



Module 3 - System Administration PowerShell

Session 3 - Syntax, Scripting, & Variables

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YOUR GATEWAY TO CYBERSECURITY SKILLS AND CAREERS

Welcome to Cyber Aces, Module 3! This module provides an introduction to the latest shell for Windows, PowerShell. In this session we'll discuss additional syntax as well as scripting and variables.

SANS CYBER ACES ONLINE TUTORIALS

YOUR GATEWAY TO CYBERSECURITY SKILLS AND CAREERS

1. Introduction to Operating Systems

- 01. Linux
- 02. Windows

2. Networking

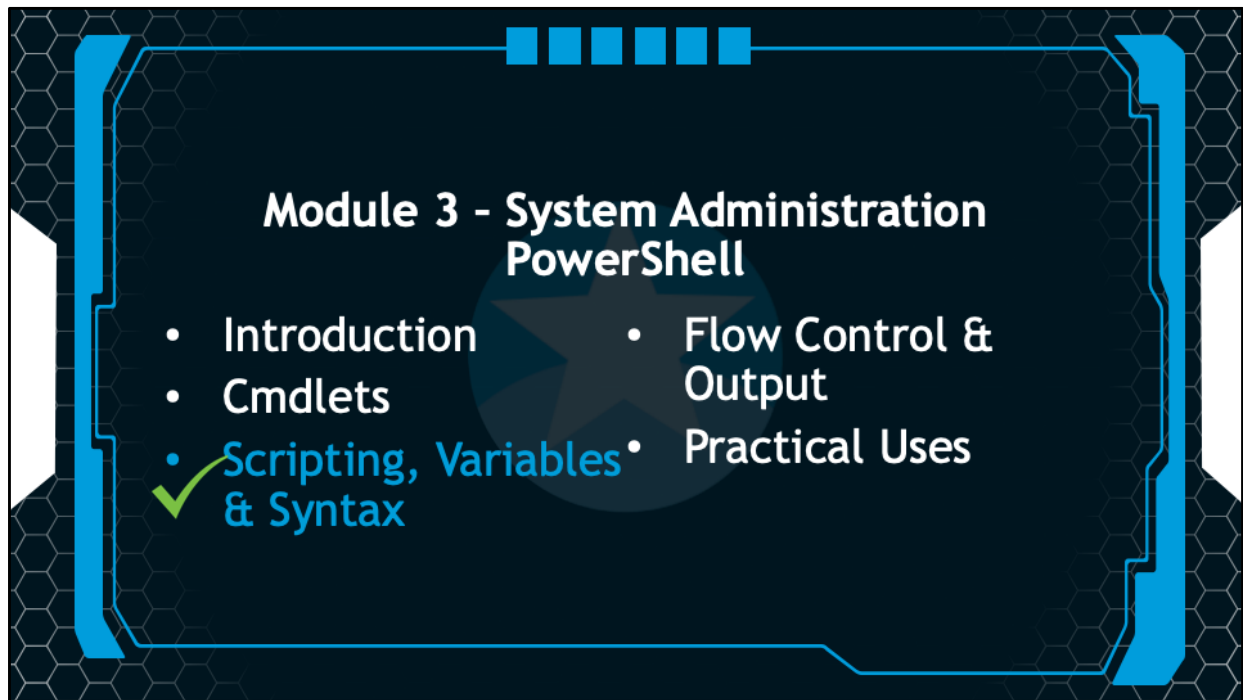
3. System Administration

- 01. Bash
- 02. PowerShell
- 03. Python

This training material was originally developed to help students, teachers, and mentors prepare for the Cyber Aces Online Competition. This module focuses on the basics of what an operating system is as well as the two predominant OS's, Windows and Linux. In this session we will provide a walkthrough of the installation of a Windows VM using VMware Fusion (MacOS) and VMware Player (Windows & Linux). These sessions include hands-on labs, but before we begin those labs we need to install the operating systems used in those labs. We will be using VMware to virtualize these operating systems. You can use other virtualization technologies if you like, but instruction for their setup and use are not included in this training.

The three modules of Cyber Aces Online are Operating Systems, Networking, and System Administration.

For more information about the Cyber Aces program, please visit the Cyber Aces website at <https://CyberAces.org/>.



In this section, you will be introduced to PowerShell and some basic syntax.



PowerShell Scripts



Use the extension .ps1

Not associated with PowerShell

- Meaning, double click of ps1 file will not cause execution
- Security feature to prevent accidental execution due to phishing or trojan style attack

No special syntax or header necessary to create a script

As with any shell, you can write scripts to automate common tasks, and this can make life a lot easier. Scripts can make boring and repetitive tasks much easier and quicker. Why ever do the same thing twice?

These scripts have the extension ".ps1", and do not require any special headers. The syntax of variables and commands in scripts is the same as that used on the command line. However, there are a few security features surrounding the execution of these script files.

The first security feature is, by default, double clicking on a ".ps1" file will not execute the script, but rather will open it in a text editor. This prevents the inadvertent execution of script files. To manually execute a script, it must be run from the command line.



Execution Policy



Default Execution Policy is "Restricted"

- PowerShell will only operate as an interactive shell (no script execution)

Other common options

- AllSigned - Only signed scripts can be run
- RemoteSigned - Remote scripts must be signed, local scripts do not have to be signed (The most common non-default setting)
- Unrestricted - All scripts, no signing

Get current policy: **Get-ExecutionPolicy**

Set policy: **Set-ExecutionPolicy <name>**

- You must be in an elevated prompt to change this setting

Detailed help: **Get-Help about_execution_policies**

PowerShell can be launched with a specific policy using the -ExecutionPolicy parameter (-exec for short):

```
PS C:\> Powershell.exe -exec bypass
```

The second security feature is that, by default, no scripts can be run. The default "ExecutionPolicy" is "Restricted." In this mode, PowerShell only operates as an interactive shell.

If you need to run scripts, the most secure setting is "AllSigned." With this setting, scripts can run, but all scripts and configuration files must be signed by a trusted publisher. Even scripts written on the local computer must be signed, and that can make writing and debugging scripts difficult. Because this setting can be a pain, the most common setting is "RemoteSigned." It is the same as "AllSigned," except locally written scripts do not have to be signed. With "RemoteSigned", any scripts or configuration files downloaded from the Internet, e-mail, or IM still must be signed. Use the "Set-ExecutionPolicy" cmdlet to change this setting.

```
PS C:\> Set-ExecutionPolicy AllSigned
```

```
PS C:\> Set-ExecutionPolicy RemoteSigned
```

These commands can be run to change the execution policy to "AllSigned" or "RemoteSigned" respectively. Please note that you may need to run PowerShell with elevated permissions to use the "Set-ExecutionPolicy" cmdlet!

PowerShell can be executed with a specific policy using the -ExecutionPolicy parameter (-exec for short):

```
PS C:\> powershell.exe -exec bypass
```



Review



- 1) By default, does PowerShell allow you to run scripts that you have written on the local computer?
 - Yes
 - No
- 2) What is the noun used in the cmdlets to view and set whether scripts can be executed?
 - ExecutionPolicy
 - AllowScripts
 - AllSigned
 - RemoteSigned
 - Execution_Policy

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 - AllowScripts
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Answers



- 1) By default, does PowerShell allow you to run scripts that you have written on the local computer?
 - No
 - The default policy of "Restricted" prevents running of all script files
- 2) What is the noun used in the cmdlets to view and set whether scripts can be executed?
 - ExecutionPolicy
 - Remember, nouns don't contain the underscore character (_)

- 1) By default, does PowerShell allow you to run scripts that you have written on the local computer?
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 - Remember, nouns don't contain the underscore character (_)



Variables



Prefixed with a dollar sign (\$), similar syntax to Perl Set a variable

```
PS C:\> $a = 7
```

Output a variable

```
PS C:\> $a
```

```
7
```

Can hold command output, stores objects not output

```
PS C:\> $o = Get-ChildItem C:\
```

The first two commands have the same output as the last single command

```
PS C:\> $o = dir C:\
```

```
PS C:\> $o | Sort-Object -Property Name -Descending
```

```
PS C:\> dir C:\ | sort name -desc
```

Variables are useful for storing data that you want to use later. Variables in PowerShell are preceded by a dollar sign ("\$"), so we could use the following to store the number 7 in the variable "\$a":

```
PS C:\> $a = 7
```

We can then output the variable "\$a" just by typing it on the command line.

```
PS C:\> $a
```

```
7
```

Variables can store collections of objects, such as the output of a directory listing.

```
PS C:\> $o = Get-ChildItem
```

```
PS C:\> $o
```

```
Directory: C:\
```

Mode	LastWriteTime	Length	Name
d-r--	1/2/2011 1:27 PM		Program Files
d-r--	12/8/2010 8:56 AM		Users
d----	12/31/2010 11:50 AM		Windows
-a---	6/10/2009 4:42 PM	24	autoexec.bat
-a---	6/10/2009 4:42 PM	10	config.sys



Types



PowerShell variables can hold data of any type (e.g. integer, string, object)

A variable can be explicitly typed by prefixing it with [typename]

```
PS C:\> [int]$a = 7
```

If the variable is set to a non-integer an error will be thrown

```
PS C:\> $a = "Seven"
```

```
Cannot convert value "Seven" to type  
"System.Int32". Error: "Input string was  
not in a correct format."
```

We can also explicitly cast a variable to be of a certain type by using "[type]" so that it will only store values of the given type. Here "\$a" is declared as an integer and set to "7". Let's see what happens when "\$a" is set to an invalid value.

```
PS C:\> [int]$a = 7
```

```
PS C:\> $a = "Seven"
```

```
Cannot convert value "Seven" to type "System.Int32".  
Error: "Input string was not in a correct format."
```

PowerShell throws an error since the string "Seven" is not an integer.



Arrays



Simply, a collection of objects

```
$days = "Sun", "Mon", "Tue", "Wed", "Thu", "Fri", "Sat"  
$o = Get-ChildItem C:\
```

To access an item use the index number surrounded by square brackets []

```
PS C:\> $days[0]
```

Sun

- Remember, computers count from 0!

A range (..) can be used as well

```
PS C:\> $days[2..3]
```

Tue

Wed

The last item can be accessed by using a negative 1

```
PS C:\> $days[-1]
```

Sat

The array's length property shows the number of objects in the array

```
PS C:\> $days.length
```

7

The most common mistake with arrays is the "Off-by-One" error, when the programmer forgets that the index is base 0 and accesses the wrong item in an array or attempts to access the last item in an array and uses a non-existent index number.

Arrays are just a collection of objects. They can be created manually:

```
PS C:\> $days= "Sun", "Mon", "Tue", "Wed", "Thu", "Fri", "Sat"
```

...or they can be from the output of another command:

```
PS C:\> $files = Get-ChildItem C:\
```

Both the "\$days" and "\$files" variables are arrays. We can access an item in the array using square brackets ([]). PowerShell arrays are base zero, meaning the first item is 0.

```
PS C:\> $days[0]
```

Sun

Multiple items can be accessed like this:

```
PS C:\> $days[1..3]
```

Mon

Tue

Wed

```
PS C:\> $days[2,4,6]
```

Tue

Thu

Sat

The last item in an array can be accessed by counting backwards:

```
PS C:\> $days[-1]
```

Sat



Special Variables



\$ Current Pipeline Object

- Used in script blocks, filters (Where-Object), ForEach-Object, and the Switch statement
- Can be omitted in certain circumstances (PowerShell v3 and later)
- We'll use this a lot later when we filter or iterate through collections/arrays of objects

Other common variables: **\$true**, **\$false**, **\$null**

See them all with: **Get-ChildItem variable:**

- Remember, Get-ChildItem will display the contents of any container, and "variable:" is just another container

The Current Pipeline object (\$_) is used a lot in PowerShell. It is used when iterating over a number of objects or for filtering with the Where-Object cmdlet. We'll use this variable quite a bit towards the end of this module. The use of this variable is not required in PowerShell version 3 which ships with Windows 8 and later.

In PowerShell v1 and v2, the Where-Object command is used similar to this:

```
PS C:\> Get-Process | where {$_.CPU -gt 25}
```

...but in v3 and later it can be shortened to this:

```
PS C:\> Get-Process | where CPU -gt 25
```

The Get-ChildItem (aliases of ls or dir) can be used to view the variables currently in use:

```
PS C:\> Get-ChildItem variable:
```

```
PS C:\> dir variable:
```

```
PS C:\> ls variable:
```



Review



1) Will this series of commands throw an error?

```
PS C:\> $a = 12
```

```
PS C:\> $a = "Rodgers"
```

2) What is the name of the \$_ variable?

- Current Object
- Current Pipeline Object
- Iterator Object
- Filter Object
- Null

1) Will this series of commands throw an error?

```
PS C:\> $a = 12
```

```
PS C:\> $a = "Rodgers"
```

2) What is the name of the \$_ variable?

Current Object

Current Pipeline Object

Iterator Object

Filter Object

Null



Answers



1) Will this series of commands throw an error?

```
PS C:\> $a = 12
```

```
PS C:\> $a = "Rodgers"
```

- No
- PowerShell variables can contain any "type" of data, unless explicitly declared using [typename]

2) What is the name of the \$_ variable?

- Current Pipeline Object
- This object is used in ForEach-Object (alias %) loops and the Where-Object (alias ?) filter. This variable is used a lot in PowerShell.

1) Will this series of commands throw an error?

```
PS C:\> $a = 12
```

```
PS C:\> $a = "Rodgers"
```

No, PowerShell variables can contain any "type" of data, unless explicitly declared using [typename]

2) What is the name of the \$_ variable?

Current Pipeline Object

This object is used in ForEach-Object (alias %) loops and the Where-Object (alias ?) filter. This variable is used a lot in PowerShell.



Parentheses ()



Used in ForEach (different from ForEach-Object) loops, If statements, and Switch statements

```
PS C:\> if ($num -gt 7) { "Bigger than 7" }  
PS C:\> ForEach ($f in $files) { $f.Name }
```

Also, to complete one command and access properties of the output object(s)

```
PS C:\> (Get-Date).DayOfWeek  
Tuesday  
PS C:\> (Get-ChildItem)[0]
```

If a cmdlet returns output and you would like to access a property, method, or item then wrap it in parenthesis and then use the operator in question.

As previously mentioned, the output of cmdlets are objects. Objects have properties that we may need to access. For example, the Get-Date cmdlet returns a Date Object that has a DayOfWeek property. To get the day of the week we need to get the current date and then access that property.

```
PS C:\> (Get-Date).DayOfWeek  
Tuesday
```

Similarly, the Get-ChildItem command will return a list of objects and to access the first object (technically the 0th) we need to wrap it in parenthesis to finish the command and then access the first item in the array.



Curly Braces {}



Used with "Script Blocks"

- Essentially commands inside other commands

Used with common cmdlets

- ForEach-Object (alias %)

```
ls | % { $_.length / 1024 }
```

- Prints the length of each file divided by 1024

- Where-Object (alias ?)

```
ls | ? { $_.length -gt 1000 }
```

- Lists files in the current directory with a size greater than 1000 bytes

Commonly used with control structures

- If statements
- Switch statements
- While Statements

Curly braces are used with "script blocks," which are essentially commands inside of commands. This is most commonly used with "Where-Object", "ForEach-Object", and control structures like the "If", "While", and "Switch" statements.



Square Brackets []



Type declaration (see variables)

Arrays (see earlier reference)

Regular Expression (regex) set, e.g match files starting with a U or P

```
PS C:\> dir [UP]*
```

- The Get-ChildItem uses a modified regex character set to support backwards compatibility, but other commands support the official set
- `b[aeiou]g` matches bag, beg, big, bog, and bug, not not bbg
- Help on Regex: `Get-Help about_regular_expressions`

Square brackets have a number of uses in PowerShell: Regular Expressions, Type Declaration, and accessing an item in an array.

Regular expressions, also called "regex", allow for very flexible and specific searching. This is a very deep subject; in fact, multiple books have been written on just Regular Expressions. We won't discuss this in depth, but suffice it to say that the values inside the brackets are part of the search set. For example, the set of "[a-eh]" includes "a", "b", "c", "d", "e", and "h". In a practical example, the command below will get all files and folders beginning with "U" or "P".

```
PS C:\> Get-ChildItem [UP]*
```

```
Directory: C:\
```

Mode	LastWriteTime	Length	Name
d-r--	1/2/2011 1:27 PM		Program Files
d-r--	12/8/2010 8:56 AM		Users

What a nifty way to search.

Square brackets are also used to cast an object or declare a variable with a specific type (as shown in the "Variables" section). Also, the square brackets are used to access items in an array (see the "Arrays" slide).



Quotes



Double Quotes (") and single quotes (') are mostly interchangeable

- Except when a variable is referenced

```
PS C:\> $a = "Inigo Montoya"
```

```
PS C:\> Write-Host "Hello, my name is $a"
```

```
Hello, my name is Inigo Montoya
```

```
PS C:\> Write-Host 'Hello, my name is $a'
```

```
Hello, my name is $a
```

Backtick (`) can escape the dollar sign

```
PS C:\> Write-Host "Hello, my name is `$a"
```

```
Hello, my name is $a
```

Need to use \$() to wrap an object's property

```
PS C:\> echo "Creation time of `$f is $f.CreationTime"
```

```
Creation time of $f is file1.txt.CreationTime
```

```
PS C:\> echo "Creation time of `$f is $($f.CreationTime)"
```

```
Creation time of $f is 02/13/2009 17:31:30
```

For the most part, the single and double quotes are nearly interchangeable. The only difference is PowerShell tries to expand text inside double quotes, but not inside single quotes. Here is an example:

```
PS C:\> $a = "Inigo Montoya"
```

```
PS C:\> Write-Host "Hello, my name is $a"
```

```
Hello, my name is Inigo Montoya
```

```
PS C:\> Write-Host 'Hello, my name is $a'
```

```
Hello, my name is $a
```

You can accomplish the same thing with double quotes, but you need to use the backtick as a delimiter to escape the dollar sign:

```
PS C:\> Write-Host "Hello, my name is `$a"
```

```
Hello, my name is $a
```

If you want to use a variable inside quotes, you simply use the variable; but what if you want to access a property or a specific array index of that variable? Let's start with the basic version of the command by just accessing the variable.

```
PS C:\> $a = Get-Item Windows
```

```
PS C:\> echo "The variable `$a contains $a"
```

The variable \$a contains C:\Windows

Now, what if we try to access the "CreationTime" property of the object "\$a"?

```
PS C:\> echo "The creation time of `$a is
```

```
$a.CreationTime"
```

```
The creation time of $a is C:\Windows.CreationTime
```

Uh oh, that doesn't work! To access a property in a string, we need to wrap it in "\$(", called the sub-expression operator. Here is the right way of doing the same thing.

```
PS C:\> echo "The creation time of `$a is
```

```
$($a.CreationTime)"
```

```
The creation time of $a is 02/13/2009 17:31:30
```



Review



- 1) Assuming the current directory contains only two files named file.txt and otherfile.txt. What is the output of the following two commands?

```
$a = ls [fo]* | Sort-Object -Name  
echo "The length of `a is `${a.Length} and the first  
file is `${a[1]}"
```

 - The length of C:\file.txt C:\otherfile.txt is 2 and the first file is C:\otherfile.txt
 - The length of \$a is 2 and the first file is C:\otherfile.txt
 - The length of \$a is 2 and the first file is C:\file.txt
 - The length of `a is `\${a.Length} and the firstfile is `\${a[1]}
- 2) Curly Braces are used for which of the following?
 - Script Blocks
 - Arrays
 - Type declarations
 - Order of operations

- 1) Assuming the current directory contains only two files named file.txt and otherfile.txt. What is the output of the following two commands?

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echo "The length of `a is `${a.Length} and the  
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```

 - a. The length of C:\file.txt C:\otherfile.txt is 2 and the first file is C:\otherfile.txt
 - b. The length of \$a is 2 and the first file is C:\otherfile.txt
 - c. The length of \$a is 2 and the first file is C:\file.txt
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Answers



- 1) Assuming the current directory contains only two files named file.txt and otherfile.txt. What is the output of the following two commands?

```
$a = ls [fo]* | Sort-Object -Name
```

```
echo "The length of `a is $($a.Length) and the first  
file is $($a[1])"
```

- The length of \$a is 2 and the first file is C:\otherfile.txt
- The first instance is escaped with a back tick, so \$a is displayed
- The second is properly wrapped in parentheses and the length of the array is 2
- The last is properly wrapped, but the coder incorrectly used index 1 when attempting to reference the first file. Remember, the first item is 0, so index 1 references the second file (otherfile.txt)

- 2) Curly Braces are used for which of the following?

- Script Blocks
- Used in some commands to run other commands inside the current command

- 1) Assuming the current directory contains only two files named file.txt and otherfile.txt. What is the output of the following two commands?

```
$a = ls [fo]* | Sort-Object -Name
```

```
echo "The length of `a is $($a.Length) and the  
first file is $($a[1])"
```

- a. The length of C:\file.txt C:\otherfile.txt is 2
and the first file is C:\otherfile.txt
- b. The length of \$a is 2 and the first file is
C:\otherfile.txt
- c. The length of \$a is 2 and the first file is
C:\file.txt
- d. The length of `a is \$(\$a.Length) and the
firstname is \$(\$a[1])

- 2) Curly Braces are used for which of the following?

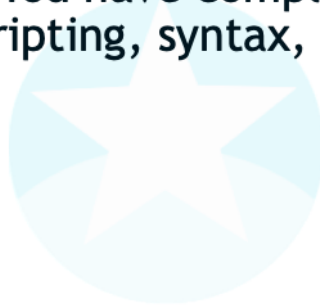
- Script Blocks
- Arrays
- Type declarations
- Order of operations



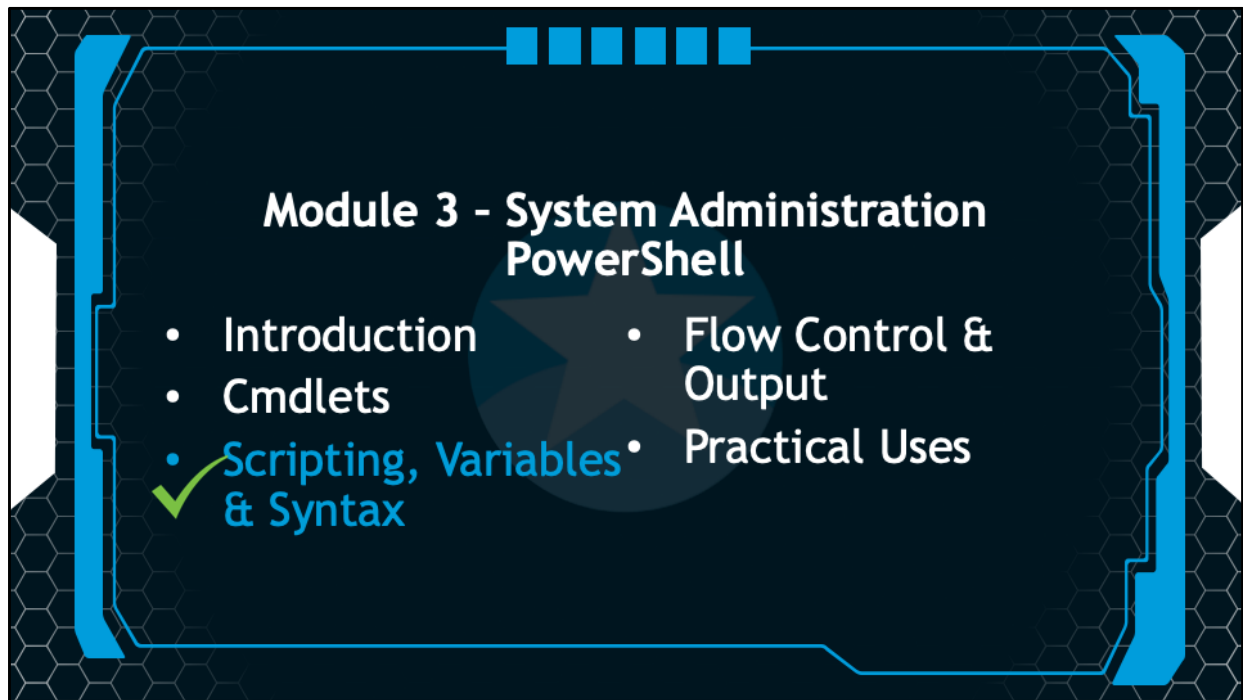
Exercise Complete!



Congratulations! You have completed the session on PowerShell scripting, syntax, and variables



Exercise Complete



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