IAN MIELL

LEARN BASH THE HARD WAY

MASTER BASH USING THE ONLY METHOD THAT WORKS

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Master Bash Using The Only Method That Works

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Introduction to Sample

This is a free sample of 'Learn Bash the Hard Way'.

It contains half of the first part of the book and a later section.

The book can be bought at leanpub[1] for just $5.

Structure

This book is structured into four parts:

Part I - Core Bash

Core foundational concepts essential for understanding bash on the command line.

Part II - Scripting Bash

Gets your bash scripting skills up to a proficient point.

Part III - Tips

A primer on commonly-used techniques and features that are useful to know about.

Part IV - Advanced Bash

Building on the first three chapters, and introducing some more advanced features, this chapter takes your bash skills beyond the norm.

If you have any questions about the book before buying, please contact the author[2] at ian@mail.meirionconsulting.co

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Foreword

Almost every day of my 20-year software career, I've had to work with bash in some way or other. Bash is so ubiquitous that we take it for granted that people know it, and under-valued as a skill because it's easy to 'get by' with it.

It's my argument that the software community is woefully under-served when it comes to learning about bash, and that mastering it pays massive dividends, and not just when using bash.

Either you are given:

- Impenetrable man pages full of jargon that assumes you understand far more than you do
- One-liners to solve your particular problem, leaving you no better off the next time you want to do something
- Bash 'guides' that are like extended man pages - theoretical, full of jargon, and quite hard to follow

All of the above is what this book tries to address.

If you've ever been confused by things like:

- The difference between `[` and `[[`
- The difference between globbing and regexes
- The difference between single or double quoting in bash
- What `` ` `` means
- What a subshell is
- Your terminal 'going crazy'

then this book is for you.

It uses the 'Hard Way' method to ensure that you have to understand what's needed to be understood to read those impenetrable man pages and take your understanding deeper when you need to.

Enjoy!

Learn Bash the Hard Way

This bash course has been written to help bash users to get to a deeper understanding and proficiency in bash. It doesn't aim to make you an expert immediately, but you will be more confident about using bash for more tasks than just one-off commands.

Introduction

Why Learn Bash?

There are a few reasons to learn bash in a structured way:

- Bash is ubiquitous
- Bash is powerful

You often use bash without realising it, and people often get confused by why it sometimes doesn't work as you expect it to, or even why bash works after they're given one-liners to run.

It doesn't take long to get a better understanding of bash, and once you have the basics, its power and ubiquity mean that you can be useful in all sorts of contexts.

Why Learn Bash The 'Hard Way'?

The 'Hard Way' is a method that emphasises the process required to learn anything. You don't learn to ride a bike by reading about it, and you don't learn to cook by reading recipes. Books can help (this one hopefully does) but it's up to you to do the work.

This book shows you the path in small digestible pieces based on my decades of experience and tells you to *actually type out the code*. This is as important as riding a bike is to learning to ride a bike. Without the brain and the body working together, the knowledge does not get there.

If you follow this course, you will get an understanding of bash that can form the basis of mastery as you use it in the future.

What You Will Get

This course aims to give students:

- A hands-on, quick and practical understanding of bash

- Enough information to understand what is going on as they go deeper into bash
- A familiarity with advanced bash usage

It does not:

- Give you a mastery of all the tools you might use on the command line, eg sed, awk, perl
- Give a complete theoretical understanding of all the subtleties and underpinning technologies of bash
- Explain everything. Plenty of time to go deeper and get all the nuances later if you need them

You are going to have to think sometimes to understand what is happening. This is the Hard Way, and it's the only way to really learn. This course will save you time as you scratch your head later wondering what something means, or why that StackOverflow answer worked.

Sometimes the course will go into other areas closely associated with bash, but not directly bash-related, eg specific tools, terminal knowledge. Again, this is always oriented around my decades of experience using bash and other shells.

Assumptions

It assumes some familiarity with *very* basic shell usage and commands. For those looking to get to that point, I recommend following this set of mini-tutorials:

https://learnpythonthehardway.org/book/appendixa.html

It also assumes you are equipped with a bash shell and a terminal. If you're unsure whether you're in bash, type:

```
echo $BASH_VERSION
```

into your terminal. If you get a bash version string output like this then you are in bash:

```
3.2.57(1)-release
```

How The Course Works

The course *demands* that you type out all the exercises to follow it.

Frequently, the output will not be shown in the text, or even described.

Any explanatory text will assume you typed it out. Again, this is the Hard Way, and we use it because it works.

This is really important: you must get used to working in bash, and figuring out what's going on by scratching your head and trying to work it out before I explain it to you. Eventually you will be on our own out there and will need to think for yourself. I'm trying to prepare you for that day.

Each section is self-contained, and must be followed in full. To help show you where you are, the shell command lines are numbered 1-n and the number is followed by a `$` sign, eg:

```
$ first command
$ second command
```

At the end of each section is a set of 'cleanup' commands (where needed) if you want to use them to leave no trace of your work.

What is Bash?

Bash is a shell program.

A shell program is typically an executable binary that takes commands that you type and (once you hit return), translates those commands into (ultimately) system calls to the Operating System API.

> ## Note
> A binary is a file that contains the instructions for a program, ie it is a 'program' file, rather than a 'text' file, or an 'application' file (such as a Word document).

If you're not sure what this means, then don't worry. You only need to know that a shell program is a program that allows you to tell the computer what to do. In that way, it's not much different to many other kinds of programming languages.

What makes bash different from some other languages is that it is a language designed to 'glue' together other programs.

In this section, you will learn a little about the history of bash and other related shells.

How Important is this Section?

This section is background and scene-setting material. It's not essential to material in the rest of the book, but contains information it's useful to be aware of when you read around the subject.

Other Shells

Other shells include:

- `sh`
- `ash`
- `dash`
- `ksh`
- `csh`
- `tcsh`
- `tclsh`

These other shells have different rules, conventions, logic, and histories that means they can look similar.

Because other shells are also programs, they can be run from within one another!

Here you run tcsh from within your bash terminal. Note that you get a different prompt (by default):

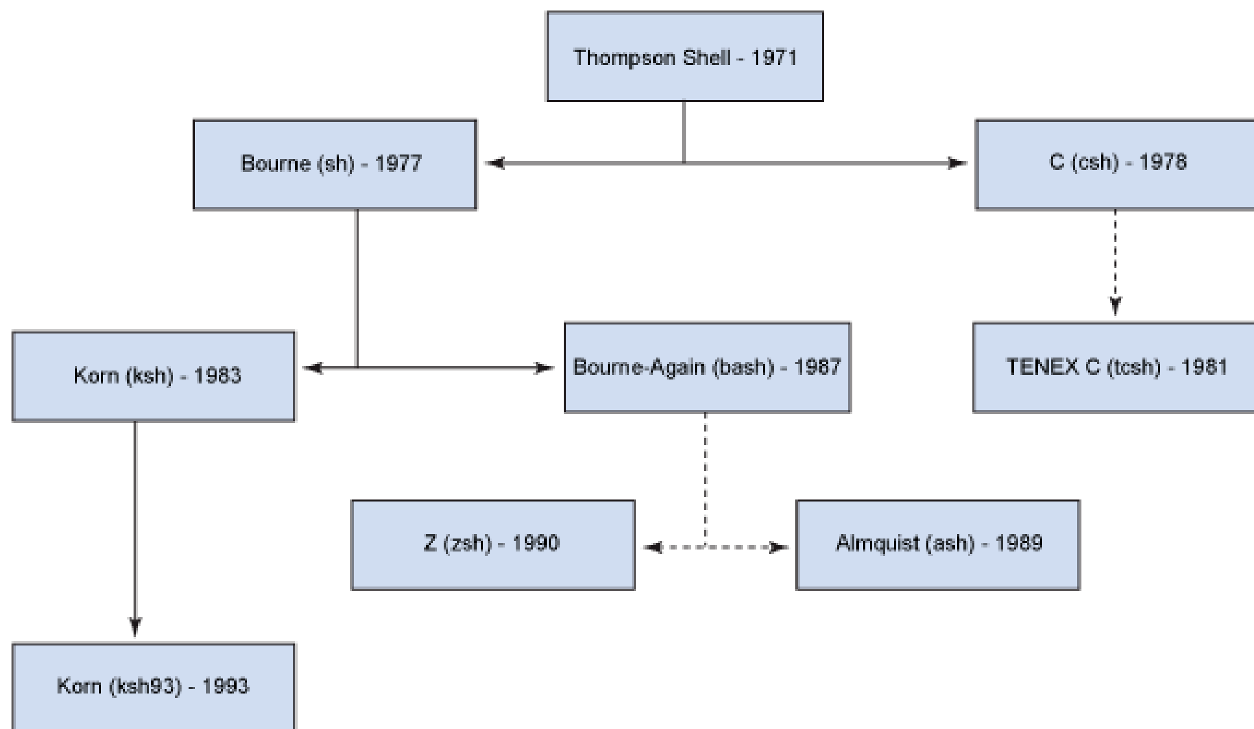
```
$ tcsh
% echo $dirstack
% exit
$
```

Typically, a tcsh will give you a prompt with a percent sign, while bash will give you a prompt with a dollar sign. This is configurable, though, so your setup may be different.

The `dirstack` variable is set by tcsh and will output something meaningful. It's not there by default in bash (try typing the echo commmand in when you are back in the bash shell at the end!)

History of bash

This diagram helps give a picture of the history of bash:



Bash is called the 'Bourne Again SHell'. It is a descendant of the 'Thompson Shell' and then the Bourne 'sh' shell. Bash has other 'siblings' (eg ksh), 'cousins' (eg tcsh), and 'children', eg 'zsh'.

The details aren't important, but it's important to know that different shells exist and they can be related and somewhat compatible.

Bash is the most widely seen and used shell as of 2017. However, it is still not unheard of to end up on servers that do not have bash!

What You Learned

- What a shell is
- How to start up a different shell
- The family tree of shells

What Next?

Next you look at two thorny but ever-present subjects in bash: globbing and quoting.

Exercises

1) Run `sh` from a bash command line. What happens?

2) What commands can you find that work in `bash`, but do not work in `sh`?

Unpicking the Shell: Globbing and Quoting

You may have wondered what the `*` in bash commands really means, and how it is different from regular expressions. This section will explain all, and introduce you to the joy of quoting in bash.

> ## Note
>
> Do not panic if you don't know what regular expressions are. Regular expressions are patterns used to search for matching strings. Globs look similar and perform a similar function, but are not the same. That's the key point in the above paragraph.

In this section you will learn:

- What globbing is
- The special globbing characters
- The difference between single and double quotes
- The difference between globbing and regular expressions

How Important is this Section?

Globbing and quoting are essential topics when using bash. It's rare to come across a set of commands or a script that doesn't depend on knowledge of them.

Globbing

Type these commands into your terminal

```
1 $ mkdir lbthw_glob
2 $ cd lbthw_glob
3 $ touch file1 file2 file3
4 $ ls *
5 $ echo *
```

- Line 1 above makes a new folder that should not exist already.
- Line 2 moves into that folder.
- Line 3 creates three files (file1,file2,file3).
- Line 4 runs the `ls` command, which lists files, asking to list the files matching `*`
- Line 5 runs the echo command using `*` as the argument to echo

What you should have seen was the three files listed in both cases.

The shell has taken your `*` character and converted it to match all the files in the current working directory. In other words, it's converted the `*` character into the string `file1 file2 file3` and then processed the resulting command.

Quoting

What do you think will be output happen if we run these commands?

Think about it first, make a prediction, and then type it out!

```
6 $ ls '*'
7 $ ls "*"
8 $ echo '*'
9 $ echo "*"
```

- Line 6 lists files matching the `*` character in single quotes
- Line 7 lists files matching the `*` character in double quotes
- Line 8 echoes the `*` character in single quotes
- Line 9 echoes the `*` character in double quotes

This is difficult even if you are an expert in bash!

Was the output what you expected? Can you explain it? Ironically it may be harder to explain if you have experience of quoting variables in bash!

Quoting in bash is a very tricky topic. You may want to take from this that quoting globs removes their effect. But in other contexts single and double quotes have different meanings.

Quoting changes the way bash can read the line, making it decide whether to take these characters and transform them into something else, or just leave them be.

What you should take from this is that "quoting in bash is tricky" and be prepared for some head-scratching later!

Other Glob Characters

`*` is not the only globbing primitive. Other globbing primitives are:

- `?` - matches any single character
- `[abd]` - matches any character from a, b or d
- `[a-d]` - matches any character from a, b, c or d

Try running these commands and see if the output is what you expect:

```
10 $ ls *1
11 $ ls file[a-z]
12 $ ls file[0-9]
```

- Line 10 list all the files that end in '1'
- Line 11 list all files that start with 'file' and end with a character from a to z
- Line 12 list all files that start with 'file' and end with a character from 0 to 9

Dotfiles

Dotfiles are like normal files, except their name begins with a dot. Create some with `touch` and `mkdir`:

```
13 $ touch .adotfile
14 $ mkdir .adotfolder
15 $ touch .adotfolder/file1 .adotfolder/.adotfile
```

You've now created some dotfiles. If you run `ls`:

```
16 $ ls
```

those files don't show up. So these files are hidden from us in normal view. What if we try to use a `*` as a glob?

```
17 $ ls *
```

Same result. Those files are hidden. While this may seem (and sometimes is) annoying, having files that don't match even a `*` glob is very useful. Frequently you want to have a file that sits alongside other files but that is generally ignored. For example, you might write some code that reformats a set of text files in a folder, but you don't want to reformat a dotfile that contains information about what's in those text files.

Unfortunately, it can be annoying when you really do want to see *all* the files in a folder. To achieve this, type:

```
18 $ echo .*
```

This tells bash that you want to see all filenames in the current folder that begin with a `.` character. `ls .*` will give you a different output, but we will get to that in a moment.

> ### Note
> The `.` character has no special significance in a globbing context. It literally just means the dot character. If you know regular expressions already, then this can be very confusing, as `.*` means 'match everything'. We go over this again below.

You'll also get a couple of extra 'special' files shown that you may not have been aware of before. These are the single dot folder: `.`, and the double dot folder: `..`

The single dot folder (`.`) is a special file that represents the folder that you are in. For example, if you type:

```
20  $ cd .
```

You will go nowhere! You've changed directory to the same folder that you are in.

The double dot folder (`..`) is another special folder that represents the parent folder of the one you are in.

What do you think happens at the root folder (`/`) if you `cd ..`? Have a look and find out.

If you re-run the last echo command with `ls`:

```
19  $ ls .*
```

you get a slightly more complicated output, as `ls` returns richer output depending on whether the item is a file or a folder. If it's a folder, it shows every (non-hidden) file within that folder under a separate heading.

Differences to Regular Expressions

While globs look similar to regular expressions (regexes), they are used in different contexts and are separate things.

The `*` characters in this command have a different significance depending on whether it is being treated as a glob or a regular expression.

```
21  $ rename -n 's/(.*)/new$1/' *
22  'file1' would be renamed to 'newfile1'
23  'file2' would be renamed to 'newfile2'
24  'file3' would be renamed to 'newfile3'
```

- Line 21 contains the command that renames all filenames to prepend 'new' in front. The `-n` flag tells rename to just print out the files that would be changed, and not actually carry out the renaming
- Lines 22-24 show the files that would be renamed

> **Note**
>
> You may not see the same output as above (or indeed any output), depending on your version of `rename`.

The first `*` character is treated as regular expressions, because it is not interpreted by the shell, but rather by the `rename` command. The reason it is not interpreted by the shell is because it is enclosed in single quotes. The last `*` is treated as a glob by the shell, and expands to all the files in the local directory.

> **Note**
>
> This assumes you have the program `rename` installed.

Again, the key takeaway here is that context is key.

Note that '.' has no meaning as a glob, and that some shells offer more powerful extended globbing capabilities. Bash is one of the shells that offers extended globbing, which we do not cover here, as it would potentially confuse the reader further. Just be aware that more sophisticated globbing is possible.

Cleanup

Now clean up what you just did:

```
25 $ cd ..
26 $ rm -rf lbthw_glob
```

What You Learned

- What a glob is
- What a dotfile is
- Globs and regexes are different
- Single and double quotes around globs can be significant!

What Next?

Next up is another fundamental topic: variables.

Exercises

1) Create a folder with files with very similar names and use globs to list one and not the other.

2) Research regular expressions online.

3) Research the program 'grep'. If you already know it, read the grep man page. (Type 'man grep').

Variables in Bash

As in any programming environment, variables are critical to an understanding of bash. In this section you'll learn about variables in bash and some of their subtleties.

You will cover:

- Basic variables
- Quoting variables
- Quoting and globs
- The `env` and `export` commands
- Simple arrays

By the end you will have a good overview of how variables work in bash and some of their pitfalls.

How Important is this Section?

Variables are fundamental to understanding bash commands, much as they are in any programming language.

Basic Variables

Start by creating a variable and echoing it.

```
1 $ MYSTRING=astring
2 $ echo $MYSTRING
```

Simple enough: you create a variable by stating its name, immediately adding an equals sign, and then immediately stating the value.

Variables don't need to be capitalised, but they generally are by convention.

To get the value out of the variable, you have to use the dollar sign to tell bash that you want the variable dereferenced.

Variables and Quoting

Things get more interesting when you start quoting.

Quoting can be used to group different 'words' into a single variable value:

```
3  $ MYSENTENCE=A sentence
4  $ MYSENTENCE="A sentence"
5  $ echo $MYSENTENCE
```

Since (by default) the shell reads each word in separated by a space, it thinks the word 'sentence' is not related to the variable assigment, and treats it as a program. To get the sentence into the variable with the space in it, you can enclose it in the double quotes, as above.

Things get even more interesting when we embed other variables in the quoted string:

```
6  $ MYSENTENCE="A sentence with $MYSTRING in it"
7  $ echo $MYSENTENCE
8  $ MYSENTENCE='A sentence with $MYSTRING in it'
9  $ echo $MYSENTENCE
```

If you were expecting similar behaviour to the previous section you may have got a surprise!

This illustrated an important point if you're reading shell scripts: the bash shell translates the variable into its value if it's in double quotes, but does not if it's in single quotes.

Remember from the previous section that this is not true when globbing!

Type this out and see. As ever, make sure you think about the output you expect before you see it:

```
10 $ MYGLOB=*
11 $ echo $MYGLOB
12 $ MYGLOB="*"
13 $ echo "$MYGLOB"
14 $ MYGLOB='*'
15 $ echo "$MYGLOB"
16 $ echo '$MYGLOB'
17 $ echo $MYGLOB
```

Globs are not expanded when in either single or double quotes. Confusing isn't it?

Shell Variables

Some variables are special, and set up when bash starts:

```
18 $ echo $PPID
19 $ PPID=nonsense
20 $ echo $PPID
```

- Line 18 - `PPID` is a special variable set by the bash shell. It contains the bash's parent process id.
- Line 19 - Try and set the `PPID` variable to something else.
- Line 20 - Output `PPID` again.

What happened there?

If you want to make a readonly variable, put `readonly` in front of it, like this:

```
21  $ readonly MYVAR=astring
22  $ MYVAR=anotherstring
```

`export`

Type in these commands, and try to predict what will happen:

```
23  $ MYSTRING=astring
24  $ bash
25  $ echo $MYSTRING
26  $ exit
27  $ echo $MYSTRING
28  $ unset MYSTRING
29  $ echo $MYSTRING
30  $ export MYSTRING=anotherstring
31  $ bash
32  $ echo $MYSTRING
33  $ exit
```

Based on this, what do you think `export` does?

You've already seen that a variable set in a bash terminal can be referenced later by using the dollar sign.

But what happens when you set a variable, and then start up another process?

In this case, you set a variable (`MYSTRING`) to the value `astring`, and then start up a new bash shell process. Within that bash shell process, `MYSTRING` does not exist, so an error is thrown. In other words, the variable was not inherited by the bash process you just started.

After exiting that bash session, and unsetting the `MYSTRING` variable to ensure it's gone, you set it again, but this time `export` the variable, so that any processes started by the running shell will have it in their environment. You show this by starting up another bash shell, and it 'echoes' the new value 'anotherstring' to the terminal.

It's not just shells that have environment variables! All processes have environment variables.

Outputting Exported and Shell Variables

Wherever you are, you can see the exported variables that are set by running `env`:

```
$ env
TERM_PROGRAM=Apple_Terminal
TERM=xterm-256color
SHELL=/bin/bash
HISTSIZE=1000000
TMPDIR=/var/folders/mt/mrfvc55j5mg73dxm9jd3n4680000gn/T/
PERL5LIB=/home/imiell/perl5/lib/perl5
GOBIN=/space/go/bin
Apple_PubSub_Socket_Render=/private/tmp/com.apple.launchd.2BE31oXVrF/Render
TERM_PROGRAM_VERSION=361.1
PERL_MB_OPT=--install_base "/home/imiell/perl5"
TERM_SESSION_ID=07101F8B-1F4C-42F4-8EFF-1E8003E8A024
HISTFILESIZE=1000000
USER=imiell
SSH_AUTH_SOCK=/private/tmp/com.apple.launchd.uNwbe2XukJ/Listeners
__CF_USER_TEXT_ENCODING=0x1F5:0x0:0x0
PATH=/home/imiell/perl5/bin:/opt/local/bin:/opt/local/sbin:/Users/imiell/google-clou\
d-sdk/bin:/usr/local/bin:/usr/bin:/bin:/usr/sbin:/sbin:/opt/X11/bin:/space/git/shuti\
t:/space/git/work/bin:/space/git/home/bin:~/.dotfiles/bin:/space/go/bin
PWD=/space/git/work
LANG=en_GB.UTF-8
XPC_FLAGS=0x0
HISTCONTROL=ignoredups:ignorespace
XPC_SERVICE_NAME=0
HOME=/Users/imiell
SHLVL=2
PERL_LOCAL_LIB_ROOT=/home/imiell/perl5
LOGNAME=imiell
GOPATH=/space/go
DISPLAY=/private/tmp/com.apple.launchd.lwUJWwBy9y/org.macosforge.xquartz:0
SECURITYSESSIONID=186a7
PERL_MM_OPT=INSTALL_BASE=/home/imiell/perl5
HISTTIMEFORMAT=%d/%m/%y %T
HISTFILE=/home/imiell/.bash_history
_=/usr/bin/env
OLDPWD=/Users/imiell/Downloads
```

The output of `env` will likely be different wherever you run it.

That isn't all the variables that are set in your shell, though. It's just the *environment* variables that are exported to processes that you start in the shell.

If you want to see all the variables that are available to you in your shell, type:

```
69  $ compgen -v
```

`compgen` is a command that generates list of possible 'word completions' in bash when you hit tab repeatedly. The `-v` flag shows all the variables that could be completed in the context, which has the side effect here of listing all variables (exported and local to the shell) set where you are.

Arrays

Worth mentioning here also are arrays. One such built-in, read only array is `BASH_VERSINFO`. As in other languages, arrays in bash are zero-indexed.

Type out the following commands, which illustrate how to reference the version information's major number:

```
70  $ bash --version
71  $ echo $BASH_VERSINFO
72  $ echo $BASH_VERSINFO[0]
73  $ echo ${BASH_VERSINFO[0]}
74  $ echo ${BASH_VERSINFO}
```

Arrays can be tricky to deal with, and bash doesn't give you much help!

The first thing to notice is that if the array will output the item at the first element (0) if no index is given.

The second thing to notice is that simply adding `[0]` to a normal array reference does not work. Bash treats the square bracket as a character not associated with the variable and appends it to the end of the array.

You have to tell bash to treat the whole string `BASH_VERSION[0]` as the variable to be dereferenced. You do this by using the curly braces.

These curly braces can be used on simple variables too:

```
76  $ echo $BASH_VERSION_and_some_string
77  $ echo ${BASH_VERSION}_and_some_string
```

In fact, 'simple variables' can be treated as arrays with one element!

```
78 $ echo ${BASH_VERSION[0]}
```

So all bash variables are 'really' arrays!

Bash has 6 items (0-5) in its `BASH_VERSINFO` array:

```
79 $ echo ${BASH_VERSINFO[0]}
80 $ echo ${BASH_VERSINFO[1]}
81 $ echo ${BASH_VERSINFO[2]}
82 $ echo ${BASH_VERSINFO[3]}
83 $ echo ${BASH_VERSINFO[4]}
84 $ echo ${BASH_VERSINFO[5]}
85 $ echo ${BASH_VERSINFO[6]}
```

As ever with variables, if the item does not exist then the output will be an empty line.

What You Learned

- Basic variable usage in bash
- Variables and quoting
- Variables set up by bash
- `env` and `export`
- Bash arrays

What Next?

Next you will learn about another core language feature implemented in bash: functions.

Exercises

1) Take the output of `env` in your shell and work out why each item is there and what it might be used by. You may want to use `man bash`, or use google to figure it out. Or you could try re-setting it and see what happens.

2) Find out what the items in `BASH_VERSINFO` mean.