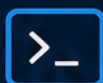


PowerShell:

THE COMPLETE REFERENCE

WINDOWS POWERSHELL AND POWERSHELL 7+
FOR SYSTEM ADMINISTRATION, AUTOMATION,
AND ENTERPRISE SCRIPTING



COMMANDS
& CMDLETS



SCRIPTING
& LANGUAGE



AUTOMATION
& REMOTING



SECURITY
& MANAGEMENT



TOOLS, MODULES
& PERFORMANCE



WINDOWS
POWERSHELL 5.1



POWERSHELL 7+
CROSS-PLATFORM



ENTERPRISE
ADMINISTRATION



CLOUD, APIs
& INTEGRATION



JSON, XML, CSV
& DATA

JULIA REINER

PowerShell: The Complete Reference

Windows PowerShell and PowerShell 7+ for System Administration, Automation, and Enterprise Scripting

Steve Publications

This book is available at

<https://leanpub.com/powershellthecompletereference>

This version was published on 2026-07-22



This is a [Leanpub](#) book. Leanpub empowers authors and publishers with the Lean Publishing process. [Lean Publishing](#) is the act of publishing an in-progress ebook using lightweight tools and many iterations to get reader feedback, pivot until you have the right book and build traction once you do.

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Complete Guide to Windows PowerShell and PowerShell 7+ for System Administration, Automation, and Enterprise Scripting

This book is a comprehensive technical reference for Microsoft PowerShell, covering everything from fundamental concepts to advanced enterprise automation. It documents the architecture of PowerShell including the pipeline, objects, providers, and modules; every built-in cmdlet in the core modules with complete syntax and parameters; language constructs including operators, keywords, variables, and classes; remoting, background jobs, Desired State Configuration (DSC), error handling, debugging, security, profiles, formatting, and performance optimization. It covers both Windows PowerShell 5.1 and cross-platform PowerShell 7+, with practical examples for file systems, processes, services, event logs, the registry, Active Directory, networking, storage, Hyper-V, scheduled tasks, certificates, WMI/CIM, REST APIs, JSON, XML, CSV, databases, cloud administration, and enterprise management. All technical content is based on official Microsoft documentation and current PowerShell behavior.

Introduction: The PowerShell Ecosystem

PowerShell is not merely a command-line shell. It is an object-oriented automation framework built on the .NET platform, designed from the ground up to help system administrators manage complex IT environments with precision, consistency, and scale. This book treats it as such.

When Microsoft first released Windows PowerShell 1.0 in November 2006, it was a radical departure from the text-based shells that dominated server administration at the time. Where traditional shells like `cmd.exe` passed strings between commands, PowerShell passed objects – structured data with properties and methods that retained their full fidelity as they moved through pipelines. This single architectural decision changed everything about how automation could be written, composed, and maintained.

Over nearly two decades of development, PowerShell has evolved from a Windows-only tool into an open-source, cross-platform automation engine. The transition began in 2016 with PowerShell Core 6.0, built on .NET Core to run on Linux and macOS alongside Windows. In 2020, the unified release of PowerShell 7 brought together the best features from both the legacy Windows PowerShell line (which ended at version 5.1) and the new cross-platform edition. Today, PowerShell 7.x is the actively developed version, receiving regular updates with new language features, performance improvements, and cross-platform capabilities, while Windows PowerShell 5.1 remains in maintenance mode on supported Windows systems.

This book covers both editions – PowerShell 7+ as the primary focus, with Windows PowerShell 5.1 documented where compatibility matters. Throughout, you will find version-specific notes indicating when a feature is available only in one edition or when behavior differs between them.

Who Should Use This Book

This reference is written for system administrators, DevOps engineers, IT professionals, and developers who work with PowerShell in production environ-

ments. You do not need prior PowerShell experience to start reading, but you should be comfortable with basic computing concepts: file systems, processes, networks, and the idea of automating repetitive tasks. If you are a seasoned PowerShell user looking for detailed parameter documentation or obscure behavioral notes, this book is organized so you can find specific information quickly while also discovering related topics through cross-references.

How This Book Is Organized

The material progresses from foundational concepts to advanced administration and scripting:

Chapters 1 through 3 establish the mental model for PowerShell – its architecture as an object-oriented shell, the language constructs that form scripts, and the pipeline mechanism that makes command composition powerful. Without this foundation, cmdlet syntax is just memorization without understanding.

Chapter 4 covers PowerShell's formatting system – how objects are displayed, `Format.ps1xml` files, custom views, and best practices for output control. This is essential because what you see on screen is not the raw object, and misunderstanding formatting leads to common scripting mistakes.

Chapters 5 through 7 document the core built-in cmdlets, providers, and error handling mechanisms that you will use daily. Chapter 5 is reference-heavy, covering every cmdlet in the `Microsoft.PowerShell.Core`, `Management`, `Utility`, and `Security` modules with complete syntax, parameter descriptions, and examples.

Chapters 8 through 10 cover scripting fundamentals – writing functions, organizing code into modules, and using PowerShell's class system for structured programming. This is where you learn to move from ad-hoc commands to maintainable automation libraries.

Chapters 11 through 13 address cross-machine administration: remoting via WinRM and SSH, background jobs and parallel execution with `runspaces`, and Desired State Configuration (DSC) for infrastructure-as-code scenarios including pull server deployments.

Chapters 14 through 21 cover specific administrative domains – event logs, performance monitoring, structured logging for production automation,

Active Directory management, networking with the NetTCPIP module, storage management, Hyper-V virtualization management, scheduled tasks, certificates and PKI operations, and cloud administration for Azure and AWS.

Chapters 22 through 28 address advanced topics: WMI and CIM for low-level system management, data format handling (JSON, XML, CSV), external integration via REST APIs and databases (including comprehensive SQL Server module coverage), profiles and environment configuration, script signing and enterprise deployment with JEA (Just Enough Administration), testing with Pester, static analysis with PSScriptAnalyzer, performance optimization, and cross-platform considerations for PowerShell 7+.

The Conclusion synthesizes the material and discusses PowerShell's role in modern IT automation and DevOps toolchains.

How to Use This Book

You can approach this book in three ways:

1. **Read sequentially** from start to finish if you are new to PowerShell or want a thorough understanding of how all the pieces fit together. The chapters build on each other intentionally.
2. **Use as a reference** by jumping directly to specific chapters when you need detailed information about a particular feature, cmdlet, or administrative task. Each chapter is self-contained enough to be useful this way.
3. **Study specific domains** – for example, if your immediate need is Active Directory automation, go directly to the AD chapter while using earlier chapters as needed for language and scripting fundamentals.

Throughout the book, code examples are fully explained. Every command demonstrates a real-world scenario rather than an artificial syntax exercise. Where multiple approaches exist, alternatives are presented with their trade-offs so you can choose based on your requirements.

Conventions Used in This Book

- PowerShell commands, parameters, variables, and keywords appear in monospace font: `Get-Process`, `-ErrorAction`, `$Error`.

- Code blocks show complete, runnable examples with comments explaining each step.
- Version-specific notes are marked as “Windows PowerShell only,” “PowerShell 7+ only,” or “Cross-platform.”
- Inline citations reference the References section at the end of the book.
- Cross-references to other chapters use the format “see Chapter N.”

Prerequisites

To follow along with examples in this book, you will need:

- A Windows system with PowerShell installed (Windows 10/11 and Windows Server include Windows PowerShell 5.1 by default) or a Linux/macOS system with PowerShell 7+ installed from learn.microsoft.com/powershell.
- Administrative privileges for examples that modify system settings, install modules, or manage services.
- Access to a domain controller and Active Directory environment for the AD management chapter (or a test lab).

To check your PowerShell version at any time, run:

```
1 $PSVersionTable.PSVersion
2 $PSVersionTable.PSEdition
```

This returns the version number and edition. “Desktop” indicates Windows PowerShell 5.1; “Core” indicates PowerShell 7+.

Let us begin.

Chapter 1: PowerShell Foundations and Architecture

Understanding PowerShell requires understanding what it is not. It is not a traditional command-line interpreter that reads text commands and produces text output. It is not a scripting language bolted onto an existing shell. PowerShell is a unified automation framework where the interactive shell, the scripting language, and the underlying object model are designed as one coherent system.

This chapter establishes that foundation by covering PowerShell's history, its architectural choices, how it differs from other shells, and the components that make it work.

What PowerShell Is and Isn't

PowerShell began development in 2001 under the codename Monad, led by Jeffrey Snover. The motivation was straightforward: Windows system administration had become too complex for the tools available. `cmd.exe` was limited to text processing; GUI tools did not scale to hundreds of servers; VBScript and other scripting languages lacked integration with the operating system. Microsoft wanted a shell that could manage the entire platform consistently.

The result, released as Windows PowerShell 1.0 in November 2006 [1], introduced several innovations:

- **Object-oriented pipeline:** Commands pass .NET objects between each other, not text. A command that lists files returns actual file objects with properties like Name, Length, LastWriteTime – not a formatted string you must parse.
- **Verb-Noun naming convention:** Every cmdlet (PowerShell's term for its built-in commands) follows the pattern Verb-Noun: `Get-Process`, `Set-Service`, `Remove-Item`. This makes commands self-documenting and discoverable.

- **.NET integration:** PowerShell runs on the .NET Framework, giving scripts direct access to every class and method in the framework without special syntax.
- **Providers:** Data stores like the file system, registry, and certificate store are exposed through a consistent interface using familiar file-system commands.
- **Common parameters:** Every cmdlet supports standard parameters like `-Verbose`, `-Debug`, `-ErrorAction`, `-WhatIf`, and `-Confirm`, providing uniform behavior across all commands.

PowerShell 2.0 (2009) added remoting, jobs, advanced functions, and module support – features that made it production-ready for enterprise automation [2]. PowerShell 3.0 (2012) introduced Desired State Configuration (DSC), CIM cmdlets to replace WMI cmdlets, and improved session state. PowerShell 4.0 (2013) added the NetTCPIP networking module and enhanced DSC. PowerShell 5.0 (2015) brought classes and enums for object-oriented scripting. PowerShell 5.1 (2016) was the final major release of the Windows-only edition, built on .NET Framework 4.5+.

In 2016, Microsoft open-sourced PowerShell and released PowerShell Core 6.0, rebuilt on .NET Core to run on Linux and macOS [3]. This was not an update to Windows PowerShell but a parallel implementation. PowerShell 7.0 (2020) unified the branding: “PowerShell” now refers to the cross-platform edition, while “Windows PowerShell” specifically means the legacy 5.1 line. Current versions as of 2026 include PowerShell 7.4 LTS and 7.5+, with 7.6 in development [4].

Key distinction: Windows PowerShell and PowerShell 7+ can coexist on the same Windows system. Windows PowerShell runs via `powershell.exe` and is built into the OS. PowerShell 7+ runs via `pwsh.exe` and must be installed separately. They use different module paths by default, have different .NET runtimes underneath, and are not fully compatible.

The Object-Oriented Shell

The defining architectural choice of PowerShell is its object-oriented pipeline. To understand why this matters, compare how three shells handle listing files larger than 1 megabyte:

cmd.exe (text-based):

```
1 dir /s /b | findstr ".txt"
```

This produces text output that you must parse as strings. There is no concept of “file size” in the pipeline – only characters.

Bash (text-based with utilities):

```
1 find . -name "*.txt" -size +1M
```

More capable, but still fundamentally string manipulation.

PowerShell (object-based):

```
1 Get-ChildItem -Path C:\Data -Filter *.txt -Recurse | Where-Object { $_.Length  
  ↪ -gt 1MB }
```

Here, `Get-ChildItem` returns `System.IO.FileInfo` objects. Each object has a `Length` property that is an actual integer representing bytes. The comparison `$_ .Length -gt 1MB` operates on numbers, not text. You can access any property of the file object without parsing output.

This difference becomes critical at scale. When you pipe objects through a pipeline:

- Properties retain their types. A date property stays a `[datetime]` object; a size property stays an integer.
- Methods are available. You can call `.ToString()`, `.GetType()`, or any other method on the piped object.
- Formatting is deferred. What you see on screen is a formatted view of the objects, not the objects themselves. The full data remains available downstream.

Consider this pipeline:

```
1 Get-Process | Where-Object { $_.CPU -gt 100 } | Sort-Object CPU -Descending |  
  ↪ Select-Object Name, Id, CPU, WorkingSet64
```

Each stage works with `System.Diagnostics.Process` objects:

1. `Get-Process` returns all running processes as objects.

2. `Where-Object` filters by the numeric CPU property (seconds of processor time).
3. `Sort-Object` sorts numerically by CPU usage.
4. `Select-Object` extracts four properties from each object for display.

At no point does the data become text. If you wanted to stop those processes instead of displaying them, you could pipe directly to `Stop-Process`:

```
1 Get-Process | Where-Object { $_.CPU -gt 100 } | Stop-Process
```

`Stop-Process` accepts `Process` objects by value because its `-InputObject` parameter is bound automatically from the pipeline. This composability – where commands are designed to work together through shared object types – is PowerShell’s superpower.

The trade-off is that PowerShell has more overhead than text-based shells for simple tasks. Creating and passing .NET objects is slower than piping text through a pipe character. For interactive use and automation scripts, this cost is negligible. For extremely high-throughput scenarios processing millions of records, you may need to optimize by using .NET methods directly or minimizing pipeline depth. Chapter 27 covers performance optimization in detail.

PowerShell Hosts and Runspaces

PowerShell code runs inside a “host” application. The host provides the user interface, handles input and output, and manages the connection to the PowerShell engine. Understanding hosts matters because some features behave differently depending on which host you are using.

ConsoleHost (`powershell.exe` or `pwsh`): The default interactive shell. On Windows, `powershell.exe` launches Windows PowerShell 5.1 `ConsoleHost`; `pwsh.exe` launches PowerShell 7+ `ConsoleHost`. This is what most administrators use daily.

Windows PowerShell ISE: The Integrated Scripting Environment, available only in Windows PowerShell 5.1. It provides a split-pane editor with integrated debugging and help. ISE was removed from PowerShell 7+. Microsoft recommends Visual Studio Code with the PowerShell extension as the replacement [5].

Visual Studio Code: With the official PowerShell extension, VS Code provides syntax highlighting, IntelliSense, integrated debugging, terminal, and PSScriptAnalyzer integration. This is the recommended development environment for PowerShell 7+ [6].

Remote hosts: When you use `Enter-PSSession` or `Invoke-Command`, your commands run in a remote host on another computer. The remote host can be `ConsoleHost` or a custom session configuration.

Embedded hosts: Applications can embed PowerShell as a scripting engine. Examples include the Exchange Management Shell, SharePoint Management Shell, and Azure PowerShell module. These hosts add application-specific cmdlets while using the same underlying PowerShell engine.

Check your current host with:

```
1 $Host.Name
2 $Host.Version
```

A “runspace” is the execution environment where PowerShell commands run. Each runspace maintains its own session state: variables, functions, loaded modules, and current location. By default, an interactive PowerShell session has one runspace. Background jobs each get their own runspace. Advanced scripts can create custom runspaces for parallel processing using the `System.Management.Automation.Runspaces` namespace.

The Execution Model

When you type a command in PowerShell, several stages occur before execution:

1. **Parsing:** The PowerShell parser converts your text input into an Abstract Syntax Tree (AST), checking for syntax errors.
2. **Command resolution:** PowerShell determines what kind of command you entered – a cmdlet, function, script file, filter, or external executable. It searches in this order: alias, function, cmdlet, script, then external program [7].
3. **Binding:** Parameters are bound to their values. Pipeline input is matched to parameters that accept it. Type conversions occur as needed.

4. **Execution:** The command runs, producing output objects that flow down the pipeline or to the host for display.

You can inspect this process using advanced features:

```
1 # Parse a script block and examine the AST
2 $ast = [System.Management.Automation.Language.Parser]::ParseInput("Get-Process
   ↳ -Name notepad", [ref]$null, [ref]$errors)
3 $ast.FindAll({ $args[0] -is [System.Management.Automation.Language.CommandAst]
   ↳ }, $true)
4
5 # Trace parameter binding
6 Trace-Command -Name ParameterBinding -Expression { Get-Process -Name notepad }
   ↳ -Verbose
```

Understanding execution order matters for scripting. Consider this:

```
1 Get-ChildItem *.txt | ForEach-Object { $_.Length } | Measure-Object -Average
```

PowerShell does not wait for all files to be enumerated before starting the length calculation, nor does it wait for all lengths before computing the average. Each stage processes objects as they arrive. This streaming behavior is efficient for large datasets but means that some operations (like sorting) must collect all input before producing output.

Installation and Setup

Windows PowerShell 5.1: Included by default on Windows 10, Windows 11, and Windows Server 2012 R2 through 2025. It is installed as part of the operating system and cannot be removed. To check if it is available:

```
1 powershell.exe -Command "$PSVersionTable.PSVersion"
```

PowerShell 7+ on Windows: Install from Microsoft's official packages. Options include MSI installer, MSIX bundle, Winget package manager, or Chocolatey [8]:

```
1 # Using winget (Windows Package Manager)
2 winget install Microsoft.PowerShell
3
4 # Verify installation
5 pwsh -Command "$PSVersionTable.PSVersion"
```

After installation, PowerShell 7+ runs via `pwsh.exe`. It installs side-by-side with Windows PowerShell 5.1 and does not replace it.

PowerShell 7+ on Linux: Install via your distribution's package manager. Examples:

```
1 # Ubuntu/Debian
2 sudo apt-get update
3 sudo apt-get install -y powershell
4
5 # RHEL/CentOS/Fedora
6 sudo dnf install -y powershell
7
8 # Verify
9 pwsh --version
```

PowerShell 7+ on macOS: Install via Homebrew or the official installer:

```
1 # Using Homebrew
2 brew install --cask powershell
3
4 # Verify
5 pwsh --version
```

Verifying your environment: Regardless of platform, run this to see your complete PowerShell environment:

```
1 $PSVersionTable | Format-List
```

This displays the version, edition (Desktop or Core), CLR version, Git commit ID, OS information, and platform details. For a quick check:

```
1  # Version number only
2  $PSVersionTable.PSVersion
3
4  # Is this Windows PowerShell or cross-platform?
5  $PSVersionTable.PSEdition
6
7  # Platform detection variables (PowerShell 6+)
8  $IsWindows    # $true on Windows
9  $IsLinux      # $true on Linux
10 $IsMacOS      # $true on macOS
11 $IsCoreCLR    # $true for PowerShell 7+, $false for Windows PowerShell
```

These boolean variables (`$IsWindows`, `$IsLinux`, `$IsMacOS`) are automatic variables introduced in PowerShell 6.0 and are the recommended way to write cross-platform scripts that behave differently based on the operating system.

Module paths: PowerShell finds modules by searching directories listed in `$env:PSModulePath`. On Windows with both editions installed, PowerShell 7+ typically includes paths for both its own modules and Windows PowerShell modules, but only loads modules marked as compatible [9]. Check your module path:

```
1  $env:PSModulePath -split [System.IO.Path]::PathSeparator
```

Understanding these paths matters when you install or create modules, as the location determines whether a module is available to all users or only to the current user, and which PowerShell editions can find it.

This chapter has established what PowerShell is, how it differs from traditional shells, and the architectural components that make it work. The next chapter dives into the language itself: variables, types, operators, and keywords that form every PowerShell script.

Chapter 2: The Language Core

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

Variables and Scope

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

Data Types and Type Accelerators

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

Operators

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

Common Parameters Reference

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

-Verbose and -Debug (Output Control)

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

-ErrorAction and -ErrorVariable (Error Handling)

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

-WarningAction and -WarningVariable (Warnings)

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

-InformationAction and -InformationVariable (Information Stream)

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

-OutVariable and -OutBuffer (Output Capture)

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

-PipelineVariable (PowerShell 3+)

This content is not available in the sample book. The book can be purchased on Leanpub at <https://leanpub.com/powershellthecompletereference>.

-WhatIf and -Confirm (Risk Mitigation)

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-ProgressAction (PowerShell 7+)

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