

# Windows 11

## Minimum Hardware Requirements

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# Minimum hardware requirements

## Section 1.0 – Introduction

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### 1.1 Overview

This specification defines the minimum hardware requirements for types of devices designed for Windows 11. Microsoft will build and validate the Windows 11 OS against the requirements described in this specification.

#### 1.1.1 Purpose of this specification

This specification defines the minimum hardware requirements necessary to:

- Boot and run Windows 11
- Update and service Windows 11
- Provide a baseline user experience that is comparable with similar devices

The goal of this specification is to enable Windows ecosystem partners to make design decisions for components and devices that will run Windows 11

This specification does not provide compatibility and certification requirements for components and computers that run Windows 11 or implementation guidance for exceptional user experiences. Refer to [Windows Hardware Compatibility Program \(WHCP\)](#) requirements and [Windows Engineering Guide](#) for detailed guidance.

#### 1.1.2 Device types supported by the Windows 11

The table below provides the supported device types that run Windows 11.

## Minimum Hardware Requirements for Windows 11

Device Type	Definition	Supported processor types	SMBIOS = Enclosure Type = (Byte Value)
All-in-one	<p>One of the following:</p> <ul style="list-style-type: none"> <li>Fixed all-in-one PC. Integrates a display with other hardware components in a single chassis.</li> <li>Portable all-in-one PC. Integrates a display and a battery with other hardware components in a single chassis for home or office portability.</li> </ul>	x64, ARM64	0Dh
Convertible	“Convertible” means a device that combines a display, battery and point device into a single chassis with an adjustable (any motion: flips, swivels, turns) display to be facing forward or facing away from the attached keyboard.	x64, ARM64	1Fh
Desktop PC	“Desktop” means a device in a tower case and is not a portable device. It does not include an integrated display and inputs	x64, ARM64	03h
Detachable	“Detachable” means a device that combines a display, rechargeable power source, and pointing device into a single chassis together with a detachable keyboard. In the case where the device’s form factor allows for a keyboard, not including Bluetooth or other wireless keyboards, to be physically connected to the chassis but the physical keyboard is sold as an optional accessory to the End User, the “enclosure type” field is to be identified as a “Detachable”.	X64, ARM64	20h
Mini PC	“Mini PC” means a Partner System that does not include an integrated display and input (keyboard/mouse) or optical drive and where volume is <1 liters.	x64, ARM64	23h
Notebook	“Notebook” means a device with a clamshell form factor and has a non-detachable keyboard. <b>Portable (08h)</b> or <b>Laptop (09h)</b> are not to be used when identifying a “Notebook”.	x64, ARM64	0Ah
Tablet	“Tablet” means a device that combines a display, rechargeable power source, and other components into a single chassis, and utilizes touch as its primary means of input. It does not include a physically attached keyboard. In the case where the device’s form factor does not allow for a keyboard to be physically connected to the chassis, but a Bluetooth or other wireless keyboard is sold as an optional accessory to the End User, the “enclosure type” field is to be identified as a “Tablet”	x64, ARM64	1Eh

### 1.1.3 Design verification and compliance

The policies and requirements expressed within are applicable for the versions of Windows noted, except as otherwise required by or subject to local law, rule, regulation, order, or decree from an applicable governing regulatory authority.

## 1.2 Minimum hardware requirements summary

The summary below provides an overview of the minimum hardware requirements for Windows 11. Refer to the hardware requirements under Section 3 for more details.

**REQUIRED:** Must include/implement the component

**OPTIONAL:** Not required for bring up Windows 11. If an optional device is implemented, it must comply with the respective [WHCP requirements](#)

Components		Windows 11
Processor		<b>REQUIRED:</b> 1 GHz
		<b>REQUIRED:</b> 2 Cores
		<b>REQUIRED:</b> Processor generation and model: Refer to <a href="#">the Silicon Support Policy</a> for the supported processor list
System memory		<b>REQUIRED:</b> 4 GB
Storage		<b>REQUIRED:</b> 64 GB
System firmware		<b>REQUIRED:</b> UEFI
Security	TPM	<b>REQUIRED:</b> TPM 2.0
	UEFI Secure Boot (enabled by default)	<b>REQUIRED:</b> Required
Audio	Audio Codec	Optional <sup>1</sup>
	Primary microphone	Optional <sup>1</sup>
	Loudspeaker	Optional <sup>1</sup>
Display	Screen	<b>REQUIRED:</b> > 9" (exclude Desktop PC)
	Resolution	<b>REQUIRED:</b> High-Definition (720p)
	Bit depth	<b>REQUIRED:</b> 8 bits per color channel

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	<b>Graphics</b>	<b>REQUIRED:</b> DirectX 12 API
		<b>REQUIRED:</b> WDDM 2.0
<b>Camera</b>	<b>Rear-facing Camera</b>	Optional <sup>1</sup>
	<b>Forward-facing Camera</b>	Optional <sup>1</sup>
<b>Connectivity</b>	<b>Bluetooth</b>	<b>REQUIRED</b> (exclude <b>Desktop PC</b> ) <sup>1</sup>
	<b>Cellular Radio</b>	Optional <sup>1</sup>
	<b>Ethernet</b>	<b>REQUIRED</b> (if Wi-Fi is not implemented)
	<b>NFC</b>	Optional <sup>1</sup>
	<b>Wi-Fi</b>	<b>REQUIRED</b> (if Ethernet is not implemented)
<b>Digitizer</b>	<b>Touch</b>	Optional <sup>1</sup>
	<b>Precision Touchpad</b>	<b>REQUIRED</b> (if touchpad is implemented)
	<b>Active Pen</b>	Optional <sup>1</sup>
<b>Sensors</b>	<b>Accelerometer Sensor</b>	Optional <sup>1</sup>
	<b>Ambient light Sensor</b>	Optional <sup>1</sup>
	<b>Color Sensor</b>	Optional <sup>1</sup>
	<b>Gyroscope Sensor</b>	Optional <sup>1</sup>
	<b>Hinge Angle Sensor</b>	Optional <sup>1</sup>
	<b>Magnetometer/Compass Sensor</b>	Optional <sup>1</sup>
	<b>Orientation Sensor</b>	Optional <sup>1</sup>
	<b>Proximity Sensor</b>	Optional <sup>1</sup>
	<b>Simple Device Orientation Sensor</b>	Optional <sup>1</sup>
<b>Hardware buttons</b>	<b>Power Button</b>	<b>REQUIRED</b>
	<b>Audio Volume Up/Down Buttons</b>	<b>REQUIRED</b>
	<b>Rotation lock</b>	Optional <sup>1</sup>
<b>Connectors</b>	<b>Headphone/headset Jack (3.5mm)</b>	Optional <sup>1</sup>
	<b>Removable Storage Slot</b>	Optional <sup>1</sup>
	<b>SIM Slot</b>	Optional <sup>1</sup>

	USB Ports	REQUIRED: At least 1 port
	Video Output	REQUIRED
Notification	Hardware Notification LED	Optional <sup>1</sup>

<sup>1</sup>Certain feature requires specific hardware, see <https://go.microsoft.com/fwlink/?linkid=2163320>

## Section 2.0 – Hardware driver requirements

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All drivers installed on the shipped image of each Windows 11 device must be qualified and digitally signed through the respective version of [Windows Hardware Compatibility Program \(WHCP\)](#) <sup>1</sup>

## Section 3.0 – Hardware requirements

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This section provides detailed hardware requirements that apply to all applicable device types supported by Windows 11. In addition to these requirements, components and drivers within device is required to meet all respective **Windows Hardware Compatibility Program requirements and policy**. Refer to [Windows Hardware Compatibility Program requirements](#) for details.

### 3.1 Camera

- Forward facing camera – Optional\*
- Rear facing camera - Optional

\*Starting from January 1, 2023, all Device Types except Desktop PC, are required to have Forward-facing camera which meets the following requirements. A rear-facing camera is optional.

#### 3.1.1 Camera specification

The camera must support the following:

- The camera must:
  - Have a resolution of High-Definition (HD) or better
  - Auto Exposure (AE)

- Auto White Balance (AWB)
- For camera button specifications, see section [4.2.2 “Camera button behavior.”](#)

**Camera still-capture functional specifications**

Parameter	Minimum requirement
Still image resolution	1280 x 720 (HD)
Viewfinder (preview) resolution	1280 x 720 (HD) with frame rate $\geq$ 15 FPS (for rear-facing and forward-facing camera) with lighting $\geq$ 200 lux. In low light conditions the frame rate should maintain a minimum of 10 FPS for all supported resolutions. For higher resolutions, the device must support the same frame rate requirements.
Pixel aspect ratio	1:1 (square pixels)
Defective pixels <sup>1</sup>	0 defective pixels in center 50% image; < 10 minor defective pixels outside center 50% image
Autofocus range <sup>2</sup>	10 cm to infinity

<sup>1</sup> Minor defects: pixel deviates [10,20] gray levels from neighboring pixels when imaging black, white, and 18% gray images. Major defect: pixel deviates >20 gray levels from neighboring pixels when imaging black, white, and 18% gray images.

<sup>2</sup> This requirement applies only if autofocus is available.

**Camera video functional specifications**

Parameter	Minimum requirement
Video capture resolution	1280 x 720 (HD)
Viewfinder (preview) resolution	1280 x720 (HD) with frame rate $\geq$ 15 FPS (for rear-facing and forward-facing camera) with lighting $\geq$ 200 lux. In low light conditions the frame rate should maintain a minimum of 10 FPS for all supported resolutions.
Defective pixels <sup>1</sup>	0 defective pixels in center 50% image; <10 minor defective pixels outside center 50% image
Autofocus range <sup>2</sup>	10 cm to infinity

<sup>1</sup>Minor defect: pixel deviates [10,20] gray levels from neighboring pixels when imaging black, white, and 18% gray images. Major defect: pixel deviates >20 gray levels from neighboring pixels when imaging black, white, and 18% gray images.

<sup>2</sup> This requirement applies only if autofocus is available.

## 3.2 Connectivity

Windows 11 device must include at least one network connectivity option, such as Ethernet or Wi-Fi.

Cellular Radio/Mobile Broadband is optional.

### 3.2.1 Bluetooth

*Optional for **Desktop PC, All-in-one** Device Type*

The Bluetooth controller must comply with the Basic Rate (BR) and Low Energy (LE) Combined Core Configuration Controller Parts and Host/Controller Interface (HCI) Core Configuration requirements outlined in the Compliance Bluetooth Version 4.0 specifications.

*It is highly recommended to support Bluetooth 4.1 with LE Link Layer Topology which provides better proximal experiences and cross-device connectivity over Bluetooth LE.*

*“The Bluetooth radio HW shall be qualified as a “Controller Subsystem” and may additionally be qualified as a “Component” through the Bluetooth Special Interest Group.”*

## 3.3 Digitizer

### 3.3.1 Precision Touchpad (PTP)

If an integrated touchpad is included in a device, it must be compliant with relevant Precision Touchpad requirements within [Windows Hardware Compatibility Program](#).

## 3.4 Display and graphics

### 3.4.1 GPU and Driver

The device must meet:

- Windows Display Driver Model (WDDM) version 2.0 or later
- GPU and display driver supports DirectX 12 API or later

### 3.4.2 Display bit, depth, resolution, and size

Windows 11 device must support a minimum display pixel resolution of 720P (HD) (e.g. 1280 x 720), with a signaling bit depth of 8 bits per color channel (6 bits with dithering\* is permitted), on each output simultaneously, and a minimum diagonal display size for the primary display of 9-inch or larger.

\* If dithering is used, it may occur anywhere within the system, e.g., GPU or display; the requirement is that the effective bit depth exposed to Windows is 8-bits. Microsoft is partnering with Graphics IHVs to standardize the reporting of the effective bit depth, device must comply with the Minimum Display Requirements Supplemental Guidance and the respective [Windows Hardware Compatibility Requirements](#) to implement the bit depth correctly starting from the Windows release in 2023.

### 3.4.3 Display output

Windows 11 devices must support at least one of the following display outputs, except for devices with All-in-One as Device Type

- Display Port
- DVI
- HD-15 (typically VGA connection)
- HDMI
- Thunderbolt
- USB Type-C

## 3.5 Processor

Devices that run Windows 11 require a 1 GHz or faster processor that meets the following requirements.

- Supports 2 Processor Cores
- Compatible with the x64 or ARM64 instruction set
- Supports [PF\\_ARM\\_V81\\_ATOMIC\\_INSTRUCTIONS\\_AVAILABLE](#) instruction set (for ARM64 processor)
- Supports PAE, NX and SSE4.1
- Supports CMPXCHG16b, LAHF/SAHF, and PrefetchW
- Meets the supported processor generation list

Refer to the [Silicon Support Policy](#) for the supported processor list

## 3.6 Security

### 3.6.1 Trusted Platform Module (TPM)

All device models, lines or series must implement and be in compliance with the International Standard ISO/IEC 11889:2015 or the Trusted Computing Group TPM 2.0 Library and a component which implements the TPM 2.0 must be present and enabled by default.

The following requirements must be met:

- All TPM configurations must comply with local laws and regulations.
- Firmware-based components that implement TPM capabilities must implement version 2.0 of the TPM specification.
- An EK certificate must either be pre-provisioned to the TPM by the hardware vendor or be capable of being retrieved by the device during the first boot experience.
- It must ship with SHA-256 PCR banks and implement PCRs 0 through 23 for SHA-256. Note that it is acceptable to ship TPMs with a single switchable PCR bank that can be utilized for SHA-256 measurements.
- It must support TPM2\_HMAC command.

A UEFI firmware option to turn off the TPM is not required. Upon approval from Microsoft, OEM systems for special purpose commercial systems, custom order, and customer systems with a custom image are not required to ship with a TPM support enabled.

For detailed and to-to-date TPM requirements, refer to the relevant section in Windows Hardware Compatibility Program requirements

### 3.6.2 UEFI and Secure Boot

System firmware must be compliant with the UEFI Specification Version 2.3.1 Errata or higher. Windows 11 devices must ship with UEFI Secure Boot enabled by default. Refer to **System.Fundamentals.Firmware.UEFI Secure Boot** requirement under [Windows Hardware Compatibility Program](#) requirements.

### 3.6.3 Memory security

Device with external PCIe capable ports (e.g. Thunderbolt) must support Memory Access Protection or Kernel DMA Protection (kDMA) and enabled/opted-in by default.

- PCIe Native Control must be enabled in system firmware

## 3.7 Storage

### 3.7.1 Storage device size

Devices that run Windows 11 must include at least 64GB of storage device. While non-rotational storage is not required, it is highly recommended to achieve optimal performance.

### 3.7.2 Storage controller

Storage controllers used in devices that run Windows 11 must meet the following requirements:

- Storage controllers must support booting using the Extensible Firmware Interface (EFI) and implement device paths as defined in EDD-3.
- Storage host controllers and adapters must meet the requirements for the device protocol used and any requirements related to the device storage bus type.
- Bus-attached controllers must implement the correct class/subclass code as specified in the PCI Codes and Assignments v1.6 specification.

## 3.8 System memory

Devices that run Windows 11 must include at least 4GB of system memory.

# 4 Additional components

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## 4.1 USB

### 4.1.1 USB Ports

Devices that run Windows 11 require to have at least one USB port exposed outside of device chassis.

### 4.1.2 USB Power Delivery

If a USB Type-C PD silicon (e.g. PD controller) is implemented, it must implement version 1.1 of the USB Type-C spec or higher and revision 2.0 v1.1 and optionally support revision 3.0 v1.0 or higher of the PD spec and must be certified according to the USB-IF's USB-C product testing matrix.

## 4.2 Hardware buttons and behavior

Hardware button requirements for Windows 11

- Power button
- Volume up/down button is required for **Tablet** device Type, optional for the other Device Types.

### 4.2.1 Button wake up requirements for devices

Hardware buttons must be able to interrupt and wake up the devices' application processor from its lowest supported idle state as below. This capability is needed for the OS power policy manager to control when a button press is processed and when it is ignored.

Source (action)	Source type	Wake-up capability
Camera button (full press)	Button	Required
Volume Up/Down buttons	Button	Required if an audio stream is active to adjust the volume.
Power button	Button	Required

### 4.2.2 Camera button behavior

If the Camera button is implemented, it must meet the following requirement:

If a dedicated camera button is implemented, it can be a dual-action camera button with the ability to detect “half-press” and “full-press” as distinct separate actions or a single-action camera button that does not support a "half-press" functionality.

### 4.2.3 Power button behavior

If the Power button is implemented, it must meet the following requirements:

- When the device is off, pressing the power button must turn on the device. In addition, the device must show activity when it is turned on (such as vibrating or turning on the display).
- The device must implement a hardware timer to allow for either turning off the device or power cycling the device (turning off the device and then turning it on again) regardless of the current state of the device. This must be implemented by using at least one of the following options:
  - Press and hold the Power button.
  - Press and hold the Power button and the Volume Down button at the same time.

Either of these button options must start the hardware timer and the duration of the timer must be 10 seconds.

Releasing any of the buttons used to start the timer must stop the timer. Upon expiration of the timer, the device must either power cycle or turn off the device.

**Note** We recommend that the Power and Volume Down combination be used to start a power cycle on devices where the display is the only sign of life (for example, devices with no fan or LED).

## 4.3 Hardware Notifications

Windows offers software controls to fine-tune privacy settings, reducing unexpected or unauthorized access. However, OEM is strongly encouraged to add additional physical controls in the form of camera privacy shutters. Devices that run Windows 11 may optionally include notification LEDs (NLEDs) or On-air indicator LED which provides visual notification when camera is in-used.

## 5 Virtual Machine

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Microsoft recognizes that the user experience when running the Windows 11 in virtualized environments may vary from the experience when running non-virtualized. So, while Microsoft recommends that all virtualized instances of the Windows 11 follow the same minimum hardware requirements as described in [Section 1.2](#), the Windows 11 does not apply the hardware-compliance check for virtualized instances either during setup or upgrade. Note that, if the virtualized environment is provisioned such that it does not meet the minimum requirements, this will have an impact to aspects of the user experience when running the OS in the virtualized environment.

## 6 Accessibility

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Windows 11 operating systems include the Narrator screen reader feature for accessibility. For Narrator to work correctly on a device that uses touch for the primary means of user input, the device must include a touch controller that can report at least four simultaneous contacts. OEMs should be aware of this when planning devices for markets with accessibility requirements.

Where providing user input or output device connection points, provide at least one input and/or output connection that conforms to an industry standard non-proprietary format, directly or through the use of commercially available adapters.

Numeric keys arranged in a rectangular keypad layout must have the number five key tactilely distinct from the other keys. If key repeat is supported, the delay before repeat must be adjustable to 2 seconds or more. Keystroke should be adjustable of at least 0.5 seconds. And, the status of all locking or toggle controls must be discernible visually and either through touch or sound.

All mechanically operated controls and keys shall comply with accessibility standards. In other words, all controls and keys for the normal operation of a device must be accessible. This includes the keyboard, keypad, power switch, reset button, unlocking controls for docking stations, and release buttons for expansion cards and drives.

## Minimum Hardware Requirements for Windows 11

Hardware controls need to balance between the need to prevent accidental activation, especially for users with tremors or limited coordination, and the need to allow activation without using excessive force. The force required to activate controls and keys shall be 5 lbs. (22.2 N) maximum. In other words, mechanically operated controls must be usable with one hand, without particular motions (twisting of the wrist, tight grasping, pinching) or considerable exertion (more than five pounds of force).

Provide a means to discern without vision each operable part of the experience such that users of all abilities are able to manipulate and control a device as expected. Example, visually impaired users should be able to operate the device.

Where hardware is intended for shared use and speech output is available, a tactile indication of the means to initiate the speech mode of operation shall be provided.

Architecturally installed or free-standing non-portable products intended to be used in one location must have all controls necessary to access full functionality positioned for users with limited reach (such as for people who use wheelchairs).

Do not use color as the only visual means of conveying information. Do not use color in a way that requires the user to discriminate between hues, indicate an action, prompt a response, or distinguish a visual element.