorflow -j
```

Running the test

1. Run the test:

```
cm run script --tags=run-mlperf,inference --model=resnet50 --implementation=reference
--framework=tensorflow --category=edge --scenario=Offline --execution-mode=valid --quiet --offline_
target_qps=130 -clean
```

2. Record the result.
3. Repeat steps 1 and 2 twice, waiting 15 minutes between each run.

Testing with the Geekbench ML benchmark (Windows & macOS)

Setting up the test

1. Download and install Geekbench ML from <https://www.geekbench.com/ml/download/>.

Running the test

1. Launch Geekbench ML.
2. From the Inference Backend drop-down menu, choose GPU (on macOS) or DirectML (on Windows 11). On Windows 11, select the RTX 3500 GPU for the Inference Device using the DirectML backend.
3. Click Run Inference Benchmark.
4. Record the result.
5. Wait 5 minutes before re-running. Repeat steps 1 through 5 two more times.

Testing with the Procyon AI Computer Vision Benchmark (Windows)

Setting up the test

1. Purchase and download the Procyon AI Computer Vision benchmark from <https://benchmarks.ul.com/procyon>.
2. Install the Procyon benchmark.
3. Double-click the installer.
4. Click Next.
5. Click to agree to EULA, and click Next.
6. Click Next.
7. Launch Procyon.
8. Select Settings and input the Procyon AI Computer Vision license key.
9. Close Procyon.

Running the test

1. Launch Procyon.
2. Select the Computer Vision test.
3. Select the NVIDIA TensorRT tab.
4. To begin the test, click Run.
5. When the test completes, record the results, and wait 15 minutes before re-running.
6. Repeat steps 4 through 5 twice more, and record the results.

Testing with the Procyon AI Computer Vision Benchmark (macOS)

Setting up the test

1. Download and install a licensed version of Procyon AI Computer Vision Benchmark from <https://benchmarks.ul.com/direct-download/Procyon-v2-1-24-ai-computer-vision-benchmark-macos.pkg>.
2. To install the package, click it.
3. Click Install.
4. Click Continue twice
5. Click Agree.
6. Click Allow.
7. Click Continue.
8. Click Install.
9. Enter your password, and click Install Software.
10. Launch Terminal.
11. Type `cd /Library/UL/Procyon/AIComputerVision`
12. Type `./UL_Procyon --register <license key>` and press Enter.

Running the test

1. Launch Terminal.
2. Type `cd /Library/UL/Procyon/AIComputerVision`
3. Type `./UL_Procyon -d "ai_computer_vision_coreml_all_fp32.def" -o "/Users/ptuser/test01.zip" -l 2 --export-simple-csv "/Users/ptuser/test01.csv"` and press Enter.
4. If prompted, click Accept to allow Terminal access to System Events.
5. Wait 15 minutes before rerunning the benchmark, changing `test01` to `test02`.
6. Repeat steps 3 through 4 twice, waiting 15 minutes between runs and changing `test01` to `test02` or `test03` depending on run.

Testing with Copilot

We tested the following workflows using Copilot for Microsoft 365 on Windows 11. For each prompt, we recorded the time it took for Copilot to completely respond to the prompt and/or perform the requested actions.

Testing workflow 1: Email and calendar management

We used the Copilot integration in Outlook to simulate the following workflow, timing how long it took Copilot to fully respond with output for each prompt. We used an active PT employee's Microsoft 365 business account to provide real organizational data for Copilot to work with (with names anonymized).

Use case: Reviewing weekly agenda

Prompt: Tell me what needs to be on my radar this week based on my recent emails and calendar invites and make a table of all scheduled meetings or calls.

Use case: Summarizing an email thread

Prompt: Summarize my recent email thread with John Doe and highlight any important information about draft feedback.

Use case: Generating a draft email

Prompt: Draft an email to John Doe including a project timeline with placeholder dates for a market research report we are preparing for him. Include a generic outline for the report itself, including a sample executive summary.

Running the email and calendar management workflow tests

1. Launch Outlook.
2. In the left menu, click the Copilot button.
3. Prepare the stopwatch, and input the first use case prompt.
4. Simultaneously submit the prompt by pressing Enter and start the stopwatch.
5. When Copilot finishes generating output in response, stop the stopwatch and record the result.
6. Repeat steps 3 through 5 for the second use case prompt and the third use case prompt.
7. Close Outlook.
8. Repeat steps 1 through 7 twice more.

Testing workflow 2: Animation project planning

We used the Copilot native app with the web toggle active to simulate the following content creation workflow, timing how long it took Copilot to generate a response to each prompt.

Use case: Conducting research

Prompt: Generate a 500-word research report on best practices when creating compelling animations and short animation projects and include at least five examples of possible animation projects that fit those criteria.

Use case: Drafting a project proposal

Prompt: Choose one of the animation project examples and write an internal project proposal for developing the concept and producing a short 3-5 minute animated film. Include a sample project timeline, milestone tracking, and executive summary. Make the tone professional but not overly formal.

Use case: Generating social media plan

Prompt: Generate a social media plan to help market the animation project. Include which social media platforms to focus on and plans for publicizing our short animated film both prior to and after its release. Suggest a few ideas for social media based promotions, giveaways, or other ways to engage our audience as part of the social media campaign.

Running the animation project planning workflow tests

1. In the taskbar, click the Copilot button.
2. Prepare the stopwatch, and input the first use case prompt.
3. Simultaneously submit the prompt by pressing Enter and start the stopwatch.
4. When Copilot finishes generating output in response, stop the stopwatch, and record the result.
5. Repeat steps 2 through 4 for the second use case prompt and the third use case prompt.
6. Close the Copilot app.
7. Repeat steps 1 through twice more.

Testing workflow 3: Presentation creation and revision

We used the Copilot integration in Microsoft PowerPoint to simulate the following workflow and use cases, timing how long it took Copilot to finish performing each prompted action.

Use case: Generating an internal presentation template

Prompt: Create a presentation about an internal proposal for a short animated film project of 3-5 minutes. Include slides for project timeline, internal milestones, and estimated budget.

Use case: Adding a new slide

Prompt: Add a slide about our proposed social media campaign to accompany the announcement and eventual release of the short film.

Use case: Adding animations to a slide

Prompt: Animate this slide and then animate all other slides.

Running the presentation creation and revision workflow tests

1. Launch PowerPoint.
2. Click Blank Presentation.
3. In the top-right menu, click the Copilot button.
4. Prepare the stopwatch, and input the first use case prompt.
5. Simultaneously submit the prompt by pressing Enter and start the stopwatch.
6. When Copilot finishes generating output in response, stop the stopwatch, and record the result.
7. Repeat steps 4 through 6 for the second use case prompt and the third use case prompt.
8. Close PowerPoint.
9. Repeat steps 1 through 8 two more times.

Testing Arnold GPU rendering on Autodesk Maya (Windows & macOS)

Setting up the test

1. Download and install the Maya 2022 30-day trial from <https://www.autodesk.com/products/maya/free-trial>. During installation, verify that Arnold renderer is selected for installation as an additional component.
2. Launch Maya 2022, and point the Project Window to the correct directory:
 - a. Go to File → Project Window.
 - b. Click New, and enter the name `Dinner_scene`.
 - c. Set the Location to `Documents/maya/projects`.
 - d. Click Accept.
3. Create a Maya 2022 test workload scene named `Dinner_scene`. We used the YouTube tutorial created by the Creative Tap channel: https://www.youtube.com/watch?v=U2Z-2bEqP_c.
4. Copy the Maya 2022 `Dinner_scene` test workload to the `Documents\maya\projects` directory onto the other test system. When you see the prompt, select Yes to overwrite the `Dinner_scene` directory.
5. Close Maya 2022.

Running the test

1. Launch Maya 2022, and to select the test workload scene, browse to Documents\maya\projects\Dinner_scene\Dinner_scene_v1.mb.
2. From the top menu bar, select the Display render settings icon.
3. Next to the Render Using field, select Arnold Renderer.
4. Under the Common tab, make the following edits:
 - a. Next to File name prefix, type a project name.
 - b. Next to Image Format, select PNG.
 - c. Next to Frame/Animation ext, select name_#.ext.
 - d. Next to Start frame, select 1.000.
 - e. Next to End frame, select 250.000.
 - f. Next to Renderable Camera, select camera1.
 - g. Next to Image Size Presets, select HD_1080.
5. Under the Arnold Renderer tab, select the following settings:
 - Camera (AA): 3
 - Diffuse: 2
 - Specular: 2
 - Transmission: 2
 - SSS: 2
 - Volume Indirect: 2
6. Under the System tab, select GPU as the Render Device, if available.
7. Close the Render Settings dialog.
8. From the top menu, select Open Render View.
9. In the top left toolbar, in the drop-down menu, select Rendering.
10. Click Render, and to the right of Render Sequence, click the small square.
11. In the Current Camera field, select camera1.
12. Simultaneously start the stopwatch and click Render Sequence.
13. Repeat steps 1 through 12 four more times.

Enhancing Speech on Adobe Premiere Pro v24.5 (Windows & macOS)

1. Launch Adobe Premiere Pro.
2. Click New Project.
3. Navigate to the test video recording (a 1-minute iPhone video of speech with loud background noise) under the Local tab, and click Create.
4. In the top right, click the Workspaces icon, and select the Audio workspace.
5. In the timeline, select the clip audio. In the right panel, click Dialogue to tag the clip as dialogue.
6. Under Enhance Speech in the Essential Sound window, set the mix amount to maximum (10.0).
7. Simultaneously start the stopwatch and click Enhance.
8. Stop the timer when the progress bar indicates the audio clip has been fully processed, and record the result.
9. Close Premiere Pro.
10. Repeat steps 1 through 9 twice more.

Testing with Stable Diffusion (Windows & macOS)

The information below is used to install Stable Diffusion AUTOMATIC1111 on both Microsoft Windows and MacBook Pro M-class systems with the V1-5-pruned-emaonly model

Installing Stable Diffusion (Windows 11)

1. Download Python from <https://www.python.org/ftp/python/3.10.6/python-3.10.6-amd64.exe>.
2. Double-click the installer.
3. Check the box for Add Python 3.10 to PATH, and click Install Now.
4. To end the installer wizard, click Close.
5. Download git from <https://github.com/git-for-windows/git/releases/download/v2.45.2.windows.1/Git-2.45.2-64-bit.exe>.
6. Double-click the installer.
7. Click Next through the default options, and click Install.
8. To end the installer wizard, click Finish.
9. Reboot the system.
10. Open a command prompt, and navigate to c:\Users\[your username].
11. From that prompt, enter the following command:

```
git clone https://github.com/AUTOMATIC1111/stable-diffusion-webui.git
```

12. On completion, open file explorer, and browse to C:\Users\[your username]\stable-diffusion-webui\models\.
13. Open a web browser, and download a checkpoint file from <https://huggingface.co/runwayml/stable-diffusion-v1-5/resolve/main/v1-5-pruned-emaonly.ckpt>.
14. Copy that downloaded checkpoint file into the models folder.
15. Browse up one level to C:\Users\[your username]\stable-diffusion-webui\ and execute the webui-user.bat file. The batch file will take about 5 minutes to complete and will launch a browser with <http://127.0.0.1:7860> as the address. Use this browser window to execute testing.
16. Close the command session, and repeat step 11 for each subsequent test.

Installing Stable Diffusion (macOS)

1. To install Homebrew, run the following command in Terminal:

```
/bin/bash -c "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/HEAD/install.sh)"  
Execute the following command:  
echo 'eval "$(/opt/homebrew/bin/brew shellenv)"' >> /Users/$USER/.zprofile
```

2. Execute the following command:

```
eval "$(/opt/homebrew/bin/brew shellenv)"  
Install Python:  
brew install python@3.10 git wget
```

3. Clone the AUTOMATIC1111 repository (a folder named stable-diffusion-webui will be created in your home directory):

```
git clone https://github.com/AUTOMATIC1111/stable-diffusion-webui  
Execute the following command:  
cd ~/stable-diffusion-webui; ./webui.sh
```

The script will take about 5 minutes to complete, and will launch a browser with <http://127.0.0.1:7860> as the address. Use this browser window to execute testing.

4. Close the Terminal session, and repeat step 6 for each subsequent test.

Using Stable Diffusion

For testing, we used default settings, except for the following modifications:

1. Set width to 640 and height to 360.
2. Check the box for Hires. Fix. Expand the panel, and change the upscale to 3 for 1080p image quality, or upscale to 2 for 720p.
3. Change sampling steps from 20 to 100.
4. Enter a prompt into the txt2image text box. Click Generate to start the image creation.

Researching serviceability documentation

For both systems under test, we researched whether public-facing documentation was freely available for servicing the devices.

1. Note whether self-service repair or customer-replaceable parts documentation is or is not available online.
2. If documentation is available for a device, read through the documentation, and note whether it includes the following information:
 - Identification of the product (type of product, trademark, trade name, model, and serial number)
 - A disassembly map or exploded view of the device
 - Electronic boards diagrams
 - A list of necessary equipment for repair
 - Instructions for repair of specific parts
 - Diagnostic fault and error codes
 - Component and diagnosis information
 - Instructions for software and firmware reset
 - Information on how to access internal data records of reported failure incidents
 - Specific guidance for self-repair
 - How to contact authorized repairers
 - Failure detection and required action items
 - User and maintenance instructions
3. Report findings.

We referenced documentation at the following URLs on July 12, 2024:

- Dell Precision 5690: <https://dl.dell.com/content/manual20726432-precision-5690-owner-s-manual.pdf?language=en-us>
- Apple MacBook Pro 16": <https://support.apple.com/en-us/118619>

Completing disassembly and replacement of parts

We determined how easy it was to replace four components on each system: the fan, battery, heatsink, and storage. We noted how many tools we needed, whether we could complete the replacements with basic tools or with proprietary tools, and, when necessary, why we could not replace parts.

For each replacement, we followed these general steps:

1. Start with the system fully assembled.
2. Start the timer, and begin the process to replace that part.
3. Record the time and number of steps to replace that part.

Replacing the fan on the Dell Precision 5690

1. On the bottom of the system, unscrew the eight T5 Torx screws (non-captive screws).
2. Using a plastic scribe, lift and remove the bottom cover.
3. Remove the two 00 Phillips-head screws that secure the right fan in place.
4. Remove the two 00 Phillips-head screws that secure the left fan in place.
5. Disconnect the right fan connector from the main board.
6. Disconnect the left fan connector from the main board.
7. Lift and remove the left and right fan from the system board.
8. Insert a new left and right fan onto the system board.
9. Connect the right fan connector to the main board.
10. Connect the left fan connector to the main board.
11. Screw in the two 00 Phillips-head screws that secure the right fan in place.
12. Screw in the two 00 Phillips-head screws that secure the left fan in place.
13. Attach the bottom cover, and snap it back into place.
14. To secure the bottom cover, on the bottom of the system, screw the eight T5 Torx screws back into place.

Replacing the battery on the Dell Precision 5690

1. On the bottom of the system, unscrew the eight T5 Torx screws (non-captive screws).
2. Using a plastic scribe, lift and remove the bottom cover.
3. Unscrew the two 00 Phillips-head screws from the battery cable shield cover (captive screws).
4. Remove the battery cable shield cover.
5. Remove the battery cable from the system board.
6. Unscrew the six 0 Phillips-head screws that secure the battery in place.
7. Remove the battery from the enclosure.
8. Insert the new battery into the enclosure.
9. Screw in the six 0 Phillips-head screws that secure the new battery in place.
10. Connect the battery cable to the system board.
11. Apply the battery cable shield cover.
12. Screw in the two 00 Phillips-head screws that secure the battery cable shield cover.
13. Attach the bottom cover, and snap it back into place.
14. To secure the bottom cover, on the bottom of the system, screw the eight T5 Torx screws back into place.

Replacing the storage on the Dell Precision 5690

1. On the bottom of the system, unscrew the eight T5 Torx screws (non-captive screws).
2. Using a plastic scribe, lift and remove the bottom cover.
3. Remove the SSD shield mounting screw.
4. Remove the shield.
5. Remove the SSD device.
6. Insert the new SSD device into the M.2 SSD slot.
7. Attach the SSD shield.
8. Attach the SSD shield mounting screw.
9. Attach the bottom cover, and snap it back into place.
10. To secure the bottom cover, on the bottom of the system, screw the eight T5 Torx screws back into place.

Replacing the heatsink on the Dell Precision 5690

1. On the bottom of the system, unscrew the eight T5 Torx screws (non-captive screws).
2. Using a plastic scribe, lift and remove the bottom cover.
3. In descending order, unscrew the seven captive 00 Phillips-head screws that secure the heatsink in place.
4. Remove the heatsink.
5. Insert a new heatsink.
6. In ascending order, screw in the seven captive 00 Phillips-head screws that secure the heatsink in place.
7. Attach the bottom cover, and snap it back into place.
8. To secure the bottom cover, on the bottom of the system, screw the eight T5 Torx screws back into place.

Replacing the fan on the Apple MacBook Pro 16"

1. On the bottom of the system, unscrew the eight non-captive P5 pentalobe screws (proprietary screws).
2. Using a plastic scribe, lift the bottom cover, and pull the bottom case to remove it.
3. Unscrew and remove the two T3 Torx screws that secure the trackpad cable bracket.
4. Remove the trackpad cable bracket.
5. Disconnect the trackpad connector from the board.
6. Peel back the tape covering the battery data connector.
7. Unlatch the battery data cable from the main board.
8. Disconnect the battery data cable from the main board.
9. Peel back the tape covering the battery data cable connector on the battery board.
10. Unlatch the battery data cable on the battery board.
11. Disconnect and remove the battery data cable from the battery board.
12. Unscrew the T5 Torx screw that secures the battery connector.
13. Unscrew the three T3 Torx screws that secure the antenna cable cover.
14. Remove the antenna cable cover.
15. Disconnect the three antenna cables.
16. Unscrew the four T3 Torx screws that secure the display cable covers.
17. Remove the display cable covers.

18. Disconnect the three display connectors from the logic board.
19. Unscrew the nine P2 pentalobe screws that secure the antenna bar in place.
20. Unscrew the six T5 Torx screws that secure the antenna bar in place.
21. Remove the antenna bar.
22. Unscrew the eleven T3 Torx screws that secure the right cable covers in place.
23. Remove the right cable covers.
24. On the right side of the logic board, disconnect the six connectors.
25. Peel back the tape covering the microphone connector.
26. Disconnect the microphone.
27. Unscrew the six T3 Torx screws that secure the left cable covers in place.
28. Remove the left cable covers.
29. On the left side of the logic board, disconnect the three connectors.
30. Peel back the tape covering the keyboard connectors.
31. Disconnect the keyboard cables.
32. Peel back the tape covering the right fan connector.
33. Disconnect the right fan cable.
34. Peel back the tape covering the left fan connector.
35. Disconnect the left fan cable.
36. Unscrew the ten T5 Torx screws that secure the logic board.
37. Unscrew the two 4mm hex screws that secure the logic board.
38. Unscrew the two T6 Torx screws that secure the logic board.
39. Remove the logic board.
40. Remove the fan screw covers.
41. Unscrew the four T3 Torx screws that secure the fans.
42. Unscrew the four T5 Torx screws that secure the fans.
43. Remove the fans.
44. Place new fans.
45. Screw in the four T5 Torx screws that secure the fans.
46. Screw in the four T3 Torx screws that secure the fans.
47. Place the logic board.
48. Screw in the two T6 Torx screws that secure the logic board.
49. Screw in the two 4mm hex screws that secure the logic board.
50. Screw in the ten T5 Torx screws that secure the logic board.
51. Connect the left fan cable, and reapply the tape that covers the connector.
52. Connect the right fan cable, and reapply the tape that covers the connector.
53. Connect the keyboard cables, and reapply the tape that covers the connectors.
54. On the left side of the logic board, connect the three connectors.
55. Place the left cable covers.
56. Screw in the six T3 Torx screws that secure the left cable covers.
57. Connect the microphone cable, and reapply the tape that covers the connector.
58. On the right side of the logic board, connect the six connectors.
59. Place the right cable covers.
60. Screw in the eleven T3 Torx screws that secure the right cable covers.
61. Place the antenna bar.
62. Screw in the six T5 Torx screws that secure the antenna bar.
63. Screw in the nine P2 pentalobe screws that secure the antenna bar.
64. Connect the three display connectors to the logic board.
65. Place the display cable connector covers.
66. Screw in the four T3 Torx screws that secure the display cable covers.
67. Connect the three antenna cables.
68. Place the antenna cable cover.
69. Screw in the three T3 Torx screws that secure the antenna cable cover.
70. Screw in the T5 Torx screw that secure the battery connector.
71. Connect the battery data cable to the battery board.
72. Latch the battery data cable to the battery board.
73. Connect the battery data cable to the main board.

74. Latch the battery data cable on the main board.
75. Connect the trackpad back to the main board.
76. Place the trackpad cable bracket.
77. Screw in the two T3 Torx screws that secure the trackpad cable bracket.
78. Attach the bottom cover, and snap it into place.
79. On the bottom of the system, screw in the eight non-captive P5 pentalobe screws (proprietary screws).

Replacing the battery on the Apple MacBook Pro 16"

1. On the bottom of the system, unscrew the eight non-captive P5 pentalobe screws (proprietary screws).
2. Using a plastic scribe, lift the bottom cover, and pull the bottom case to remove it.
3. Unscrew and remove the two T3 Torx screws that secure the trackpad cable bracket.
4. Remove the trackpad cable bracket.
5. Disconnect the trackpad connector from the board.
6. Peel back the tape covering the battery data connector.
7. Unlatch the battery data cable from the main board.
8. Disconnect the battery data cable from the main board.
9. Peel back the tape covering the battery data cable connector on the battery board.
10. Unlatch the battery data cable on the battery board.
11. Disconnect and remove the battery data cable from the battery board.
12. Unscrew the T5 Torx screw that secure the battery connector.
13. Unscrew and remove the 13 T5 Torx screws that secure the trackpad.
14. Remove the trackpad.
15. Unscrew the two T5 Torx screws that secure the battery board.
16. Remove the 14 adhesive strips that keep the battery in place. (Note: We could only perform this step on the first of the three times we performed the swap. This step took us 15 minutes. We account for that 15 minutes in the timings for our second and third times completing the swap.)
17. Remove the battery from the enclosure.
18. Insert a new battery into the enclosure.
19. Screw in the two T5 Torx screws that secure the battery board.
20. Insert the trackpad into the enclosure.
21. Screw in the thirteen T5 Torx screws that secure the trackpad.
22. Screw in the T5 Torx screw that secure the battery connector.
23. Connect the battery data cable to the battery board.
24. Latch the battery data cable to the battery board.
25. Connect the battery data cable to the main board.
26. Latch the battery data cable to the main board.
27. Connect the trackpad back to the main board.
28. Place the trackpad cable bracket.
29. Screw in the two T3 Torx screws that secure the trackpad cable bracket.
30. Attach the bottom cover, and snap it into place.
31. On the bottom of the system, screw in the eight non-captive P5 pentalobe screws (proprietary screws).

Replacing the storage on the Apple MacBook Pro 16"

The storage on the MacBook Pro 16" was soldered to the board, so we could not replace it.

Replacing the heatsink on the Apple MacBook Pro 16"

1. On the bottom of the system, unscrew the eight non-captive P5 pentalobe screws (proprietary screws).
2. Using a plastic scribe, lift the bottom cover, and pull the bottom case to remove it.
3. Unscrew and remove the two T3 Torx screws that secure the trackpad cable bracket.
4. Remove the trackpad cable bracket.
5. Disconnect the trackpad connector from the board.
6. Peel back the tape covering the battery data connector.
7. Unlatch the battery data cable from the main board.
8. Disconnect the battery data cable from the main board.
9. Peel back the tape covering the battery data cable connector on the battery board.
10. Unlatch the battery data cable on the battery board.
11. Disconnect and remove the battery data cable from the battery board.

12. Unscrew the T5 Torx screw that secures the battery connector.
13. Unscrew the three T3 Torx screws that secure the antenna cable cover.
14. Remove the antenna cable cover.
15. Disconnect the three antenna cables.
16. Unscrew the four T3 Torx screws that secure the display cable covers.
17. Remove the display cable covers.
18. Disconnect the three display connectors from the logic board.
19. Unscrew the nine P2 pentalobe screws that secure the antenna bar.
20. Unscrew the six T5 Torx screws that secure the antenna bar.
21. Remove the antenna bar.
22. Unscrew the eleven T3 Torx screws that secure the right cable covers.
23. Remove the right cable covers.
24. On the right side of the logic board, disconnect the six connectors.
25. Peel back the tape covering the microphone connector.
26. Disconnect the microphone.
27. Unscrew the six T3 Torx screws that secure the left cable covers in place.
28. Remove the left cable covers.
29. On the left side of the logic board, disconnect the three connectors.
30. Peel back the tape covering the keyboard connectors.
31. Disconnect the keyboard cables.
32. Peel back the tape covering the right fan connector.
33. Disconnect the right fan cable.
34. Peel back the tape covering the left fan connector.
35. Disconnect the left fan cable.
36. Unscrew the ten T5 Torx screws that secure the logic board.
37. Unscrew the two 4mm hex screws that secure the logic board
38. Unscrew the two T6 Torx screws that secure the logic board.
39. Remove the logic board.
40. Unscrew the four T5 Torx screws that secure the tension brackets to the logic board.
41. Remove the tension brackets.
42. Lift the logic board from the heatsink.
43. Place logic board on new heatsink.
44. Place the tension brackets.
45. Screw in the four T5 Torx screws that secure the tension brackets to the logic board.
46. Place the logic board.
47. Screw in the two T6 Torx screws that secure the logic board
48. Screw in the two 4mm hex screws that secure the logic board.
49. Screw in the ten T5 Torx screws that secure the logic board.
50. Connect the left fan cable, and apply the tape to cover the connector.
51. Connect the right fan cable, and apply the tape to cover the connector.
52. Connect the keyboard cables, and apply the tape to cover the connectors.
53. On the left side of the logic board, connect the three connectors.
54. Place the left cable covers.
55. Screw in the six T3 Torx screws that secure the left cable covers.
56. Connect the microphone cable, and reapply the tape to cover the connector.
57. On the right side of the logic board, connect the six connectors.
58. Place the right cable covers.
59. Screw in the eleven T3 Torx screws that secure the right cable covers.
60. Place the antenna bar.
61. Screw in the six T5 Torx screws that secure the antenna bar.
62. Screw in the nine P2 pentalobe screws that secure the antenna bar.
63. Connect the three display connectors to the logic board.
64. Place the display cable connector covers.
65. Screw in the four T3 Torx screws that secure the display cable covers.
66. Connect the three antenna cables.
67. Place the antenna cable cover.

68. Screw in the three T3 Torx screws that secure the antenna cable cover in place.
69. Screw in the T5 Torx screw that secures the battery connector.
70. Connect the battery data cable to the battery board.
71. Latch the battery data cable to the battery board.
72. Connect the battery data cable to the main board.
73. Latch the battery data cable to the main board.
74. Connect the trackpad back to the main board.
75. Place the trackpad cable bracket.
76. Screw in the two T3 Torx screws that secure the trackpad cable bracket.
77. Attach the bottom cover, and snap it into place.
78. On the bottom of the system, screw in the four non-captive P5 pentalobe screws (proprietary screws).

Read the report at <https://facts.pt/n3vx8MU> ▶

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