The science behind the report:

Educators and students: Get a responsive Chromebook to help assess student work, plan lectures, communicate remotely, and more

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 Educators and students: Get a responsive Chromebook to help assess student work, plan lectures, communicate remotely, and more.

We concluded our hands-on testing on September 2, 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 August 23, 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.

Task	HP Pro c640 G2 Chromebook™ with an Intel® Core™ i7-1185G7 processor	HP Pro c640 G2 Chromebook with an Intel Core i5-1145G7 processor	Lenovo® C13 Yoga® Gen 1 Chromebook with an AMD Ryzen™ 7 3700C processor	Chromebook with Core i7 processor vs. Chromebook with Core i5 processor	Chromebook with Core i5 processor vs. Chromebook with Ryzen 7 processor	Chromebook with Core i7 processor vs. Chromebook with Ryzen 7 processor
Scenario 1 (median sum of all tasks)	**35.6**	**37.3**	**51.2**	**4%**	**27%**	**30%**
Google Meet™						
Launching the application	1.9	1.9	2.1	0%	9%	9%
Launching a Google Meet meeting	3.0	3.1	2.8	3%	-10%	-7%
Google Drive™						
Opening a PDF preview from Google Drive	3.8	4.1	6.5	7%	36%	41%

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September 2021

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Google Sheets™						
Opening a Microsoft Excel document from Google Drive	8.9	9.2	11.8	3%	22%	24%
Creating a chart	4.2	4.4	5.8	4%	24%	27%
Google Slides™						
Opening Google Slides presentation	12.7	13.4	20.8	5%	35%	38%
Copying and pasting a chart into Google Slides	1.1	1.2	1.4	8%	14%	21%
Scenario 2 (median sum of all tasks)	**465.1**	**526.5**	**620.8**	**11%**	**15%**	**25%**
Chrome OS™						
Unzipping 280 .JPG photos to desktop	9.3	10.7	12.9	13%	17%	27%
Adobe® Lightroom®						
Importing 280 .JPG photos	230.4	260.0	309.0	11%	15%	25%
Batch processing 280 .JPG photos	43.5	51.2	57.9	15%	11%	24%
Exporting 280 .JPG photos	177.9	200.3	236.1	11%	15%	24%
Adobe Photoshop® Express						
Creating a nine-image collage	4.0	4.3	4.9	6%	12%	18%
Windows apps running in Chrome™ with Parallels Desktop® for Chrome OS						
Parallels						
Launching Windows VM	8.5	8.6	N/A	**1%**	N/A	N/A
Microsoft Excel						
Opening large Microsoft Excel spreadsheet	11.3	11.2	N/A	**-.8%**	N/A	N/A
Creating a bar chart from range	4.5	4.4	N/A	**-2%**	N/A	N/A
Running Microsoft Excel macro to export range as PDF	64.2	77.5	N/A	**17%**	N/A	N/A
Microsoft PowerPoint						
Opening a PowerPoint presentation	3.7	3.9	N/A	**5%**	N/A	N/A
Pasting a graph from Microsoft Excel into a presentation	3.6	3.5	N/A	**-2%**	N/A	N/A

Educators and students: Get a responsive Chromebook to help assess student work, plan lectures, communicate remotely, and more

Study commissioned by Intel

September 2021 | 2

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Individually timed tasks in Chrome OS						
Zoom						
Sharing a Google Sheet from Google Drive	8.7	10.3	12.3	**15%**	**16%**	**29%**
Autodesk® Tinkercad						
Copying and tinkering a telescope project	9.5	9.9	12.0	**4%**	**17%**	**20%**
Minecraft: Education Edition						
Launching Minecraft: Education Edition	5.0	5.2	5.8	**3%**	**10%**	**13%**
Loading the Hour of Code 2019 (AI) Demo	9.1	9.6	13.5	**5%**	**28%**	**32%**

Table 2: Results of WebXPRT 3 benchmark testing.

	HP Pro c640 G2 laptop with an Intel Core i7-1185G7 processor	HP Pro c640 G2 laptop with an Intel Core i5-1145G7 processor	Lenovo C13 Yoga Gen 1 laptop with an AMD Ryzen 7 3700C processor	Chromebook with Core i7 processor vs. Chromebook with Core i5 processor	Chromebook with Core i5 processor i5 vs. Chromebook with Ryzen 7 processor	Chromebook with Core i7 processor vs Chromebook with Ryzen 7 processor
WebXPRT 3 score	313	295	183	**5%**	**37%**	**41%**

Table 3: Results of Speedometer 2.0 benchmark testing.

	HP Pro c640 G2 laptop with an Intel Core i7-1185G7 processor	HP Pro c640 G2 laptop with an Intel Core i5-1145G7 processor	Lenovo C13 Yoga Gen 1 laptop with an AMD Ryzen 7 3700C processor	Chromebook with Core i7 processor vs. Chromebook with Core i5 processor	Chromebook with Core i5 processor i5 vs. Chromebook with Ryzen 7 processor	Chromebook with Core i7 processor vs Chromebook with Ryzen 7 processor
Speedometer 2.0	200.0	192.0	98.9	**4%**	**48%**	**50%**

System configuration information

Table 4: Detailed information on the system we tested.

System	HP Pro c640 G2 Chromebook Enterprise	HP Pro c640 G2 Chromebook Enterprise	Lenovo ThinkPad C13 Yoga Gen 1 Chromebook
Processor	Intel Core i7-1185G7	Intel Core i5-1145G7	AMD Ryzen 7 3700C
Processor frequency (GHz)	3.00 – 4.80	2.60 – 4.40	2.30 – 4.00
Processor cores	4	4	4
Memory (GB)	16	8	16
Storage (GB)	256	64	256
Bluetooth	5	5	5
USB	2x USB 3.2 Gen 1 Type-A 2x USB 3.2 Gen 1 Type-C	2x USB 3.2 Gen 1 Type-A 2x USB 3.2 Gen 1 Type-C	2x USB 3.2 Gen 1 Type-A 2x USB 3.2 Gen 1 Type-C
Battery type	Lithium-Ion	Lithium-Ion	Lithium-Ion
Battery capacity (Wh)	58	58	51
Display resolution	14.0" 1920x1080	14.0" 1920x1080	13.3" 3840x2160
OS (version)	92.0.4515.162	92.0.4515.162	92.0.4515.162
System Weight (lbs.)	3.26	3.26	3.30

How we tested

Scenario testing

For our scenario testing, we opened the Google Meet application, and joined a four-participant video meeting. We tested each task for a given scenario sequentially.

Scenario #1

Google Meet

Launching Google Meet

1. Simultaneously start the timer and launch the Google Meet app from the shelf.
2. When the app fully loads, stop the timer.

Launching a new Google Meet meeting

1. From the Google Meet main screen, click New meeting.
2. Simultaneously start the timer and click Start an instant meeting.
3. When the meeting invite code appears and the webcam loads, stop the timer.
4. For the remainder of our timings, we joined a four-way video meeting, and minimized the app.

Google Drive

Opening a PDF preview from Google Drive

1. From the Google Meet chat window, simultaneously start the timer and click the link to the test PDF.
2. When the PDF preview fully loads in the web browser, stop the timer.

Google Sheets

Opening a shared Excel file with Google Drive

1. From the Google Meet chat window, simultaneously start the timer and click the link to the test .csv file via Google Drive.
2. When the Google Sheets spreadsheet fully loads, stop the timer.

Creating a chart in Google Sheets

1. From Google Sheets, select the range of data, and click Insert.
2. Simultaneously start the timer and click Chart.
3. When the chart fully loads into the document, stop the timer.

Google Slides

Opening a shared Google Slides presentation

1. From the Google Meet chat window, simultaneously start the timer and click the link to the Google Slides test document via Google Drive.
2. When the Slides presentation fully loads, stop the timer.

Copying and pasting a graph from Google Sheets into a Google Slides presentation

1. Navigate to the Google Sheets test document tab.
2. Select and copy the bar graph.
3. Navigate to the first slide of the Google Slides presentation.
4. Simultaneously start the timer and paste the bar graph into the first slide.
5. When the bar graph fully loads, stop the timer.

Educators and students: Get a responsive Chromebook to help assess student work, plan lectures, communicate remotely, and more

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Scenario #2

Google System: Unarchiving Photos

Unzipping 280 photos from the desktop

1. From the Files application, navigate to the test archive location.
2. To open the test archive using the default system viewer, double-click the archive.
3. Select the contents of the test archive, and click and drag the contents to an empty folder.
4. Simultaneously start the timer and unclick the dragged content.
5. When the copying files dialog completes, stop the timer.

Adobe Lightroom

Importing 280 photos

1. From the app shelf, launch Adobe Lightroom.
2. From the Adobe Lightroom home page, click the blue import photos icon.
3. Sort by Device Folders. To select the unarchived test photos, click the checkbox next to the folder name.
4. Simultaneously start the timer and click Add.
5. When the import dialog completes, stop the timer.

Batch-processing 280 photos with a filter preset

1. From the Adobe Lightroom home page, click the collection containing the test photos.
2. Click the first image.
3. Click the Adjustments icon.
4. To apply auto-adjustments, click Auto.
5. Click the menu button in the top right, and select Copy Settings.
6. Leave the default Copy Settings, and click OK.
7. To return to the collection view, click the back arrow.
8. Long-click the first photo to select it.
9. Click the menu button in the top right, and select Select All.
10. Click the menu button in the top right again, and select Paste Settings.
11. Simultaneously start the timer and click Apply.
12. When the processing dialog closes, and "Changes applied to 140 photos" appears, stop the timer.

Exporting 280 photos

1. From the Adobe Lightroom home page, click the collection containing the test photos.
2. Click to select the first image.
3. From the dropdown menu, click Select All images.
4. With all images selected, click the Share icon.
5. From the Share dialog box, click Export As…
6. Leave the default settings. Simultaneously start the timer and click the checkmark icon.
7. When the export dialog completes, stop the timer.

Adobe Photoshop Express

Creating a nine-image collage

1. From the app shelf, launch Adobe Photoshop Express from the shelf.
2. Click the Collage icon in the bottom right.
3. Click to select the nine test images.
4. Simultaneously start the timer and click the next arrow.
5. When the collage fully loads, stop the timer.

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Other app tasks

Zoom

Sharing a Google Sheets spreadsheet from Google Drive

1. From the chat window, simultaneously start the timer and click the link to the shared Google Sheets document.
2. Stop the timer when the Google Drive preview has fully loaded.

Minecraft: Education Edition

Launching Minecraft: Education Edition

1. Simultaneously start the timer and launch the Minecraft: Education Edition app from the shelf.
2. When the app fully loads, stop the timer.

Loading the Hour of Code 2019 demo

1. From the shelf, launch Minecraft: Education Edition.
2. Click Try A Demo Lesson.
3. Click to check Accept Terms, and click Play.
4. When the Demo Experience loads, click Start Lesson.
5. From the Demo Lessons, simultaneously start the timer and click Hour of Code 2019.
6. When the game fully loads, stop the timer.

Parallels Desktop for Chrome OS

Installing Parallels Desktop for Chrome OS and creating the base Windows 10 Image

1. Ensure the device under test is eligible for Chrome Enterprise enrollment and meets the minimum requirements for installing Parallels Desktop for Chrome OS. You can find more information on minimum requirements at the Parallels website: https://www.parallels.com/products/desktop/chrome/
2. You need a Google Workspace account to deploy and license the Parallels Desktop for Chrome OS application. Ensure the requisite licenses are applied to the correct Organization Unit in the Google Workspace Admin console.
3. Log into the device under test with the Chrome Enterprise admin account. With the correct Organization Unit settings applied, the Parallels Desktop application will be automatically downloaded on initial setup.
4. Download a Windows 10 .iso from the Microsoft website and transfer it to the device under test's Downloads folder.
5. To launch the crosh Terminal, launch Google Chrome, and press Ctrl + Alt + T.
6. Create the Windows 10 VM:

   ```
   vmc create -p PvmDefault win10.iso
   ```

7. When the command completes, start the virtual machine:

   ```
   vmc start PvmDefault
   ```

8. The Windows 10 installation media will launch in the virtual machine window. Follow the wizard to install Windows 10, and install the applications for the base image. For our testing, we installed the Microsoft Office suite.
9. When creation of the Windows 10 base image is complete, shut down the virtual machine.
10. From the crosh Terminal, export the newly created virtual machine:

    ```
    vmc export -d PvmDefault PvmDefault.zip
    ```

11. The virtual machine will export to a .zip file in the device's Downloads folder and include a hash. For our environment, we uploaded the .zip file to our user's Google Drive.
12. From the Google Workspace Admin Console, Navigate to Devices → Chrome → Settings → Users & Browsers, click on the User & Browser Settings Tab, and scroll to the Parallels Desktop section.
13. Enter the URL to the shared .zip file containing the exported virtual machine, and enter the SHA-256 hash generated in the device's Downloads folder.
14. Log out, and log back into the device with the Chrome Enterprise test account.
15. After initial setup is complete, open the Parallels Desktop application.
16. The Windows 10 virtual machine image will be automatically downloaded and installed on the test user's account.

Launching the Windows Virtual Machine

1. Simultaneously start the timer and click the Parallels Desktop app icon from the shelf.
2. When the Windows virtual machine boots to the desktop, stop the timer.

Microsoft Excel: Opening an Excel Spreadsheet

1. From the Windows virtual machine, navigate to the folder containing the test Excel document.
2. Right-click the document, and simultaneously start the timer and click Open.
3. When the Excel document has fully loaded, stop the timer.

Microsoft Excel: Creating a bar chart from a range

1. From the Windows virtual machine, open the test Excel document.
2. Click to select a range of data.
3. From the Excel ribbon menu, click Insert → Recommended Charts.
4. Click the All Charts tab.
5. Select the Clustered Column chart.
6. Simultaneously start the timer and click OK.
7. When the bar chart has fully loaded, stop the timer.

Microsoft Excel: Running an Excel macro to export range as PDF

1. From the Windows virtual machine, open the test Excel document.
2. From the Excel ribbon menu, click View → Macros.
3. Enter a name for the macro, and click Create.
4. From the macro editor window, export the selected range to PDF:

```
Sub SaveSelectedRangeAsPdf
Selection.ExportAsFixedFormat Type:=xlTypePDF, OpenAfterPublish:=True
End Sub
```

5. Save the macro, and return to the Excel application window.
6. Click to select the range of data.
7. From the Excel ribbon menu, click View, Macros.
8. Select the test Macro.
9. Simultaneously start the timer and click Run.
10. When the PDF opens in the web browser, stop the timer.

Benchmark testing

WebXPRT 3

Running WebXPRT 3

1. Power on the device, and log in.
2. Allow the device to idle for 10 minutes to clear any background startup activity.
3. Open the default web browser, and navigate to https://www.principledtechnologies.com/benchmarkxprt/webxprt/.
4. Click Run WebXPRT 3.
5. Click Continue.
6. Click Start.
7. When the test completes, record the score.

Speedometer 2.0 - BrowserBench

Running Speedometer 2.0

1. Power on the device, and log in.
2. Allow the device to idle for 10 minutes to clear any background startup activity.
3. Open the default web browser, and navigate to https://browserbench.org/Speedometer2.0/.
4. Click Start Test.
5. When the test completes, record the score.

Educators and students: Get a responsive Chromebook to help assess student work, plan lectures, communicate remotely, and more

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