

Bourne-Again SHell and Linux CLI

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Set interpreter: `#!/bin/bash` Remarks: `# this is comment`

Interactive control

Action	set -o vi	set -o emacs
vi-command mode (C)	ESC	—
Previous/next command in history	↑ / ↵	CTRL+↑ / CTRL+↵ PAGEUP / PAGEDOWN
Automatic fill of file name	ESC ESC	↑ ↓
List of all matches	ESC g	↑ ↓ ↵
Horizontal move in command line	← / →	CTRL+← / CTRL+→ / ← / →
Jump to line begin/end	← / →	CTRL+← / CTRL+→
Backward/forward search in history	↶ / ↷	CTRL+↶ / CTRL+↷
Delete word to the end/begin	↵ / ↶	ESC d / ESC b
Delete text from cursor to the line end/begin	↵ / ↶	CTRL+↵ / CTRL+↶

1.1. Command line history

- `history`, `fc -l` – display numbered history of commands
- `!n` – run command number *n*
- `!p` – run last command beginning by *p*
- `!!` – repeat last entered command
- `!:n` – expand *n*-th parameter of last command
- `!$` – expand the last parameter of last command
- `fc` – run defined `$EDITOR` wit last command
- `fc -e vim z k` – open `vim` editor with commands from *z* to *k*
- `~old~new` – substitute *old* with *new* in last command
- `program `!!`` – use output of last command as input

1.2. Help and manuals

- `type -a command` – information about command
- `help command` – brief help on bash command
- `man command`, `info command` – detailed help
- `man -k key`, `apropos key`, `whatis key` – find command

2. Debugging

Run a script as: `bash option script and its parameters`

- `bash -x` – print commands before execution
- `bash -u` – stop with error if undefined variable is used
- `bash -v` – print script lines before execution
- `bash -n` – do not execute commands

3. Variables, arrays and hashes

- `NAME=10` – set value to variable `$NAME`, `${NAME}`
- `export NAME=10`, `typedef -x NAME` – set as environment variable
- `D=${date}`; `D=`date`` – variable contains output of command `date`
- `env`, `printenv` – list all environment variables
- `set` – list env. variables, can set bash options and flags `shopt`
- `unset name` – destroy variable of function
- `typeset`, `declare` – set type of variable
- `readonly variable` – set as read only
- `local variable` – set local variable inside function
- `${!var}`, `eval \$$var` – indirect reference
- `${parameter-word}` – if *parameter* has value, then it is used, else *word* is used
- `${parameter=word}` – if *parameter* has no value assing *word*. Doesn't work with `$1`, `$2`, etc.
- `${parameter:-word}` – works with `$1`, `$2`, etc.
- `${parameter?word}` – if *parameter* has value, use it; if no display *word* and exit script.
- `${parameter+word}` – if *parameter* has value, use *word*, else use empty string
- `array=(a b c)`; `echo ${array[1]}` – print ,b‘
- `array+=(d e f)` – append new item/array at the end
- `${array[*]}`, `${array[@]}` – all items of array
- `${#array[*]}`, `${#array[@]}` – number of array items
- `declare -A hash` – create associative array (from version)
- `hash=([key1]=value ["other key2"]="other value")` – store items
- `${hash["other key2"]}`, `${hash[other key2]}` – access
- `${hash[@]}`, `${hash[*]}` – all items
- `${!hash[@]}`, `${!hash[*]}` – all keys

3.1. Strings

- `STRING="Hello"` – indexing: `H`₀ `e`₁ `l`₂ `l`₃ `o`₄
- `STRING+=" world!"` – concatenate strings
- `${#string}`, `expr length $string` – string length
- `${string:position}` – extract substrng from position
- `${string:position:length}` – extract substr. of length from position
- `${string/substring/substitution}` – substitute first occurrence
- `${string//substring/substitution}` – substitute all
- `${string/%substring/substitution}` – substitute last occurrence
- `${string#substring}` – erase shortest substring
- `${string##substring}` – erase longest substring

3.2. Embedded variables

- `~`, `$HOME` – home directory of current user
- `$PS1`, `$PS2` – primary, secondary user prompt
- `$PWD`, `~+ / $OLDPWD`, `--` – actual/previous directory
- `$RANDOM` – random number generator, 0 – 32,767
- `$?` – return value of last command
- `$$` – process id. of current process
- `$!` – process id. of last background command
- `$PPID` – process id. of parent process
- `$-` – display of bash flags
- `$LINENO` – current line number in executed script

- `$PATH` – list of paths to executable commands
- `$IFS` – Internal field separator. List of chars, that delimiter words from input, usually space, tabulator `$'\t'` and new line `$'\n'`.

4. Script command line parameters

- `$0`, `${0}` – name of script
- `$1` to `$9`, `${1}` to `${255}` – positional command line parameters
- `$#` – number of command line parameters (argc)
- `$*` – expand all parameters, `"$*" = "$1 $2 $3..."`
- `$@` – expand all parameters, `"$@" = "$1" "$2" "$3"..."`
- `$_` – last parameter of previous command
- `shift` – rename arguments, `$2` to `$1`, `$3` to `$2`, etc.; lower counter `$#`
- `xargs command` – read stdin and put it as parameters of *command*

4.1. Read options from command line

while getopts "a:b" opt; do case \$opt in

- a) `echo a = $OPTARG` ;;
- b) `echo b` ;;
- `\?) echo "Unknown parameter!" ;;`

esac; done

shift $$(($OPTIND - 1))$; echo "Last: `$1`"

5. Control expressions

- `(commands)`, `$(commands)`, ``commands``, `{commands}` – run in subshell
- `$(program)`, ``program`` – output of program replaces command
- `test`, `[]` – condition evaluation:
 - numeric comparison: `a -eq b ...a = b`, `a -ge b ...a ≥ b`, `a -gt b ...a > b`, `a -le b ...a ≤ b`, `a -lt b ...a < b`
 - file system: `-d file` is directory, `-f file` exists and is not dir., `-r file` exists and is readable, `-w file` exists and is writable, `-s file` is non-zero size, `-a file` exists
 - logical: `-a` and, `-o` or, `!` negation
- `[[]]` – comparison of strings, equal `=`, non-equal `!=`, `-z string` is zero sized, `-n string` is non-zero sized, `<`, `>` lexical comparison
- `[condition] && [condition]`
- `true` – returns 0 value
- `false` – returns 1 value
- `break` – terminates executed cycle
- `continue` – starts new iteration of cycle
- `eval parameters` – executes parameters as command
- `exit value` – terminates script with return value
- `. script`, `source script` – reads and interprets another script
- `:` *argument* – just expand argument or do redirect
- `alias name='commands'` – expand *name* to commands
- `unalias name` – cancel alias
- `if [condition]; then commands;`
 - `elif [condition]; then commands;`
 - `else commands; fi`
- `for variable in arguments; do commands; done`
 - `{a..z}` – expands to `a b c ...z`
 - `{i..n.s}` – sequence from *i* to *n* with step *s*
 - `{a,b,c}` – expands to `"a" "b" "c"`
 - `{1,2}{a,b}` – expands to `1a 1b 2a 2b`
 - `seq start step end` – number sequence
- `for((i=1; i<10; i++)); do commands; done`
- `while returns true; do commands; done`
- `until [test returns true]; do commands; done`
- `case $prom in value1) commands ;;`
 - `value2) commands ;;`
 - `*) implicit. commands ;;`
- `esac`
- Function definition: `function name () {commands; }`
- `return value` – return value of the function
- `declare -f function` – print function declaration

6. Redirections

- 0 stdin/input, 1 stdout/output, 2 stderr/error output
- `> file` – redirection, create new file or truncate it to zero size
- `>> file` – append new data at the end of file
- `command1<<<command2` – ouput from 2nd to stdin of 1st
- `command < file` – read stdin from file
- `tee file` – read stdin, writes to file and to stdout
- `command 2> file` – redirect error messages to file
- `exec 1> >(tee -a log.txt)` – redirect stdout also to file
- `2>&1` – merge stderr and stdout
- `exec 3<>/dev/tcp/addr/port` – create descriptor for network read/write
- `exec 3>&-` – close descriptor
- `command > /dev/null 2>&1` – suppress all output
- `n> n>> n>&m` – operation redirect for descriptors *n*, *m*
- `mkfifo name` – make a named pipe, it can be written and read as file
- `command1 | command2` – pipe, connection between processes
- `read parameters` – read input line and separate it into parameters

6.1. Input for interactive programs (here documents)

```
./program << EOF      ./program <<-'EOF' # suppress tabulators
Input1               Input1
Input2               Input2
EOF                  EOF
```

6.2. Process file line by line

cat file.txt | (while read L; do echo "\$L"; done)

7. Evaluating mathematical expressions

- `let expression`, `expr expression`, `$((expression))`, `$((expression1, expression2))`, `$(expression)`
- Numeric systems: `base#number`; hexa `0xABC`, octal `0253`, binary `2#10101011`
- Operators: `i++`, `++i`, `i--`, `--i`, `+`, `-`; `**` power, `*`, `/`, `%` remainder; logical: `!` neg., `&&` and, `||` or; binary: `-`, `&`, `|`; `<<`, `>>` shifts; assignment: `=` `**` `/=` `%=` `+=` `-=` `<=>` `&=`

- `factor n` – factorize *n* into primes
- Floating point operations: `echo "scale=10; 22/7" | bc`

8. Screen output

- `echo "text"` – print text, `echo *` print all files in current dir
- `echo -e "text"` – interpret escape-sequences (`\t` tab., `\a` beep, `\f` new page, `\n` new line), `-n`, `\c` suppressing `\n`, `\xHH` hex-byte, `\ynn` oct. byte, `\u03B1 „a“` (U+03B1) in UTF-8
- `stty` – change and print terminal line settings
- `tty` – print name of terminal connected to stdout
- `printf format values` – format output
- `printf -v variable form. val.` – form. output into variable
 - `% [flags][width][.precision][length]specifier`
 - Specifier: `%u`, `%d`, `%i` decimal; `%f`, `%F` float, `%x`, `%X` hex; `%o` octal, `%s` string, `%c` char `%`
 - Width: *n* prints at least *n* chars, spaces from right, `0n` print at least *n* chars, zeros from left, `*` width specified in preceding parameter
 - Precision: min. number of digits, digits after decimal point, number of printed chars, `*` number of chars given by preceding parameter
 - Flags: `-` left-justify, `+` prints number with sign `+/-`
- `printf "%d" \A` – display ASCII code of char “A” (65)
- `printf \\$(printf '%03o' 65)` – print char given by ASCII code
- `tput action` – terminal dependent action
- `reset`, `tput sgr0`, `tset` – reset terminal, cancel attributes
- `clear`, `tput clear` – clear screen

9. Process management

- `command &` – run *command* in background
- `prog1 && prog2` – run `prog2`, if `prog1` ends with success
- `prog1 || prog2` – rub `prog2`, if `prog1` ends with error
- (CTRL+Z)** – stop process (SIGSTOP)
- `bg/fg` – run last stopped process in background/foreground
- `jobs` – list processes running in background
- `exec command` – shell is replaced by *command*
- `wait` – wait for end of background tasks
- `top` – watch CPU, memory, system utilization
- `ps -xau` – list processes and users, `ps -xaf`, `pstree` tree listing
- `pgrep process`, `pidof process` – get PID by name of process
- `nice -n p command` – priority *p* od -20 (max.) to 19 (min.)
- `renice -n p -p pid` – change priority of running process
- `kill -s k n` – send signal *k* to proces id. *n*, 0, 1 SIGHUP; 2 SIGINT
- (CTRL+C)** 3 SIGQUIT; 9 SIGKILL; 15 SIGTERM; 24 SIGSTOP
- `trap 'command' signals` – run command when signal received
- `killall name` – send signals to process by name
- `nohup command &` – command will continue after logout
- `time command` – print time of process execution
- `times` – print user and system time utilization in current shell
- `watch -n s command` – every *s* seconds run command

10. Time and process planning

- `date` – print date, `date --date=@unix_time`
- `date +%Y%m%d%H:%M:%S%Z` – format to 20130610 13:39:02 CEST
- `cal` – display calendar
- `crontab -e` – edit crontab, `-l` list, format *min hour date month day command, * * * * * command run every minute, `1 * * * *` command 1st min of every hour*
- `at`, `batch`, `atq`, `atrm` – queue, examine or delete jobs for later execution

11. File operations

File name wildchars: `?` a char; `*` zero or more chars; `[set]` one or more given chars, interval `[0-9]` `[a-z]`, `[A-Z]`; `![set]`, `[^set]` none of chars.

- `ls` – list directory, `ls -la`, `vdir` all files with info
- `tree` – display hierarchy tree of directories
- `file file` – determine file by its magic number
- `lsattr`, `chattr` – list and change file attributes for ext2,3
- `umask` – define permission mask for new file
- `pwd (-P)` – logical (physical) path to current directory
- `cd directory` – change directory, `cd jump to $HOME`, `cd -` to `$OLDPWD`
- `dirs` – list stack of directories
- `pushd directory` – store *directory* to stack
- `popd` – set top stack directory as actual directory
- `cp source target` – copy file
- `ln -s source link` – create a symbolic link
- `mkdir`, `rmdir` – create, remove directory
- `rm file`, `rm -r -f directory`, `unlink` – delete
- `touch file` – create file, set actual time to existing file
- `du -h` – display space usage of directories
- `stat file` – file statistics, `stat --format=%s size`
- `basename name suffix` – remove path or suffix
- `dirname /path/to/file` – print only path
- `repquota` – summarize quotas for a filesystem
- `mktemp` – create file with unique name in `/tmp`

12. Work with file content

- `cat` – concatenate files and print them to stdout
- `cat > file` – create file, end with **(CTRL+d)**
- `tac` – like `cat`, but from bottom to top line
- `more`, `less` – print by pages, scrollable
- `od`, `hexdump -C`, `xxd` – print in octal, hex dump
- `wc` – get number of lines `-l`, chars `-n`, bytes `-c`, words `-w`
- `head/tail` – print begin/end, `tailf`, `tail -f` wait for new lines
- `split`, `csplit` – split file by size, content
- `sort - -n` numerical, `-r` reverse, `-f` ignore case
- `uniq` – omit repeated lines, `-d` show only duplicates

- `sed -e 'script'` – stream editor, script `y/ABC/abc/` replaces *A*, *B*, *C* for *a*, *b*, *c*; `s/regexp/substitution/`
- `tr a b` – replace char *a* for *b*
- `tr '[a-z]' '[A-Z]'` `< file.txt` – change lowercase to uppercase
- `awk '/pattern/ {action}' file` – process lines containing pattern
- `cut -d delimiter -f field` – print column(s)
- `cmp file1 file2` – compare files and print first difference
- `diff`, `diff3`, `sdiff`, `vimdiff` – compare whole files
- `dd if=in of=out bs=k count=n` – read *n* blocks of *k* bytes
- `strings` – show printable strings in binary file
- `paste file1 file2` – merge lines of files
- `rev` – reverse every line

13. Search

- `whereis`, `which` – find path to command
- `grep -i` ignore case, `-n` print line number, `-v` display everything except pattern, `-E` extended regexp
- `locate file` – find file
- `find path -name 'file*'` – search for *file**
- `find path -exec grep text -H {};` – find file containing *text*

14. Users and permissions

- `whoami`, `who am i` – tell who I am :)
- `w`, `who`, `users`, `finger` – list connected users
- `last / lastb` – history successful / unsuccessful logins
- `logout`, **(CTRL+d)** – exit shell
- `su login` – change user to *login*
- `sudo` – run command as other user
- `id login`, `groups login` – show user details
- `useradd`, `userdel`, `usermod` – create, delete, edit user
- `groupadd`, `groupdel`, `groupmod` – create, delete, edit group
- `passwd` – change password
- `pwck` – check integrity of `/etc/passwd`
- `chown user:group file` – change owner, `-R` recursion
- `chgrp group file` – change group of file
- `chmod permissions file` – change permissions in octal of user, group, others; `444=-r--r--r--`, `700=-rwx-----`, `550=-r-xr-x---`
- `runuser login -c "command"` – run command as user

15. System utilities

- `uname -a` – name and version of operating system
- `uptime` – how long the system has been running
- `fuser` – identify processes using files or sockets
- `lsof` – list open files
- `sync` – flush file system buffers
- `chroot dir command` – run command with special root directory
- `strace`, `ltrace program` – show used system/library calls
- `ldd binary` – show library dependencies

15.1. Disk partitions

- `df` – display free space
- `mount` – print mounted partitions
- `mount -o remount -r -n /` – change mount read only
- `mount -o remount -w -n /` – change mount writable
- `mount -t iso9660 cdrom.iso /mnt/dir -o loop` – mount image
- `mount -t cifs \\server\lftp /mnt/adr -o user=a,passwd=b`
- `umount partition` – unmount partition
- `fdisk -l` – list disk devices and partitions
- `blkid` – display attributes of block devices
- `tune2fs` – change ext2/3/4 filesystem parameters
- `mkfs.ext2`, `mkfs.ext3` – build file-system
- `hdparm` – set/read parameters of SATA/IDE devices

15.2. System utilization

- `ulimit -l` – print limits of system resources
- `free`, `vmstat` – display usage of physical, virt. memory
- `lspci`, `lsusb` – list PCI, USB devices
- `dmesg` – display messages from kernel
- `sysctl` – configure kernel parameters at runtime
- `dmidecode` – decoder for BIOS data (DMI table)
- `init`, `telinit` – command `init` to change runlevel
- `runlevel`, `who -r` – display current runlevel

16. Networking

- `hostname` – display computer hostname
- `ping host` – send ICMP ECHO_REQUEST
- `dhclient eth0` – dynamically set `eth0` configuration
- `host`, `nslookup host/adr` – DNS query
- `dig` – get record from DNS
- `whois domain` – finds owner of domain or network range
- `ethtool eth0` – change HW parameters of network interface `eth0`
- `ifconfig` – display network devices, device configuration
- `ifconfig eth0 add 10.0.0.1 netmask 255.255.255.0`
- `ifconfig eth0 hw ether 01:02:03:04:05:06` – change MAC address
- `route add default gw 10.0.0.138` – set network gateway
- `route -n`, `netstat -rn` – display route table
- `netstat -tlnp` – display processes listening on ports
- `arp` – display ARP table
- `iptables -L` – display firewall rules
- `tcpdump -i eth0 'tcp port 80'` – display HTTP communication
- `tcpdump -i eth0 'not port ssh'` – all communication except SSH
- `ssh user@hostname command` – run command remotely
- `mail -s "subject" address` – send email to address
- `wget -e robots=off -r -L http://path` – mirror given page