This manual documents version 9.4 of the GNU core utilities, including the standard programs for text and file manipulation.

Copyright © 1994–2023 Free Software Foundation, Inc.

Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with no Invariant Sections, with no Front-Cover Texts, and with no Back-Cover Texts. A copy of the license is included in the section entitled “GNU Free Documentation License”.
Short Contents

1 Introduction ........................................ 1
2 Common options ...................................... 2
3 Output of entire files ................................. 12
4 Formatting file contents ............................... 22
5 Output of parts of files ............................... 29
6 Summarizing files ..................................... 41
7 Operating on sorted files .............................. 49
8 Operating on fields .................................... 72
9 Operating on characters ............................... 82
10 Directory listing ...................................... 89
11 Basic operations ..................................... 104
12 Special file types .................................... 128
13 Changing file attributes ............................. 137
14 File space usage ..................................... 145
15 Printing text ......................................... 159
16 Conditions ........................................... 163
17 Redirection ........................................... 170
18 File name manipulation ............................... 173
19 Working context ..................................... 180
20 User information ..................................... 188
21 System context ....................................... 192
22 SELinux context ...................................... 204
23 Modified command invocation ....................... 207
24 Process control ...................................... 223
25 Delaying .............................................. 224
26 Numeric operations ................................... 225
27 File permissions ....................................... 233
28 File timestamps ....................................... 241
29 Date input formats ................................... 242
30 Version sort ordering ................................ 250
31 Opening the Software Toolbox ..................... 262
A GNU Free Documentation License .................. 270
Index .................................................. 278
Table of Contents

1 Introduction ................................................. 1

2 Common options ............................................. 2
  2.1 Backup options ........................................ 2
  2.2 Block size ............................................. 3
  2.3 Signal specifications .................................... 5
  2.4 chown, chgrp, chroot, id: Disambiguating user names and IDs ... 6
  2.5 Sources of random data .................................. 7
  2.6 Target directory ......................................... 7
  2.7 Trailing slashes ......................................... 9
  2.8 Traversing symlinks ..................................... 9
  2.9 Treating \ / specially ................................... 9
  2.10 Special built-in utilities ............................... 10
  2.11 Exit status ............................................ 10
  2.12 Floating point numbers ................................ 10
  2.13 Standards conformance ................................ 11
  2.14 coreutils: Multi-call program ......................... 11

3 Output of entire files ...................................... 12
  3.1 cat: Concatenate and write files ....................... 12
  3.2 tac: Concatenate and write files in reverse .......... 13
  3.3 nl: Number lines and write files ...................... 13
  3.4 od: Write files in octal or other formats ............ 15
  3.5 base32: Transform data into printable data .......... 18
  3.6 base64: Transform data into printable data .......... 19
  3.7 basenc: Transform data into printable data .......... 19

4 Formatting file contents ................................. 22
  4.1 fmt: Reformat paragraph text ......................... 22
  4.2 pr: Paginate or columnate files for printing .......... 23
  4.3 fold: Wrap input lines to fit in specified width .... 27

5 Output of parts of files .................................. 29
  5.1 head: Output the first part of files .................. 29
  5.2 tail: Output the last part of files ................... 30
  5.3 split: Split a file into pieces ....................... 33
  5.4 csplit: Split a file into context-determined pieces 37

6 Summarizing files ......................................... 41
  6.1 wc: Print newline, word, and byte counts .......... 41
  6.2 sum: Print checksum and block counts ............... 42
6.3 cksum: Print and verify file checksums ............... 43
   6.3.1 cksum output modes ................................ 43
   6.3.2 cksum general options .............................. 43
   6.3.3 cksum common options ............................ 45
6.4 md5sum: Print or check MD5 digests .................. 46
6.5 b2sum: Print or check BLAKE2 digests ................. 47
6.6 sha1sum: Print or check SHA-1 digests ............... 47
6.7 sha2 utilities: Print or check SHA-2 digests ....... 48

7 Operating on sorted files ............................ 49
   7.1 sort: Sort text files .................................. 49
   7.2 shuf: Shuffling text ................................ 57
   7.3 uniq: Uniquify files ................................ 59
   7.4 comm: Compare two sorted files line by line ....... 61
   7.5 ptex: Produce permuted indexes ..................... 63
      7.5.1 General options ................................ 64
      7.5.2 Charset selection ................................ 64
      7.5.3 Word selection and input processing ............ 64
      7.5.4 Output formatting ................................ 66
      7.5.5 The GNU extensions to ptex ..................... 68
   7.6 tsort: Topological sort ..................... 69
      7.6.1 tsort: Background .............................. 71

8 Operating on fields ...................................... 72
   8.1 cut: Print selected parts of lines .................. 72
   8.2 paste: Merge lines of files ........................ 73
   8.3 join: Join lines on a common field ................. 75
      8.3.1 General options ................................. 75
      8.3.2 Pre-sorting .................................... 77
      8.3.3 Working with fields ................................ 78
      8.3.4 Controlling join’s field matching ............. 78
      8.3.5 Header lines .................................... 80
      8.3.6 Union, Intersection and Difference of files ... 80

9 Operating on characters ............................... 82
   9.1 tr: Translate, squeeze, and/or delete characters ... 82
      9.1.1 Specifying arrays of characters ............... 82
      9.1.2 Translating .................................... 85
      9.1.3 Squeezing repeats and deleting ................ 85
   9.2 expand: Convert tabs to spaces ..................... 86
   9.3 unexpand: Convert spaces to tabs .................. 87
10 Directory listing ........................................ 89
   10.1 ls: List directory contents ............................... 89
   10.1.1 Which files are listed ................................. 89
   10.1.2 What information is listed ............................ 91
   10.1.3 Sorting the output ................................... 95
   10.1.4 General output formatting ............................ 96
   10.1.5 Formatting file timestamps ........................... 99
   10.1.6 Formatting the file names ............................ 101
   10.2 dir: Briefly list directory contents ................... 102
   10.3 vdir: Verbosely list directory contents ............... 102
   10.4 dircolors: Color setup for ls ........................ 103

11 Basic operations ........................................ 104
   11.1 cp: Copy files and directories .......................... 104
   11.2 dd: Convert and copy a file ............................. 111
   11.3 install: Copy files and set attributes .................. 117
   11.4 mv: Move (rename) files ................................. 120
   11.5 rm: Remove files or directories ........................ 122
   11.6 shred: Remove files more securely ...................... 124

12 Special file types ........................................ 128
   12.1 link: Make a hard link via the link syscall .......... 128
   12.2 ln: Make links between files ........................... 128
   12.3 mkdir: Make directories ................................. 132
   12.4 mkfifo: Make FIFOs (named pipes) ....................... 133
   12.5 mknod: Make block or character special files ......... 134
   12.6 readlink: Print value of a symlink or canonical file name 134
   12.7 rmdir: Remove empty directories ....................... 136
   12.8 unlink: Remove files via the unlink syscall ......... 136

13 Changing file attributes ................................. 137
   13.1 chown: Change file owner and group .................... 137
   13.2 chgrp: Change group ownership .......................... 139
   13.3 chmod: Change access permissions ...................... 141
   13.4 touch: Change file timestamps .......................... 142

14 File space usage .......................................... 145
   14.1 df: Report file system space usage .................... 145
   14.2 du: Estimate file space usage .......................... 148
   14.3 stat: Report file or file system status ............... 153
   14.4 sync: Synchronize cached writes to persistent storage .... 157
   14.5 truncate: Shrink or extend the size of a file ....... 158
15  Printing text ........................................... 159
    15.1 echo: Print a line of text .............................. 159
    15.2 printf: Format and print data ......................... 160
    15.3 yes: Print a string until interrupted ............... 162

16  Conditions ............................................. 163
    16.1 false: Do nothing, unsuccessfully ...................... 163
    16.2 true: Do nothing, successfully ......................... 163
    16.3 test: Check file types and compare values .......... 163
       16.3.1 File type tests ................................ 164
       16.3.2 Access permission tests .......................... 165
       16.3.3 File characteristic tests ......................... 165
       16.3.4 String tests .................................... 165
       16.3.5 Numeric tests .................................... 166
       16.3.6 Connectives for test .............................. 166
    16.4 expr: Evaluate expressions .............................. 167
       16.4.1 String expressions ................................ 167
       16.4.2 Numeric expressions ............................... 168
       16.4.3 Relations for expr ................................. 168
       16.4.4 Examples of using expr ............................ 169

17  Redirection .............................................. 170
    17.1 tee: Redirect output to multiple files or processes .... 170

18  File name manipulation .................................... 173
    18.1 basename: Strip directory and suffix from a file name 173
    18.2 dirname: Strip last file name component ................ 174
    18.3 pathchk: Check file name validity and portability .... 174
    18.4 mktemp: Create temporary file or directory .......... 175
    18.5 realpath: Print the resolved file name ............... 177
       18.5.1 Realpath usage examples ......................... 178

19  Working context .......................................... 180
    19.1 pwd: Print working directory ........................... 180
    19.2 stty: Print or change terminal characteristics ....... 180
       19.2.1 Control settings .................................. 181
       19.2.2 Input settings .................................... 182
       19.2.3 Output settings ................................... 182
       19.2.4 Local settings .................................... 183
       19.2.5 Combination settings ............................... 184
       19.2.6 Special characters ................................. 185
       19.2.7 Special settings ................................. 186
    19.3 printenv: Print all or some environment variables .... 186
    19.4 tty: Print file name of terminal on standard input ... 187
20 User information .......................... 188
20.1 id: Print user identity ..................... 188
20.2 logname: Print current login name .......... 189
20.3 whoami: Print effective user name .......... 189
20.4 groups: Print group names a user is in .... 189
20.5 users: Print login names of users currently logged in .. 189
20.6 who: Print who is currently logged in ....... 190

21 System context ............................ 192
21.1 date: Print or set system date and time .... 192
  21.1.1 Specifying the format of date output ... 192
    21.1.1.1 Time conversion specifiers .......... 192
    21.1.1.2 Date conversion specifiers .......... 193
    21.1.1.3 Literal conversion specifiers ....... 194
    21.1.1.4 Padding and other flags ............ 194
  21.1.2 Setting the time ....................... 196
  21.1.3 Options for date ....................... 196
  21.1.4 Examples of date ....................... 198
21.2 arch: Print machine hardware name .......... 200
21.3 nproc: Print the number of available processors .. 200
21.4 uname: Print system information ............ 201
21.5 hostname: Print or set system name .......... 202
21.6 hostid: Print numeric host identifier ........ 202
21.7 uptime: Print system uptime and load .......... 203

22 SELinux context ........................... 204
22.1 chcon: Change SELinux context of file ...... 204
22.2 runcon: Run a command in specified SELinux context ... 205

23 Modified command invocation ................. 207
23.1 chroot: Run a command with a different root directory ... 207
23.2 env: Run a command in a modified environment .... 208
  23.2.1 General options ......................... 209
  23.2.2 -S/--split-string usage in scripts ...... 211
    Testing and troubleshooting .................. 212
  23.2.3 -S/--split-string syntax ............... 213
    Splitting arguments by whitespace .......... 213
    Escape sequences ............................ 214
    Comments ................................. 215
    Environment variable expansion ............. 215
23.3 nice: Run a command with modified niceness ........ 216
23.4 nohup: Run a command immune to hangups ........ 218
23.5 stdbuf: Run a command with modified I/O stream buffering .. 218
23.6 timeout: Run a command with a time limit ......... 220
24 Process control ........................................... 223
   24.1 kill: Send a signal to processes ...................... 223

25 Delaying .................................................... 224
   25.1 sleep: Delay for a specified time ...................... 224

26 Numeric operations ....................................... 225
   26.1 factor: Print prime factors ........................... 225
   26.2 numfmt: Reformat numbers .............................. 225
      26.2.1 General options ................................. 226
      26.2.2 Possible units: ................................ 227
      26.2.3 Examples of using numfmt ....................... 229
   26.3 seq: Print numeric sequences ......................... 231

27 File permissions .......................................... 233
   27.1 Structure of File Mode Bits ........................... 233
   27.2 Symbolic Modes ....................................... 234
      27.2.1 Setting Permissions .............................. 234
      27.2.2 Copying Existing Permissions .................... 235
      27.2.3 Changing Special Mode Bits ..................... 236
      27.2.4 Conditional Executability ....................... 236
      27.2.5 Making Multiple Changes ......................... 236
      27.2.6 The Umask and Protection ....................... 237
   27.3 Numeric Modes ......................................... 238
   27.4 Operator Numeric Modes ............................... 239
   27.5 Directories and the Set-User-ID and Set-Group-ID Bits .... 239

28 File timestamps ............................................ 241

29 Date input formats ....................................... 242
   29.1 General date syntax ................................... 242
   29.2 Calendar date items .................................. 243
   29.3 Time of day items .................................... 244
   29.4 Time zone items ...................................... 245
   29.5 Combined date and time of day items ................. 245
   29.6 Day of week items ................................... 245
   29.7 Relative items in date strings ....................... 246
   29.8 Pure numbers in date strings ........................ 247
   29.9 Seconds since the Epoch .............................. 247
   29.10 Specifying time zone rules .......................... 247
   29.11 Authors of parse_datetime ......................... 248
# 30 Version sort ordering

## 30.1 Version sort overview

## 30.1.1 Using version sort in GNU Coreutils

## 30.1.2 Version sort and natural sort

## 30.1.3 Variations in version sort order

## 30.2 Version sort implementation

## 30.2.1 Version-sort ordering rules

## 30.2.2 Version sort is not the same as numeric sort

## 30.2.3 Version sort punctuation

## 30.2.4 Punctuation vs letters

## 30.2.5 The tilde ‘~’

## 30.2.6 Version sort ignores locale

## 30.3 Differences from Debian version sort

## 30.3.1 Hyphen-minus ‘-’ and colon ‘:’

## 30.3.2 Special priority in GNU Coreutils version sort

## 30.3.3 Special handling of file extensions

## 30.3.4 Comparing two strings using Debian’s algorithm

## 30.4 Advanced Topics

## 30.4.1 Reporting version sort bugs

## 30.4.2 Other version/natural sort implementations

## 30.4.3 Related source code

# 31 Opening the Software Toolbox

## Toolbox Introduction

## I/O Redirection

## The `who` Command

## The `cut` Command

## The `sort` Command

## The `uniq` Command

## Putting the Tools Together

# Appendix A GNU Free Documentation License

# Index


1 Introduction

This manual is a work in progress: many sections make no attempt to explain basic concepts in a way suitable for novices. Thus, if you are interested, please get involved in improving this manual. The entire GNU community will benefit.

The GNU utilities documented here are mostly compatible with the POSIX standard.

Please report bugs to bug-coreutils@gnu.org. Include the version number, machine architecture, input files, and any other information needed to reproduce the bug: your input, what you expected, what you got, and why it is wrong.

If you have a problem with sort or date, try using the --debug option, as it can often help find and fix problems without having to wait for an answer to a bug report. If the debug output does not suffice to fix the problem on your own, please compress and attach it to the rest of your bug report.

Although diffs are welcome, please include a description of the problem as well, since this is sometimes difficult to infer. See Section “Bugs” in Using and Porting GNU CC.

This manual was originally derived from the Unix man pages in the distributions, which were written by David MacKenzie and updated by Jim Meyering. What you are reading now is the authoritative documentation for these utilities; the man pages are no longer being maintained. The original fmt man page was written by Ross Paterson. François Pinard did the initial conversion to Texinfo format. Karl Berry did the indexing, some reorganization, and editing of the results. Brian Youmans of the Free Software Foundation office staff combined the manuals for textutils, fileutils, and sh-utils to produce the present omnibus manual. Richard Stallman contributed his usual invaluable insights to the overall process.
2 Common options

Certain options are available in all of these programs. Rather than writing identical
descriptions for each of the programs, they are described here. (In fact, every GNU program
accepts (or should accept) these options.)

Normally options and operands can appear in any order, and programs act as if all the
options appear before any operands. For example, ‘sort -r passwd -t :’ acts like ‘sort
-r -t : passwd’, since ‘:’ is an option-argument of -t. However, if the POSIXLY_CORRECT
environment variable is set, options must appear before operands, unless otherwise specified
for a particular command.

A few programs can usefully have trailing operands with leading ‘-‘. With such a program,
options must precede operands even if POSIXLY_CORRECT is not set, and this fact is noted in
the program description. For example, the env command’s options must appear before its
operands, since in some cases the operands specify a command that itself contains options.

Most programs that accept long options recognize unambiguous abbreviations of those
options. For example, ‘rmdir --ignore-fail-on-non-empty’ can be invoked as ‘rmdir
--ignore-fail’ or even ‘rmdir --i’. Ambiguous options, such as ‘ls --h’, are identified
as such.

Some of these programs recognize the --help and --version options only when one of
them is the sole command line argument. For these programs, abbreviations of the long
options are not always recognized.

‘--help’ Print a usage message listing all available options, then exit successfully.

‘--version’
Print the version number, then exit successfully.

‘--’ Delimit the option list. Later arguments, if any, are treated as operands even if
they begin with ‘-‘. For example, ‘sort -- -r’ reads from the file named -r.

A single ‘-‘ operand is not really an option, though it looks like one. It stands for a file
operand, and some tools treat it as standard input, or as standard output if that is clear
from the context. For example, ‘sort -’ reads from standard input, and is equivalent to
plain ‘sort’. Unless otherwise specified, a ‘-‘ can appear as any operand that requires a file
name.

2.1 Backup options

Some GNU programs (at least cp, install, ln, and mv) optionally make backups of files
before writing new versions. These options control the details of these backups. The options
are also briefly mentioned in the descriptions of the particular programs.

‘--b’
‘--backup[=method]’
Make a backup of each file that would otherwise be overwritten or removed.
Without this option, the original versions are destroyed. Use method to deter-
mine the type of backups to make. When this option is used but method is not
specified, then the value of the VERSION_CONTROL environment variable is used.
And if VERSION_CONTROL is not set, the default backup type is ‘existing’.
Note that the short form of this option, \(-b\) does not accept any argument. Using \(-b\) is equivalent to using \(--backup=existing\).

This option corresponds to the Emacs variable \('version-control'\); the values for method are the same as those used in Emacs. This option also accepts more descriptive names. The valid methods are (unique abbreviations are accepted):

- 'none'
  Never make backups.
- 'off'
  Always make numbered backups.
- 'numbered'
- 't'
  Make numbered backups of files that already have them, simple backups of the others.
- 'existing'
- 'nil'
  Always make simple backups. Please note 'never' is not to be confused with 'none'.

\(-S\) suffix
\(--suffix=suffix\)

Append suffix to each backup file made with \(-b\). If this option is not specified, the value of the SIMPLE_BACKUP_SUFFIX environment variable is used. And if SIMPLE_BACKUP_SUFFIX is not set, the default is '~', just as in Emacs.

2.2 Block size

Some GNU programs (at least \(df\), \(du\), and \(ls\)) display sizes in “blocks”. You can adjust the block size and method of display to make sizes easier to read. The block size used for display is independent of any file system block size. Fractional block counts are rounded up to the nearest integer.

The default block size is chosen by examining the following environment variables in turn; the first one that is set determines the block size.

DF_BLOCK_SIZE

This specifies the default block size for the \(df\) command. Similarly, DU_BLOCK_SIZE specifies the default for \(du\) and LS_BLOCK_SIZE for \(ls\).

BLOCK_SIZE

This specifies the default block size for all three commands, if the above command-specific environment variables are not set.

BLOCKSIZE

This specifies the default block size for all values that are normally printed as blocks, if neither BLOCK_SIZE nor the above command-specific environment variables are set. Unlike the other environment variables, BLOCKSIZE does not affect values that are normally printed as byte counts, e.g., the file sizes contained in \(ls -l\) output.

POSIXLY_CORRECT

If neither command_BLOCK_SIZE, nor BLOCK_SIZE, nor BLOCKSIZE is set, but this variable is set, the block size defaults to 512.
If none of the above environment variables are set, the block size currently defaults to 1024 bytes in most contexts, but this number may change in the future. For \texttt{ls} file sizes, the block size defaults to 1 byte.

A block size specification can be a positive integer specifying the number of bytes per block, or it can be \texttt{human-readable} or \texttt{si} to select a human-readable format. Integers may be followed by suffixes that are upward compatible with the SI prefixes (http://www.bipm.org/en/publications/si-brochure/chapter3.html) for decimal multiples and with the ISO/IEC 80000-13 (formerly IEC 60027-2) prefixes (https://physics.nist.gov/cuu/Units/binary.html) for binary multiples.

With human-readable formats, output sizes are followed by a size letter such as ‘M’ for megabytes. \texttt{BLOCK\_SIZE=human-readable} uses powers of 1024; ‘M’ stands for 1,048,576 bytes. \texttt{BLOCK\_SIZE=si} is similar, but uses powers of 1000 and appends ‘B’; ‘MB’ stands for 1,000,000 bytes.

A block size specification preceded by ‘’ causes output sizes to be displayed with thousands separators. The \texttt{LC\_NUMERIC} locale specifies the thousands separator and grouping. For example, in an American English locale, ‘--block-size="'1kB"’ would cause a size of 1234000 bytes to be displayed as ‘1,234’. In the default C locale, there is no thousands separator so a leading ‘’ has no effect.

An integer block size can be followed by a suffix to specify a multiple of that size. A bare size letter, or one followed by ‘iB’, specifies a multiple using powers of 1024. A size letter followed by ‘B’ specifies powers of 1000 instead. For example, ‘1M’ and ‘1MiB’ are equivalent to ‘1048576’, whereas ‘1MB’ is equivalent to ‘1000000’.

A plain suffix without a preceding integer acts as if ‘1’ were prepended, except that it causes a size indication to be appended to the output. For example, ‘--block-size="kB”’ displays 3000 as ‘3kB’.

The following suffixes are defined. Large sizes like 1Q may be rejected by your computer due to limitations of its arithmetic.

\begin{itemize}
  \item ‘kB’ kilobyte: $10^3 = 1000.$
  \item ‘k’
  \item ‘K’
  \item ‘KiB’ kibibyte: $2^{10} = 1024$. ‘K’ is special: the SI prefix is ‘k’ and the ISO/IEC 80000-13 prefix is ‘Ki’, but tradition and POSIX use ‘k’ to mean ‘KiB’.
  \item ‘MB’ megabyte: $10^6 = 1,000,000.$
  \item ‘M’
  \item ‘MiB’ mebibyte: $2^{20} = 1,048,576.$
  \item ‘GB’ gigabyte: $10^9 = 1,000,000,000.$
  \item ‘G’
  \item ‘GiB’ gibibyte: $2^{30} = 1,073,741,824.$
  \item ‘TB’ terabyte: $10^{12} = 1,000,000,000,000.$
  \item ‘T’
  \item ‘TiB’ tebibyte: $2^{40} = 1,099,511,627,776.$
  \item ‘PB’ petabyte: $10^{15} = 1,000,000,000,000,000.$
\end{itemize}
Block size defaults can be overridden by an explicit \texttt{--block-size=size} option. The \texttt{-k} option is equivalent to \texttt{--block-size=1K}, which is the default unless the POSIXLY_CORRECT environment variable is set. The \texttt{-h} or \texttt{--human-readable} option is equivalent to \texttt{--block-size=human-readable}. The \texttt{--si} option is equivalent to \texttt{--block-size=si}. Note for \texttt{ls} the \texttt{-k} option does not control the display of the apparent file sizes, whereas the \texttt{--block-size} option does.

\subsection*{2.3 Signal specifications}

A \textit{signal} may be a signal name like ‘HUP’, or a signal number like ‘1’, or an exit status of a process terminated by the signal. A signal name can be given in canonical form or prefixed by ‘SIG’. The case of the letters is ignored. The following signal names and numbers are supported on all POSIX compliant systems:

‘HUP’ 1. Hangup.
‘INT’ 2. Terminal interrupt.
‘QUIT’ 3. Terminal quit.
‘KILL’ 9. Kill (cannot be caught or ignored).
‘TERM’ 15. Termination.

Other supported signal names have system-dependent corresponding numbers. All systems conforming to POSIX 1003.1-2001 also support the following signals:

‘BUS’ Access to an undefined portion of a memory object.
Chapter 2: Common options

‘CHLD’ Child process terminated, stopped, or continued.
‘CONT’ Continue executing, if stopped.
‘FPE’ Erroneous arithmetic operation.
‘ILL’ Illegal Instruction.
‘PIPE’ Write on a pipe with no one to read it.
‘SEGV’ Invalid memory reference.
‘STOP’ Stop executing (cannot be caught or ignored).
‘TSTP’ Terminal stop.
‘TTIN’ Background process attempting read.
‘TTOU’ Background process attempting write.
‘URG’ High bandwidth data is available at a socket.
‘USR1’ User-defined signal 1.
‘USR2’ User-defined signal 2.

POSIX 1003.1-2001 systems that support the XSI extension also support the following signals:

‘POLL’ Pollable event.
‘PROF’ Profiling timer expired.
‘SYS’ Bad system call.
‘TRAP’ Trace/breakpoint trap.
‘VTALRM’ Virtual timer expired.
‘XCPU’ CPU time limit exceeded.
‘XFSZ’ File size limit exceeded.

POSIX 1003.1-2001 systems that support the XRT extension also support at least eight real-time signals called ‘RTMIN’, ‘RTMIN+1’, . . . , ‘RTMAX-1’, ‘RTMAX’.

2.4 chown, chgrp, chroot, id: Disambiguating user names and IDs

Since the user and group arguments to these commands may be specified as names or numeric IDs, there is an apparent ambiguity. What if a user or group name is a string of digits? Should the command interpret it as a user name or as an ID? (Using a number as a user name is common in some environments.) POSIX requires that these commands first attempt to resolve the specified string as a name, and only once that fails, then try to interpret it as an ID. This is troublesome when you want to specify a numeric ID, say 42, and it must work even in a pathological situation where ‘42’ is a user name that maps to some other user ID, say 1000. Simply invoking chown 42 F, will set F’s owner ID to 1000 – not what you intended.
GNU `chown`, `chgrp`, `chroot`, and `id` provide a way to work around this, that at the same time may result in a significant performance improvement by eliminating a database look-up. Simply precede each numeric user ID and/or group ID with a `+`, in order to force its interpretation as an integer:

```
chown +42 F
chgrp +$numeric_group_id another-file
chown +0:+0 /
```

The name look-up process is skipped for each `+`-prefixed string, because a string containing `+` is never a valid user or group name. This syntax is accepted on most common Unix systems, but not on Solaris 10.

### 2.5 Sources of random data

The `shuf`, `shred`, and `sort` commands sometimes need random data to do their work. For example, `sort -R` must choose a hash function at random, and it needs random data to make this selection.

By default these commands use an internal pseudo-random generator initialized by a small amount of entropy, but can be directed to use an external source with the `--random-source=file` option. An error is reported if `file` does not contain enough bytes.

For example, the device file `/dev/urandom` could be used as the source of random data. Typically, this device gathers environmental noise from device drivers and other sources into an entropy pool, and uses the pool to generate random bits. If the pool is short of data, the device reuses the internal pool to produce more bits, using a cryptographically secure pseudo-random number generator. But be aware that this device is not designed for bulk random data generation and is relatively slow.

/dev/urandom suffices for most practical uses, but applications requiring high-value or long-term protection of private data may require an alternate data source like `/dev/random` or `/dev/arandom`. The set of available sources depends on your operating system.

To reproduce the results of an earlier invocation of a command, you can save some random data into a file and then use that file as the random source in earlier and later invocations of the command. Rather than depending on a file, one can generate a reproducible arbitrary amount of pseudo-random data given a seed value, using for example:

```
get_seeded_random()
{
    seed="$1"
    openssl enc -aes-256-ctr -pass pass:"$seed" -nosalt \
    </dev/zero 2>/dev/null
}

shuf -i1-100 --random-source=</(get_seeded_random 42)
```

### 2.6 Target directory

The `cp`, `install`, `ln`, and `mv` commands normally treat the last operand specially when it is a directory or a symbolic link to a directory. For example, `cp source dest` is equivalent to `cp source dest/source` if `dest` is a directory. Sometimes this behavior is not exactly
what is wanted, so these commands support the following options to allow more fine-grained control:

`-T`
`--no-target-directory`

Do not treat the last operand specially when it is a directory or a symbolic link to a directory. This can help avoid race conditions in programs that operate in a shared area. For example, when the command `mv /tmp/source /tmp/dest` succeeds, there is no guarantee that `/tmp/source` was renamed to `/tmp/dest`; it could have been renamed to `/tmp/dest/source` instead, if some other process created `/tmp/dest` as a directory. However, if `mv -T /tmp/source /tmp/dest` succeeds, there is no question that `/tmp/source` was renamed to `/tmp/dest`.

In the opposite situation, where you want the last operand to be treated as a directory and want a diagnostic otherwise, you can use the `--target-directory` (`-t`) option.

`-t directory`
`--target-directory=directory`

Use `directory` as the directory component of each destination file name.

The interface for most programs is that after processing options and a finite (possibly zero) number of fixed-position arguments, the remaining argument list is either expected to be empty, or is a list of items (usually files) that will all be handled identically. The `xargs` program is designed to work well with this convention.

The commands in the `mv`-family are unusual in that they take a variable number of arguments with a special case at the end (namely, the target directory). This makes it nontrivial to perform some operations, e.g., “move all files from here to `../.d/`”, because `mv * ../.d/` might exhaust the argument space, and `ls | xargs ...` doesn’t have a clean way to specify an extra final argument for each invocation of the subject command. (It can be done by going through a shell command, but that requires more human labor and brain power than it should.)

The `--target-directory` (`-t`) option allows the `cp`, `install`, `ln`, and `mv` programs to be used conveniently with `xargs`. For example, you can move the files from the current directory to a sibling directory, `d` like this:

```
ls | xargs mv -t ../.d --
```

However, this doesn’t move files whose names begin with `.`. If you use the GNU `find` program, you can move those files too, with this command:

```
find . -mindepth 1 -maxdepth 1 \ 
| xargs mv -t ../.d
```

But both of the above approaches fail if there are no files in the current directory, or if any file has a name containing a blank or some other special characters.

The following example removes those limitations and requires both GNU `find` and GNU `xargs`:

```
find . -mindepth 1 -maxdepth 1 -print0 \ 
| xargs --null --no-run-if-empty \ 
  mv -t ../.d
```
The \texttt{--target-directory} (-t) and \texttt{--no-target-directory} (-T) options cannot be combined.

2.7 Trailing slashes

Some GNU programs (at least \texttt{cp} and \texttt{mv}) allow you to remove any trailing slashes from each source argument before operating on it. The \texttt{--strip-trailing-slashes} option enables this behavior.

This is useful when a source argument may have a trailing slash and specify a symbolic link to a directory. This scenario is in fact rather common because some shells can automatically append a trailing slash when performing file name completion on such symbolic links. Without this option, \texttt{mv}, for example, (via the system’s rename function) must interpret a trailing slash as a request to dereference the symbolic link and so must rename the indirectly referenced directory and not the symbolic link. Although it may seem surprising that such behavior be the default, it is required by POSIX and is consistent with other parts of that standard.

2.8 Traversing symlinks

The following options modify how \texttt{chown} and \texttt{chgrp} traverse a hierarchy when the \texttt{--recursive} (-R) option is also specified. If more than one of the following options is specified, only the final one takes effect. These options specify whether processing a symbolic link to a directory entails operating on just the symbolic link or on all files in the hierarchy rooted at that directory.

These options are independent of \texttt{--dereference} and \texttt{--no-dereference} (-h), which control whether to modify a symlink or its referent.

\begin{itemize}
  \item \texttt{-H} \quad \text{If \texttt{--recursive} (-R) is specified and a command line argument is a symbolic link to a directory, traverse it.}
  \item \texttt{-L} \quad \text{In a recursive traversal, traverse every symbolic link to a directory that is encountered.}
  \item \texttt{-P} \quad \text{Do not traverse any symbolic links. This is the default if none of \texttt{-H}, \texttt{-L}, or \texttt{-P} is specified.}
\end{itemize}

2.9 Treating \texttt{/} specially

Certain commands can operate destructively on entire hierarchies. For example, if a user with appropriate privileges mistakenly runs \texttt{rm -rf / tmp/junk}, that may remove all files on the entire system. Since there are so few legitimate uses for such a command, GNU \texttt{rm} normally declines to operate on any directory that resolves to \texttt{/}. If you really want to try to remove all the files on your system, you can use the \texttt{--no-preserve-root} option, but the default behavior, specified by the \texttt{--preserve-root} option, is safer for most purposes.

The commands \texttt{chgrp}, \texttt{chmod} and \texttt{chown} can also operate destructively on entire hierarchies, so they too support these options. Although, unlike \texttt{rm}, they don’t actually unlink files, these commands are arguably more dangerous when operating recursively on \texttt{/}, since they often work much more quickly, and hence damage more files before an alert user can interrupt them. Tradition and POSIX require these commands to operate recursively on
so they default to --no-preserve-root, but using the --preserve-root option makes them safer for most purposes. For convenience you can specify --preserve-root in an alias or in a shell function.

Note that the --preserve-root option also ensures that chgrp and chown do not modify / even when dereferencing a symlink pointing to /.

2.10 Special built-in utilities

Some programs like nice can invoke other programs; for example, the command ‘nice cat file’ invokes the program cat by executing the command ‘cat file’. However, special built-in utilities like exit cannot be invoked this way. For example, the command ‘nice exit’ does not have a well-defined behavior: it may generate an error message instead of exiting.

Here is a list of the special built-in utilities that are standardized by POSIX 1003.1-2004.

. : break continue eval exec exit export readonly return set shift times trap unset

For example, because ‘.’, ‘:’, and ‘exec’ are special, the commands ‘nice . foo.sh’, ‘nice :’, and ‘nice exec pwd’ do not work as you might expect.

Many shells extend this list. For example, Bash has several extra special built-in utilities like history, and suspend, and with Bash the command ‘nice suspend’ generates an error message instead of suspending.

2.11 Exit status

Nearly every command invocation yields an integral exit status that can be used to change how other commands work. For the vast majority of commands, an exit status of zero indicates success. Failure is indicated by a nonzero value – typically ‘1’, though it may differ on unusual platforms as POSIX requires only that it be nonzero.

However, some of the programs documented here do produce other exit status values and a few associate different meanings with the values ‘0’ and ‘1’. Here are the exceptions: chroot, env, expr, ls, nice, nohup, numfmt, printenv, runcon, sort, stdbuf, test, timeout, tty.

2.12 Floating point numbers

Commands that accept or produce floating point numbers employ the floating point representation of the underlying system, and suffer from rounding error, overflow, and similar floating-point issues. Almost all modern systems use IEEE-754 floating point, and it is typically portable to assume IEEE-754 behavior these days. IEEE-754 has positive and negative infinity, distinguishes positive from negative zero, and uses special values called NaNs to represent invalid computations such as dividing zero by itself. For more information, please see David Goldberg’s paper What Every Computer Scientist Should Know About Floating-Point Arithmetic (https://docs.oracle.com/cd/E19957-01/806-3568/ncg_goldberg.html).

Commands that accept floating point numbers as options, operands or input use the standard C functions strtod and strtold to convert from text to floating point numbers. These floating point numbers therefore can use scientific notation like 1.0e-34 and -10e100.
Commands that parse floating point also understand case-insensitive `inf`, `infinity`, and `NaN`, although whether such values are useful depends on the command in question. Modern C implementations also accept hexadecimal floating point numbers such as `-0x.ep-3`, which stands for $-14/16 \times 2^{-3}$, which equals $-0.109375$. See Section “Parsing of Floats” in *The GNU C Library Reference Manual*.

Normally the `LC_NUMERIC` locale determines the decimal-point character. However, some commands’ descriptions specify that they accept numbers in either the current or the C locale; for example, they treat `‘3.14’` like `‘3,14’` if the current locale uses comma as a decimal point.

### 2.13 Standards conformance

In a few cases, the GNU utilities’ default behavior is incompatible with the POSIX standard. To suppress these incompatibilities, define the `POSIXLY_CORRECT` environment variable. Unless you are checking for POSIX conformance, you probably do not need to define `POSIXLY_CORRECT`.

Newer versions of POSIX are occasionally incompatible with older versions. For example, older versions of POSIX required the command `‘sort +1’` to sort based on the second and succeeding fields in each input line, but in POSIX 1003.1-2001 the same command is required to sort the file named `+1`, and you must instead use the command `‘sort -k 2’` to get the field-based sort. To complicate things further, POSIX 1003.1-2008 allows an implementation to have either the old or the new behavior.

The GNU utilities normally conform to the version of POSIX that is standard for your system. To cause them to conform to a different version of POSIX, define the `_POSIX2_VERSION` environment variable to a value of the form `yyyymm` specifying the year and month the standard was adopted. Three values are currently supported for `_POSIX2_VERSION`: `‘199209’` stands for POSIX 1003.2-1992, `‘200112’` stands for POSIX 1003.1-2001, and `‘200809’` stands for POSIX 1003.1-2008. For example, if you have a POSIX 1003.1-2001 system but are running software containing traditional usage like `‘sort +1’` or `‘tail +10’`, you can work around the compatibility problems by setting `‘_POSIX2_VERSION=200809’` in your environment.

### 2.14 coreutils: Multi-call program

The `coreutils` command invokes an individual utility, either implicitly selected by the last component of the name used to invoke `coreutils`, or explicitly with the `--coreutils-prog` option. Synopsis:

```
coreutils --coreutils-prog=PROGRAM ...
```

The `coreutils` command is not installed by default, so portable scripts should not rely on its existence.
3 Output of entire files

These commands read and write entire files, possibly transforming them in some way.

3.1 cat: Concatenate and write files

cat copies each file (`-' means standard input), or standard input if none are given, to standard output. Synopsis:

    cat [option] [file]...

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-A'
`--show-all'
    Equivalent to `-vET'.

`-b'
`--number-nonblank'
    Number all nonempty output lines, starting with 1.

`-e'
    Equivalent to `-vE'.

`-E'
`--show-ends'
    Display a `$' after the end of each line. The `\r\n' combination is shown as `^M$'.

`-n'
`--number'
    Number all output lines, starting with 1. This option is ignored if `-b' is in effect.

`-s'
`--squeeze-blank'
    Suppress repeated adjacent blank lines; output just one empty line instead of several.

`-t'
    Equivalent to `-vT'.

`-T'
`--show-tabs'
    Display TAB characters as `^I'.

`-u'
    Ignored; for POSIX compatibility.

`-v'
`--show-nonprinting'
    Display control characters except for LFD and TAB using `-' notation and precede characters that have the high bit set with `M-'.

On systems like MS-DOS that distinguish between text and binary files, cat normally reads and writes in binary mode. However, cat reads in text mode if one of the options `-bensAE' is used or if cat is reading from standard input and standard input is a terminal. Similarly, cat writes in text mode if one of the options `-bensAE' is used or if standard output is a terminal.
An exit status of zero indicates success, and a nonzero value indicates failure. Examples:

```
# Output f's contents, then standard input, then g's contents.
cat f - g

# Copy standard input to standard output.
cat
```

3.2 **tac: Concatenate and write files in reverse**

*tac* copies each *file* (‘-’ means standard input), or standard input if none are given, to standard output, reversing the records (lines by default) in each separately. Synopsis:

```
tac [option]... [file]...
```

*Records* are separated by instances of a string (newline by default). By default, this separator string is attached to the end of the record that it follows in the file.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-b’
‘--before’

The separator is attached to the beginning of the record that it precedes in the file.

‘-r’
‘--regex’ Treat the separator string as a regular expression.

‘-s separator’
‘--separator=separator’

Use *separator* as the record separator, instead of newline. Note an empty *separator* is treated as a zero byte. I.e., input and output items are delimited with ASCII NUL.

On systems like MS-DOS that distinguish between text and binary files, *tac* reads and writes in binary mode.

An exit status of zero indicates success, and a nonzero value indicates failure. Example:

```
# Reverse a file character by character.
tac -r -s 'x\|[^x]'
```

3.3 **nl: Number lines and write files**

*n1* writes each *file* (‘-’ means standard input), or standard input if none are given, to standard output, with line numbers added to some or all of the lines. Synopsis:

```
n1 [option]... [file]...
```

*n1* decomposes its input into (logical) page sections; by default, the line number is reset to 1 at each logical page section. *n1* treats all of the input files as a single document; it does not reset line numbers or logical pages between files.

A logical page consists of three sections: header, body, and footer. Any of the sections can be empty. Each can be numbered in a different style from the others.
Chapter 3: Output of entire files

The beginnings of the sections of logical pages are indicated in the input file by a line containing exactly one of these delimiter strings:

\:\:\:\: start of header;
\:\:\:\: start of body;
\:\: start of footer.

The characters from which these strings are made can be changed from ‘\’ and ‘:\’ via options (see below), but the pattern of each string cannot be changed.

A section delimiter is replaced by an empty line on output. Any text that comes before the first section delimiter string in the input file is considered to be part of a body section, so n1 treats a file that contains no section delimiters as a single body section.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-b style’
‘--body-numbering=style’
Select the numbering style for lines in the body section of each logical page. When a line is not numbered, the current line number is not incremented, but the line number separator character is still prepended to the line. The styles are:

‘a’ number all lines,
‘t’ number only nonempty lines (default for body),
‘n’ do not number lines (default for header and footer),
‘pbre’ number only lines that contain a match for the basic regular expression bre. See Section “Regular Expressions” in The GNU Grep Manual.

‘-d cd’
‘--section-delimiter=cd’
Set the section delimiter characters to cd; default is ‘:\:’. If only c is given, the second remains ‘:\’. As a GNU extension more than two characters can be specified, and also if cd is empty (-d '') , then section matching is disabled. (Remember to protect ‘\’ or other metacharacters from shell expansion with quotes or extra backslashes.)

‘-f style’
‘--footer-numbering=style’
Analogous to --body-numbering.

‘-h style’
‘--header-numbering=style’
Analogous to --body-numbering.

‘-i number’
‘--line-increment=number’
Increment line numbers by number (default 1). number can be negative to decrement.
Consider *number* (default 1) consecutive empty lines to be one logical line for numbering, and only number the last one. Where fewer than *number* consecutive empty lines occur, do not number them. An empty line is one that contains no characters, not even spaces or tabs.

Select the line numbering format (default is `rn`):

- `ln` left justified, no leading zeros;
- `rn` right justified, no leading zeros;
- `rz` right justified, leading zeros.

Do not reset the line number at the start of a logical page.

Separate the line number from the text line in the output with *string* (default is the TAB character).

Set the initial line number on each logical page to *number* (default 1). The starting *number* can be negative.

Use *number* characters for line numbers (default 6).

An exit status of zero indicates success, and a nonzero value indicates failure.

### 3.4 od: Write files in octal or other formats

`od` writes an unambiguous representation of each file (`-` means standard input), or standard input if none are given. Synopses:

- `od [option]... [file]...
- `od [-abcdfilosx]... [file] [[+]offset[.]][b]
- `od [option]... --traditional [file] [[+]offset[.]][b] [[+]label[.]][b]]`

Each line of output consists of the offset in the input, followed by groups of data from the file. By default, `od` prints the offset in octal, and each group of file data is a C `short_int`'s worth of input printed as a single octal number.

If `offset` is given, it specifies how many input bytes to skip before formatting and writing. By default, it is interpreted as an octal number, but the optional trailing decimal point causes it to be interpreted as decimal. If no decimal is specified and the offset begins with `‘0x’` or `‘0X’` it is interpreted as a hexadecimal number. If there is a trailing `‘b’`, the number of bytes skipped will be `offset` multiplied by 512.
If a command is of both the first and second forms, the second form is assumed if the last operand begins with `+' or (if there are two operands) a digit. For example, in `od foo 10' and `od +10' the '10' is an offset, whereas in `od 10' the '10' is a file name.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-A radix'
`--address-radix=radix'
Select the base in which file offsets are printed. radix can be one of the following:
- 'd' decimal;
- 'o' octal;
- 'x' hexadecimal;
- 'n' none (do not print offsets).
The default is octal.

`--endian=order'
Reorder input bytes, to handle inputs with differing byte orders, or to provide consistent output independent of the endian convention of the current system. Swapping is performed according to the specified --type size and endian order, which can be 'little' or 'big'.

`-j bytes'
`--skip-bytes=bytes'
Skip bytes input bytes before formatting and writing. If bytes begins with '0x' or '0X', it is interpreted in hexadecimal; otherwise, if it begins with '0', in octal; otherwise, in decimal. bytes may be, or may be an integer optionally followed by, one of the following multiplicative suffixes:
- 'b' => 512 ("blocks")
- 'KB' => 1000 (KiloBytes)
- 'K' => 1024 (KibiBytes)
- 'MB' => 1000*1000 (MegaBytes)
- 'M' => 1024*1024 (MebiBytes)
- 'GB' => 1000*1000*1000 (GigaBytes)
- 'G' => 1024*1024*1024 (GibiBytes)
and so on for 'T', 'P', 'E', 'Z', 'Y', 'R', and 'Q'. Binary prefixes can be used, too: 'KiB'='K', 'MiB'='M', and so on.

`-N bytes'
`--read-bytes=bytes'
Output at most bytes bytes of the input. Prefixes and suffixes on bytes are interpreted as for the -j option.

`-S bytes'
`--strings[]=bytes'
Instead of the normal output, output only string constants: at least bytes consecutive printable characters, followed by a zero byte (ASCII NUL). Prefixes and suffixes on bytes are interpreted as for the -j option.
If bytes is omitted with --strings, the default is 3.
'--format=type'
Select the format in which to output the file data.  type is a string of one or more of the below type indicator characters.  If you include more than one type indicator character in a single type string, or use this option more than once, od writes one copy of each output line using each of the data types that you specified, in the order that you specified.

Adding a trailing “z” to any type specification appends a display of the single byte character representation of the printable characters to the output line generated by the type specification.

'a'  named character, ignoring high-order bit
'c'  printable single byte character, C backslash escape or a 3 digit octal sequence
'd'  signed decimal
'f'  floating point (see Section 2.12 [Floating point], page 10)
'o'  octal
'u'  unsigned decimal
'x'  hexadecimal

The type a outputs things like ‘sp’ for space, ‘nl’ for newline, and ‘nul’ for a zero byte.  Only the least significant seven bits of each byte is used; the high-order bit is ignored. Type c outputs ‘ ’, ‘\n’, and \0, respectively.

Except for types ‘a’ and ‘c’, you can specify the number of bytes to use in interpreting each number in the given data type by following the type indicator character with a decimal integer.  Alternately, you can specify the size of one of the C compiler’s built-in data types by following the type indicator character with one of the following characters.  For integers ('d', 'o', 'u', 'x'):

'C'  char
'S'  short
'I'  int
'L'  long

For floating point (f):
F  float
D  double
L  long double

'--output-duplicates'
Output consecutive lines that are identical.  By default, when two or more consecutive output lines would be identical, od outputs only the first line, and puts just an asterisk on the following line to indicate the elision.
Chapter 3: Output of entire files

'--w[n]'  
'--width[=n]'
Dump n input bytes per output line. This must be a multiple of the least common multiple of the sizes associated with the specified output types.

If this option is not given at all, the default is 16. If n is omitted, the default is 32.

The next several options are shorthands for format specifications. GNU od accepts any combination of shorthands and format specification options. These options accumulate.

'--a'  
Output as named characters. Equivalent to '--t a'.

'--b'  
Output as octal bytes. Equivalent to '--t o1'.

'--c'  
Output as printable single byte characters, C backslash escapes or 3 digit octal sequences. Equivalent to '--t c'.

'--d'  
Output as unsigned decimal two-byte units. Equivalent to '--t u2'.

'--f'  
Output as floats. Equivalent to '--t fF'.

'--i'  
Output as decimal ints. Equivalent to '--t dI'.

'--l'  
Output as decimal long ints. Equivalent to '--t dL'.

'--o'  
Output as octal two-byte units. Equivalent to '--t o2'.

'--s'  
Output as decimal two-byte units. Equivalent to '--t d2'.

'--x'  
Output as hexadecimal two-byte units. Equivalent to '--t x2'.

'--traditional'
Recognize the non-option label argument that traditional od accepted. The following syntax:


can be used to specify at most one file and optional arguments specifying an offset and a pseudo-start address, label. The label argument is interpreted just like offset, but it specifies an initial pseudo-address. The pseudo-addresses are displayed in parentheses following any normal address.

An exit status of zero indicates success, and a nonzero value indicates failure.

3.5 base32: Transform data into printable data

base32 transforms data read from a file, or standard input, into (or from) base32 encoded form. The base32 encoded form uses printable ASCII characters to represent binary data. The usage and options of this command are precisely the same as for base64. See Section 3.6 [base64 invocation], page 19. For more general encoding functionality see Section 3.7 [bascnc invocation], page 19.
3.6 base64: Transform data into printable data

base64 transforms data read from a file, or standard input, into (or from) base64 encoded form. The base64 encoded form uses printable ASCII characters to represent binary data.

Synopses:

```
base64 [option]... [file]
base64 --decode [option]... [file]
```

The base64 encoding expands data to roughly 133% of the original. The base32 encoding expands data to roughly 160% of the original. The format conforms to RFC 4648 (https://tools.ietf.org/search/rfc4648).

For more general encoding functionality see Section 3.7 [basenc invocation], page 19.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-w cols`
`--wrap=cols`
During encoding, wrap lines after cols characters. This must be a positive number.
The default is to wrap after 76 characters. Use the value 0 to disable line wrapping altogether.

`-d`
`--decode`
Change the mode of operation, from the default of encoding data, to decoding data. Input is expected to be base64 encoded data, and the output will be the original data.

`-i`
`--ignore-garbage`
When decoding, newlines are always accepted. During decoding, ignore unrecognized bytes, to permit distorted data to be decoded.

An exit status of zero indicates success, and a nonzero value indicates failure.

3.7 basenc: Transform data into printable data

basenc transforms data read from a file, or standard input, into (or from) various common encoding forms. The encoded form uses printable ASCII characters to represent binary data.

Synopses:

```
basenc encoding [option]... [file]
basenc encoding --decode [option]... [file]
```

The encoding argument is required. If file is omitted, basenc reads from standard input. The -w/--wrap, -i/--ignore-garbage, -d/--decode options of this command are precisely the same as for base64. See Section 3.6 [base64 invocation], page 19.

Supported encodings are:

`--base64`
Encode into (or decode from with -d/--decode) base64 form. The format conforms to RFC 4648#4 (https://tools.ietf.org/search/rfc4648#section-4). Equivalent to the base64 command.
Chapter 3: Output of entire files

`--base64url`
Encode into (or decode from with `--d/--decode`) file-and-url-safe base64 form (using `_` and `-` instead of `+` and `/`). The format conforms to RFC 4648#5 (https://tools.ietf.org/search/rfc4648#section-5).

`--base32`
Encode into (or decode from with `--d/--decode`) base32 form. The encoded data uses the `ABCDEFGHIJKLMNOPQRSTUVWXYZ234567=` characters. The format conforms to RFC 4648#6 (https://tools.ietf.org/search/rfc4648#section-6). Equivalent to the `base32` command.

`--base32hex`
Encode into (or decode from with `--d/--decode`) Extended Hex Alphabet base32 form. The encoded data uses the `0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZPQRSTUVWXYZA BCD=++` characters. The format conforms to RFC 4648#7 (https://tools.ietf.org/search/rfc4648#section-7).

`--base16`
Encode into (or decode from with `--d/--decode`) base16 (hexadecimal) form. The encoded data uses the `0123456789ABCDEF` characters. The format conforms to RFC 4648#8 (https://tools.ietf.org/search/rfc4648#section-8).

`--base2lsbf`
Encode into (or decode from with `--d/--decode`) binary string form (`0` and `1`) with the least significant bit of every byte first.

`--base2msbf`
Encode into (or decode from with `--d/--decode`) binary string form (`0` and `1`) with the most significant bit of every byte first.

`--z85`
Encode into (or decode from with `--d/--decode`) Z85 form (a modified Ascii85 form). The encoded data uses the `0123456789abcdefghijklmnopqrstuvwxyzABCDEFGHIJKLMNOPQRSTUVWXYZPQRSTUVWXYZ*+\-%_@` characters. The format conforms to ZeroMQ spec:32/Z85 (https://rfc.zeromq.org/spec:32/Z85/).

When encoding with `--z85`, input length must be a multiple of 4; when decoding with `--z85`, input length must be a multiple of 5.

Encoding/decoding examples:

```
$ printf '\376\117\202' | basenc --base64
/k+C

$ printf '\376\117\202' | basenc --base64url
_k-C

$ printf '\376\117\202' | basenc --base32
7ZHYE===

$ printf '\376\117\202' | basenc --base32hex
VP704===
```
$ printf '\376\117\202' | basenc --base16
   FE4F82

$ printf '\376\117\202' | basenc --base2lsbf
   011111111111001001000001

$ printf '\376\117\202' | basenc --base2msbf
   111111100100111110000010

$ printf '\376\117\202\000' | basenc --z85
   @.FaC

$ printf 01010100 | basenc --base2msbf --decode
   T

$ printf 01010100 | basenc --base2lsbf --decode
   *
4 Formatting file contents

These commands reformat the contents of files.

4.1 fmt: Reformat paragraph text

fmt fills and joins lines to produce output lines of (at most) a given number of characters (75 by default). Synopsis:

```
fmt [option]... [file]...
```

fmt reads from the specified file arguments (or standard input if none are given), and writes to standard output.

By default, blank lines, spaces between words, and indentation are preserved in the output; successive input lines with different indentation are not joined; tabs are expanded on input and introduced on output.

fmt prefers breaking lines at the end of a sentence, and tries to avoid line breaks after the first word of a sentence or before the last word of a sentence. A sentence break is defined as either the end of a paragraph or a word ending in any of '.', '?', or '!'.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--c'

'--crown-margin'

Crown margin mode: preserve the indentation of the first two lines within a paragraph, and align the left margin of each subsequent line with that of the second line.

'--tagged-paragraph'

Tagged paragraph mode: like crown margin mode, except that if indentation of the first line of a paragraph is the same as the indentation of the second, the first line is treated as a one-line paragraph.

'--split-only'

Split lines only. Do not join short lines to form longer ones. This prevents sample lines of code, and other such “formatted” text from being unduly combined.

'--uniform-spacing'

Uniform spacing. Reduce spacing between words to one space, and spacing between sentences to two spaces.

'--width width'

Fill output lines up to width characters (default 75 or goal plus 10, if goal is provided).
`-g goal`
`--goal=goal`

fmt initially tries to make lines goal characters wide. By default, this is 7% shorter than width.

`-p prefix`
`--prefix=prefix`

Only lines beginning with prefix (possibly preceded by whitespace) are subject to formatting. The prefix and any preceding whitespace are stripped for the formatting and then re-attached to each formatted output line. One use is to format certain kinds of program comments, while leaving the code unchanged.

An exit status of zero indicates success, and a nonzero value indicates failure.

4.2 pr: Paginate or columnate files for printing

pr writes each file (`-` means standard input), or standard input if none are given, to standard output, paginating and optionally outputting in multicolumn format; optionally merges all files, printing all in parallel, one per column. Synopsis:

```bash
pr [option]... [file]...
```

By default, a 5-line header is printed at each page: two blank lines; a line with the date, the file name, and the page count; and two more blank lines. A footer of five blank lines is also printed. The default page length is 66 lines. The default number of text lines is therefore 56. The text line of the header takes the form `date string page`, with spaces inserted around string so that the line takes up the full page width. Here, date is the date (see the `-D` or `--date-format` option for details), string is the centered header string, and page identifies the page number. The LC_MESSAGES locale category affects the spelling of page; in the default C locale, it is `Page number` where number is the decimal page number.

Form feeds in the input cause page breaks in the output. Multiple form feeds produce empty pages.

Columns are of equal width, separated by an optional string (default is `space`). For multicolumn output, lines will always be truncated to page_width (default 72), unless you use the `-J` option. For single column output no line truncation occurs by default. Use `-W` option to truncate lines in that case.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`+first_page[:last_page]`

Begin printing with page first_page and stop with last_page. Missing `last_page` implies end of file. While estimating the number of skipped pages each form feed in the input file results in a new page. Page counting with and without `+first_page` is identical. By default, counting starts with the first page of input file (not first page printed). Line numbering may be altered by `-N` option.

`-column`

With each single file, produce column columns of output (default is 1) and print columns down, unless `-a` is used. The column width is automatically decreased
as column increases; unless you use the -W/-w option to increase page width as well. This option might well cause some lines to be truncated. The number of lines in the columns on each page are balanced. The options -e and -i are on for multiple text-column output. Together with -J option column alignment and line truncation is turned off. Lines of full length are joined in a free field format and -S option may set field separators. -column may not be used with -m option.

`-a`
`--across`
With each single file, print columns across rather than down. The -column option must be given with column greater than one. If a line is too long to fit in a column, it is truncated.

`-c`
`--show-control-chars`
Print control characters using hat notation (e.g., `^G`); print other nonprinting characters in octal backslash notation. By default, nonprinting characters are not changed.

`-d`
`--double-space`
Double space the output.

`-D format`
`--date-format=format`
Format header dates using format, using the same conventions as for the command `date +format`. See Section 21.1 [date invocation], page 192. Except for directives, which start with `%`, characters in format are printed unchanged. You can use this option to specify an arbitrary string in place of the header date, e.g., `--date-format="Monday morning"`.

The default date format is `%Y-%m-%d %H:%M` (for example, `2020-07-09 23:59`); but if the POSIXLY_CORRECT environment variable is set and the LC_TIME locale category specifies the POSIX locale, the default is `%b %e %H:%M %Y` (for example, `Jul 9 23:59 2020`).

Timestamps are listed according to the time zone rules specified by the TZ environment variable, or by the system default rules if TZ is not set. See Section “Specifying the Time Zone with TZ” in The GNU C Library Reference Manual.

`-e[in-tabchar[=in-tabwidth]]`
`--expand-tabs[=in-tabchar[=in-tabwidth]]`
Expand tabs to spaces on input. Optional argument in-tabchar is the input tab character (default is the TAB character). Second optional argument in-tabwidth is the input tab character’s width (default is 8).

`-f`
`-F`
`--form-feed`
Use a form feed instead of newlines to separate output pages. This does not alter the default page length of 66 lines.
'–h header'
'--header=header'
Replace the file name in the header with the centered string header. When using
the shell, header should be quoted and should be separated from –h by a space.

'–i[out-tabchar[out-tabwidth]]'
'--output-tabs=[out-tabchar[out-tabwidth]]'
Replace spaces with tabs on output. Optional argument out-tabchar is the
output tab character (default is the TAB character). Second optional argument
out-tabwidth is the output tab character’s width (default is 8).

'–J'
'--join-lines'
Merge lines of full length. Used together with the column options -column, -a
-column or -m. Turns off -W/-w line truncation; no column alignment used; may
be used with --sep-string=[string]. -J has been introduced (together with
-W and --sep-string) to disentangle the old (POSIX-compliant) options -w
and -s along with the three column options.

'–l page_length'
'--length=page_length'
Set the page length to page_length (default 66) lines, including the lines of the
header [and the footer]. If page_length is less than or equal to 10, the header
and footer are omitted, as if the –t option had been given.

'–m'
'--merge'
Merge and print all files in parallel, one in each column. If a line is too long to fit in
a column, it is truncated, unless the –J option is used. --sep-string=[string]
may be used. Empty pages in some files (form feeds set) produce empty columns,
still marked by string. The result is a continuous line numbering and column
marking throughout the whole merged file. Completely empty merged pages
show no separators or line numbers. The default header becomes ‘date page’
with spaces inserted in the middle; this may be used with the –h or --header
option to fill up the middle blank part.

'–n[number-separator[digits]]'
'--number-lines=[number-separator[digits]]'
Provide digits digit line numbering (default for digits is 5). With multicol
output the number occupies the first digits column positions of each text column
or only each line of –m output. With single column output the number precedes
each line just as –m does. Default counting of the line numbers starts with the
first line of the input file (not the first line printed, compare the --page option
and -N option). Optional argument number-separator is the character appended
to the line number to separate it from the text followed. The default separator
is the TAB character. In a strict sense a TAB is always printed with single
column output only. The TAB width varies with the TAB position, e.g., with
the left margin specified by –o option. With multicol output priority is
given to ‘equal width of output columns’ (a POSIX specification). The TAB
width is fixed to the value of the first column and does not change with different
values of left margin. That means a fixed number of spaces is always printed
in the place of the number-separator TAB. The tabification depends upon the output position.

`-N line_number`
`--first-line-number=line_number`
Start line counting with the number line_number at first line of first page printed (in most cases not the first line of the input file).

`-o margin`
`--indent=margin`
Indent each line with a margin margin spaces wide (default is zero). The total page width is the size of the margin plus the page_width set with the -w/-W option. A limited overflow may occur with numbered single column output (compare -n option).

`-r`
`--no-file-warnings`
Do not print a warning message when an argument file cannot be opened. (The exit status will still be nonzero, however.)

`s[char]`
`s=string`
Separate columns by a single character char. The default for char is the TAB character without -w and 'no character' with -w. Without -s the default separator 'space' is set. -s[char] turns off line truncation of all three column options (-COLUMN|-a -COLUMN|-m) unless -w is set. This is a POSIX-compliant formulation.

`-S[string]`
`--sep-string[string]`
Use string to separate output columns. The -S option doesn't affect the -w/-W option, unlike the -s option which does. It does not affect line truncation or column alignment. Without -S, and with -J, pr uses the default output separator, TAB. Without -S or -J, pr uses a 'space' (same as -S " "). If no 'string' argument is specified, " " is assumed.

`-t`
`--omit-header`
Do not print the usual header [and footer] on each page, and do not fill out the bottom of pages (with blank lines or a form feed). No page structure is produced, but form feeds set in the input files are retained. The predefined pagination is not changed. -t or -T may be useful together with other options; e.g.: -t -e4, expand TAB characters in the input file to 4 spaces but don’t make any other changes. Use of -t overrides -h.

`-T`
`--omit-pagination`
Do not print header [and footer]. In addition eliminate all form feeds set in the input files.
Chapter 4: Formatting file contents

`-v`
`--show-nonprinting`
Print nonprinting characters in octal backslash notation.

`-w page_width`
`--width=page_width`
Set page width to page_width characters for multiple text-column output only (default for page_width is 72). The specified page_width is rounded down so that columns have equal width. -s[CHAR] turns off the default page width and any line truncation and column alignment. Lines of full length are merged, regardless of the column options set. No page_width setting is possible with single column output. A POSIX-compliant formulation.

`-W page_width`
`--page_width=page_width`
Set the page width to page_width characters, honored with and without a column option. With a column option, the specified page_width is rounded down so that columns have equal width. Text lines are truncated, unless -J is used. Together with one of the three column options (-column, -a -column or -m) column alignment is always used. The separator options -S or -s don’t disable the -W option. Default is 72 characters. Without -W page_width and without any of the column options NO line truncation is used (defined to keep downward compatibility and to meet most frequent tasks). That’s equivalent to -W 72 -J. The header line is never truncated.

An exit status of zero indicates success, and a nonzero value indicates failure.

4.3 fold: Wrap input lines to fit in specified width

fold writes each file (- means standard input), or standard input if none are given, to standard output, breaking long lines. Synopsis:

fold [option]... [file]...

By default, fold breaks lines wider than 80 columns. The output is split into as many lines as necessary.

fold counts screen columns by default; thus, a tab may count more than one column, backspace decreases the column count, and carriage return sets the column to zero.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-b`
`--bytes`
Count bytes rather than columns, so that tabs, backspaces, and carriage returns are each counted as taking up one column, just like other characters.

`-s`
`--spaces`
Break at word boundaries: the line is broken after the last blank before the maximum line length. If the line contains no such blanks, the line is broken at the maximum line length as usual.
'--width=width'

Use a maximum line length of width columns instead of 80.

For compatibility fold supports an obsolete option syntax \texttt{-width}. New scripts should use \texttt{-w width} instead.

An exit status of zero indicates success, and a nonzero value indicates failure.
5 Output of parts of files

These commands output pieces of the input.

5.1 head: Output the first part of files

head prints the first part (10 lines by default) of each file; it reads from standard input if no files are given or when given a file of -. Synopsis:

```bash
head [option]... [file]...
```

If more than one file is specified, head prints a one-line header consisting of:

```plaintext
== file name ==
```

before the output for each file.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-c [-]num`

`--bytes= [-]num`

Print the first `num` bytes, instead of initial lines. However, if `num` is prefixed with a `-`, print all but the last `num` bytes of each file. `num` may be, or may be an integer optionally followed by, one of the following multiplicative suffixes:

- `b` => 512 ("blocks")
- `KB` => 1000 (KiloBytes)
- `K` => 1024 (KibiBytes)
- `MB` => 1000*1000 (MegaBytes)
- `M` => 1024*1024 (MebiBytes)
- `GB` => 1000*1000*1000 (GigaBytes)
- `G` => 1024*1024*1024 (GibiBytes)

and so on for `T`, `P`, `E`, `Z`, `Y`, `R`, and `Q`. Binary prefixes can be used, too: `KiB`=`k`, `MiB`=`M`, and so on.

`-n [-]num`

`--lines= [-]num`

Output the first `num` lines. However, if `num` is prefixed with a `-`, print all but the last `num` lines of each file. Size multiplier suffixes are the same as with the `-c` option.

`-q`

`--quiet`

`--silent`

Never print file name headers.

`-v`

`--verbose`

Always print file name headers.

`-z`

`--zero-terminated`

Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII
NUL. This option can be useful in conjunction with ‘perl -0’ or ‘find -print0’ and ‘xargs -0’ which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters).

For compatibility head also supports an obsolete option syntax -[num][bkm][cqv], which is recognized only if it is specified first. num is a decimal number optionally followed by a size letter ('b', 'k', 'm') as in -c, or 'l' to mean count by lines, or other option letters ('cqv'). Scripts intended for standard hosts should use -c num or -n num instead. If your script must also run on hosts that support only the obsolete syntax, it is usually simpler to avoid head, e.g., by using ‘sed 5q’ instead of ‘head -5’.

An exit status of zero indicates success, and a nonzero value indicates failure.

5.2 tail: Output the last part of files

tail prints the last part (10 lines by default) of each file; it reads from standard input if no files are given or when given a file of ‘-’. Synopsis:

```
tail [option]... [file]...
```

If more than one file is specified, tail prints a one-line header before the output for each file, consisting of:
```
==> file name <==
```

For further processing of tail output, it can be useful to convert the file headers to line prefixes, which can be done like:

```
tail ... |
awk '
    /^==> .* <==$/ {prefix=substr($0,5,length-$8)"":"; next}
    {print prefix$0}
' | ...
```

GNU tail can output any amount of data (some other versions of tail cannot). It also has no -r option (print in reverse), since reversing a file is really a different job from printing the end of a file; BSD tail (which is the one with -r) can only reverse files that are at most as large as its buffer, which is typically 32 KiB. A more reliable and versatile way to reverse files is the GNU tac command.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

```
'c [+]num'
'--bytes=[+]num'
```

Output the last num bytes, instead of final lines. If num is prefixed with a ‘+’, start printing with byte num from the start of each file. For example to skip the first byte use tail -c +2, while to skip all but the last byte use tail -c 1. num may be, or may be an integer optionally followed by one of the following multiplicative suffixes:

```
'b' => 512 ("blocks")
'KB' => 1000 (KiloBytes)
'K' => 1024 (KibiBytes)
'MB' => 1000*1000 (MegaBytes)
'M' => 1024*1024 (MebiBytes)
```
Chapter 5: Output of parts of files

'GB' => 1000*1000*1000 (GigaBytes)
'G'  => 1024*1024*1024 (GibiBytes)

and so on for 'T', 'P', 'E', 'Z', 'Y', 'R', and 'Q'. Binary prefixes can be used, too: 'KiB'=‘K', 'MiB'=‘M', and so on.

'-f'

'--follow[=how]'
Loop forever trying to read more characters at the end of the file, presumably because the file is growing. If more than one file is given, tail prints a header whenever it gets output from a different file, to indicate which file that output is from.

There are two ways to specify how you’d like to track files with this option, but that difference is noticeable only when a followed file is removed or renamed. If you’d like to continue to track the end of a growing file even after it has been unlinked, use --follow=descriptor. This is the default behavior, but it is not useful if you’re tracking a log file that may be rotated (removed or renamed, then reopened). In that case, use --follow=name to track the named file, perhaps by reopening it periodically to see if it has been removed and recreated by some other program. Note that the inotify-based implementation handles this case without the need for any periodic reopening.

No matter which method you use, if the tracked file is determined to have shrunk, tail prints a message saying the file has been truncated and resumes tracking from the start of the file, assuming it has been truncated to 0, which is the usual truncation operation for log files.

When a file is removed, tail’s behavior depends on whether it is following the name or the descriptor. When following by name, tail can detect that a file has been removed and gives a message to that effect, and if --retry has been specified it will continue checking periodically to see if the file reappears. When following a descriptor, tail does not detect that the file has been unlinked or renamed and issues no message; even though the file may no longer be accessible via its original name, it may still be growing.

The option values ‘descriptor’ and ‘name’ may be specified only with the long form of the option, not with -f.

The -f option is ignored if no file operand is specified and standard input is a FIFO or a pipe. Likewise, the -f option has no effect for any operand specified as '-', when standard input is a FIFO or a pipe.

With kernel inotify support, output is triggered by file changes and is generally very prompt. Otherwise, tail sleeps for one second between checks – use --sleep-interval=n to change that default – which can make the output appear slightly less responsive or bursty. When using tail without inotify support, you can make it more responsive by using a sub-second sleep interval, e.g., via an alias like this:

    alias tail='tail -s.1'

'-F'

This option is the same as --follow=name --retry. That is, tail will attempt to reopen a file when it is removed. Should this fail, tail will keep trying until it becomes accessible again.
‘--max-unchanged-stats=n’
When tailing a file by name, if there have been n (default n=5) consecutive iterations for which the file has not changed, then open/fstat the file to determine if that file name is still associated with the same device/inode-number pair as before. When following a log file that is rotated, this is approximately the number of seconds between when tail prints the last pre-rotation lines and when it prints the lines that have accumulated in the new log file. This option is meaningful only when polling (i.e., without inotify) and when following by name.

‘-n [+]<num>’
‘--lines=[+]’
Output the last num lines. If num is prefixed with a ‘+’, start printing with line num from the start of each file. For example to skip the first line use tail -n +2, while to skip all but the last line use tail -n 1. Size multiplier suffixes are the same as with the -c option.

‘--pid=pid’
When following by name or by descriptor, you may specify the process ID, pid, of the sole writer of all file arguments. Then, shortly after that process terminates, tail will also terminate. This will work properly only if the writer and the tailing process are running on the same machine. For example, to save the output of a build in a file and to watch the file grow, if you invoke make and tail like this then the tail process will stop when your build completes. Without this option, you would have had to kill the tail -f process yourself.

$ make >& makerr & tail --pid=$! -f makerr
If you specify a pid that is not in use or that does not correspond to the process that is writing to the tailed files, then tail may terminate long before any files stop growing or it may not terminate until long after the real writer has terminated. Note that --pid cannot be supported on some systems; tail will print a warning if this is the case.

‘-q’
‘--quiet’
‘--silent’
Never print file name headers.

‘--retry’
Indefinitely try to open the specified file. This option is useful mainly when following (and otherwise issues a warning).

When following by file descriptor (i.e., with --follow=descriptor), this option only affects the initial open of the file, as after a successful open, tail will start following the file descriptor.

When following by name (i.e., with --follow=name), tail infinitely retries to re-open the given files until killed.

Without this option, when tail encounters a file that doesn’t exist or is otherwise inaccessible, it reports that fact and never checks it again.
Chapter 5: Output of parts of files

'-s number'
'--sleep-interval=number'
Change the number of seconds to wait between iterations (the default is 1.0). During one iteration, every specified file is checked to see if it has changed size. When tail uses inotify, this polling-related option is usually ignored. However, if you also specify --pid=p, tail checks whether process p is alive at least every number seconds. The number must be non-negative and can be a floating-point number in either the current or the C locale. See Section 2.12 [Floating point], page 10.

'-v'
'--verbose'
Always print file name headers.

'-z'
'--zero-terminated'
Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with `perl -0` or `find -print0` and `xargs -0` which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters).

For compatibility tail also supports an obsolete usage `tail -[num][bcl][f] [file]`, which is recognized only if it does not conflict with the usage described above. This obsolete form uses exactly one option and at most one file. In the option, num is an optional decimal number optionally followed by a size letter (‘b’, ‘c’, ‘l’) to mean count by 512-byte blocks, bytes, or lines, optionally followed by ‘f’ which has the same meaning as -f.

On systems not conforming to POSIX 1003.1-2001, the leading ‘-’ can be replaced by ‘+’ in the traditional option syntax with the same meaning as in counts, and on obsolete systems predating POSIX 1003.1-2001 traditional usage overrides normal usage when the two conflict. This behavior can be controlled with the _POSIX2_VERSION environment variable (see Section 2.13 [Standards conformance], page 11).

Scripts intended for use on standard hosts should avoid traditional syntax and should use -c num[b], -n num, and/or -f instead. If your script must also run on hosts that support only the traditional syntax, you can often rewrite it to avoid problematic usages, e.g., by using `sed -n '$p'` rather than `tail -1`. If that’s not possible, the script can use a test like `if tail -c +1 </dev/null >/dev/null 2>&1; then ...` to decide which syntax to use.

Even if your script assumes the standard behavior, you should still beware usages whose behaviors differ depending on the POSIX version. For example, avoid `tail - main.c`, since it might be interpreted as either `tail main.c` or as `tail -- main.c`; avoid `tail -c 4`, since it might mean either `tail -c4` or `tail -c 10 4`; and avoid `tail +4`, since it might mean either `tail ./+4` or `tail -n +4`.

An exit status of zero indicates success, and a nonzero value indicates failure.

5.3 split: Split a file into pieces.

split creates output files containing consecutive or interleaved sections of input (standard input if none is given or input is ‘-’). Synopsis:
split [option] [input [prefix]]

By default, split puts 1000 lines of input (or whatever is left over for the last section), into each output file.

The output files’ names consist of prefix (‘x’ by default) followed by a group of characters (‘aa’, ‘ab’, . . . by default), such that concatenating the output files in traditional sorted order by file name produces the original input file (except -nr/n). By default split will initially create files with two generated suffix characters, and will increase this width by two when the next most significant position reaches the last character. (‘yz’, ‘zaaa’, ‘zaab’, . . .). In this way an arbitrary number of output files are supported, which sort as described above, even in the presence of an --additional-suffix option. If the -a option is specified and the output file names are exhausted, split reports an error without deleting the output files that it did create.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-l lines’
‘--lines=lines’
Put lines lines of input into each output file. If --separator is specified, then lines determines the number of records.
For compatibility split also supports an obsolete option syntax -lines. New scripts should use -l lines instead.

‘-b size’
‘--bytes=size’
Put size bytes of input into each output file. size may be, or may be an integer optionally followed by, one of the following multiplicative suffixes:

- ‘b’ => 512 ("blocks")
- ‘KB’ => 1000 (KiloBytes)
- ‘K’  => 1024 (KibiBytes)
- ‘MB’ => 1000*1000 (MegaBytes)
- ‘M’  => 1024*1024 (MebiBytes)
- ‘GB’ => 1000*1000*1000 (GigaBytes)
- ‘G’  => 1024*1024*1024 (GibiBytes)


‘-C size’
‘--line-bytes=size’
Put into each output file as many complete lines of input as possible without exceeding size bytes. Individual lines or records longer than size bytes are broken into multiple files. size has the same format as for the --bytes option. If --separator is specified, then lines determines the number of records.

‘--filter=command’
With this option, rather than simply writing to each output file, write through a pipe to the specified shell command for each output file. command should use the $FILE environment variable, which is set to a different output file name for each invocation of the command. For example, imagine that you have a 1TiB compressed file that, if uncompressed, would be too large to reside on
secondary storage, yet you must split it into individually-compressed pieces of a more manageable size. To do that, you might run this command:

```
xz -dc BIG.xz | split -b200G --filter='xz > $FILE.xz' - big-
```

Assuming a 10:1 compression ratio, that would create about fifty 20GiB files with names `big-aa.xz`, `big-ab.xz`, `big-ac.xz`, etc.

`-n chunks`

Split input to chunks output files where chunks may be:

- `n` generate `n` files based on current size of input
- `k/n` output only `kth` of `n` to standard output
- `1/n` generate `n` files without splitting lines or records
- `1/k/n` likewise but output only `kth` of `n` to stdout
- `r/n` like ‘`l`’ but use round robin distribution
- `r/k/n` likewise but output only `kth` of `n` to stdout

If the input size is not a multiple of `n`, early output files are one byte longer than later output files, to make up the difference. Any excess bytes appearing after the initial calculation are discarded (except when using ‘`r`’ mode).

All `n` files are created even if there are fewer than `n` lines, or the input is truncated.

For ‘`l`’ mode, chunks are approximately input size / `n`. Although the input is still partitioned as before into `n` regions of approximately equal size, if a line starts within a partition it is written completely to the corresponding file. Since lines or records are not split even if they overlap a partition, the files written can be larger or smaller than the partition size, and even empty if a line/record is so long as to completely overlap the partition.

When the input is a pipe or some other special file where the size cannot easily be determined, there is no trouble for ‘`r`’ mode because the size of the input is irrelevant. For other modes, such an input is first copied to a temporary to determine its size.

`-a length`

Use suffixes of length `length`. If a `length` of 0 is specified, this is the same as if (any previous) `-a` was not specified, and thus enables the default behavior, which starts the suffix length at 2, and unless `-n` or `--numeric-suffixes=from` is specified, will auto increase the length by 2 as required.

`-d`

Use digits in suffixes rather than lower-case letters. The numerical suffix counts from `from` if specified, 0 otherwise.

`from` is supported with the long form option, and is used to either set the initial suffix for a single run, or to set the suffix offset for independently split inputs, and consequently the auto suffix length expansion described above is disabled. Therefore you may also want to use option `-a` to allow suffixes beyond ‘`99`’.

Note if option `--number` is specified and the number of files is less than `from`, a
single run is assumed and the minimum suffix length required is automatically
determined.

'-x'
'--hex-suffixes[=from]'  
Like --numeric-suffixes, but use hexadecimal numbers (in lower case).

'--additional-suffix=suffix'  
Append an additional suffix to output file names. suffix must not contain slash.

'-e'
'--elide-empty-files'  
Suppress the generation of zero-length output files. This can happen with the
-number option if a file is (truncated to be) shorter than the number requested,
or if a line is so long as to completely span a chunk. The output file sequence
numbers, always run consecutively even when this option is specified.

'-t separator'
'--separator=separator'  
Use character separator as the record separator instead of the default newline
character (ASCII LF). To specify ASCII NUL as the separator, use the two-
character string '\0', e.g., 'split -t '\0''.

'-u'
'--unbuffered'  
Immediately copy input to output in --number r/... mode, which is a much
slower mode of operation.

'--verbose'  
Write a diagnostic just before each output file is opened.

An exit status of zero indicates success, and a nonzero value indicates failure.Here are a
few examples to illustrate how the --number (-n) option works:

Notice how, by default, one line may be split onto two or more:

$ seq -w 6 10 > k; split -n3 k; head xax
  ==> xaa ==>
06
07
  ==> xab ==>
08
0
  ==> xac ==>
  9
  10

Use the "l/" modifier to suppress that:

$ seq -w 6 10 > k; split -nl/3 k; head xax
  ==> xaa ==>
06
07
Use the "r/" modifier to distribute lines in a round-robin fashion:

```
$ seq -w 6 10 > k; split -nr/3 k; head x?
```

You can also extract just the Kth chunk. This extracts and prints just the 7th "chunk" of 33:

```
$ seq 100 > k; split -nl/7/33 k
```

5.4 csplit: Split a file into context-determined pieces

csplit creates zero or more output files containing sections of input (standard input if input is '-'). Synopsis:

```
csplit [option]... input pattern...
```

The contents of the output files are determined by the pattern arguments, as detailed below. An error occurs if a pattern argument refers to a nonexistent line of the input file (e.g., if no remaining line matches a given regular expression). After every pattern has been matched, any remaining input is copied into one last output file.

By default, csplit prints the number of bytes written to each output file after it has been created.

The types of pattern arguments are:

- **'n'**
  Create an output file containing the input up to but not including line n (a positive integer). If followed by a repeat count, also create an output file containing the next n lines of the input file once for each repeat.

- **'/regexp/[offset]'**
  Create an output file containing the current line up to (but not including) the next line of the input file that contains a match for regexp. The optional offset
is an integer, that can be preceded by `+` or `-`. If it is given, the input up to (but not including) the matching line plus or minus offset is put into the output file, and the line after that begins the next section of input. Note lines within a negative offset of a regexp pattern are not matched in subsequent regexp patterns.

`%regexp%[offset]`  
Like the previous type, except that it does not create an output file, so that section of the input file is effectively ignored.

`{repeat-count}`  
Repeat the previous pattern repeat-count additional times. The repeat-count can either be a positive integer or an asterisk, meaning repeat as many times as necessary until the input is exhausted.

The output files’ names consist of a prefix (‘xx’ by default) followed by a suffix. By default, the suffix is an ascending sequence of two-digit decimal numbers from ‘00’ to ‘99’. In any case, concatenating the output files in sorted order by file name produces the original input file, excluding portions skipped with a `%regexp%` pattern or the --suppress-matched option.

By default, if csplit encounters an error or receives a hangup, interrupt, quit, or terminate signal, it removes any output files that it has created so far before it exits.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-f prefix`  
`--prefix=prefix`  
Use prefix as the output file name prefix.

`-b format`  
`--suffix-format=format`  
Use format as the output file name suffix. When this option is specified, the suffix string must include exactly one printf(3)-style conversion specification, possibly including format specification flags, a field width, a precision specification, or all of these kinds of modifiers. The format letter must convert a binary unsigned integer argument to readable form. The format letters ‘d’ and ‘i’ are aliases for ‘u’, and the ‘u’, ‘o’, ‘x’, and ‘X’ conversions are allowed. The entire format is given (with the current output file number) to sprintf(3) to form the file name suffixes for each of the individual output files in turn. If this option is used, the --digits option is ignored.

`-n digits`  
`--digits=digits`  
Use output file names containing numbers that are digits digits long instead of the default 2.

`-k`  
`--keep-files`  
Do not remove output files when errors are encountered.

`--suppress-matched`  
Do not output lines matching the specified pattern. i.e., suppress the boundary line from the start of the second and subsequent splits.
Chapter 5: Output of parts of files

'-z'
'--elide-empty-files'
Suppress the generation of zero-length output files. (In cases where the section delimiters of the input file are supposed to mark the first lines of each of the sections, the first output file will generally be a zero-length file unless you use this option.) The output file sequence numbers always run consecutively starting from 0, even when this option is specified.

'-s'
'-q'
'--silent'
'--quiet'  Do not print counts of output file sizes.

An exit status of zero indicates success, and a nonzero value indicates failure. Here is an example of its usage. First, create an empty directory for the exercise, and cd into it:

$ mkdir d && cd d

Now, split the sequence of 1..14 on lines that end with 0 or 5:

$ seq 14 | csplit - '/[05]$/' '{*}'
8
10
15

Each number printed above is the size of an output file that csplit has just created. List the names of those output files:

$ ls
xx00  xx01  xx02

Use head to show their contents:

$ head xx*
==> xx00 <==
1
2
3
4

==> xx01 <==
5
6
7
8
9

==> xx02 <==
10
11
12
13
14

Example of splitting input by empty lines:

$ csplit --suppress-matched input.txt '/^$/' '{*}'}
6 Summarizing files

These commands generate just a few numbers representing entire contents of files.

6.1 wc: Print newline, word, and byte counts

wc counts the number of bytes, characters, words, and newlines in each given file, or standard input if none are given or for a file of ‘-‘. A word is a nonzero length sequence of printable characters delimited by white space. Synopsis:

    wc [option]... [file]...

wc prints one line of counts for each file, and if the file was given as an argument, it prints the file name following the counts. By default if more than one file is given, wc prints a final line containing the cumulative counts, with the file name total. This ‘total’ line can be controlled with the --total option, which is a GNU extension. The counts are printed in this order: newlines, words, characters, bytes, maximum line length. Each count is printed right-justified in a field with at least one space between fields so that the numbers and file names normally line up nicely in columns. The width of the count fields varies depending on the inputs, so you should not depend on a particular field width. However, as a GNU extension, if only one count is printed, it is guaranteed to be printed without leading spaces.

By default, wc prints three counts: the newline, words, and byte counts. Options can specify that only certain counts be printed. Options do not undo others previously given, so

    wc --bytes --words

prints both the byte counts and the word counts.

With the --max-line-length option, wc prints the length of the longest line per file, and if there is more than one file it prints the maximum (not the sum) of those lengths. The line lengths here are measured in screen columns, according to the current locale and assuming tab positions in every 8th column.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-c’

‘--bytes’ Print only the byte counts.

‘-m’

‘--chars’ Print only the character counts, as per the current locale. Invalid characters are not counted.

‘-w’

‘--words’ Print only the word counts. A word is a nonzero length sequence of printable characters separated by white space.

‘-l’

‘--lines’ Print only the newline character counts. Note a file without a trailing newline character, will not have that last portion included in the line count.

‘-L’

‘--max-line-length’

Print only the maximum display widths. Tabs are set at every 8th column. Display widths of wide characters are considered. Non-printable characters are given 0 width.
Chapter 6: Summarizing files

`--total=when`

Control when and how the final line with cumulative counts is printed. when is one of:

- `auto` - This is the default mode of `wc` when no `--total` option is specified. Output a total line if more than one file is specified.
- `always` - Always output a total line, irrespective of the number of files processed.
- `only` - Only output total counts. I.e., don’t print individual file counts, suppress any leading spaces, and don’t print the ‘total’ word itself, to simplify subsequent processing.
- `never` - Never output a total line.

`--files0-from=file`

Disallow processing files named on the command line, and instead process those named in file file; each name being terminated by a zero byte (ASCII NUL). This is useful when the list of file names is so long that it may exceed a command line length limitation. In such cases, running `wc` via `xargs` is undesirable because it splits the list into pieces and makes `wc` print a total for each sublist rather than for the entire list. One way to produce a list of ASCII NUL terminated file names is with GNU `find`, using its `-print0` predicate. If `file` is `-' then the ASCII NUL terminated file names are read from standard input.

For example, to find the length of the longest line in any `.c` or `.h` file in the current hierarchy, do this:

```
find . -name '*.[ch]' -print0 |
wc -L --files0-from=- | tail -n1
```

An exit status of zero indicates success, and a nonzero value indicates failure.

### 6.2 sum: Print checksum and block counts

`sum` computes a 16-bit checksum for each given file, or standard input if none are given or for a file of `-' . Synopsis:

```
sum [option]... [file]...
```

`sum` prints the checksum for each file followed by the number of blocks in the file (rounded up). If at least one file is given, file names are also printed.

By default, GNU `sum` computes checksums using an algorithm compatible with BSD `sum` and prints file sizes in units of 1024-byte blocks.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-r` Use the default (BSD compatible) algorithm. This option is included for compatibility with the System V `sum`. Unless `-s` was also given, it has no effect.

`-s` `--sysv` Compute checksums using an algorithm compatible with System V `sum`’s default, and print file sizes in units of 512-byte blocks.

`sum` is provided for compatibility; the `cksum` program (see next section) is preferable in new applications.
An exit status of zero indicates success, and a nonzero value indicates failure.

### 6.3 cksum: Print and verify file checksums

`cksum` by default computes a 32-bit cyclic redundancy check (CRC) checksum for each given file, or standard input if none are given or for a file of `-'.

`cksum` also supports the `-a/--algorithm` option to select the digest algorithm to use. `cksum` is the preferred interface to these digests, subsuming the other standalone checksumming utilities, which can be emulated using `cksum -a md5 --untagged "$@"` etc. Synopsis:

```
cksum [option]... [file]...
```

`cksum` is typically used to ensure that files have not been corrupted, by comparing the `cksum` output for the received files with the `cksum` output for the original files (typically given in the distribution).

#### 6.3.1 cksum output modes

**Legacy output format**

`cksum` by default prints the POSIX standard CRC checksum for each file along with the number of bytes in the file, and the file name unless no arguments were given. The 32-bit CRC used is based on the polynomial used for CRC error checking in the ISO/IEC 8802-3:1996 standard (Ethernet). Similar output formats are used for the other legacy checksums selectable with `--algorithm=sysv` or `--algorithm=bsd`, detailed at Section 6.2 [sum invocation], page 42.

**Tagged output format**

With the `--algorithm` option selecting non legacy checksums, the `cksum` command defaults to output of the form:

```
digest_name (file name) = digest
```

Note the standalone checksum utilities can select this output mode by using the `--tag` option.

**Untagged output format**

With the `--untagged` option and the `--algorithm` option selecting non legacy checksums, the following output format is used. Note this is the default output format of the standalone checksum utilities. For each file, we print the checksum, a space, a flag indicating binary or text input mode, and the file name. Binary mode is indicated with `*`, text mode with ` ` (space). Binary mode is the default on systems where it’s significant, otherwise text mode is the default.

Note without `--zero`, and with non legacy output formats, if file contains a backslash, newline, or carriage return, the line is started with a backslash, and each problematic character in the file name is escaped with a backslash, making the output unambiguous even in the presence of arbitrary file names. Since the backslash character itself is escaped, any other backslash escape sequences are reserved for future use.

#### 6.3.2 cksum general options

`-a`

`--algorithm`

Compute checksums using the specified digest algorithm.
Supported legacy checksums (which are not supported by --check):

- 'sysv' equivalent to sum -s
- 'bsd' equivalent to sum -r
- 'crc' equivalent to cksum (the default)

Supported more modern digest algorithms are:

- 'md5' equivalent to md5sum
- 'sha1' equivalent to sha1sum
- 'sha224' equivalent to sha224sum
- 'sha256' equivalent to sha256sum
- 'sha384' equivalent to sha384sum
- 'sha512' equivalent to sha512sum
- 'blake2b' equivalent to b2sum
- 'sm3' only available through cksum

'--base64'
Print base64-encoded digests not hexadecimal. This option is ignored with --check. The format conforms to RFC 4648#4 (https://tools.ietf.org/search/rfc4648#section-4).

Note that each base64-encoded digest has zero, one or two trailing padding ('=') bytes. The length of that padding is the checksum-bit-length modulo 3, and the --check parser requires precisely the same input digest string as what is output. I.e., removing or adding any '=' padding renders a digest non-matching.

'--debug'
Output extra information to stderr, like the checksum implementation being used.

'--length'
Change (shorten) the default digest length. This is specified in bits and thus must be a multiple of 8. This option is ignored when --check is specified, as the length is automatically determined when checking.

'--raw'
Print only the unencoded raw binary digest for a single input. Do not output the file name or anything else. Use network byte order (big endian) where applicable: for 'bsd', 'crc', and 'sysv'. This option works only with a single input. Unlike other output formats, cksum provides no way to --check a --raw checksum.

'--untagged'
Output using the original Coreutils format used by the other standalone checksum utilities like md5sum for example. This format has the checksum at the start of the line, and may be more amenable to further processing by other utilities, especially in combination with the --zero option. Note this does not identify the digest algorithm used for the checksum. See Section 6.3.1 [cksum output modes], page 43, for details of this format.
6.3.3 cksum common options

`-b`
`--binary`

Note this option is not supported by the `cksum` command, as it operates in binary mode exclusively. Treat each input file as binary, by reading it in binary mode and outputting a `*' flag. This is the inverse of `--text`. On systems like GNU that do not distinguish between binary and text files, this option merely flags each input mode as binary: the checksum is unaffected. This option is the default on systems like MS-DOS that distinguish between binary and text files, except for reading standard input when standard input is a terminal.

`-c`
`--check`

Read file names and checksum information (not data) from each file (or from standard input if no file was specified) and report whether the checksums match the contents of the named files. The input to this mode is usually the output of a prior, checksum-generating run of the command.

Three input formats are supported. Either the default output format described above, the `--tag` output format, or the BSD reversed mode format which is similar to the default mode, but doesn’t use a character to distinguish binary and text modes.

For the `cksum` command, the `--check` option supports auto-detecting the digest algorithm to use, when presented with checksum information in the `--tag` output format.

Also for the `cksum` command, the `--check` option auto-detects the digest encoding, accepting both standard hexadecimal checksums and those generated via `cksum` with its `--base64` option.

Output with `--zero` enabled is not supported by `--check`.

For each such line, `cksum` reads the named file and computes its checksum. Then, if the computed message digest does not match the one on the line with the file name, the file is noted as having failed the test. Otherwise, the file passes the test. By default, for each valid line, one line is written to standard output indicating whether the named file passed the test. After all checks have been performed, if there were any failures, a warning is issued to standard error. Use the `--status` option to inhibit that output. If any listed file cannot be opened or read, if any valid line has a checksum inconsistent with the associated file, or if no valid line is found, `cksum` exits with nonzero status. Otherwise, it exits successfully. Note the `cksum` command doesn’t support `--check` with the older `sysv`, `bsd`, or `crc` algorithms.

`--ignore-missing`

This option is useful only when verifying checksums. When verifying checksums, don’t fail or report any status for missing files. This is useful when verifying a subset of downloaded files given a larger list of checksums.

`--quiet`

This option is useful only when verifying checksums. When verifying checksums, don’t generate an 'OK' message per successfully checked file. Files that fail the
verification are reported in the default one-line-per-file format. If there is any checksum mismatch, print a warning summarizing the failures to standard error.

`--status`

This option is useful only when verifying checksums. When verifying checksums, don’t generate the default one-line-per-file diagnostic and don’t output the warning summarizing any failures. Failures to open or read a file still evoke individual diagnostics to standard error. If all listed files are readable and are consistent with the associated checksums, exit successfully. Otherwise exit with a status code indicating there was a failure.

`--tag`

Output BSD style checksums, which indicate the checksum algorithm used. As a GNU extension, if `--zero` is not used, file names with problematic characters are escaped as described above, using the same escaping indicator of ‘\’ at the start of the line, as used with the other output format. The `--tag` option implies binary mode, and is disallowed with `--text` mode as supporting that would unnecessarily complicate the output format, while providing little benefit. See Section 6.3.1 [cksum output modes], page 43, for details of this format. The `cksum` command, uses `--tag` as its default output format.

`-t`

`--text`

Note this option is not supported by the `cksum` command. Treat each input file as text, by reading it in text mode and outputting a ‘ ’ flag. This is the inverse of `--binary`. This option is the default on systems like GNU that do not distinguish between binary and text files. On other systems, it is the default for reading standard input when standard input is a terminal. This mode is never defaulted to if `--tag` is used.

`-w`

`--warn`

When verifying checksums, warn about improperly formatted checksum lines. This option is useful only if all but a few lines in the checked input are valid.

`--strict`

When verifying checksums, if one or more input line is invalid, exit nonzero after all warnings have been issued.

`-z`

`--zero`

Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines. Also file name escaping is not used.

6.4 md5sum: Print or check MD5 digests

`md5sum` computes a 128-bit checksum (or fingerprint or message-digest) for each specified file.

Note: The MD5 digest is more reliable than a simple CRC (provided by the `cksum` command) for detecting accidental file corruption, as the chances of accidentally having two files with identical MD5 are vanishingly small. However, it should not be considered secure against malicious tampering: although finding a file with a given MD5 fingerprint is considered infeasible at the moment, it is known how to modify certain files, including
digital certificates, so that they appear valid when signed with an MD5 digest. For more secure hashes, consider using SHA-2, or the newer b2sum command. See Section 6.7 [sha2 utilities], page 48. See Section 6.5 [b2sum invocation], page 47.

If a file is specified as ‘-’ or if no files are given md5sum computes the checksum for the standard input. md5sum can also determine whether a file and checksum are consistent. Synopsis:

```
md5sum [option]... [file]...
```

md5sum uses the ‘Untagged output format’ for each specified file, as described at Section 6.3.1 [cksum output modes], page 43.

The program accepts Section 6.3.3 [cksum common options], page 45. Also see Chapter 2 [Common options], page 2.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 6.5 b2sum: Print or check BLAKE2 digests

b2sum computes a 512-bit checksum for each specified file.

If a file is specified as ‘-’ or if no files are given b2sum computes the checksum for the standard input. b2sum can also determine whether a file and checksum are consistent. Synopsis:

```
b2sum [option]... [file]...
```

b2sum uses the ‘Untagged output format’ for each specified file, as described at Section 6.3.1 [cksum output modes], page 43.

The program accepts Section 6.3.3 [cksum common options], page 45. Also see Chapter 2 [Common options], page 2.

In addition b2sum supports the following options.

‘-l’

‘--length’

Change (shorten) the default digest length. This is specified in bits and thus must be a multiple of 8. This option is ignored when --check is specified, as the length is automatically determined when checking.

### 6.6 sha1sum: Print or check SHA-1 digests

sha1sum computes a 160-bit checksum for each specified file.

Note: The SHA-1 digest is more reliable than a simple CRC (provided by the cksum command) for detecting accidental file corruption, as the chances of accidentally having two files with identical SHA-1 are vanishingly small. However, it should not be considered secure against malicious tampering: although finding a file with a given SHA-1 fingerprint is considered infeasible at the moment, it is known how to modify certain files, including digital certificates, so that they appear valid when signed with an SHA-1 digest. For more secure hashes, consider using SHA-2, or the newer b2sum command. See Section 6.7 [sha2 utilities], page 48. See Section 6.5 [b2sum invocation], page 47.
If a file is specified as ‘-’ or if no files are given sha1sum computes the checksum for the standard input. sha1sum can also determine whether a file and checksum are consistent. Synopsis:

```
sha1sum [option]... [file]...
```

sha1sum uses the ‘Untagged output format’ for each specified file, as described at Section 6.3.1 [cksum output modes], page 43.

The program accepts Section 6.3.3 [cksum common options], page 45. Also see Chapter 2 [Common options], page 2.

### 6.7 sha2 utilities: Print or check SHA-2 digests

The commands sha224sum, sha256sum, sha384sum and sha512sum compute checksums of various lengths (respectively 224, 256, 384 and 512 bits), collectively known as the SHA-2 hashes.

If a file is specified as ‘-’ or if no files are given sha???sum computes the checksum for the standard input. sha???sum can also determine whether a file and checksum are consistent. Synopsis:

```
sha???sum [option]... [file]...
```

sha???sum uses the ‘Untagged output format’ for each specified file, as described at Section 6.3.1 [cksum output modes], page 43.

The program accepts Section 6.3.3 [cksum common options], page 45. Also see Chapter 2 [Common options], page 2.
7 Operating on sorted files

These commands work with (or produce) sorted files.

7.1 sort: Sort text files

sort sorts, merges, or compares all the lines from the given files, or standard input if none are given or for a file of ‘-’. By default, sort writes the results to standard output. Synopsis:

    sort [option]... [file]...

Many options affect how sort compares lines; if the results are unexpected, try the --debug option to see what happened. A pair of lines is compared as follows: sort compares each pair of fields (see --key), in the order specified on the command line, according to the associated ordering options, until a difference is found or no fields are left. If no key fields are specified, sort uses a default key of the entire line. Finally, as a last resort when all keys compare equal, sort compares entire lines as if no ordering options other than --reverse (-r) were specified. The --stable (-s) option disables this last-resort comparison so that lines in which all fields compare equal are left in their original relative order. The --unique (-u) option also disables the last-sort comparison.

Unless otherwise specified, all comparisons use the character collating sequence specified by the LC_COLLATE locale. Grand Unified Newline is not part of the line for comparison purposes. If the final byte of an input file is not a newline, GNU sort silently supplies one. GNU sort (as specified for all GNU utilities) has no limit on input line length or restrictions on bytes allowed within lines.

sort has three modes of operation: sort (the default), merge, and check for order. The following options change the operation mode:

'--check'
'--check=diagnose-first'

Check whether the given file is already sorted: if it is not all sorted, print a diagnostic containing the first out-of-order line and exit with a status of 1. Otherwise, exit successfully. At most one input file can be given.

'--check=quiet'
'--check=silent'

Exit successfully if the given file is already sorted, and exit with status 1 otherwise. At most one input file can be given. This is like --check, except it does not print a diagnostic.

'--merge'

Merge the given files by sorting them as a group. Each input file must always be individually sorted. It always works to sort instead of merge; merging is provided because it is faster, in the case where it works.

1 If you use a non-POSIX locale (e.g., by setting LC_ALL to 'en_US'), then sort may produce output that is sorted differently than you're accustomed to. In that case, set the LC_COLLATE environment variable to 'C'. Note that setting only LC_COLLATE has two problems. First, it is ineffective if LC_ALL is also set. Second, it has undefined behavior if LC_CTYPE (or LANG, if LC_CTYPE is unset) is set to an incompatible value. For example, you get undefined behavior if LC_CTYPE is ja_JP.PCK but LC_COLLATE is en_US.UTF-8.
Exit status:
0 if no error occurred
1 if invoked with -c or -C and the input is not sorted
2 if an error occurred

If the environment variable TMPDIR is set, sort uses its value as the directory for temporary files instead of /tmp. The --temporary-directory (-T) option in turn overrides the environment variable.

The following options affect the ordering of output lines. They may be specified globally or as part of a specific key field. If no key fields are specified, global options apply to comparison of entire lines; otherwise the global options are inherited by key fields that do not specify any special options of their own. In pre-POSIX versions of sort, global options affect only later key fields, so portable shell scripts should specify global options first.

- `'-b'` 
  `--ignore-leading-blanks`
  Ignore leading blanks when finding sort keys in each line. By default a blank is a space or a tab, but the LC_CTYPE locale can change this. Note blanks may be ignored by your locale’s collating rules, but without this option they will be significant for character positions specified in keys with the -k option.

- `'-d'` 
  `--dictionary-order`
  Sort in phone directory order: ignore all characters except letters, digits and blanks when sorting. By default letters and digits are those of ASCII and a blank is a space or a tab, but the LC_CTYPE locale can change this.

- `'-f'` 
  `--ignore-case`
  Fold lowercase characters into the equivalent uppercase characters when comparing so that, for example, ‘b’ and ‘B’ sort as equal. The LC_CTYPE locale determines character types. When used with --unique those lower case equivalent lines are thrown away. (There is currently no way to throw away the upper case equivalent instead. (Any --reverse given would only affect the final result, after the throwing away.))

- `'-g'` 
  `--general-numeric-sort` 
  `--sort=general-numeric`
  Sort numerically, converting a prefix of each line to a long double-precision floating point number. See Section 2.12 [Floating point], page 10. Do not report overflow, underflow, or conversion errors. Use the following collating sequence:
  - Lines that do not start with numbers (all considered to be equal).
  - NaNs (“Not a Number” values, in IEEE floating point arithmetic) in a consistent but machine-dependent order.
  - Minus infinity.
  - Finite numbers in ascending numeric order (with –0 and +0 equal).
  - Plus infinity.
Use this option only if there is no alternative; it is much slower than 
\texttt{--numeric-sort (-n)} and it can lose information when converting to floating point.

You can use this option to sort hexadecimal numbers prefixed with `	exttt{0x}' or `	exttt{0X}', where those numbers are not fixed width, or of varying case. However for hex numbers of consistent case, and left padded with `0' to a consistent width, a standard lexicographic sort will be faster.

`-h'
\texttt{--human-numeric-sort}'
\texttt{--sort=human-numeric}'
Sort numerically, first by numeric sign (negative, zero, or positive); then by SI suffix (either empty, or `k' or `K', or one of `MGTEZYRQ', in that order; see Section 2.2 [Block size], page 3); and finally by numeric value. For example, `1023M' sorts before `1G' because `M' (mega) precedes `G' (giga) as an SI suffix. This option sorts values that are consistently scaled to the nearest suffix, regardless of whether suffixes denote powers of 1000 or 1024, and it therefore sorts the output of any single invocation of the \texttt{df}, \texttt{du}, or \texttt{ls} commands that are invoked with their \texttt{--human-readable} or \texttt{--si} options. The syntax for numbers is the same as for the \texttt{--numeric-sort} option; the SI suffix must immediately follow the number. Note also the \texttt{numfmt} command, which can be used to reformat numbers to human format after the sort, thus often allowing sort to operate on more accurate numbers.

`-i'
\texttt{--ignore-nonprinting}'
Ignore nonprinting characters. The \texttt{LC_CTYPE} locale determines character types. This option has no effect if the stronger \texttt{--dictionary-order (-d)} option is also given.

`-M'
\texttt{--month-sort}'
\texttt{--sort=month}'
An initial string, consisting of any amount of blanks, followed by a month name abbreviation, is folded to UPPER case and compared in the order `JAN' < `FEB' < \ldots < `DEC'. Invalid names compare low to valid names. The \texttt{LC_TIME} locale category determines the month spellings. By default a blank is a space or a tab, but the \texttt{LC_CTYPE} locale can change this.

`-n'
\texttt{--numeric-sort}'
\texttt{--sort=numeric}'
Sort numerically. The number begins each line and consists of optional blanks, an optional `-' sign, and zero or more digits possibly separated by thousands separators, optionally followed by a decimal-point character and zero or more digits. An empty number is treated as `0'. The \texttt{LC_NUMERIC} locale specifies the decimal-point character and thousands separator. By default a blank is a space or a tab, but the \texttt{LC_CTYPE} locale can change this.

Comparison is exact; there is no rounding error.
Neither a leading ‘+’ nor exponential notation is recognized. To compare such strings numerically, use the \texttt{--general-numeric-sort (-g)} option.

\texttt{--version-sort}

Sort by version name and number. It behaves like a standard sort, except that each sequence of decimal digits is treated numerically as an index/version number. (See Chapter 30 [Version sort ordering], page 250.)

\texttt{--reverse}

Reverse the result of comparison, so that lines with greater key values appear earlier in the output instead of later.

\texttt{--random-sort}

Sort by hashing the input keys and then sorting the hash values. Choose the hash function at random, ensuring that it is free of collisions so that differing keys have differing hash values. This is like a random permutation of the inputs (see Section 7.2 [shuf invocation], page 57), except that keys with the same value sort together.

If multiple random sort fields are specified, the same random hash function is used for all fields. To use different random hash functions for different fields, you can invoke \texttt{sort} more than once.

The choice of hash function is affected by the \texttt{--random-source} option.

Other options are:

\texttt{--compress-program=prog}

Compress any temporary files with the program \texttt{prog}.

With no arguments, \texttt{prog} must compress standard input to standard output, and when given the \texttt{-d} option it must decompress standard input to standard output.

Terminate with an error if \texttt{prog} exits with nonzero status.

White space and the backslash character should not appear in \texttt{prog}; they are reserved for future use.

\texttt{--files0-from=file}

Disallow processing files named on the command line, and instead process those named in file \texttt{file}; each name being terminated by a zero byte (ASCII NUL). This is useful when the list of file names is so long that it may exceed a command line length limitation. In such cases, running \texttt{sort} via \texttt{xargs} is undesirable because it splits the list into pieces and makes \texttt{sort} print sorted output for each sublist rather than for the entire list. One way to produce a list of ASCII NUL terminated file names is with GNU \texttt{find}, using its \texttt{-print0} predicate. If \texttt{file} is \texttt{`-'} then the ASCII NUL terminated file names are read from standard input.
Chapter 7: Operating on sorted files

\[-k \text{pos1[,\textpos2]}\]
\[---key=\text{pos1[,\textpos2]}\]

Specify a sort field that consists of the part of the line between pos1 and pos2 (or the end of the line, if pos2 is omitted), inclusive.

In its simplest form pos specifies a field number (starting with 1), with fields being separated by runs of blank characters, and by default those blanks being included in the comparison at the start of each field. To adjust the handling of blank characters see the -b and -t options.

More generally, each pos has the form \['f[.c][\text{opts}]'\], where \(f\) is the number of the field to use, and \(c\) is the number of the first character from the beginning of the field. Fields and character positions are numbered starting with 1; a character position of zero in pos2 indicates the field’s last character. If \('.c'\) is omitted from pos1, it defaults to 1 (the beginning of the field); if omitted from pos2, it defaults to 0 (the end of the field). opts are ordering options, allowing individual keys to be sorted according to different rules; see below for details.

Keys can span multiple fields.

Example: To sort on the second field, use \[---key=2,2 (\text{-k 2,2})\]. See below for more notes on keys and more examples. See also the \[---debug\] option to help determine the part of the line being used in the sort.

\[---debug\]

Highlight the portion of each line used for sorting. Also issue warnings about questionable usage to standard error.

\[---batch-size=nmerge\]

Merge at most nmerge inputs at once.

When sort has to merge more than nmerge inputs, it merges them in groups of nmerge, saving the result in a temporary file, which is then used as an input in a subsequent merge.

A large value of nmerge may improve merge performance and decrease temporary storage utilization at the expense of increased memory usage and I/O. Conversely a small value of nmerge may reduce memory requirements and I/O at the expense of temporary storage consumption and merge performance.

The value of nmerge must be at least 2. The default value is currently 16, but this is implementation-dependent and may change in the future.

The value of nmerge may be bounded by a resource limit for open file descriptors. The commands \[\text{'ulimit -n'} \text{or 'getconf OPEN_MAX'}\] may display limits for your systems; these limits may be modified further if your program already has some files open, or if the operating system has other limits on the number of open files. If the value of nmerge exceeds the resource limit, sort silently uses a smaller value.

\[-o \text{output-file}\]
\[---output=\text{output-file}\]

Write output to output-file instead of standard output. Normally, sort reads all input before opening output-file, so you can sort a file in place by using commands like \[\text{sort -o F F and cat F | sort -o F.}\] However, it is often safer to output to an otherwise-unused file, as data may be lost if the system crashes...
or `sort` encounters an I/O or other serious error while a file is being sorted in place. Also, `sort` with `--merge (-m)` can open the output file before reading all input, so a command like `cat F | sort -m -o F - G` is not safe as `sort` might start writing `F` before `cat` is done reading it.

On newer systems, `-o` cannot appear after an input file if `POSIXLY_CORRECT` is set, e.g., `sort F -o F`. Portable scripts should specify `-o output-file` before any input files.

`'--random-source=file'`
Use `file` as a source of random data used to determine which random hash function to use with the `-R` option. See Section 2.5 [Random sources], page 7.

`'--stable'`
Make `sort` stable by disabling its last-resort comparison. This option has no effect if no fields or global ordering options other than `--reverse (-r)` are specified.

`'--buffer-size=size'`
Use a main-memory sort buffer of the given `size`. By default, `size` is in units of 1024 bytes. Appending `%` causes `size` to be interpreted as a percentage of physical memory. Appending `K` multiplies `size` by 1024 (the default), `M` by 1,048,576, `G` by 1,073,741,824, and so on for `T`, `P`, `E`, `Z`, `Y`, `R`, and `Q`. Appending `b` causes `size` to be interpreted as a byte count, with no multiplication.

This option can improve the performance of `sort` by causing it to start with a larger or smaller sort buffer than the default. However, this option affects only the initial buffer size. The buffer grows beyond `size` if `sort` encounters input lines larger than `size`.

`'--field-separator=separator'`
Use character `separator` as the field separator when finding the sort keys in each line. By default, fields are separated by the empty string between a non-blank character and a blank character. By default a blank is a space or a tab, but the `LC_CTYPE` locale can change this.

That is, given the input line `foo bar`, `sort` breaks it into fields `foo` and `bar`. The field separator is not considered to be part of either the field preceding or the field following, so with `sort -t " "` the same input line has three fields: an empty field, `foo`, and `bar`. However, fields that extend to the end of the line, as `-k 2`, or fields consisting of a range, as `-k 2,3`, retain the field separators present between the endpoints of the range.

To specify ASCII NUL as the field separator, use the two-character string `\0'`, e.g., `sort -t '\0'`. 

Chapter 7: Operating on sorted files

'--tempdir'

Use directory tempdir to store temporary files, overriding the TMPDIR environment variable. If this option is given more than once, temporary files are stored in all the directories given. If you have a large sort or merge that is I/O-bound, you can often improve performance by using this option to specify directories on different file systems.

'--parallel=n'

Set the number of sorts run in parallel to n. By default, n is set to the number of available processors, but limited to 8, as there are diminishing performance gains after that. Note also that using n threads increases the memory usage by a factor of log n. Also see Section 21.3 [nproc invocation], page 200.

'--unique'

Normally, output only the first of a sequence of lines that compare equal. For the --check (-c or -C) option, check that no pair of consecutive lines compares equal.

This option also disables the default last-resort comparison.

The commands sort -u and sort | uniq are equivalent, but this equivalence does not extend to arbitrary sort options. For example, sort -n -u inspects only the value of the initial numeric string when checking for uniqueness, whereas sort -n | uniq inspects the entire line. See Section 7.3 [uniq invocation], page 59.

'--zero-terminated'

Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with 'perl -0' or 'find -print0' and 'xargs -0' which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters).

Historical (BSD and System V) implementations of sort have differed in their interpretation of some options, particularly -b, -f, and -n. GNU sort follows the POSIX behavior, which is usually (but not always!) like the System V behavior. According to POSIX, -n no longer implies -b. For consistency, -M has been changed in the same way. This may affect the meaning of character positions in field specifications in obscure cases. The only fix is to add an explicit -b.

A position in a sort field specified with -k may have any of the option letters ‘MbdghinRrV’ appended to it, in which case no global ordering options are inherited by that particular field. The -b option may be independently attached to either or both of the start and end positions of a field specification, and if it is inherited from the global options it will be attached to both. If input lines can contain leading or adjacent blanks and -t is not used, then -k is typically combined with -b or an option that implicitly ignores leading blanks (‘Mghn’) as otherwise the varying numbers of leading blanks in fields can cause confusing results.
If the start position in a sort field specifier falls after the end of the line or after the end field, the field is empty. If the -b option was specified, the ‘.c’ part of a field specification is counted from the first nonblank character of the field.

On systems not conforming to POSIX 1003.1-2001, sort supports a traditional origin-zero syntax ‘pos1 [-pos2]’ for specifying sort keys. The traditional command ‘sort +a.x -b.y’ is equivalent to ‘sort -k a+1.x+1,b’ if y is ‘0’ or absent, otherwise it is equivalent to ‘sort -k a+1.x+1,b+1.y’.

This traditional behavior can be controlled with the _POSIX2_VERSION environment variable (see Section 2.13 [Standards conformance], page 11); it can also be enabled when POSIXLY_CORRECT is not set by using the traditional syntax with ‘-pos2’ present.

Scripts intended for use on standard hosts should avoid traditional syntax and should use -k instead. For example, avoid ‘sort +2’, since it might be interpreted as either ‘sort ./+2’ or ‘sort -k 3’. If your script must also run on hosts that support only the traditional syntax, it can use a test like ‘if sort -k 1 </dev/null >/dev/null 2>&1; then ...’ to decide which syntax to use.

Here are some examples to illustrate various combinations of options.

- Sort in descending (reverse) numeric order.
  
  ```
  sort -n -r
  ```

- Run no more than 4 sorts concurrently, using a buffer size of 10M.
  
  ```
  sort --parallel=4 -S 10M
  ```

- Sort alphabetically, omitting the first and second fields and the blanks at the start of the third field. This uses a single key composed of the characters beginning at the start of the first nonblank character in field three and extending to the end of each line.
  
  ```
  sort -k 3b
  ```

- Sort numerically on the second field and resolve ties by sorting alphabetically on the third and fourth characters of field five. Use ‘:’ as the field delimiter.
  
  ```
  sort -t : -k 2,2n -k 5.3,5.4
  ```

  Note that if you had written -k 2n instead of -k 2,2n sort would have used all characters beginning in the second field and extending to the end of the line as the primary numeric key. For the large majority of applications, treating keys spanning more than one field as numeric will not do what you expect.

  Also note that the ‘n’ modifier was applied to the field-end specifier for the first key. It would have been equivalent to specify -k 2n,2 or -k 2n,2n. All modifiers except ‘b’ apply to the associated field, regardless of whether the modifier character is attached to the field-start and/or the field-end part of the key specifier.

- Sort the password file on the fifth field and ignore any leading blanks. Sort lines with equal values in field five on the numeric user ID in field three. Fields are separated by ‘:’.
  
  ```
  sort -t : -k 5b,5 -k 3,3n /etc/passwd
  sort -t : -n -k 5b,5 -k 3,3 /etc/passwd
  sort -t : -b -k 5,5 -k 3,3n /etc/passwd
  ```

  These three commands have equivalent effect. The first specifies that the first key’s start position ignores leading blanks and the second key is sorted numerically. The other
two commands rely on global options being inherited by sort keys that lack modifiers. The inheritance works in this case because `-k 5b,5b` and `-k 5b,5` are equivalent, as the location of a field-end lacking a `'.c'` character position is not affected by whether initial blanks are skipped.

- Sort a set of log files, primarily by IPv4 address and secondarily by timestamp. If two lines’ primary and secondary keys are identical, output the lines in the same order that they were input. The log files contain lines that look like this:

  4.150.156.3 - - [01/Apr/2020:06:31:51 +0000] message 1
  211.24.3.231 - - [24/Apr/2020:20:17:39 +0000] message 2

  Fields are separated by exactly one space. Sort IPv4 addresses lexicographically, e.g., 212.61.52.2 sorts before 212.129.233.201 because 61 is less than 129.

  `sort -s -t ' ' -k 4.9n -k 4.5M -k 4.2n -k 4.14,4.21 file*.log |
  sort -s -t '.' -k 1,1n -k 2,2n -k 3,3n -k 4,4n`

  This example cannot be done with a single POSIX `sort` invocation, since IPv4 address components are separated by `'. '` while dates come just after a space. So it is broken down into two invocations of `sort`: the first sorts by timestamp and the second by IPv4 address. The timestamp is sorted by year, then month, then day, and finally by hour-minute-second field, using `-k` to isolate each field. Except for hour-minute-second there’s no need to specify the end of each key field, since the `‘n’` and `‘M’` modifiers sort based on leading prefixes that cannot cross field boundaries. The IPv4 addresses are sorted lexicographically. The second sort uses `‘-s’` so that ties in the primary key are broken by the secondary key; the first sort uses `‘-s’` so that the combination of the two sorts is stable. Note as a GNU extension, the above example could be achieved in a single `sort` invocation by sorting the IPv4 address field using a `‘V’` version type, like `‘-k1,1V’`.

- Generate a tags file in case-insensitive sorted order.

  `find src -type f -print0 | sort -z -f | xargs -0 etags --append`

  The use of `-print0`, `-z`, and `-0` in this case means that file names that contain blanks or other special characters are not broken up by the sort operation.

- Use the common DSU, Decorate Sort Undecorate idiom to sort lines according to their length.

  `awk '{print length, $0}' /etc/passwd | sort -n | cut -f2- -d' '`

  In general this technique can be used to sort data that the `sort` command does not support, or is inefficient at, sorting directly.

- Shuffle a list of directories, but preserve the order of files within each directory. For instance, one could use this to generate a music playlist in which albums are shuffled but the songs of each album are played in order.

  `ls */* | sort -t / -k 1,1R -k 2,2`

### 7.2 shuf: Shuffling text

`shuf` shuffles its input by outputting a random permutation of its input lines. Each output permutation is equally likely. Synopses:

```
shuf [option]... [file]
```
shuf -e [option]...
shuf -i lo-hi [option]...

shuf has three modes of operation that affect where it obtains its input lines. By default, it reads lines from standard input. The following options change the operation mode:

`-e`  
Treat each command-line operand as an input line.

`-i lo-hi`  
Act as if input came from a file containing the range of unsigned decimal integers $lo \ldots hi$, one per line.

`-n count`  
Output at most $count$ lines. By default, all input lines are output.

`-o output-file`  
Write output to $output-file$ instead of standard output. shuf reads all input before opening $output-file$, so you can safely shuffle a file in place by using commands like `shuf -o F <F` and `cat F | shuf -o F`.

`--random-source=file`  
Use $file$ as a source of random data used to determine which permutation to generate. See Section 2.5 [Random sources], page 7.

`-r`  
Repeat output values, that is, select with replacement. With this option the output is not a permutation of the input; instead, each output line is randomly chosen from all the inputs. This option is typically combined with `--head-count`; if `--head-count` is not given, shuf repeats indefinitely.

`-z`  
Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with `perl -0` or `find -print0` and `xargs -0` which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters).

For example:

```
shuf <<EOF
A man,
a plan,
a canal:
Panama!
EOF
```
might produce the output

Panama!
A man,
a canal:
a plan,

Similarly, the command:

```
shuf -e clubs hearts diamonds spades
```

might output:

```
clubs
diamonds
spades
hearts
```

and the command `shuf -i 1-4` might output:

```
4
2
1
3
```

The above examples all have four input lines, so `shuf` might produce any of the twenty-four possible permutations of the input. In general, if there are \( n \) input lines, there are \( n! \) (i.e., \( n \) factorial, or \( n \times (n - 1) \times \ldots \times 1 \)) possible output permutations.

To output 50 random numbers each in the range 0 through 9, use:

```
shuf -r -n 50 -i 0-9
```

To simulate 100 coin flips, use:

```
shuf -r -n 100 -e Head Tail
```

An exit status of zero indicates success, and a nonzero value indicates failure.

### 7.3 uniq: Uniquify files

`uniq` writes the unique lines in the given `input`, or standard input if nothing is given or for an `input` name of `-'`.

**Synopsis:**

```
uniq [option]... [input [output]]
```

By default, `uniq` prints its input lines, except that it discards all but the first of adjacent repeated lines, so that no output lines are repeated. Optionally, it can instead discard lines that are not repeated, or all repeated lines.

The input need not be sorted, but repeated input lines are detected only if they are adjacent. If you want to discard non-adjacent duplicate lines, perhaps you want to use `sort -u`. See Section 7.1 [sort invocation], page 49.

Comparisons honor the rules specified by the `LC_COLLATE` locale category.

If no `output` file is specified, `uniq` writes to standard output.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`'-f n'`

Skip \( n \) fields on each line before checking for uniqueness. Use a null string for comparison if a line has fewer than \( n \) fields. Fields are a sequence of blank
characters followed by non-blank characters. Field numbers are one based, i.e.,
-f 1 will skip the first field (which may optionally have leading blanks).
For compatibility uniq supports a traditional option syntax -n. New scripts
should use -f n instead.

'-s n'
'--skip-chars=n'
Skip n characters before checking for uniqueness. Use a null string for comparison
if a line has fewer than n characters. If you use both the field and character
skipping options, fields are skipped over first.
On systems not conforming to POSIX 1003.1-2001, uniq supports a traditional
option syntax +n. Although this traditional behavior can be controlled with
the _POSIX2_VERSION environment variable (see Section 2.13 [Standards con-
formance], page 11), portable scripts should avoid commands whose behavior
depends on this variable. For example, use ‘uniq ./+10’ or ‘uniq -s 10’ rather
than the ambiguous ‘uniq +10’.

'-c'
'--count'
Print the number of times each line occurred along with the line.

'-i'
'--ignore-case'
Ignore differences in case when comparing lines.

'-d'
'--repeated'
Discard lines that are not repeated. When used by itself, this option causes
uniq to print the first copy of each repeated line, and nothing else.

'-D'
'--all-repeated[=delimit-method]'
Do not discard the second and subsequent repeated input lines, but discard lines
that are not repeated. This option is useful mainly in conjunction with other
options e.g., to ignore case or to compare only selected fields. The optional
delimit-method, supported with the long form option, specifies how to delimit
groups of repeated lines, and must be one of the following:

'none' Do not delimit groups of repeated lines. This is equivalent to
--all-repeated (-D).

'prepend' Output a newline before each group of repeated lines. With
--zero-terminated (-z), use a zero byte (ASCII NUL) instead of
a newline as the delimiter.

'separate' Separate groups of repeated lines with a single newline. This is the
same as using 'prepend', except that no delimiter is inserted before
the first group, and hence may be better suited for output direct
to users. With --zero-terminated (-z), use a zero byte (ASCII
NUL) instead of a newline as the delimiter.
Note that when groups are delimited and the input stream contains blank lines, then the output is ambiguous. To avoid that, filter the input through `tr -s '\n'` to remove blank lines. This is a GNU extension.

`--group[=delimit-method]`

Output all lines, and delimit each unique group. With `--zero-terminated` (-z), use a zero byte (ASCII NUL) instead of a newline as the delimiter. The optional `delimit-method` specifies how to delimit groups, and must be one of the following:

- **`separate`**
  Separate unique groups with a single delimiter. This is the default delimiting method if none is specified, and better suited for output direct to users.

- **`prepend`**
  Output a delimiter before each group of unique items.

- **`append`**
  Output a delimiter after each group of unique items.

- **`both`**
  Output a delimiter around each group of unique items.

Note that when groups are delimited and the input stream contains blank lines, then the output is ambiguous. To avoid that, filter the input through `tr -s '\n'` to remove blank lines. This is a GNU extension.

`-u`

`--unique`

Discard the last line that would be output for a repeated input group. When used by itself, this option causes `uniq` to print unique lines, and nothing else.

`-w n`

`--check-chars=n`

Compare at most `n` characters on each line (after skipping any specified fields and characters). By default the entire rest of the lines are compared.

`-z`

`--zero-terminated`

Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with `perl -0` or `find -print0` and `xargs -0` which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters). Note with `-z` the newline character is treated as a field separator.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 7.4 comm: Compare two sorted files line by line

`comm` writes to standard output lines that are common, and lines that are unique, to two input files; a file name of `-' means standard input. Synopsis:

```
    comm [option]... file1 file2
```

Before `comm` can be used, the input files must be sorted using the collating sequence specified by the `LC_COLLATE` locale. If an input file ends in a non-newline character, a
newline is silently appended. The `sort` command with no options always outputs a file that is suitable input to `comm`.

With no options, `comm` produces three-column output. Column one contains lines unique to `file1`, column two contains lines unique to `file2`, and column three contains lines common to both files. Columns are separated by a single TAB character.

The options `-1`, `-2`, and `-3` suppress printing of the corresponding columns (and separators). Also see Chapter 2 [Common options], page 2.

Unlike some other comparison utilities, `comm` has an exit status that does not depend on the result of the comparison. Upon normal completion `comm` produces an exit code of zero. If there is an error it exits with nonzero status.

If the `--check-order` option is given, unsorted inputs will cause a fatal error message. If the option `--nocheck-order` is given, unsorted inputs will never cause an error message. If neither of these options is given, wrongly sorted inputs are diagnosed only if an input file is found to contain unpairable lines. If an input file is diagnosed as being unsorted, the `comm` command will exit with a nonzero status (and the output should not be used).

Forcing `comm` to process wrongly sorted input files containing unpairable lines by specifying `--nocheck-order` is not guaranteed to produce any particular output. The output will probably not correspond with whatever you hoped it would be.

`'--check-order'`
Fail with an error message if either input file is wrongly ordered.

`'--nocheck-order'`
Do not check that both input files are in sorted order.

Other options are:

`'--output-delimiter=str'`
Print `str` between adjacent output columns, rather than the default of a single TAB character.

The delimiter `str` may be empty, in which case the ASCII NUL character is used to delimit output columns.

`'--total'` Output a summary at the end.

Similar to the regular output, column one contains the total number of lines unique to `file1`, column two contains the total number of lines unique to `file2`, and column three contains the total number of lines common to both files, followed by the word `‘total’` in the additional column four.

In the following example, `comm` omits the regular output (-123), thus just printing the summary:

```
$ printf '%s\n' a b c d e > file1
$ printf '%s\n' b c d e f g > file2
$ comm --total -123 file1 file2
1 2 4 total
```

This option is a GNU extension. Portable scripts should use `wc` to get the totals, e.g. for the above example files:

```
$ comm -23 file1 file2 | wc -l # number of lines only in file1
```
$ comm -13 file1 file2 | wc -l # number of lines only in file2
$ comm -12 file1 file2 | wc -l # number of lines common to both files

`-z`
`--zero-terminated`
Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with `perl -0` or `find -print0` and `xargs -0` which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters).

7.5 ptx: Produce permuted indexes

ptx reads a text file and essentially produces a permuted index, with each keyword in its context. The calling sketch is either one of:

```
ptx [option ...] [file ...]
ptx -G [option ...] [input [output]]
```

The `-G` (or its equivalent: `--traditional`) option disables all GNU extensions and reverts to traditional mode, thus introducing some limitations and changing several of the program’s default option values. When `-G` is not specified, GNU extensions are always enabled. GNU extensions to ptx are documented wherever appropriate in this document. See Section 7.5.5 [Compatibility in ptx], page 68, for the full list.

Individual options are explained in the following sections.

When GNU extensions are enabled, there may be zero, one or several files after the options. If there is no file, the program reads the standard input. If there is one or several files, they give the name of input files which are all read in turn, as if all the input files were concatenated. However, there is a full contextual break between each file and, when automatic referencing is requested, file names and line numbers refer to individual text input files. In all cases, the program outputs the permuted index to the standard output.

When GNU extensions are not enabled, that is, when the program operates in traditional mode, there may be zero, one or two parameters besides the options. If there are no parameters, the program reads the standard input and outputs the permuted index to the standard output. If there is only one parameter, it names the text input to be read instead of the standard input. If two parameters are given, they give respectively the name of the input file to read and the name of the output file to produce. Be very careful to note that, in this case, the contents of file given by the second parameter is destroyed. This behavior is dictated by System V ptx compatibility; GNU Standards normally discourage output parameters not introduced by an option.

Note that for any file named as the value of an option or as an input text file, a single dash `-' may be used, in which case standard input is assumed. However, it would not make sense to use this convention more than once per program invocation.
7.5.1 General options

`-G`
`--traditional`
As already explained, this option disables all GNU extensions to `ptx` and switches
to traditional mode.

`--help`
Print a short help on standard output, then exit without further processing.

`--version`
Print the program version on standard output, then exit without further pro-
cessing.

An exit status of zero indicates success, and a nonzero value indicates failure.

7.5.2 Charset selection

As it is set up now, `ptx` assumes that the input file is coded using 8-bit characters, and it
may not work well in multibyte locales. In a single-byte locale, the default regular expression
for a keyword allows foreign or diacriticized letters. Keyword sorting, however, is still crude;
it obeys the underlying character set ordering quite blindly.

The output of `ptx` assumes the locale’s character encoding. For example, with `ptx`’s
-T option, if the locale uses the Latin-1 encoding you may need a LaTeX directive like
`
\usepackage[latin1]{inputenc}`
to render non-ASCII characters correctly.

`-f`
`--ignore-case`
Fold lower case letters to upper case for sorting.

7.5.3 Word selection and input processing

`-b file`
`--break-file=file`
This option provides an alternative (to -W) method of describing which characters
make up words. It introduces the name of a file which contains a list of characters
which cannot be part of one word; this file is called the Break file. Any character
which is not part of the Break file is a word constituent. If both options -b and
-W are specified, then -W has precedence and -b is ignored.

When GNU extensions are enabled, the only way to avoid newline as a break
character is to write all the break characters in the file with no newline at all,
not even at the end of the file. When GNU extensions are disabled, spaces, tabs
and newlines are always considered as break characters even if not included in
the Break file.

`-i file`
`--ignore-file=file`
The file associated with this option contains a list of words which will never be
taken as keywords in concordance output. It is called the Ignore file. The file
contains exactly one word in each line; the end of line separation of words is not
subject to the value of the -S option.
-o file
--only-file=file

The file associated with this option contains a list of words which will be retained in concordance output; any word not mentioned in this file is ignored. The file is called the Only file. The file contains exactly one word in each line; the end of line separation of words is not subject to the value of the -S option.

There is no default for the Only file. When both an Only file and an Ignore file are specified, a word is considered a keyword only if it is listed in the Only file and not in the Ignore file.

-r
--references

On each input line, the leading sequence of non-white space characters will be taken to be a reference that has the purpose of identifying this input line in the resulting permuted index. See Section 7.5.4 [Output formatting in ptx], page 66, for more information about reference production. Using this option changes the default value for option -S.

Using this option, the program does not try very hard to remove references from contexts in output, but it succeeds in doing so when the context ends exactly at the newline. If option -r is used with -S default value, or when GNU extensions are disabled, this condition is always met and references are completely excluded from the output contexts.

-S regexp
--sentence-regexp=regexp

This option selects which regular expression will describe the end of a line or the end of a sentence. In fact, this regular expression is not the only distinction between end of lines or end of sentences, and input line boundaries have no special significance outside this option. By default, when GNU extensions are enabled and if -r option is not used, end of sentences are used. In this case, this regex is imported from GNU Emacs:

```
[.?!][]"\')]*\($\|\t\|\n\]|\t\n]*
```

Whenever GNU extensions are disabled or if -r option is used, end of lines are used; in this case, the default regexp is just:

```
\n
```

Using an empty regexp is equivalent to completely disabling end of line or end of sentence recognition. In this case, the whole file is considered to be a single big line or sentence. The user might want to disallow all truncation flag generation as well, through option -F "". See Section “Syntax of Regular Expressions” in The GNU Emacs Manual.

When the keywords happen to be near the beginning of the input line or sentence, this often creates an unused area at the beginning of the output context line; when the keywords happen to be near the end of the input line or sentence, this often creates an unused area at the end of the output context line. The program tries to fill those unused areas by wrapping around context in them; the tail of the input line or sentence is used to fill the unused area on the left of the output.
line; the head of the input line or sentence is used to fill the unused area on the right of the output line.

As a matter of convenience to the user, many usual backslashed escape sequences from the C language are recognized and converted to the corresponding characters by ptx itself.

\texttt{-w \texttt{regexp}}
\texttt{--word-regexp=\texttt{regexp}}

This option selects which regular expression will describe each keyword. By default, if GNU extensions are enabled, a word is a sequence of letters; the \texttt{regexp} used is \texttt{\textquoteleft w\textquoteleft}. When GNU extensions are disabled, a word is by default anything which ends with a space, a tab or a newline; the \texttt{regexp} used is \texttt{\textquoteleft[^t\n]\textquoteleft}. An empty \texttt{regexp} is equivalent to not using this option. See Section “Syntax of Regular Expressions” in \textit{The GNU Emacs Manual}.

As a matter of convenience to the user, many usual backslashed escape sequences, as found in the C language, are recognized and converted to the corresponding characters by ptx itself.

### 7.5.4 Output formatting

Output format is mainly controlled by the \texttt{-O} and \texttt{-T} options described in the table below. When neither \texttt{-O} nor \texttt{-T} are selected, and if GNU extensions are enabled, the program chooses an output format suitable for a dumb terminal. Each keyword occurrence is output to the center of one line, surrounded by its left and right contexts. Each field is properly justified, so the concordance output can be readily observed. As a special feature, if automatic references are selected by option \texttt{-A} and are output before the left context, that is, if option \texttt{-R} is \textit{not} selected, then a colon is added after the reference; this nicely interfaces with GNU Emacs \texttt{next-error} processing. In this default output format, each white space character, like newline and tab, is merely changed to exactly one space, with no special attempt to compress consecutive spaces. This might change in the future. Except for those white space characters, every other character of the underlying set of 256 characters is transmitted verbatim.

Output format is further controlled by the following options.

\texttt{-g \texttt{number}}
\texttt{--gap-size=\texttt{number}}

Select the size of the minimum white space gap between the fields on the output line.

\texttt{-w \texttt{number}}
\texttt{--width=\texttt{number}}

Select the maximum output width of each final line. If references are used, they are included or excluded from the maximum output width depending on the value of option \texttt{-R}. If this option is not selected, that is, when references are output before the left context, the maximum output width takes into account the maximum length of all references. If this option is selected, that is, when references are output after the right context, the maximum output width does
not take into account the space taken by references, nor the gap that precedes them.

`-A`

`--auto-reference`
Select automatic references. Each input line will have an automatic reference made up of the file name and the line ordinal, with a single colon between them. However, the file name will be empty when standard input is being read. If both `-A` and `-r` are selected, then the input reference is still read and skipped, but the automatic reference is used at output time, overriding the input reference.

`-R`

`--right-side-refs`
In the default output format, when option `-R` is not used, any references produced by the effect of options `-r` or `-A` are placed to the far right of output lines, after the right context. With default output format, when the `-R` option is specified, references are rather placed at the beginning of each output line, before the left context. For any other output format, option `-R` is ignored, with one exception: with `-R` the width of references is not taken into account in total output width given by `-w`.

This option is automatically selected whenever GNU extensions are disabled.

`-F string`

`--flag-truncation=string`
This option will request that any truncation in the output be reported using the string `string`. Most output fields theoretically extend towards the beginning or the end of the current line, or current sentence, as selected with option `-S`. But there is a maximum allowed output line width, changeable through option `-w`, which is further divided into space for various output fields. When a field has to be truncated because it cannot extend beyond the beginning or the end of the current line to fit in, then a truncation occurs. By default, the string used is a single slash, as in `-F /`.

`string` may have more than one character, as in `-F ...`. Also, in the particular case when `string` is empty (`-F `""`), truncation flagging is disabled, and no truncation marks are appended in this case.

As a matter of convenience to the user, many usual backslashed escape sequences, as found in the C language, are recognized and converted to the corresponding characters by `ptx` itself.

`-M string`

`--macro-name=string`
Select another `string` to be used instead of `xx`, while generating output suitable for nroff, troff or TeX.

`-O`

`--format=roff`
Choose an output format suitable for nroff or troff processing. Each output line will look like:

```
.xx "tail" "before" "keyword_and_after" "head" "ref"
```
so it will be possible to write a '.xx' roff macro to take care of the output typesetting. This is the default output format when GNU extensions are disabled. Option -M can be used to change 'xx' to another macro name.

In this output format, each non-graphical character, like newline and tab, is merely changed to exactly one space, with no special attempt to compress consecutive spaces. Each quote character " is doubled so it will be correctly processed by nroff ortroff.

'T'  
'--format= tex'  
Choose an output format suitable for TeX processing. Each output line will look like:

\xx {tail} {before} {keyword} {after} {head} {ref}  
so it will be possible to write a \xx definition to take care of the output typesetting. Note that when references are not being produced, that is, neither option -A nor option -r is selected, the last parameter of each \xx call is inhibited. Option -M can be used to change 'xx' to another macro name.

In this output format, some special characters, like $, %, &, # and _ are automatically protected with a backslash. Curly brackets {' ' , '}' are protected with a backslash and a pair of dollar signs (to force mathematical mode). The backslash itself produces the sequence \{backslash\}. Circumflex and tilde diacritical marks produce the sequence ^\{ } and ~\{ } respectively. Other diacriticized characters of the underlying character set produce an appropriate TeX sequence as far as possible. The other non-graphical characters, like newline and tab, and all other characters which are not part of ASCII, are merely changed to exactly one space, with no special attempt to compress consecutive spaces. Let me know how to improve this special character processing for TeX.

7.5.5 The GNU extensions to ptx

This version of ptx contains a few features which do not exist in System V ptx. These extra features are suppressed by using the -G command line option, unless overridden by other command line options. Some GNU extensions cannot be recovered by overriding, so the simple rule is to avoid -G if you care about GNU extensions. Here are the differences between this program and System V ptx.

- This program can read many input files at once, it always writes the resulting concordance on standard output. On the other hand, System V ptx reads only one file and sends the result to standard output or, if a second file parameter is given on the command, to that file.

Having output parameters not introduced by options is a dangerous practice which GNU avoids as far as possible. So, for using ptx portably between GNU and System V, you should always use it with a single input file, and always expect the result on standard output. You might also want to automatically configure in a -G option to ptx calls in products using ptx, if the configurator finds that the installed ptx accepts -G.

- The only options available in System V ptx are options -b, -f, -g, -i, -o, -r, -t and -w. All other options are GNU extensions and are not repeated in this enumeration.
Moreover, some options have a slightly different meaning when GNU extensions are enabled, as explained below.

- By default, concordance output is not formatted for *troff* or *nroff*. It is rather formatted for a dumb terminal. *troff* or *nroff* output may still be selected through option `-O`.

- Unless `-R` option is used, the maximum reference width is subtracted from the total output line width. With GNU extensions disabled, width of references is not taken into account in the output line width computations.

- All 256 bytes, even ASCII NUL bytes, are always read and processed from input file with no adverse effect, even if GNU extensions are disabled. However, System V *ptx* does not accept 8-bit characters, a few control characters are rejected, and the tilde `~` is also rejected.

- Input line length is only limited by available memory, even if GNU extensions are disabled. However, System V *ptx* processes only the first 200 characters in each line.

- The break (non-word) characters default to be every character except all letters of the underlying character set, diacriticized or not. When GNU extensions are disabled, the break characters default to space, tab and newline only.

- The program makes better use of output line width. If GNU extensions are disabled, the program rather tries to imitate System V *ptx*, but still, there are some slight disposition glitches this program does not completely reproduce.

- The user can specify both an Ignore file and an Only file. This is not allowed with System V *ptx*.

### 7.6 tsort: Topological sort

tsort performs a topological sort on the given file, or standard input if no input file is given or for a file of `~`. For more details and some history, see Section 7.6.1 [tsort background], page 71. Synopsis:

```
    tsort [option] [file]
```

*tsort* reads its input as pairs of strings, separated by blanks, indicating a partial ordering. The output is a total ordering that corresponds to the given partial ordering.

For example:

```
    tsort <<EOF
    a b c
d
e f
b c d e
EOF
```

will produce the output

```
a
b
c
d
e
```
Consider a more realistic example. You have a large set of functions all in one file, and they may all be declared static except one. Currently that one (say main) is the first function defined in the file, and the ones it calls directly follow it, followed by those they call, etc. Let’s say that you are determined to take advantage of prototypes, so you have to choose between declaring all of those functions (which means duplicating a lot of information from the definitions) and rearranging the functions so that as many as possible are defined before they are used. One way to automate the latter process is to get a list for each function of the functions it calls directly. Many programs can generate such lists. They describe a call graph. Consider the following list, in which a given line indicates that the function on the left calls the one on the right directly.

```
main parse_options
main tail_file
main tail_forever
tail_file pretty_name
tail_file write_header
tail_file tail
tail_forever recheck
tail_forever pretty_name
tail_forever write_header
tail_forever dump_remainder
tail tail_lines
tail tail_bytes
tail_lines start_lines
tail_lines dump_remainder
tail_lines file_lines
tail_lines pipe_lines
tail_bytes xlseek
tail_bytes start_bytes
tail_bytes dump_remainder
tail_bytes pipe_bytes
file_lines dump_remainder
recheck pretty_name
```

then you can use tsort to produce an ordering of those functions that satisfies your requirement.

```
example$ tsort call-graph | tac
dump_remainder
start_lines
file_lines
pipe_lines
xlseek
start_bytes
pipe_bytes
tail_lines
tail_bytes
pretty_name
```
7.6.1 tsort: Background

tsort exists because very early versions of the Unix linker processed an archive file exactly once, and in order. As ld read each object in the archive, it decided whether it was needed in the program based on whether it defined any symbols which were undefined at that point in the link.

This meant that dependencies within the archive had to be handled specially. For example, scanf probably calls read. That means that in a single pass through an archive, it was important for scanf.o to appear before read.o, because otherwise a program which calls scanf but not read might end up with an unexpected unresolved reference to read.

The way to address this problem was to first generate a set of dependencies of one object file on another. This was done by a shell script called lorder. The GNU tools don’t provide a version of lorder, as far as I know, but you can still find it in BSD distributions.

Then you ran tsort over the lorder output, and you used the resulting sort to define the order in which you added objects to the archive.

This whole procedure has been obsolete since about 1980, because Unix archives now contain a symbol table (traditionally built by ranlib, now generally built by ar itself), and the Unix linker uses the symbol table to effectively make multiple passes over an archive file.

Anyway, that’s where tsort came from. To solve an old problem with the way the linker handled archive files, which has since been solved in different ways.
8 Operating on fields

8.1 cut: Print selected parts of lines

cut writes to standard output selected parts of each line of each input file, or standard input if no files are given or for a file name of ‘-‘. Synopsis:

```
cut option... [file]...
```

In the table which follows, the `byte-list`, `character-list`, and `field-list` are one or more numbers or ranges (two numbers separated by a dash) separated by commas. Bytes, characters, and fields are numbered starting at 1. Incomplete ranges may be given: `-m` means `1-`m`; `n-` means `n` through end of line or last field. The list elements can be repeated, can overlap, and can be specified in any order; but the selected input is written in the same order that it is read, and is written exactly once.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-b byte-list`
`--bytes=byte-list`
Select for printing only the bytes in positions listed in `byte-list`. Tabs and backspaces are treated like any other character; they take up 1 byte. If an output delimiter is specified, (see the description of `--output-delimiter`), then output that string between ranges of selected bytes.

`-c character-list`
`--characters=character-list`
Select for printing only the characters in positions listed in `character-list`. The same as `-b` for now, but internationalization will change that. Tabs and backspaces are treated like any other character; they take up 1 character. If an output delimiter is specified, (see the description of `--output-delimiter`), then output that string between ranges of selected bytes.

`-f field-list`
`--fields=field-list`
Select for printing only the fields listed in `field-list`. Fields are separated by a TAB character by default. Also print any line that contains no delimiter character, unless the `--only-delimited` (`-s`) option is specified.

Note `awk` supports more sophisticated field processing, like reordering fields, and handling fields aligned with blank characters. By default `awk` uses (and discards) runs of blank characters to separate fields, and ignores leading and trailing blanks.

```
awk '{print $2}'     # print the second field
awk '{print $(NF-1)}' # print the penultimate field
awk '{print $2,$1}'  # reorder the first two fields
```

Note while `cut` accepts field specifications in arbitrary order, output is always in the order encountered in the file.

In the unlikely event that `awk` is unavailable, one can use the `join` command, to process blank characters as `awk` does above.

```
join -al -o 1.2 - /dev/null # print the second field
```
### Chapter 8: Operating on fields

Join the first two fields:

```
join -a1 -o 1.2,1.1 - /dev/null  # reorder the first two fields
```

- `-d input_delim_byte`
- `--delimiter=input_delim_byte`

With `-f`, use the first byte of `input_delim_byte` as the input fields separator (default is TAB).

- `-n`
  Do not split multi-byte characters (no-op for now).

- `-s`
- `--only-delimited`

For `-f`, do not print lines that do not contain the field separator character. Normally, any line without a field separator is printed verbatim.

- `--output-delimiter=output_delim_string`

With `-f`, output fields are separated by `output_delim_string`. The default with `-f` is to use the input delimiter. When using `-b` or `-c` to select ranges of byte or character offsets (as opposed to ranges of fields), output `output_delim_string` between non-overlapping ranges of selected bytes.

- `--complement`

This option is a GNU extension. Select for printing the complement of the bytes, characters or fields selected with the `-b`, `-c` or `-f` options. In other words, do not print the bytes, characters or fields specified via those options. This option is useful when you have many fields and want to print all but a few of them.

- `-z`
- `--zero-terminated`

Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with `perl -0` or `find -print0` and `xargs -0` which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters).

An exit status of zero indicates success, and a nonzero value indicates failure.

### 8.2 paste: Merge lines of files

**paste** writes to standard output lines consisting of sequentially corresponding lines of each given file, separated by a TAB character. Standard input is used for a file name of `-' or if no input files are given.

**Synopsis:**

```
paste [option]... [file]...
```

For example, with:

```
$ cat num2
1
2
$ cat let3
a
b
```
Take lines sequentially from each file:

$ paste num2 let3
1  a
2  b
c

Duplicate lines from a file:

$ paste num2 let3 num2
1  a  1
2  b  2
c

Intermix lines from standard input:

$ paste - let3 - < num2
1  a  2
b  2
%c

Join consecutive lines with a space:

$ seq 4 | paste -d ' ' - -
1  2
3  4

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--serial'
Paste the lines of one file at a time rather than one line from each file. Using the above example data:

$ paste --serial num2 let3
1  a  1
2  b  2
c

'--delimiters=delim-list'
Consecutively use the characters in delim-list instead of TAB to separate merged lines. When delim-list is exhausted, start again at its beginning. Using the above example data:

$ paste --delimiters= '%_' -d '%_' num2 let3 num2
1%a_1
2%b_2
%c_

'--zero-terminated'
Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with ‘perl -0’ or ‘find -print0’ and ‘xargs -0’ which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters).
An exit status of zero indicates success, and a nonzero value indicates failure.

## 8.3 join: Join lines on a common field

join writes to standard output a line for each pair of input lines that have identical join fields. Synopsis:

```
join [option]... file1 file2
```

Either `file1` or `file2` (but not both) can be ‘-’, meaning standard input. `file1` and `file2` should be sorted on the join fields.

```bash
$ cat file1
a 1
b 2
e 5

$ cat file2
a X
e Y
f Z

$ join file1 file2
a 1 X
e 5 Y
```

join’s default behavior (when no options are given):

- the join field is the first field in each line;
- fields in the input are separated by one or more blanks, with leading blanks on the line ignored;
- fields in the output are separated by a space;
- each output line consists of the join field, the remaining fields from `file1`, then the remaining fields from `file2`.

### 8.3.1 General options

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-a file-number`

Print a line for each unpairable line in file `file-number` (either ‘1’ or ‘2’), in addition to the normal output.

`--check-order`

Fail with an error message if either input file is wrongly ordered.

`--nocheck-order`

Do not check that both input files are in sorted order. This is the default.

`-e string`

Replace those output fields that are missing in the input with `string`. I.e., missing fields specified with the `-12j` options.
'--header'
Treat the first line of each input file as a header line. The header lines will be joined and printed as the first output line. If -o is used to specify output format, the header line will be printed according to the specified format. The header lines will not be checked for ordering even if --check-order is specified. Also if the header lines from each file do not match, the heading fields from the first file will be used.

'-i'
'--ignore-case'
Ignore differences in case when comparing keys. With this option, the lines of the input files must be ordered in the same way. Use `sort -f` to produce this ordering.

'-1 field' Join on field field (a positive integer) of file 1.

'-2 field' Join on field field (a positive integer) of file 2.

'-j field' Equivalent to `-1 field -2 field`.

'-o field-list'
'-o auto'
If the keyword ‘auto’ is specified, infer the output format from the first line in each file. This is the same as the default output format but also ensures the same number of fields are output for each line. Missing fields are replaced with the -e option and extra fields are discarded.

Otherwise, construct each output line according to the format in field-list. Each element in field-list is either the single character ‘0’ or has the form m.n where the file number, m, is ‘1’ or ‘2’ and n is a positive field number.

A field specification of ‘0’ denotes the join field. In most cases, the functionality of the ‘0’ field spec may be reproduced using the explicit m.n that corresponds to the join field. However, when printing unpairable lines (using either of the -a or -v options), there is no way to specify the join field using m.n in field-list if there are unpairable lines in both files. To give join that functionality, POSIX invented the ‘0’ field specification notation.

The elements in field-list are separated by commas or blanks. Blank separators typically need to be quoted for the shell. For example, the commands `join -o 1.2,2.2` and `join -o '1.2 2.2'` are equivalent.

All output lines – including those printed because of any -a or -v option – are subject to the specified field-list.

'-t char'
Use character char as the input and output field separator. Treat as significant each occurrence of char in the input file. Use `sort -t char`, without the -b option of `sort`, to produce this ordering. If `join -t ''` is specified, the whole line is considered, matching the default operation of sort. If `-t \0` is specified then the ASCII NUL character is used to delimit the fields.

'-v file-number'
Print a line for each unpairable line in file file-number (either ‘1’ or ‘2’), instead of the normal output.
Chapter 8: Operating on fields

'--z'
'--zero-terminated'

Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat input as items separated by ASCII NUL and terminate output items with ASCII NUL. This option can be useful in conjunction with ‘perl -0’ or ‘find -print0’ and ‘xargs -0’ which do the same in order to reliably handle arbitrary file names (even those containing blanks or other special characters). Note with --z the newline character is treated as a field separator.

An exit status of zero indicates success, and a nonzero value indicates failure. If the --check-order option is given, unsorted inputs will cause a fatal error message. If the option --nocheck-order is given, unsorted inputs will never cause an error message. If neither of these options is given, wrongly sorted inputs are diagnosed only if an input file is found to contain unpairable lines, and when both input files are non empty. If an input file is diagnosed as being unsorted, the join command will exit with a nonzero status (and the output should not be used).

Forcing join to process wrongly sorted input files containing unpairable lines by specifying --nocheck-order is not guaranteed to produce any particular output. The output will probably not correspond with whatever you hoped it would be.

8.3.2 Pre-sorting

join requires sorted input files. Each input file should be sorted according to the key (=field/column number) used in join. The recommended sorting option is ‘sort -k 1b,1’ (assuming the desired key is in the first column).

Typical usage:

```
$ sort -k 1b,1 file1 > file1.sorted
$ sort -k 1b,1 file2 > file2.sorted
$ join file1.sorted file2.sorted > file3
```

Normally, the sort order is that of the collating sequence specified by the LC_COLLATE locale. Unless the -t option is given, the sort comparison ignores blanks at the start of the join field, as in sort -b. If the --ignore-case option is given, the sort comparison ignores the case of characters in the join field, as in sort -f:

```
$ sort -k 1bf,1 file1 > file1.sorted
$ sort -k 1bf,1 file2 > file2.sorted
$ join --ignore-case file1.sorted file2.sorted > file3
```

The sort and join commands should use consistent locales and options if the output of sort is fed to join. You can use a command like ‘sort -k 1b,1’ to sort a file on its default join field, but if you select a non-default locale, join field, separator, or comparison options, then you should do so consistently between join and sort.

To avoid any locale-related issues, it is recommended to use the ‘C’ locale for both commands:

```
$ LC_ALL=C sort -k 1b,1 file1 > file1.sorted
$ LC_ALL=C sort -k 1b,1 file2 > file2.sorted
$ LC_ALL=C join file1.sorted file2.sorted > file3
```
8.3.3 Working with fields

Use `-1,-2` to set the key fields for each of the input files. Ensure the preceding `sort` commands operated on the same fields.

The following example joins two files, using the values from seventh field of the first file and the third field of the second file:

```
$ sort -k 7b,7 file1 > file1.sorted
$ sort -k 3b,3 file2 > file2.sorted
$ join -1 7 -2 3 file1.sorted file2.sorted > file3
```

If the field number is the same for both files, use `-j`:

```
$ sort -k4b,4 file1 > file1.sorted
$ sort -k4b,4 file2 > file2.sorted
$ join -j4 file1.sorted file2.sorted > file3
```

Both `sort` and `join` operate of whitespace-delimited fields. To specify a different delimiter, use `-t` in both:

```
$ sort -t, -k3b,3 file1 > file1.sorted
$ sort -t, -k3b,3 file2 > file2.sorted
$ join -t, -j3 file1.sorted file2.sorted > file3
```

To specify a tab (ASCII 0x09) character instead of whitespace, use:\(^1\)

```
$ sort -t$'	' -k3b,3 file1 > file1.sorted
$ sort -t$'	' -k3b,3 file2 > file2.sorted
$ join -t$'	' -j3 file1.sorted file2.sorted > file3
```

If `join -t ''` is specified then the whole line is considered which matches the default operation of `sort`:

```
$ sort file1 > file1.sorted
$ sort file2 > file2.sorted
$ join -t '' file1.sorted file2.sorted > file3
```

8.3.4 Controlling `join`’s field matching

In this section the `sort` commands are omitted for brevity. Sorting the files before joining is still required.

`join`’s default behavior is to print only lines common to both input files. Use `-a` and `-v` to print unpairable lines from one or both files.

All examples below use the following two (pre-sorted) input files:

```
$ cat file1
a 1
b 2

$ cat file2
a A
c C
```

---

\(^1\) the `$'	'` is supported in most modern shells. For older shells, use a literal tab.
# Chapter 8: Operating on fields

## Command Outcome

<table>
<thead>
<tr>
<th>Command</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>$ join file1 file2</code></td>
<td>common lines <em>(intersection)</em></td>
</tr>
<tr>
<td>$ join file1 file2</td>
<td></td>
</tr>
<tr>
<td>a 1 A</td>
<td></td>
</tr>
<tr>
<td>$ join -a 1 file1 file2</td>
<td>common lines <em>and</em> unpaired lines from the first file</td>
</tr>
<tr>
<td>$ join -a 1 file1 file2</td>
<td></td>
</tr>
<tr>
<td>a 1 A</td>
<td></td>
</tr>
<tr>
<td>b 2</td>
<td></td>
</tr>
<tr>
<td>$ join -a 2 file1 file2</td>
<td>common lines <em>and</em> unpaired lines from the second file</td>
</tr>
<tr>
<td>$ join -a 1 -a 2 file1 file2</td>
<td>all lines (paired and unpaired) from both files <em>(union)</em>.</td>
</tr>
<tr>
<td>$ join -a 1 -a 2 file1 file2</td>
<td></td>
</tr>
<tr>
<td>a 1 A</td>
<td></td>
</tr>
<tr>
<td>b 2</td>
<td></td>
</tr>
<tr>
<td>c C</td>
<td></td>
</tr>
<tr>
<td>$ join -v 1 file1 file2</td>
<td>unpaired lines from the first file <em>(difference)</em></td>
</tr>
<tr>
<td>$ join -v 1 file1 file2</td>
<td></td>
</tr>
<tr>
<td>b 2</td>
<td></td>
</tr>
<tr>
<td>$ join -v 2 file1 file2</td>
<td>unpaired lines from the second file <em>(difference)</em></td>
</tr>
<tr>
<td>$ join -v 2 file1 file2</td>
<td></td>
</tr>
<tr>
<td>c C</td>
<td></td>
</tr>
<tr>
<td>$ join -v 1 -v 2 file1 file2</td>
<td>unpaired lines from both files, omitting common lines <em>(symmetric difference)</em>.</td>
</tr>
<tr>
<td>$ join -v 1 -v 2 file1 file2</td>
<td></td>
</tr>
<tr>
<td>b 2</td>
<td></td>
</tr>
<tr>
<td>c C</td>
<td></td>
</tr>
</tbody>
</table>

The `-o auto` `-e X` options are useful when dealing with unpaired lines. The following example prints all lines (common and unpaired) from both files. Without `-o auto` it is not easy to discern which fields originate from which file:

<table>
<thead>
<tr>
<th>Command</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>$ join -a 1 -a 2 file1 file2</code></td>
<td></td>
</tr>
<tr>
<td>$ join -a 1 -a 2 file1 file2</td>
<td></td>
</tr>
<tr>
<td>a 1 A</td>
<td></td>
</tr>
<tr>
<td>b 2</td>
<td></td>
</tr>
<tr>
<td>c C</td>
<td></td>
</tr>
<tr>
<td>$ join -o auto -e X -a 1 -a 2 file1 file2</td>
<td></td>
</tr>
<tr>
<td>$ join -o auto -e X -a 1 -a 2 file1 file2</td>
<td></td>
</tr>
<tr>
<td>a 1 A</td>
<td></td>
</tr>
<tr>
<td>b 2 X</td>
<td></td>
</tr>
<tr>
<td>c X C</td>
<td></td>
</tr>
</tbody>
</table>

If the input has no unpairable lines, a GNU extension is available; the sort order can be any order that considers two fields to be equal if and only if the sort comparison described above considers them to be equal. For example:
$ cat file1
  a a1
  c c1
  b b1

$ cat file2
  a a2
  c c2
  b b2

$ join file1 file2
  a a1 a2
  c c1 c2
  b b1 b2

8.3.5 Header lines

The \texttt{--header} option can be used when the files to join have a header line which is not sorted:

$ cat file1
  Name  Age
  Alice  25
  Charlie  34

$ cat file2
  Name  Country
  Alice  France
  Bob  Spain

$ join --header -o auto -e NA -a1 -a2 file1 file2
  Name  Age  Country
  Alice  25  France
  Bob  NA  Spain
  Charlie  34  NA

To sort a file with a header line, use GNU \texttt{sed -u}. The following example sort the files but keeps the first line of each file in place:

$ ( sed -u 1q ; sort -k2b,2 ) < file1 > file1.sorted
$ ( sed -u 1q ; sort -k2b,2 ) < file2 > file2.sorted
$ join --header -o auto -e NA -a1 -a2 file1.sorted file2.sorted > file3

8.3.6 Union, Intersection and Difference of files

Combine \texttt{sort}, \texttt{uniq} and \texttt{join} to perform the equivalent of set operations on files:

<table>
<thead>
<tr>
<th>Command</th>
<th>outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>sort -u file1 file2</td>
<td>Union of unsorted files</td>
</tr>
<tr>
<td>sort file1 file2</td>
<td>uniq -d</td>
</tr>
</tbody>
</table>
sort file1 file1 file2 | uniq -u  Difference of unsorted files
sort file1 file2 | uniq -u  Symmetric Difference of unsorted files
join -t '' -a1 -a2 file1 file2  Union of sorted files
join -t '' file1 file2  Intersection of sorted files
join -t '' -v2 file1 file2  Difference of sorted files
join -t '' -v1 -v2 file1 file2  Symmetric Difference of sorted files

All examples above operate on entire lines and not on specific fields: sort without -k and join -t '' both consider entire lines as the key.
9 Operating on characters

These commands operate on individual characters.

9.1 *tr*: Translate, squeeze, and/or delete characters

Synopsis:

```
tr [option]... string1 [string2]
```

*tr* copies standard input to standard output, performing one of the following operations:

- translate, and optionally squeeze repeated characters in the result,
- squeeze repeated characters,
- delete characters,
- delete characters, then squeeze repeated characters from the result.

The *string1* and *string2* operands define arrays of characters *array1* and *array2*. By default *array1* lists input characters that *tr* operates on, and *array2* lists corresponding translations. In some cases the second operand is omitted.

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands.

`-c`
`-C`
`--complement`

Instead of *array1*, use its complement (all characters not specified by *string1*), in ascending order. Use this option with caution in multibyte locales where its meaning is not always clear or portable; see Section 9.1.1 [Character arrays], page 82.

`-d`
`--delete`

Delete characters in *array1*; do not translate.

`-s`
`--squeeze-repeats`

Replace each sequence of a repeated character that is listed in the last specified array, with a single occurrence of that character.

`-t`
`--truncate-set1`

Truncate *array1* to the length of *array2*.

An exit status of zero indicates success, and a nonzero value indicates failure.

9.1.1 Specifying arrays of characters

The *string1* and *string2* operands are not regular expressions, even though they may look similar. Instead, they merely represent arrays of characters. As a GNU extension to POSIX, an empty string operand represents an empty array of characters.

The interpretation of *string1* and *string2* depends on locale. GNU *tr* fully supports only safe single-byte locales, where each possible input byte represents a single character.
Unfortunately, this means GNU \texttt{tr} will not handle commands like ‘\texttt{tr ß Ł}’ the way you might expect, since (assuming a UTF-8 encoding) this is equivalent to ‘\texttt{tr ‘\textbackslash 303\textbackslash 266’ ‘\textbackslash 305\textbackslash 201’}’ and GNU \texttt{tr} will simply transliterate all ‘\textbackslash 303’ bytes to ‘\textbackslash 305’ bytes, etc. POSIX does not clearly specify the behavior of \texttt{tr} in locales where characters are represented by byte sequences instead of by individual bytes, or where data might contain invalid bytes that are encoding errors. To avoid problems in this area, you can run \texttt{tr} in a safe single-byte locale by using a shell command like ‘\texttt{LC\_ALL=C tr}’ instead of plain \texttt{tr}.

Although most characters simply represent themselves in \texttt{string1} and \texttt{string2}, the strings can contain shorthands listed below, for convenience. Some shorthands can be used only in \texttt{string1} or \texttt{string2}, as noted below.

Backslash escapes

The following backslash escape sequences are recognized:

\begin{itemize}
  \item \texttt{\textbackslash a} Bell (BEL, Control-G).
  \item \texttt{\textbackslash b} Backspace (BS, Control-H).
  \item \texttt{\textbackslash f} Form feed (FF, Control-L).
  \item \texttt{\textbackslash n} Newline (LF, Control-J).
  \item \texttt{\textbackslash r} Carriage return (CR, Control-M).
  \item \texttt{\textbackslash t} Tab (HT, Control-I).
  \item \texttt{\textbackslash v} Vertical tab (VT, Control-K).
  \item \texttt{\textbackslash \texttt{\textbackslash ooo}} The eight-bit byte with the value given by \texttt{ooo}, which is the longest sequence of one to three octal digits following the backslash. For portability, \texttt{ooo} should represent a value that fits in eight bits. As a GNU extension to POSIX, if the value would not fit, then only the first two digits of \texttt{ooo} are used, e.g., ‘\textbackslash 400’ is equivalent to ‘\textbackslash 0400’ and represents a two-byte sequence.
  \item \texttt{\textbackslash \textbackslash} A backslash.
\end{itemize}

It is an error if no character follows an unescaped backslash. As a GNU extension, a backslash followed by a character not listed above is interpreted as that character, removing any special significance; this can be used to escape the characters ‘[’ and ‘]’ when they would otherwise be special.

Ranges

The notation ‘m-n’ expands to the characters from \texttt{m} through \texttt{n}, in ascending order. \texttt{m} should not collate after \texttt{n}; if it does, an error results. As an example, ‘0-9’ is the same as ‘\texttt{0123456789}’.

GNU \texttt{tr} does not support the System V syntax that uses square brackets to enclose ranges. Translations specified in that format sometimes work as expected, since the brackets are often transliterated to themselves. However, they should be avoided because they sometimes behave unexpectedly. For example, ‘\texttt{tr -d ‘\texttt{[0-9] ‘]’}’ deletes brackets as well as digits.

Many historically common and even accepted uses of ranges are not fully portable. For example, on EBCDIC hosts using the ‘A-Z’ range will not do what most
would expect because ‘A’ through ‘Z’ are not contiguous as they are in ASCII. One way to work around this is to use character classes (see below). Otherwise, it is most portable (and most ugly) to enumerate the members of the ranges.

Repeated characters
The notation ‘[c*n]’ in string2 expands to n copies of character c. Thus, ‘[y*6]’ is the same as ‘yyyyyy’. The notation ‘[c*]’ in string2 expands to as many copies of c as are needed to make array2 as long as array1. If n begins with ‘0’, it is interpreted in octal, otherwise in decimal. A zero-valued n is treated as if it were absent.

Character classes
The notation ‘[:class:]’ expands to all characters in the (predefined) class class. When the --delete (-d) and --squeeze-repeats (-s) options are both given, any character class can be used in string2. Otherwise, only the character classes lower and upper are accepted in string2, and then only if the corresponding character class (upper and lower, respectively) is specified in the same relative position in string1. Doing this specifies case conversion. Except for case conversion, a class’s characters appear in no particular order. The class names are given below; an error results when an invalid class name is given.

alnum   Letters and digits.
alpha   Letters.
blank   Horizontal whitespace.
cntrl   Control characters.
digit   Digits.
graph   Printable characters, not including space.
lower   Lowercase letters.
print   Printable characters, including space.
punct   Punctuation characters.
space   Horizontal or vertical whitespace.
upper   Uppercase letters.
xdigit  Hexadecimal digits.

Equivalence classes
The syntax ‘[=c=]’ expands to all characters equivalent to c, in no particular order. These equivalence classes are allowed in string2 only when --delete (-d) and --squeeze-repeats -s are both given.

Although equivalence classes are intended to support non-English alphabets, there seems to be no standard way to define them or determine their contents. Therefore, they are not fully implemented in GNU tr; each character’s equivalence class consists only of that character, which is of no particular use.
9.1.2 Translating

tr performs translation when string1 and string2 are both given and the --delete (-d) option is not given. tr translates each character of its input that is in array1 to the corresponding character in array2. Characters not in array1 are passed through unchanged.

As a GNU extension to POSIX, when a character appears more than once in array1, only the final instance is used. For example, these two commands are equivalent:

```
tr aaa xyz
tr a z
```

A common use of tr is to convert lowercase characters to uppercase. This can be done in many ways. Here are three of them:

```
tr abcdefghijklmnopqrstuvwxyz ABCDEFGHIJKLMNOPQRSTUVWXYZ
tr a-z A-Z
tr \[:lower:\] \[:upper:\]
```

However, ranges like a-z are not portable outside the C locale.

When tr is performing translation, array1 and array2 typically have the same length. If array1 is shorter than array2, the extra characters at the end of array2 are ignored.

On the other hand, making array1 longer than array2 is not portable; POSIX says that the result is undefined. In this situation, BSD tr pads array2 to the length of array1 by repeating the last character of array2 as many times as necessary. System V tr truncates array1 to the length of array2.

By default, GNU tr handles this case like BSD tr. When the --truncate-set1 (-t) option is given, GNU tr handles this case like the System V tr instead. This option is ignored for operations other than translation.

Acting like System V tr in this case breaks the relatively common BSD idiom:

```
tr -cs A-Za-z0-9 '\012'
```

because it converts only zero bytes (the first element in the complement of array1), rather than all non-alphanumeric, to newlines.

By the way, the above idiom is not portable because it uses ranges, and it assumes that the octal code for newline is 012. Here is a better way to write it:

```
tr -cs \[:alnum:\] \[\n*\]
```

9.1.3 Squeezing repeats and deleting

When given just the --delete (-d) option, tr removes any input characters that are in array1.

When given just the --squeeze-repeats (-s) option and not translating, tr replaces each input sequence of a repeated character that is in array1 with a single occurrence of that character.

When given both --delete and --squeeze-repeats, tr first performs any deletions using array1, then squeezes repeats from any remaining characters using array2.

The --squeeze-repeats option may also be used when translating, in which case tr first performs translation, then squeezes repeats from any remaining characters using array2.
Here are some examples to illustrate various combinations of options:

- Remove all zero bytes:
  \[\text{tr} \ -d \ '\0'\]

- Put all words on lines by themselves. This converts all non-alphanumeric characters to newlines, then squeezes each string of repeated newlines into a single newline:
  \[\text{tr} \ -cs \ '[:alnum:]' \ '[:\n*]'\]

- Convert each sequence of repeated newlines to a single newline. I.e., delete empty lines:
  \[\text{tr} \ -s \ ':\n'\]

- Find doubled occurrences of words in a document. For example, people often write “the the” with the repeated words separated by a newline. The Bourne shell script below works first by converting each sequence of punctuation and blank characters to a single newline. That puts each “word” on a line by itself. Next it maps all uppercase characters to lower case, and finally it runs \texttt{uniq} with the \texttt{-d} option to print out only the words that were repeated.

\[
#!/bin/sh
\text{cat} \ -- \ "$@" \ \\
| \text{tr} \ -s \ '[:punct:][:blank:]' \ '[:\n*]' \ \\
| \text{tr} \ '[:upper:]' \ '[:lower:]' \ \\
| \text{uniq} \ -d
\]

- Deleting a small set of characters is usually straightforward. For example, to remove all ‘a’s, ‘x’s, and ‘M’s you would do this:
  \[\text{tr} \ -d \ axM\]

However, when ‘-’ is one of those characters, it can be tricky because ‘-’ has special meanings. Performing the same task as above but also removing all ‘-’ characters, we might try \texttt{tr -d -axM}, but that would fail because \texttt{tr} would try to interpret \texttt{-a} as a command-line option. Alternatively, we could try putting the hyphen inside the string, \texttt{tr -d a-xM}, but that wouldn’t work either because it would make \texttt{tr} interpret \texttt{a-x} as the range of characters ‘a’...’x’ rather than the three. One way to solve the problem is to put the hyphen at the end of the list of characters:

\[\text{tr} \ -d \ axM-\]

Or you can use ‘--’ to terminate option processing:

\[\text{tr} \ -d \ --\]

9.2 \textit{expand}: Convert tabs to spaces

\texttt{expand} writes the contents of each given \texttt{file}, or standard input if none are given or for a \texttt{file} of ‘-’, to standard output, with tab characters converted to the appropriate number of spaces. Synopsis:

\[\texttt{expand} \ [\text{option}]\ldots \ [\text{file}]\ldots\]

By default, \texttt{expand} converts all tabs to spaces. It preserves backspace characters in the output; they decrement the column count for tab calculations. The default action is equivalent to \texttt{-t 8} (set tabs every 8 columns).

The program accepts the following options. Also see Chapter 2 [Common options], page 2.
‘-t tab1[,tab2]...’
‘--tabs=tab1[,tab2]...’
If only one tab stop is given, set the tabs tab1 spaces apart (default is 8).
Otherwise, set the tabs at columns tab1, tab2, ... (numbered from 0), and replace any tabs beyond the last tab stop given with single spaces. Tab stops can be separated by blanks as well as by commas.

As a GNU extension the last tab specified can be prefixed with a ‘/’ to indicate a tab size to use for remaining positions. For example, --tabs=2,4,/8 will set tab stops at position 2 and 4, and every multiple of 8 after that.

Also the last tab specified can be prefixed with a ‘+’ to indicate a tab size to use for remaining positions, offset from the final explicitly specified tab stop. For example, to ignore the 1 character gutter present in diff output, one can specify a 1 character offset using --tabs=1,+8, which will set tab stops at positions 1,9,17, ... For compatibility, GNU expand also accepts the obsolete option syntax, -t1[,t2].... New scripts should use -t t1[,t2]... instead.

‘-i’
‘--initial’
Only convert initial tabs (those that precede all non-space or non-tab characters) on each line to spaces.

An exit status of zero indicates success, and a nonzero value indicates failure.

9.3 unexpand: Convert spaces to tabs

unexpand writes the contents of each given file, or standard input if none are given or for a file of ‘-’, to standard output, converting blanks at the beginning of each line into as many tab characters as needed. In the default POSIX locale, a blank is a space or a tab; other locales may specify additional blank characters. Synopsis:

    unexpand [option]... [file]...

By default, unexpand converts only initial blanks (those that precede all non-blank characters) on each line. It preserves backspace characters in the output; they decrement the column count for tab calculations. By default, tabs are set at every 8th column.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-t tab1[,tab2]...’
‘--tabs=tab1[,tab2]...’
If only one tab stop is given, set the tabs tab1 columns apart instead of the default 8. Otherwise, set the tabs at columns tab1, tab2, ... (numbered from 0), and leave blanks beyond the tab stops given unchanged. Tab stops can be separated by blanks as well as by commas.

As a GNU extension the last tab specified can be prefixed with a ‘/’ to indicate a tab size to use for remaining positions. For example, --tabs=2,4,/8 will set tab stops at position 2 and 4, and every multiple of 8 after that.

Also the last tab specified can be prefixed with a ‘+’ to indicate a tab size to use for remaining positions, offset from the final explicitly specified tab stop. For example, to ignore the 1 character gutter present in diff output, one can specify
a 1 character offset using --tabs=1,+8, which will set tab stops at positions 1,9,17,\ldots This option implies the -a option.

For compatibility, GNU unexpand supports the obsolete option syntax, -tab1[,tab2]..., where tab stops must be separated by commas. (Unlike -t, this obsolete option does not imply -a.) New scripts should use --first-only -t tab1[,tab2]... instead.

'-a'
'--all' Also convert all sequences of two or more blanks just before a tab stop, even if they occur after non-blank characters in a line.

An exit status of zero indicates success, and a nonzero value indicates failure.
10 Directory listing

This chapter describes the `ls` command and its variants `dir` and `vdir`, which list information about files.

10.1 `ls`: List directory contents

The `ls` program lists information about files (of any type, including directories). Options and file arguments can be intermixed arbitrarily, as usual. Later options override earlier options that are incompatible.

For non-option command-line arguments that are directories, by default `ls` lists the contents of directories, not recursively, and omitting files with names beginning with `.`. For other non-option arguments, by default `ls` lists just the file name. If no non-option argument is specified, `ls` operates on the current directory, acting as if it had been invoked with a single argument of `.`.

By default, the output is sorted alphabetically, according to the locale settings in effect.¹ If standard output is a terminal, the output is in columns (sorted vertically) and control characters are output as question marks; otherwise, the output is listed one per line and control characters are output as-is.

Because `ls` is such a fundamental program, it has accumulated many options over the years. They are described in the subsections below; within each section, options are listed alphabetically (ignoring case). The division of options into the subsections is not absolute, since some options affect more than one aspect of `ls`’s operation.

Exit status:

0 success
1 minor problems (e.g., failure to access a file or directory not specified as a command line argument. This happens when listing a directory in which entries are actively being removed or renamed.)
2 serious trouble (e.g., memory exhausted, invalid option, failure to access a file or directory specified as a command line argument or a directory loop)

Also see Chapter 2 [Common options], page 2.

10.1.1 Which files are listed

These options determine which files `ls` lists information for. By default, `ls` lists files and the contents of any directories on the command line, except that in directories it ignores files whose names start with `.`.

`-a`

`--all` In directories, do not ignore file names that start with `.`.

`-A`

`--almost-all` In directories, do not ignore all file names that start with `.`; ignore only . and ...

¹ If you use a non-POSIX locale (e.g., by setting `LC_ALL` to `en_US`), then `ls` may produce output that is sorted differently than you’re accustomed to. In that case, set the `LC_ALL` environment variable to `C`.
`-B`
`--ignore-backups`
In directories, ignore files that end with `~`. This option is equivalent to
`--ignore='*~' --ignore='.*~'`.

`-d`
`--directory`
List just the names of directories, as with other types of files, rather than
listing their contents. Do not follow symbolic links listed on the command
line unless the `--dereference-command-line (-H)`, `--dereference (-L)`, or
`--dereference-command-line-symlink-to-dir` options are specified.

`-H`
`--dereference-command-line`
If a command line argument specifies a symbolic link, show information for the
file the link references rather than for the link itself.

`--dereference-command-line-symlink-to-dir`
Do not dereference symbolic links, with one exception: if a command line
argument specifies a symbolic link that refers to a directory, show informa-
tion for that directory rather than for the link itself. This is the default
behavior unless long format is being used or any of the following options
is in effect: `--classify (-F)`, `--directory (-d)`, `--dereference (-L)`, or
`--dereference-command-line (-H)`.

`--group-directories-first`
Group all the directories before the files and then sort the directories and the
files separately using the selected sort key (see `--sort` option). That is, this
option specifies a primary sort key, and the `--sort` option specifies a secondary
key. However, any use of `--sort=none (-U)` disables this option altogether.

`--hide=_PATTERN`
In directories, ignore files whose names match the shell pattern `pattern`, unless
the `--all (-a)` or `--almost-all (-A)` is also given. This option acts like
`--ignore=pattern` except that it has no effect if `--all (-a)` or `--almost-all
(-A)` is also given.
This option can be useful in shell aliases. For example, if `lx` is an alias for `ls
--hide='*~'` and `ly` is an alias for `ls --ignore='*~'`, then the command
`lx -A` lists the file `README~` even though `ly -A` would not.

`-I pattern`
`--ignore=pattern`
In directories, ignore files whose names match the shell pattern (not regular
expression) `pattern`. As in the shell, an initial `.` in a file name does not match
a wildcard at the start of `pattern`. Sometimes it is useful to give this option
several times. For example,

```
$ ls --ignore='.*' --ignore='.[.]' --ignore='#@'
```
The first option ignores names of length 3 or more that start with `.`., the second
ignores all two-character names that start with `.` except `. ..`, and the third
ignores names that start with `#`.
Chapter 10: Directory listing

\texttt{-L}'
\texttt{--dereference}'
When showing file information for a symbolic link, show information for the file
the link references rather than the link itself. However, even with this option,
\texttt{ls} still prints the name of the link itself, not the name of the file that the link
points to.

\texttt{-R}'
\texttt{--recursive}'
List the contents of all directories recursively.

\textbf{10.1.2 What information is listed}
These options affect the information that \texttt{ls} displays. By default, only file names are shown.

\texttt{--author}'
In long format, list each file’s author. In GNU/Hurd, file authors can differ from
their owners, but in other operating systems the two are the same.

\texttt{-D}'
\texttt{--dired}'
Print an additional line after the main output:

\begin{verbatim}
//DIRED// beg1 end1 beg2 end2 ...
\end{verbatim}

The \texttt{begn} and \texttt{endn} are unsigned integers that record the byte position of the
beginning and end of each file name in the output. This makes it easy for Emacs
to find the names, even when they contain unusual characters such as space or
newline, without fancy searching.

If directories are being listed recursively via \texttt{--recursive} (-R), output a similar
line with offsets for each subdirectory name:

\begin{verbatim}
//SUBDIRED// beg1 end1 ...
\end{verbatim}

Finally, output a line of the form:

\begin{verbatim}
//DIRED-OPTIONS// --quoting-style=word
\end{verbatim}

where \texttt{word} is the quoting style (see Section 10.1.6 [Formatting the file names],
page 101).

Here is an actual example:

```
$ mkdir -p a/sub/deeper a/sub2
$ touch a/f1 a/f2
$ touch a/sub/deeper/file
$ ls -gloRF --dired a
a:
  total 8
  -rw-r--r-- 1 0 Jun 10 12:27 f1
  -rw-r--r-- 1 0 Jun 10 12:27 f2
drwxr-xr-x 3 4096 Jun 10 12:27 sub/
drwxr-xr-x 2 4096 Jun 10 12:27 sub2/
```

```
a/sub:
  total 4
```
drwxr-xr-x 2 4096 Jun 10 12:27 deeper/
a/sub/deeper:
total 0
-rw-r--r-- 1 0 Jun 10 12:27 file

a/sub2:
total 0
//DIRED// 48 50 84 86 120 123 158 162 217 223 282 286
//SUBDIRED// 2 3 167 172 228 240 290 296
//DIREOPTIONS// --quoting-style=literal

The pairs of offsets on the //DIRED// line above delimit these names: f1, f2, sub, sub2, deeper, file. The offsets on the //SUBDIRED// line delimit the following directory names: a, a/sub, a/sub/deeper, a/sub2.

Here is an example of how to extract the fifth entry name, 'deeper', corresponding to the pair of offsets, 222 and 228:

$ ls -gloRF --dired a > out
$ dd bs=1 skip=222 count=6 < out 2>/dev/null; echo deeper

Although the listing above includes a trailing slash for the 'deeper' entry, the offsets select the name without the trailing slash. However, if you invoke ls with --dired (-D) along with an option like --escape (-b) and operate on a file whose name contains special characters, the backslash is included:

$ touch 'a b'
$ ls -blog --dired 'a b'
-rw-r--r-- 1 0 Jun 10 12:28 a\ b
//DIRED// 30 34
//DIREOPTIONS// --quoting-style=escape

If you use a quoting style like --quoting-style=c (-Q) that adds quote marks, then the offsets include the quote marks. So beware that the user may select the quoting style via the environment variable QUOTING_STYLE. Hence, applications using --dired should either specify an explicit --quoting-style=literal (-N) option on the command line, or else be prepared to parse the escaped names.

The --dired (-D) option has well-defined behavior only when long format is in effect and hyperlinks are disabled (e.g., --hyperlink=none).

`--full-time`
Produce long format, and list times in full. It is equivalent to using --format=long (-l) with --time-style=full-iso (see Section 10.1.5 [Formatting file timestamps], page 99).

`-g`
Produce long format, but omit owner information.

`-G`

`--no-group`
Inhibit display of group information in long format. (This is the default in some non-GNU versions of ls, so we provide this option for compatibility.)
Chapter 10: Directory listing

- `h`
  `--human-readable`
  Append a size letter to each size, such as ‘M’ for mebibytes. Powers of 1024 are used, not 1000; ‘M’ stands for 1,048,576 bytes. This option is equivalent to `--block-size=human-readable`. Use the `--si` option if you prefer powers of 1000.

- `i`
  `--inode`
  Print the inode number (also called the file serial number and index number) of each file to the left of the file name. (This number uniquely identifies each file within a particular file system.)

- `l`
  `--format=long`
  `--format=verbose`
  Produce long format. In addition to the name of each file, print the file type, file mode bits, number of hard links, owner name, group name, size, and timestamp (see Section 10.1.5 [Formatting file timestamps], page 99), normally the modification timestamp (the mtime, see Chapter 28 [File timestamps], page 241). If the owner or group name cannot be determined, print the owner or group ID instead, right-justified as a cue that it is a number rather than a textual name. Print question marks for other information that cannot be determined.

  Normally the size is printed as a byte count without punctuation, but this can be overridden (see Section 2.2 [Block size], page 3). For example, `--human-readable (-h)` prints an abbreviated, human-readable count, and `--block-size='1'` prints a byte count with the thousands separator of the current locale.

  For each directory that is listed, preface the files with a line ‘total blocks’, where blocks is the file system allocation for all files in that directory. The block size currently defaults to 1024 bytes, but this can be overridden (see Section 2.2 [Block size], page 3). The blocks computed counts each hard link separately; this is arguably a deficiency.

  The file type is one of the following characters:
  `-` regular file
  `b` block special file
  `c` character special file
  `C` high performance (“contiguous data”) file
  `d` directory
  `D` door (Solaris)
  `l` symbolic link
  `M` off-line (“migrated”) file (Cray DMF)
  `n` network special file (HP-UX)
'p'  FIFO (named pipe)
'P'  port (Solaris)
's'  socket
'? '  some other file type

The file mode bits listed are similar to symbolic mode specifications (see Section 27.2 [Symbolic Modes], page 234). But `ls` combines multiple bits into the third character of each set of permissions as follows:

's'  If the set-user-ID or set-group-ID bit and the corresponding executable bit are both set.
'S'  If the set-user-ID or set-group-ID bit is set but the corresponding executable bit is not set.
't'  If the restricted deletion flag or sticky bit, and the other-executable bit, are both set. The restricted deletion flag is another name for the sticky bit. See Section 27.1 [Mode Structure], page 233.
'T'  If the restricted deletion flag or sticky bit is set but the other-executable bit is not set.
'x'  If the executable bit is set and none of the above apply.
'-'  Otherwise.

Following the file mode bits is a single character that specifies whether an alternate access method such as an access control list applies to the file. When the character following the file mode bits is a space, there is no alternate access method. When it is a printing character, then there is such a method.

GNU `ls` uses a ‘.’ character to indicate a file with a security context, but no other alternate access method. A file with any other combination of alternate access methods is marked with a ‘+’ character.

'--numeric-uid-gid'

Produce long format, but display right-justified numeric user and group IDs instead of left-justified owner and group names.

'--size'

Print the file system allocation of each file to the left of the file name. This is the amount of file system space used by the file, which is usually a bit more than the file’s size, but it can be less if the file has holes.

Normally the allocation is printed in units of 1024 bytes, but this can be overridden (see Section 2.2 [Block size], page 3).

For files that are NFS-mounted from an HP-UX system to a BSD system, this option reports sizes that are half the correct values. On HP-UX systems, it
reports sizes that are twice the correct values for files that are NFS-mounted from BSD systems. This is due to a flaw in HP-UX; it also affects the HP-UX ls program.

`--si` Append an SI-style abbreviation to each size, such as ‘M’ for megabytes. Powers of 1000 are used, not 1024; ‘M’ stands for 1,000,000 bytes. This option is equivalent to `--block-size=si`. Use the `-h` or `--human-readable` option if you prefer powers of 1024.

`-Z`
`--context`
Display the SELinux security context or ‘?’ if none is found. In long format, print the security context to the left of the size column.

### 10.1.3 Sorting the output

These options change the order in which `ls` sorts the information it outputs. By default, sorting is done by character code (e.g., ASCII order).

`-c`
`--time=ctime`
`--time=status`
In long format, print the status change timestamp (the ctime) instead of the mtime. When sorting by time or when not using long format, sort according to the ctime. See Chapter 28 [File timestamps], page 241.

`-f`
Produce an unsorted directory listing. This is equivalent to the combination of `--all (-a), --sort=none (-U), -1, --color=none, and --hyperlink=none`, while also disabling any previous use of `--size (-s)`.

`-r`
`--reverse`
Reverse whatever the sorting method is – e.g., list files in reverse alphabetical order, youngest first, smallest first, or whatever. This option has no effect when `--sort=none (-U)` is in effect.

`-S`
`--sort=size`
Sort by file size, largest first.

`-t`
`--sort=time`
Sort by modification timestamp (mtime) by default, newest first. The timestamp to order by can be changed with the `--time` option. See Chapter 28 [File timestamps], page 241.

`-u`
`--time=atime`
`--time=access`
`--time=use`
In long format, print the last access timestamp (the atime). When sorting by time or when not using long format, sort according to the atime. See Chapter 28 [File timestamps], page 241.
'--time=mtime'
'--time=modification'
This is the default timestamp display and sorting mode. In long format, print the last data modification timestamp (the mtime). When sorting by time or when not using long format, sort according to the mtime. See Chapter 28 [File timestamps], page 241.

'--time=birth'
'--time=creation'
In long format, print the file creation timestamp if available, falling back to the file modification timestamp (mtime) if not. When sorting by time or when not using long format, sort according to the birth time. See Chapter 28 [File timestamps], page 241.

'-U'
'--sort=none'
Do not sort; list the files in whatever order they are stored in the directory. (Do not do any of the other unrelated things that -f does.) This can be useful when listing large directories, where sorting can take some time.

'-v'
'--sort=version'
Sort by version name and number, lowest first. It behaves like a default sort, except that each sequence of decimal digits is treated numerically as an index/version number. See Chapter 30 [Version sort ordering], page 250.

'--sort=width'
Sort by printed width of file names. This can be useful with the --format=vertical (-C) output format, to most densely display the listed files.

'-X'
'--sort=extension'
Sort directory contents alphabetically by file extension (characters after the last '.') ; files with no extension are sorted first.

10.1.4 General output formatting
These options affect the appearance of the overall output.

'--format=single-column'
List one file name per line, with no other information. This is the default for ls when standard output is not a terminal. See also the --escape (-b), --hide-control-chars (-q), and --zero options to disambiguate output of file names containing newline characters.

'-1'
List one file per line. This is like --format=single-column except that it has no effect if long format is also in effect.

'-C'
'--format=vertical'
List files in columns, sorted vertically, with no other information. This is the default for ls if standard output is a terminal. It is always the default for the
dir program. GNU ls uses variable width columns to display as many files as possible in the fewest lines.

`--color [=when]`
Specify whether to use color for distinguishing file types; when may be omitted, or one of:
- none - Do not use color at all. This is the default.
- auto - Only use color if standard output is a terminal.
- always - Always use color.

Specifying `--color` and no `when` is equivalent to `--color=always`. If piping a colored listing through a pager like less, use the pager’s `-R` option to pass the color codes to the terminal.

Using the `--color` option may incur a noticeable performance penalty when run in a large directory, because the default settings require that ls stat every single file it lists. However, if you would like most of the file-type coloring but can live without the other coloring options (e.g., executable, orphan, sticky, other-writable, capability), use dircolors to set the LS_COLORS environment variable like this,
```
    eval $(dircolors -p | perl -pe 's/^((CAP|S[ET]|0[TR]|M|E)\w+).*/$1 00/' | dircolors -)
```
and on a dirent.d_type-capable file system, ls will perform only one stat call per command line argument.

`-F`
`--classify [=when]`
`--indicator-style=file-type`
Append a character to each file name indicating the file type. This is like `--classify` (-F), except that executables are not marked.

Do not follow symbolic links listed on the command line unless the `--dereference-command-line` (-H), `--dereference` (-L), or `--dereference-command-line-symlink-to-dir` options are specified.

`--hyperlink [=when]`
Output codes recognized by some terminals to link to files using the ‘file://’ URI format. when may be omitted, or one of:
- none - Do not use hyperlinks at all. This is the default.
• auto - Only use hyperlinks if standard output is a terminal.
• always - Always use hyperlinks.

Specifying --hyperlink and no when is equivalent to --hyperlink=always.

'--indicator-style=word'
Append a character indicator with style word to entry names, as follows:
'none'       Do not append any character indicator; this is the default.
'slash'      Append '/' for directories. This is the same as the -p option.
'file-type'  Append '/' for directories, '@' for symbolic links, 'l' for FIFOs, '=' for sockets, and nothing for regular files. This is the same as the --file-type option.
'classify'   Append '*' for executable regular files, otherwise behave as for 'file-type'. This is the same as the --classify (-F) option.

'--kibibytes'
Set the default block size to its normal value of 1024 bytes, overriding any contrary specification in environment variables (see Section 2.2 [Block size], page 3). If --block-size, --human-readable (-h), or --si options are used, they take precedence even if --kibibytes (-k) is placed after

The --kibibytes (-k) option affects the per-directory block count written in long format, and the file system allocation written by the --size (-s) option.
It does not affect the file size in bytes that is written in long format.

'--format=commas'
List files horizontally, with as many as will fit on each line, separated by ',', (a comma and a space), and with no other information.

'--format=across'
List the files in columns, sorted horizontally.

'--tabsize=cols'
Assume that each tab stop is cols columns wide. The default is 8. ls uses tabs where possible in the output, for efficiency. If cols is zero, do not use tabs at all.
Some terminal emulators might not properly align columns to the right of a TAB following a non-ASCII byte. You can avoid that issue by using the -T0 option or put TABSIZE=0 in your environment, to tell ls to align using spaces, not tabs.
If you set a terminal’s hardware tabs to anything other than the default, you should also use a `--tabsize` option or `TABSIZE` environment variable either to match the hardware tabs, or to disable the use of hardware tabs. Otherwise, the output of `ls` may not line up. For example, if you run the shell command `tabs -4` to set hardware tabs to every four columns, you should also run `export TABSIZE=4` or `export TABSIZE=0`, or use the corresponding `--tabsize` options.

`-w cols`

`--width=cols`

Assume the screen is `cols` columns wide. The default is taken from the terminal settings if possible; otherwise the environment variable `COLUMNS` is used if it is set; otherwise the default is 80. With a `cols` value of ‘0’, there is no limit on the length of the output line, and that single output line will be delimited with spaces, not tabs.

`--zero`

Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines. This option is incompatible with the `--dired` (–D) option. This option also implies the options `--show-control-chars`, `-1`, `--color=none`, and `--quoting-style=literal` (–N).

### 10.1.5 Formatting file timestamps

By default, file timestamps are listed in abbreviated form, using a date like ‘Mar 30 2020’ for non-recent timestamps, and a date-without-year and time like ‘Mar 30 23:45’ for recent timestamps. This format can change depending on the current locale as detailed below.

A timestamp is considered to be *recent* if it is less than six months old, and is not dated in the future. If a timestamp dated today is not listed in recent form, the timestamp is in the future, which means you probably have clock skew problems which may break programs like `make` that rely on file timestamps. See Chapter 28 [File timestamps], page 241.

Timestamps are listed according to the time zone rules specified by the `TZ` environment variable, or by the system default rules if `TZ` is not set. See Section “Specifying the Time Zone with `TZ`” in *The GNU C Library Reference Manual*.

The following option changes how file timestamps are printed.

`--time-style=style`

List timestamps in style `style`. The `style` should be one of the following:

`+format`

List timestamps using `format`, where `format` is interpreted like the format argument of `date` (see Section 21.1 [date invocation], page 192). For example, `--time-style="+%Y-%m-%d %H:%M:%S"` causes `ls` to list timestamps like ‘2020–03–30 23:45:56’. As with `date`, `format`’s interpretation is affected by the `LC_TIME` locale category.

If `format` contains two format strings separated by a newline, the former is used for non-recent files and the latter for recent files; if you want output columns to line up, you may need to insert spaces in one of the two formats.
Chapter 10: Directory listing

‘full-iso’
List timestamps in full using ISO 8601-like date, time, and time zone components with nanosecond precision, e.g., ‘2020-07-21 23:45:56.477817180 -0400’. This style is equivalent to ‘+%Y-%m-%d %H:%M:%S.%N %z’.

This is useful because the time output includes all the information that is available from the operating system. For example, this can help explain `make`’s behavior, since GNU `make` uses the full timestamp to determine whether a file is out of date.

‘long-iso’
List ISO 8601 date and time components with minute precision, e.g., ‘2020-03-30 23:45’. These timestamps are shorter than ‘full-iso’ timestamps, and are usually good enough for everyday work. This style is equivalent to ‘+%Y-%m-%d %H:%M’.

‘iso’
List ISO 8601 dates for non-recent timestamps (e.g., ‘2020-03-30’), and ISO 8601-like month, day, hour, and minute for recent timestamps (e.g., ‘03-30 23:45’). These timestamps are uglier than ‘long-iso’ timestamps, but they carry nearly the same information in a smaller space and their brevity helps `ls` output fit within traditional 80-column output lines. The following two `ls` invocations are equivalent:

```
newline=''

ls -l --time-style="+%Y-%m-%d %newline%m-%d %H:%M"
ls -l --time-style="iso"
```

‘locale’
List timestamps in a locale-dependent form. For example, a French locale might list non-recent timestamps like ‘30 mars 2020’ and recent timestamps like ‘30 mars 23:45’. Locale-dependent timestamps typically consume more space than ‘iso’ timestamps and are harder for programs to parse because locale conventions vary so widely, but they are easier for many people to read.

The `LC_TIME` locale category specifies the timestamp format. The default POSIX locale uses timestamps like ‘Mar 30 2020’ and ‘Mar 30 23:45’; in this locale, the following two `ls` invocations are equivalent:

```
newline=''

ls -l --time-style="+%b %e %Y$newline%b %e %H:%M"
ls -l --time-style="locale"
```

Other locales behave differently. For example, in a German locale, `--time-style="locale"` might be equivalent to `--time-style="+%e. %b %Y $newline%e. %b %H:%M"` and might generate timestamps like ‘30. Mär 2020 ’ and ‘30. Mär 23:45’.
`posix-style`

List POSIX-locale timestamps if the LC_TIME locale category is POSIX, style timestamps otherwise. For example, the `posix-long-iso` style lists timestamps like ‘Mar 30 2020’ and ‘Mar 30 23:45’ when in the POSIX locale, and like ‘2020-03-30 23:45’ otherwise.

You can specify the default value of the `--time-style` option with the environment variable `TIME_STYLE`; if `TIME_STYLE` is not set the default style is ‘locale’. GNU Emacs 21.3 and later use the `--dired` option and therefore can parse any date format, but if you are using Emacs 21.1 or 21.2 and specify a non-POSIX locale you may need to set `TIME_STYLE="posix-long-iso"`.

To avoid certain denial-of-service attacks, timestamps that would be longer than 1000 bytes may be treated as errors.

### 10.1.6 Formatting the file names

These options change how file names themselves are printed.

`-b`

`--escape`

`--quoting-style=escape`

Quote nongraphic characters in file names using alphabetic and octal backslash sequences like those used in C.

`-N`

`--literal`

`--quoting-style=literal`

Do not quote file names. However, with `ls` nongraphic characters are still printed as question marks if the output is a terminal and you do not specify the `--show-control-chars` option.

`-q`

`--hide-control-chars`

Print question marks instead of nongraphic characters in file names. This is the default if the output is a terminal and the program is `ls`.

`-Q`

`--quote-name`

`--quoting-style=c`

Enclose file names in double quotes and quote nongraphic characters as in C.

`--quoting-style=word`

Use style `word` to quote file names and other strings that may contain arbitrary characters. The `word` should be one of the following:

`literal`  Output strings as-is; this is the same as the `--literal (-N)` option.

`shell` Quote strings for the shell if they contain shell metacharacters or would cause ambiguous output. The quoting is suitable for POSIX-compatible shells like `bash`, but it does not always work for incompatible shells like `csh`. 
Chapter 10: Directory listing

'shell-always'
Quote strings for the shell, even if they would normally not require quoting.

'shell-escape'
Like 'shell', but also quoting non-printable characters using the POSIX proposed '¨' syntax suitable for most shells.

'shell-escape-always'
Like 'shell-escape', but quote strings even if they would normally not require quoting.

'c'
Quote strings as for C character string literals, including the surrounding double-quote characters; this is the same as the --quote-name (-q) option.

'escape'
Quote strings as for C character string literals, except omit the surrounding double-quote characters; this is the same as the --escape (-b) option.

'locale'
Quote strings as for C character string literals, except use surrounding quotation marks appropriate for the locale.

'locale'
Quote strings as for C character string literals, except use surrounding quotation marks appropriate for the locale, and quote 'like this' instead of "like this" in the default C locale. This looks nicer on many displays.

You can specify the default value of the --quoting-style option with the environment variable QUOTING_STYLE. If that environment variable is not set, the default value is 'shell-escape' when the output is a terminal, and 'literal' otherwise.

'--show-control-chars'
Print nongraphic characters as-is in file names. This is the default unless the output is a terminal and the program is ls.

10.2 dir: Briefly list directory contents

dir is equivalent to ls -C -b; that is, by default files are listed in columns, sorted vertically, and special characters are represented by backslash escape sequences.

See Section 10.1 [ls invocation], page 89.

10.3 vdir: Verbosely list directory contents

vdir is equivalent to ls -l -b; that is, by default files are listed in long format and special characters are represented by backslash escape sequences.

See Section 10.1 [ls invocation], page 89.
10.4 dircolors: Color setup for ls

dircolors outputs a sequence of shell commands to set up the terminal for color output from `ls` (and `dir`, etc.). Typical usage:

```bash
eval "$(dircolors [option]... [file])"
```

If `file` is specified, dircolors reads it to determine which colors to use for which file types and extensions. Otherwise, a precompiled database is used. For details on the format of these files, run `dircolors --print-database`.

To make dircolors read a `~/.dircolors` file if it exists, you can put the following lines in your `~/.bashrc` (or adapt them to your favorite shell):

```bash
d=.dircolors
test -r $d && eval "$(dircolors $d)"
```

The output is a shell command to set the `LS_COLORS` environment variable. You can specify the shell syntax to use on the command line, or dircolors will guess it from the value of the `SHELL` environment variable.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-b`
`--sh`
`--bourne-shell`
Output Bourne shell commands. This is the default if the `SHELL` environment variable is set and does not end with `csh` or `tcsh`.

`-c`
`--csh`
`--c-shell`
Output C shell commands. This is the default if `SHELL` ends with `csh` or `tcsh`.

`-p`
`--print-database`
Print the (compiled-in) default color configuration database. This output is itself a valid configuration file, and is fairly descriptive of the possibilities.

`--print-ls-colors`
Print the `LS_COLORS` entries on separate lines, each colored as per the color they represent.

An exit status of zero indicates success, and a nonzero value indicates failure.
11 Basic operations

This chapter describes the commands for basic file manipulation: copying, moving (renaming), and deleting (removing).

11.1 cp: Copy files and directories

cp copies files (or, optionally, directories). The copy is completely independent of the original. You can either copy one file to another, or copy arbitrarily many files to a destination directory. Synopses:

```
cp [option]... [-T] source dest
cp [option]... source... directory
cp [option]... -t directory source...
```

- If two file names are given, cp copies the first file to the second.
- If the `--target-directory` (-t) option is given, or failing that if the last file is a directory and the `--no-target-directory` (-T) option is not given, cp copies each source file to the specified directory, using the sources' names.

Generally, files are written just as they are read. For exceptions, see the `--sparse` option below.

By default, cp does not copy directories. However, the `-R`, `-a`, and `-r` options cause cp to copy recursively by descending into source directories and copying files to corresponding destination directories.

When copying from a symbolic link, cp normally follows the link only when not copying recursively or when `--link` (-l) is used. This default can be overridden with the `--archive` (-a), `-d`, `--dereference` (-L), `--no-dereference` (-P), and `-H` options. If more than one of these options is specified, the last one silently overrides the others.

When copying to a symbolic link, cp follows the link only when it refers to an existing regular file. However, when copying to a dangling symbolic link, cp refuses by default, and fails with a diagnostic, since the operation is inherently dangerous. This behavior is contrary to historical practice and to POSIX. Set `POSIXLY_CORRECT` to make cp attempt to create the target of a dangling destination symlink, in spite of the possible risk. Also, when an option like `--backup` or `--link` acts to rename or remove the destination before copying, cp renames or removes the symbolic link rather than the file it points to.

By default, cp copies the contents of special files only when not copying recursively. This default can be overridden with the `--copy-contents` option.

cp generally refuses to copy a file onto itself, with the following exception: if `--force` `--backup` is specified with source and dest identical, and referring to a regular file, cp will make a backup file, either regular or numbered, as specified in the usual ways (see Section 2.1 [Backup options], page 2). This is useful when you simply want to make a backup of an existing file before changing it.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-a`
`'--archive'`

Preserve as much as possible of the structure and attributes of the original files in the copy (but do not attempt to preserve internal directory structure; i.e.,
'ls -U' may list the entries in a copied directory in a different order). Try to preserve SELinux security context and extended attributes (xattr), but ignore any failure to do that and print no corresponding diagnostic. Equivalent to -dR --preserve=all with the reduced diagnostics.

'--attributes-only'
Copy only the specified attributes of the source file to the destination. If the destination already exists, do not alter its contents. See the --preserve option for controlling which attributes to copy.

'-b'
'--backup[=method]'
See Section 2.1 [Backup options], page 2. Make a backup of each file that would otherwise be overwritten or removed. As a special case, cp makes a backup of source when the force and backup options are given and source and dest are the same name for an existing, regular file. One useful application of this combination of options is this tiny Bourne shell script:

```
#!/bin/sh
# Usage: backup FILE...
# Create a GNU-style backup of each listed FILE.
fail=0
for i; do
cp --backup --force --preserve=all -- "$i" "$i" || fail=1
done
echo $fail
```

'--copy-contents'
If copying recursively, copy the contents of any special files (e.g., FIFOs and device files) as if they were regular files. This means trying to read the data in each source file and writing it to the destination. It is usually a mistake to use this option, as it normally has undesirable effects on special files like FIFOs and the ones typically found in the /dev directory. In most cases, cp -R --copy-contents will hang indefinitely trying to read from FIFOs and special files like /dev/console, and it will fill up your destination file system if you use it to copy /dev/zero. This option has no effect unless copying recursively, and it does not affect the copying of symbolic links.

'-d'
Copy symbolic links as symbolic links rather than copying the files that they point to, and preserve hard links between source files in the copies. Equivalent to --no-dereference --preserve=links.

'--debug'
Print extra information to stdout, explaining how files are copied. This option implies the --verbose option.

'-f'
'--force'
When copying without this option and an existing destination file cannot be opened for writing, the copy fails. However, with --force, when a destination file cannot be opened, cp then tries to recreate the file by first removing it. Note --force alone will not remove dangling symlinks. When this option is combined with --link (-l) or --symbolic-link (-s), the destination link is replaced, and
unless --backup (-b) is also given there is no brief moment when the destination does not exist. Also see the description of --remove-destination. This option is independent of the --interactive or -i option: neither cancels the effect of the other. This option is ignored when the --no-clobber or -n option is also used.

'-H'
If a command line argument specifies a symbolic link, then copy the file it points to rather than the symbolic link itself. However, copy (preserving its nature) any symbolic link that is encountered via recursive traversal.

'-i'
'--interactive'
When copying a file other than a directory, prompt whether to overwrite an existing destination file, and fail if the response is not affirmative. The -i option overrides a previous -n option.

'-l'
'--link'
Make hard links instead of copies of non-directories.

'-L'
'--dereference'
Follow symbolic links when copying from them. With this option, cp cannot create a symbolic link. For example, a symlink (to regular file) in the source tree will be copied to a regular file in the destination tree.

'-n'
'--no-clobber'
Do not overwrite an existing file; silently fail instead. This option overrides a previous -i option. This option is mutually exclusive with -b or --backup option.

'-p'
'--no-dereference'
Copy symbolic links as symbolic links rather than copying the files that they point to. This option affects only symbolic links in the source; symbolic links in the destination are always followed if possible.

'-p'
'--preserve[=attribute_list]'
Preserve the specified attributes of the original files. If specified, the attribute_list must be a comma-separated list of one or more of the following strings:

'mode'
Preserve attributes relevant to access permissions, including file mode bits and (if possible) access control lists (ACLs). ACL preservation is system-dependent, and ACLs are not necessarily translated when the source and destination are on file systems with different ACL formats (e.g., NFSv4 versus POSIX formats).

'ownership'
Preserve the owner and group. On most modern systems, only users with appropriate privileges may change the owner of a file, and
ordinary users may preserve the group ownership of a file only if they happen to be a member of the desired group.

'timestamps'
Preserve the times of last access and last modification, when possible. On older systems, it is not possible to preserve these attributes when the affected file is a symbolic link. However, many systems now provide the utimensat function, which makes it possible even for symbolic links.

'links' Preserve in the destination files any links between corresponding source files. Note that with -L or -H, this option can convert symbolic links to hard links. For example,

```
$ mkdir c; : > a; ln -s a b; cp -aH a b c; ls -il c
74161745 a
74161745 b
```

Note the inputs: b is a symlink to regular file a, yet the files in destination directory, c/, are hard-linked. Since -a implies --no-dereference it would copy the symlink, but the later -H tells cp to dereference the command line arguments where it then sees two files with the same inode number. Then the --preserve=links option also implied by -a will preserve the perceived hard link.

Here is a similar example that exercises cp’s -L option:

```
$ mkdir b c; (cd b; : > a; ln -s a b); cp -aL b c; ls -il c/b
74163295 a
74163295 b
```

'context' Preserve SELinux security context of the file, or fail with full diagnostics.

'xattr' Preserve extended attributes of the file, or fail with full diagnostics. If cp is built without xattr support, ignore this option. If SELinux context, ACLs or Capabilities are implemented using xattrs, they are preserved implicitly by this option as well, i.e., even without specifying --preserve=mode or --preserve=context.

'all' Preserve all file attributes. Equivalent to specifying all of the above, but with the difference that failure to preserve SELinux security context or extended attributes does not change cp’s exit status. In contrast to -a, all but 'Operation not supported' warnings are output.

Using --preserve with no attribute_list is equivalent to --preserve=mode,ownership,timestamps.

In the absence of this option, the permissions of existing destination files are unchanged. Each new file is created with the mode of the corresponding source file minus the set-user-ID, set-group-ID, and sticky bits as the create mode; the operating system then applies either the umask or a default ACL, possibly resulting in a more restrictive file mode. See Chapter 27 [File permissions], page 233.
'--no-preserve=attribute_list'
Do not preserve the specified attributes. The attribute_list has the same form as for --preserve.

'--parents'
Form the name of each destination file by appending to the target directory a slash and the specified name of the source file. The last argument given to cp must be the name of an existing directory. For example, the command:

```
cp --parents a/b/c existing_dir
```

copies the file a/b/c to existing_dir/a/b/c, creating any missing intermediate directories.

'--reflink[=when]'  
Perform a lightweight, copy-on-write (COW) copy, if supported by the file system. Once it has succeeded, beware that the source and destination files share the same data blocks as long as they remain unmodified. Thus, if an I/O error affects data blocks of one of the files, the other suffers the same fate.

The when value can be one of the following:

'always' If the copy-on-write operation is not supported then report the failure for each file and exit with a failure status. Plain --reflink is equivalent to --reflink=always.

'auto' If the copy-on-write operation is not supported then fall back to the standard copy behavior. This is the default if no --reflink option is given.

'never' Disable copy-on-write operation and use the standard copy behavior.

This option is overridden by the --link, --symbolic-link and --attributes-only options, thus allowing it to be used to configure the default data copying behavior for cp.

'--remove-destination'
Remove each existing destination file before attempting to open it (contrast with -f above).
A **sparse file** contains **holes** – a sequence of zero bytes that does not occupy any file system blocks; the ‘**read**’ system call reads these as zeros. This can both save considerable space and increase speed, since many binary files contain lots of consecutive zero bytes. By default, **cp** detects holes in input source files via a crude heuristic and makes the corresponding output file sparse as well. Only regular files may be sparse.

The *when* value can be one of the following:

- **auto**  The default behavior: if the input file is sparse, attempt to make the output file sparse, too. However, if an output file exists but refers to a non-regular file, then do not attempt to make it sparse.

- **always**  For each sufficiently long sequence of zero bytes in the input file, attempt to create a corresponding hole in the output file, even if the input file does not appear to be sparse. This is useful when the input file resides on a file system that does not support sparse files (for example, ‘**efs**’ file systems in SGI IRIX 5.3 and earlier), but the output file is on a type of file system that does support them. Holes may be created only in regular files, so if the destination file is of some other type, **cp** does not even try to make it sparse.

- **never**  Never make the output file sparse. This is useful in creating a file for use with the **mkswap** command, since such a file must not have any holes.

For example, with the following alias, **cp** will use the minimum amount of space supported by the file system. (Older versions of **cp** can also benefit from **--reflink=auto** here.)

```
alias cp='cp --sparse=always'
```

- **--strip-trailing-slashes**  Remove any trailing slashes from each source argument. See Section 2.7 [Trailing slashes], page 9.

- **-s**

- **--symbolic-link**  Make symbolic links instead of copies of non-directories. All source file names must be absolute (starting with ‘/’) unless the destination files are in the current directory. This option merely results in an error message on systems that do not support symbolic links.

- **-S suffix**

- **--suffix=**  Append suffix to each backup file made with **-b**. See Section 2.1 [Backup options], page 2.

- **-t directory**

- **--target-directory=**  Specify the destination directory. See Section 2.6 [Target directory], page 7.
Do not treat the last operand specially when it is a directory or a symbolic link to a directory. See Section 2.6 [Target directory], page 7.

Do not copy a non-directory that has an existing destination with the same or newer modification timestamp; instead, silently skip the file without failing. If timestamps are being preserved, the comparison is to the source timestamp truncated to the resolutions of the destination file system and of the system calls used to update timestamps; this avoids duplicate work if several `cp -pu' commands are executed with the same source and destination. This option is ignored if the -n or --no-clobber option is also specified. Also, if --preserve=links is also specified (like with `cp -au' for example), that will take precedence; consequently, depending on the order that files are processed from the source, newer files in the destination may be replaced, to mirror hard links in the source.

which gives more control over which existing files in the destination are replaced, and its value can be one of the following:

'all' This is the default operation when an --update option is not specified, and results in all existing files in the destination being replaced.

'none' This is similar to the --no-clobber option, in that no files in the destination are replaced, but also skipping a file does not induce a failure.

'older' This is the default operation when --update is specified, and results in files being replaced if they’re older than the corresponding source file.

Print the name of each file before copying it.

Skip subdirectories that are on different file systems from the one that the copy started on. However, mount point directories are copied.

Without a specified context, adjust the SELinux security context according to the system default type for destination files, similarly to the restorecon command. The long form of this option with a specific context specified, will set the context for newly created files only. With a specified context, if both SELinux and SMACK are disabled, a warning is issued. This option is mutually exclusive with the --preserve=context option, and overrides the --preserve=all and -a options.

An exit status of zero indicates success, and a nonzero value indicates failure.
11.2 dd: Convert and copy a file

dd copies input to output with a changeable I/O block size, while optionally performing conversions on the data. Synopses:

```
    dd [operand]...
    dd option
```

The only options are `--help` and `--version`. See Chapter 2 [Common options], page 2.

By default, dd copies standard input to standard output. To copy, dd repeatedly does the following steps in order:

1. Read an input block.
2. If converting via ‘sync’, pad as needed to meet the input block size. Pad with spaces if converting via ‘block’ or ‘unblock’, NUL bytes otherwise.
3. If ‘bs=’ is given and no conversion mentioned in steps (4) or (5) is given, output the data as a single block and skip all remaining steps.
4. If the ‘swab’ conversion is given, swap each pair of input bytes. If the input data length is odd, preserve the last input byte (since there is nothing to swap it with).
5. If any of the conversions ‘swab’, ‘block’, ‘unblock’, ‘lcase’, ‘ucase’, ‘ascii’, ‘ebcdic’ and ‘ibm’ are given, do these conversions. These conversions operate independently of input blocking, and might deal with records that span block boundaries.
6. Aggregate the resulting data into output blocks of the specified size, and output each output block in turn. Do not pad the last output block; it can be shorter than usual.

dd accepts the following operands, whose syntax was inspired by the DD (data definition) statement of OS/360 JCL.

- `if=file` Read from file instead of standard input.
- `of=file` Write to file instead of standard output. Unless `conv=notrunc` is given, truncate file before writing it.
- `ibs=bytes` Set the input block size to bytes. This makes dd read bytes per block. The default is 512 bytes.
- `obs=bytes` Set the output block size to bytes. This makes dd write bytes per block. The default is 512 bytes.
- `bs=bytes` Set both input and output block sizes to bytes. This makes dd read and write bytes per block, overriding any ‘ibs’ and ‘obs’ settings. In addition, if no data-transforming `conv` operand is specified, input is copied to the output as soon as it’s read, even if it is smaller than the block size.
- `cbs=bytes` Set the conversion block size to bytes. When converting variable-length records to fixed-length ones (conv=block) or the reverse (conv=unblock), use bytes as the fixed record length.
'skip\equal{}n’
Skip \(n\) ’ib’s’-byte blocks in the input file before copying. If \(n\) ends in the letter ’B’, interpret \(n\) as a byte count rather than a block count. (’B’ and the ’iseek=’ spelling are GNU extensions to POSIX.)

’iseek=n’
Skip \(n\) ’obs’-byte blocks in the input file before copying. If \(n\) ends in the letter ’B’, interpret \(n\) as a byte count rather than a block count. (’B’ and the ’oseek=’ spelling are GNU extensions to POSIX.)

’seek=n’
Skip \(n\) ’obs’-byte blocks in the output file before truncating or copying. If \(n\) ends in the letter ’B’, interpret \(n\) as a byte count rather than a block count. (’B’ and the ’oseek=’ spelling are GNU extensions to POSIX.)

’oseek=n’
Skip \(n\) ’obs’-byte blocks in the output file before truncating or copying. If \(n\) ends in the letter ’B’, interpret \(n\) as a byte count rather than a block count. (’B’ and the ’oseek=’ spelling are GNU extensions to POSIX.)

’count=n’
Copy \(n\) ’ib’s’-byte blocks from the input file, instead of everything until the end of the file. If \(n\) ends in the letter ’B’, interpret \(n\) as a byte count rather than a block count; this is a GNU extension to POSIX. If short reads occur, as could be the case when reading from a pipe for example, ’iflag=fullblock’ ensures that ’count’ counts complete input blocks rather than input read operations. As an extension to POSIX, ’count=0’ copies zero blocks instead of copying all blocks.

’status=level’
Specify the amount of information printed. If this operand is given multiple times, the last one takes precedence. The level value can be one of the following:

’none’ Do not print any informational or warning messages to standard error. Error messages are output as normal.

’noxfer’ Do not print the final transfer rate and volume statistics that normally make up the last status line.

’progress’ Print the transfer rate and volume statistics on standard error, when processing each input block. Statistics are output on a single line at most once every second, but updates can be delayed when waiting on I/O.

Transfer information is normally output to standard error upon receipt of the ’INFO’ signal or when dd exits, and defaults to the following form in the C locale:

\[
\begin{align*}
7287+1 & \text{ records in} \\
116608+0 & \text{ records out} \\
59703296 & \text{ bytes (60 MB, 57 MiB) copied, 0.0427974 s, 1.4 GB/s} \\
\end{align*}
\]

The notation ’\(w+p\)’ stands for \(w\) whole blocks and \(p\) partial blocks. A partial block occurs when a read or write operation succeeds but transfers less data than the block size. An additional line like ’1 truncated record’ or ’10 truncated records’ is output after the ’records out’ line if ’conv=block’ processing truncated one or more input records.

The ’status=’ operand is a GNU extension to POSIX.

’conv=conversion[,conversion]...’
Convert the file as specified by the conversion argument(s). (No spaces around any comma(s).)
Conversions:
Convert EBCDIC to ASCII, using the conversion table specified by POSIX. This provides a 1:1 translation for all 256 bytes. This implies `conv=unblock`; input is converted to ASCII before trailing spaces are deleted.

Convert ASCII to EBCDIC. This is the inverse of the `asci` conversion. This implies `conv=block`; trailing spaces are added before being converted to EBCDIC.

This acts like `conv=ebcdic`, except it uses the alternate conversion table specified by POSIX. This is not a 1:1 translation, but reflects common historical practice for ‘~’, ‘[’, and ‘]’.

The `asci`, `ebcdic`, and `ibm` conversions are mutually exclusive. If you use any of these conversions, you should also use the `cbs=` operand.

For each line in the input, output `cbs` bytes, replacing the input newline with a space and truncating or padding input lines with spaces as necessary.

Remove any trailing spaces in each `cbs`-sized input block, and append a newline.

The `block` and `unblock` conversions are mutually exclusive. If you use either of these conversions, you should also use the `cbs=` operand.

Change uppercase letters to lowercase.

Change lowercase letters to uppercase.

The `lcase` and `ucase` conversions are mutually exclusive.

Try to seek rather than write NUL output blocks. On a file system that supports sparse files, this will create sparse output when extending the output file. Be careful when using this conversion in conjunction with `conv=notrunc` or `oflag=append`. With `conv=notrunc`, existing data in the output file corresponding to NUL blocks from the input, will be untouched. With `oflag=append` the seeks performed will be ineffective. Similarly, when the output is a device rather than a file, NUL input blocks are not copied, and therefore this conversion is most useful with virtual or pre zeroed devices.

The `sparse` conversion is a GNU extension to POSIX.

Swap every pair of input bytes.

Pad every input block to size of `ibs` with trailing zero bytes. When used with `block` or `unblock`, pad with spaces instead of zero bytes.

The following “conversions” are really file flags and don’t affect internal processing:

Fail if the output file already exists; `dd` must create the output file itself.
Chapter 11: Basic operations

'`nocreat`' Do not create the output file; the output file must already exist. The 'excl' and 'nocreat' conversions are mutually exclusive, and are GNU extensions to POSIX.

'`notrunc`' Do not truncate the output file.

'`noerror`' Continue after read errors.

'`fdatasync`' Synchronize output data just before finishing, even if there were write errors. This forces a physical write of output data, so that even if power is lost the output data will be preserved. If neither this nor 'fsync' are specified, output is treated as usual with file systems, i.e., output data and metadata may be cached in primary memory for some time before the operating system physically writes it, and thus output data and metadata may be lost if power is lost. See Section 14.4 [sync invocation], page 157. This conversion is a GNU extension to POSIX.

'`fsync`' Synchronize output data and metadata just before finishing, even if there were write errors. This acts like 'fdatasync' except it also preserves output metadata, such as the last-modified time of the output file; for this reason it may be a bit slower than 'fdatasync' although the performance difference is typically insignificant for dd. This conversion is a GNU extension to POSIX.

'`iflag=flag[,,flag]...`'
Access the input file using the flags specified by the flag argument(s). (No spaces around any comma(s).)

'`oflag=flag[,,flag]...`'
Access the output file using the flags specified by the flag argument(s). (No spaces around any comma(s).)

Here are the flags.

'`append`' Write in append mode, so that even if some other process is writing to this file, every dd write will append to the current contents of the file. This flag makes sense only for output. If you combine this flag with the 'of=file' operand, you should also specify 'conv=notrunc' unless you want the output file to be truncated before being appended to.

'`cio`' Use concurrent I/O mode for data. This mode performs direct I/O and drops the POSIX requirement to serialize all I/O to the same file. A file cannot be opened in CIO mode and with a standard open at the same time.

'`direct`' Use direct I/O for data, avoiding the buffer cache. Note that the kernel may impose restrictions on read or write buffer sizes. For example, with an ext4 destination file system and a Linux-based kernel, using 'oflag=direct' will cause writes to fail with EINVAL if the output buffer size is not a multiple of 512.
‘directory’
Fail unless the file is a directory. Most operating systems do not allow I/O to a directory, so this flag has limited utility.

‘dsync’
Use synchronized I/O for data. For the output file, this forces a physical write of output data on each write. For the input file, this flag can matter when reading from a remote file that has been written to synchronously by some other process. Metadata (e.g., last-access and last-modified time) is not necessarily synchronized.

‘sync’
Use synchronized I/O for both data and metadata.

‘nocache’
Request to discard the system data cache for a file. When count=0 all cached data for the file is specified, otherwise the cache is dropped for the processed portion of the file. Also when count=0, failure to discard the cache is diagnosed and reflected in the exit status.

Note data that is not already persisted to storage will not be discarded from cache, so note the use of the ‘sync’ conversions in the examples below, which are used to maximize the effectiveness of the ‘nocache’ flag.

Here are some usage examples:

```
# Advise to drop cache for whole file
dd if=ifile iflag=nocache count=0

# Ensure drop cache for the whole file
dd of=ofile oflag=nocache conv=notrunc,fdatasync count=0

# Advise to drop cache for part of file
# Note the kernel will only consider complete and
# already persisted pages.
dd if=ifile iflag=nocache skip=10 count=10 of=/dev/null

# Stream data using just the read-ahead cache.
# See also the ‘direct’ flag.
dd if=ifile of=ofile iflag=nocache oflag=nocache,sync
```

‘nonblock’
Use non-blocking I/O.

‘noatime’
Do not update the file’s access timestamp. See Chapter 28 [File timestamps], page 241. Some older file systems silently ignore this flag, so it is a good idea to test it on your files before relying on it.

‘noctty’
Do not assign the file to be a controlling terminal for dd. This has no effect when the file is not a terminal. On many hosts (e.g., GNU/Linux hosts), this flag has no effect at all.

‘nofollow’
Do not follow symbolic links.

‘nolinks’
Fail if the file has multiple hard links.
‘binary’  Use binary I/O. This flag has an effect only on nonstandard platforms that distinguish binary from text I/O.

‘text’  Use text I/O. Like ‘binary’, this flag has no effect on standard platforms.

‘fullblock’  
Accumulate full blocks from input. The read system call may return early if a full block is not available. When that happens, continue calling read to fill the remainder of the block. This flag can be used only with iflag. This flag is useful with pipes for example as they may return short reads. In that case, this flag is needed to ensure that a ‘count=’ argument is interpreted as a block count rather than a count of read operations.

These flags are all GNU extensions to POSIX. They are not supported on all systems, and ‘dd’ rejects attempts to use them when they are not supported. When reading from standard input or writing to standard output, the ‘nofollow’ and ‘noctty’ flags should not be specified, and the other flags (e.g., ‘nonblock’) can affect how other processes behave with the affected file descriptors, even after dd exits.

The behavior of dd is unspecified if operands other than ‘conv=’, ‘iflag=’, ‘oflag=’, and ‘status=’ are specified more than once.

The numeric-valued strings above (n and bytes) are unsigned decimal integers that can be followed by a multiplier: ‘b’=512, ‘c’=1, ‘w’=2, ‘xm’=m, or any of the standard block size suffixes like ‘k’=1024 (see Section 2.2 [Block size], page 3). These multipliers are GNU extensions to POSIX, except that POSIX allows bytes to be followed by ‘k’, ‘b’, and ‘xm’. Note ‘xm’ can be used more than once in a number. Block sizes (i.e., specified by bytes strings) must be nonzero.

Any block size you specify via ‘bs=’, ‘ibs=’, ‘obs=’, ‘cbs=’ should not be too large – values larger than a few megabytes are generally wasteful or (as in the gigabyte..exabyte case) downright counterproductive or error-inducing.

To process data with offset or size that is not a multiple of the I/O block size, you can use a numeric string n that ends in the letter ‘B’. For example, the following shell commands copy data in 1 MiB blocks between a flash drive and a tape, but do not save or restore a 512-byte area at the start of the flash drive:

```
flash=/dev/sda
tape=/dev/st0

# Copy all but the initial 512 bytes from flash to tape.
dd if=$flash iseek=512B bs=1MiB of=$tape

# Copy from tape back to flash, leaving initial 512 bytes alone.
dd if=$tape bs=1MiB of=$flash oseek=512B
```

For failing storage devices, other tools come with a great variety of extra functionality to ease the saving of as much data as possible before the device finally dies, e.g. GNU ddrescue (https://www.gnu.org/software/ddrescue/). However, in some cases such
a tool is not available or the administrator feels more comfortable with the handling of
$\text{dd}$. As a simple rescue method, call $\text{dd}$ as shown in the following example: the operand
\texttt{conv=\textit{noerror},\textit{sync}} is used to continue after read errors and to pad out bad reads with
NULs, while \texttt{iflag=\textit{fullblock}} caters for short reads (which traditionally never occur on
flash or similar devices):

\begin{verbatim}
# Rescue data from an (unmounted!) partition of a failing device.
\texttt{dd conv=\textit{noerror},\textit{sync} iflag=\textit{fullblock} \textless \textbackslash /dev/sda1 > /mnt/rescue.img}
\end{verbatim}

Sending an \texttt{INFO} signal (or \texttt{USR1} signal where that is unavailable) to a running $\text{dd}$
process makes it print I/O statistics to standard error and then resume copying. In the
example below, $\text{dd}$ is run in the background to copy 5GB of data. The $\texttt{kill}$ command
makes it output intermediate I/O statistics, and when $\text{dd}$ completes normally or is killed by
the \texttt{SIGINT} signal, it outputs the final statistics.

\begin{verbatim}
# Ignore the signal so we never inadvertently terminate the dd child.
# Note this is not needed when SIGINFO is available.
trap '' USR1

# Run dd with the fullblock iflag to avoid short reads
# which can be triggered by reception of signals.
\texttt{dd iflag=\textit{fullblock} if=/dev/zero of=/dev/null count=5000000 bs=1000 & pid=$!}

# Output stats every second.
while \texttt{kill -s USR1 $pid} 2>/dev/null; do sleep 1; done
\end{verbatim}

The above script will output in the following format:

3441325+0 records in
3441325+0 records out
3441325000 bytes (3.4 GB, 3.2 GiB) copied, 1.00036 s, 3.4 GB/s
5000000+0 records in
5000000+0 records out
5000000000 bytes (5.0 GB, 4.7 GiB) copied, 1.44433 s, 3.5 GB/s

The \texttt{status=progress} operand periodically updates the last line of the transfer statistics
above.

On systems lacking the \texttt{INFO} signal \texttt{dd} responds to the \texttt{USR1} signal instead, unless the
\texttt{POSIXLY\_CORRECT} environment variable is set.

An exit status of zero indicates success, and a nonzero value indicates failure.

\subsection*{11.3 \texttt{install}: Copy files and set attributes}

\texttt{install} copies files while setting their file mode bits and, if possible, their owner and group.

\texttt{Synopses:}

\begin{verbatim}
install [option]... [-T] source dest
install [option]... source... directory
install [option]... -t directory source...
install [option]... -d directory...
\end{verbatim}

\begin{itemize}
  \item If two file names are given, \texttt{install} copies the first file to the second.
\end{itemize}
Chapter 11: Basic operations

- If the `--target-directory (-t)` option is given, or failing that if the last file is a directory and the `--no-target-directory (-T)` option is not given, `install` copies each source file to the specified directory, using the sources' names.

- If the `--directory (-d)` option is given, `install` creates each directory and any missing parent directories. Parent directories are created with mode ‘u=rwx,go=rx’ (755), regardless of the `-m` option or the current umask. See Section 27.5 [Directory Setuid and Setgid], page 239, for how the set-user-ID and set-group-ID bits of parent directories are inherited.

`install` is similar to `cp`, but allows you to control the attributes of destination files. It is typically used in Makefiles to copy programs into their destination directories. It refuses to copy files onto themselves.

`install` never preserves extended attributes (xattr).

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--backup[=method]'

See Section 2.1 [Backup options], page 2. Make a backup of each file that would otherwise be overwritten or removed.

'--compare'

Compare content of source and destination files, and if there would be no change to the destination content, owner, group, permissions, and possibly SELinux context, then do not modify the destination at all. Note this option is best used in conjunction with `--user`, `--group` and `--mode` options, lest `install` incorrectly determines the default attributes that installed files would have (as it doesn’t consider setgid directories and POSIX default ACLs for example). This could result in redundant copies or attributes that are not reset to the correct defaults.

'--debug'

Print extra information to stdout, explaining how files are copied. This option implies the `--verbose` option.

'--group=group'

Set the group ownership of installed files or directories to `group`. The default is the process’s current group. `group` may be either a group name or a numeric group ID.
The file mode bits for the installed file or directory to mode, which can be either an octal number, or a symbolic mode as in chmod, with ‘a=’ (no access allowed to anyone) as the point of departure (see Chapter 27 [File permissions], page 233). The default mode is ‘u=rwx,go=rx,a-s’ – read, write, and execute for the owner, read and execute for group and other, and with set-user-ID and set-group-ID disabled. This default is not quite the same as ‘755’, since it disables instead of preserving set-user-ID and set-group-ID on directories. See Section 27.5 [Directory Setuid and Setgid], page 239.

If install has appropriate privileges (is run as root), set the ownership of installed files or directories to owner. The default is root. owner may be either a user name or a numeric user ID.

Preserve the SELinux security context of files and directories. Failure to preserve the context in all of the files or directories will result in an exit status of 1. If SELinux is disabled then print a warning and ignore the option.

Set the time of last access and the time of last modification of each installed file to match those of each corresponding original file. When a file is installed without this option, its last access and last modification timestamps are both set to the time of installation. This option is useful if you want to use the last modification timestamps of installed files to keep track of when they were last built as opposed to when they were last installed.

Strip the symbol tables from installed binary executables.

Program used to strip binaries.

Append suffix to each backup file made with -b. See Section 2.1 [Backup options], page 2.

Specify the destination directory. See Section 2.6 [Target directory], page 7. Also specifying the -D option will ensure the directory is present.

Do not treat the last operand specially when it is a directory or a symbolic link to a directory. See Section 2.6 [Target directory], page 7.
'-v'
'--verbose'
Print the name of each file before copying it.

'-Z'
'--context[=context]' Without a specified context, adjust the SELinux security context according to the system default type for destination files, similarly to the restorecon command. The long form of this option with a specific context specified, will set the context for newly created files only. With a specified context, if both SELinux and SMACK are disabled, a warning is issued. This option is mutually exclusive with the --preserve-context option.

An exit status of zero indicates success, and a nonzero value indicates failure.

11.4 mv: Move (rename) files

mv moves or renames files (or directories). Synopses:

\[ mv \ [\text{option}]... \ [-T] \ source \ dest \]
\[ mv \ [\text{option}]... \ source... \ directory \]
\[ mv \ [\text{option}]... \ -t \ directory \ source... \]

- If two file names are given, mv moves the first file to the second.
- If the --target-directory (-t) option is given, or failing that if the last file is a directory and the --no-target-directory (-T) option is not given, mv moves each source file to the specified directory, using the source's names.

To move a file, mv ordinarily simply renames it. However, if renaming does not work because the destination's file system differs, mv falls back on copying as if by cp -a, then (assuming the copy succeeded) it removes the original. If the copy fails, then mv removes any partially created copy in the destination. If you were to copy three directories from one file system to another and the copy of the first directory succeeded, but the second didn't, the first would be left on the destination file system and the second and third would be left on the original file system.

mv always tries to copy extended attributes (xattr), which may include SELinux context, ACLs or Capabilities. Upon failure all but ‘Operation not supported’ warnings are output.

If a destination file exists but is normally unwritable, standard input is a terminal, and the -f or --force option is not given, mv prompts the user for whether to replace the file. (You might own the file, or have write permission on its directory.) If the response is not affirmative, the file is skipped.

Warning: Avoid specifying a source name with a trailing slash, when it might be a symlink to a directory. Otherwise, mv may do something very surprising, since its behavior depends on the underlying rename system call. On a system with a modern Linux-based kernel, it fails with errno=ENOTDIR. However, on other systems (at least FreeBSD 6.1 and Solaris 10) it silently renames not the symlink but rather the directory referenced by the symlink. See Section 2.7 (Trailing slashes), page 9.

Note: mv will only replace empty directories in the destination. Conflicting populated directories are skipped with a diagnostic.
The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-b`
`--backup=`method`

See Section 2.1 [Backup options], page 2. Make a backup of each file that would otherwise be overwritten or removed.

`--debug`

Print extra information to stdout, explaining how files are copied. This option implies the `--verbose` option.

`-f`
`--force`

Do not prompt the user before removing a destination file. If you specify more than one of the -i, -f, -n options, only the final one takes effect.

`-i`
`--interactive`

Prompt whether to overwrite each existing destination file, regardless of its permissions, and fail if the response is not affirmative. If you specify more than one of the -i, -f, -n options, only the final one takes effect.

`-n`
`--no-clobber`

Do not overwrite an existing file; silently fail instead. If you specify more than one of the -i, -f, -n options, only the final one takes effect. This option is mutually exclusive with -b or --backup option. See also the `--update=none` option which will skip existing files but not fail.

`--no-copy`

If a file cannot be renamed because the destination file system differs, fail with a diagnostic instead of copying and then removing the file.

`-u`
`--update`

Do not move a non-directory that has an existing destination with the same or newer modification timestamp; instead, silently skip the file without failing. If the move is across file system boundaries, the comparison is to the source timestamp truncated to the resolutions of the destination file system and of the system calls used to update timestamps; this avoids duplicate work if several `mv -u` commands are executed with the same source and destination. This option is ignored if the -n or `--no-clobber` option is also specified.

which gives more control over which existing files in the destination are replaced, and its value can be one of the following:

`all` This is the default operation when an `--update` option is not specified, and results in all existing files in the destination being replaced.

`none` This is similar to the `--no-clobber` option, in that no files in the destination are replaced, but also skipping a file does not induce a failure.

`older` This is the default operation when `--update` is specified, and results in files being replaced if they’re older than the corresponding source file.
Chapter 11: Basic operations

'--verbose'
Print the name of each file before moving it.

'--strip-trailing-slashes'
Remove any trailing slashes from each source argument. See Section 2.7 [Trailing slashes], page 9.

'--suffix=suffix'
Append suffix to each backup file made with -b. See Section 2.1 [Backup options], page 2.

'--target-directory=directory'
Specify the destination directory. See Section 2.6 [Target directory], page 7.

'Do not treat the last operand specially when it is a directory or a symbolic link to a directory. See Section 2.6 [Target directory], page 7.

'--context'
This option functions similarly to the restorecon command, by adjusting the SELinux security context according to the system default type for destination files and each created directory.

An exit status of zero indicates success, and a nonzero value indicates failure.

11.5 rm: Remove files or directories
rm removes each given file. By default, it does not remove directories. Synopsis:

```
rm [option]... [file]...
```

If the -I or --interactive=once option is given, and there are more than three files or the -r, -R, or --recursive are given, then rm prompts the user for whether to proceed with the entire operation. If the response is not affirmative, the entire command is aborted.

Otherwise, if a file is unwritable, standard input is a terminal, and the -f or --force option is not given, or the -i or --interactive=always option is given, rm prompts the user for whether to remove the file. If the response is not affirmative, the file is skipped.

Any attempt to remove a file whose last file name component is . or .. is rejected without any prompting, as mandated by POSIX.

**Warning:** If you use rm to remove a file, it is usually possible to recover the contents of that file. If you want more assurance that the contents are unrecoverable, consider using shred.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--dir'
Remove the listed directories if they are empty.
-f
--force
Ignore nonexistent files and missing operands, and never prompt the user. Ignore any previous --interactive (-i) option.

-i
Prompt whether to remove each file. If the response is not affirmative, silently skip the file without failing. Ignore any previous --force (-f) option. Equivalent to --interactive=always.

-I
Prompt once whether to proceed with the command, if more than three files are named or if a recursive removal is requested. Ignore any previous --force (-f) option. Equivalent to --interactive=once.

--interactive [=when]
Specify when to issue an interactive prompt. when may be omitted, or one of:
- never - Do not prompt at all.
- once - Prompt once if more than three files are named or if a recursive removal is requested. Equivalent to -I.
- always - Prompt for every file being removed. Equivalent to -i.

--interactive with no when is equivalent to --interactive=always.

--one-file-system
When removing a hierarchy recursively, do not remove any directory that is on a file system different from that of the corresponding command line argument. This option is useful when removing a build “chroot” hierarchy, which normally contains no valuable data. However, it is not uncommon to bind-mount /home into such a hierarchy, to make it easier to use one’s start-up file. The catch is that it’s easy to forget to unmount /home. Then, when you use rm -rf to remove your normally throw-away chroot, that command will remove everything under /home, too. Use the --one-file-system option, and it will diagnose and skip directories on other file systems. Of course, this will not save your /home if it and your chroot happen to be on the same file system. See also --preserve-root=all to protect command line arguments themselves.

--preserve-root [=all]
Fail upon any attempt to remove the root directory, /, when used with the --recursive option. This is the default behavior. See Section 2.9 [Treating / specially], page 9. When ‘all’ is specified, reject any command line argument that is not on the same file system as its parent.

--no-preserve-root
Do not treat / specially when removing recursively. This option is not recommended unless you really want to remove all the files on your computer. See Section 2.9 [Treating / specially], page 9.

-r
-R
--recursive
Remove the listed directories and their contents recursively.
'--verbose'

Print the name of each file before removing it.

One common question is how to remove files whose names begin with a ‘-’. GNU rm, like every program that uses the getopt function to parse its arguments, lets you use the ‘--’ option to indicate that all following arguments are non-options. To remove a file called -f in the current directory, you could type either:

```
rm -- -f
```
or:

```
rm ./-f
```

The Unix rm program’s use of a single ‘-’ for this purpose predates the development of the getopt standard syntax.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 11.6 shred: Remove files more securely

shred overwrites devices or files, to help prevent even extensive forensics from recovering the data.

Ordinarily when you remove a file (see Section 11.5 [rm invocation], page 122), its data and metadata are not actually destroyed. Only the file’s directory entry is removed, and the file’s storage is reclaimed only when no process has the file open and no other directory entry links to the file. And even if file’s data and metadata’s storage space is freed for further reuse, there are undelete utilities that will attempt to reconstruct the file from the data in freed storage, and that can bring the file back if the storage was not rewritten.

On a busy system with a nearly-full device, space can get reused in a few seconds. But there is no way to know for sure. And although the undelete utilities and already-existing processes require insider or superuser access, you may be wary of the superuser, of processes running on your behalf, or of attackers that can physically access the storage device. So if you have sensitive data, you may want to be sure that recovery is not possible by plausible attacks like these.

The best way to remove something irretrievably is to destroy the media it’s on with acid, melt it down, or the like. For cheap removable media this is often the preferred method. However, some storage devices are expensive or are harder to destroy, so the shred utility tries to achieve a similar effect non-destructively, by overwriting the file with non-sensitive data.

Please note that shred relies on a crucial assumption: that the file system and hardware overwrite data in place. Although this is common and is the traditional way to do things, many modern file system designs do not satisfy this assumption. Exceptions include:

- Log-structured or journaled file systems, such as ext3/ext4 (in data=journal mode), Btrfs, NTFS, ReiserFS, XFS, ZFS, file systems supplied with AIX and Solaris, etc., when they are configured to journal data.
- File systems that write redundant data and carry on even if some writes fail, such as RAID-based file systems.
- File systems that make snapshots, such as Network Appliance’s NFS server.
File systems that cache in temporary locations, such as NFS version 3 clients.

Compressed file systems.

For ext3 and ext4 file systems, `shred` is less effective when the file system is in `data=journal` mode, which journals file data in addition to just metadata. In both the `data=ordered` (default) and `data=writeback` modes, `shred` works as usual. The ext3/ext4 journaling modes can be changed by adding the `data=something` option to the mount options for a particular file system in the `/etc/fstab` file, as documented in the `mount man` page ("man mount"). Alternatively, if you know how large the journal is, you can shred the journal by shredding enough file data so that the journal cycles around and fills up with shredded data.

If you are not sure how your file system operates, then you should assume that it does not overwrite data in place, which means `shred` cannot reliably operate on regular files in your file system.

Generally speaking, it is more reliable to shred a device than a file, since this bypasses file system design issues mentioned above. However, devices are also problematic for shredding, for reasons such as the following:

- Solid-state storage devices (SSDs) typically do wear leveling to prolong service life, and this means writes are distributed to other blocks by the hardware, so “overwritten” data blocks are still present in the underlying device.
- Most storage devices map out bad blocks invisibly to the application; if the bad blocks contain sensitive data, `shred` won’t be able to destroy it.
- With some obsolete storage technologies, it may be possible to take (say) a floppy disk back to a laboratory and use a lot of sensitive (and expensive) equipment to look for the faint “echoes” of the original data underneath the overwritten data. With these older technologies, if the file has been overwritten only once, it’s reputedly not even that hard. Luckily, this kind of data recovery has become difficult, and there is no public evidence that today’s higher-density storage devices can be analyzed in this way.

The `shred` command can use many overwrite passes, with data patterns chosen to maximize the damage they do to the old data. By default the patterns are designed for best effect on hard drives using now-obsolete technology; for newer devices, a single pass should suffice. For more details, see the source code and Peter Gutmann’s paper Secure Deletion of Data from Magnetic and Solid-State Memory (https://www.cs.auckland.ac.nz/~pgut001/pubs/securedel.html), from the proceedings of the Sixth USENIX Security Symposium (San Jose, California, July 22–25, 1996).

`shred` makes no attempt to detect or report these problems, just as it makes no attempt to do anything about backups. However, since it is more reliable to shred devices than files, `shred` by default does not deallocate or remove the output file. This default is more suitable for devices, which typically cannot be deallocated and should not be removed.

Finally, consider the risk of backups and mirrors. File system backups and remote mirrors may contain copies of the file that cannot be removed, and that will allow a shredded file to be recovered later. So if you keep any data you may later want to destroy using `shred`, be sure that it is not backed up or mirrored.

```
shred [option]... file[...]
```
The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'\-f'
'\--force' Override file permissions if necessary to allow overwriting.

'\-n number'
'\--iterations=number'
By default, shred uses 3 passes of overwrite. You can reduce this to save time, or increase it if you think it's appropriate. After 25 passes all of the internal overwrite patterns will have been used at least once.

'\--random-source=file'
Use file as a source of random data used to overwrite and to choose pass ordering. See Section 2.5 [Random sources], page 7.

'\-s bytes'
'\--size=bytes'
Shred the first bytes bytes of the file. The default is to shred the whole file. bytes can be followed by a size specification like 'K', 'M', or 'G' to specify a multiple. See Section 2.2 [Block size], page 3.

'\-u'
'\--remove[=how]'
After shredding a file, deallocate it (if possible) and then remove it. If a file has multiple links, only the named links will be removed. Often the file name is less sensitive than the file data, in which case the optional how parameter, supported with the long form option, gives control of how to more efficiently remove each directory entry. The 'unlink' parameter will just use a standard unlink call, 'wipe' will also first obfuscate bytes in the name, and 'wipesync' will also sync each obfuscated byte in the name to the file system. Note 'wipesync' is the default method, but can be expensive, requiring a sync for every character in every file. This can become significant with many files, or is redundant if your file system provides synchronous metadata updates.

'\-v'
'\--verbose'
Display to standard error all status updates as sterilization proceeds.

'\-x'
'\--exact'
By default, shred rounds the size of a regular file up to the next multiple of the file system block size to fully erase the slack space in the last block of the file. This space may contain portions of the current system memory on some systems for example. Use --exact to suppress that behavior. Thus, by default if you shred a 10-byte regular file on a system with 512-byte blocks, the resulting file will be 512 bytes long. With this option, shred does not increase the apparent size of the file.

'\-z'
'\--zero'
Normally, the last pass that shred writes is made up of random data. If this would be conspicuous on your storage device (for example, because it looks like encrypted data), or you just think it's tidier, the --zero option adds an
additional overwrite pass with all zero bits. This is in addition to the number of passes specified by the \texttt{--iterations} option.

You might use the following command to erase the file system you created on a USB flash drive. This command typically takes several minutes, depending on the drive’s size and write speed. On modern storage devices a single pass should be adequate, and will take one third the time of the default three-pass approach.

\texttt{shred -v -n 1 /dev/sdd1}

Similarly, to erase all data on a selected partition of your device, you could give a command like the following.

\texttt{# 1 pass, write pseudo-random data; 3x faster than the default}
\texttt{shred -v -n1 /dev/sda5}

To be on the safe side, use at least one pass that overwrites using pseudo-random data. I.e., don’t be tempted to use \texttt{--zero}, in case some device controller optimizes the process of writing blocks of all zeros, and thereby does not clear all bytes in a block. Some SSDs may do just that.

A file of \texttt{-} denotes standard output. The intended use of this is to shred a removed temporary file. For example:

\begin{verbatim}
i=$(mktemp)
exec 3<"$i"
rm -- "$i"
echo "Hello, world" >&3
shred - >&3
exec 3>-3
\end{verbatim}

However, the command \texttt{shred - >file} does not shred the contents of \texttt{file}, since the shell truncates \texttt{file} before invoking \texttt{shred}. Use the command \texttt{shred file} or (if using a Bourne-compatible shell) the command \texttt{shred - 1<>file} instead.

An exit status of zero indicates success, and a nonzero value indicates failure.
12 Special file types

This chapter describes commands which create special types of files (and rmdir, which removes directories, one special file type).

Although Unix-like operating systems have markedly fewer special file types than others, not everything can be treated only as the undifferentiated byte stream of normal files. For example, when a file is created or removed, the system must record this information, which it does in a directory – a special type of file. Although you can read directories as normal files, if you’re curious, in order for the system to do its job it must impose a structure, a certain order, on the bytes of the file. Thus it is a “special” type of file.

Besides directories, other special file types include named pipes (FIFOs), symbolic links, sockets, and so-called special files.

12.1 link: Make a hard link via the link syscall

link creates a single hard link at a time. It is a minimalist interface to the system-provided link function. See Section “Hard Links” in The GNU C Library Reference Manual. It avoids the bells and whistles of the more commonly-used ln command (see Section 12.2 [ln invocation], page 128). Synopsis:

```c
link filename linkname
```

filename must specify an existing file, and linkname must specify a nonexistent entry in an existing directory. link simply calls link (filename, linkname) to create the link.

On a GNU system, this command acts like ‘ln --directory --no-target-directory filename linkname’. However, the --directory and --no-target-directory options are not specified by POSIX, and the link command is more portable in practice.

If filename is a symbolic link, it is unspecified whether linkname will be a hard link to the symbolic link or to the target of the symbolic link. Use ln -P or ln -L to specify which behavior is desired.

An exit status of zero indicates success, and a nonzero value indicates failure.

12.2 ln: Make links between files

ln makes links between files. By default, it makes hard links; with the -s option, it makes symbolic (or soft) links. Synopses:

```
ln [option]... [-T] target linkname
ln [option]... target
ln [option]... target... directory
ln [option]... -t directory target...
```

• If two file names are given, ln creates a link to the first file from the second.
• If one target is given, ln creates a link to that file in the current directory.
• If the --target-directory (-t) option is given, or failing that if the last file is a directory and the --no-target-directory (-T) option is not given, ln creates a link to each target file in the specified directory, using the targets’ names.
Normally `ln` does not replace existing files. Use the `--force (-f)` option to replace them unconditionally, the `--interactive (-i)` option to replace them conditionally, and the `--backup (-b)` option to rename them. Unless the `--backup (-b)` option is used there is no brief moment when the destination does not exist; this is an extension to POSIX.

A **hard link** is another name for an existing file; the link and the original are indistinguishable. Technically speaking, they share the same inode, and the inode contains all the information about a file – indeed, it is not incorrect to say that the inode *is* the file. Most systems prohibit making a hard link to a directory; on those where it is allowed, only the super-user can do so (and with caution, since creating a cycle will cause problems to many other utilities). Hard links cannot cross file system boundaries. (These restrictions are not mandated by POSIX, however.)

**Symbolic links** (symlinks for short), on the other hand, are a special file type (which not all kernels support: System V release 3 (and older) systems lack symlinks) in which the link file actually refers to a different file, by name. When most operations (opening, reading, writing, and so on) are passed the symbolic link file, the kernel automatically dereferences the link and operates on the target of the link. But some operations (e.g., removing) work on the link file itself, rather than on its target. The owner and group of a symlink are not significant to file access performed through the link, but do have implications on deleting a symbolic link from a directory with the restricted deletion bit set. On the GNU system, the mode of a symlink has no significance and cannot be changed, but on some BSD systems, the mode can be changed and will affect whether the symlink will be traversed in file name resolution. See Section “Symbolic Links” in The GNU C Library Reference Manual.

Symbolic links can contain arbitrary strings; a **dangling symlink** occurs when the string in the symlink does not resolve to a file. There are no restrictions against creating dangling symbolic links. There are trade-offs to using absolute or relative symlinks. An absolute symlink always points to the same file, even if the directory containing the link is moved. However, if the symlink is visible from more than one machine (such as on a networked file system), the file pointed to might not always be the same. A relative symbolic link is resolved in relation to the directory that contains the link, and is often useful in referring to files on the same device without regards to what name that device is mounted on when accessed via networked machines.

When creating a relative symlink in a different location than the current directory, the resolution of the symlink will be different than the resolution of the same string from the current directory. Therefore, many users prefer to first change directories to the location where the relative symlink will be created, so that tab-completion or other file resolution will find the same target as what will be placed in the symlink.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`'-b'
`'--backup[=method]'`

See Section 2.1 [Backup options], page 2. Make a backup of each file that would otherwise be overwritten or removed.
Chapter 12: Special file types

'--directory'
Allow users with appropriate privileges to attempt to make hard links to directories. However, note that this will probably fail due to system restrictions, even for the super-user.

'--force'
Remove existing destination files.

'--interactive'
Prompt whether to remove existing destination files, and fail if the response is not affirmative.

'--logical'
If -s is not in effect, and the source file is a symbolic link, create the hard link to the file referred to by the symbolic link, rather than the symbolic link itself.

'--no-dereference'
Do not treat the last operand specially when it is a symbolic link to a directory. Instead, treat it as if it were a normal file.

When the destination is an actual directory (not a symlink to one), there is no ambiguity. The link is created in that directory. But when the specified destination is a symlink to a directory, there are two ways to treat the user’s request. ln can treat the destination just as it would a normal directory and create the link in it. On the other hand, the destination can be viewed as a non-directory – as the symlink itself. In that case, ln must delete or backup that symlink before creating the new link. The default is to treat a destination that is a symlink to a directory just like a directory.

This option is weaker than the --no-target-directory (-T) option, so it has no effect if both options are given.

'--physical'
If -s is not in effect, and the source file is a symbolic link, create the hard link to the symbolic link itself. On platforms where this is not supported by the kernel, this option creates a symbolic link with identical contents; since symbolic link contents cannot be edited, any file name resolution performed through either link will be the same as if a hard link had been created.

'--relative'
Make symbolic links relative to the link location. This option is only valid with the --symbolic option.

Example:

```
ln -srv /a/file /tmp
```
'/tmp/file' -> ' ../a/file'

Relative symbolic links are generated based on their canonicalized containing directory, and canonicalized targets. I.e., all symbolic links in these file names will be resolved. See Section 18.5 [realpath invocation], page 177, which gives greater control over relative file name generation, as demonstrated in the following example:

```bash
ln--relative() {
    test "$1" = --no-symlinks && { nosym=$1; shift; }
    target='$1';
    test -d "$2" && link="$2/." || link="$2"
    rtarget="$(realpath $nosym -m "$target" --relative-to "$(dirname "$link")")"
    ln -s -v "$rtarget" "$link"
}
```

`-s`
`--symbolic`

Make symbolic links instead of hard links. This option merely produces an error message on systems that do not support symbolic links.

`-S suffix`
`--suffix=suffix`

Append suffix to each backup file made with -b. See Section 2.1 [Backup options], page 2.

`-t directory`
`--target-directory=directory`

Specify the destination directory. See Section 2.6 [Target directory], page 7.

`-T`
`--no-target-directory`

Do not treat the last operand specially when it is a directory or a symbolic link to a directory. See Section 2.6 [Target directory], page 7.

`-v`
`--verbose`

Print the name of each file after linking it successfully.

If -L and -P are both given, the last one takes precedence. If -s is also given, -L and -P are silently ignored. If neither option is given, then this implementation defaults to -P if the system link supports hard links to symbolic links (such as the GNU system), and -L if link follows symbolic links (such as on BSD).

An exit status of zero indicates success, and a nonzero value indicates failure. Examples:

Bad Example:

```bash
# Create link ../a pointing to a in that directory.
# Not really useful because it points to itself.
ln -s a ..
```
Better Example:

    # Change to the target before creating symlinks to avoid being confused.
    cd..
    ln -s adir/a .

Bad Example:

    # Hard coded file names don't move well.
    ln -s $(pwd)/a /some/dir/

Better Example:

    # Relative file names survive directory moves and also
    # work across networked file systems.
    ln -s afile anotherfile
    ln -s ../adir/afile yetanotherfile

### 12.3 mkdir: Make directories

`mkdir` creates directories with the specified names. Synopsis:

```
mkdir [option]... name...
```

`mkdir` creates each directory `name` in the order given. It reports an error if `name` already exists, unless the `-p` option is given and `name` is a directory.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`'-m mode'`

`'--mode=mode'`

Set the file permission bits of created directories to `mode`, which uses the same syntax as in `chmod` and uses `a=rwx` (read, write and execute allowed for everyone) for the point of the departure. See Chapter 27 [File permissions], page 233. This option affects only directories given on the command line; it does not affect any parents that may be created via the `-p` option.

Normally the directory has the desired file mode bits at the moment it is created. As a GNU extension, `mode` may also mention special mode bits, but in this case there may be a temporary window during which the directory exists but its special mode bits are incorrect. See Section 27.5 [Directory Setuid and Setgid], page 239, for how the set-user-ID and set-group-ID bits of directories are inherited unless overridden in this way.

`'-p'`

`'--parents'`

Make any missing parent directories for each argument, setting their file permission bits to `'=rwx,u+wx'`, that is, with the umask modified by `u+wx`. Ignore existing parent directories, and do not change their file permission bits.

If the `-m` option is also given, it does not affect file permission bits of any newly-created parent directories. To control these bits, set the umask before
invoking `mkdir`. For example, if the shell command 
`'(umask u=rwx,go=rx; mkdir -p P/Q)'` creates the parent P it sets the parent’s file permission bits to `‘u=rwx,go=rx’`. (The umask must include `‘u=wx’` for this method to work.) To set a parent’s special mode bits as well, you can invoke `chmod` after `mkdir`. See Section 27.5 [Directory Setuid and Setgid], page 239, for how the set-user-ID and set-group-ID bits of newly-created parent directories are inherited.

`’-v’`  
`’--verbose’`  
Print a message for each created directory. This is most useful with `--parents`.

`’-Z’`  
`’--context[=context]’`  
Without a specified `context`, adjust the SELinux security context according to the system default type for destination files, similarly to the `restorecon` command. The long form of this option with a specific context specified, will set the context for newly created files only. With a specified context, if both SELinux and SMACK are disabled, a warning is issued.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 12.4 mkfifo: Make FIFOs (named pipes)

`mkfifo` creates FIFOs (also called named pipes) with the specified names. Synopsis:

```
 mkfifo [option] name...
```

A FIFO is a special file type that permits independent processes to communicate. One process opens the FIFO file for writing, and another for reading, after which data can flow as with the usual anonymous pipe in shells or elsewhere.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`’-m mode’`  
`’--mode=mode’`  
Set the mode of created FIFOs to `mode`, which is symbolic as in `chmod` and uses `‘a=rw’` (read and write allowed for everyone) for the point of departure. `mode` should specify only file permission bits. See Chapter 27 [File permissions], page 233.

`’-Z’`  
`’--context[=context]’`  
Without a specified `context`, adjust the SELinux security context according to the system default type for destination files, similarly to the `restorecon` command. The long form of this option with a specific context specified, will set the context for newly created files only. With a specified context, if both SELinux and SMACK are disabled, a warning is issued.

An exit status of zero indicates success, and a nonzero value indicates failure.
12.5 mknod: Make block or character special files

mknod creates a FIFO, character special file, or block special file with the specified name.

Synopsis:

```
mknod [option]... name type [major minor]
```

Unlike the phrase “special file type” above, the term special file has a technical meaning on Unix: something that can generate or receive data. Usually this corresponds to a physical piece of hardware, e.g., a printer or a flash drive. (These files are typically created at system-configuration time.) The mknod command is what creates files of this type. Such devices can be read either a character at a time or a “block” (many characters) at a time, hence we say there are block special files and character special files.

Due to shell aliases and built-in mknod functions, using an unadorned mknod interactively or in a script may get you different functionality than that described here. Invoke it via env (i.e., env mknod ...) to avoid interference from the shell.

The arguments after name specify the type of file to make:

- ‘p’ for a FIFO
- ‘b’ for a block special file
- ‘c’ for a character special file

When making a block or character special file, the major and minor device numbers must be given after the file type. If a major or minor device number begins with ’0x’ or ’0X’, it is interpreted as hexadecimal; otherwise, if it begins with ’0’, as octal; otherwise, as decimal.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-m mode`
`--mode=mode`
Set the mode of created files to mode, which is symbolic as in chmod and uses ‘a=rw’ as the point of departure. mode should specify only file permission bits. See Chapter 27 [File permissions], page 233.

`-Z`
`--context[=context]`
Without a specified context, adjust the SELinux security context according to the system default type for destination files, similarly to the restorecon command. The long form of this option with a specific context specified, will set the context for newly created files only. With a specified context, if both SELinux and SMACK are disabled, a warning is issued.

An exit status of zero indicates success, and a nonzero value indicates failure.

12.6 readlink: Print value of a symlink or canonical file

name

readlink may work in one of two supported modes:

`Readlink mode`

readlink outputs the value of the given symbolic links. If readlink is invoked with an argument other than the name of a symbolic link, it produces no output and exits with a nonzero exit code.
'Canonicalize mode'

readlink outputs the absolute name of the given files which contain no ., .. components nor any repeated separators (/) or symbolic links. Note the realpath command is the preferred command to use for canonicalization. See Section 18.5 [realpath invocation], page 177.

readlink [option]... file...

By default, readlink operates in readlink mode.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--canonicalize'

Activate canonicalize mode. If any component of the file name except the last one is missing or unavailable, readlink produces no output and exits with a nonzero exit code. A trailing slash is ignored.

'--canonicalize-existing'

Activate canonicalize mode. If any component is missing or unavailable, readlink produces no output and exits with a nonzero exit code. A trailing slash requires that the name resolve to a directory.

'--canonicalize-missing'

Activate canonicalize mode. If any component is missing or unavailable, readlink treats it as a directory.

'--no-newline'

Do not print the output delimiter, when a single file is specified. Print a warning if specified along with multiple files.

'--silent'

Suppress most error messages. On by default.

'--verbose'

Report error messages.

'--zero'

Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines.

The readlink utility first appeared in OpenBSD 2.1.

The realpath command without options, operates like readlink in canonicalize mode.

An exit status of zero indicates success, and a nonzero value indicates failure.
12.7 rmdir: Remove empty directories

rmdir removes empty directories. Synopsis:

    rmdir [option]... directory...

If any directory argument does not refer to an existing empty directory, it is an error.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--ignore-fail-on-non-empty'
    Ignore each failure to remove a directory that is non-empty.

'--parents'
    Remove directory, then try to remove each component of directory. So, for example, 'rmdir -p a/b/c' is similar to 'rmdir a/b/c a/b a'. As such, it fails if any of those directories turns out not to be empty. Use the --ignore-fail-on-non-empty option to make it so such a failure does not evoke a diagnostic and does not cause rmdir to exit un-successfully.

'-v'
    Give a diagnostic for each successful removal. directory is removed.

See Section 11.5 [rm invocation], page 122, for how to remove non-empty directories recursively.

To remove all empty directories under dirname, including directories that become empty because other directories are removed, you can use either of the following commands:

    # This uses GNU extensions.
    find dirname -type d -empty -delete

    # This runs on any POSIX platform.
    find dirname -depth -type d -exec rmdir {} +

An exit status of zero indicates success, and a nonzero value indicates failure.

12.8 unlink: Remove files via the unlink syscall

unlink deletes a single specified file name. It is a minimalist interface to the system-provided unlink function. See Section “Deleting Files” in The GNU C Library Reference Manual. Synopsis: It avoids the bells and whistles of the more commonly-used rm command (see Section 11.5 [rm invocation], page 122).

    unlink filename

On some systems unlink can be used to delete the name of a directory. On others, it can be used that way only by a privileged user. In the GNU system unlink can never delete the name of a directory.

The unlink command honors the --help and --version options. To remove a file whose name begins with '-', prefix the name with '.', e.g., 'unlink ./--help'.

An exit status of zero indicates success, and a nonzero value indicates failure.
13 Changing file attributes

A file is not merely its contents, a name, and a file type (see Chapter 12 [Special file types], page 128). A file also has an owner (a user ID), a group (a group ID), permissions (what the owner can do with the file, what people in the group can do, and what everyone else can do), various timestamps, and other information. Collectively, we call these a file’s attributes.

These commands change file attributes.

13.1 chown: Change file owner and group

chown changes the user and/or group ownership of each given file to new-owner or to the user and group of an existing reference file. Synopsis:

```
chown [option]... {new-owner | --reference=ref_file} file...
```

If used, new-owner specifies the new owner and/or group as follows (with no embedded white space):

```
[owner] [: [group] ]
```

Specifically:

owner If only an owner (a user name or numeric user ID) is given, that user is made the owner of each given file, and the files’ group is not changed.

owner': 'group

If the owner is followed by a colon and a group (a group name or numeric group ID), with no spaces between them, the group ownership of the files is changed as well (to group).

owner': 

If a colon but no group name follows owner, that user is made the owner of the files and the group of the files is changed to owner’s login group.

'': 'group

If the colon and following group are given, but the owner is omitted, only the group of the files is changed; in this case, chown performs the same function as chgrp.

'':

If only a colon is given, or if new-owner is empty, neither the owner nor the group is changed.

If owner or group is intended to represent a numeric user or group ID, then you may specify it with a leading ‘+’. See Section 2.4 [Disambiguating names and IDs], page 6.

Some older scripts may still use ‘.’ in place of the ‘:’ separator. POSIX 1003.1-2001 (see Section 2.13 [Standards conformance], page 11) does not require support for that, but for backward compatibility GNU chown supports ‘.’ so long as no ambiguity results, although it issues a warning and support may be removed in future versions. New scripts should avoid the use of ‘.’ because it is not portable, and because it has undesirable results if the entire owner’. group happens to identify a user whose name contains ‘.’.

It is system dependent whether a user can change the group to an arbitrary one, or the more portable behavior of being restricted to setting a group of which the user is a member. The chown command sometimes clears the set-user-ID or set-group-ID permission bits. This behavior depends on the policy and functionality of the underlying chown system call, which may make system-dependent file mode modifications outside the control of the
The chown command. For example, the chown command might not affect those bits when invoked by a user with appropriate privileges, or when the bits signify some function other than executable permission (e.g., mandatory locking). When in doubt, check the underlying system behavior.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--changes'
Verbosely describe the action for each file whose ownership actually changes.

'--silent'
'--quiet'
Do not print error messages about files whose ownership cannot be changed.

'--from=old-owner'
Change a file’s ownership only if it has current attributes specified by old-owner. old-owner has the same form as new-owner described above. This option is useful primarily from a security standpoint in that it narrows considerably the window of potential abuse. For example, to reflect a user ID numbering change for one user’s files without an option like this, root might run

\`
find / -owner OLDUSER -print0 | xargs -0 chown -h NEWUSER
``
But that is dangerous because the interval between when the find tests the existing file’s owner and when the chown is actually run may be quite large. One way to narrow the gap would be to invoke chown for each file as it is found:

\`
find / -owner OLDUSER -exec chown -h NEWUSER {} \
``
But that is very slow if there are many affected files. With this option, it is safer (the gap is narrower still) though still not perfect:

\`
chown -h -R --from=OLDUSER NEWUSER /
``

'--dereference'
Do not act on symbolic links themselves but rather on what they point to. This is the default when not operating recursively.

Combining this dereferencing option with the --recursive option may create a security risk: During the traversal of the directory tree, an attacker may be able to introduce a symlink to an arbitrary target; when the tool reaches that, the operation will be performed on the target of that symlink, possibly allowing the attacker to escalate privileges.

'--no-dereference'
Act on symbolic links themselves instead of what they point to. This mode relies on the lchown system call. On systems that do not provide the lchown system call, chown fails when a file specified on the command line is a symbolic link. By default, no diagnostic is issued for symbolic links encountered during a recursive traversal, but see --verbose.

'--preserve-root'
Fail upon any attempt to recursively change the root directory, /.

Without --recursive, this option has no effect. See Section 2.9 [Treating / specially], page 9.
Chapter 13: Changing file attributes

'--no-preserve-root'
Cancel the effect of any preceding --preserve-root option. See Section 2.9 [Treating / specially], page 9.

'--reference=ref_file'
Change the user and group of each file to be the same as those of ref_file. If ref_file is a symbolic link, do not use the user and group of the symbolic link, but rather those of the file it refers to.

'--verbose'
Output a diagnostic for every file processed. If a symbolic link is encountered during a recursive traversal on a system without the lchown system call, and --no-dereference is in effect, then issue a diagnostic saying neither the symbolic link nor its referent is being changed.

'--recursive'
Recursively change ownership of directories and their contents.

'--recursive'
If --recursive (-R) is specified and a command line argument is a symbolic link to a directory, traverse it. See Section 2.8 [Traversing symlinks], page 9.

'--recursive'
In a recursive traversal, traverse every symbolic link to a directory that is encountered.
Combining this dereferencing option with the --recursive option may create a security risk: During the traversal of the directory tree, an attacker may be able to introduce a symlink to an arbitrary target; when the tool reaches that, the operation will be performed on the target of that symlink, possibly allowing the attacker to escalate privileges. See Section 2.8 [Traversing symlinks], page 9.

'--recursive'
Do not traverse any symbolic links. This is the default if none of -H, -L, or -P is specified. See Section 2.8 [Traversing symlinks], page 9.

An exit status of zero indicates success, and a nonzero value indicates failure. Examples:

# Change the owner of /u to "root".
chown root /u

# Likewise, but also change its group to "staff".
chown root:staff /u

# Change the owner of /u and subfiles to "root".
chown -R root /u

13.2 chgrp: Change group ownership

chgrp changes the group ownership of each given file to group (which can be either a group name or a numeric group ID) or to the group of an existing reference file. See Section 13.1 [chown invocation], page 137. Synopsis:

chgrp [option]... {group | --reference=ref_file} file...
If *group* is intended to represent a numeric group ID, then you may specify it with a leading ‘+’. See Section 2.4 [Disambiguating names and IDs], page 6.

It is system dependent whether a user can change the group to an arbitrary one, or the more portable behavior of being restricted to setting a group of which the user is a member. The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-c’
‘--changes’
Verbosely describe the action for each file whose group actually changes.

‘-f’
‘--silent’
‘--quiet’ Do not print error messages about files whose group cannot be changed.

‘--dereference’
Do not act on symbolic links themselves but rather on what they point to. This is the default when not operating recursively.
Combining this dereferencing option with the --recursive option may create a security risk: During the traversal of the directory tree, an attacker may be able to introduce a symlink to an arbitrary target; when the tool reaches that, the operation will be performed on the target of that symlink, possibly allowing the attacker to escalate privileges.

‘-h’
‘--no-dereference’
Act on symbolic links themselves instead of what they point to. This mode relies on the `lchown` system call. On systems that do not provide the `lchown` system call, `chgrp` fails when a file specified on the command line is a symbolic link. By default, no diagnostic is issued for symbolic links encountered during a recursive traversal, but see --verbose.

‘--preserve-root’
Fail upon any attempt to recursively change the root directory, /. Without --recursive, this option has no effect. See Section 2.9 [Treating / specially], page 9.

‘--no-preserve-root’
Cancel the effect of any preceding --preserve-root option. See Section 2.9 [Treating / specially], page 9.

‘--reference=ref_file’
Change the group of each file to be the same as that of ref_file. If ref_file is a symbolic link, do not use the group of the symbolic link, but rather that of the file it refers to.

‘-v’
‘--verbose’
Output a diagnostic for every file processed. If a symbolic link is encountered during a recursive traversal on a system without the `lchown` system call, and --no-dereference is in effect, then issue a diagnostic saying neither the symbolic link nor its referent is being changed.
```
'--recursive'
Recursively change the group ownership of directories and their contents.

'--recursive (-R) is specified and a command line argument is a symbolic
link to a directory, traverse it. See Section 2.8 [Traversing symlinks], page 9.

'-L'
In a recursive traversal, traverse every symbolic link to a directory that is
encountered.
Combining this dereferencing option with the --recursive option may create
a security risk: During the traversal of the directory tree, an attacker may be
able to introduce a symlink to an arbitrary target; when the tool reaches that,
the operation will be performed on the target of that symlink, possibly allowing
the attacker to escalate privileges. See Section 2.8 [Traversing symlinks], page 9.

'-P'
Do not traverse any symbolic links. This is the default if none of -H, -L, or -P is
specified. See Section 2.8 [Traversing symlinks], page 9.
```

An exit status of zero indicates success, and a nonzero value indicates failure. Examples:
```
# Change the group of /u to "staff".
chgrp staff /u

# Change the group of /u and subfiles to "staff".
chgrp -hR staff /u
```

### 13.3 chmod: Change access permissions

`chmod` changes the access permissions of the named files. Synopsis:

```
chmod [option]... {mode | --reference=ref_file} file...
```

`chmod` never changes the permissions of symbolic links, since the `chmod` system call cannot change their permissions. This is not a problem since the permissions of symbolic links are never used. However, for each symbolic link listed on the command line, `chmod` changes the permissions of the pointed-to file. In contrast, `chmod` ignores symbolic links encountered during recursive directory traversals.

Only a process whose effective user ID matches the user ID of the file, or a process with appropriate privileges, is permitted to change the file mode bits of a file.

A successful use of `chmod` clears the set-group-ID bit of a regular file if the file’s group ID does not match the user’s effective group ID or one of the user’s supplementary group IDs, unless the user has appropriate privileges. Additional restrictions may cause the set-user-ID and set-group-ID bits of `mode` or `ref_file` to be ignored. This behavior depends on the policy and functionality of the underlying `chmod` system call. When in doubt, check the underlying system behavior.

If used, `mode` specifies the new file mode bits. For details, see the section on Chapter 27 [File permissions], page 233. If you really want `mode` to have a leading ‘-‘, you should use `--` first, e.g., `chmod -- -w file`. Typically, though, `chmod a-w file` is preferable, and `chmod -w file` (without the `--`) complains if it behaves differently from what `chmod a-w file` would do.
The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-c`
`--changes`
Verbosely describe the action for each file whose permissions actually change.

`-f`
`--silent`
`--quiet`
Do not print error messages about files whose permissions cannot be changed.

`--preserve-root`
Fail upon any attempt to recursively change the root directory, `/`. Without
`--recursive`, this option has no effect. See Section 2.9 [Treating / specially],
page 9.

`--no-preserve-root`
Cancel the effect of any preceding `--preserve-root` option. See Section 2.9
[Treating / specially], page 9.

`-v`
`--verbose`
Verbosely describe the action or non-action taken for every file.

`--reference=ref_file`
Change the mode of each file to be the same as that of ref_file. See Chapter 27
[File permissions], page 233. If ref_file is a symbolic link, do not use the mode
of the symbolic link, but rather that of the file it refers to.

`-R`
`--recursive`
Recursively change permissions of directories and their contents.

An exit status of zero indicates success, and a nonzero value indicates failure. Examples:

```bash
# Change file permissions of FOO to be world readable
# and user writable, with no other permissions.
chmod 644 foo
chmod a=r,u+w foo

# Add user and group execute permissions to FOO.
chmod +110 file
chmod ug+x file

# Set file permissions of DIR and subsidiary files to
# be the umask default, assuming execute permissions for
# directories and for files already executable.
chmod -R a=,+rwX dir
```

13.4 **touch**: Change file timestamps

**touch** changes the access and/or modification timestamps of the specified files. Synopsis:

```
touch [option]... file...
```

Any file argument that does not exist is created empty, unless option `--no-create (-c)`
or `--no-dereference (-h)` was in effect.
A file argument string of ‘-’ is handled specially and causes touch to change the times of the file associated with standard output.

By default, touch sets file timestamps to the current time. Because touch acts on its operands left to right, the resulting timestamps of earlier and later operands may disagree.

When setting file timestamps to the current time, touch can change the timestamps for files that the user does not own but has write permission for. Otherwise, the user must own the files. Some older systems have a further restriction: the user must own the files unless both the access and modification timestamps are being set to the current time.

The touch command cannot set a file’s status change timestamp to a user-specified value, and cannot change the file’s birth time (if supported) at all. Also, touch has issues similar to those affecting all programs that update file timestamps. For example, touch may set a file’s timestamp to a value that differs slightly from the requested time. See Chapter 28 [File timestamps], page 241.

Timestamps assume the time zone rules specified by the TZ environment variable, or by the system default rules if TZ is not set. See Section “Specifying the Time Zone with TZ” in The GNU C Library Reference Manual. You can avoid ambiguities during daylight saving transitions by using UTC timestamps.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'-a'
'--time=atime'
'--time=access'
'--time=use'

Change the access timestamp only. See Chapter 28 [File timestamps], page 241.

'-c'
'--no-create'

Do not warn about or create files that do not exist.

'-d time'
'--date=time'

Use time instead of the current time. It can contain month names, time zones, ‘am’ and ‘pm’, ‘yesterday’, etc. For example, --date="2020-07-21 14:19:13.489392193 +0530" specifies the instant of time that is 489,392,193 nanoseconds after July 21, 2020 at 2:19:13 PM in a time zone that is 5 hours and 30 minutes east of UTC. See Chapter 29 [Date input formats], page 242. File systems that do not support high-resolution timestamps silently ignore any excess precision here.

'-f'

Ignored; for compatibility with BSD versions of touch.

'-h'
'--no-dereference'

Attempt to change the timestamps of a symbolic link, rather than what the link refers to. When using this option, empty files are not created, but option --c must also be used to avoid warning about files that do not exist. Not all systems support changing the timestamps of symlinks, since underlying system support for this action was not required until POSIX 2008. Also, on some systems, the mere act of examining a symbolic link changes the access timestamp, such
that only changes to the modification timestamp will persist long enough to be observable. When coupled with option \(-r\), a reference timestamp is taken from a symbolic link rather than the file it refers to.

\[-m\]
\[-time=mtime\]
\[-time=modify\]
Change the modification timestamp only.

\[-r file\]
\[-reference=file\]
Use the times of the reference file instead of the current time. If this option is combined with the \--date=time (-d time) option, the reference file’s time is the origin for any relative times given, but is otherwise ignored. For example, \(-r foo -d \'-5 seconds\'\) specifies a timestamp equal to five seconds before the corresponding timestamp for foo. If file is a symbolic link, the reference timestamp is taken from the target of the symlink, unless \-h was also in effect.

\[-t \[[cc]\]yy]mmddhhmm[.ss]\]
Use the argument (optional four-digit or two-digit years, months, days, hours, minutes, optional seconds) instead of the current time. If the year is specified with only two digits, then \(cc\) is 20 for years in the range 0 . . . 68, and 19 for years in 69 . . . 99. If no digits of the year are specified, the argument is interpreted as a date in the current year. On the atypical systems that support leap seconds, \(ss\) may be ‘60’.

On systems predating POSIX 1003.1-2001, touch supports an obsolete syntax, as follows. If no timestamp is given with any of the \-d, \-r, or \-t options, and if there are two or more files and the first file is of the form ‘mmddhhmm[yy]’ and this would be a valid argument to the \-t option (if the \(yy\), if any, were moved to the front), and if the represented year is in the range 1969–1999, that argument is interpreted as the time for the other files instead of as a file name. Although this obsolete behavior can be controlled with the \_POSIX2_VERSION\ environment variable (see Section 2.13 [Standards conformance], page 11), portable scripts should avoid commands whose behavior depends on this variable. For example, use ‘touch ./12312359 main.c’ or ‘touch -t 12312359 main.c’ rather than the ambiguous ‘touch 12312359 main.c’.

An exit status of zero indicates success, and a nonzero value indicates failure.
14 File space usage

No file system can hold an infinite amount of data. These commands report how much storage is in use or available, report other file and file status information, and write buffers to file systems.

14.1 df: Report file system space usage

df reports the amount of space used and available on file systems. Synopsis:

df [option]... [file]...

With no arguments, df reports the space used and available on all currently mounted file systems (of all types). Otherwise, df reports on the file system containing each argument file.

Normally the space is printed in units of 1024 bytes, but this can be overridden (see Section 2.2 [Block size], page 3). Non-integer quantities are rounded up to the next higher unit.

For bind mounts and without arguments, df only outputs the statistics for that device with the shortest mount point name in the list of file systems (mtab), i.e., it hides duplicate entries, unless the -a option is specified.

With the same logic, df elides a mount entry of a dummy pseudo device if there is another mount entry of a real block device for that mount point with the same device number, e.g. the early-boot pseudo file system 'rootfs' is not shown per default when already the real root device has been mounted.

If an argument file resolves to a special file containing a mounted file system, df shows the space available on that file system rather than on the file system containing the device node. GNU df does not attempt to determine the usage on unmounted file systems, because on most kinds of systems doing so requires extremely non-portable intimate knowledge of file system structures.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--a'
 Include in the listing dummy, duplicate, or inaccessible file systems, which are omitted by default. Dummy file systems are typically special purpose pseudo file systems such as '/proc', with no associated storage. Duplicate file systems are local or remote file systems that are mounted at separate locations in the local file hierarchy, or bind mounted locations. Inaccessible file systems are those which are mounted but subsequently over-mounted by another file system at that point, or otherwise inaccessible due to permissions of the mount point etc.

'--all'

'--block-size=size'
 Scale sizes by size before printing them (see Section 2.2 [Block size], page 3). For example, -BG prints sizes in units of 1,073,741,824 bytes.

'--human-readable'
 Append a size letter to each size, such as 'M' for mebibytes. Powers of 1024 are used, not 1000; 'M' stands for 1,048,576 bytes. This option is equivalent to
`--block-size=human-readable`. Use the `--si` option if you prefer powers of 1000.

`-H` Equivalent to `--si`.

`-i`

`--inodes` List inode usage information instead of block usage. An inode (short for index node) contains information about a file such as its owner, permissions, timestamps, and location on the file system.

`-k` Print sizes in 1024-byte blocks, overriding the default block size (see Section 2.2 [Block size], page 3). This option is equivalent to `--block-size=1K`.

`-l` `--local` Limit the listing to local file systems. By default, remote file systems are also listed.

`--no-sync` Do not invoke the `sync` system call before getting any usage data. This may make `df` run significantly faster on systems with many file systems, but on some systems (notably Solaris) the results may be slightly out of date. This is the default.

`--output`

`--output[=field_list]` Use the output format defined by `field_list`, or print all fields if `field_list` is omitted. In the latter case, the order of the columns conforms to the order of the field descriptions below.

The use of the `--output` together with each of the options `-i`, `-P`, and `-T` is mutually exclusive.

FIELD_LIST is a comma-separated list of columns to be included in `df`’s output and therefore effectively controls the order of output columns. Each field can thus be used at the place of choice, but yet must only be used once.

Valid field names in the `field_list` are:

`source` The source of the mount point, usually a device.

`fstype` File system type.

`itotal` Total number of inodes.

`iused` Number of used inodes.

`iavail` Number of available inodes.

`ipcent` Percentage of `iused` divided by `itotal`.

`size` Total number of blocks.

`used` Number of used blocks.

`avail` Number of available blocks.

`pcent` Percentage of `used` divided by `size`.
The file name if specified on the command line.

‘target’ The mount point.

The fields for block and inodes statistics are affected by the scaling options like 
-h as usual.

The definition of the field_list can even be split among several --output uses.

```bash
#!/bin/sh
# Print the TARGET (i.e., the mount point) along with their percentage
# statistic regarding the blocks and the inodes.
df --out=target --output=pcent,ipcent

# Print all available fields.
df --o
```

‘-p’

‘--portability’

Use the POSIX output format. This is like the default format except for the following:

1. The information about each file system is always printed on exactly one line; a mount device is never put on a line by itself. This means that if the mount device name is more than 20 characters long (e.g., for some network mounts), the columns are misaligned.

2. The labels in the header output line are changed to conform to POSIX.

3. The default block size and output format are unaffected by the DF_BLOCK_SIZE, BLOCK_SIZE and BLOCKSIZE environment variables. However, the default block size is still affected by POSIXLY_CORRECT: it is 512 if POSIXLY_CORRECT is set, 1024 otherwise. See Section 2.2 [Block size], page 3.

‘--si’ Append an SI-style abbreviation to each size, such as ‘M’ for megabytes. Powers of 1000 are used, not 1024; ‘M’ stands for 1,000,000 bytes. This option is equivalent to --block-size=si. Use the -h or --human-readable option if you prefer powers of 1024.

‘--sync’ Invoke the sync system call before getting any usage data. On some systems (notably Solaris), doing this yields more up to date results, but in general this option makes df much slower, especially when there are many or very busy file systems.

‘--total’ Print a grand total of all arguments after all arguments have been processed. This can be used to find out the total size, usage and available space of all listed devices. If no arguments are specified df will try harder to elide file systems insignificant to the total available space, by suppressing duplicate remote file systems.

For the grand total line, df prints ‘"total"’ into the source column, and ‘"-"’ into the target column. If there is no source column (see --output), then df prints ‘"total"’ into the target column, if present.
Chapter 14: File space usage

'--type=fstype'
'--exclude-type=fstype'
Limit the listing to file systems of type fstype. Multiple file system types can be specified by giving multiple -t options. By default, nothing is omitted.

'--print-type'
Print each file system’s type. The types printed here are the same ones you can include or exclude with -t and -x. The particular types printed are whatever is supported by the system. Here are some of the common names (this list is certainly not exhaustive):

'nfs' An NFS file system, i.e., one mounted over a network from another machine. This is the one type name which seems to be used uniformly by all systems.

'ext2, ext3, ext4, xfs, btrfs...'
A file system on a locally-mounted device. (The system might even support more than one type here; GNU/Linux does.)

'iso9660, cdfs'
A file system on a CD or DVD drive. HP-UX uses 'cdfs', most other systems use 'iso9660'.

'ntfs, fat' File systems used by MS-Windows / MS-DOS.

'--exclude-type=fstype'
Limit the listing to file systems not of type fstype. Multiple file system types can be eliminated by giving multiple -x options. By default, no file system types are omitted.

'-v'
Ignored; for compatibility with System V versions of df.

df is installed only on systems that have usable mount tables, so portable scripts should not rely on its existence.

An exit status of zero indicates success, and a nonzero value indicates failure. Failure includes the case where no output is generated, so you can inspect the exit status of a command like 'df -t ext3 -t reiserfs dir' to test whether dir is on a file system of type 'ext3' or 'reiserfs'.

Since the list of file systems (mtab) is needed to determine the file system type, failure includes the cases when that list cannot be read and one or more of the options -a, -l, -t or -x is used together with a file name argument.

14.2 du: Estimate file space usage
du reports the space needed to represent a set of files. Synopsis:

    du [option]... [file]...

With no arguments, du reports the space needed to represent the files at or under the current directory. Normally the space is printed in units of 1024 bytes, but this can be
overridden (see Section 2.2 [Block size], page 3). Non-integer quantities are rounded up to the next higher unit.

If two or more hard links point to the same file, only one of the hard links is counted. The `file` argument order affects which links are counted, and changing the argument order may change the numbers and entries that `du` outputs.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-0`
`--null` Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines.

`-a`
`--all` Show counts for all files, not just directories.

`--apparent-size`
Print apparent sizes, rather than file system usage. The apparent size of a file is the number of bytes reported by `wc -c` on regular files, or more generally, `ls -l --block-size=1` or `stat --format=\%s`. For example, a file containing the word 'zoo' with no newline would, of course, have an apparent size of 3. Such a small file may require anywhere from 0 to 16 KiB or more of file system space, depending on the type and configuration of the file system on which the file resides. However, a sparse file created with this command:

```
dd bs=1 seek=2GiB if=/dev/null of=big
```

has an apparent size of 2 GiB, yet on most modern file systems, it actually uses almost no space.

Apparent sizes are meaningful only for regular files and symbolic links. Other file types do not contribute to apparent size.

`-B size`
`--block-size=size`
Scale sizes by `size` before printing them (see Section 2.2 [Block size], page 3). For example, `-BG` prints sizes in units of 1,073,741,824 bytes.

`-b`
`--bytes` Equivalent to `--apparent-size --block-size=1`.

`-c`
`--total` Print a grand total of all arguments after all arguments have been processed. This can be used to find out the total file system usage of a given set of files or directories.

`-D`
`--dereference-args` Dereference symbolic links that are command line arguments. Does not affect other symbolic links. This is helpful for finding out the file system usage of directories, such as `/usr/tmp`, which are often symbolic links.
'--max-depth=depth'
Show the total for each directory (and file if --all) that is at most MAX_DEPTH levels down from the root of the hierarchy. The root is at level 0, so du --max-depth=0 is equivalent to du -s.

'--files0-from=file'
Disallow processing files named on the command line, and instead process those named in file file; each name being terminated by a zero byte (ASCII NUL). This is useful when the list of file names is so long that it may exceed a command line length limitation. In such cases, running du via xargs is undesirable because it splits the list into pieces and makes du print with the --total (-c) option for each sublist rather than for the entire list. One way to produce a list of ASCII NUL terminated file names is with GNU find, using its -print0 predicate. If file is '-' then the ASCII NUL terminated file names are read from standard input.

'--dereference-args (-D)'
Equivalent to --dereference-args (-D).

'--human-readable'
Append a size letter to each size, such as 'M' for mebibytes. Powers of 1024 are used, not 1000; 'M' stands for 1,048,576 bytes. This option is equivalent to --block-size=human-readable. Use the --si option if you prefer powers of 1000.

'--inodes'
List inode usage information instead of block usage. This option is useful for finding directories which contain many files, and therefore eat up most of the inodes space of a file system (see df, option --inodes). It can well be combined with the options -a, -c, -h, -l, -s, -S, -t and -x; however, passing other options regarding the block size, for example -b, -m and --apparent-size, is ignored.

'--dereference'
Dereference symbolic links (show the file system space used by the file or directory that the link points to instead of the space used by the link).

'--count-links'
Count the size of all files, even if they have appeared already (as a hard link).

'--block-size=1K'
Print sizes in 1024-byte blocks, overriding the default block size (see Section 2.2 [Block size], page 3). This option is equivalent to --block-size=1K.

'--no-dereference'
For each symbolic link encountered by du, consider the file system space used by the symbolic link itself.
'--separate-dirs'

Normally, in the output of `du` (when not using `--summarize`), the size listed next to a directory name, \( d \), represents the sum of sizes of all entries beneath \( d \) as well as the size of \( d \) itself. With `--separate-dirs`, the size reported for a directory name, \( d \), will exclude the size of any subdirectories.

'--si'

Append an SI-style abbreviation to each size, such as ‘\( M \)’ for megabytes. Powers of 1000 are used, not 1024; ‘\( M \)’ stands for 1,000,000 bytes. This option is equivalent to `--block-size=si`. Use the `-h` or `--human-readable` option if you prefer powers of 1024.

'--summarize'

Display only a total for each argument.

'--threshold=\( \text{size} \)'

Exclude entries based on a given size. The size refers to used blocks in normal mode (see Section 2.2 [Block size], page 3), or inodes count in conjunction with the `--inodes` option.

If size is positive, then `du` will only print entries with a size greater than or equal to that.

If size is negative, then `du` will only print entries with a size smaller than or equal to that.

Although GNU `find` can be used to find files of a certain size, `du`’s `--threshold` option can be used to also filter directories based on a given size.

When combined with the `--apparent-size` option, the `--threshold` option elides entries based on apparent size. When combined with the `--inodes` option, it elides entries based on inode counts.

Here’s how you would use `--threshold` to find directories with a size greater than or equal to 200 megabytes:

```
    du --threshold=200MB
```

Here’s how you would use `--threshold` to find directories and files – note the `-a` – with an apparent size smaller than or equal to 500 bytes:

```
    du -a -t -500 --apparent-size
```

Here’s how you would use `--threshold` to find directories on the root file system with more than 20000 inodes used in the directory tree below:

```
    du --inodes -x --threshold=20000 /
```

'--time'

Show the most recent modification timestamp (mtime) of any file in the directory, or any of its subdirectories. See Chapter 28 [File timestamps], page 241.

'--time=ctime'

'--time=status'

'--time=use'

Show the most recent status change timestamp (ctime) of any file in the directory, or any of its subdirectories. See Chapter 28 [File timestamps], page 241.
'--time=atime'
'--time=access'

Show the most recent access timestamp (atime) of any file in the directory, or any of its subdirectories. See Chapter 28 [File timestamps], page 241.

'--time-style=style'

List timestamps in style style. This option has an effect only if the --time option is also specified. The style should be one of the following:

'+format' List timestamps using format, where format is interpreted like the format argument of date (see Section 21.1 [date invocation], page 192). For example, --time-style="+%Y-%m-%d %H:%M:%S" causes du to list timestamps like ‘2020-07-21 23:45:56’. As with date, format’s interpretation is affected by the LC_TIME locale category.

'full-iso' List timestamps in full using ISO 8601-like date, time, and time zone components with nanosecond precision, e.g., ‘2020-07-21 23:45:56.477817180 -0400’. This style is equivalent to ‘+%Y-%m-%d %H:%M:%S.%N %z’.

'long-iso' List ISO 8601 date and time components with minute precision, e.g., ‘2020-07-21 23:45’. These timestamps are shorter than ‘full-iso’ timestamps, and are usually good enough for everyday work. This style is equivalent to ‘+%Y-%m-%d %H:%M’.

'iso' List ISO 8601 dates for timestamps, e.g., ‘2020-07-21’. This style is equivalent to ‘+%Y-%m-%d’.

You can specify the default value of the --time-style option with the environment variable TIME_STYLE; if TIME_STYLE is not set the default style is ‘long-iso’. For compatibility with ls, if TIME_STYLE begins with ‘+’ and contains a newline, the newline and any later characters are ignored; if TIME_STYLE begins with ‘posix-’ the ‘posix-’ is ignored; and if TIME_STYLE is ‘locale’ it is ignored.

'-X file'
'--exclude-from=file'

Like --exclude, except take the patterns to exclude from file, one per line. If file is ‘-’, take the patterns from standard input.

'--exclude=pattern'

When recursing, skip subdirectories or files matching pattern. For example, du --exclude='*.o' excludes files whose names end in ‘.o’.

'-x'
'--one-file-system'

Skip directories that are on different file systems from the one that the argument being processed is on.

Since du relies on information reported by the operating system, its output might not reflect the space consumed in the underlying devices. For example;
Chapter 14: File space usage

- Operating systems normally do not report device space consumed by duplicate or backup blocks, error correction bits, and so forth. This causes `du` to underestimate the device space actually used.
- In file systems that use copy-on-write, if two distinct files share space the output of `du` typically counts the space that would be consumed if all files’ non-holes were rewritten, not the space currently consumed.
- In file systems that use compression, the operating system might report the uncompressed space. (If it does report the compressed space, that report might change after one merely overwrites existing file data.)
- Networked file systems historically have had difficulty communicating accurate file system information from server to client.

For these reasons `du` might better be thought of as an estimate of the size of a `tar` or other conventional backup for a set of files, rather than as a measure of space consumed in the underlying devices.

An exit status of zero indicates success, and a nonzero value indicates failure.

14.3 `stat`: Report file or file system status

`stat` displays information about the specified file(s). Synopsis:

```
stat [option]... [file]...
```

With no option, `stat` reports all information about the given files. But it also can be used to report the information of the file systems the given files are located on. If the files are links, `stat` can also give information about the files the links point to.

Due to shell aliases and built-in `stat` functions, using an unadorned `stat` interactively or in a script may get you different functionality than that described here. Invoke it via `env` (i.e., `env stat ...`) to avoid interference from the shell.

`-L`

`--dereference`

Change how `stat` treats symbolic links. With this option, `stat` acts on the file referenced by each symbolic link argument. Without it, `stat` acts on any symbolic link argument directly.

`-f`

`--file-system`

Report information about the file systems where the given files are located instead of information about the files themselves. This option implies the `-L` option.

`--cached=mode`

Control how attributes are read from the file system; if supported by the system. This allows one to control the trade-off between freshness and efficiency of attribute access, especially useful with remote file systems. `mode` can be:

`always`  Always read the already cached attributes if available.

`never`    Always synchronize with the latest file system attributes. This also mounts automounted files.
"default"  Leave the caching behavior to the underlying file system.

'--c'
'--format=format'
  Use format rather than the default format. format is automatically newline-terminated, so running a command like the following with two or more file operands produces a line of output for each operand:
  
  ```
  $ stat --format=%d:%i / /usr
  2050:2
  2057:2
  ```

'--printf=format'
  Use format rather than the default format. Like --format, but interpret backslash escapes, and do not output a mandatory trailing newline. If you want a newline, include '\n' in the format. Here's how you would use --printf to print the device and inode numbers of / and /usr:
  
  ```
  $ stat --printf='%d:%i\n' / /usr
  2050:2
  2057:2
  ```

'--t'
'--terse'
  Print the information in terse form, suitable for parsing by other programs.
  The output of the following commands are identical and the --format also identifies the items printed (in fuller form) in the default format. Note the format string would include another '%C' at the end with an active SELinux security context.
  
  ```
  $ stat --format="%n %s %b %f %u %g %D %i %h %t %T %X %Y %Z %W %o" ...
  $ stat --terse ...
  ```
  The same illustrating terse output in --file-system mode:
  
  ```
  $ stat -f --format="%n %i %l %t %s %S %b %f %a %c %d" ...
  $ stat -f --terse ...
  ```

The valid format directives for files with --format and --printf are:

- %a – Permission bits in octal (note ‘#’ and ‘0’ printf flags)
- %A – Permission bits in symbolic form (similar to ls -ld)
- %b – Number of blocks allocated (see ‘%B’)
- %B – The size in bytes of each block reported by ‘%b’
- %C – The SELinux security context of a file, if available
- %d – Device number in decimal (st_dev)
- %D – Device number in hex (st_dev)
- %Hd – Major device number in decimal
- %Ld – Minor device number in decimal
- %f – Raw mode in hex
- %F – File type
- %g – Group ID of owner
• %G – Group name of owner
• %h – Number of hard links
• %i – Inode number
• %m – Mount point (See note below)
• %n – File name
• %N – Quoted file name with dereference if symbolic link (see below)
• %o – Optimal I/O transfer size hint
• %s – Total size, in bytes
• %r – Device type in decimal (st_rdev)
• %R – Device type in hex (st_rdev)
• %Hr – Major device type in decimal (see below)
• %Lr – Minor device type in decimal (see below)
• %t – Major device type in hex (see below)
• %T – Minor device type in hex (see below)
• %u – User ID of owner
• %U – User name of owner
• %w – Time of file birth, or ‘-’ if unknown
• %W – Time of file birth as seconds since Epoch, or ‘0’
• %x – Time of last access
• %X – Time of last access as seconds since Epoch
• %y – Time of last data modification
• %Y – Time of last data modification as seconds since Epoch
• %z – Time of last status change
• %Z – Time of last status change as seconds since Epoch

The ‘%a’ format prints the octal mode, and so it is useful to control the zero padding of the output with the ‘#’ and ‘0’ printf flags. For example to pad to at least 3 wide while making larger numbers unambiguously octal, you can use ‘%#03a’.

The ‘%N’ format can be set with the environment variable QUOTING_STYLE. If that environment variable is not set, the default value is ‘shell-escape-always’. Valid quoting styles are:

‘literal’ Output strings as-is; this is the same as the --literal (-N) option.

‘shell’ Quote strings for the shell if they contain shell metacharacters or would cause ambiguous output. The quoting is suitable for POSIX-compatible shells like bash, but it does not always work for incompatible shells like csh.

‘shell-always’ Quote strings for the shell, even if they would normally not require quoting.

‘shell-escape’ Like ‘shell’, but also quoting non-printable characters using the POSIX proposed ‘$’”’ syntax suitable for most shells.
'shell-escape-always'
Like 'shell-escape', but quote strings even if they would normally not require quoting.

'c'
Quote strings as for C character string literals, including the surrounding double-quote characters; this is the same as the --quote-name (-Q) option.

'escape'
Quote strings as for C character string literals, except omit the surrounding double-quote characters; this is the same as the --escape (-b) option.

'locale'
Quote strings as for C character string literals, except use surrounding quotation marks appropriate for the locale.

'locname'
Quote strings as for C character string literals, except use surrounding quotation marks appropriate for the locale, and quote 'like this' instead of "like this" in the default C locale. This looks nicer on many displays.

The 'r', 'R', '%t', and '%T' formats operate on the st_rdev member of the stat(2) structure, i.e., the represented device rather than the containing device, and so are only defined for character and block special files. On some systems or file types, st_rdev may be used to represent other quantities.

The '%W', '%X', '%Y', and '%Z' formats accept a precision preceded by a period to specify the number of digits to print after the decimal point. For example, '%.3X' outputs the access timestamp to millisecond precision. If a period is given but no precision, stat uses 9 digits, so '%.X' is equivalent to '%.9X'. When discarding excess precision, timestamps are truncated toward minus infinity.

zero pad:
$ stat -c ' [%015Y]' /usr
[000001288929712]

space align:
$ stat -c ' [%15Y]' /usr
[ 1288929712]
$ stat -c ' [%-15Y]' /usr
[1288929712 ]

precision:
$ stat -c ' [% .3Y]' /usr
[1288929712.114]
$ stat -c ' [% .Y]' /usr
[1288929712.114951834]

The mount point printed by '%m' is similar to that output by df, except that:
- stat does not dereference symlinks by default (unless -L is specified)
- stat does not search for specified device nodes in the file system list, instead operating on them directly
- stat outputs the alias for a bind mounted file, rather than the initial mount point of its backing device. One can recursively call stat until there is no change in output, to get the current base mount point

When listing file system information (--file-system (--f)), you must use a different set of format directives:
- %a – Free blocks available to non-super-user
• %b – Total data blocks in file system
• %c – Total file nodes in file system
• %d – Free file nodes in file system
• %f – Free blocks in file system
• %i – File System ID in hex
• %l – Maximum length of file names
• %n – File name
• %s – Block size (for faster transfers)
• %S – Fundamental block size (for block counts)
• %t – Type in hex
• %T – Type in human readable form

Timestamps are listed according to the time zone rules specified by the TZ environment variable, or by the system default rules if TZ is not set. See Section “Specifying the Time Zone with TZ” in The GNU C Library Reference Manual.

An exit status of zero indicates success, and a nonzero value indicates failure.

14.4 sync: Synchronize cached writes to persistent storage

sync synchronizes in memory files or file systems to persistent storage. Synopsis:

    sync [option] [file]...

sync writes any data buffered in memory out to the storage device. This can include (but is not limited to) modified superblocks, modified inodes, and delayed reads and writes. This must be implemented by the kernel; The sync program does nothing but exercise the sync, syncfs, fsync, and fdatasync system calls.

The kernel keeps data in memory to avoid doing (relatively slow) device reads and writes. This improves performance, but if the computer crashes, data may be lost or the file system corrupted as a result. The sync command instructs the kernel to write data in memory to persistent storage.

If any argument is specified then only those files will be synchronized using the fsync(2) syscall by default.

If at least one file is specified, it is possible to change the synchronization method with the following options. Also see Chapter 2 [Common options], page 2.

’-d’
‘--data’ Use fdatasync(2) to sync only the data for the file, and any metadata required to maintain file system consistency.

’-f’
‘--file-system’
Synchronize all the I/O waiting for the file systems that contain the file, using the syscall syncfs(2). Note you would usually not specify this option if passing a device node like ‘/dev/sda’ for example, as that would sync the containing file system rather than the referenced one. Note also that depending on the system, passing individual device nodes or files may have different sync characteristics
than using no arguments. I.e., arguments passed to fsync(2) may provide greater
guarantees through write barriers, than a global sync(2) used when no arguments
are provided.

An exit status of zero indicates success, and a nonzero value indicates failure.

14.5 truncate: Shrink or extend the size of a file

truncate shrinks or extends the size of each file to the specified size. Synopsis:

\[ \text{truncate option... file...} \]

Any file that does not exist is created.

If a file is larger than the specified size, the extra data is lost. If a file is shorter, it is
extended and the sparse extended part (or hole) reads as zero bytes.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

\[ '-c' \]

Do not create files that do not exist.

\[ '-o' \]

\[ '--no-create' \]

Treat size as number of I/O blocks of the file rather than bytes.

\[ '-r rfile' \]

Base the size of each file on the size of rfile.

\[ '-s size' \]

\[ '--size=size' \]

Set or adjust the size of each file according to size. size is in bytes unless
--io-blocks is specified. size may be, or may be an integer optionally followed
by, one of the following multiplicative suffixes:

\[ 'KB' => 1000 \text{(KiloBytes)} \]

\[ 'K' => 1024 \text{(KibiBytes)} \]

\[ 'MB' => 1000*1000 \text{(MegaBytes)} \]

\[ 'M' => 1024*1024 \text{(MebiBytes)} \]

\[ 'GB' => 1000*1000*1000 \text{(GigaBytes)} \]

\[ 'G' => 1024*1024*1024 \text{(GibiBytes)} \]

and so on for ‘T’, ‘P’, ‘E’, ‘Z’, ‘Y’, ‘R’, and ‘Q’. Binary prefixes can be used, too:
\[ 'KiB'=\text{’K’}, 'MiB'=\text{’M’}, \text{and so on}. \]

size may also be prefixed by one of the following to adjust the size of each file
based on its current size:

\[ '+' => \text{extend by} \]

\[ '-' => \text{reduce by} \]

\[ '<' => \text{at most} \]

\[ '>' => \text{at least} \]

\[ '/' => \text{round down to multiple of} \]

\[ '%' => \text{round up to multiple of} \]

An exit status of zero indicates success, and a nonzero value indicates failure.
15 Printing text

This section describes commands that display text strings.

15.1 echo: Print a line of text

echo writes each given string to standard output, with a space between each and a newline after the last one. Synopsis:

echo [option]... [string]...

Due to shell aliases and built-in echo functions, using an unadorned echo interactively or in a script may get you different functionality than that described here. Invoke it via env (i.e., env echo ...) to avoid interference from the shell.

Due to historical and backwards compatibility reasons, certain bare option-like strings cannot be passed to echo as non-option arguments. It is therefore not advisable to use echo for printing unknown or variable arguments. The printf command is recommended as a more portable and flexible replacement for tasks historically performed by echo. See Section 15.2 [printf invocation], page 160.

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands, and the normally-special argument ‘--’ has no special meaning and is treated like any other string.

‘-n’ Do not output the trailing newline.

‘-e’ Enable interpretation of the following backslash-escaped characters in each string:

‘\a’ alert (bell)

‘\b’ backspace

‘\c’ produce no further output

‘\e’ escape

‘\f’ form feed

‘\n’ newline

‘\r’ carriage return

‘\t’ horizontal tab

‘\v’ vertical tab

‘\’ backslash

‘\0nnn’ the eight-bit value that is the octal number nnn (zero to three octal digits), if nnn is a nine-bit value, the ninth bit is ignored

‘\nnn’ the eight-bit value that is the octal number nnn (one to three octal digits), if nnn is a nine-bit value, the ninth bit is ignored

‘\xhh’ the eight-bit value that is the hexadecimal number hh (one or two hexadecimal digits)

‘-E’ Disable interpretation of backslash escapes in each string. This is the default. If -e and -E are both specified, the last one given takes effect.
If the POSIXLY_CORRECT environment variable is set, then when echo’s first argument is not \-n it outputs option-like arguments instead of treating them as options. For example, echo \-ne hello outputs ‘-ne hello’ instead of plain ‘hello’. Also backslash escapes are always enabled. Note to echo the string \-n, one of the characters can be escaped in either octal or hexadecimal representation. For example, echo \-e \"x2dn\".

POSIX does not require support for any options, and says that the behavior of echo is implementation-defined if any string contains a backslash or if the first argument is \-n. Portable programs should use the printf command instead. See Section 15.2 [printf invocation], page 160.

An exit status of zero indicates success, and a nonzero value indicates failure.

15.2 printf: Format and print data

printf does formatted printing of text. Synopsis:

printf format [argument] ...

printf prints the format string, interpreting ‘%’ directives and ‘\’ escapes to format numeric and string arguments in a way that is mostly similar to the C ‘printf’ function. See Section “printf format directives” in The GNU C Library Reference Manual, for details. The differences are listed below.

Due to shell aliases and built-in printf functions, using an unadorned printf interactively or in a script may get you different functionality than that described here. Invoke it via env (i.e., env printf ...) to avoid interference from the shell.

- The format argument is reused as necessary to convert all the given arguments. For example, the command ‘printf %s a b’ outputs ‘ab’.
- Missing arguments are treated as null strings or as zeros, depending on whether the context expects a string or a number. For example, the command ‘printf %sx%d’ prints ‘x0’.
- An additional escape, ‘\c’, causes printf to produce no further output. For example, the command ‘printf \%s\cA\cD\cE’ prints ‘ABC’.
- The hexadecimal escape sequence ‘\xhh’ has at most two digits, as opposed to C where it can have an unlimited number of digits. For example, the command ‘printf \%sx\%d’ prints two bytes, whereas the C statement ‘printf ("\x07e")’ prints just one.
- An additional directive ‘%b’, prints its argument string with ‘\’ escapes interpreted in the same way as in the format string, except that octal escapes are of the form ‘\0ooo’ where ooo is 0 to 3 octal digits. If ‘\ooo’ is nine-bit value, ignore the ninth bit. If a precision is also given, it limits the number of bytes printed from the converted string.
- An additional directive ‘%q’, prints its argument string in a format that can be reused as input by most shells. Non-printable characters are escaped with the POSIX proposed ‘\$’ syntax, and shell metacharacters are quoted appropriately. This is an equivalent format to ls --quoting=shell-escape output.
- Numeric arguments must be single C constants, possibly with leading ‘+’ or ‘-‘. For example, ‘printf %.4d -3’ outputs ‘-0003’.
- If the leading character of a numeric argument is ‘#’ or ‘+’ then its value is the numeric value of the immediately following character. Any remaining characters are silently
ignored if the POSIXLY_CORRECT environment variable is set; otherwise, a warning is printed. For example, `printf "\d" 'a'` outputs '97' on hosts that use the ASCII character set, since 'a' has the numeric value 97 in ASCII.

A floating point argument is interpreted according to the LC_NUMERIC category of either the current or the C locale, and is printed according to the current locale. For example, in a locale whose decimal point character is a comma, the command `printf '%g %g' 2.5 2.5` outputs '2,5 2,5'. See Section 2.12 [Floating point], page 10.

printf interprets `\ooo` in format as an octal number (if ooo is 1 to 3 octal digits) specifying a byte to print, and `\xhh` as a hexadecimal number (if hh is 1 to 2 hex digits) specifying a character to print. Note however that when `\ooo` specifies a number larger than 255, printf ignores the ninth bit. For example, `printf '\400'` is equivalent to `printf '\0'`.

printf interprets two syntax forms for specifying Unicode (ISO/IEC 10646) characters. `\u` for 16-bit Unicode characters, specified as four hexadecimal digits hhhh, and `\U` for 32-bit Unicode characters, specified as eight hexadecimal digits hhhhhhhhh. printf outputs the Unicode characters according to the LC_CTYPE locale. Unicode characters in the range U+D800...U+DFFF cannot be specified by this syntax. This syntax fully supports the universal character subset introduced in ISO C 99.

The processing of `\u` and `\U` requires a full-featured iconv facility. It is activated on systems with glibc 2.2 (or newer), or when libiconv is installed prior to this package. Otherwise `\u` and `\U` will print as-is.

Unicode character syntax is useful for writing strings in a locale independent way. For example, a string containing the Euro currency symbol

```
$ env printf '\u20AC 14.95'
```

will be output correctly in all locales supporting the Euro symbol (ISO-8859-15, UTF-8, and others). Similarly, a Chinese string

```
$ env printf '\u4e2d\u6587'
```

will be output correctly in all Chinese locales (GB2312, BIG5, UTF-8, etc).

Note that in these examples, the printf command has been invoked via env to ensure that we run the program found via your shell’s search path, and not a shell alias or a built-in function.

For larger strings, you don’t need to look up the hexadecimal code values of each character one by one. ASCII characters mixed with `\u` escape sequences is also known as the JAVA source file encoding. You can use GNU recode 3.5c (or newer) to convert strings to this encoding. Here is how to convert a piece of text into a shell script which will output this text in a locale-independent way:

```
$ LC_CTYPE=zh_TW.big5 env printf "\\u4e2d\\u6587\n" > sample.txt
$ recode BIG5..JAVA < sample.txt | sed -e "s|\^|env printf '|" -e "s|%|%%|g" -e "s|\||\\\n" | > sample.sh
```

The only options are a lone --help or --version. See Chapter 2 [Common options], page 2. Options must precede operands.

An exit status of zero indicates success, and a nonzero value indicates failure.
15.3 yes: Print a string until interrupted

yes prints the command line arguments, separated by spaces and followed by a newline, forever until it is killed. If no arguments are given, it prints ‘y’ followed by a newline forever until killed.

Upon a write error, yes exits with status ‘1’.

The only options are a lone --help or --version. To output an argument that begins with ‘-‘, precede it with --, e.g., ‘yes -- --help’. See Chapter 2 [Common options], page 2.
16 Conditions

This section describes commands that are primarily useful for their exit status, rather than their output. Thus, they are often used as the condition of shell if statements, or as the last command in a pipeline.

16.1 false: Do nothing, unsuccessfully

false does nothing except return an exit status of 1, meaning failure. It can be used as a place holder in shell scripts where an unsuccessful command is needed. In most modern shells, false is a built-in command, so when you use ‘false’ in a script, you’re probably using the built-in command, not the one documented here.

false honors the --help and --version options.

This version of false is implemented as a C program, and is thus more secure and faster than a shell script implementation, and may safely be used as a dummy shell for the purpose of disabling accounts.

Note that false (unlike all other programs documented herein) exits unsuccessfully, even when invoked with --help or --version.

Portable programs should not assume that the exit status of false is 1, as it is greater than 1 on some non-GNU hosts.

16.2 true: Do nothing, successfully

true does nothing except return an exit status of 0, meaning success. It can be used as a place holder in shell scripts where a successful command is needed, although the shell built-in command : (colon) may do the same thing faster. In most modern shells, true is a built-in command, so when you use ‘true’ in a script, you’re probably using the built-in command, not the one documented here.

true honors the --help and --version options.

Note, however, that it is possible to cause true to exit with nonzero status: with the --help or --version option, and with standard output already closed or redirected to a file that evokes an I/O error. For example, using a Bourne-compatible shell:

$ ./true --version >&-
./true: write error: Bad file number
$ ./true --version > /dev/full
./true: write error: No space left on device

This version of true is implemented as a C program, and is thus more secure and faster than a shell script implementation, and may safely be used as a dummy shell for the purpose of disabling accounts.

16.3 test: Check file types and compare values

test returns a status of 0 (true) or 1 (false) depending on the evaluation of the conditional expression expr. Each part of the expression must be a separate argument.

test has file status checks, string operators, and numeric comparison operators.
test has an alternate form that uses opening and closing square brackets instead a leading ‘test’. For example, instead of ‘test -d /’, you can write ‘[ -d / ]’. The square brackets must be separate arguments; for example, ‘[-d /]’ does not have the desired effect. Since ‘test expr’ and ‘[ expr ]’ have the same meaning, only the former form is discussed below.

Synopses:

```
test expression
```
```
test
 [ expression ]
 [ ]
 [ option]
```

Due to shell aliases and built-in test functions, using an unadorned test interactively or in a script may get you different functionality than that described here. Invoke it via env (i.e., `env test ...`) to avoid interference from the shell.

If expression is omitted, test returns false. If expression is a single argument, test returns false if the argument is null and true otherwise. The argument can be any string, including strings like ‘-d’, ‘-l’, ‘--’, ‘--help’, and ‘--version’ that most other programs would treat as options. To get help and version information, invoke the commands ‘[ --help’ and ‘[ --version’, without the usual closing brackets. See Chapter 2 [Common options], page 2.

Exit status:

0 if the expression is true,
1 if the expression is false,
2 if an error occurred.

### 16.3.1 File type tests

These options test for particular types of files. (Everything’s a file, but not all files are the same!)

‘-b file’ True if file exists and is a block special device.

‘-c file’ True if file exists and is a character special device.

‘-d file’ True if file exists and is a directory.

‘-f file’ True if file exists and is a regular file.

‘-h file’

‘-L file’ True if file exists and is a symbolic link. Unlike all other file-related tests, this test does not dereference file if it is a symbolic link.

‘-p file’ True if file exists and is a named pipe.

‘-S file’ True if file exists and is a socket.

‘-t fd’ True if fd is a file descriptor that is associated with a terminal.
16.3.2 Access permission tests
These options test for particular access permissions.

`-g file`  True if file exists and has its set-group-ID bit set.

`-k file`  True if file exists and has its sticky bit set.

`-r file`  True if file exists and the user has read access.

`-u file`  True if file exists and has its set-user-ID bit set.

`-w file`  True if file exists and the user has write access.

`-x file`  True if file exists and the user has execute access (or search permission, if it is a directory).

`-o file`  True if file exists and is owned by the current effective user ID.

`-G file`  True if file exists and is owned by the current effective group ID.

16.3.3 File characteristic tests
These options test other file characteristics.

`-e file`  True if file exists.

`-s file`  True if file exists and has a size greater than zero.

`file1 -nt file2`
True if file1 is newer (according to modification date) than file2, or if file1 exists and file2 does not.

`file1 -ot file2`
True if file1 is older (according to modification date) than file2, or if file2 exists and file1 does not.

`file1 -ef file2`
True if file1 and file2 have the same device and inode numbers, i.e., if they are hard links to each other.

`-N file`  True if file exists and has been modified (mtime) since it was last read (atime).

16.3.4 String tests
These options test string characteristics. You may need to quote string arguments for the shell. For example:

```
    test -n "$V"
```

The quotes here prevent the wrong arguments from being passed to test if `$V` is empty or contains special characters.

`-z string`
True if the length of string is zero.

`-n string`
`string`  True if the length of string is nonzero.

`string1 = string2`
True if the strings are equal.
'string1 == string2'
   True if the strings are equal (syonym for =). Note this form is not as portable
to other shells and systems.

'string1 != string2'
   True if the strings are not equal.

16.3.5 Numeric tests
Numeric relational operators. The arguments must be entirely numeric (possibly negative),
or the special expression -l string, which evaluates to the length of string.

'arg1 -eq arg2'
'arg1 -ne arg2'
'arg1 -lt arg2'
'arg1 -le arg2'
'arg1 -gt arg2'
'arg1 -ge arg2'
   These arithmetic binary operators return true if arg1 is equal, not-equal, less-
than, less-than-or-equal, greater-than, or greater-than-or-equal than arg2, re-
spectively.

For example:
   test -1 -gt -2 && echo yes
⇒ yes
   test -l abc -gt 1 && echo yes
⇒ yes
   test 0x100 -eq 1
     error test: integer expression expected before -eq

16.3.6 Connectives for test
Note it's preferred to use shell logical primitives rather than these logical connectives internal
to test, because an expression may become ambiguous depending on the expansion of its
parameters.

For example, this becomes ambiguous when ‘$1’ is set to ‘!’ and ‘$2’ to the empty
string ‘’:
   test "$1" -a "$2"
   and should be written as:
   test "$1" && test "$2"

Note the shell logical primitives also benefit from short circuit operation, which can be
significant for file attribute tests.

'! expr'
   True if expr is false. ‘!’ has lower precedence than all parts of expr. Note ‘!’
   needs to be specified to the left of a binary expression, i.e., ‘1 ! -gt 2’ rather
   than ‘1 '!*' -gt 2’. Also ‘!’ is often a shell special character and is best used
   quoted.

'expr1 -a expr2'
   True if both expr1 and expr2 are true. ‘-a’ is left associative, and has a higher
   precedence than ‘-o’.
'expr -o expr2'
True if either expr1 or expr2 is true. ‘-o’ is left associative.

16.4 expr: Evaluate expressions

expr evaluates an expression and writes the result on standard output. Each token of the expression must be a separate argument.

Operands are either integers or strings. Integers consist of one or more decimal digits, with an optional leading ‘-’. expr converts anything appearing in an operand position to an integer or a string depending on the operation being applied to it.

Strings are not quoted for expr itself, though you may need to quote them to protect characters with special meaning to the shell, e.g., spaces. However, regardless of whether it is quoted, a string operand should not be a parenthesis or any of expr’s operators like +, so you cannot safely pass an arbitrary string $str to expr merely by quoting it to the shell. One way to work around this is to use the GNU extension +, (e.g., + "$str" = foo); a more portable way is to use "$str" and to adjust the rest of the expression to take the leading space into account (e.g., "$str" = " foo").

You should not pass a negative integer or a string with leading ‘-’ as expr’s first argument, as it might be misinterpreted as an option; this can be avoided by parenthesization. Also, portable scripts should not use a string operand that happens to take the form of an integer; this can be worked around by inserting leading spaces as mentioned above.

Operators may be given as infix symbols or prefix keywords. Parentheses may be used for grouping in the usual manner. You must quote parentheses and many operators to avoid the shell evaluating them, however.

Because expr uses multiple-precision arithmetic, it works with integers wider than those of machine registers.

The only options are --help and --version. See Chapter 2 [Common options], page 2. Options must precede operands.

Exit status:
0 if the expression is neither null nor 0,
1 if the expression is null or 0,
2 if the expression is invalid,
3 if an internal error occurred (e.g., arithmetic overflow).

16.4.1 String expressions

expr supports pattern matching and other string operators. These have higher precedence than both the numeric and relational operators (in the next sections).

‘string : regex’
Perform pattern matching. The arguments are converted to strings and the second is considered to be a (basic, a la GNU grep) regular expression, with a " implicitly prepended. The first argument is then matched against this regular expression.

If regex does not use ‘\(‘ and ‘\)’, the : expression returns the number of characters matched, or 0 if the match fails.
If regex uses ‘\(’ and ‘\)’, the : expression returns the part of string that matched the subexpression, or the null string if the match failed or the subexpression did not contribute to the match.

Only the first ‘\( . . . \)’ pair is relevant to the return value; additional pairs are meaningful only for grouping the regular expression operators.

In the regular expression, \+, \?, and \| are operators which respectively match one or more, zero or one, or separate alternatives. These operators are GNU extensions. See Section “Regular Expressions” in The GNU Grep Manual, for details of regular expression syntax. Some examples are in Section 16.4.4 [Examples of expr], page 169.

'match string regex'
An alternative way to do pattern matching. This is the same as 'string : regex'.

'substr string position length'
Returns the substring of string beginning at position with length at most length. If either position or length is negative, zero, or non-numeric, returns the null string.

'index string charset'
Returns the first position in string where the first character in charset was found. If no character in charset is found in string, return 0.

'length string'
Returns the length of string.

'+ token' Interpret token as a string, even if it is a keyword like match or an operator like / . This makes it possible to test expr length + "$x" or expr + "$x" : '.*\(.*\)' and have it do the right thing even if the value of $x happens to be (for example) / or index . This operator is a GNU extension. Portable shell scripts should use " $token" : ' \(\.*\)' instead of + "$token".

To make expr interpret keywords as strings, you must use the quote operator.

16.4.2 Numeric expressions

expr supports the usual numeric operators, in order of increasing precedence. These numeric operators have lower precedence than the string operators described in the previous section, and higher precedence than the connectives (next section).

'+ -' Addition and subtraction. Both arguments are converted to integers; an error occurs if this cannot be done.

'* / %' Multiplication, division, remainder. Both arguments are converted to integers; an error occurs if this cannot be done.

16.4.3 Relations for expr

expr supports the usual logical connectives and relations. These have lower precedence than the string and numeric operators (previous sections). Here is the list, lowest-precedence operator first.
‘|’ Returns its first argument if that is neither null nor zero, otherwise its second argument if it is neither null nor zero, otherwise 0. It does not evaluate its second argument if its first argument is neither null nor zero.

‘&’ Return its first argument if neither argument is null or zero, otherwise 0. It does not evaluate its second argument if its first argument is null or zero.

‘< <= == != >= >’

Compare the arguments and return 1 if the relation is true, 0 otherwise. == is a synonym for =. expr first tries to convert both arguments to integers and do a numeric comparison; if either conversion fails, it does a lexicographic comparison using the character collating sequence specified by the LC_COLLATE locale.

16.4.4 Examples of using expr

Here are a few examples, including quoting for shell metacharacters.

To add 1 to the shell variable foo, in Bourne-compatible shells:

```
foo=$(expr $foo + 1)
```

To print the non-directory part of the file name stored in $fname, which need not contain a /:

```
expr $fname : '.*/\(..*\)' '|' $fname
```

An example showing that \+ is an operator:

```
expr aaa : 'a\+'
⇒ 3
expr abc : 'a\(.\)c'
⇒ b
expr index abcdef cz
⇒ 3
expr index index a
⇒ 0
```
17 Redirection

Unix shells commonly provide several forms of redirection – ways to change the input source or output destination of a command. But one useful redirection is performed by a separate command, not by the shell; it’s described here.

17.1 tee: Redirect output to multiple files or processes

The tee command copies standard input to standard output and also to any files given as arguments. This is useful when you want not only to send some data down a pipe, but also to save a copy. Synopsis:

```
    tee [option]... [file]...
```

If a file being written to does not already exist, it is created. If a file being written to already exists, the data it previously contained is overwritten unless the `-a` option is used.

In previous versions of GNU Coreutils (5.3.0–8.23), a `file` of `-` caused tee to send another copy of input to standard output. However, as the interleaved output was not very useful, tee now conforms to POSIX and treats `-` as a file name.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-a`

`--append`

Append standard input to the given files rather than overwriting them.

`-i`

`--ignore-interrupts`

Ignore interrupt signals.

`-p`

`--output-error[=mode]`

Adjust the behavior with errors on the outputs. In summary `-p` allows tee to operate in a more appropriate manner with pipes, and to continue to process data to any remaining outputs, if any pipe outputs exit early. The default operation when `--output-error` is not specified is to exit immediately on error writing to a pipe, and diagnose errors writing to a non-pipe. The long form `--output-error` option supports selection between the following modes:

`warn`

Warn on error opening or writing any output, including pipes. Writing is continued to still open files/pipes. Exit status indicates failure if any output has an error.

`warn-nopipe`

This is the default mode when not specified, or when the short form `-p` is used. Warn on error opening or writing any output, except pipes. Writing is continued to still open files/pipes. Exit immediately if all remaining outputs become broken pipes. Exit status indicates failure if any non pipe output had an error.

`exit`

Exit on error opening or writing any output, including pipes.
'exit-nopipe'

Exit on error opening or writing any output, except pipes. Exit immediately if all remaining outputs become broken pipes.

The `tee` command is useful when you happen to be transferring a large amount of data and also want to summarize that data without reading it a second time. For example, when you are downloading a DVD image, you often want to verify its signature or checksum right away. The inefficient way to do it is simply:

```
wget https://example.com/some.iso && sha1sum some.iso
```

One problem with the above is that it makes you wait for the download to complete before starting the time-consuming SHA1 computation. Perhaps even more importantly, the above requires reading the DVD image a second time (the first was from the network).

The efficient way to do it is to interleave the download and SHA1 computation. Then, you'll get the checksum for free, because the entire process parallelizes so well:

```
# slightly contrived, to demonstrate process substitution
wget -O - https://example.com/dvd.iso | tee >(sha1sum > dvd.sha1) > dvd.iso
```

That makes `tee` write not just to the expected output file, but also to a pipe running `sha1sum` and saving the final checksum in a file named `dvd.sha1`.

Note, however, that this example relies on a feature of modern shells called process substitution (the `>(command)` syntax, above; See Section “Process Substitution” in The Bash Reference Manual.), so it works with `zsh`, `bash`, and `ksh`, but not with `/bin/sh`. So if you write code like this in a shell script, be sure to start the script with `#!/bin/bash`.

Note also that if any of the process substitutions (or piped standard output) might exit early without consuming all the data, the `-p` option is needed to allow `tee` to continue to process the input to any remaining outputs.

Since the above example writes to one file and one process, a more conventional and portable use of `tee` is even better:

```
wget -O - https://example.com/dvd.iso | tee dvd.iso | sha1sum > dvd.sha1
```

You can extend this example to make `tee` write to two processes, computing MD5 and SHA1 checksums in parallel. In this case, process substitution is required:

```
wget -O - https://example.com/dvd.iso | tee >(sha1sum > dvd.sha1) 
  >(md5sum > dvd.md5) 
  > dvd.iso
```

This technique is also useful when you want to make a compressed copy of the contents of a pipe. Consider a tool to graphically summarize file system usage data from `du -ak`. For a large hierarchy, `du -ak` can run for a long time, and can easily produce terabytes of data, so you won’t want to rerun the command unnecessarily. Nor will you want to save the uncompressed output.

Doing it the inefficient way, you can’t even start the GUI until after you’ve compressed all of the `du` output:

```
du -ak | gzip -9 > /tmp/du.gz
```
gzip -d /tmp/du.gz | checkspace -a

With `tee` and process substitution, you start the GUI right away and eliminate the decompression completely:

du -ak | tee >(gzip -9 > /tmp/du.gz) | checkspace -a

Finally, if you regularly create more than one type of compressed tarball at once, for example when `make dist` creates both gzip-compressed and bzip2-compressed tarballs, there may be a better way. Typical `automake`-generated `Makefile` rules create the two compressed tar archives with commands in sequence, like this (slightly simplified):

```bash
tardir=your-pkg-M.N
 tar chof - "$tardir" | gzip -9 -c > your-pkg-M.N.tar.gz
 tar chof - "$tardir" | bzip2 -9 -c > your-pkg-M.N.tar.bz2
```

However, if the hierarchy you are archiving and compressing is larger than a couple megabytes, and especially if you are using a multi-processor system with plenty of memory, then you can do much better by reading the directory contents only once and running the compression programs in parallel:

```bash
tardir=your-pkg-M.N
 tar chof - "$tardir" \
 | tee >(gzip -9 -c > your-pkg-M.N.tar.gz) \
 | bzip2 -9 -c > your-pkg-M.N.tar.bz2
```

If you want to further process the output from process substitutions, and those processes write atomically (i.e., write less than the system’s `PIPE_BUF` size at a time), that’s possible with a construct like:

```bash
tardir=your-pkg-M.N
 tar chof - "$tardir" \
 | tee >(md5sum --tag) > >(sha256sum --tag) \
 | sort | gpg --clearsign > your-pkg-M.N.tar.sig
```

An exit status of zero indicates success, and a nonzero value indicates failure.
18 File name manipulation

This section describes commands that manipulate file names.

18.1 basename: Strip directory and suffix from a file name

`basename` removes any leading directory components from `name`. Synopsis:

```
basename name [suffix]
basename option... name...
```

If `suffix` is specified and is identical to the end of `name`, it is removed from `name` as well. Note that since trailing slashes are removed prior to suffix matching, `suffix` will do nothing if it contains slashes. `basename` prints the result on standard output.

Together, `basename` and `dirname` are designed such that if `ls "$name"` succeeds, then the command sequence `cd "$(dirname "$name")"; ls "$(basename "$name")"` will, too. This works for everything except file names containing a trailing newline. POSIX allows the implementation to define the results if `name` is empty or `//`. In the former case, GNU `basename` returns the empty string. In the latter case, the result is `//` on platforms where `//` is distinct from `/`, and `/` on platforms where there is no difference.

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands.

`-a`
`--multiple`
Support more than one argument. Treat every argument as a `name`. With this, an optional `suffix` must be specified using the `-s` option.

`-s suffix`
`--suffix=suffix`
Remove a trailing `suffix`. This option implies the `-a` option.

`-z`
`--zero`
Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines.

An exit status of zero indicates success, and a nonzero value indicates failure. Examples:

```
# Output "sort".
basename /usr/bin/sort

# Output "stdio".
basename include/stdio.h .h

# Output "stdio".
basename -s .h include/stdio.h

# Output "stdio" followed by "stdlib"
basename -a -s .h include/stdio.h include/stdlib.h
```
18.2 dirname: Strip last file name component

dirname prints all but the final slash-delimited component of each name. Slashes on either side of the final component are also removed. If the string contains no slash, dirname prints "." (meaning the current directory). Synopsis:

```
dirname [option] name...
```

name need not be a file name, but if it is, this operation effectively lists the directory that contains the final component, including the case when the final component is itself a directory.

Together, basename and dirname are designed such that if `ls "$name"` succeeds, then the command sequence `cd "$(dirname "$name")"; ls "$(basename "$name")"` will, too. This works for everything except file names containing a trailing newline. POSIX allows the implementation to define the results if name is "/". With GNU dirname, the result is "/" on platforms where "/" is distinct from "/", and "/" on platforms where there is no difference.

The program accepts the following option. Also see Chapter 2 [Common options], page 2.

`-z`

`--zero` Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines.

An exit status of zero indicates success, and a nonzero value indicates failure. Examples:

```
# Output "/usr/bin".
dirname /usr/bin/sort
dirname /usr/bin/../

# Output "dir1" followed by "dir2"
dirname dir1/str dir2/str

# Output ".".
dirname stdio.h
```

18.3 pathchk: Check file name validity and portability

pathchk checks validity and portability of file names. Synopsis:

```
pathchk [option]... name...
```

For each name, pathchk prints an error message if any of these conditions is true:
1. One of the existing directories in name does not have search (execute) permission,
2. The length of name is larger than the maximum supported by the operating system.
3. The length of one component of name is longer than its file system’s maximum.

A nonexistent name is not an error, so long as a file with that name could be created under the above conditions.

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands.

`-p` Instead of performing checks based on the underlying file system, print an error message if any of these conditions is true:
1. A file name is empty.
2. A file name contains a character outside the POSIX portable file name character set, namely, the ASCII letters and digits, ‘.’, ‘_’, ‘-’, and ‘/’.

3. The length of a file name or one of its components exceeds the POSIX minimum limits for portability.

‘-P’ Print an error message if a file name is empty, or if it contains a component that begins with ‘-’.

‘--portability’ Print an error message if a file name is not portable to all POSIX hosts. This option is equivalent to ‘-p -P’.

Exit status:
   0 if all specified file names passed all checks,
   1 otherwise.

18.4 mktemp: Create temporary file or directory

mktemp manages the creation of temporary files and directories. Synopsis:

        mktemp [option]... [template]

      Safely create a temporary file or directory based on template, and print its name. If given, template must include at least three consecutive ‘X’s in the last component. If omitted, the template ‘tmp.XXXXXXXXXX’ is used, and option --tmpdir is implied. The final run of ‘X’s in the template will be replaced by alpha-numeric characters; thus, on a case-sensitive file system, and with a template including a run of \( n \) instances of ‘X’, there are \( 62^{*n} \) potential file names.

Older scripts used to create temporary files by simply joining the name of the program with the process id (‘$$’) as a suffix. However, that naming scheme is easily predictable, and suffers from a race condition where the attacker can create an appropriately named symbolic link, such that when the script then opens a handle to what it thought was an unused file, it is instead modifying an existing file. Using the same scheme to create a directory is slightly safer, since the mkdir will fail if the target already exists, but it is still inferior because it allows for denial of service attacks. Therefore, modern scripts should use the mktemp command to guarantee that the generated name will be unpredictable, and that knowledge of the temporary file name implies that the file was created by the current script and cannot be modified by other users.

When creating a file, the resulting file has read and write permissions for the current user, but no permissions for the group or others; these permissions are reduced if the current umask is more restrictive.

Here are some examples (although note that if you repeat them, you will most likely get different file names):

- Create a temporary file in the current directory.
  
  \$ mktemp file.XXXX
  
  file.H47c

- Create a temporary file with a known suffix.
  
  \$ mktemp --suffix=.txt file-XXXX
Chapter 18: File name manipulation

176

file-H08W.txt
$ mktemp file-XXXX-XXXX.txt
file-XXXX-eI9L.txt
• Create a secure fifo relative to the user’s choice of TMPDIR, but falling back to the
current directory rather than /tmp. Note that mktemp does not create fifos, but can
create a secure directory in which the fifo can live. Exit the shell if the directory or fifo
could not be created.
$ dir=$(mktemp -p "${TMPDIR:-.}" -d dir-XXXX) || exit 1
$ fifo=$dir/fifo
$ mkfifo "$fifo" || { rmdir "$dir"; exit 1; }
• Create and use a temporary file if possible, but ignore failure. The file will reside in the
directory named by TMPDIR, if specified, or else in /tmp.
$ file=$(mktemp -q) && {
>
# Safe to use $file only within this block. Use quotes,
>
# since $TMPDIR, and thus $file, may contain whitespace.
>
echo ... > "$file"
>
rm "$file"
> }
• Act as a semi-random character generator (it is not fully random, since it is impacted by
the contents of the current directory). To avoid security holes, do not use the resulting
names to create a file.
$ mktemp -u XXX
Gb9
$ mktemp -u XXX
nzC
The program accepts the following options. Also see Chapter 2 [Common options], page 2.
‘-d’
‘--directory’
Create a directory rather than a file. The directory will have read, write, and
search permissions for the current user, but no permissions for the group or
others; these permissions are reduced if the current umask is more restrictive.
‘-q’
‘--quiet’

Suppress diagnostics about failure to create a file or directory. The exit status
will still reflect whether a file was created.

‘-u’
‘--dry-run’
Generate a temporary name that does not name an existing file, without changing
the file system contents. Using the output of this command to create a new file
is inherently unsafe, as there is a window of time between generating the name
and using it where another process can create an object by the same name.
‘-p dir’
‘--tmpdir[=dir]’
Treat template relative to the directory dir. If dir is not specified (only possible
with the long option --tmpdir) or is the empty string, use the value of TMPDIR


if available, otherwise use ‘/tmp’. If this is specified, template must not be absolute. However, template can still contain slashes, although intermediate directories must already exist.

‘--suffix=suffix’
Append suffix to the template. suffix must not contain slash. If --suffix is specified, template must end in ‘X'; if it is not specified, then an appropriate --suffix is inferred by finding the last ‘X’ in template. This option exists for use with the default template and for the creation of a suffix that starts with ‘X’.

‘-t’
Treat template as a single file relative to the value of TMPDIR if available, or to the directory specified by -p, otherwise to ‘/tmp’. template must not contain slashes. This option is deprecated; the use of -p without -t offers better defaults (by favoring the command line over TMPDIR) and more flexibility (by allowing intermediate directories).

Exit status:
0 if the file was created,
1 otherwise.

18.5 realpath: Print the resolved file name.
realpath expands all symbolic links and resolves references to ‘./’, ‘/./’ and extra ‘/’ characters. By default, all but the last component of the specified files must exist. Synopsis:

realpath [option]... file...

The file name canonicalization functionality overlaps with that of the readlink command. This is the preferred command for canonicalization as it’s a more suitable and standard name. In addition this command supports relative file name processing functionality.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-e’
‘--canonicalize-existing’
Ensure that all components of the specified file names exist. If any component is missing or unavailable, realpath will output a diagnostic unless the -q option is specified, and exit with a nonzero exit code. A trailing slash requires that the name resolve to a directory.

‘-m’
‘--canonicalize-missing’
If any component of a specified file name is missing or unavailable, treat it as a directory.

‘-L’
‘--logical’
Symbolic links are resolved in the specified file names, but they are resolved after any subsequent ‘.’ components are processed.
Symbolic links are resolved in the specified file names, and they are resolved before any subsequent ‘..’ components are processed. This is the default mode of operation.

Suppress diagnostic messages for specified file names.

Print the resolved file names relative to the specified directory. Note this option honors the -m and -e options pertaining to file existence.

Print the resolved file names as relative if the files are descendants of dir. Otherwise, print the resolved file names as absolute. Note this option honors the -m and -e options pertaining to file existence. For details about combining --relative-to and --relative-base, see Section 18.5.1 [Realpath usage examples], page 178.

Do not resolve symbolic links. Only resolve references to ‘../’, ‘/..’ and remove extra ‘/’ characters. When combined with the -m option, realpath operates only on the file name, and does not touch any actual file.

Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines.

Exit status:
0 if all file names were printed without issue.
1 otherwise.

18.5.1 Realpath usage examples
By default, realpath prints the absolute file name of given files (symlinks are resolved, words is resolved to american-english):

```
cd /home/user
realpath /usr/bin/sort /tmp/foo /usr/share/dict/words 1.txt
⇒ /usr/bin/sort
⇒ /tmp/foo
⇒ /usr/share/dict/american-english
⇒ /home/user/1.txt
```

With --relative-to, file names are printed relative to the given directory:
realpath --relative-to=/usr/bin \
/usr/bin/sort /tmp/foo /usr/share/dict/words 1.txt
⇒ sort
⇒ ../../tmp/foo
⇒ ../share/dict/american-english
⇒ ../../home/user/1.txt
With --relative-base, relative file names are printed if the resolved file name is below the given base directory. For files outside the base directory absolute file names are printed:

realpath --relative-base=/usr \
/usr/bin/sort /tmp/foo /usr/share/dict/words 1.txt
⇒ bin/sort
⇒ /tmp/foo
⇒ share/dict/american-english
⇒ /home/user/1.txt
When both --relative-to=DIR1 and --relative-base=DIR2 are used, file names are printed relative to dir1 if they are located below dir2. If the files are not below dir2, they are printed as absolute file names:

realpath --relative-to=/usr/bin --relative-base=/usr \
/usr/bin/sort /tmp/foo /usr/share/dict/words 1.txt
⇒ sort
⇒ /tmp/foo
⇒ ../share/dict/american-english
⇒ /home/user/1.txt
When both --relative-to=DIR1 and --relative-base=DIR2 are used, dir1 must be a subdirectory of dir2. Otherwise, realpath prints absolutes file names.
19 Working context

This section describes commands that display or alter the context in which you are working: the current directory, the terminal settings, and so forth. See also the user-related commands in the next section.

19.1 pwd: Print working directory

`pwd` prints the name of the current directory. Synopsis:

```
pwd [option]...
```

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-L’
‘--logical’
If the contents of the environment variable `PWD` provide an absolute name of the current directory with no ‘.’ or ‘..’ components, but possibly with symbolic links, then output those contents. Otherwise, fall back to default -P handling.

‘-P’
‘--physical’
Print a fully resolved name for the current directory. That is, all components of the printed name will be actual directory names – none will be symbolic links.

If -L and -P are both given, the last one takes precedence. If neither option is given, then this implementation uses -P as the default unless the `POSIXLY_CORRECT` environment variable is set.

Due to shell aliases and built-in `pwd` functions, using an unadorned `pwd` interactively or in a script may get you different functionality than that described here. Invoke it via `env` (i.e., `env pwd ...`) to avoid interference from the shell.

An exit status of zero indicates success, and a nonzero value indicates failure.

19.2 stty: Print or change terminal characteristics

`stty` prints or changes terminal characteristics, such as baud rate. Synopses:

```
stty [option] [setting]...
stty [option]
```

If given no line settings, `stty` prints the baud rate, line discipline number (on systems that support it), and line settings that have been changed from the values set by `stty sane`. By default, mode reading and setting are performed on the tty line connected to standard input, although this can be modified by the `--file` option.

`stty` accepts many non-option arguments that change aspects of the terminal line operation, as described below.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-a’
‘--all’
Print all current settings in human-readable form. This option may not be used in combination with any line settings.
'--file=device'
Set the line opened by the file name specified in device instead of the tty line connected to standard input. This option is necessary because opening a POSIX tty requires use of the O_NONDELAY flag to prevent a POSIX tty from blocking until the carrier detect line is high if the clocal flag is not set. Hence, it is not always possible to allow the shell to open the device in the traditional manner.

'--save'
Print all current settings in a form that can be used as an argument to another stty command to restore the current settings. This option may not be used in combination with any line settings.

Many settings can be turned off by preceding them with a ‘-‘. Such arguments are marked below with “May be negated” in their description. The descriptions themselves refer to the positive case, that is, when not negated (unless stated otherwise, of course).

Some settings are not available on all POSIX systems, since they use extensions. Such arguments are marked below with “Non-POSIX” in their description. On non-POSIX systems, those or other settings also may not be available, but it’s not feasible to document all the variations: just try it and see.

stty is installed only on platforms with the POSIX terminal interface, so portable scripts should not rely on its existence on non-POSIX platforms.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 19.2.1 Control settings

Control settings:

'parenb'  Generate parity bit in output and expect parity bit in input. May be negated.

'parodd'  Set odd parity (even if negated). May be negated.

'cmspar'  Use "stick" (mark/space) parity. If parodd is set, the parity bit is always 1; if parodd is not set, the parity bit is always zero. Non-POSIX. May be negated.

'cs5'  'cs6'  'cs7'  'cs8'  Set character size to 5, 6, 7, or 8 bits.

'hup'  'hupcl'  Send a hangup signal when the last process closes the tty. May be negated.

'cstopb'  Use two stop bits per character (one if negated). May be negated.

'cread'  Allow input to be received. May be negated.

'clocal'  Disable modem control signals. May be negated.

'crtstscts'  Enable RTS/CTS flow control. Non-POSIX. May be negated.

'cdtrdsr'  Enable DTR/DSR flow control. Non-POSIX. May be negated.
19.2.2 Input settings

These settings control operations on data received from the terminal.

- ‘ignbrk’ Ignore break characters. May be negated.
- ‘brkint’ Make breaks cause an interrupt signal. May be negated.
- ‘ignpar’ Ignore characters with parity errors. May be negated.
- ‘parmrk’ Mark parity errors (with a 255-0-character sequence). May be negated.
- ‘inpck’ Enable input parity checking. May be negated.
- ‘istrip’ Clear high (8th) bit of input characters. May be negated.
- ‘inlcr’ Translate newline to carriage return. May be negated.
- ‘igncr’ Ignore carriage return. May be negated.
- ‘icrnl’ Translate carriage return to newline. May be negated.
- ‘iutf8’ Assume input characters are UTF-8 encoded. May be negated.
- ‘ixon’ Enable XON/XOFF flow control (that is, Ctrl-S/Ctrl-Q). May be negated.
- ‘ixoff’ Enable sending of stop character when the system input buffer is almost full, and start character when it becomes almost empty again. May be negated.
- ‘iucr’ Translate uppercase characters to lowercase. Non-POSIX. May be negated. Note ilcuc is not implemented, as one would not be able to issue almost any (lowercase) Unix command, after invoking it.
- ‘ixany’ Allow any character to restart output (only the start character if negated). Non-POSIX. May be negated.
- ‘imaxbel’ Enable beeping and not flushing input buffer if a character arrives when the input buffer is full. Non-POSIX. May be negated.

19.2.3 Output settings

These settings control operations on data sent to the terminal.

- ‘opost’ Postprocess output. May be negated.
- ‘olcuc’ Translate lowercase characters to uppercase. Non-POSIX. May be negated. (Note oulc is not currently implemented.)
- ‘ocrnl’ Translate carriage return to newline. Non-POSIX. May be negated.
- ‘onlcr’ Translate newline to carriage return-newline. Non-POSIX. May be negated.
- ‘onocr’ Do not print carriage returns in the first column. Non-POSIX. May be negated.
- ‘onlret’ Newline performs a carriage return. Non-POSIX. May be negated.
- ‘ofill’ Use fill (padding) characters instead of timing for delays. Non-POSIX. May be negated.
- ‘ofdel’ Use ASCII DEL characters for fill instead of ASCII NUL characters. Non-POSIX. May be negated.
Chapter 19: Working context

'nl1'         Newline delay style. Non-POSIX.
'nl0'
'cr3''cr2''cr1''cr0'     Carriage return delay style. Non-POSIX.
'tab3'tab2'tab1'tab0'     Horizontal tab delay style. Non-POSIX.
'bs1'              Backspace delay style. Non-POSIX.
'vt1'              Vertical tab delay style. Non-POSIX.
'ff1'              Form feed delay style. Non-POSIX.

19.2.4 Local settings

'isig'        Enable interrupt, quit, and suspend special characters. May be negated.
'icanon'      Enable erase, kill, werase, and rprnt special characters. May be negated.
'ixtten'      Enable non-POSIX special characters. May be negated.
'echo'        Echo input characters. May be negated.
'echoe'       Echo a newline after a kill character. May be negated.
'echonl'      Echo newline even if not echoing other characters. May be negated.
'noflush'     Disable flushing after interrupt and quit special characters. May be negated.
'xcase'       Enable input and output of uppercase characters by preceding their lowercase equivalents with '\', when icanon is set. Non-POSIX. May be negated.
'tostop'      Stop background jobs that try to write to the terminal. Non-POSIX. May be negated.
'echoprt'     Echo erased characters backward, between '\' and '/'. Non-POSIX. May be negated.
'prterase'    Echo control characters in hat notation ('\c') instead of literally. Non-POSIX. May be negated.
'echoctl'     Echo control characters in hat notation ("c") instead of literally. Non-POSIX. May be negated.
‘echoke’
‘crtkill’
   Echo the kill special character by erasing each character on the line as indicated by the echoprt and echoe settings, instead of by the echoctl and echok settings. Non-POSIX. May be negated.

‘extproc’
   Enable ‘LINEMODE’, which is used to avoid echoing each character over high latency links. See also Internet RFC 1116 (https://tools.ietf.org/search/rfc1116). Non-POSIX. May be negated.

‘flusho’
   Discard output. Note this setting is currently ignored on GNU/Linux systems. Non-POSIX. May be negated.

19.2.5 Combination settings

Combination settings:

‘evenp’
‘parity’
   Same as parenb -parodd cs7. May be negated. If negated, same as -parenb cs8.

‘oddp’
   Same as parenb parodd cs7. May be negated. If negated, same as -parenb cs8.

‘nl’
   Same as -icrnl -onlcr. May be negated. If negated, same as icrnl -inlcr -igncr onlcr -ocrnl -onlret.

‘ek’
   Reset the erase and kill special characters to their default values.

‘sane’
   Same as:
   cread -ignbrk brkint -inlcr -igncr icrnl icanon iexten echo echoe echok -echonl -noflsh -ixoff -iutf8 -iuc1c -ixany imaxbel -xcase -olcuc -ocrnl opost -ofill onlcr -onocr -onlret n10 cr0 bs0 vt0 ff0 isig -tostop -ofdel -echoprt echoctl echoke -extproc and also sets all special characters to their default values.

‘cooked’
   Same as brkint ignpar istrip icrnl ixon opost isig icanon, plus sets the eof and eol characters to their default values if they are the same as the min and time characters. May be negated. If negated, same as raw.

‘raw’
   Same as:
   -ignbrk -brkint -ignpar -parmrk -inpck -istrip -inlcr -igncr -icrnl -ixon -ixoff -icanon -opost -isig -iuc1c -ixany -imaxbel -xcase min 1 time 0
   May be negated. If negated, same as cooked.

‘cbreak’
   Same as -icanon. May be negated. If negated, same as icanon.

‘pass8’
   Same as -parenb -istrip cs8. May be negated. If negated, same as parenb istrip cs7.

‘litout’
   Same as -parenb -istrip -opost cs8. May be negated. If negated, same as parenb istrip opost cs7.
Chapter 19: Working context

‘deceptlq’  Same as -ixany. Non-POSIX. May be negated.
‘tabs’  Same as tab0. Non-POSIX. May be negated. If negated, same as tab3.
‘lcase’  Same as xcase iuclc olcuc. Non-POSIX. May be negated. (Used for terminals with uppercase characters only.)
‘crt’  Same as echo echoctl echoe.
‘dec’  Same as echo echoctl echoe -ixany intr ^C erase ^? kill C-u.

19.2.6 Special characters

The special characters’ default values vary from system to system. They are set with the syntax ‘name value’, where the names are listed below and the value can be given either literally, in hat notation (‘^c’), or as an integer which may start with ‘0x’ to indicate hexadecimal, ‘0’ to indicate octal, or any other digit to indicate decimal.

For GNU stty, giving a value of ‘~’ or undef disables that special character. (This is incompatible with Ultrix stty, which uses a value of ‘u’ to disable a special character. GNU stty treats a value ‘u’ like any other, namely to set that special character to U.)

‘intr’  Send an interrupt signal.
‘quit’  Send a quit signal.
‘erase’  Erase the last character typed.
‘kill’  Erase the current line.
‘eof’  Send an end of file (terminate the input).
‘eol’  End the line.
‘eol2’  Alternate character to end the line. Non-POSIX.
‘discard’  Alternate character to toggle discarding of output. Non-POSIX.
‘sctswtch’  Switch to a different shell layer. Non-POSIX.
‘status’  Send an info signal. Not currently supported on GNU/Linux. Non-POSIX.
‘start’  Restart the output after stopping it.
‘stop’  Stop the output.
‘susps’  Send a terminal stop signal.
‘dsusp’  Send a terminal stop signal after flushing the input. Non-POSIX.
‘rprnt’  Redraw the current line. Non-POSIX.
‘werase’  Erase the last word typed. Non-POSIX.
‘lnext’  Enter the next character typed literally, even if it is a special character. Non-POSIX.
19.2.7 Special settings

`min n`  Set the minimum number of characters that will satisfy a read until the time value has expired, when `-icanon` is set.

`time n`  Set the number of tenths of a second before reads time out if the minimum number of characters have not been read, when `-icanon` is set.

`ispeed n`  Set the input speed to `n`.

`ospeed n`  Set the output speed to `n`.

`rows n`  Tell the tty kernel driver that the terminal has `n` rows. Non-POSIX.

`cols n`  `columns n`  Tell the kernel that the terminal has `n` columns. Non-POSIX.

`drain`  Apply settings after first waiting for pending output to be transmitted. This is enabled by default for GNU `stty`. Note this is treated as an option rather than a line setting, and will follow the option processing rules described in the summary above. It is useful to disable this option in cases where the system may be in a state where serial transmission is not possible. For example, if the system has received the `DC3` character with `ixon` (software flow control) enabled, then `stty` would block without `-drain` being specified. May be negated. Non-POSIX.

`size`  Print the number of rows and columns that the kernel thinks the terminal has. (Systems that don’t support rows and columns in the kernel typically use the environment variables `LINES` and `COLUMNS` instead; however, GNU `stty` does not know anything about them.) Non-POSIX.

`line n`  Use line discipline `n`. Non-POSIX.

`speed`  Print the terminal speed.

`n`  Set the input and output speeds to `n`. `n` can be one of: 0 50 75 110 134 134.5 150 200 300 600 1200 1800 2400 4800 9600 19200 38400 exta extb. `exta` is the same as 19200; `extb` is the same as 38400. Many systems, including GNU/Linux, support higher speeds. The `stty` command includes support for speeds of 57600, 115200, 230400, 460800, 500000, 576000, 921600, 1000000, 1152000, 1500000, 2000000, 2500000, 3000000, 3500000, or 4000000 where the system supports these. 0 hangs up the line if `-clocal` is set.

19.3 printenv: Print all or some environment variables

`printenv` prints environment variable values. Synopsis:

```
printenv [option] [variable]...
```

If no `variables` are specified, `printenv` prints the value of every environment variable. Otherwise, it prints the value of each `variable` that is set, and nothing for those that are not set.
The program accepts the following option. Also see Chapter 2 [Common options], page 2.

`-0`

`--null` Output a zero byte (ASCII NUL) at the end of each line, rather than a newline. This option enables other programs to parse the output even when that output would contain data with embedded newlines.

Exit status:

0 if all variables specified were found
1 if at least one specified variable was not found
2 if a write error occurred

19.4 tty: Print file name of terminal on standard input

tty prints the file name of the terminal connected to its standard input. It prints ‘not a tty’ if standard input is not a terminal. Synopsis:

    tty [option]...

The program accepts the following option. Also see Chapter 2 [Common options], page 2.

`-s`

`--silent`

`--quiet` Print nothing; only return an exit status.

Exit status:

0 if standard input is a terminal
1 if standard input is a non-terminal file
2 if given incorrect arguments
3 if a write error occurs
20 User information

This section describes commands that print user-related information: logins, groups, and so forth.

20.1 id: Print user identity

id prints information about the given user, or the process running it if no user is specified. Synopsis:

```
  id [option]... [user]...
```

user can be either a user ID or a name, with name look-up taking precedence unless the ID is specified with a leading ‘+’. See Section 2.4 [Disambiguating names and IDs], page 6.

By default, it prints the real user ID, real group ID, effective user ID if different from the real user ID, effective group ID if different from the real group ID, and supplemental group IDs. In addition, if SELinux is enabled and the `POSIXLY_CORRECT` environment variable is not set, then print ‘context=c’, where c is the security context.

Each of these numeric values is preceded by an identifying string and followed by the corresponding user or group name in parentheses.

The options cause id to print only part of the above information. Also see Chapter 2 [Common options], page 2.

- `-g`
  - `--group` Print only the group ID.

- `-G`
  - `--groups` Print only the group ID and the supplementary groups.

- `-n`
  - `--name` Print the user or group name instead of the ID number. Requires `-u`, `-g`, or `-G`.

- `-r`
  - `--real` Print the real, instead of effective, user or group ID. Requires `-u`, `-g`, or `-G`.

- `-u`
  - `--user` Print only the user ID.

- `-Z`
  - `--context` Print only the security context of the process, which is generally the user’s security context inherited from the parent process. If neither SELinux or SMACK is enabled then print a warning and set the exit status to 1.

- `-z`
  - `--zero` Delimit output items with ASCII NUL characters. This option is not permitted when using the default format. When multiple users are specified, and the `--groups` option is also in effect, groups are delimited with a single NUL character, while users are delimited with two NUL characters.

Example:

```
  $ id -Gn --zero
  users <NUL> devs <NUL>
```
Primary and supplementary groups for a process are normally inherited from its parent and are usually unchanged since login. This means that if you change the group database after logging in, `id` will not reflect your changes within your existing login session. Running `id` with a user argument causes the user and group database to be consulted afresh, and so will give a different result.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 20.2 `logname`: Print current login name

`logname` prints the calling user’s name, as found in a system-maintained file (often `/var/run/utmp` or `/etc/utmp`), and exits with a status of 0. If there is no entry for the calling process, `logname` prints an error message and exits with a status of 1.

The only options are `--help` and `--version`. See Chapter 2 [Common options], page 2.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 20.3 `whoami`: Print effective user name

`whoami` prints the user name associated with the current effective user ID. It is equivalent to the command ‘`id -un`’.

The only options are `--help` and `--version`. See Chapter 2 [Common options], page 2.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 20.4 `groups`: Print group names a user is in

`groups` prints the names of the primary and any supplementary groups for each given `username`, or the current process if no names are given. If more than one name is given, the name of each user is printed before the list of that user’s groups and the user name is separated from the group list by a colon. Synopsis:

```
groups [username]...
```

The group lists are equivalent to the output of the command ‘`id -Gn`’.

The only options are `--help` and `--version`. See Chapter 2 [Common options], page 2.

Primary and supplementary groups for a process are normally inherited from its parent and are usually unchanged since login. This means that if you change the group database after logging in, `groups` will not reflect your changes within your existing login session. Running `groups` with a list of users causes the user and group database to be consulted afresh, and so will give a different result.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 20.5 `users`: Print login names of users currently logged in

`users` prints on a single line a blank-separated list of user names of users currently logged in to the current host. Each user name corresponds to a login session, so if a user has more than one login session, that user’s name will appear the same number of times in the output. Synopsis:

```
users [file]
```
With no file argument, `users` extracts its information from a system-maintained file (often `/var/run/utmp` or `/etc/utmp`). If a file argument is given, `users` uses that file instead. A common choice is `/var/log/wtmp`.

The only options are `--help` and `--version`. See Chapter 2 [Common options], page 2.

The `users` command is installed only on platforms with the POSIX `<utmpx.h>` include file or equivalent, so portable scripts should not rely on its existence on non-POSIX platforms.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 20.6 who: Print who is currently logged in

`who` prints information about users who are currently logged on. Synopsis:

```
who [option] [file] [am i]
```

If given no non-option arguments, `who` prints the following information for each user currently logged on: login name, terminal line, login time, and remote hostname or X display.

If given one non-option argument, `who` uses that instead of a default system-maintained file (often `/var/run/utmp` or `/etc/utmp`) as the name of the file containing the record of users logged on. `/var/log/wtmp` is commonly given as an argument to `who` to look at who has previously logged on.

If given two non-option arguments, `who` prints only the entry for the user running it (determined from its standard input), preceded by the hostname. Traditionally, the two arguments given are `am i`, as in `who am i`.

Timestamps are listed according to the time zone rules specified by the `TZ` environment variable, or by the system default rules if `TZ` is not set. See Section “Specifying the Time Zone with `TZ`” in *The GNU C Library Reference Manual*.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

- `-a`
- `--all` Same as `-b -d --login -p -r -t -T -u`.
- `-b`
- `--boot` Print the date and time of last system boot.
- `-d`
- `--dead` Print information corresponding to dead processes.
- `-H`
- `--heading` Print a line of column headings.
- `-l`
- `--login` List only the entries that correspond to processes via which the system is waiting for a user to login. The user name is always `LOGIN`.

- `--lookup`

  Attempt to canonicalize hostnames found in utmp through a DNS lookup. This is not the default because it can cause significant delays on systems with automatic dial-up internet access.

- `-m`

  Same as `who am i`.
The `who` command is installed only on platforms with the POSIX `<utmpx.h>` include file or equivalent, so portable scripts should not rely on its existence on non-POSIX platforms.

An exit status of zero indicates success, and a nonzero value indicates failure.
21 System context

This section describes commands that print or change system-wide information.

21.1 date: Print or set system date and time

Synopses:

```
date [option]... [+format]
date [-u|--utc|--universal] [ MMDDhhmm[[CC]YY][.ss] ]
```

The `date` command displays the date and time. With the `--set (-s)` option, or with `'MMDDhhmm[[CC]YY][.ss]'`, it sets the date and time.

Invoking `date` with no `format` argument is equivalent to invoking it with a default format that depends on the LC_TIME locale category. In the default C locale, this format is `'+%a %b %e %H:%M:%S %Z %Y'`, so the output looks like ‘Thu Jul 9 17:00:00 EDT 2020’.

Normally, `date` uses the time zone rules indicated by the `TZ` environment variable, or the system default rules if `TZ` is not set. See Section “Specifying the Time Zone with `TZ`” in The GNU C Library Reference Manual.

An exit status of zero indicates success, and a nonzero value indicates failure.

21.1.1 Specifying the format of `date` output

If given an argument that starts with a `'+`’, `date` prints the current date and time (or the date and time specified by the `--date` option, see below) in the format defined by that argument, which is similar to that of the `strftime` function. Except for conversion specifiers, which start with `‘%’`, characters in the format string are printed unchanged. The conversion specifiers are described below.

21.1.1.1 Time conversion specifiers

`date` conversion specifiers related to times.

```
‘%H’   hour (‘00’...‘23’)
‘%I’   hour (‘01’...‘12’)
‘%k’   hour, space padded (‘0’...‘23’); equivalent to ‘%H’. This is a GNU extension.
‘%l’   hour, space padded (‘1’...‘12’); equivalent to ‘%I’. This is a GNU extension.
‘%M’   minute (‘00’...‘59’)
‘%N’   nanoseconds (‘000000000’...‘999999999’). This is a GNU extension.
‘%p’   locale’s equivalent of either ‘AM’ or ‘PM’; blank in many locales. Noon is treated as ‘PM’ and midnight as ‘AM’.
‘%p’   like ‘%p’, except lower case. This is a GNU extension.
‘%r’   locale’s 12-hour clock time (e.g., ‘11:11:04 PM’)
‘%R’   24-hour hour and minute. Same as ‘%H:%M’.
‘%s’   seconds since the Epoch, i.e., since 1970-01-01 00:00 UTC. Leap seconds are not counted unless leap second support is available. See [%s-examples], page 199, for examples. This is a GNU extension.
```
Section 21: System context

'\%S' second (‘00’...‘60’). This may be ‘60’ if leap seconds are supported.

'\%T' 24-hour hour, minute, and second. Same as ‘\%H:\%M:\%S’.

'\%X' locale’s time representation (e.g., ‘23:13:48’)

'\%Z' Four-digit numeric time zone, e.g., ‘-0600’ or ‘+0530’, or ‘-0000’ if no time zone is determinable. This value reflects the numeric time zone appropriate for the current time, using the time zone rules specified by the TZ environment variable. A time zone is not determinable if its numeric offset is zero and its abbreviation begins with ‘-’. The time (and optionally, the time zone rules) can be overridden by the --date option.

'\%:z' Numeric time zone with ‘:’, e.g., ‘-06:00’ or ‘+05:30’), or ‘-00:00’ if no time zone is determinable. This is a GNU extension.

'\%::z' Numeric time zone to the nearest second with ‘:’ (e.g., ‘-06:00:00’ or ‘+05:30:00’), or ‘-00:00:00’ if no time zone is determinable. This is a GNU extension.

'\%:::z' Numeric time zone with ‘:’ using the minimum necessary precision (e.g., ‘-06’, ‘+05:30’, or ‘-04:56:02’), or ‘-00’ if no time zone is determinable. This is a GNU extension.

'\%Z' alphabetic time zone abbreviation (e.g., ‘EDT’), or nothing if no time zone is determinable. See ‘\%z’ for how it is determined.

21.1.1.2 Date conversion specifiers
date conversion specifiers related to dates.

'\%a' locale’s abbreviated weekday name (e.g., ‘Sun’)

'\%A' locale’s full weekday name, variable length (e.g., ‘Sunday’)

'\%b' locale’s abbreviated month name (e.g., ‘Jan’)

'\%B' locale’s full month name, variable length (e.g., ‘January’)

'\%c' locale’s date and time (e.g., ‘Thu Mar 3 23:05:25 2020’)

'\%C' century. This is like ‘\%Y’, except the last two digits are omitted. For example, it is ‘20’ if ‘\%Y’ is ‘2019’, and is ‘0’ if ‘\%Y’ is ‘001’. It is normally at least two characters, but it may be more.

'\%d' day of month (e.g., ‘01’)

'\%D' date; same as ‘\%m/%d/%Y’

'\%e' day of month, space padded; same as ‘\%d’

'\%F' full date in ISO 8601 format; like ‘%Y-%m-%d’ except that any flags or field width override the ‘+’ and (after subtracting 6) the ‘4’. This is a good choice for a date format, as it is standard and is easy to sort in the usual case where years are in the range 0000...9999.
Chapter 21: System context

21.1.1.3 Literal conversion specifiers
date conversion specifiers that produce literal strings.

‘%’ a literal %

‘%n’ a newline

‘%t’ a horizontal tab

21.1.1.4 Padding and other flags

Unless otherwise specified, date normally pads numeric fields with zeros, so that, for example, numeric months are always output as two digits. Most numeric fields are padded on the left. However, nanoseconds are padded on the right since they are commonly used after decimal points in formats like ‘%s.%-N’. Also, seconds since the Epoch are not padded since there is no natural width for them.
The following optional flags can appear after the ‘%’:

‘-’ (hyphen) Do not pad the field; useful if the output is intended for human consumption. This is a GNU extension. As a special case, ‘%-N’ outputs only enough trailing digits to not lose information, assuming that the timestamp’s resolution is the same as the current hardware clock. For example, if the hardware clock resolution is 1 microsecond, ‘%s.%-N’ outputs something like ‘1640890100.395710’.

‘_’ (underscore) Pad with spaces; useful if you need a fixed number of characters in the output, but zeros are too distracting. This is a GNU extension.

‘0’ (zero) Pad with zeros even if the conversion specifier would normally pad with spaces.

‘+’ Pad with zeros, like ‘0’. In addition, precede any year number with ‘+’ if it exceeds 9999 or if its field width exceeds 4; similarly, precede any century number with ‘+’ if it exceeds 99 or if its field width exceeds 2. This supports ISO 8601 formats for dates far in the future; for example, the command `date --date=12019-02-25 +%+13F` outputs the string ‘+012019-02-25’.

‘#’ Use opposite case characters if possible. A field that is normally upper case becomes lower case, and vice versa. This is a GNU extension.

Here are some examples of padding:

```
date +%d/%m -d "Feb 1"
⇒ 01/02

date +%-d/%-m -d "Feb 1"
⇒ 1/2

date +%d/%_m -d "Feb 1"
⇒ 1/ 2
```

You can optionally specify the field width (after any flag, if present) as a decimal number. If the natural size of the output of the field has less than the specified number of characters, the result is normally written right adjusted and padded to the given size. For example, ‘%9B’ prints the right adjusted month name in a field of width 9. Nanoseconds are left adjusted, and are truncated or padded to the field width.

An optional modifier can follow the optional flag and width specification. The modifiers are:

‘E’ Use the locale’s alternate representation for date and time. This modifier applies to the ‘%c’, ‘%C’, ‘%x’, ‘%X’, ‘%y’ and ‘%Y’ conversion specifiers. In a Japanese locale, for example, ‘%Ex’ might yield a date format based on the Japanese Emperors’ reigns.

‘0’ Use the locale’s alternate numeric symbols for numbers. This modifier applies only to numeric conversion specifiers.

If the format supports the modifier but no alternate representation is available, it is ignored.
POSIX specifies the behavior of flags and field widths only for ‘%c’, ‘%F’, ‘%G’, and ‘%Y’ (all without modifiers), and requires a flag to be present if and only if a field width is also present. Other combinations of flags, field widths and modifiers are GNU extensions.

21.1.2 Setting the time

You must have appropriate privileges to set the system clock. For changes to persist across a reboot, the hardware clock may need to be updated from the system clock, which might not happen automatically on your system.

To set the clock, you can use the `--set` (-s) option (see Section 21.1.3 [Options for date], page 196). To set the clock without using GNU extensions, you can give `date` an argument of the form ‘MMDDhhmm[[[CC]YY]][.ss]’ where each two-letter component stands for two digits with the following meanings:

- **MM**  month
- **DD**  day within month
- **hh**  hour
- **mm**  minute
- **CC**  first two digits of year (optional)
- **YY**  last two digits of year (optional)
- **ss**  second (optional)

Note, the `--date` and `--set` options may not be used with an argument in the above format. The `--universal` option may be used with such an argument to indicate that the specified date and time are relative to Universal Time rather than to the local time zone.

21.1.3 Options for date

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Except for `-u`, these options are all GNU extensions to POSIX.

All options that specify the date to display are mutually exclusive. I.e.: `--date`, `--file`, `--reference`, `--resolution`.

`-d datestr`  
`--date=datestr`  
Display the date and time specified in `datestr` instead of the current date and time. `datestr` can be in almost any common format. It can contain month names, time zones, ‘am’ and ‘pm’, ‘yesterday’, etc. For example, `--date="2020-07-21 14:19:13.489392193 +0530"` specifies the instant of time that is 489,392,193 nanoseconds after July 21, 2020 at 2:19:13 PM in a time zone that is 5 hours and 30 minutes east of UTC.

Note: input currently must be in locale independent format. E.g., the LC_TIME=C below is needed to print back the correct date in many locales:

```
    date -d "$(LC_TIME=C date)"
```

See Chapter 29 [Date input formats], page 242.

`--debug`  
Annotate the parsed date, display the effective time zone, and warn about potential misuse.
'--file= datefile'
Parse each line in datefile as with -d and display the resulting date and time. If datefile is '-', use standard input. This is useful when you have many dates to process, because the system overhead of starting up the date executable many times can be considerable.

'--iso-8601[=timespec]' Display the date using an ISO 8601 format, '%Y-%m-%d'.

The argument timespec specifies the number of additional terms of the time to include. It can be one of the following:

‘auto’ Print just the date. This is the default if timespec is omitted. This is like the format %Y-%m-%d.

‘hours’ Also print hours and time zone. This is like the format %Y-%m-%dT%H:%z.

‘minutes’ Also print minutes. This is like the format %Y-%m-%dT%H:%M:%z.

‘seconds’ Also print seconds. This is like the format %Y-%m-%dT%H:%M:%S:%z.

‘ns’ Also print nanoseconds. This is like the format %Y-%m-%dT%H:%M:%S,%N:%z.

This format is always suitable as input for the --date (-d) and --file (-f) options, regardless of the current locale.

'--reference= file'

Display the date and time of the last modification of file, instead of the current date and time.

'--resolution'

Display the timestamp resolution instead of the time. Current clock timestamps that are output by date are integer multiples of the timestamp resolution. With this option, the format defaults to '%s.%N'. For example, if the clock resolution is 1 millisecond, the output is:

0.001000000

'--rfc-email'

Display the date and time using the format ‘%a, %d %b %Y %H:%M:%S %z’, evaluated in the C locale so abbreviations are always in English. For example:

Mon, 09 Jul 2020 17:00:00 -0400

This format conforms to Internet RFCs 5322 (https://tools.ietf.org/search/rfc5322), 2822 (https://tools.ietf.org/search/rfc2822) and 822 (https://tools.ietf.org/search/rfc822), the current and previous standards for Internet email. For compatibility with older versions of date, --rfc-2822 and --rfc-822 are aliases for --rfc-email.
‘--rfc-3339=timespec’

Display the date using a format specified by Internet RFC 3339 (https://tools.ietf.org/search/rfc3339). This is like ‘--iso-8601’, except that a space rather than a ‘T’ separates dates from times, and a period rather than a comma separates seconds from subseconds. This format is always suitable as input for the ‘--date (-d) and --file (-f) options, regardless of the current locale. The argument timespec specifies how much of the time to include. It can be one of the following:

‘date’ Print just the full-date, e.g., ‘2020-07-21’. This is like the format ‘%Y-%m-%d’.

‘seconds’ Print the full-date and full-time separated by a space, e.g., ‘2020-07-21 04:30:37+05:30’. The output ends with a numeric time-offset; here the ‘+05:30’ means that local time is five hours and thirty minutes east of UTC. This is like the format ‘%Y-%m-%d %H:%M:%S%:z’.

‘ns’ Like ‘seconds’, but also print nanoseconds, e.g., ‘2020-07-21 04:30:37.998458565+05:30’. This is like the format ‘%Y-%m-%d %H:%M:%S.%N%:z’.

‘-s datestr’

‘--set=datestr’

Set the date and time to datestr. See -d above. See also Section 21.1.2 [Setting the time], page 196.

‘-u’

‘--utc’

‘--universal’

Use Universal Time by operating as if the TZ environment variable were set to the string ‘UTC0’. UTC stands for Coordinated Universal Time, established in 1960. Universal Time is often called “Greenwich Mean Time” (GMT) for historical reasons. Typically, systems ignore leap seconds and thus implement an approximation to UTC rather than true UTC.

21.1.4 Examples of date

Here are a few examples. Also see the documentation for the -d option in the previous section.

- To print the date of the day before yesterday:
  
  date --date='2 days ago'

- To print the date of the day three months and one day hence:
  
  date --date='3 months 1 day'

- To print the day of year of Christmas in the current year:
  
  date --date='25 Dec' +%j

- To print the current full month name and the day of the month:
  
  date '+%B %d'
But this may not be what you want because for the first nine days of the month, the `\%d` expands to a zero-padded two-digit field, for example `date -d 1may '+%B %d'` will print `May 01'.

- To print a date without the leading zero for one-digit days of the month, you can use the (GNU extension) `\%' flag to suppress the padding altogether:

  ```bash
date -d 1may '+%B %-d'
  ```

- To print the current date and time in the format required by many non-GNU versions of date when setting the system clock:

  ```bash
date +%m%d%H%M%Y.%S
  ```

- To set the system clock forward by two minutes:

  ```bash
date --set='+2 minutes'
  ```

- To print the date in Internet RFC 5322 format, use `date --rfc-email'`. Here is some example output:

  ```
  Tue, 09 Jul 2020 19:00:37 -0400
  ```

- To convert a date string to the number of seconds since the Epoch (which is 1970-01-01 00:00 UTC), use the `--date` option with the `\%s' format. That can be useful in sorting and/or graphing and/or comparing data by date. The following command outputs the number of the seconds since the Epoch for the time two minutes after the Epoch:

  ```bash
date --date='1970-01-01 00:02:00 +0000' +%s
  ```

  ```
  120
  ```

To convert a date string from one time zone from to another to, specify `TZ="from"' in the environment and `TZ="to"' in the `--date` option. See Section 29.10 [Specifying time zone rules], page 247. For example:

```bash
TZ="Asia/Tokyo" date --date='TZ="America/New_York" 2023-05-07 12:23'
```

```bash
Mon May 8 01:23:00 JST 2023
```
To convert such an unwieldy number of seconds back to a more readable form, use a command like this:

```bash
date -d @1595289600 +"%F %T %z"
```

2020-07-20 20:00:00 -0400

Often it is better to output UTC-relative date and time:

```bash
date -u -d @1595289600 +"%F %T %z"
```

2020-07-21 00:00:00 +0000

- Typically the seconds count omits leap seconds, but some systems are exceptions. Because leap seconds are not predictable, the mapping between the seconds count and a future timestamp is not reliable on the atypical systems that include leap seconds in their counts.

Here is how the two kinds of systems handle the leap second at the end of the year 2016:

```
# Typical systems ignore leap seconds:
date --date='2016-12-31 23:59:59 +0000' +%s
1483228799

date --date='2016-12-31 23:59:60 +0000' +%s
date: invalid date '2016-12-31 23:59:60 +0000'

date --date='2017-01-01 00:00:00 +0000' +%s
1483228800

# Atypical systems count leap seconds:
date --date='2016-12-31 23:59:59 +0000' +%s
1483228825

date --date='2016-12-31 23:59:60 +0000' +%s
1483228826

date --date='2017-01-01 00:00:00 +0000' +%s
1483228827
```

## 21.2 arch: Print machine hardware name

The `arch` command prints the machine hardware name, and is equivalent to `uname -m`. Synopsis:

```bash
arch [option]
```

The program accepts the Chapter 2 [Common options], page 2, only.

- `arch` is not installed by default, so portable scripts should not rely on its existence.

An exit status of zero indicates success, and a nonzero value indicates failure.

## 21.3 nproc: Print the number of available processors

Print the number of processing units available to the current process, which may be less than the number of online processors. If this information is not accessible, then print the number of processors installed. If the OMP_NUM_THREADS or OMP_THREAD_LIMIT environment variables are set, then they will determine the minimum and maximum returned value respectively. The result is guaranteed to be greater than zero. Synopsis:

```bash
nproc [option]
```
The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`--all` Print the number of installed processors on the system, which may be greater than the number online or available to the current process. The OMP_NUM_THREADS or OMP_THREAD_LIMIT environment variables are not honored in this case.

`--ignore=number` If possible, exclude this number of processing units.

An exit status of zero indicates success, and a nonzero value indicates failure.

### 21.4 `uname`: Print system information

`uname` prints information about the machine and operating system it is run on. If no options are given, `uname` acts as if the `-s` option were given. Synopsis:

```
uname [option]...
```

If multiple options or `-a` are given, the selected information is printed in this order:

```
kernell-name nodename kernel-release kernel-version
machine processor hardware-platform operating-system
```

The information may contain internal spaces, so such output cannot be parsed reliably. In the following example, `kernel-version` is `#1 SMP Fri Jul 17 17:18:38 UTC 2020`:

```
uname -a
⇒ Linux dumdum.example.org 5.9.16-200.fc33.x86_64 #1 SMP Mon Dec 21 14:08:22 UTC 2020
```

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

`-a`

`--all` Print all of the below information, except omit the processor type and the hardware platform name if they are unknown.

`-i`

`--hardware-platform` Print the hardware platform name (sometimes called the hardware implementation). Print `unknown` if this information is not available. Note this is non-portable (even across GNU/Linux distributions).

`-m`

`--machine` Print the machine hardware name (sometimes called the hardware class or hardware type).

`-n`

`--nodename` Print the network node hostname.

`-p`

`--processor` Print the processor type (sometimes called the instruction set architecture or ISA). Print `unknown` if this information is not available. Note this is non-portable (even across GNU/Linux distributions).
'--o'
'--operating-system'
Print the name of the operating system.

'--r'
'--kernel-release'
Print the kernel release.

'--s'
'--kernel-name'
Print the kernel name. POSIX 1003.1-2001 (see Section 2.13 [Standards conformance], page 11) calls this “the implementation of the operating system”, because the POSIX specification itself has no notion of “kernel”. The kernel name might be the same as the operating system name printed by the -o or --operating-system option, but it might differ. Some operating systems (e.g., FreeBSD, HP-UX) have the same name as their underlying kernels; others (e.g., GNU/Linux, Solaris) do not.

'--v'
'--kernel-version'
Print the kernel version.

An exit status of zero indicates success, and a nonzero value indicates failure.

21.5 hostname: Print or set system name
With no arguments, hostname prints the name of the current host system. With one argument, it sets the current host name to the specified string. You must have appropriate privileges to set the host name. Synopsis:

    hostname [name]

The only options are --help and --version. See Chapter 2 [Common options], page 2.

hostname is not installed by default, and other packages also supply a hostname command, so portable scripts should not rely on its existence or on the exact behavior documented above.

An exit status of zero indicates success, and a nonzero value indicates failure.

21.6 hostid: Print numeric host identifier
hostid prints the numeric identifier of the current host in hexadecimal. This command accepts no arguments. The only options are --help and --version. See Chapter 2 [Common options], page 2.

For example, here’s what it prints on one system I use:

    $ hostid
    1bac013d

On that system, the 32-bit quantity happens to be closely related to the system’s Internet address, but that isn’t always the case.

hostid is installed only on systems that have the gethostid function, so portable scripts should not rely on its existence.
An exit status of zero indicates success, and a nonzero value indicates failure.

21.7 uptime: Print system uptime and load

`uptime` prints the current time, the system’s uptime, the number of logged-in users and the current load average.

If an argument is specified, it is used as the file to be read to discover how many users are logged in. If no argument is specified, a system default is used (`uptime --help` indicates the default setting).

The only options are `--help` and `--version`. See Chapter 2 [Common options], page 2.

For example, here’s what it prints right now on one system I use:

```
$ uptime
14:07 up 3:35, 3 users, load average: 1.39, 1.15, 1.04
```

The precise method of calculation of load average varies somewhat between systems. Some systems calculate it as the average number of runnable processes over the last 1, 5 and 15 minutes, but some systems also include processes in the uninterruptible sleep state (that is, those processes which are waiting for device I/O). The Linux kernel includes uninterruptible processes.

`uptime` is installed only on platforms with infrastructure for obtaining the boot time, and other packages also supply an `uptime` command, so portable scripts should not rely on its existence or on the exact behavior documented above.

An exit status of zero indicates success, and a nonzero value indicates failure.
22 SELinux context

This section describes commands for operations with SELinux contexts.

22.1 chcon: Change SELinux context of file

chcon changes the SELinux security context of the selected files. Synopses:

chcon [option]... context file...
chcon [option]... [-u user] [-r role] [-l range] [-t type] file...
chcon [option]... --reference=rfile file...

Change the SELinux security context of each file to context. With --reference, change the security context of each file to that of rfile.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--dereference'
Do not affect symbolic links but what they refer to; this is the default.

'-h'
'--no-dereference'
Affect the symbolic links themselves instead of any referenced file.

'--reference=rfile'
Use rfile’s security context rather than specifying a context value.

'-R'
'--recursive'
Operate on files and directories recursively.

'--preserve-root'
Refuse to operate recursively on the root directory, /, when used together with the --recursive option. See Section 2.9 [Treating / specially], page 9.

'--no-preserve-root'
Do not treat the root directory, /, specially when operating recursively; this is the default. See Section 2.9 [Treating / specially], page 9.

'-H'
If --recursive (-R) is specified and a command line argument is a symbolic link to a directory, traverse it. See Section 2.8 [Traversing symlinks], page 9.

'-L'
In a recursive traversal, traverse every symbolic link to a directory that is encountered. See Section 2.8 [Traversing symlinks], page 9.

'-P'
Do not traverse any symbolic links. This is the default if none of -H, -L, or -P is specified. See Section 2.8 [Traversing symlinks], page 9.

'-v'
'--verbose'
Output a diagnostic for every file processed.

'-u user'
'--user=user'
Set user user in the target security context.
A exit status of zero indicates success, and a nonzero value indicates failure.

22.2 runcon: Run a command in specified SELinux context

runcon runs file in specified SELinux security context.

Synopses:

```
runcon context command [args]
runcon [-c] [-u user] [-r role] [-t type] [-l range] command [args]
```

Run command with completely-specified context, or with current or transitioned security context modified by one or more of level, role, type and user.

If none of -c, -t, -u, -r, or -l is specified, the first argument is used as the complete context. Any additional arguments after command are interpreted as arguments to the command.

With neither context nor command, print the current security context.

Note also the setpriv command which can be used to set the NO_NEW_PRIVS bit using `setpriv --no-new-privs runcon ...`, thus disallowing usage of a security context with more privileges than the process would normally have.

runcon accepts the following options. Also see Chapter 2 [Common options], page 2.

`'-c'`
`'--compute'`
Compute process transition context before modifying.

`'-u user'`
`'--user=user'`
Set user user in the target security context.

`'-r role'`
`'--role=role'`
Set role role in the target security context.

`'-t type'`
`'--type=type'`
Set type type in the target security context.

`'-l range'`
`'--range=range'`
Set range range in the target security context.
Exit status:

125 if `runcon` itself fails
126 if `command` is found but cannot be invoked
127 if `command` cannot be found
the exit status of `command` otherwise
### 23 Modified command invocation

This section describes commands that run other commands in some context different than the current one: a modified environment, as a different user, etc.

#### 23.1 chroot: Run a command with a different root directory

`chroot` runs a command with a specified root directory. On many systems, only the super-user can do this. Synopses:

```
chroot option newroot [command [args]...]
chroot option
```

Ordinarily, file names are looked up starting at the root of the directory structure, i.e., `/`. `chroot` changes the root to the directory `newroot` (which must exist), then changes the working directory to `/`, and finally runs `command` with optional `args`. If `command` is not specified, the default is the value of the `SHELL` environment variable or `/bin/sh` if not set, invoked with the `-i` option. `command` must not be a special built-in utility (see Section 2.10 [Special built-in utilities], page 10).

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands.

- **`--groups=groups`**
  
  Use this option to override the supplementary `groups` to be used by the new process. The items in the list (names or numeric IDs) must be separated by commas. Use `--groups=''` to disable the supplementary group look-up implicit in the `--userspec` option.

- **`--userspec=user[:group]`**
  
  By default, `command` is run with the same credentials as the invoking process. Use this option to run it as a different `user` and/or with a different primary `group`. If a `user` is specified then the supplementary groups are set according to the system defined list for that user, unless overridden with the `--groups` option.

- **`--skip-chdir`**

  Use this option to not change the working directory to `/` after changing the root directory to `newroot`, i.e., inside the chroot. This option is only permitted when `newroot` is the old `/` directory, and therefore is mostly useful together with the `--groups` and `--userspec` options to retain the previous working directory.

The user and group name look-up performed by the `--userspec` and `--groups` options, is done both outside and inside the chroot, with successful look-ups inside the chroot taking precedence. If the specified user or group items are intended to represent a numeric ID, then a name to ID resolving step is avoided by specifying a leading `+'`. See Section 2.4 [Disambiguating names and IDs], page 6.

---

1 However, some systems (e.g., FreeBSD) can be configured to allow certain regular users to use the `chroot` system call, and hence to run this program. Also, on Cygwin, anyone can run the `chroot` command, because the underlying function is non-privileged due to lack of support in MS-Windows. Furthermore, the `chroot` command avoids the `chroot` system call when `newroot` is identical to the old `/` directory for consistency with systems where this is allowed for non-privileged users.
Chapter 23: Modified command invocation

Here are a few tips to help avoid common problems in using chroot. To start with a simple example, make command refer to a statically linked binary. If you were to use a dynamically linked executable, then you’d have to arrange to have the shared libraries in the right place under your new root directory.

For example, if you create a statically linked ls executable, and put it in /tmp/empty, you can run this command as root:

```
$ chroot /tmp/empty /ls -Rl /
```

Then you’ll see output like this:

```
/: 
  total 1023 
  -rwxr-xr-x 1 0 0 1041745 Aug 16 11:17 ls
```

If you want to use a dynamically linked executable, say bash, then first run `ldd bash` to see what shared objects it needs. Then, in addition to copying the actual binary, also copy the listed files to the required positions under your intended new root directory. Finally, if the executable requires any other files (e.g., data, state, device files), copy them into place, too.

chroot is installed only on systems that have the chroot function, so portable scripts should not rely on its existence.

Exit status:

- 125 if chroot itself fails
- 126 if command is found but cannot be invoked
- 127 if command cannot be found
- the exit status of command otherwise

### 23.2 env: Run a command in a modified environment


env runs a command with a modified environment. Synopses:

```
env [option]... [name=value]... [command [args]...]
env -[v]S'[option]... [name=value]... [command [args]...]'
env
```

env is commonly used on first line of scripts (shebang line):

```
#!/usr/bin/env command
#!/usr/bin/env -[v]S[option]... [name=value]... command [args]...
```

Operands of the form ‘variable=value’ set the environment variable variable to value. value may be empty (‘variable=’). Setting a variable to an empty value is different from unsetting it. These operands are evaluated left-to-right, so if two operands mention the same variable the earlier is ignored.

Environment variable names can be empty, and can contain any characters other than ‘=’ and ASCII NUL. However, it is wise to limit yourself to names that consist solely of underscores, digits, and ASCII letters, and that begin with a non-digit, as applications like the shell do not work well with other names.

The first operand that does not contain the character ‘=’ specifies the program to invoke; it is searched for according to the PATH environment variable. Any remaining arguments are
passed as arguments to that program. The program should not be a special built-in utility (see Section 2.10 [Special built-in utilities], page 10).

Modifications to PATH take effect prior to searching for command. Use caution when reducing PATH; behavior is not portable when PATH is undefined or omits key directories such as /bin.

In the rare case that a utility contains a ‘=’ in the name, the only way to disambiguate it from a variable assignment is to use an intermediate command for command, and pass the problematic program name via args. For example, if ./prog= is an executable in the current PATH:

```bash
env prog= true # runs 'true', with prog= in environment
env ./prog= true # runs 'true', with ./prog= in environment
env -- prog= true # runs 'true', with prog= in environment
env sh -c '\prog= true' # runs 'prog=' with argument 'true'
env sh -c 'exec "$@"' sh prog= true # also runs 'prog='
```

If no command name is specified following the environment specifications, the resulting environment is printed. This is like specifying the printenv program.

For some examples, suppose the environment passed to env contains ‘LOGNAME=rms’, ‘EDITOR=emacs’, and ‘PATH=.:/gnubin:/hacks’:

- Output the current environment.
  ```bash
  $ env | LC_ALL=C sort
  EDITOR=emacs
  LOGNAME=rms
  PATH=.:/gnubin:/hacks
  ```

- Run foo with a reduced environment, preserving only the original PATH to avoid problems in locating foo.
  ```bash
  env - PATH="$PATH" foo
  ```

- Run foo with the environment containing ‘LOGNAME=rms’, ‘EDITOR=emacs’, and ‘PATH=.:/gnubin:/hacks’, and guarantees that foo was found in the file system rather than as a shell built-in.
  ```bash
  env foo
  ```

- Run nemacs with the environment containing ‘LOGNAME=foo’, ‘EDITOR=emacs’, ‘PATH=.:/gnubin:/hacks’, and ‘DISPLAY=gnu:0’.
  ```bash
  env DISPLAY=gnu:0 LOGNAME=foo nemacs
  ```

- Attempt to run the program /energy/-- (as that is the only possible path search result); if the command exists, the environment will contain ‘LOGNAME=rms’ and ‘PATH=/energy’, and the arguments will be ‘e=mc2’, ‘bar’, and ‘baz’.
  ```bash
  env -u EDITOR PATH=/energy -- e=mc2 bar baz
  ```

### 23.2.1 General options

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands.
'-0'
'-null'
Output a zero byte (ASCII NUL) at the end of each line, rather than a newline.
This option enables other programs to parse the output even when that output
would contain data with embedded newlines.

'-u name'
'-unset=name'
Remove variable name from the environment, if it was in the environment.

'-'
'-i'
'-ignore-environment'
Start with an empty environment, ignoring the inherited environment.

'-C dir'
'-chdir=dir'
Change the working directory to dir before invoking command. This differs
from the shell built-in cd in that it starts command as a subprocess rather than
altering the shell’s own working directory; this allows it to be chained with other
commands that run commands in a different context. For example:

```
# Run 'true' with /chroot as its root directory and /srv as its working
# directory.
chroot /chroot env --chdir=/srv true
# Run 'true' with /build as its working directory, FOO=bar in its
# environment, and a time limit of five seconds.
env --chdir=/build FOO=bar timeout 5 true
```

'--default-signal[=sig]'
Unblock and reset signal sig to its default signal handler. Without sig all
known signals are unblocked and reset to their defaults. Multiple signals can be
comma-separated. An empty sig argument is a no-op. The following command
runs seq with SIGINT and SIGPIPE set to their default (which is to terminate
the program):

```
env --default-signal=PIPE,INT seq 1000 | head -n1
```
In the following example, we see how this is not possible to do with traditional
shells. Here the first trap command sets SIGPIPE to ignore. The second trap
command ostensibly sets it back to its default, but POSIX mandates that the
shell must not change inherited state of the signal – so it is a no-op.

```
trap '' PIPE && sh -c 'trap - PIPE ; seq inf | head -n1'
```
Using --default-signal=PIPE we can ensure the signal handling is set to its
default behavior:

```
trap '' PIPE && sh -c 'env --default-signal=PIPE seq inf | head -n1'
```

'--ignore-signal[=sig]'
Ignore signal sig when running a program. Without sig all known signals are set
to ignore. Multiple signals can be comma-separated. An empty sig argument
is a no-op. The following command runs seq with SIGINT set to be ignored –
pressing Ctrl-C will not terminate it:

```
env --ignore-signal=INT seq inf > /dev/null
```
'SIGCHLD' is special, in that --ignore-signal=CHLD might have no effect (POSIX says it's unspecified).
Most operating systems do not allow ignoring 'SIGKILL', 'SIGSTOP' (and possibly other signals). Attempting to ignore these signals will fail.
Multiple (and contradictory) --default-signal=SIG and --ignore-signal=SIG options are processed left-to-right, with the latter taking precedence. In the following example, 'SIGPIPE' is set to default while 'SIGINT' is ignored:
```
env --default-signal=INT,PIPE --ignore-signal=INT
```

'--block-signal=[=sig]'  
Block signal(s) sig from being delivered. Without sig all known signals are set to blocked. Multiple signals can be comma-separated. An empty sig argument is a no-op.

'--list-signal-handling'  
List blocked or ignored signals to standard error, before executing a command.

'--debug'  
Show verbose information for each processing step.
```
$ env -v -uTERM A=B uname -s
unset:     TERM
setenv:    A=B
executing: uname
    arg[0]= 'uname'
    arg[1]= '-s'
Linux
```
When combined with -S it is recommended to list -v first, e.g. env -vS'string'.

'--split-string=string'  
process and split string into separate arguments used to pass multiple arguments on shebang lines. env supports FreeBSD's syntax of several escape sequences and environment variable expansions. See below for details and examples.

Exit status:
0 if no command is specified and the environment is output
125 if env itself fails
126 if command is found but cannot be invoked
127 if command cannot be found
the exit status of command otherwise

23.2.2 -S/--split-string usage in scripts
The -S/--split-string option enables use of multiple arguments on the first line of scripts (the shebang line, '#!').

When a script's interpreter is in a known location, scripts typically contain the absolute file name in their first line:
Shell script:          #!/bin/sh
                        echo hello
When a script’s interpreter is in a non-standard location in the PATH environment variable, it is recommended to use env on the first line of the script to find the executable and run it:

Shell script:
```bash
#!/usr/bin/env bash
echo hello
```

Perl script:
```perl
#!/usr/bin/env perl
print "hello\n";
```

Python script:
```python
#!/usr/bin/env python3
print("hello")
```

Most operating systems (e.g. GNU/Linux, BSDs) treat all text after the first space as a single argument. When using env in a script it is thus not possible to specify multiple arguments.

In the following example:
```bash
#!/usr/bin/env perl -T -w
print "hello\n";
```

The operating system treats ‘perl -T -w’ as one argument (the program’s name), and executing the script fails with:

```
/usr/bin/env: ‘perl -T -w’: No such file or directory
```

The -S option instructs env to split the single string into multiple arguments. The following example works as expected:

```bash
$ cat hello.pl
#!/usr/bin/env -S perl -T -w
print "hello\n";

$ chmod a+x hello.pl
$ ./hello.pl
hello
```

And is equivalent to running `perl -T -w hello.pl` on the command line prompt.

**Testing and troubleshooting**

To test env -S on the command line, use single quotes for the -S string to emulate a single parameter. Single quotes are not needed when using env -S in a shebang line on the first line of a script (the operating system already treats it as one argument).

The following command is equivalent to the hello.pl script above:

```bash
$ env -S'perl -T -w' hello.pl
```

To troubleshoot -S usage add the -v as the first argument (before -S).
Using `-vS` on a shebang line in a script:

```
$ cat hello-debug.pl
#!/usr/bin/env -vS perl -T -w
print "hello\n";
```

```
$ chmod a+x hello-debug.pl
$ ./hello-debug.pl
split -S: 'perl -T -w'
into:  'perl'
  &  '-T'
  &  '-w'
executing: perl
  arg[0]= 'perl'
  arg[1]= '-T'
  arg[2]= '-w'
  arg[3]= './hello-debug.pl'
hello
```

Using `-vS` on the command line prompt (adding single quotes):

```
$ env -vS'perl -T -w' hello-debug.pl
split -S: 'perl -T -w'
into:  'perl'
  &  '-T'
  &  '-w'
executing: perl
  arg[0]= 'perl'
  arg[1]= '-T'
  arg[2]= '-w'
  arg[3]= 'hello-debug.pl'
hello
```

### 23.2.3 `-S/--split-string syntax`

#### Splitting arguments by whitespace

Running `env -Sstring` splits the `string` into arguments based on unquoted spaces or tab characters. (Newlines, carriage returns, vertical tabs and form feeds are treated like spaces and tabs.)

In the following contrived example the `awk` variable `OFS` will be `<space>xyz<space>` as these spaces are inside double quotes. The other space characters are used as argument separators:

```
$ cat one.awk
#!/usr/bin/env -S awk -v OFS=" xyz " -f
BEGIN {print 1,2,3}
```

```
$ chmod a+x one.awk
$ ./one.awk
1 xyz 2 xyz 3
```
When using `-S` on the command line prompt, remember to add single quotes around the entire string:

```
$ env -S'awk -v OFS=" xyz " -f' one.awk
1 xyz 2 xyz 3
```

**Escape sequences**

`env` supports several escape sequences. These sequences are processed when unquoted or inside double quotes (unless otherwise noted). Single quotes disable escape sequences except `\'` and `\"`.

- `\c` Ignore the remaining characters in the string. Cannot be used inside double quotes.
- `\f` form-feed character (ASCII 0x0C)
- `\n` new-line character (ASCII 0x0A)
- `\r` carriage-return character (ASCII 0x0D)
- `\t` tab character (ASCII 0x09)
- `\v` vertical tab character (ASCII 0x0B)
- `\#` A hash `#` character. Used when a `#` character is needed as the first character of an argument (see 'comments' section below).
- `\$` A dollar-sign character `$`. Unescaped `$` characters are used to expand environment variables (see 'variables' section below).
- `\_` Inside double-quotes, replaced with a single space character. Outside quotes, treated as an argument separator. `\_` can be used to avoid space characters in a shebang line (see examples below).
- `\"` A double-quote character.
- `\'` A single-quote character. This escape sequence works inside single-quoted strings.
- `\\` A backslash character. This escape sequence works inside single-quoted strings.

The following `awk` script will use tab character as input and output field separator (instead of spaces and tabs):

```
$ cat tabs.awk
#!/usr/bin/env -S awk -v OFS="\t" -f one.awk
...
Comments

The escape sequence ‘\c’ (used outside single/double quotes) causes env to ignore the rest of the string.

The ‘#’ character causes env to ignore the rest of the string when it appears as the first character of an argument. Use ‘\#’ to reverse this behavior.

```
$ env -S 'printf %s\n A B C'
A
B
C

$ env -S 'printf %s\n A# B C'
A#
B
C

$ env -S 'printf %s\n A \#B C'
A
#B
C

$ env -S 'printf %s\n A\cB C'
A
```

NOTE: The above examples use single quotes as they are executed on the command-line.

Environment variable expansion

The pattern ‘${VARNAME}’ is used to substitute a value from the environment variable. The pattern must include the curly braces (‘{’, ‘}’). Without them env will reject the string. Special shell variables (such as ‘$@’, ‘$*’, ‘$$’) are not supported.

If the environment variable is empty or not set, the pattern will be replaced by an empty string. The value of ‘${VARNAME}’ will be that of the executed env, before any modifications using ‘-i/--ignore-environment’ or ‘-u/--unset’ or setting new values using ‘VAR=VALUE’.

The following python script prepends /opt/custom/modules to the python module search path environment variable (‘PYTHONPATH’):

```
#!/usr/bin/env -S PYTHONPATH=/opt/custom/modules:python
print "hello"
```

The expansion of ‘${PYTHONPATH}’ is performed by env, not by a shell. If the curly braces are omitted, env will fail:

```
#!/usr/bin/env -S PYTHONPATH=/opt/custom/modules/ python
print "hello"
```
... 

$ chmod a+x custom.py
$ custom.py
/usr/bin/env: only ${VARNAME} expansion is supported, error at: $PYTHONPATH python

Environment variable expansion happens before clearing the environment (with -i) or unsetting specific variables (with -u):

$ env -S '-i OLDUSER=${USER} env'
OLDUSER=gordon

Use -v to diagnose the operations step-by-step:

$ env -vS '-i OLDUSER=${USER} env'
expanding ${USER} into 'gordon'
split -S: '-i OLDUSER=${USER} env'
  into:  '-i'
    & 'OLDUSER=gordon'
    & 'env'
cleaning environ
setenv:  OLDUSER=gordon
executing: env
  arg[0]= 'env'
OLDUSER=gordon

23.3 nice: Run a command with modified niceness

nice prints a process’s niceness, or runs a command with modified niceness. niceness affects how favorably the process is scheduled in the system. Synopsis:

    nice [option]... [command [arg]...]

If no arguments are given, nice prints the current niceness. Otherwise, nice runs the given command with its niceness adjusted. By default, its niceness is incremented by 10.

Niceness values range at least from −20 (process has high priority and gets more resources, thus slowing down other processes) through 19 (process has lower priority and runs slowly itself, but has less impact on the speed of other running processes). Some systems may have a wider range of niceness values; conversely, other systems may enforce more restrictive limits. An attempt to set the niceness outside the supported range is treated as an attempt to use the minimum or maximum supported value.

A niceness should not be confused with a scheduling priority, which lets applications determine the order in which threads are scheduled to run. Unlike a priority, a niceness is merely advice to the scheduler, which the scheduler is free to ignore. Also, as a point of terminology, POSIX defines the behavior of nice in terms of a nice value, which is the non-negative difference between a niceness and the minimum niceness. Though nice conforms to POSIX, its documentation and diagnostics use the term “niceness” for compatibility with historical practice.

command must not be a special built-in utility (see Section 2.10 [Special built-in utilities], page 10).
Due to shell aliases and built-in `nice` functions, using an unadorned `nice` interactively or in a script may get you different functionality than that described here. Invoke it via `env` (i.e., `env nice ...`) to avoid interference from the shell.

Note to change the niceness of an existing process, one needs to use the `renice` command.

The program accepts the following option. Also see Chapter 2 [Common options], page 2. Options must precede operands.

`-n adjustment`

`--adjustment=adjustment`

Add `adjustment` instead of 10 to the command’s niceness. If `adjustment` is negative and you lack appropriate privileges, `nice` issues a warning but otherwise acts as if you specified a zero adjustment.

For compatibility `nice` also supports an obsolete option syntax `-adjustment`. New scripts should use `-n adjustment` instead.

`nice` is installed only on systems that have the POSIX `setpriority` function, so portable scripts should not rely on its existence on non-POSIX platforms.

Exit status:

```
0  if no command is specified and the niceness is output
125 if nice itself fails
126 if command is found but cannot be invoked
127 if command cannot be found
the exit status of command otherwise
```

It is sometimes useful to run a non-interactive program with reduced niceness.

```
$ nice factor 4611686018427387903
```

Since `nice` prints the current niceness, you can invoke it through itself to demonstrate how it works.

The default behavior is to increase the niceness by `10`:

```
$ nice
0

$ nice nice
10

$ nice -n 10 nice
10
```

The `adjustment` is relative to the current niceness. In the next example, the first `nice` invocation runs the second one with niceness 10, and it in turn runs the final one with a niceness that is 3 more:

```
$ nice nice -n 3 nice
13
```

Specifying a niceness larger than the supported range is the same as specifying the maximum supported value:

```
$ nice -n 10000000000 nice
19
```

Only a privileged user may run a process with lower niceness:

```
$ nice -n -1 nice
```
nice: cannot set niceness: Permission denied

0

$ sudo nice -n -1 nice

-1

23.4 nohup: Run a command immune to hangups

nohup runs the given command with hangup signals ignored, so that the command can continue running in the background after you log out. Synopsis:

```
nohup command [arg]...
```

If standard input is a terminal, redirect it so that terminal sessions do not mistakenly consider the terminal to be used by the command. Make the substitute file descriptor unreadable, so that commands that mistakenly attempt to read from standard input can report an error. This redirection is a GNU extension; programs intended to be portable to non-GNU hosts can use `nohup command [arg]... 0>/dev/null' instead.

If standard output is a terminal, the command’s standard output is appended to the file nohup.out; if that cannot be written to, it is appended to the file $HOME/nohup.out; and if that cannot be written to, the command is not run. Any nohup.out or $HOME/nohup.out file created by nohup is made readable and writable only to the user, regardless of the current umask settings.

If standard error is a terminal, it is normally redirected to the same file descriptor as the (possibly-redirected) standard output. However, if standard output is closed, standard error terminal output is instead appended to the file nohup.out or $HOME/nohup.out as above.

To capture the command’s output to a file other than nohup.out you can redirect it. For example, to capture the output of make:

```
nohup make > make.log
```

nohup does not automatically put the command it runs in the background; you must do that explicitly, by ending the command line with an ‘&’. Also, nohup does not alter the niceness of command; use nice for that, e.g., ‘nohup nice command’.

command must not be a special built-in utility (see Section 2.10 [Special built-in utilities], page 10).

The only options are --help and --version. See Chapter 2 [Common options], page 2. Options must precede operands.

Exit status:

- 125 if nohup itself fails, and POSIXLY_CORRECT is not set
- 126 if command is found but cannot be invoked
- 127 if command cannot be found
- the exit status of command otherwise

If POSIXLY_CORRECT is set, internal failures give status 127 instead of 125.

23.5 stdbuf: Run a command with modified I/O stream buffering

stdbuf allows one to modify the buffering operations of the three standard I/O streams associated with a program. Synopsis:
stdbuf option... command

command must start with the name of a program that
1. uses the ISO C FILE streams for input/output (note the programs dd and cat don’t do that),
2. does not adjust the buffering of its standard streams (note the program tee is not in this category).

Any additional args are passed as additional arguments to the command.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

‘-i mode’
‘--input=mode’
Adjust the standard input stream buffering.

‘-o mode’
‘--output=mode’
Adjust the standard output stream buffering.

‘-e mode’
‘--error=mode’
Adjust the standard error stream buffering.

The mode can be specified as follows:

‘L’ Set the stream to line buffered mode. In this mode data is coalesced until a newline is output or input is read from any stream attached to a terminal device. This option is invalid with standard input.

‘0’ Disable buffering of the selected stream. In this mode, data is output immediately and only the amount of data requested is read from input. Note the difference in function for input and output. Disabling buffering for input will not influence the responsiveness or blocking behavior of the stream input functions. For example fread will still block until EOF or error, even if the underlying read returns less data than requested.

‘size’ Specify the size of the buffer to use in fully buffered mode. size may be, or may be an integer optionally followed by, one of the following multiplicative suffixes:

‘KB’ => 1000 (KiloBytes)
‘K’ => 1024 (KibiBytes)
‘MB’ => 1000*1000 (MegaBytes)
‘M’ => 1024*1024 (MebiBytes)
‘GB’ => 1000*1000*1000 (GigaBytes)
‘G’ => 1024*1024*1024 (GibiBytes)


stdbuf is installed only on platforms that use the Executable and Linkable Format (ELF) and support the constructor attribute, so portable scripts should not rely on its existence.

Exit status:
125 if stdbuf itself fails
126 if *command* is found but cannot be invoked
127 if *command* cannot be found
otherwise

the exit status of *command* otherwise

**23.6 timeout: Run a command with a time limit**

*timeout* runs the given *command* and kills it if it is still running after the specified time interval. Synopsis:

```
timeout [option] duration command [arg]...
```

*command* must not be a special built-in utility (see Section 2.10 [Special built-in utilities], page 10).

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands.

`--preserve-status`
Return the exit status of the managed *command* on timeout, rather than a specific exit status indicating a timeout. This is useful if the managed *command* supports running for an indeterminate amount of time.

`--foreground`
Don’t create a separate background program group, so that the managed *command* can use the foreground TTY normally. This is needed to support two situations when timing out commands, when not invoking *timeout* from an interactive shell.

1. *command* is interactive and needs to read from the terminal for example
2. the user wants to support sending signals directly to *command* from the terminal (like Ctrl-C for example)

Note in this mode of operation, any children of *command* will not be timed out. Also SIGCONT will not be sent to *command*, as it’s generally not needed with foreground processes, and can cause intermittent signal delivery issues with programs that are monitors themselves (like GDB for example).

`-k duration`
`--kill-after=duration`
Ensure the monitored *command* is killed by also sending a ‘KILL’ signal.

The specified *duration* starts from the point in time when *timeout* sends the initial signal to *command*, i.e., not from the beginning when the *command* is started.

This option has no effect if either the main *duration* of the *timeout* command, or the *duration* specified to this option, is 0.

This option may be useful if the selected signal did not kill the *command*, either because the signal was blocked or ignored, or if the *command* takes too long (e.g. for cleanup work) to terminate itself within a certain amount of time.
Chapter 23: Modified command invocation

'--signal=signal'

Send this signal to command on timeout, rather than the default ‘TERM’ signal. signal may be a name like ‘HUP’ or a number. See Section 2.3 [Signal specifications], page 5.

'--verbose'

Diagnose to standard error, any signal sent upon timeout.

duration is a floating point number in either the current or the C locale (see Section 2.12 [Floating point], page 10) followed by an optional unit:

's' for seconds (the default)

'm' for minutes

'h' for hours

'd' for days

A duration of 0 disables the associated timeout. Note that the actual timeout duration is dependent on system conditions, which should be especially considered when specifying sub-second timeouts.

Exit status:

124 if command times out, and --preserve-status is not specified
125 if timeout itself fails
126 if command is found but cannot be invoked
127 if command cannot be found
137 if command or timeout is sent the KILL(9) signal (128+9)
the exit status of command otherwise

In the case of the ‘KILL(9)’ signal, timeout returns with exit status 137, regardless of whether that signal is sent to command or to timeout itself, i.e., these cases cannot be distinguished. In the latter case, the command process may still be alive after timeout has forcefully been terminated.

Examples:

# Send the default TERM signal after 20s to a short-living 'sleep 1'.
# As that terminates long before the given duration, 'timeout' returns
# with the same exit status as the command, 0 in this case.
timeout 20 sleep 1

# Send the INT signal after 5s to the 'sleep' command. Returns after
# 5 seconds with exit status 124 to indicate the sending of the signal.
timeout -s INT 5 sleep 20

# Likewise, but the command ignoring the INT signal due to being started
# via 'env --ignore-signal'. Thus, 'sleep' terminates regularly after
# the full 20 seconds, still 'timeout' returns with exit status 124.
timeout -s INT 5s env --ignore-signal=INT sleep 20

# Likewise, but sending the KILL signal 3 seconds after the initial
# INT signal. Hence, 'sleep' is forcefully terminated after about 8 seconds (5+3), and 'timeout' returns with an exit status of 137.

timeout -s INT -k 3s 5s env --ignore-signal=INT sleep 20
24 Process control

24.1 kill: Send a signal to processes

The kill command sends a signal to processes, causing them to terminate or otherwise act upon receiving the signal in some way. Alternatively, it lists information about signals. Synopses:

```
kill [-s signal | --signal signal | -signal] pid...
kill [-l | --list | -t | --table] [signal]...
```

Due to shell aliases and built-in kill functions, using an unadorned kill interactively or in a script may get you different functionality than that described here. Invoke it via `env` (i.e., `env kill ...`) to avoid interference from the shell.

The first form of the kill command sends a signal to all `pid` arguments. The default signal to send if none is specified is ‘TERM’. The special signal number ‘0’ does not denote a valid signal, but can be used to test whether the `pid` arguments specify processes to which a signal could be sent.

If `pid` is positive, the signal is sent to the process with the process ID `pid`. If `pid` is zero, the signal is sent to all processes in the process group of the current process. If `pid` is −1, the signal is sent to all processes for which the user has permission to send a signal. If `pid` is less than −1, the signal is sent to all processes in the process group that equals the absolute value of `pid`.

If `pid` is not positive, a system-dependent set of system processes is excluded from the list of processes to which the signal is sent.

If a negative `pid` argument is desired as the first one, it should be preceded by `--`. However, as a common extension to POSIX, `--` is not required with `kill -signal -pid`.

The following commands are equivalent:

```
nkill -15 -1
kill -TERM -1
kill -s TERM -- -1
kill -- -1
```

The first form of the kill command succeeds if every `pid` argument specifies at least one process that the signal was sent to.

The second form of the kill command lists signal information. Either the `-l` or `--list` option, or the `-t` or `--table` option must be specified. Without any `signal` argument, all supported signals are listed. The output of `-l` or `--list` is a list of the signal names, one per line; if `signal` is already a name, the signal number is printed instead. The output of `-t` or `--table` is a table of signal numbers, names, and descriptions. This form of the kill command succeeds if all `signal` arguments are valid and if there is no output error.

The kill command also supports the `--help` and `--version` options. See Chapter 2 [Common options], page 2.

A `signal` may be a signal name like ‘HUP’, or a signal number like ‘1’, or an exit status of a process terminated by the signal. A signal name can be given in canonical form or prefixed by ‘SIG’. The case of the letters is ignored, except for the `-signal` option which must use upper case to avoid ambiguity with lower case option letters. See Section 2.3 [Signal specifications], page 5, for a list of supported signal names and numbers.
25 Delaying

25.1 sleep: Delay for a specified time

sleep pauses for an amount of time specified by the sum of the values of the command line arguments. Synopsis:

    sleep number[smhd]...

Each argument is a non-negative number followed by an optional unit; the default is seconds. The units are:

- ‘s’ seconds
- ‘m’ minutes
- ‘h’ hours
- ‘d’ days

Although portable POSIX scripts must give sleep a single non-negative integer argument without a suffix, GNU sleep also accepts two or more arguments, unit suffixes, and floating-point numbers in either the current or the C locale. See Section 2.12 [Floating point], page 10.

For instance, the following could be used to sleep for 1 second, 234 milli-, 567 micro- and 890 nanoseconds:

    sleep 1234e-3 567.89e-6

Also one could sleep indefinitely like:

    sleep inf

The only options are --help and --version. See Chapter 2 [Common options], page 2.

Due to shell aliases and built-in sleep functions, using an unadorned sleep interactively or in a script may get you different functionality than that described here. Invoke it via env (i.e., env sleep ...) to avoid interference from the shell.

An exit status of zero indicates success, and a nonzero value indicates failure.
26 Numeric operations

These programs do numerically-related operations.

26.1 factor: Print prime factors

factor prints prime factors. Synopsis:

```
factor [option]... [number]...
```

If no number is specified on the command line, factor reads numbers from standard input, delimited by newlines, tabs, or spaces.

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

'--h'
'--exponents'

print factors in the form $p^e$, rather than repeating the prime 'p', 'e' times. If the exponent 'e' is 1, then it is omitted.

```
$ factor --exponents 3000
3000: 2^3 3 5^3
```

If the number to be factored is small (less than $2^{127}$ on typical machines), factor uses a faster algorithm. For example, on a circa-2017 Intel Xeon Silver 4116, factoring the product of the eighth and ninth Mersenne primes (approximately $2^{92}$) takes about 4 ms of CPU time:

```
$ M8=$(echo 2^31-1 | bc)
$ M9=$(echo 2^61-1 | bc)
$ n=$(echo "$M8 * $M9" | bc)
$ bash -c "time factor $n"
4951760154835678088235319297: 2147483647 2305843009213693951
```

real 0m0.004s
user 0m0.004s
sys 0m0.000s

For larger numbers, factor uses a slower algorithm. On the same platform, factoring the eighth Fermat number $2^{256} + 1$ takes about 14 seconds, and the slower algorithm would have taken about 750 ms to factor $2^{127} - 3$ instead of the 50 ms needed by the faster algorithm.

Factoring large numbers is, in general, hard. The Pollard-Brent rho algorithm used by factor is particularly effective for numbers with relatively small factors. If you wish to factor large numbers which do not have small factors (for example, numbers which are the product of two large primes), other methods are far better.

An exit status of zero indicates success, and a nonzero value indicates failure.

26.2 numfmt: Reformat numbers

numfmt reads numbers in various representations and reformats them as requested. The most common usage is converting numbers to/from human representation (e.g. ‘4G’ $\mapsto$ ‘4,000,000,000’).

```
umfmt [option]... [number]
```
**numfmt** converts each *number* on the command-line according to the specified options (see below). If no numbers are given, it reads numbers from standard input. **numfmt** can optionally extract numbers from specific columns, maintaining proper line padding and alignment.

An exit status of zero indicates success, and a nonzero value indicates failure. See **--invalid** for additional information regarding exit status.

### 26.2.1 General options

The program accepts the following options. Also see Chapter 2 [Common options], page 2.

**‘--debug’** Print (to standard error) warning messages about possible erroneous usage.

**‘-d d’**

**‘--delimiter=d’**

Use the character *d* as input field separator (default: whitespace). *Note*: Using non-default delimiter turns off automatic padding.

**‘--field=fields’**

Convert the number in input field *fields* (default: 1). *fields* supports cut style field ranges:

- **N** N'th field, counted from 1
- **N-** from N'th field, to end of line
- **N-M** from N'th to M'th field (inclusive)
- **-M** from first to M'th field (inclusive)
- **-** all fields

**‘--format=format’**

Use printf-style floating FORMAT string. The *format* string must contain one ‘%f’ directive, optionally with ‘+’, ‘-’, ‘0’, width or precision modifiers. The ‘+’ modifier will enable **--grouping**, the ‘-’ modifier will enable left-aligned **--padding** and the width modifier will enable right-aligned **--padding**. The ‘0’ width modifier (without the ‘-’ modifier) will generate leading zeros on the number, up to the specified width. A precision specification like ‘%.1f’ will override the precision determined from the input data or set due to **--to** option auto scaling.

**‘--from=unit’**

Auto-scales input numbers according to *unit*. See UNITS below. The default is no scaling, meaning suffixes (e.g. ‘M’, ‘G’) will trigger an error.

**‘--from-unit=n’**

Specify the input unit size (instead of the default 1). Use this option when the input numbers represent other units (e.g. if the input number ‘10’ represents 10 units of 512 bytes, use ‘--from-unit=512’). Suffixes are handled as with ‘--from=auto’.

**‘--grouping’**

Group digits in output numbers according to the current locale’s grouping rules (e.g. Thousands Separator character, commonly ‘.’ (dot) or ‘,’ comma). This option has no effect in ‘POSIX/C’ locale.
'--header=[n]'  
Print the first n (default: 1) lines without any conversion.

'--invalid=mode'  
The default action on input errors is to exit immediately with status code 2.  
--invalid='abort' explicitly specifies this default mode. With a mode of  
'fail', print a warning for each conversion error, and exit with status 2. With  
a mode of 'warn', exit with status 0, even in the presence of conversion errors,  
and with a mode of 'ignore' do not even print diagnostics.

'--padding=n'  
Pad the output numbers to n characters, by adding spaces. If n is a positive  
number, numbers will be right-aligned. If n is a negative number, numbers will  
be left-aligned. By default, numbers are automatically aligned based on the  
input line’s width (only with the default delimiter).

'--round=method'  
When converting number representations, round the number according to method,  
which can be 'up', 'down', 'from-zero' (the default), 'towards-zero', 'nearest'.

'--suffix=suffix'  
Add ‘SUFFIX’ to the output numbers, and accept optional ‘SUFFIX’ in input  
numbers.

'--to=unit'  
Auto-scales output numbers according to unit. See Units below. The default is  
no scaling, meaning all the digits of the number are printed.

'--to-unit=n'  
Specify the output unit size (instead of the default 1). Use this option when the  
output numbers represent other units (e.g. to represent ‘4,000,000’ bytes in  
blocks of 1KB, use ‘--to=si --to-unit=1000’). Suffixes are handled as with  
'--from=auto'.

'-z'  
'--zero-terminated'  
Delimit items with a zero byte rather than a newline (ASCII LF). I.e., treat  
input as items separated by ASCII NUL and terminate output items with ASCII  
NUL. This option can be useful in conjunction with ‘perl -0’ or ‘find -print0’  
and ‘xargs -0’ which do the same in order to reliably handle arbitrary file  
names (even those containing blanks or other special characters). Note with -z  
the newline character is treated as a field separator.

26.2.2 Possible units:
The following are the possible unit options with --from=UNITS and --to=UNITS:

none  No scaling is performed. For input numbers, no suffixes are accepted, and  
any trailing characters following the number will trigger an error. For output  
numbers, all digits of the numbers will be printed.

si  Auto-scale numbers according to the International System of Units (SI) stan-

dard. For input numbers, accept one of the following suffixes. For output
numbers, values larger than 1000 will be rounded, and printed with one of the following suffixes:

- ‘K’ => 1000\(^{1}\) = 10\(^{3}\) (Kilo)
- ‘M’ => 1000\(^{2}\) = 10\(^{6}\) (Mega)
- ‘G’ => 1000\(^{3}\) = 10\(^{9}\) (Giga)
- ‘T’ => 1000\(^{4}\) = 10\(^{12}\) (Tera)
- ‘P’ => 1000\(^{5}\) = 10\(^{15}\) (Peta)
- ‘E’ => 1000\(^{6}\) = 10\(^{18}\) (Exa)
- ‘Z’ => 1000\(^{7}\) = 10\(^{21}\) (Zetta)
- ‘Y’ => 1000\(^{8}\) = 10\(^{24}\) (Yotta)
- ‘R’ => 1000\(^{9}\) = 10\(^{27}\) (Ronna)
- ‘Q’ => 1000\(^{10}\) = 10\(^{30}\) (Quetta)

The **iec** option uses a single letter suffix (e.g. ‘G’), which is not fully standard, as the **iec** standard recommends a two-letter symbol (e.g. ‘Gi’) – but in practice, this method is common. Compare with the **iec-i** option.

- ‘Ki’ => 1024\(^{1}\) = 2\(^{10}\) (Kibi)
- ‘Mi’ => 1024\(^{2}\) = 2\(^{20}\) (Mebi)
- ‘Gi’ => 1024\(^{3}\) = 2\(^{30}\) (Gibi)
- ‘Ti’ => 1024\(^{4}\) = 2\(^{40}\) (Tebi)
- ‘Pi’ => 1024\(^{5}\) = 2\(^{50}\) (Pebi)
- ‘Ei’ => 1024\(^{6}\) = 2\(^{60}\) (Exbi)
- ‘Zi’ => 1024\(^{7}\) = 2\(^{70}\) (Zebi)
- ‘Yi’ => 1024\(^{8}\) = 2\(^{80}\) (Yobi)
- ‘Ri’ => 1024\(^{9}\) = 2\(^{90}\) (Robi)
- ‘Qi’ => 1024\(^{10}\) = 2\(^{100}\) (Quebi)
The \texttt{iec-i} option uses a two-letter suffix symbol (e.g. \texttt{Gi}' ), as the \texttt{iec} standard recommends, but this is not always common in practice. Compare with the \texttt{iec} option.

\texttt{auto} ‘auto’ can only be used with \texttt{--from}. With this method, numbers with single-letter suffixes like ‘K’ suffixes are interpreted as \textit{SI} values, and numbers with two-letter suffixes like ‘Ki’ are interpreted as \textit{IEC} values.

### 26.2.3 Examples of using \texttt{numfmt}

Converting a single number from/to \textit{human} representation:

```bash
$ numfmt --to=si 500000
500K

$ numfmt --to=iec 500000
489K

$ numfmt --to=iec-i 500000
489Ki

$ numfmt --from=si 1M
1000000

$ numfmt --from=iec 1M
1048576

# with '--from=auto', M=Mega, Mi=Mebi
$ numfmt --from=auto 1M
1000000
$ numfmt --from=auto 1Mi
1048576

Converting from ‘SI’ to ‘IEC’ scales (e.g. when a drive’s capacity is advertised as ‘1TB’, while checking the drive’s capacity gives lower values):

```
$ numfmt --from=si --to=iec 1T
932G
```

With both input and output scales specified, the largest defined prefixes are supported:

```
$ numfmt --from=si --to=iec-i 2000R
1.6Qi
```

Converting a single field from an input file / piped input (these contrived examples are for demonstration purposes only, as both \texttt{ls} and \texttt{df} support the \texttt{--human-readable} option to output sizes in human-readable format):

```
# Third field (file size) will be shown in SI representation
$ ls -log | numfmt --field 3 --header --to=si | head -n4
-rw-r--r-- 1 94K Aug 23 2011 ABOUT-NLS
-rw-r--r-- 1 3.7K Jan 7 16:15 AUTHORS
-rw-r--r-- 1 36K Jun 1 2011 COPYING
-rw-r--r-- 1 0 Jan 7 15:15 ChangeLog
```
# Second field (size) will be shown in IEC representation

$ df --block-size=1 | numfmt --field 2 --header --to=iec | head -n4

File system  1B-blocks   Used  Available  Use%  Mounted on
rootfs       132G  104741408  26554036  80%  /
.tmpfs        794M   7580   804960   1%  /run/shm
/dev/sdb1    694G  651424756  46074696  94%  /home

Output can be tweaked using --padding or --format:

# Pad to 10 characters, right-aligned
$ du -s * | numfmt --to=si --padding=10
  2.5K  config.log
  108  config.status
  1.7K  configure
   20  configure.ac

# Pad to 10 characters, left-aligned
$ du -s * | numfmt --to=si --padding=-10
   2.5K  config.log
   108  config.status
   1.7K  configure
    20  configure.ac

# Pad to 10 characters, left-aligned, using 'format'
$ du -s * | numfmt --to=si --format=":%10f"
  2.5K  config.log
   108  config.status
   1.7K  configure
    20  configure.ac

# Pad to 10 characters, left-aligned, using 'format'
$ du -s * | numfmt --to=si --padding="%-10f"
  2.5K  config.log
   108  config.status
   1.7K  configure
    20  configure.ac

With locales that support grouping digits, using --grouping or --format enables grouping. In `POSIX` locale, grouping is silently ignored:

$ LC_ALL=C numfmt --from=iec --grouping 2G
  2147483648

$ LC_ALL=en_US.utf8 numfmt --from=iec --grouping 2G
  2,147,483,648

$ LC_ALL=ta_IN numfmt --from=iec --grouping 2G
  2,14,74,83,648
26.3 seq: Print numeric sequences

seq prints a sequence of numbers to standard output. Synopses:

```
seq [option]... last
seq [option]... first last
seq [option]... first increment last
```

seq prints the numbers from first to last by increment. By default, each number is printed on a separate line. When increment is not specified, it defaults to ‘1’, even when first is larger than last. first also defaults to ‘1’. So `seq 1` prints ‘1’, but `seq 0` and `seq 10 5` produce no output. The sequence of numbers ends when the sum of the current number and increment would become greater than last, so `seq 1 10 10` only produces ‘1’. increment must not be ‘0’; use the tool `yes` to get repeated output of a constant number. first, increment and last must not be NaN, but inf is supported. Floating-point numbers may be specified in either the current or the C locale. See Section 2.12 [Floating point], page 10.

The program accepts the following options. Also see Chapter 2 [Common options], page 2. Options must precede operands.

`-f format`
`--format=format`

Print all numbers using format. format must contain exactly one of the `printf`-style floating point conversion specifications ‘%a’, ‘%e’, ‘%f’, ‘%g’, ‘%A’, ‘%E’, ‘%F’, ‘%G’. The ‘%’ may be followed by zero or more flags taken from the set ‘-+#0 ’, then an optional width containing one or more digits, then an optional precision consisting of a ‘.’ followed by zero or more digits. format may also contain any number of ‘%’ conversion specifications. All conversion specifications have the same meaning as with `printf`.

The default format is derived from first, step, and last. If these all use a fixed point decimal representation, the default format is ‘%.pf’, where p is the minimum precision that can represent the output numbers exactly. Otherwise, the default format is ‘%g’.

`-s string`
`--separator=string`

Separate numbers with string; default is a newline. The output always terminates with a newline.
Chapter 26: Numeric operations

`-w`
`--equal-width`
Print all numbers with the same width, by padding with leading zeros. first, step, and last should all use a fixed point decimal representation. (To have other kinds of padding, use `--format`).

You can get finer-grained control over output with `-f`:

```
$ seq -f '(%9.2E)' -9e5 1.1e6 1.3e6
(-9.00E+05)
 ( 2.00E+05)
 ( 1.30E+06)
```

If you want hexadecimal integer output, you can use `printf` to perform the conversion:

```
$ printf '%x\n' $(seq 1048575 1024 1050623)
fffff
1003ff
1007ff
```

For very long lists of numbers, use xargs to avoid system limitations on the length of an argument list:

```
$ seq 1000000 | xargs printf '%x\n' | tail -n 3
f423e
f423f
f4240
```

To generate octal output, use the `printf %o` format instead of `%x`.

On most systems, `seq` can produce whole-number output for values up to at least $2^{53}$. Larger integers are approximated. The details differ depending on your floating-point implementation. See Section 2.12 [Floating point], page 10. A common case is that `seq` works with integers through $2^{64}$, and larger integers may not be numerically correct:

```
$ seq 50000000000000000000 2 50000000000000000004
50000000000000000000
50000000000000000000
50000000000000000004
```

However, note that when limited to non-negative whole numbers, an increment of less than 200, and no format-specifying option, `seq` can print arbitrarily large numbers. Therefore `seq inf` can be used to generate an infinite sequence of numbers.

Be careful when using `seq` with outlandish values: otherwise you may see surprising results, as `seq` uses floating point internally. For example, on the x86 platform, where the internal representation uses a 64-bit fraction, the command:

```
seq 1 0.000000000000000000001 1.000000000000000000009
```

outputs 1.000000000000000000007 twice and skips 1.000000000000000000008.

An exit status of zero indicates success, and a nonzero value indicates failure.
27 File permissions

Each file has a set of file mode bits that control the kinds of access that users have to that file. They can be represented either in symbolic form or as an octal number.

27.1 Structure of File Mode Bits

The file mode bits have two parts: the file permission bits, which control ordinary access to the file, and special mode bits, which affect only some files.

There are three kinds of permissions that a user can have for a file:
1. permission to read the file. For directories, this means permission to list the contents of the directory.
2. permission to write to (change) the file. For directories, this means permission to create and remove files in the directory.
3. permission to execute the file (run it as a program). For directories, this means permission to access files in the directory.

There are three categories of users who may have different permissions to perform any of the above operations on a file:
1. the file’s owner;
2. other users who are in the file’s group;
3. everyone else.

Files are given an owner and group when they are created. Usually the owner is the current user and the group is the group of the directory the file is in, but this varies with the operating system, the file system the file is created on, and the way the file is created. You can change the owner and group of a file by using the chown and chgrp commands.

In addition to the three sets of three permissions listed above, the file mode bits have three special components, which affect only executable files (programs) and, on most systems, directories:

The set-user-ID bit (setuid bit).

On execution, set the process’s effective user ID to that of the file. For directories on a few systems, give files created in the directory the same owner as the directory, no matter who creates them, and set the set-user-ID bit of newly-created subdirectories.

The set-group-ID bit (setgid bit).

On execution, set the process’s effective group ID to that of the file. For directories on most systems, give files created in the directory the same group as the directory, no matter what group the user who creates them is in, and set the set-group-ID bit of newly-created subdirectories.

The restricted deletion flag or sticky bit.

Prevent unprivileged users from removing or renaming a file in a directory unless they own the file or the directory; this is commonly found on world-writable directories like /tmp. For regular files on some older systems, save the program’s text image on the swap device so it will load more quickly when run, so that the image is “sticky”.

In addition to the file mode bits listed above, there may be file attributes specific to the
file system, e.g., access control lists (ACLs), whether a file is compressed, whether a file can
be modified (immutability), and whether a file can be dumped. These are usually set using
programs specific to the file system. For example:

**ext2**  On GNU and GNU/Linux the file attributes specific to the ext2 file system are
        set using `chattr`.

**FFS**   On FreeBSD the file flags specific to the FFS file system are set using `chflags`.

Even if a file’s mode bits allow an operation on that file, that operation may still fail,
because:

- the file-system-specific attributes or flags do not permit it; or
- the file system is mounted as read-only.

For example, if the immutable attribute is set on a file, it cannot be modified, regardless
of the fact that you may have just run `chmod a+w FILE`.

### 27.2 Symbolic Modes

Symbolic modes represent changes to files’ mode bits as operations on single-character
symbols. They allow you to modify either all or selected parts of files’ mode bits, optionally
based on their previous values, and perhaps on the current `umask` as well (see Section 27.2.6
[Umask and Protection], page 237).

The format of symbolic modes is:

```
[ugoa...][-+=perms...[,....]
```

where `perms` is either zero or more letters from the set ‘rwxXst’, or a single letter from the
set ‘ugo’.

The following sections describe the operators and other details of symbolic modes.

#### 27.2.1 Setting Permissions

The basic symbolic operations on a file’s permissions are adding, removing, and setting
the permission that certain users have to read, write, and execute or search the file. These
operations have the following format:

```
users operation permissions
```

The spaces between the three parts above are shown for readability only; symbolic modes
cannot contain spaces.

The `users` part tells which users’ access to the file is changed. It consists of one or more
of the following letters (or it can be empty; see Section 27.2.6 [Umask and Protection],
page 237, for a description of what happens then). When more than one of these letters is
given, the order that they are in does not matter.

- u  the user who owns the file;
- g  other users who are in the file’s group;
- o  all other users;
- a  all users; the same as ‘ugo’.

```
The *operation* part tells how to change the affected users' access to the file, and is one of the following symbols:

+ to add the *permissions* to whatever permissions the *users* already have for the file;
-
  to remove the *permissions* from whatever permissions the *users* already have for the file;
=
  to make the *permissions* the only permissions that the *users* have for the file.

The *permissions* part tells what kind of access to the file should be changed; it is normally zero or more of the following letters. As with the *users* part, the order does not matter when more than one letter is given. Omitting the *permissions* part is useful only with the ‘=’ operation, where it gives the specified *users* no access at all to the file.

- **r** the permission the *users* have to read the file;
- **w** the permission the *users* have to write to the file;
- **x** the permission the *users* have to execute the file, or search it if it is a directory.

For example, to give everyone permission to read and write a regular file, but not to execute it, use:

```
a=rw
```

To remove write permission for all users other than the file’s owner, use:

```
go-w
```

The above command does not affect the access that the owner of the file has to it, nor does it affect whether other users can read or execute the file.

To give everyone except a file’s owner no permission to do anything with that file, use the mode below. Other users could still remove the file, if they have write permission on the directory it is in.

```
go=
```

Another way to specify the same thing is:

```
og-rwx
```

### 27.2.2 Copying Existing Permissions

You can base a file’s permissions on its existing permissions. To do this, instead of using a series of ‘r’, ‘w’, or ‘x’ letters after the operator, you use the letter ‘u’, ‘g’, or ‘o’. For example, the mode

```
0+g
```

adds the permissions for users who are in a file’s group to the permissions that other users have for the file. Thus, if the file started out as mode 664 (‘rw-rw-r--’), the above mode would change it to mode 666 (‘rw-rw-rw-’). If the file had started out as mode 741 (‘rwxr----x’), the above mode would change it to mode 745 (‘rwxr--r-x’). The ‘-’ and ‘=’ operations work analogously.
27.2.3 Changing Special Mode Bits

In addition to changing a file's read, write, and execute/search permissions, you can change its special mode bits. See Section 27.1 [Mode Structure], page 233, for a summary of these special mode bits.

To change the file mode bits to set the user ID on execution, use ‘u’ in the users part of the symbolic mode and ‘s’ in the permissions part.

To change the file mode bits to set the group ID on execution, use ‘g’ in the users part of the symbolic mode and ‘s’ in the permissions part.

To set both user and group ID on execution, omit the users part of the symbolic mode (or use ‘a’) and use ‘s’ in the permissions part.

To change the file mode bits to set the restricted deletion flag or sticky bit, omit the users part of the symbolic mode (or use ‘a’) and use ‘t’ in the permissions part.

For example, to set the set-user-ID mode bit of a program, you can use the mode:

```
u+s
```

To remove both set-user-ID and set-group-ID mode bits from it, you can use the mode:

```
a-s
```

To set the restricted deletion flag or sticky bit, you can use the mode:

```
t
```

The combination ‘o+s’ has no effect. On GNU systems the combinations ‘u+t’ and ‘g+t’ have no effect, and ‘o+t’ acts like plain ‘+t’.

The ‘=’ operator is not very useful with special mode bits. For example, the mode:

```
o=t
```

does set the restricted deletion flag or sticky bit, but it also removes all read, write, and execute/search permissions that users not in the file’s group might have had for it.

See Section 27.5 [Directory Setuid and Setgid], page 239, for additional rules concerning set-user-ID and set-group-ID bits and directories.

27.2.4 Conditional Executability

There is one more special type of symbolic permission: if you use ‘X’ instead of ‘x’, execute/search permission is affected only if the file is a directory or already had execute permission.

For example, this mode:

```
a+X
```
gives all users permission to search directories, or to execute files if anyone could execute them before.

27.2.5 Making Multiple Changes

The format of symbolic modes is actually more complex than described above (see Section 27.2.1 [Setting Permissions], page 234). It provides two ways to make multiple changes to files' mode bits.

The first way is to specify multiple operation and permissions parts after a users part in the symbolic mode.
For example, the mode:

\texttt{og+rX-w}

gives users other than the owner of the file read permission and, if it is a directory or if someone already had execute permission to it, gives them execute/search permission; and it also denies them write permission to the file. It does not affect the permission that the owner of the file has for it. The above mode is equivalent to the two modes:

\texttt{og+rX}

\texttt{og-w}

The second way to make multiple changes is to specify more than one simple symbolic mode, separated by commas. For example, the mode:

\texttt{a+r,g+o-w}

gives everyone permission to read the file and removes write permission on it for all users except its owner. Another example:

\texttt{u=rwx,g=rx,o=}

sets all of the permission bits for the file explicitly. (It gives users who are not in the file’s group no permission at all for it.)

The two methods can be combined. The mode:

\texttt{a+r,g+x-w}

gives all users permission to read the file, and gives users who are in the file’s group permission to execute/search it as well, but not permission to write to it. The above mode could be written in several different ways; another is:

\texttt{u+r,g+rx,o+r,g-w}

\textbf{27.2.6 The Umask and Protection}

If the \texttt{users} part of a symbolic mode is omitted, it defaults to ‘a’ (affect all users), except that any permissions that are \texttt{set} in the system variable \texttt{umask} are \textit{not affected}. The value of \texttt{umask} can be set using the \texttt{umask} command. Its default value varies from system to system.

Omitting the users part of a symbolic mode is generally not useful with operations other than ‘\texttt{+}’. It is useful with ‘\texttt{+}’ because it allows you to use \texttt{umask} as an easily customizable protection against giving away more permission to files than you intended to.

As an example, if \texttt{umask} has the value 2, which removes write permission for users who are not in the file’s group, then the mode:

\texttt{+w}

adds permission to write to the file to its owner and to other users who are in the file’s group, but \textit{not} to other users. In contrast, the mode:

\texttt{a+w}

ignores \texttt{umask}, and \textit{does} give write permission for the file to all users.
27.3 Numeric Modes

As an alternative to giving a symbolic mode, you can give an octal (base 8) number that represents the mode.

The permissions granted to the user, to other users in the file’s group, and to other users not in the file’s group each require three bits: one bit for read, one for write, and one for execute/search permission. These three bits are represented as one octal digit; for example, if all three are present, the resulting 111 (in binary) is represented as the digit 7 (in octal). The three special mode bits also require one bit each, and they are as a group represented as another octal digit. Here is how the bits are arranged, starting with the highest valued bit:

<table>
<thead>
<tr>
<th>Value in Mode</th>
<th>Corresponding Mode Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4000</td>
<td>Set user ID</td>
</tr>
<tr>
<td>2000</td>
<td>Set group ID</td>
</tr>
<tr>
<td>1000</td>
<td>Restricted deletion flag or sticky bit</td>
</tr>
</tbody>
</table>

The file's owner:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mode Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>Read</td>
</tr>
<tr>
<td>200</td>
<td>Write</td>
</tr>
<tr>
<td>100</td>
<td>Execute/search</td>
</tr>
</tbody>
</table>

Other users in the file's group:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mode Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Read</td>
</tr>
<tr>
<td>20</td>
<td>Write</td>
</tr>
<tr>
<td>10</td>
<td>Execute/search</td>
</tr>
</tbody>
</table>

Other users not in the file's group:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Mode Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Read</td>
</tr>
<tr>
<td>2</td>
<td>Write</td>
</tr>
<tr>
<td>1</td>
<td>Execute/search</td>
</tr>
</tbody>
</table>

For example, numeric mode ‘4751’ corresponds to symbolic mode ‘u=srwx,g=rx,o=x’, and numeric mode ‘664’ corresponds to symbolic mode ‘ug=rx,o=r’. Numeric mode ‘0’ corresponds to symbolic mode ‘a=’.

A numeric mode is usually shorter than the corresponding symbolic mode, but it is limited in that normally it cannot take into account the previous file mode bits; it can only set them absolutely. The set-user-ID and set-group-ID bits of directories are an exception to this general limitation. See Section 27.5 [Directory Setuid and Setgid], page 239. Also, operator numeric modes can take previous file mode bits into account. See Section 27.4 [Operator Numeric Modes], page 239.

Numeric modes are always interpreted in octal; you do not have to add a leading ‘0’, as you do in C. Mode ‘0055’ is the same as mode ‘55’. However, modes of five digits or more, such as ‘00055’, are sometimes special (see Section 27.5 [Directory Setuid and Setgid], page 239).
27.4 Operator Numeric Modes

An operator numeric mode is a numeric mode that is prefixed by a ‘-‘, ‘+‘, or ‘=‘ operator, which has the same interpretation as in symbolic modes. For example, ‘+440’ enables read permission for the file’s owner and group, ‘-1’ disables execute permission for other users, and ‘=600’ clears all permissions except for enabling read-write permission for the file’s owner. Operator numeric modes can be combined with symbolic modes by separating them with a comma; for example, ‘=0,u+r’ clears all permissions except for enabling read permission for the file’s owner.

The commands ‘chmod =755 dir’ and ‘chmod 755 dir’ differ in that the former clears the directory dir’s setuid and setgid bits, whereas the latter preserves them. See Section 27.5 [Directory Setuid and Setgid], page 239.

Operator numeric modes are a GNU extension.

27.5 Directories and the Set-User-ID and Set-Group-ID Bits

On most systems, if a directory’s set-group-ID bit is set, newly created subfiles inherit the same group as the directory, and newly created subdirectories inherit the set-group-ID bit of the parent directory. On a few systems, a directory’s set-user-ID bit has a similar effect on the ownership of new subfiles and the set-user-ID bits of new subdirectories. These mechanisms let users share files more easily, by lessening the need to use chmod or chown to share new files.

These convenience mechanisms rely on the set-user-ID and set-group-ID bits of directories. If commands like chmod and mkdir routinely cleared these bits on directories, the mechanisms would be less convenient and it would be harder to share files. Therefore, a command like chmod does not affect the set-user-ID or set-group-ID bits of a directory unless the user specifically mentions them in a symbolic mode, or uses an operator numeric mode such as ‘=755’, or sets them in a numeric mode, or clears them in a numeric mode that has five or more octal digits. For example, on systems that support set-group-ID inheritance:

```
# These commands leave the set-user-ID and
# set-group-ID bits of the subdirectories alone,
# so that they retain their default values.
mkdir A B C
chmod 755 A
chmod 0755 B
chmod u=rwx,go=rx C
mkdir -m 755 D
mkdir -m 0755 E
mkdir -m u=rwx,go=rx F
```

If you want to try to set these bits, you must mention them explicitly in the symbolic or numeric modes, e.g.:

```
# These commands try to set the set-user-ID
# and set-group-ID bits of the subdirectories.
mkdir G
chmod 6755 G
chmod +6000 G
```


```
chmod u=rwx,go=rx,a+s G
mkdir -m 6755 H
mkdir -m +6000 I
mkdir -m u=rwx,go=rx,a+s J
```

If you want to try to clear these bits, you must mention them explicitly in a symbolic mode, or use an operator numeric mode, or specify a numeric mode with five or more octal digits, e.g.:

```
# These commands try to clear the set-user-ID
# and set-group-ID bits of the directory D.
chmod a-s D
chmod -6000 D
chmod =755 D
chmod 00755 D
```

This behavior is a GNU extension. Portable scripts should not rely on requests to set or clear these bits on directories, as POSIX allows implementations to ignore these requests. The GNU behavior with numeric modes of four or fewer digits is intended for scripts portable to systems that preserve these bits; the behavior with numeric modes of five or more digits is for scripts portable to systems that do not preserve the bits.
28 File timestamps

Standard POSIX files have three timestamps: the access timestamp (atime) of the last read, the modification timestamp (mtime) of the last write, and the status change timestamp (ctime) of the last change to the file’s meta-information. Some file systems support a fourth time: the birth timestamp (birthtime) of when the file was created; by definition, birthtime never changes.

One common example of a ctime change is when the permissions of a file change. Changing the permissions doesn’t access the file, so atime doesn’t change, nor does it modify the file, so the mtime doesn’t change. Yet, something about the file itself has changed, and this must be noted somewhere. This is the job of the ctime field. This is necessary, so that, for example, a backup program can make a fresh copy of the file, including the new permissions value. Another operation that modifies a file’s ctime without affecting the others is renaming.

Naively, a file’s atime, mtime, and ctime are set to the current time whenever you read, write, or change the attributes of the file respectively, and searching a directory counts as reading it. A file’s atime and mtime can also be set directly, via the `touch` command (see Section 13.4 [touch invocation], page 142). In practice, though, timestamps are not updated quite that way.

For efficiency reasons, many systems are lazy about updating atimes: when a program accesses a file, they may delay updating the file’s atime, or may not update the file’s atime if the file has been accessed recently, or may not update the atime at all. Similar laziness, though typically not quite so extreme, applies to mtimes and ctimes.

Some systems emulate timestamps instead of supporting them directly, and these emulations may disagree with the naive interpretation. For example, a system may fake an atime or ctime by using the mtime.

The determination of what time is “current” depends on the platform. Platforms with network file systems often use different clocks for the operating system and for file systems; because updates typically uses file systems’ clocks by default, clock skew can cause the resulting file timestamps to appear to be in a program’s “future” or “past”.

When the system updates a file timestamp to a desired time $t$ (which is either the current time, or a time specified via the `touch` command), there are several reasons the file’s timestamp may be set to a value that differs from $t$. First, $t$ may have a higher resolution than supported. Second, a file system may use different resolutions for different types of times. Third, file timestamps may use a different resolution than operating system timestamps. Fourth, the operating system primitives used to update timestamps may employ yet a different resolution. For example, in theory a file system might use 10-microsecond resolution for access timestamp and 100-nanosecond resolution for modification timestamp, and the operating system might use nanosecond resolution for the current time and microsecond resolution for the primitive that `touch` uses to set a file’s timestamp to an arbitrary value.
29 Date input formats

First, a quote:

Our units of temporal measurement, from seconds on up to months, are so complicated, asymmetrical and disjunctive so as to make coherent mental reckoning in time all but impossible. Indeed, had some tyrannical god contrived to enslave our minds to time, to make it all but impossible for us to escape subjection to sodden routines and unpleasant surprises, he could hardly have done better than handing down our present system. It is like a set of trapezoidal building blocks, with no vertical or horizontal surfaces, like a language in which the simplest thought demands ornate constructions, useless particles and lengthy circumlocutions. Unlike the more successful patterns of language and science, which enable us to face experience boldly or at least level-headedly, our system of temporal calculation silently and persistently encourages our terror of time.

... It is as though architects had to measure length in feet, width in meters and height in ells; as though basic instruction manuals demanded a knowledge of five different languages. It is no wonder then that we often look into our own immediate past or future, last Tuesday or a week from Sunday, with feelings of helpless confusion. . . .

—Robert Grudin, Time and the Art of Living.

This section describes the textual date representations that GNU programs accept. These are the strings you, as a user, can supply as arguments to the various programs. The C interface (via the parse_datetime function) is not described here.

29.1 General date syntax

A date is a string, possibly empty, containing many items separated by whitespace. The whitespace may be omitted when no ambiguity arises. The empty string means the beginning of today (i.e., midnight). Order of the items is immaterial. A date string may contain many flavors of items:

- calendar date items
- time of day items
- time zone items
- combined date and time of day items
- day of the week items
- relative items
- pure numbers.

We describe each of these item types in turn, below.

A few ordinal numbers may be written out in words in some contexts. This is most useful for specifying day of the week items or relative items (see below). Among the most commonly used ordinal numbers, the word ‘last’ stands for −1, ‘this’ stands for 0, and ‘first’ and ‘next’ both stand for 1. Because the word ‘second’ stands for the unit of time there is no way to write the ordinal number 2, but for convenience ‘third’ stands for 3,

When a month is written this way, it is still considered to be written numerically, instead of being “spelled in full”; this changes the allowed strings.


The output of the date command is not always acceptable as a date string, not only because of the language problem, but also because there is no standard meaning for time zone items like ‘IST’. When using date to generate a date string intended to be parsed later, specify a date format that is independent of language and that does not use time zone items other than ‘UTC’ and ‘Z’. Here are some ways to do this:

$ LC_ALL=C TZ=UTC0 date
Tue Nov 15 02:02:42 UTC 2022

$ TZ=UTC0 date +'%Y-%m-%d %H:%M:%SZ'
2022-11-15 02:02:42Z

$ date --rfc-3339=ns # --rfc-3339 is a GNU extension.
2022-11-14 21:02:42.000000000-05:00

$ date --rfc-email # a GNU extension
Mon, 14 Nov 2022 21:02:42 -0500

$ date +'%Y-%m-%d %H:%M:%S %z' # %z is a GNU extension.
2022-11-14 21:02:42 -0500

$ date +'@%s.%N' # %s and %N are GNU extensions.
@1668477762.692722128

Alphabetic case is completely ignored in dates. Comments may be introduced between round parentheses, as long as included parentheses are properly nested. Hyphens not followed by a digit are currently ignored. Leading zeros on numbers are ignored.

Invalid dates like ‘2022-02-29’ or times like ‘24:00’ are rejected. In the typical case of a host that does not support leap seconds, a time like ‘23:59:60’ is rejected even if it corresponds to a valid leap second.

### 29.2 Calendar date items

A calendar date item specifies a day of the year. It is specified differently, depending on whether the month is specified numerically or literally. All these strings specify the same calendar date:

2022-11-14  # ISO 8601.
22-11-14  # Assume 19xx for 69 through 99,
           # 20xx for 00 through 68 (not recommended).
11/14/2022  # Common U.S. writing.
14 November 2022
14 Nov 2022  # Three-letter abbreviations always allowed.
November 14, 2022
14-nov-2022
14nov2022

The year can also be omitted. In this case, the last specified year is used, or the current year if none. For example:
Here are the rules.

For numeric months, the ISO 8601 format ‘year-month-day’ is allowed, where year is any positive number, month is a number between 01 and 12, and day is a number between 01 and 31. A leading zero must be present if a number is less than ten. If year is 68 or smaller, then 2000 is added to it; otherwise, if year is less than 100, then 1900 is added to it. The construct ‘month/day/year’, popular in the United States, is accepted. Also ‘month/day’, omitting the year.


When months are written literally, the calendar date may be given as any of the following:

\[
\begin{align*}
\text{day month year} \\
\text{day month} \\
\text{month day year} \\
\text{day–month–year}
\end{align*}
\]

Or, omitting the year:

\[
\text{month day}
\]

### 29.3 Time of day items

A *time of day item* in date strings specifies the time on a given day. Here are some examples, all of which represent the same time:

\[
\begin{align*}
20:02:00.000000 \\
20:02 \\
8:02pm \\
20:02-0500 & \# \text{ In EST (U.S. Eastern Standard Time).}
\end{align*}
\]

More generally, the time of day may be given as ‘hour:minute:second’, where *hour* is a number between 0 and 23, *minute* is a number between 0 and 59, and *second* is a number between 0 and 59 possibly followed by ‘.’ or ‘,’ and a fraction containing one or more digits. Alternatively, ‘:second’ can be omitted, in which case it is taken to be zero. On the rare hosts that support leap seconds, *second* may be 60.

If the time is followed by ‘am’ or ‘pm’ (or ‘a.m.’ or ‘p.m.’), *hour* is restricted to run from 1 to 12, and ‘:minute’ may be omitted (taken to be zero). ‘am’ indicates the first half of the day, ‘pm’ indicates the second half of the day. In this notation, 12 is the predecessor of 1: midnight is ‘12am’ while noon is ‘12pm’. (This is the zero-oriented interpretation of ‘12am’ and ‘12pm’, as opposed to the old tradition derived from Latin which uses ‘12m’ for noon and ‘12pm’ for midnight.)

The time may alternatively be followed by a time zone correction, expressed as ‘shhmm’, where s is ‘+’ or ‘–’, hh is a number of zone hours and mm is a number of zone minutes. The zone minutes term, mm, may be omitted, in which case the one- or two-digit correction is interpreted as a number of hours. You can also separate hh from mm with a colon. When a time zone correction is given this way, it forces interpretation of the time relative to
Coordinated Universal Time (UTC), overriding any previous specification for the time zone or the local time zone. For example, ‘+0530’ and ‘+05:30’ both stand for the time zone 5.5 hours ahead of UTC (e.g., India). This is the best way to specify a time zone correction by fractional parts of an hour. The maximum zone correction is 24 hours.

Either ‘am’/’pm’ or a time zone correction may be specified, but not both.

### 29.4 Time zone items

A *time zone item* specifies an international time zone, indicated by a small set of letters, e.g., ‘UTC’ or ‘Z’ for Coordinated Universal Time. Any included periods are ignored. By following a non-daylight-saving time zone by the string ‘DST’ in a separate word (that is, separated by some white space), the corresponding daylight saving time zone may be specified. Alternatively, a non-daylight-saving time zone can be followed by a time zone correction, to add the two values. This is normally done only for ‘UTC’; for example, ‘UTC+05:30’ is equivalent to ‘+05:30’.

Time zone items other than ‘UTC’ and ‘Z’ are obsolescent and are not recommended, because they are ambiguous; for example, ‘EST’ has a different meaning in Australia than in the United States, and ‘A’ has different meaning as a military time zone than as an obsolete RFC 822 time zone. Instead, it’s better to use unambiguous numeric time zone corrections like ‘-0500’, as described in the previous section.

If neither a time zone item nor a time zone correction is supplied, timestamps are interpreted using the rules of the default time zone (see Section 29.10 [Specifying time zone rules], page 247).

### 29.5 Combined date and time of day items

The ISO 8601 date and time of day extended format consists of an ISO 8601 date, a ‘T’ character separator, and an ISO 8601 time of day. This format is also recognized if the ‘T’ is replaced by a space.

In this format, the time of day should use 24-hour notation. Fractional seconds are allowed, with either comma or period preceding the fraction. ISO 8601 fractional minutes and hours are not supported. Typically, hosts support nanosecond timestamp resolution; excess precision is silently discarded.

Here are some examples:

<table>
<thead>
<tr>
<th>Date and Time</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>2022-09-24T20:02:00</td>
<td>2022-09-24T20:02:00.052-05:00</td>
</tr>
<tr>
<td>2022-12-31T23:59:59.999999999</td>
<td>2022-12-31T23:59:59,999999999+11:00</td>
</tr>
<tr>
<td>1970-01-01 00:00Z</td>
<td>1970-01-01 00:00Z</td>
</tr>
</tbody>
</table>

### 29.6 Day of week items

The explicit mention of a day of the week will forward the date (only if necessary) to reach that day of the week in the future.

Days of the week may be spelled out in full: ‘Sunday’, ‘Monday’, ‘Tuesday’, ‘Wednesday’, ‘Thursday’, ‘Friday’ or ‘Saturday’. Days may be abbreviated to their first three letters, optionally followed by a period. The special abbreviations ‘Tues’ for ‘Tuesday’, ‘Wednes’ for ‘Wednesday’ and ‘Thur’ or ‘Thurs’ for ‘Thursday’ are also allowed.
A number may precede a day of the week item to move forward supplementary weeks. It is best used in expression like ‘third monday’. In this context, ‘last day’ or ‘next day’ is also acceptable; they move one week before or after the day that day by itself would represent.

A comma following a day of the week item is ignored.

29.7 Relative items in date strings

Relative items adjust a date (or the current date if none) forward or backward. The effects of relative items accumulate. Here are some examples:

- 1 year
- 1 year ago
- 3 years
- 2 days

The unit of time displacement may be selected by the string ‘year’ or ‘month’ for moving by whole years or months. These are fuzzy units, as years and months are not all of equal duration. More precise units are ‘fortnight’ which is worth 14 days, ‘week’ worth 7 days, ‘day’ worth 24 hours, ‘hour’ worth 60 minutes, ‘minute’ or ‘min’ worth 60 seconds, and ‘second’ or ‘sec’ worth one second. An ‘s’ suffix on these units is accepted and ignored.

The unit of time may be preceded by a multiplier, given as an optionally signed number. Unsigned numbers are taken as positively signed. No number at all implies 1 for a multiplier. Following a relative item by the string ‘ago’ is equivalent to preceding the unit by a multiplier with value −1.

The string ‘tomorrow’ is worth one day in the future (equivalent to ‘day’), the string ‘yesterday’ is worth one day in the past (equivalent to ‘day ago’).

The strings ‘now’ or ‘today’ are relative items corresponding to zero-valued time displacement, these strings come from the fact a zero-valued time displacement represents the current time when not otherwise changed by previous items. They may be used to stress other items, like in ‘12:00 today’. The string ‘this’ also has the meaning of a zero-valued time displacement, but is preferred in date strings like ‘this thursday’.

When a relative item causes the resulting date to cross a boundary where the clocks were adjusted, typically for daylight saving time, the resulting date and time are adjusted accordingly.

The fuzz in units can cause problems with relative items. For example, ‘2022-12-31 -1 month’ might evaluate to 2022-12-01, because 2022-11-31 is an invalid date. To determine the previous month more reliably, you can ask for the month before the 15th of the current month. For example:

```
$ date -R
Thu, 31 Dec 2022 13:02:39 -0400
$ date --date='-1 month' +'Last month was %B?'
Last month was December?
$ date --date="$(date +%Y-%m-15) -1 month" +'Last month was %B!,'
Last month was November!
```

Also, take care when manipulating dates around clock changes such as daylight saving leaps. In a few cases these have added or subtracted as much as 24 hours from the clock,
so it is often wise to adopt universal time by setting the TZ environment variable to ‘UTC0’ before embarking on calendrical calculations.

29.8 Pure numbers in date strings

The precise interpretation of a pure decimal number depends on the context in the date string.

If the decimal number is of the form yyyymmdd and no other calendar date item (see Section 29.2 [Calendar date items], page 243) appears before it in the date string, then yyy is read as the year, mm as the month number and dd as the day of the month, for the specified calendar date.

If the decimal number is of the form hhmm and no other time of day item appears before it in the date string, then hh is read as the hour of the day and mm as the minute of the hour, for the specified time of day. mm can also be omitted.

If both a calendar date and a time of day appear to the left of a number in the date string, but no relative item, then the number overrides the year.

29.9 Seconds since the Epoch

If you precede a number with ‘@’, it represents an internal timestamp as a count of seconds. The number can contain an internal decimal point (either ‘.’ or ‘,’); any excess precision not supported by the internal representation is truncated toward minus infinity. Such a number cannot be combined with any other date item, as it specifies a complete timestamp.

Internally, computer times are represented as a count of seconds since an Epoch—a well-defined point of time. On GNU and POSIX systems, the Epoch is 1970-01-01 00:00:00 UTC, so ‘@0’ represents this time, ‘@1’ represents 1970-01-01 00:00:01 UTC, and so forth. GNU and most other POSIX-compliant systems support such times as an extension to POSIX, using negative counts, so that ‘@-1’ represents 1969-12-31 23:59:59 UTC.

Most modern systems count seconds with 64-bit two’s-complement integers of seconds with nanosecond subcounts, which is a range that includes the known lifetime of the universe with nanosecond resolution. Some obsolescent systems count seconds with 32-bit two’s-complement integers and can represent times from 1901-12-13 20:45:52 through 2038-01-19 03:14:07 UTC. A few systems sport other time ranges.

On most hosts, these counts ignore the presence of leap seconds. For example, on most hosts ‘@1483228799’ represents 2016-12-31 23:59:59 UTC, ‘@1483228800’ represents 2017-01-01 00:00:00 UTC, and there is no way to represent the intervening leap second 2016-12-31 23:59:60 UTC.

29.10 Specifying time zone rules

Normally, dates are interpreted using the rules of the current time zone, which in turn are specified by the TZ environment variable, or by a system default if TZ is not set. To specify a different set of default time zone rules that apply just to one date, start the date with a string of the form ‘TZ=”rule”’. The two quote characters (“”) must be present in the date, and any quotes or backslashes within rule must be escaped by a backslash.
For example, with the GNU date command you can answer the question “What time is it in New York when a Paris clock shows 6:30am on October 31, 2022?” by using a date beginning with ‘TZ="Europe/Paris"’ as shown in the following shell transcript:

```
$ export TZ="America/New_York"
$ date --date='TZ="Europe/Paris" 2022-10-31 06:30'
Mon Oct 31 01:30:00 EDT 2022
```

In this example, the --date operand begins with its own TZ setting, so the rest of that operand is processed according to ‘Europe/Paris’ rules, treating the string ‘2022-11-14 06:30’ as if it were in Paris. However, since the output of the date command is processed according to the overall time zone rules, it uses New York time. (Paris was normally six hours ahead of New York in 2022, but this example refers to a brief Halloween period when the gap was five hours.)

A TZ value is a rule that typically names a location in the ‘tz’ database (https://www.iana.org/time-zones). A recent catalog of location names appears in the TWiki Date and Time Gateway (https://twiki.org/cgi-bin/xtra/tzdatepick.html). A few non-GNU hosts require a colon before a location name in a TZ setting, e.g., ‘TZ=":America/New_York"’.

The ‘tz’ database includes a wide variety of locations ranging from ‘Africa/Abidjan’ to ‘Pacific/Tongatapu’, but if you are at sea and have your own private time zone, or if you are using a non-GNU host that does not support the ‘tz’ database, you may need to use a POSIX rule instead. The previously-mentioned POSIX rule ‘UTC0’ says that the time zone abbreviation is ‘UTC’, the zone is zero hours away from Greenwich, and there is no daylight saving time. POSIX rules can also specify nonzero Greenwich offsets. For example, the following shell transcript answers the question “What time is it five and a half hours east of Greenwich when a clock seven hours west of Greenwich shows 9:50pm on July 12, 2022?”

```
$ TZ="<+0530>-5:30" date --date='TZ="<-07>+7" 2022-07-12 21:50'
Wed Jul 13 10:20:00 +0530 2022
```

This example uses the somewhat-confusing POSIX convention for rules. ‘TZ="<-07>+7"’ says that the time zone abbreviation is ‘-07’ and the time zone is 7 hours west of Greenwich, and ‘TZ="<+0530>-5:30"’ says that the time zone abbreviation is ‘+0530’ and the time zone is 5 hours 30 minutes east of Greenwich. (One should never use a setting like ‘TZ="UTC-5"’, since this would incorrectly imply that local time is five hours east of Greenwich and the time zone is called “UTC”.) Although trickier POSIX TZ settings like ‘TZ="<-05>+5<-04>,M3.2.0/2,M11.1.0/2"’ can specify some daylight saving regimes, location-based settings like ‘TZ="America/New_York"’ are typically simpler and more accurate historically. See Section “Specifying the Time Zone with TZ” in The GNU C Library.

### 29.11 Authors of parse_datetime

parse_datetime started life as getdate, as originally implemented by Steven M. Bellovin (smb@research.att.com) while at the University of North Carolina at Chapel Hill. The code was later tweaked by a couple of people on Usenet, then completely overhauled by Rich Salz (rsalz@bbn.com) and Jim Berets (jberets@bbn.com) in August, 1990. Various revisions for the GNU system were made by David MacKenzie, Jim Meyering, Paul Eggert and others, including renaming it to get_date to avoid a conflict with the alternative Posix function getdate, and a later rename to parse_datetime. The Posix function getdate can
parse more locale-specific dates using 

strptime, but relies on an environment variable and

external file, and lacks the thread-safety of parse_datetime.

This chapter was originally produced by François Pinard (pinard@iro.umontreal.ca) from the parse_datetime.y source code, and then edited by K. Berry (kb@cs.umb.edu).
30 Version sort ordering

30.1 Version sort overview

Version sort puts items such as file names and lines of text in an order that feels natural to people, when the text contains a mixture of letters and digits.

Lexicographic sorting usually does not produce the order that one expects because comparisons are made on a character-by-character basis.

Compare the sorting of the following items:

<table>
<thead>
<tr>
<th>Lexicographic sort</th>
<th>Version Sort</th>
</tr>
</thead>
<tbody>
<tr>
<td>a1</td>
<td>a1</td>
</tr>
<tr>
<td>a120</td>
<td>a2</td>
</tr>
<tr>
<td>a13</td>
<td>a13</td>
</tr>
<tr>
<td>a2</td>
<td>a120</td>
</tr>
</tbody>
</table>


30.1.1 Using version sort in GNU Coreutils

Two GNU Coreutils programs use version sort: ls and sort.

To list files in version sort order, use ls with the -v or --sort=version option:

```
$ ls -1
a1
a100
a1.13
a1.4
a1.40
a2

$ ls -1 -v
a1
a100
a1.13
a1.4
a1.40
a2
```

To sort text files in version sort order, use sort with the -V or --version-sort option:

```
$ cat input
b3
b11
b1
b20

$ sort input
b1
b11
b20

$ sort -V input
b1
b3
b11
```
To sort a specific field in a file, use `-k/--key` with `V` type sorting, which is often combined with `b` to ignore leading blanks in the field:

```bash
$ cat input2
100  b3  apples
2000 b11 oranges
3000 b1  potatoes
4000 b20 bananas
$ sort -k 2bV,2 input2
3000 b1  potatoes
100  b3  apples
2000 b11 oranges
4000 b20 bananas
```

### 30.1.2 Version sort and natural sort

In GNU Coreutils, the name `version sort` was chosen because it is based on Debian GNU/Linux’s algorithm of sorting packages’ versions.

Its goal is to answer questions like “Which package is newer, `firefox-60.7.2` or `firefox-60.12.3`?”

In Coreutils this algorithm was slightly modified to work on more general input such as textual strings and file names (see Section 30.3 [Differences from Debian version sort], page 256).

In other contexts, such as other programs and other programming languages, a similar sorting functionality is called natural sort ([https://en.wikipedia.org/wiki/Natural_sort_order](https://en.wikipedia.org/wiki/Natural_sort_order)).

### 30.1.3 Variations in version sort order

Currently there is no standard for version sort.

That is: there is no one correct way or universally agreed-upon way to order items. Each program and each programming language can decide its own ordering algorithm and call it “version sort”, “natural sort”, or other names.

See Section 30.4.2 [Other version/natural sort implementations], page 260, for many examples of differing sorting possibilities, each with its own rules and variations.

If you find a bug in the Coreutils implementation of version-sort, please report it. See Section 30.4.1 [Reporting version sort bugs], page 260.

### 30.2 Version sort implementation

GNU Coreutils version sort is based on the “upstream version” part of Debian’s versioning scheme ([https://www.debian.org/doc/debian-policy/ch-controlfields.html#version](https://www.debian.org/doc/debian-policy/ch-controlfields.html#version)).

This section describes the GNU Coreutils sort ordering rules.

The next section (Section 30.3 [Differences from Debian version sort], page 256) describes some differences between GNU Coreutils and Debian version sort.
30.2.1 Version-sort ordering rules

The version sort ordering rules are:

1. The strings are compared from left to right.

2. First the initial part of each string consisting entirely of non-digit bytes is determined.
   A. These two parts (either of which may be empty) are compared lexically. If a difference is found it is returned.
   B. The lexical comparison is a lexicographic comparison of byte strings, except that:
      a. ASCII letters sort before other bytes.
      b. A tilde sorts before anything, even an empty string.

3. Then the initial part of the remainder of each string that contains all the leading digits is determined. The numerical values represented by these two parts are compared, and any difference found is returned as the result of the comparison.
   A. For these purposes an empty string (which can only occur at the end of one or both version strings being compared) counts as zero.
   B. Because the numerical value is used, non-identical strings can compare equal. For example, ‘123’ compares equal to ‘00123’, and the empty string compares equal to ‘0’.

4. These two steps (comparing and removing initial non-digit strings and initial digit strings) are repeated until a difference is found or both strings are exhausted.

Consider the version-sort comparison of two file names: `foo07.7z` and `foo7a.7z`. The two strings will be broken down to the following parts, and the parts compared respectively from each string:

<table>
<thead>
<tr>
<th>Foo</th>
<th>vs</th>
<th>Foo</th>
<th>(rule 2, non-digits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>07</td>
<td>vs</td>
<td>7</td>
<td>(rule 3, digits)</td>
</tr>
<tr>
<td>.</td>
<td>vs</td>
<td>a.</td>
<td>(rule 2)</td>
</tr>
<tr>
<td>7</td>
<td>vs</td>
<td>7</td>
<td>(rule 3)</td>
</tr>
<tr>
<td>z</td>
<td>vs</td>
<td>z</td>
<td>(rule 2)</td>
</tr>
</tbody>
</table>

Comparison flow based on above algorithm:

1. The first parts (‘foo’) are identical.
2. The second parts (‘07’ and ‘7’) are compared numerically, and compare equal.
3. The third parts (‘.’ vs ‘a.’) are compared lexically by ASCII value (rule 2.B).
4. The first byte of the first string (‘.’) is compared to the first byte of the second string (‘a’).
5. Rule 2.B.a says letters sorts before non-letters. Hence, ‘a’ comes before ‘.’.
6. The returned result is that `foo7a.7z` comes before `foo07.7z`.

Result when using sort:

```
$ cat input3
foo07.7z
foo7a.7z
$ sort -V input3
foo7a.7z
```
Chapter 30: Version sort ordering

foo07.7z

See Section 30.3 [Differences from Debian version sort], page 256, for additional rules that extend the Debian algorithm in Coreutils.

30.2.2 Version sort is not the same as numeric sort

Consider the following text file:

```
$ cat input4
8.10
8.5
8.1
8.01
8.010
8.100
8.49
```

**Numerical Sort:**

```
$ sort -n input4
8.01 8.01
8.010 8.1
8.1 8.5
8.10 8.010
8.100 8.10
8.49 8.49
8.5 8.100
```

**Version Sort:**

```
$ sort -V input4
8.01 8.01
8.1 8.5
8.10 8.010
8.100 8.10
8.49 8.49
8.5 8.100
```

**Numerical sort (``sort -n`)** treats the entire string as a single numeric value, and compares it to other values. For example, ‘8.1’, ‘8.10’ and ‘8.100’ are numerically equivalent, and are ordered together. Similarly, ‘8.49’ is numerically less than ‘8.5’, and appears before first.

**Version sort (‘`sort -V`)** first breaks down the string into digit and non-digit parts, and only then compares each part (see annotated example in Section 30.2.1 [Version-sort ordering rules], page 252).

Comparing the string ‘8.1’ to ‘8.01’, first the ‘8’s are compared (and are identical), then the dots (‘.’) are compared and are identical, and lastly the remaining digits are compared numerically (‘1’ and ‘01’) – which are numerically equal. Hence, ‘8.01’ and ‘8.1’ are grouped together.

Similarly, comparing ‘8.5’ to ‘8.49’ – the ‘8’ and ‘.’ parts are identical, then the numeric values ‘5’ and ‘49’ are compared. The resulting ‘5’ appears before ‘49’.

This sorting order (where ‘8.5’ comes before ‘8.49’) is common when assigning versions to computer programs (while perhaps not intuitive or “natural” for people).

30.2.3 Version sort punctuation

Punctuation is sorted by ASCII order (rule 2.B).

```
$ touch 1.0.5_src.tar.gz 1.0_src.tar.gz
$ ls -v -1
```
1.0.5_src.tar.gz
1.0_src.tar.gz

Why is 1.0.5_src.tar.gz listed before 1.0_src.tar.gz?

Based on the version-sort ordering rules, the strings are broken down into the following parts:

1 vs 1 (rule 3, all digits)
. vs . (rule 2, all non-digits)
0 vs 0 (rule 3)
. vs _src.tar.gz (rule 2)
5 vs empty string (no more bytes in the file name)
_src.tar.gz vs empty string

The fourth parts (‘.’ and ‘_src.tar.gz’) are compared lexically by ASCII order. The ‘.’ (ASCII value 46) is less than ‘_’ (ASCII value 95) – and should be listed before it.

Hence, 1.0.5_src.tar.gz is listed first.

If a different byte appears instead of the underscore (for example, percent sign ‘%’ ASCII value 37, which is less than dot’s ASCII value of 46), that file will be listed first:

$ touch 1.0.5_src.tar.gz 1.0%zzzzz.gz
1.0%zzzzz.gz
1.0.5_src.tar.gz

The same reasoning applies to the following example, as ‘.’ with ASCII value 46 is less than ‘/’ with ASCII value 47:

$ cat input5
3.0/
3.0.5
$ sort -V input5
3.0.5
3.0/

30.2.4 Punctuation vs letters

Rule 2.B.a says letters sort before non-letters (after breaking down a string to digit and non-digit parts).

$ cat input6
a%
a
az
$ sort -V input6
az
a%

The input strings consist entirely of non-digits, and based on the above algorithm have only one part, all non-digits (‘a%’ vs ‘az’).

Each part is then compared lexically, byte-by-byte; ‘a’ compares identically in both strings.

Rule 2.B.a says a letter like ‘z’ sorts before a non-letter like ‘%’ – hence ‘az’ appears first (despite ‘z’ having ASCII value of 122, much larger than ‘%’ with ASCII value 37).
30.2.5 The tilde ‘~’

Rule 2.B.b says the tilde ‘~’ (ASCII 126) sorts before other bytes, and before an empty string.

```
$ cat input7
1
1%
1.2
1~
```

```
$ sort -V input7
~
1~
1
1%
1.2
```

The sorting algorithm starts by breaking down the string into non-digit (rule 2) and digit parts (rule 3).

In the above input file, only the last line in the input file starts with a non-digit (‘~’). This is the first part. All other lines in the input file start with a digit – their first non-digit part is empty.

Based on rule 2.B.b, tilde ‘~’ sorts before other bytes and before the empty string – hence it comes before all other strings, and is listed first in the sorted output.

The remaining lines (‘1’, ‘1%’, ‘1.2’, ‘1~’) follow similar logic: The digit part is extracted (1 for all strings) and compares equal. The following extracted parts for the remaining input lines are: empty part, ‘%’, ‘.’, ‘~’.

Tilde sorts before all others, hence the line ‘1~’ appears next.

The remaining lines (‘1’, ‘1%’, ‘1.2’) are sorted based on previously explained rules.

30.2.6 Version sort ignores locale

In version sort, Unicode characters are compared byte-by-byte according to their binary representation, ignoring their Unicode value or the current locale.

Most commonly, Unicode characters are encoded as UTF-8 bytes; for example, GREEK SMALL LETTER ALPHA (U+03B1, ‘α’) is encoded as the UTF-8 sequence ‘0xCE 0xB1’). The encoding is compared byte-by-byte, e.g., first ‘0xCE’ (decimal value 206) then ‘0xB1’ (decimal value 177).

```
$ touch aa az "a%" "α"
$ ls -1 -v
aa
az
a%
α
```

Ignoring the first letter (‘a’) which is identical in all strings, the compared values are: ‘a’ and ‘z’ are letters, and sort before all other non-digits.
Then, percent sign ‘%’ (ASCII value 37) is compared to the first byte of the UTF-8 sequence of ‘α’, which is 0xCE or 206). The value 37 is smaller, hence ‘a%’ is listed before ‘aa’.

### 30.3 Differences from Debian version sort

GNU Coreutils version sort differs slightly from the official Debian algorithm, in order to accommodate more general usage and file name listing.

#### 30.3.1 Hyphen-minus ‘−’ and colon ‘:’

In Debian’s version string syntax the version consists of three parts:

```
[epoch:]upstream_version[-debian_revision]
```

The ‘epoch’ and ‘debian_revision’ parts are optional.

Example of such version strings:

- 60.7.2esr-1~deb9u1
- 52.9.0esr-1~deb9u1
- 1:2.3.4-1+b2
- 327-2
- 1:1.0.13-3
- 2:1.19.2-1+deb9u5

If the ‘debian_revision part’ is not present, hyphens ‘−’ are not allowed. If epoch is not present, colons ‘:’ are not allowed.

If these parts are present, hyphen and/or colons can appear only once in valid Debian version strings.

In GNU Coreutils, such restrictions are not reasonable (a file name can have many hyphens, a line of text can have many colons).

As a result, in GNU Coreutils hyphens and colons are treated exactly like all other punctuation, i.e., they are sorted after letters. See Section 30.2.3 [Version sort punctuation], page 253.

In Debian, these characters are treated differently than in Coreutils: a version string with hyphen will sort before similar strings without hyphens.

Compare:

```
$ touch 1ab-cd 1abb
$ ls -v -1
1abb
1ab-cd
```

For further details, see Section 30.3.4 [Comparing two strings using Debian’s algorithm], page 259, and GNU Bug 35939 (https://bugs.gnu.org/35939).
30.3.2 Special priority in GNU Coreutils version sort

In GNU Coreutils version sort, the following items have special priority and sort before all other strings (listed in order):

1. The empty string
2. The string ‘.’ (a single dot, ASCII 46)
3. The string ‘..’ (two dots)
4. Strings starting with dot (‘.’) sort before strings starting with any other byte.

Example:

```
$ printf '%s
' a "" b "." c ".." ".d20" ".d3" | sort -V
.
..
.d3
.d20
a
b
c
```

These priorities make perfect sense for ‘ls -v’: The special files dot ‘.’ and dot-dot ‘..’ will be listed first, followed by any hidden files (files starting with a dot), followed by non-hidden files.

For ‘sort -V’ these priorities might seem arbitrary. However, because the sorting code is shared between the ls and sort program, the ordering rules are the same.

30.3.3 Special handling of file extensions

GNU Coreutils version sort implements specialized handling of strings that look like file names with extensions. This enables slightly more natural ordering of file names.

The following additional rules apply when comparing two strings where both begin with non-‘.’. They also apply when comparing two strings where both begin with ‘.’ but neither is ‘.’ or ‘..’.

1. A suffix (i.e., a file extension) is defined as: a dot, followed by an ASCII letter or tilde, followed by zero or more ASCII letters, digits, or tildes; all repeated zero or more times, and ending at string end. This is equivalent to matching the extended regular expression `\.[A-Za-z~][A-Za-z0-9~]*$` in the C locale. The longest such match is used, except that a suffix is not allowed to match an entire nonempty string.

2. The suffixes are temporarily removed, and the strings are compared without them, using version sort (see Section 30.2.1 [Version-sort ordering rules], page 252) without special priority (see Section 30.3.2 [Special priority in GNU Coreutils version sort], page 257).

3. If the suffix-less strings do not compare equal, this comparison result is used and the suffixes are effectively ignored.

4. If the suffix-less strings compare equal, the suffixes are restored and the entire strings are compared using version sort.

Examples for rule 1:

- ‘hello-8.txt’: the suffix is ‘.txt’
• ‘hello-8.2.txt’: the suffix is ‘.txt’ (‘.2’ is not included because the dot is not followed by a letter)
• ‘hello-8.0.12.tar.gz’: the suffix is ‘.tar.gz’ (‘.0.12’ is not included)
• ‘hello-8.2’: no suffix (suffix is an empty string)
• ‘hello.foobar65’: the suffix is ‘.foobar65’
• ‘gcc-c++-10.8.12-0.7rc2.fc9.tar.bz2’: the suffix is ‘.fc9.tar.bz2’ (‘.7rc2’ is not included as it begins with a digit)
• ‘.autom4te.cfg’: the suffix is the entire string.

Examples for rule 2:
• Comparing ‘hello-8.txt’ to ‘hello-8.2.12.txt’, the ‘.txt’ suffix is temporarily removed from both strings.
• Comparing ‘foo-10.3.tar.gz’ to ‘foo-10.tar.xz’, the suffixes ‘.tar.gz’ and ‘.tar.xz’ are temporarily removed from the strings.

Example for rule 3:
• Comparing ‘hello.foobar65’ to ‘hello.foobar4’, the suffixes (‘.foobar65’ and ‘.foobar4’) are temporarily removed. The remaining strings are identical (‘hello’). The suffixes are then restored, and the entire strings are compared (‘hello.foobar4’ comes first).

Examples for rule 4:
• When comparing the strings ‘hello-8.2.txt’ and ‘hello-8.10.txt’, the suffixes (‘.txt’) are temporarily removed. The remaining strings (‘hello-8.2’ and ‘hello-8.10’) are compared as previously described (‘hello-8.2’ comes first).

(In this case the suffix removal algorithm does not have a noticeable effect on the resulting order.)

**How does the suffix-removal algorithm effect ordering results?**

Consider the comparison of hello-8.txt and hello-8.2.txt.

Without the suffix-removal algorithm, the strings will be broken down to the following parts:

- `hello-` vs `hello-` (rule 2, all non-digits)
- `8` vs `8` (rule 3, all digits)
- `txt` vs `.` (rule 2)
- `empty` vs `2`
- `empty` vs `txt`

The comparison of the third parts (‘.’ vs ‘.txt’) will determine that the shorter string comes first – resulting in hello-8.2.txt appearing first.

Indeed this is the order in which Debian’s dpkg compares the strings.

A more natural result is that hello-8.txt should come before hello-8.2.txt, and this is where the suffix-removal comes into play:

The suffixes (‘.txt’) are removed, and the remaining strings are broken down into the following parts:

- `hello-` vs `hello-` (rule 2, all non-digits)
8 vs 8 (rule 3, all digits)
empty vs . (rule 2)
empty vs 2

As empty strings sort before non-empty strings, the result is ‘hello-8’ being first.

A real-world example would be listing files such as: gcc_10.fc9.tar.gz and gcc_10.8.12.7rc2.fc9.tar.bz2: Debian’s algorithm would list gcc_10.8.12.7rc2.fc9.tar.bz2 first, while ‘ls -v’ will list gcc_10.fc9.tar.gz first.

These priorities make sense for ‘ls -v’: Versioned files will be listed in a more natural order.

For ‘sort -V’ these priorities might seem arbitrary. However, because the sorting code is shared between the ls and sort program, the ordering rules are the same.

30.3.4 Comparing two strings using Debian’s algorithm

The Debian program dpkg (available on all Debian and Ubuntu installations) can compare two strings using the --compare-versions option.

To use it, create a helper shell function (simply copy & paste the following snippet to your shell command-prompt):

```bash
compver() {
    if dpkg --compare-versions "$1" lt "$2"
    then printf '%s
' "$1" "$2"
    else printf '%s
' "$2" "$1"
    fi
}
```

Then compare two strings by calling compver:

```
$ compver 8.49 8.5
8.5
8.49
```

Note that dpkg will warn if the strings have invalid syntax:

```
$ compver "foo07.7z" "foo7a.7z"
dpkg: warning: version 'foo07.7z' has bad syntax:
    version number does not start with digit

$ compver "3.0/" "3.0.5"
dpkg: warning: version '3.0/ has bad syntax:
    invalid character in version number
```

To illustrate the different handling of hyphens between Debian and Coreutils algorithms (see Section 30.3.1 [Hyphen-minus and colon], page 256):

```
$ compver abb ab-cd 2>/dev/null
$ printf 'abb\nab-cd\n' | sort -V
abb
ab-cd
```
To illustrate the different handling of file extension: (see Section 30.3.3 [Special handling of file extensions], page 257):

```bash
$ compver hello-8.txt hello-8.2.txt 2>/dev/null
hello-8.2.txt
hello-8.txt
$ printf '%s\n' hello-8.txt hello-8.2.txt | sort -V
hello-8.txt
hello-8.2.txt
```

### 30.4 Advanced Topics

#### 30.4.1 Reporting version sort bugs

If you suspect a bug in GNU Coreutils version sort (i.e., in the output of `ls -v` or `sort -V`), please first check the following:

1. Is the result consistent with Debian’s own ordering (using `dpkg`, see Section 30.3.4 [Comparing two strings using Debian’s algorithm], page 259)? If it is, then this is not a bug – please do not report it.
2. If the result differs from Debian’s, is it explained by one of the sections in Section 30.3 [Differences from Debian version sort], page 256? If it is, then this is not a bug – please do not report it.
3. If you have a question about specific ordering which is not explained here, please write to `coreutils@gnu.org`, and provide a concise example that will help us diagnose the issue.
4. If you still suspect a bug which is not explained by the above, please write to `bug-coreutils@gnu.org` with a concrete example of the suspected incorrect output, with details on why you think it is incorrect.

#### 30.4.2 Other version/natural sort implementations

As previously mentioned, there are multiple variations on version/natural sort, each with its own rules. Some examples are:

- Natural Sorting variants in Rosetta Code ([https://rosettacode.org/wiki/Natural_sorting](https://rosettacode.org/wiki/Natural_sorting)).
- Ruby’s version_sorter ([https://github.com/github/version_sorter](https://github.com/github/version_sorter)).
- Perl has multiple packages for natural and version sorts (each likely with its own rules and nuances): Sort::Naturally ([https://metacpan.org/pod/Sort::Naturally](https://metacpan.org/pod/Sort::Naturally)), Sort::Versions ([https://metacpan.org/pod/Sort::Versions](https://metacpan.org/pod/Sort::Versions)), CPAN::Version ([https://metacpan.org/pod/CPAN::Version](https://metacpan.org/pod/CPAN::Version)).
• In zsh, the glob modifier (http://zsh.sourceforge.net/Doc/Release/Expansion.html#Glob-Qualifiers) ‘*(n)’ will expand to files in natural sort order.

• When writing C programs, the GNU libc library (‘glibc’) provides the strverscmp(3) (https://man7.org/linux/man-pages/man3/strverscmp.3.html) function to compare two strings, and versionsort(3) (https://man7.org/linux/man-pages/man3/versionsort.3.html) function to compare two directory entries (despite the names, they are not identical to GNU Coreutils version sort ordering).

• Using Debian’s sorting algorithm in:
  • python: Stack Overflow Example #4957741 (https://stackoverflow.com/a/4957741).

30.4.3 Related source code

• Debian’s code which splits a version string into `epoch/upstream_version/debian_revision` parts: `parsehelp.c:parseversion()` (https://git.dpkg.org/cgit/dpkg/dpkg.git/tree/lib/dpkg/parsehelp.c#n191).

• Debian’s code which performs the `upstream_version` comparison: `version.c` (https://git.dpkg.org/cgit/dpkg/dpkg.git/tree/lib/dpkg/version.c#n140).

• GnuLib code (used by GNU Coreutils) which performs the version comparison: `filevercmp.c` (https://git.savannah.gnu.org/cgit/gnulib.git/tree/lib/filevercmp.c).
31 Opening the Software Toolbox


Toolbox Introduction

This month's column is only peripherally related to the GNU Project, in that it describes a number of the GNU tools on your GNU/Linux system and how they might be used. What it's really about is the “Software Tools” philosophy of program development and usage.

The software tools philosophy was an important and integral concept in the initial design and development of Unix (of which GNU/Linux and GNU are essentially clones). Unfortunately, in the modern day press of Internetworking and flashy GUIs, it seems to have fallen by the wayside. This is a shame, since it provides a powerful mental model for solving many kinds of problems.

Many people carry a Swiss Army knife around in their pants pockets (or purse). A Swiss Army knife is a handy tool to have: it has several knife blades, a screwdriver, tweezers, toothpick, nail file, corkscrew, and perhaps a number of other things on it. For the everyday, small miscellaneous jobs where you need a simple, general purpose tool, it’s just the thing.

On the other hand, an experienced carpenter doesn’t build a house using a Swiss Army knife. Instead, he has a toolbox chock full of specialized tools – a saw, a hammer, a screwdriver, a plane, and so on. And he knows exactly when and where to use each tool; you won’t catch him hammering nails with the handle of his screwdriver.

The Unix developers at Bell Labs were all professional programmers and trained computer scientists. They had found that while a one-size-fits-all program might appeal to a user because there’s only one program to use, in practice such programs are

a. difficult to write,

b. difficult to maintain and debug, and

c. difficult to extend to meet new situations.

Instead, they felt that programs should be specialized tools. In short, each program “should do one thing well.” No more and no less. Such programs are simpler to design, write, and get right – they only do one thing.

Furthermore, they found that with the right machinery for hooking programs together, that the whole was greater than the sum of the parts. By combining several special purpose programs, you could accomplish a specific task that none of the programs was designed for, and accomplish it much more quickly and easily than if you had to write a special purpose program. We will see some (classic) examples of this further on in the column. (An important additional point was that, if necessary, take a detour and build any software tools you may need first, if you don’t already have something appropriate in the toolbox.)

I/O Redirection

Hopefully, you are familiar with the basics of I/O redirection in the shell, in particular the concepts of “standard input,” “standard output,” and “standard error”. Briefly, “standard
input” is a data source, where data comes from. A program should not need to either know
or care if the data source is a regular file, a keyboard, a magnetic tape, or even a punched
card reader. Similarly, “standard output” is a data sink, where data goes to. The program
should neither know nor care where this might be. Programs that only read their standard
input, do something to the data, and then send it on, are called filters, by analogy to filters
in a water pipeline.

With the Unix shell, it’s very easy to set up data pipelines:

```
program_to_create_data | filter1 | ... | filterN > final.pretty.data
```

We start out by creating the raw data; each filter applies some successive transformation
to the data, until by the time it comes out of the pipeline, it is in the desired form.

This is fine and good for standard input and standard output. Where does the standard
error come in to play? Well, think about `filter1` in the pipeline above. What happens if it
encounters an error in the data it sees? If it writes an error message to standard output, it
will just disappear down the pipeline into `filter2`’s input, and the user will probably never
see it. So programs need a place where they can send error messages so that the user will
notice them. This is standard error, and it is usually connected to your console or window,
even if you have redirected standard output of your program away from your screen.

For filter programs to work together, the format of the data has to be agreed upon.
The most straightforward and easiest format to use is simply lines of text. Unix data
files are generally just streams of bytes, with lines delimited by the ASCII LF (Line Feed)
character, conventionally called a “newline” in the Unix literature. (This is `\n` if you’re a
C programmer.) This is the format used by all the traditional filtering programs. (Many
earlier operating systems had elaborate facilities and special purpose programs for managing
binary data. Unix has always shied away from such things, under the philosophy that it’s
easiest to simply be able to view and edit your data with a text editor.)

OK, enough introduction. Let’s take a look at some of the tools, and then we’ll see how
to hook them together in interesting ways. In the following discussion, we will only present
those command line options that interest us. As you should always do, double check your
system documentation for the full story.

The who Command

The first program is the `who` command. By itself, it generates a list of the users who are
currently logged in. Although I’m writing this on a single-user system, we’ll pretend that
several people are logged in:

```
$ who
⊣ arnold   console Jan 22 19:57
⊣ miriam  ttyp0   Jan 23 14:19(:0.0)
⊣ bill    ttyp1   Jan 21 09:32(:0.0)
⊣ arnold  ttyp2   Jan 23 20:48(:0.0)
```

Here, the ‘$’ is the usual shell prompt, at which I typed ‘`who`’. There are three people
logged in, and I am logged in twice. On traditional Unix systems, user names are never
more than eight characters long. This little bit of trivia will be useful later. The output of
`who` is nice, but the data is not all that exciting.
The cut Command

The next program we'll look at is the `cut` command. This program cuts out columns or fields of input data. For example, we can tell it to print just the login name and full name from the `/etc/passwd` file. The `/etc/passwd` file has seven fields, separated by colons:

```
arnold:xyzzy:2076:10:Arnold D. Robbins:/home/arnold:/bin/bash
```

To get the first and fifth fields, we would use `cut` like this:

```
$ cut -d: -f1,5 /etc/passwd

root:Operator

arnold:Arnold D. Robbins

miriam:Miriam A. Robbins
```

With the `-c` option, `cut` will cut out specific characters (i.e., columns) in the input lines. This is useful for input data that has fixed width fields, and does not have a field separator. For example, list the Monday dates for the current month:

```
$ cal | cut -c 3-5

Mo

6
13
20
27
```

The sort Command

Next we'll look at the `sort` command. This is one of the most powerful commands on a Unix-style system; one that you will often find yourself using when setting up fancy data plumbing.

The `sort` command reads and sorts each file named on the command line. It then merges the sorted data and writes it to standard output. It will read standard input if no files are given on the command line (thus making it into a filter). The sort is based on the character collating sequence or based on user-supplied ordering criteria.

The uniq Command

Finally (at least for now), we'll look at the `uniq` program. When sorting data, you will often end up with duplicate lines, lines that are identical. Usually, all you need is one instance of each line. This is where `uniq` comes in. The `uniq` program reads its standard input. It prints only one copy of each repeated line. It does have several options. Later on, we'll use the `-c` option, which prints each unique line, preceded by a count of the number of times that line occurred in the input.

Putting the Tools Together

Now, let's suppose this is a large ISP server system with dozens of users logged in. The management wants the system administrator to write a program that will generate a sorted
list of logged in users. Furthermore, even if a user is logged in multiple times, his or her name should only show up in the output once.

The administrator could sit down with the system documentation and write a C program that did this. It would take perhaps a couple of hundred lines of code and about two hours to write it, test it, and debug it. However, knowing the software toolbox, the administrator can instead start out by generating just a list of logged on users:

```bash
$ who | cut -c1-8
⊣ arnold
⊣ miriam
⊣ bill
⊣ arnold
```

Next, sort the list:

```bash
$ who | cut -c1-8 | sort
⊣ arnold
⊣ arnold
⊣ bill
⊣ miriam
```

Finally, run the sorted list through `uniq`, to weed out duplicates:

```bash
$ who | cut -c1-8 | sort | uniq
⊣ arnold
⊣ bill
⊣ miriam
```

The `sort` command actually has a `-u` option that does what `uniq` does. However, `uniq` has other uses for which one cannot substitute `sort -u`.

The administrator puts this pipeline into a shell script, and makes it available for all the users on the system (‘#’ is the system administrator, or root, prompt):

```bash
# cat > /usr/local/bin/listusers
who | cut -c1-8 | sort | uniq
```

```
^D
```

```bash
# chmod +x /usr/local/bin/listusers
```

There are four major points to note here. First, with just four programs, on one command line, the administrator was able to save about two hours worth of work. Furthermore, the shell pipeline is just about as efficient as the C program would be, and it is much more efficient in terms of programmer time. People time is much more expensive than computer time, and in our modern “there’s never enough time to do everything” society, saving two hours of programmer time is no mean feat.

Second, it is also important to emphasize that with the combination of the tools, it is possible to do a special purpose job never imagined by the authors of the individual programs.

Third, it is also valuable to build up your pipeline in stages, as we did here. This allows you to view the data at each stage in the pipeline, which helps you acquire the confidence that you are indeed using these tools correctly.

Finally, by bundling the pipeline in a shell script, other users can use your command, without having to remember the fancy plumbing you set up for them. In terms of how you run them, shell scripts and compiled programs are indistinguishable.
After the previous warm-up exercise, we’ll look at two additional, more complicated pipelines. For them, we need to introduce two more tools.

The first is the `tr` command, which stands for “transliterate.” The `tr` command works on a character-by-character basis, changing characters. Normally it is used for things like mapping upper case to lower case:

```bash
$ echo This ExAmPlE HaS MIXED case! | tr ':upper:' ':lower:'
this example has mixed case!
```

There are several options of interest:

- `-c` work on the complement of the listed characters, i.e., operations apply to characters not in the given set
- `-d` delete characters in the first set from the output
- `-s` squeeze repeated characters in the output into just one character.

We will be using all three options in a moment.

The other command we’ll look at is `comm`. The `comm` command takes two sorted input files as input data, and prints out the files’ lines in three columns. The output columns are the data lines unique to the first file, the data lines unique to the second file, and the data lines that are common to both. The `-1`, `-2`, and `-3` command line options omit the respective columns. (This is non-intuitive and takes a little getting used to.) For example:

```bash
$ cat f1
11111
22222
33333
44444

$ cat f2
00000
22222
33333
55555

$ comm f1 f2
00000
11111
22222
33333
44444
55555
```

The file name `-t` tells `comm` to read standard input instead of a regular file.

Now we’re ready to build a fancy pipeline. The first application is a word frequency counter. This helps an author determine if he or she is over-using certain words.

The first step is to change the case of all the letters in our input file to one case. “The” and “the” are the same word when doing counting.

```bash
$ tr ':upper:' ':lower:' < whats.gnu | ...
```

The next step is to get rid of punctuation. Quoted words and unquoted words should be treated identically; it’s easiest to just get the punctuation out of the way.

```bash
$ tr ':upper:' ':lower:' < whats.gnu | tr -cd ':alnum:_\n' | ...
```
The second `tr` command operates on the complement of the listed characters, which are all the letters, the digits, the underscore, and the blank. The `\n` represents the newline character; it has to be left alone. (The ASCII tab character should also be included for good measure in a production script.)

At this point, we have data consisting of words separated by blank space. The words only contain alphanumeric characters (and the underscore). The next step is break the data apart so that we have one word per line. This makes the counting operation much easier, as we will see shortly.

```
$ tr '[:upper:]' '[:lower:]' < whats.gnu | tr -cd '[:alnum:]_\n' |
  > tr -s '' 'n' | ...
```

This command turns blanks into newlines. The `-s` option squeezes multiple newline characters in the output into just one, removing blank lines. (The `>` is the shell’s “secondary prompt.” This is what the shell prints when it notices you haven’t finished typing in all of a command.)

We now have data consisting of one word per line, no punctuation, all one case. We’re ready to count each word:

```
$ tr '[:upper:]' '[:lower:]' < whats.gnu | tr -cd '[:alnum:]_\n' |
  > tr -s '' 'n' | sort | uniq -c | ...
```

At this point, the data might look something like this:

```
60 a
2 able
6 about
1 above
2 accomplish
1 acquire
1 actually
2 additional
```

The output is sorted by word, not by count! What we want is the most frequently used words first. Fortunately, this is easy to accomplish, with the help of two more `sort` options:

- `-n` do a numeric sort, not a textual one
- `-r` reverse the order of the sort

The final pipeline looks like this:

```
$ tr '[:upper:]' '[:lower:]' < whats.gnu | tr -cd '[:alnum:]_\n' |
  > tr -s '' 'n' | sort | uniq -c | sort -n -r
```

```
<table>
<thead>
<tr>
<th></th>
<th>156 the</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60 a</td>
</tr>
<tr>
<td>1</td>
<td>58 to</td>
</tr>
<tr>
<td>1</td>
<td>51 of</td>
</tr>
<tr>
<td>1</td>
<td>51 and</td>
</tr>
<tr>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>
```

Whew! That’s a lot to digest. Yet, the same principles apply. With six commands, on two lines (really one long one split for convenience), we’ve created a program that does something interesting and useful, in much less time than we could have written a C program to do the same thing.
A minor modification to the above pipeline can give us a simple spelling checker! To determine if you’ve spelled a word correctly, all you have to do is look it up in a dictionary. If it is not there, then chances are that your spelling is incorrect. So, we need a dictionary. The conventional location for a dictionary is /usr/share/dict/words.

Now, how to compare our file with the dictionary? As before, we generate a sorted list of words, one per line:

```
$ tr '[[:upper:]]' '[[:lower:]]' < whats.gnu | tr -cd '[[:alnum:]_\n]' |
  > tr -s ' ' '\n' | sort -u | ...
```

Now, all we need is a list of words that are not in the dictionary. Here is where the `comm` command comes in. Unfortunately `comm` operates on sorted input and /usr/share/dict/words is not sorted the way that `sort` and `comm` normally use, so we first create a properly-sorted copy of the dictionary and then run a pipeline that uses the copy.

```
$ sort /usr/share/dict/words > sorted-words
$ tr '[[:upper:]]' '[[:lower:]]' < whats.gnu | tr -cd '[[:alnum:]_\n]' |
  > tr -s ' ' '\n' | sort -u |
  > comm -23 - sorted-words
```

The -2 and -3 options eliminate lines that are only in the dictionary (the second file), and lines that are in both files. Lines only in the first file (standard input, our stream of words), are words that are not in the dictionary. These are likely candidates for spelling errors. This pipeline was the first cut at a production spelling checker on Unix.

There are some other tools that deserve brief mention.

- `grep` search files for text that matches a regular expression
- `wc` count lines, words, characters
- `tee` a T-fitting for data pipes, copies data to files and to standard output
- `sed` the stream editor, an advanced tool
- `awk` a data manipulation language, another advanced tool

The software tools philosophy also espoused the following bit of advice: “Let someone else do the hard part.” This means, take something that gives you most of what you need, and then massage it the rest of the way until it’s in the form that you want.

To summarize:
1. Each program should do one thing well. No more, no less.
2. Combining programs with appropriate plumbing leads to results where the whole is greater than the sum of the parts. It also leads to novel uses of programs that the authors might never have imagined.
3. Programs should never print extraneous header or trailer data, since these could get sent on down a pipeline. (A point we didn’t mention earlier.)
4. Let someone else do the hard part.
5. Know your toolbox! Use each program appropriately. If you don’t have an appropriate tool, build one.

All the programs discussed are available as described in GNU core utilities (https://www.gnu.org/software/coreutils/coreutils.html).
None of what I have presented in this column is new. The Software Tools philosophy was first introduced in the book Software Tools, by Brian Kernighan and P.J. Plauger (Addison-Wesley, ISBN 0-201-03669-X). This book showed how to write and use software tools. It was written in 1976, using a preprocessor for FORTRAN named ratfor (RATional FORtran). At the time, C was not as ubiquitous as it is now; FORTRAN was. The last chapter presented a ratfor to FORTRAN processor, written in ratfor. ratfor looks an awful lot like C; if you know C, you won’t have any problem following the code.

In 1981, the book was updated and made available as Software Tools in Pascal (Addison-Wesley, ISBN 0-201-10342-7). Both books are still in print and are well worth reading if you’re a programmer. They certainly made a major change in how I view programming.

The programs in both books are available from Brian Kernighan’s home page (https://www.cs.princeton.edu/~bwk/). For a number of years, there was an active Software Tools Users Group, whose members had ported the original ratfor programs to essentially every computer system with a FORTRAN compiler. The popularity of the group waned in the middle 1980s as Unix began to spread beyond universities.

With the current proliferation of GNU code and other clones of Unix programs, these programs now receive little attention; modern C versions are much more efficient and do more than these programs do. Nevertheless, as exposition of good programming style, and evangelism for a still-valuable philosophy, these books are unparalleled, and I recommend them highly.

Acknowledgment: I would like to express my gratitude to Brian Kernighan of Bell Labs, the original Software Toolsmith, for reviewing this column.
Appendix A  GNU Free Documentation License

Version 1.3, 3 November 2008
https://fsf.org/

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document free in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or noncommercially. Secondarily, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of “copyleft”, which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”. You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A “Modified Version” of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A “Secondary Section” is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document’s overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The “Invariant Sections” are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released
under this License. If a section does not fit the above definition of Secondary then it is
not allowed to be designated as Invariant. The Document may contain zero Invariant
Sections. If the Document does not identify any Invariant Sections then there are none.
The “Cover Texts” are certain short passages of text that are listed, as Front-Cover
Texts or Back-Cover Texts, in the notice that says that the Document is released under
this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may
be at most 25 words.
A “Transparent” copy of the Document means a machine-readable copy, represented in a
format whose specification is available to the general public, that is suitable for revising
the document straightforwardly with generic text editors or (for images composed of
pixels) generic paint programs or (for drawings) some widely available drawing editor,
and that is suitable for input to text formatters or for automatic translation to a
variety of formats suitable for input to text formatters. A copy made in an otherwise
Transparent file format whose markup, or absence of markup, has been arranged to
thwart or discourage subsequent modification by readers is not Transparent. An image
format is not Transparent if used for any substantial amount of text. A copy that is
not “Transparent” is called “Opaque”.
Examples of suitable formats for Transparent copies include plain ASCII without
markup, Texinfo input format, LaT\TeX{} input format, SGML or XML using a publicly
available DTD, and standard-conforming simple HTML, PostScript or PDF designed
for human modification. Examples of transparent image formats include PNG, XCF
and JPG. Opaque formats include proprietary formats that can be read and edited only
by proprietary word processors, SGML or XML for which the DTD and/or processing
tools are not generally available, and the machine-generated HTML, PostScript or PDF
produced by some word processors for output purposes only.
The “Title Page” means, for a printed book, the title page itself, plus such following
pages as are needed to hold, legibly, the material this License requires to appear in the
title page. For works in formats which do not have any title page as such, “Title Page”
means the text near the most prominent appearance of the work’s title, preceding the
beginning of the body of the text.
The “publisher” means any person or entity that distributes copies of the Document to
the public.
A section “Entitled XYZ” means a named subunit of the Document whose title either
is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in
another language. (Here XYZ stands for a specific section name mentioned below, such
as “Acknowledgements”, “Dedications”, “Endorsements”, or “History”.) To “Preserve
the Title” of such a section when you modify the Document means that it remains a
section “Entitled XYZ” according to this definition.
The Document may include Warranty Disclaimers next to the notice which states that
this License applies to the Document. These Warranty Disclaimers are considered to be
included by reference in this License, but only as regards disclaiming warranties: any
other implication that these Warranty Disclaimers may have is void and has no effect
on the meaning of this License.

2. VERBATIM COPYING
You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document’s license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any,
be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.

B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.

C. State on the Title page the name of the publisher of the Modified Version, as the publisher.

D. Preserve all the copyright notices of the Document.

E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.

F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.

G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document’s license notice.

H. Include an unaltered copy of this License.

I. Preserve the section Entitled “History”, Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled “History” in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the “History” section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.

K. For any section Entitled “Acknowledgements” or “Dedications”, Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.

L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

M. Delete any section Entitled “Endorsements”. Such a section may not be included in the Modified Version.

N. Do not retitle any existing section to be Entitled “Endorsements” or to conflict in title with any Invariant Section.

O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their
titles to the list of Invariant Sections in the Modified Version’s license notice. These titles must be distinct from any other section titles.

You may add a section Entitled “Endorsements”, provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled “History” in the various original documents, forming one section Entitled “History”; likewise combine any sections Entitled “Acknowledgements”, and any sections Entitled “Dedications”. You must delete all sections Entitled “Endorsements.”

6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.
7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an “aggregate” if the copyright resulting from the compilation is not used to limit the legal rights of the compilation’s users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document’s Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled “Acknowledgements”, “Dedications”, or “History”, the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License. However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.
10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See https://www.gnu.org/licenses/.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License “or any later version” applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

11. RELICENSING

“Massive Multiauthor Collaboration Site” (or “MMC Site”) means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A “Massive Multiauthor Collaboration” (or “MMC”) contained in the site means any set of copyrightable works thus published on the MMC site.

“CC-BY-SA” means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

“Incorporate” means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is “eligible for relicensing” if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.
ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

Copyright (C) year your name.
Permission is granted to copy, distribute and/or modify this document under the terms of the GNU Free Documentation License, Version 1.3 or any later version published by the Free Software Foundation; with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts. A copy of the license is included in the section entitled ``GNU Free Documentation License''.

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the "with...Texts." line with this:

with the Invariant Sections being list their titles, with the Front-Cover Texts being list, and with the Back-Cover Texts being list.

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.
--exact ................................. 126  --ignore-nonprinting ...................... 51
--exclude-from=file .................. 152  --ignore=pattern ....................... 90
--exclude-type ....................... 148  --indent ................................. 26
--exclude=pattern .................... 152  --indicator-style ..................... 97, 98
--expand-tabs ....................... 24  --initial ................................ 87
--exponents ......................... 225  --inode .................................. 93
--field .................................. 226  --inodes .................................. 146, 150
--field-separator .................... 54  --input .................................. 219
--fields ............................... 72  --input-range ......................... 58
--file .................................. 181, 197  --interactive ......................... 106, 121, 123, 130
--file-system ....................... 153, 157  --invalid ............................ 227
--file-type ............................ 97  --io-blocks .............................. 158
--files0-from=file .................. 42, 52, 150  --iso-8601[=timespec] ................ 197
--filter ............................. 34  --iterations=number ................ 126
--first-line-number ................. 26  --join-blank-lines ................... 15
--flag-truncation .................... 67  --join-lines ............................ 25
--follow ............................. 31  --keep-files ............................ 38
--footer-numbering .................. 14  --kernel-name .......................... 202
--force .............................. 105, 121, 123, 126, 130  --kernel-release .................... 202
--foreground ......................... 220  --kernel-version ...................... 202
--form-feed .......................... 24  --key .................................. 53
--format .............................. 17, 93, 96, 98, 226, 231  --kibibytes ........................... 98
--format=format ...................... 154  --kill-after .......................... 220
--format=off .......................... 67  --length ................................ 25, 44, 47
--format=unix ......................... 68  --line-bytes ........................... 34
--format=system ...................... 138, 226  --line-increment ..................... 14
--from .................................. 134, 226  --lines ................................. 29, 32, 34, 41
--full-time .......................... 92  --link .................................. 106
--gap-size ............................ 66  --literal ............................... 101
--goal .................................. 23  --local .................................. 146
--group .................................. 61, 118, 188  --login .................................. 190
--group-directories-first .......... 90  --lookup .................................. 190
--grouping ............................ 226  --machine ............................... 201
--groups .................................. 188, 207  --macro-name ............................ 67
--hardware-platform .................. 201  --max-depth=depth ..................... 150
--head-count .......................... 58  --max-line-length ..................... 41
--header ................................ 25, 76, 227  --max-unchanged-stats ............... 32
--header-numbering .................. 14  --merge .................................. 25, 49
--header=N ........................... 227  --message ............................... 191
--heading ............................. 190  --mode .................................. 119, 132, 133, 134
--help .................................. 2  --month-sort ............................ 51
--hex-suffixes ....................... 36  --multiple .............................. 173
--hide-control-chars ................. 101  --name .................................. 188
--hide=pattern ....................... 90  --no-clobber ............................ 106, 121
--human-numeric-sort .................. 51  --no-copy ............................... 121
--human-readable ..................... 5, 93, 145, 150  --no-create ............................ 143, 158
--hyperlink ........................... 97  --no-dereference ...................... 106, 130, 138, 140, 143, 150, 204
--ignore .............................. 201  --no-file-warnings ................... 26
--ignore-backups ..................... 90  --no-group .............................. 92
--ignore-case ........................ 50, 60, 64, 76  --no-newline ........................... 135
--ignore-environment .................. 210  --no-preserve-root .................. 123, 139, 140, 142, 204
--ignore-fail-on-non-empty .......... 136  --no-rename ............................ 15
--ignore-file ......................... 64  --no-symlink ................................ 178
--ignore-garbage ..................... 19  --no-sync .............................. 146
--ignore-interrupts .................. 170  --no-target-directory ................ 8, 110, 119, 122, 131
--ignore-leading-blanks ............. 50  --no-target-directory ................ 8, 110, 119, 122, 131
--ignore-missing ..................... 45

Index 279
<table>
<thead>
<tr>
<th>Argument</th>
<th>Page Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>--nodename</td>
<td>201</td>
</tr>
<tr>
<td>--null</td>
<td>149, 187, 210</td>
</tr>
<tr>
<td>--number</td>
<td>12, 35</td>
</tr>
<tr>
<td>--number-format</td>
<td>15</td>
</tr>
<tr>
<td>--number-lines</td>
<td>25</td>
</tr>
<tr>
<td>--number-nonblank</td>
<td>12</td>
</tr>
<tr>
<td>--number-separator</td>
<td>15</td>
</tr>
<tr>
<td>--number-width</td>
<td>15</td>
</tr>
<tr>
<td>--numeric-sort</td>
<td>51</td>
</tr>
<tr>
<td>--numeric-suffixes</td>
<td>35</td>
</tr>
<tr>
<td>--numeric-uid-gid</td>
<td>94</td>
</tr>
<tr>
<td>--omit-header</td>
<td>26</td>
</tr>
<tr>
<td>--omit-pagination</td>
<td>26</td>
</tr>
<tr>
<td>--one-file-system</td>
<td>110, 123, 152</td>
</tr>
<tr>
<td>--only-delimited</td>
<td>73</td>
</tr>
<tr>
<td>--only-file</td>
<td>65</td>
</tr>
<tr>
<td>--operating-system</td>
<td>202</td>
</tr>
<tr>
<td>--output</td>
<td>53, 58, 146, 210</td>
</tr>
<tr>
<td>--output-delimiter</td>
<td>73</td>
</tr>
<tr>
<td>--output-duplicates</td>
<td>17</td>
</tr>
<tr>
<td>--output-error</td>
<td>170</td>
</tr>
<tr>
<td>--output-tabs</td>
<td>25</td>
</tr>
<tr>
<td>--owner</td>
<td>119</td>
</tr>
<tr>
<td>--padding</td>
<td>227</td>
</tr>
<tr>
<td>--page-width</td>
<td>27</td>
</tr>
<tr>
<td>--pages=page_range</td>
<td>23</td>
</tr>
<tr>
<td>--parallel</td>
<td>55</td>
</tr>
<tr>
<td>--parents</td>
<td>108, 132, 136</td>
</tr>
<tr>
<td>--physical</td>
<td>130, 178, 180</td>
</tr>
<tr>
<td>--pid</td>
<td>32</td>
</tr>
<tr>
<td>--portability</td>
<td>147, 175</td>
</tr>
<tr>
<td>--prefix</td>
<td>38</td>
</tr>
<tr>
<td>--preserve</td>
<td>106</td>
</tr>
<tr>
<td>--preserve-context</td>
<td>119</td>
</tr>
<tr>
<td>--preserve-root</td>
<td>123, 138, 140, 142, 204</td>
</tr>
<tr>
<td>--preserve-status</td>
<td>220</td>
</tr>
<tr>
<td>--preserve-timestamps</td>
<td>119</td>
</tr>
<tr>
<td>--print-database</td>
<td>103</td>
</tr>
<tr>
<td>--print-1s-colors</td>
<td>103</td>
</tr>
<tr>
<td>--print-type</td>
<td>148</td>
</tr>
<tr>
<td>--printf=colors</td>
<td>154</td>
</tr>
<tr>
<td>--process</td>
<td>191</td>
</tr>
<tr>
<td>--processor</td>
<td>201</td>
</tr>
<tr>
<td>--quiet</td>
<td>29, 32, 39, 45, 135, 138, 140, 142, 176, 178, 187</td>
</tr>
<tr>
<td>--quote-name</td>
<td>101</td>
</tr>
<tr>
<td>--quoting-style</td>
<td>101</td>
</tr>
<tr>
<td>--random-sort</td>
<td>52</td>
</tr>
<tr>
<td>--random-source</td>
<td>54, 58, 126</td>
</tr>
<tr>
<td>--range</td>
<td>205</td>
</tr>
<tr>
<td>--raw</td>
<td>44</td>
</tr>
<tr>
<td>--read-bytes</td>
<td>16</td>
</tr>
<tr>
<td>--real</td>
<td>188</td>
</tr>
<tr>
<td>--recursive</td>
<td>91, 108, 123, 139, 141, 142, 204</td>
</tr>
<tr>
<td>--reference</td>
<td>139, 140, 142, 144, 158, 197, 204</td>
</tr>
<tr>
<td>--references</td>
<td>65</td>
</tr>
<tr>
<td>--reflink=[when]</td>
<td>108</td>
</tr>
<tr>
<td>--regex [when]</td>
<td>13</td>
</tr>
<tr>
<td>--relative</td>
<td>130</td>
</tr>
<tr>
<td>--relative-base</td>
<td>178</td>
</tr>
<tr>
<td>--relative-to</td>
<td>178</td>
</tr>
<tr>
<td>--remove</td>
<td>126</td>
</tr>
<tr>
<td>--remove-destination</td>
<td>108</td>
</tr>
<tr>
<td>--remove=unlink</td>
<td>126</td>
</tr>
<tr>
<td>--remove=wipe</td>
<td>126</td>
</tr>
<tr>
<td>--remove=wipesync</td>
<td>126</td>
</tr>
<tr>
<td>--repeat</td>
<td>58</td>
</tr>
<tr>
<td>--repeated</td>
<td>60</td>
</tr>
<tr>
<td>--rfc-822</td>
<td>197</td>
</tr>
<tr>
<td>--rfc-3339=timespec</td>
<td>198</td>
</tr>
<tr>
<td>--rfc-822</td>
<td>197</td>
</tr>
<tr>
<td>--reverse</td>
<td>52, 95</td>
</tr>
<tr>
<td>--right-side-refs</td>
<td>67</td>
</tr>
<tr>
<td>--role</td>
<td>205</td>
</tr>
<tr>
<td>--round</td>
<td>227</td>
</tr>
<tr>
<td>--round=down</td>
<td>227</td>
</tr>
<tr>
<td>--round=from-zero</td>
<td>227</td>
</tr>
<tr>
<td>--round=nearest</td>
<td>227</td>
</tr>
<tr>
<td>--round=towards-zero</td>
<td>227</td>
</tr>
<tr>
<td>--runlevel</td>
<td>191</td>
</tr>
<tr>
<td>--save</td>
<td>181</td>
</tr>
<tr>
<td>--section-delimiter</td>
<td>14</td>
</tr>
<tr>
<td>--sentence-regexp</td>
<td>65</td>
</tr>
<tr>
<td>--sep-string</td>
<td>26</td>
</tr>
<tr>
<td>--set</td>
<td>198</td>
</tr>
<tr>
<td>--sh</td>
<td>103</td>
</tr>
<tr>
<td>--show-all</td>
<td>12</td>
</tr>
<tr>
<td>--show-control-chars</td>
<td>24, 102</td>
</tr>
<tr>
<td>--show-ends</td>
<td>12</td>
</tr>
<tr>
<td>--show-nonprinting</td>
<td>12, 27</td>
</tr>
<tr>
<td>--show-tabs</td>
<td>12</td>
</tr>
<tr>
<td>--si</td>
<td>5, 95, 147, 151</td>
</tr>
<tr>
<td>--signal</td>
<td>221</td>
</tr>
<tr>
<td>--silent</td>
<td>29, 32, 39, 135, 138, 140, 142, 187</td>
</tr>
<tr>
<td>--size</td>
<td>94, 158</td>
</tr>
<tr>
<td>--size=bytes</td>
<td>126</td>
</tr>
<tr>
<td>--skip-bytes</td>
<td>16</td>
</tr>
<tr>
<td>--skip-chars</td>
<td>60</td>
</tr>
<tr>
<td>--skip-chdir</td>
<td>207</td>
</tr>
<tr>
<td>--skip-fields</td>
<td>59</td>
</tr>
<tr>
<td>--sleep-interval</td>
<td>33</td>
</tr>
<tr>
<td>--sort</td>
<td>50, 51, 52, 95, 96</td>
</tr>
<tr>
<td>--spaces</td>
<td>27</td>
</tr>
<tr>
<td>--sparse=when</td>
<td>109</td>
</tr>
<tr>
<td>--split-only</td>
<td>22</td>
</tr>
<tr>
<td>--split-string</td>
<td>211</td>
</tr>
<tr>
<td>--squeeze-blank</td>
<td>12</td>
</tr>
<tr>
<td>--squeeze-repeats</td>
<td>82</td>
</tr>
<tr>
<td>--stable</td>
<td>54</td>
</tr>
<tr>
<td>Option</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------</td>
<td>------</td>
</tr>
<tr>
<td>--starting-line-number</td>
<td>15</td>
</tr>
<tr>
<td>--status</td>
<td>46</td>
</tr>
<tr>
<td>--strict</td>
<td>46</td>
</tr>
<tr>
<td>--strings</td>
<td>16</td>
</tr>
<tr>
<td>--strip</td>
<td>119, 178</td>
</tr>
<tr>
<td>--strip-program</td>
<td>119</td>
</tr>
<tr>
<td>--strip-trailing-slashes</td>
<td>109, 122</td>
</tr>
<tr>
<td>--suffix</td>
<td>3, 109, 119, 122, 131, 173, 177, 227</td>
</tr>
<tr>
<td>--suffix-format</td>
<td>38</td>
</tr>
<tr>
<td>--suffix-length</td>
<td>35</td>
</tr>
<tr>
<td>--summarize</td>
<td>151</td>
</tr>
<tr>
<td>--suppress-matched</td>
<td>38</td>
</tr>
<tr>
<td>--symbolic</td>
<td>131</td>
</tr>
<tr>
<td>--symbolic-link</td>
<td>109</td>
</tr>
<tr>
<td>--sync</td>
<td>147</td>
</tr>
<tr>
<td>--sysv</td>
<td>42</td>
</tr>
<tr>
<td>--tabs</td>
<td>87</td>
</tr>
<tr>
<td>--tagsize</td>
<td>98</td>
</tr>
<tr>
<td>--tag</td>
<td>46</td>
</tr>
<tr>
<td>--tagged-paragraph</td>
<td>22</td>
</tr>
<tr>
<td>--target-directory</td>
<td>5, 95, 96, 143, 144, 151, 152, 191</td>
</tr>
<tr>
<td>--temporary-directory</td>
<td>99, 152</td>
</tr>
<tr>
<td>--terse</td>
<td>154</td>
</tr>
<tr>
<td>--text</td>
<td>46</td>
</tr>
<tr>
<td>--threshold</td>
<td>151</td>
</tr>
<tr>
<td>--time</td>
<td>95, 103, 118, 138, 140, 142, 143, 149, 154, 158, 164, 205</td>
</tr>
<tr>
<td>--time-style</td>
<td>118, 122, 130, 143, 164, 176, 190, 196, 226</td>
</tr>
<tr>
<td>--time</td>
<td>95, 105, 121, 123, 126, 130, 135, 138, 140, 142, 143, 153, 164, 197, 231</td>
</tr>
<tr>
<td>--time</td>
<td>24, 31, 67, 97, 130, 181</td>
</tr>
<tr>
<td>--time</td>
<td>23, 50, 66, 92, 118, 165, 181, 193</td>
</tr>
<tr>
<td>--time</td>
<td>118, 122, 130, 143, 164, 176, 190, 196, 226</td>
</tr>
<tr>
<td>--to-unit</td>
<td>227</td>
</tr>
<tr>
<td>--total</td>
<td>147, 149</td>
</tr>
<tr>
<td>--total=when</td>
<td>42</td>
</tr>
<tr>
<td>--traditional</td>
<td>18</td>
</tr>
<tr>
<td>--truncate-set1</td>
<td>82</td>
</tr>
<tr>
<td>--type</td>
<td>148, 205</td>
</tr>
<tr>
<td>--unbuffered</td>
<td>36</td>
</tr>
<tr>
<td>--uniform-spacing</td>
<td>22</td>
</tr>
<tr>
<td>--unique</td>
<td>55, 61</td>
</tr>
<tr>
<td>--universal</td>
<td>198</td>
</tr>
<tr>
<td>--unset</td>
<td>210</td>
</tr>
<tr>
<td>--untagged</td>
<td>44</td>
</tr>
<tr>
<td>--update</td>
<td>121</td>
</tr>
<tr>
<td>--update[=which]</td>
<td>110</td>
</tr>
<tr>
<td>--user</td>
<td>188, 204, 205</td>
</tr>
<tr>
<td>--userspec</td>
<td>207</td>
</tr>
<tr>
<td>--utc</td>
<td>195</td>
</tr>
<tr>
<td>--verbose</td>
<td>29, 33, 36, 110, 120, 122, 124, 126, 131, 133, 135, 136, 139, 140, 142, 204, 221</td>
</tr>
<tr>
<td>--version</td>
<td>2</td>
</tr>
<tr>
<td>--version-sort</td>
<td>52</td>
</tr>
<tr>
<td>--warn</td>
<td>46</td>
</tr>
<tr>
<td>--width</td>
<td>18, 22, 27, 28, 66, 99</td>
</tr>
<tr>
<td>--word-regexp</td>
<td>66</td>
</tr>
<tr>
<td>--words</td>
<td>41</td>
</tr>
<tr>
<td>--wrap</td>
<td>19</td>
</tr>
<tr>
<td>--writable</td>
<td>191</td>
</tr>
<tr>
<td>--z85</td>
<td>20</td>
</tr>
<tr>
<td>--zero</td>
<td>46, 99, 126, 135, 173, 174, 178, 188</td>
</tr>
<tr>
<td>--zero-terminated</td>
<td>29, 33, 55, 58, 61, 63, 73, 74, 77, 227</td>
</tr>
<tr>
<td>-0</td>
<td>149, 187, 210</td>
</tr>
<tr>
<td>-1</td>
<td>62, 76, 96</td>
</tr>
<tr>
<td>-2</td>
<td>62, 76</td>
</tr>
<tr>
<td>-3</td>
<td>62</td>
</tr>
<tr>
<td>-a</td>
<td>18, 24, 35, 43, 75, 88, 89, 104, 143, 145, 149, 166, 170, 173, 180, 190, 201</td>
</tr>
<tr>
<td>-b</td>
<td>2, 12, 13, 14, 18, 27, 34, 38, 45, 50, 64, 72, 101, 103, 105, 118, 121, 129, 149, 164, 190, 191</td>
</tr>
<tr>
<td>-c</td>
<td>18, 22, 29, 30, 49, 58, 60, 72, 82, 95, 103, 118, 138, 140, 142, 143, 149, 154, 158, 164, 205</td>
</tr>
<tr>
<td>-d</td>
<td>14, 18, 19, 24, 35, 50, 60, 73, 74, 82, 90, 105, 118, 122, 130, 143, 164, 176, 190, 196, 226</td>
</tr>
<tr>
<td>-e</td>
<td>12, 24, 36, 75, 135, 159, 165, 177, 219</td>
</tr>
<tr>
<td>-ef</td>
<td>165</td>
</tr>
<tr>
<td>-eq</td>
<td>166</td>
</tr>
<tr>
<td>-ef</td>
<td>165</td>
</tr>
<tr>
<td>-f</td>
<td>14, 18, 24, 31, 38, 50, 59, 64, 72, 95, 105, 121, 123, 126, 130, 135, 138, 140, 142, 143, 153, 164, 197, 231</td>
</tr>
<tr>
<td>-h</td>
<td>5, 14, 25, 51, 93, 138, 140, 143, 145, 150, 164, 204, 225</td>
</tr>
<tr>
<td>-i</td>
<td>14, 18, 19, 25, 51, 58, 60, 64, 74, 87, 93, 106, 121, 123, 130, 146, 170, 201, 210, 219</td>
</tr>
<tr>
<td>-k</td>
<td>5, 38, 53, 98, 146, 150, 165, 220</td>
</tr>
<tr>
<td>-l</td>
<td>15, 18, 25, 34, 41, 44, 47, 93, 106, 146, 150, 190, 205</td>
</tr>
<tr>
<td>-m</td>
<td>25, 41, 49, 98, 119, 132, 133, 134, 135, 144, 150, 177, 180, 204</td>
</tr>
<tr>
<td>-n</td>
<td>9, 41, 91, 106, 130, 139, 141, 150, 153, 164, 177, 190, 201</td>
</tr>
<tr>
<td>-o</td>
<td>12, 15, 25, 29, 32, 35, 38, 51, 58, 73, 94, 106, 121, 130, 135, 159, 165, 188, 201, 217</td>
</tr>
<tr>
<td>-p</td>
<td>126</td>
</tr>
<tr>
<td>-q</td>
<td>166</td>
</tr>
<tr>
<td>-r</td>
<td>166</td>
</tr>
<tr>
<td>-t</td>
<td>166</td>
</tr>
<tr>
<td>-u</td>
<td>166</td>
</tr>
<tr>
<td>-v</td>
<td>165</td>
</tr>
<tr>
<td>-w</td>
<td>165</td>
</tr>
<tr>
<td>-x</td>
<td>16, 26, 101, 165</td>
</tr>
<tr>
<td>-y</td>
<td>18, 26, 53, 58, 65, 94, 119, 158, 167, 202, 219</td>
</tr>
</tbody>
</table>
Index

-ct ................................. 165
-o .................................. 67, 165
-F .................................. 9, 106, 130, 139, 141, 147, 150, 175, 178, 180, 204
-q .................................. 29, 32, 39, 101, 135, 176, 178, 191
-Q .................................. 101
-R .................................. 13, 26, 42, 52, 58, 65, 95, 108, 123, 130, 144, 158, 165, 188, 191, 197, 202, 205
-R .................................. 52, 67, 91, 108, 123, 139, 141, 142, 197, 204
-s ....... 12, 13, 15, 18, 22, 26, 27, 33, 39, 42, 54, 60, 73, 74, 82, 94, 109, 119, 131, 135, 151, 158, 165, 173, 178, 187, 191, 198, 202, 221, 231
-s bytes .......................... 126
-S .... 3, 16, 26, 54, 65, 95, 109, 122, 131, 151, 164, 211
-S .... 3, 16, 26, 54, 65, 95, 109, 122, 131, 151, 164, 211
-t .. 12, 17, 22, 26, 36, 46, 54, 82, 87, 95, 109, 119, 122, 131, 148, 151, 154, 164, 177, 191, 205
-T .. 12, 26, 55, 68, 98, 110, 119, 122, 131, 148, 191
-u .... 12, 22, 36, 55, 61, 95, 110, 121, 126, 165, 176, 188, 191, 198, 204, 205, 210
-U .................................. 96
-V .................................. 12, 15, 17, 27, 29, 33, 96, 110, 120, 122, 124, 126, 131, 133, 135, 136, 139, 140, 142, 202, 204, 211, 221
-V .................................. 52
-v ... 15, 18, 19, 22, 27, 28, 41, 46, 61, 66, 99, 165, 191, 232
-width ................................ 22
-W .................................. 27, 66
-x ................................. 18, 36, 98, 110, 126, 148, 152, 165
-X .................................. 96
-X file ............................. 152
-z ... 29, 33, 39, 46, 55, 58, 61, 63, 73, 74, 77, 126, 135, 165, 173, 174, 178, 188, 227
-Z .................................. 95, 110, 120, 122, 133, 134, 188

/ .................................. 168

< .................................. 169
<= .................................. 169
=
= .................................. 165, 169
== .................................. 166, 169
>
> .................................. 169
>= .................................. 169

-POSIX2_VERSION .................... 11, 33, 56, 60, 144

\
\ regexp operator .................. 168
\ regexp operator .................. 168
\ regexp operator .................. 168
\ regexp operator .................. 168
\c .................................. 160
\oo .................................. 161
\uhhh ................................ 161
\Uhhhhhhhh .......................... 161
\xhh ................................ 161

1
128-bit checksum .................... 46
16-bit checksum ..................... 42
160-bit checksum .................... 47
2
224-bit checksum .................... 48
256-bit checksum .................... 48
3
32-bit checksum ..................... 43
384-bit checksum .................... 48
5
512-bit checksum .................... 47, 48
### Index

| btrfs file system type | 148 |
| bugs, reporting | 1 |
| built-in shell commands, conflicts with | 134, 153, 159, 160, 164, 180, 216, 223, 224 |
| byte count | 41 |
| byte-swapping | 16, 113 |

### C

| c for character special file | 134 |
| C shell syntax for color setup | 103 |
| C-s/C-q flow control | 182 |
| calendar date item | 243 |
| calling combined multi-call program | 11 |
| canonical file name | 134, 177 |
| canonicalize a file name | 134, 177 |
| case folding | 50 |
| case translation | 183 |
| case, ignored in dates | 243 |
| cat | 12 |
| cbreak | 184 |
| cbs | 111 |
| CD-ROM file system type | 148 |
| cdfs file system type | 148 |
| cdtrdsr | 181 |
| change or print terminal settings | 180 |
| change SELinux context | 204 |
| changed files, vaguely describing | 140 |
| changed owners, vaguely describing | 138 |
| changing access permissions | 141 |
| changing file attributes | 137 |
| changing file ownership | 137 |
| changing file timestamps | 142 |
| changing group ownership | 137, 139 |
| changing security context | 204 |
| changing special mode bits | 236 |
| character classes | 84 |
| character count | 41 |
| character size | 181 |
| character special check | 164 |
| character special files | 134 |
| character special files, creating | 134 |
| characters, special | 185 |
| chcon | 204 |
| check file types | 163 |
| checking whether a file is sorted | 49 |
| checksum, 128-bit | 46 |
| checksum, 16-bit | 42 |
| checksum, 160-bit | 47 |
| checksum, 224-bit | 48 |
| checksum, 256-bit | 48 |
| checksum, 32-bit | 43 |
| checksum, 384-bit | 48 |
| checksum, 512-bit | 47, 48 |
| chgrp | 139 |
| chmod | 141 |
| chown | 137 |
| chroot | 207 |

| cio | 114 |
| cksum | 43 |
| local | 181 |
| clock skew | 99, 241 |
| clone | 108 |
| cmpar | 181 |
| cntrl | 84 |
| color database, printing | 103 |
| color setup | 103 |
| color, distinguishing file types with | 97 |
| cols | 186 |
| column to wrap data after | 19 |
| columns | 186 |
| COLUMNS | 99, 186 |
| combination settings | 184 |
| combined | 11 |
| combined date and time of day item | 245 |
| comm | 61 |
| command-line operands to shuffle | 58 |
| commands for controlling processes | 223 |
| commands for delaying | 224 |
| commands for exit status | 163 |
| commands for file name manipulation | 173 |
| commands for invoking other commands | 207 |
| commands for printing text | 159 |
| commands for printing the working context | 180 |
| commands for printing user information | 188 |
| commands for redirection | 170 |
| commands for SELinux context | 204 |
| commands for system context | 192 |
| commas, outputting between files | 98 |
| comments, in dates | 243 |
| common field, joining on | 75 |
| common lines | 62 |
| common options | 2 |
| compare values | 163 |
| comparing sorted files | 61 |
| comparison operators | 169 |
| compression and du | 153 |
| concatenate and write files | 12 |
| concurrent I/O | 114 |
| conditional executability | 236 |
| conditions | 163 |
| conflicts with shell built-ins | 134, 153, 159, 160, 164, 180, 216, 223, 224 |
| connectives, logical | 166, 168 |
| constant parity | 181 |
| context splitting | 37 |
| context, system | 192 |
| control characters, using "c" | 183 |
| control settings | 181 |
| controlling terminal | 115 |
| conv | 112 |
| conversion block size | 111 |
| conversion specifiers, date | 193 |
| conversion specifiers, literal | 194 |
| conversion specifiers, time | 192 |
| converting tabs to spaces | 86 |
converting while copying a file .......................... 111
crcoke .............................. 184
Coordinated Universal Time ..................... 198
copy on write .................................. 108
copy-on-write and du ......................... 153
copying directories recursively 105, 108
copying existing permissions .............. 235
copying files ................................ 12
copying files and directories ............. 104
copying files and setting attributes .... 117
core utilities ................................ 1
count ...................................... 112
COW ...................................... 108
cp .......................................... 104
 crashes and corruption ................. 157
 CRC checksum .......................... 43
cread ...................................... 181
creating directories ......................... 132
creating FIFOs (named pipes) .......... 133
creating links (hard only) ............... 128
creating links (hard or soft) .......... 128
creating output file, avoiding ......... 114
creating output file, requiring ......... 113
creation timestamp, printing or
 sorting files by .......................... 96
crn .......................................... 183
crown margin .............................. 22
crt .......................................... 185
crterase .................................. 183
crtkill ...................................... 184
 crtscts .................................. 181
csh syntax for color setup ............... 103
csn .......................................... 181
csplit ...................................... 37
cstop ......................................... 37
ctime ...................................... 241
ctime, printing or sorting by .......... 95
ctime, show the most recent ....... 151
ctlecho ...................................... 183
current working directory, printing .. 180
cut .......................................... 72
cyclic redundancy check .................. 43
data modification time, printing
 or sorting files by ......................... 96
data, erasing .................................. 124
database for color setup, printing .... 103
date ........................................ 192
date and time of day format, ISO 8601 245
date conversion specifiers .............. 193
date format, ISO 8601 ......................... 244
date input formats ......................... 242
date options ................................ 196
date strings, debugging .................... 196
date strings, parsing ....................... 196
day in date strings ......................... 246
day of week item ........................... 245
dd ........................................... 111
ddrescue ..................................... 116
debugging date strings ................... 196
debugging, copying 105, 118, 121
debugging, env -S ......................... 212
dec ........................................ 185
dectlq .................................... 185
 Decode base64 data ......................... 19
delay for a specified time ............... 224
delaying commands ......................... 224
deleting characters ......................... 85
dereferencing symbolic links .......... 129
descriptor follow option ................... 31
destination directory 8, 109, 110, 119, 122, 131
destinations, multiple output ........... 170
device file .................................. 145
df ........................................... 145
DF_BLOCK_SIZE .............................. 3
diagnostic ................................. 204
dictionary order ............................. 50
differing lines .............................. 62
digest ........................................ 43
digest algorithm ............................. 43
dir .......................................... 102
dir .......................................... 102
dircolors .................................... 103
direct ........................................ 114
direct I/O .................................. 114
directories, copying ......................... 104
directories, copying recursively .... 105, 108
directories, creating ....................... 132
directories, creating with given attributes .... 118
directories, removing ..................... 122
directories, removing (recursively) ... 123
directories, removing empty ........... 136
directory .................................. 115
directory check .............................. 164
directory components, printing .......... 174
directory deletion, ignoring failures ... 136
directory deletion, reporting .......... 136
directory I/O .................................. 115
directory listing ........................... 89
directory listing, brief ...................... 102
directory listing, recursive .......... 91
directory listing, verbose ............... 102
directory order, listing by .......... 95
directory, creating temporary .......... 175
directory, stripping from file names .. 173
dired Emacs mode support ............... 91
dirname ...................................... 174
 disabling special characters .......... 185
disambiguating group names and IDs ... 6
discard ..................................... 185
discardung file cache ...................... 115
disk device file ............................ 145
disk usage ................................ 145
disk usage by file system .................. 145
Index

...items in date strings ........................................ 242
...hour in date strings .......................................... 246
...human numeric sort ............................................ 51
...human-readable output ...................................... 4, 93, 145, 150
...hup[cl] .......................................................... 181
...hurd, author, printing ......................................... 91
...hyperlink, linking to files .................................... 97

I

...ibs ................................................................. 111
...icanon .............................................................. 183
...icnrl ............................................................... 182
...id ................................................................. 188
...idle time ........................................................ 191
...IEEE floating point ........................................... 10
...iexten ............................................................ 183
...if ................................................................. 111
...iflag .............................................................. 114
...ignbrk ........................................................... 182
...igncr ............................................................. 182
...ignore file systems ............................................ 145
...Ignore garbage in base64 stream .............................. 19
...ignoring case ................................................... 50
...ignpar ............................................................. 182
...imaxbel .......................................................... 182
...immunity to hangups .......................................... 218
...implementation, hardware ...................................... 201
...indenting lines .................................................. 26
...index ............................................................. 168
...information, about current users .............................. 190
...initial part of files, outputting ................................ 29
...initial tabs, converting ........................................ 87
...inclcr ............................................................. 182
...inode number, printing ........................................ 93
...inode usage ...................................................... 146
...inode usage, dereferencing in du .............................. 150
...inode, and hard links .......................................... 129
...inodes, written buffered ..................................... 157
...inpcck ............................................................. 182
...input block size ................................................ 111
...input encoding, UTF-8 ........................................ 182
...input range to shuffle ........................................ 58
...input settings .................................................... 182
...input tabs ........................................................ 24
...install ............................................................ 117
...intr ............................................................... 185
...invocation of commands, modified ............................ 207
...iseek .............................................................. 112
...isig ............................................................... 183
...iso9660 file system type ..................................... 148
...ISO 8601 date and time of day format ......................... 245
...ISO 8601 date format .......................................... 244
...ISO/IEC 10646 ................................................... 161
...ISO9660 file system type ..................................... 148
...ispeed ............................................................. 186
...istrip ............................................................. 182
...iterations, selecting the number of ......................... 126
...iucr ............................................................... 182
...iutf8 ............................................................. 182
...ixany ............................................................. 182
...ixoff .............................................................. 182
...ixon ............................................................... 182

J

...join ............................................................... 75

K

...kernel name ..................................................... 202
...kernel release .................................................. 202
...kernel version .................................................. 202
...kibibyte, definition of ........................................ 4
...kibibytes for file sizes ....................................... 150
...kibibytes for file system sizes ............................... 146
...kill ............................................................... 185, 223
...kilobyte, definition of ......................................... 4
...Knuth, Donald E ............................................... 22

L

...language, in dates ............................................. 243
...last day ......................................................... 196, 245
...last in date strings ............................................ 242
...last modified dates, displaying in du ......................... 151
...last part of files, outputting ................................ 30
...LC_ALL ......................................................... 49, 89
...LC_COLLATE ................................................... 49, 59, 61, 77, 169
...LCCTYPE ......................................................... 50, 51, 161
...LC_MESSAGES .................................................. 23
...LC_NUMERIC .................................................. 4, 11, 50, 51, 161
...LC_TIME ......................................................... 24, 51, 99, 100, 101, 152, 192
...lcas ............................................................... 185
...lcas, converting to ........................................... 113
...LCASE ............................................................ 185
...lchown ............................................................ 138, 140
...leading directories, creating missing ....................... 118
...leading directory components, stripping ................... 173
...leap seconds .................................................... 144, 192, 193, 198, 200, 243, 244, 247
...left margin ...................................................... 26
...length ............................................................ 168
...limiting output of du .......................................... 150
...line ............................................................... 186
...line buffered ................................................... 218
...line count ....................................................... 41
...line numbering ................................................ 13
...line separator character ...................................... 36
...line settings of terminal ..................................... 180
...line-breaking ................................................... 22
...line-by-line comparison ...................................... 61
...LINES ............................................................. 186
...link .............................................................. 128
...links, creating ................................................. 128
...Linux file system types ...................................... 148
literal conversion specifiers.......................... 194
\texttt{litout}........................................... 184
\texttt{ln}............................................... 128
\texttt{ln} format for \texttt{nl}............................ 15
\texttt{ln}............................................... 185
local file system types................................ 148
local settings........................................... 183
logging out and continuing to run.................... 218
logical and operator.................................... 166, 169
logical connectives..................................... 166, 168
logical or operator..................................... 167, 169
logical pages, numbering on................................ 13
login name, printing.................................... 189
login sessions, printing users with.................... 189
login time............................................... 190
\texttt{logname}......................................... 189
\texttt{long} ls format................................... 93
\texttt{lower}........................................... 84
lowercase, translating to output......................... 182
\texttt{ls}............................................... 89
\texttt{LS\_BLOCK\_SIZE}.................................. 3
\texttt{LS\_COLORS}..................................... 97, 103
\texttt{lutimes}......................................... 143

\textbf{M}

machine type......................................... 201
machine-readable \texttt{stty} output.................... 181
MacKenzie, D............................................ 1
MacKenzie, David...................................... 248
Makefiles, installing programs in..................... 118
manipulating files..................................... 104
manipulation of file names............................. 173
mark parity........................................... 181
\texttt{match}........................................... 168
matching patterns..................................... 167
\texttt{md5sum}........................................ 46
MD5.................................................... 46
mebibyte, definition of................................ 4
mebibytes for file sizes............................... 150
megabyte, definition of................................ 4
merging files.......................................... 73
merging files in parallel.............................. 23
merging sorted files................................... 49
message status........................................ 191
message-digest, 128-bit................................ 46
message-digest, 160-bit................................ 47
message-digest, 224-bit................................ 48
message-digest, 256-bit................................ 48
message-digest, 384-bit................................ 48
message-digest, 512-bit................................ 47, 48
Meyering, J............................................. 1
Meyering, Jim.......................................... 248
\texttt{midnight} in date strings......................... 244
\texttt{min}............................................. 186
minute in date strings................................ 246
minutes, time zone correction by...................... 244
\texttt{mkdir}........................................... 132
\texttt{mkfifo}.......................................... 133
\texttt{mknod}.......................................... 134
\texttt{mktemp}......................................... 175
modern control......................................... 181
modes and umask........................................ 237
modes of created directories, setting.................. 132
modes of created FIFOs, setting......................... 133
\texttt{modification timestamp}, sorting files by...... 95
modified command invocation........................... 207
modified environment, running......................... 208
modify time, changing.................................. 144
\texttt{month} in date strings.......................... 246
month names in date strings............................. 244
months, sorting by..................................... 51
months, written-out.................................... 243
MS-DOS file system..................................... 148
MS-Windows file system................................ 148
mtime.................................................. 241
\texttt{stime}, changing................................ 144
\texttt{stime}, printing or sorting files by............ 96
\texttt{mtime}-greater-atime file check.................. 165
\texttt{multicall}........................................ 11
multicolumn output, generating......................... 23
multiple changes to permissions......................... 236
multiplication......................................... 168
mutlipliers after numbers............................... 116
multi threaded sort.................................... 55
\texttt{mv}............................................. 120

\textbf{N}

name follow option.................................... 31
name of kernel......................................... 202
named pipe check....................................... 164
named pipes, creating.................................. 133
network node name..................................... 201
networked file systems and \texttt{du}.................... 153
\texttt{never} interactive option........................ 123
newer files, copying only............................... 110
newer files, moving only................................ 121
newer-than file check.................................. 165
newline echoing after \texttt{kill}......................... 183
newline, echoing....................................... 183
newline, translating to \texttt{crlf}...................... 182
newline, translating to return......................... 182
\texttt{next day}........................................ 196, 245
\texttt{next} in date strings............................ 242
NFS file system type.................................... 148
NFS mounts from BSD to HP-UX............................ 94
nice................................................... 216
niceness.............................................. 216
\texttt{nl}.............................................. 13, 184
\texttt{nl\_n}............................................ 183
no dereference.......................................... 204
no-op.................................................. 163
NO\_NEW\_PRIVS........................................... 205
\texttt{noatime}......................................... 115
Index

nocache ............................................. 115
nocreat ........................................... 114
noctty ............................................. 115
node name .......................................... 201
noerror ............................................ 114
noflash ............................................. 183
nofollow ........................................... 115
nochup .............................................. 218
nochup.out ......................................... 218
nolinks ............................................. 115
non-directories, copying as special files ....... 105, 108
non-directory suffix, stripping ..................... 174
nonblock ............................................ 115
nonblocking I/O ..................................... 115
nonblocking stty setting ............................. 186
none backup method ................................ 3
none classify option ................................ 97
none color option .................................... 97
none dd status= ..................................... 112
none hyperlink option ................................. 97
total option .......................................... 42
none, sorting option for ls ....................... 96
nonempty file check ................................ 165
nonprinting characters, ignoring .................... 51
nonzero-length string check ......................... 165
noon in date strings .................................. 244
not-equal string check ................................ 166
notrunc ............................................. 114
now in date strings ................................... 246
noxfer dd status= ................................... 112
nproc .................................................. 200
ntfs file system file ................................ 148
NTFS file system ..................................... 148
number of inputs to merge, nmerge ................. 53
numbered backup method ............................. 3
numbering lines ....................................... 13
numbers, written-out ................................ 242
numeric expressions ................................ 168
numeric field padding ................................ 194
numeric modes ....................................... 238
numeric operations ................................... 225
numeric sequences ................................... 231
numeric sort ......................................... 51
numeric tests ........................................ 166
numeric uid and gid ................................ 94
numeric user and group IDs .......................... 94
numfmt .............................................. 225

O

obs ..................................................... 111
ocrl .................................................. 182
octal dump of files .................................. 15
octal numbers for file modes ......................... 238
od ..................................................... 15
odd parity ............................................ 181
oddp .................................................. 184
of ..................................................... 111
ofdel .................................................. 182
ofill .................................................. 182
oflag .................................................. 114
olcuc .................................................. 182
older-than file check ................................ 165
once interactive option ............................... 123
one file system, restricting du to .................... 152
one file system, restricting rm to ................. 123
one-line output format ................................ 147
only total option ..................................... 42
onlcr .................................................. 182
onlret .................................................. 182
online option ......................................... 97
option delimiter ....................................... 2
options for date ....................................... 196
or operator ............................................ 167, 169
ordinal numbers ....................................... 242
oseek .................................................. 112
ospeed ................................................ 186
other permissions ..................................... 234
output block size ..................................... 111
output file name prefix ............................... 34, 38
output file name suffix ................................ 38
output format ......................................... 154
output format, portable ............................... 147
output NUL-byte-terminated lines .................... 46, 99, 135, 149, 173, 174, 178, 187, 210
output of entire files ................................ 12
output of parts of files ................................ 29
output settings ....................................... 182
output tabs ............................................ 25
overwriting of input, allowed ......................... 53, 58
owned by effective group ID check .................. 165
owned by effective user ID check .................... 165
owner of file, permissions for ....................... 234
owner, default ........................................ 233
ownership of installed files, setting ................. 119

P

p for FIFO file ....................................... 134
pad character ........................................ 182
pad instead of timing for delaying ................. 182
padding of numeric fields ............................. 194
paragraphs, reformattting ............................ 22
parenb .............................................. 181
parent directories and cp ............................ 108
parent directories, creating ........................ 132
parent directories, creating missing ............... 118
parent directories, removing ......................... 136
parentheses for grouping ............................. 167
parity .................................................. 184
parity errors, marking ................................ 182
parity, ignoring ...................................... 182
Index

<table>
<thead>
<tr>
<th>Term</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>parmrk</td>
<td>182</td>
</tr>
<tr>
<td>parodd</td>
<td>181</td>
</tr>
<tr>
<td>parse_datetime</td>
<td>242</td>
</tr>
<tr>
<td>parsing date strings</td>
<td>196</td>
</tr>
<tr>
<td>parts of files, output of</td>
<td>29</td>
</tr>
<tr>
<td>pass8</td>
<td>184</td>
</tr>
<tr>
<td>paste</td>
<td>73</td>
</tr>
<tr>
<td>Paterson, R.</td>
<td>1</td>
</tr>
<tr>
<td>pathchk</td>
<td>174</td>
</tr>
<tr>
<td>PATH</td>
<td>208</td>
</tr>
<tr>
<td>pattern matching</td>
<td>167</td>
</tr>
<tr>
<td>pebibo, definition of</td>
<td>5</td>
</tr>
<tr>
<td>permission tests</td>
<td>165</td>
</tr>
<tr>
<td>permissions of installed files, setting</td>
<td>119</td>
</tr>
<tr>
<td>permissions, changing access</td>
<td>141</td>
</tr>
<tr>
<td>permissions, copying existing</td>
<td>235</td>
</tr>
<tr>
<td>permissions, for changing file timestamps</td>
<td>143</td>
</tr>
<tr>
<td>permissions, output by ls</td>
<td>94</td>
</tr>
<tr>
<td>petabyte, definition of</td>
<td>4</td>
</tr>
<tr>
<td>phone directory order</td>
<td>50</td>
</tr>
<tr>
<td>pieces, splitting a file into</td>
<td>33</td>
</tr>
<tr>
<td>Pinard, F.</td>
<td>1, 249</td>
</tr>
<tr>
<td>pipe fitting</td>
<td>170</td>
</tr>
<tr>
<td>Plass, Michael F.</td>
<td>22</td>
</tr>
<tr>
<td>platform, hardware</td>
<td>201</td>
</tr>
<tr>
<td>pm in date strings</td>
<td>244</td>
</tr>
<tr>
<td>portable file names, checking for</td>
<td>174</td>
</tr>
<tr>
<td>portable output format</td>
<td>147</td>
</tr>
<tr>
<td>POSIX</td>
<td>1</td>
</tr>
<tr>
<td>POSIX output format</td>
<td>147</td>
</tr>
<tr>
<td>POSIXLY_CORRECT</td>
<td>2, 11, 24, 54, 56, 117, 160, 188</td>
</tr>
<tr>
<td>POSIXLY_CORRECT, and block size</td>
<td>3</td>
</tr>
<tr>
<td>pr</td>
<td>23</td>
</tr>
<tr>
<td>prime factors</td>
<td>225</td>
</tr>
<tr>
<td>print</td>
<td>84</td>
</tr>
<tr>
<td>print machine hardware name</td>
<td>200</td>
</tr>
<tr>
<td>print name of current directory</td>
<td>180</td>
</tr>
<tr>
<td>print system information</td>
<td>201</td>
</tr>
<tr>
<td>print terminal file name</td>
<td>187</td>
</tr>
<tr>
<td>Print the number of processors</td>
<td>200</td>
</tr>
<tr>
<td>printenv</td>
<td>186</td>
</tr>
<tr>
<td>printf</td>
<td>160</td>
</tr>
<tr>
<td>printing all or some environment variables</td>
<td>186</td>
</tr>
<tr>
<td>printing color database</td>
<td>103</td>
</tr>
<tr>
<td>printing current user information</td>
<td>190</td>
</tr>
<tr>
<td>printing current usernames</td>
<td>189</td>
</tr>
<tr>
<td>printing groups a user is in</td>
<td>189</td>
</tr>
<tr>
<td>printing ls colors</td>
<td>103</td>
</tr>
<tr>
<td>printing real and effective user</td>
<td>188</td>
</tr>
<tr>
<td>and group IDs</td>
<td></td>
</tr>
<tr>
<td>printing text</td>
<td>159</td>
</tr>
<tr>
<td>printing text, commands for</td>
<td>159</td>
</tr>
<tr>
<td>printing the current time</td>
<td>192</td>
</tr>
<tr>
<td>printing the effective user ID</td>
<td>189</td>
</tr>
<tr>
<td>printing the host identifier</td>
<td>202</td>
</tr>
<tr>
<td>printing the hostname</td>
<td>202</td>
</tr>
<tr>
<td>printing the system uptime and load</td>
<td>203</td>
</tr>
<tr>
<td>printing user's login name</td>
<td>189</td>
</tr>
<tr>
<td>printing, preparing files for</td>
<td>23</td>
</tr>
<tr>
<td>process zero-terminated items</td>
<td>29, 33, 55, 58, 61,</td>
</tr>
<tr>
<td>processes, commands for controlling</td>
<td>223</td>
</tr>
<tr>
<td>progress</td>
<td>112</td>
</tr>
<tr>
<td>prompting, and ln</td>
<td>130</td>
</tr>
<tr>
<td>prompting, and mv</td>
<td>120</td>
</tr>
<tr>
<td>prompting, and rm</td>
<td>122</td>
</tr>
<tr>
<td>prompts, forcing</td>
<td>121</td>
</tr>
<tr>
<td>prompts, omitting</td>
<td>121</td>
</tr>
<tr>
<td>prttermse</td>
<td>183</td>
</tr>
<tr>
<td>ptx</td>
<td>63</td>
</tr>
<tr>
<td>punct</td>
<td>84</td>
</tr>
<tr>
<td>pure numbers in date strings</td>
<td>247</td>
</tr>
<tr>
<td>pwd</td>
<td>180</td>
</tr>
</tbody>
</table>

Q

<table>
<thead>
<tr>
<th>Term</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>quettabyte, definition of</td>
<td>5</td>
</tr>
<tr>
<td>quit</td>
<td>185</td>
</tr>
<tr>
<td>quoting style</td>
<td>101</td>
</tr>
</tbody>
</table>

R

<table>
<thead>
<tr>
<th>Term</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>radix for file offsets</td>
<td>16</td>
</tr>
<tr>
<td>random seed</td>
<td>7</td>
</tr>
<tr>
<td>random sort</td>
<td>52</td>
</tr>
<tr>
<td>random source for shredding</td>
<td>126</td>
</tr>
<tr>
<td>random source for shuffling</td>
<td>58</td>
</tr>
<tr>
<td>random source for sorting</td>
<td>54</td>
</tr>
<tr>
<td>random sources</td>
<td>7</td>
</tr>
<tr>
<td>ranges</td>
<td>83</td>
</tr>
<tr>
<td>raw</td>
<td>184</td>
</tr>
<tr>
<td>raw binary checksum</td>
<td>44</td>
</tr>
<tr>
<td>read errors, ignoring</td>
<td>114</td>
</tr>
<tr>
<td>read from standard input and write to</td>
<td>170</td>
</tr>
<tr>
<td>standard output and files</td>
<td></td>
</tr>
<tr>
<td>read permission</td>
<td>233</td>
</tr>
<tr>
<td>read permission, symbolic</td>
<td>235</td>
</tr>
<tr>
<td>read system call, and holes</td>
<td>109</td>
</tr>
<tr>
<td>readable file check</td>
<td>165</td>
</tr>
<tr>
<td>readlink</td>
<td>134</td>
</tr>
<tr>
<td>real user and group IDs, printing</td>
<td>188</td>
</tr>
<tr>
<td>realpath</td>
<td>134, 177</td>
</tr>
<tr>
<td>record separator character</td>
<td>36</td>
</tr>
<tr>
<td>recursive directory listing</td>
<td>91</td>
</tr>
<tr>
<td>recursively changing access permissions</td>
<td>142</td>
</tr>
<tr>
<td>recursively changing file ownership</td>
<td>139</td>
</tr>
<tr>
<td>recursively changing group ownership</td>
<td>141</td>
</tr>
<tr>
<td>recursively copying directories</td>
<td>105, 108</td>
</tr>
<tr>
<td>redirection</td>
<td>170</td>
</tr>
<tr>
<td>reference file</td>
<td>204</td>
</tr>
<tr>
<td>reformatting paragraph text</td>
<td>22</td>
</tr>
<tr>
<td>regular expression matching</td>
<td>167</td>
</tr>
<tr>
<td>regular file check</td>
<td>164</td>
</tr>
<tr>
<td>relations, numeric or string</td>
<td>168</td>
</tr>
<tr>
<td>relative items in date strings</td>
<td>246</td>
</tr>
<tr>
<td>release of kernel</td>
<td>202</td>
</tr>
</tbody>
</table>
Index

relpath .................................................. 178
remainder .............................................. 168
remote hostname ..................................... 190
removing characters ................................. 85
removing empty directories ......................... 136
removing files after shredding ..................... 126
removing files or directories ....................... 122
removing files or directories (via the unlink syscall) ........................................ 136
removing permissions ................................. 235
renaming files without copying them .............. 121
repeat output values ................................ 58
repeated characters ................................ 84
repeated lines, outputting .......................... 60
repeated output of a string ......................... 162
restricted deletion flag .............................. 233
restricted security context ......................... 205
return, ignoring ....................................... 182
return, translating to newline ...................... 182
reverse sorting ....................................... 52, 95
reversing files ........................................ 13
rm ......................................................... 122
rmdir ..................................................... 136
rn format for nl ....................................... 15
ronnabyte, definition of ............................ 5
root as default owner ................................ 119
root directory, allow recursive destruction ....... 123
root directory, allow recursive modification ...... 139, 140, 142
root directory, disallow recursive destruction ... 123
root directory, disallow recursive modification ... 138, 140, 142
root directory, running a program in a specified ........................................ 207
rows ....................................................... 186
rprnt ..................................................... 185
RTS/CTS flow control ................................ 181
run commands with bounded time ................... 220
run with security context ............................ 205
runcon .................................................... 205
running a program in a modified environment ... 208
running a program in a specified root directory .... 207
rz format for nl ....................................... 15

S
Salz, Rich ................................................. 248
same file check ......................................... 165
sane ....................................................... 184
scheduling, affecting ................................. 216
screen columns ........................................ 27
scripts arguments .................................... 211
seconds since the Epoch ............................. 192
section delimiters of pages ......................... 14
security context ........................................ 95, 110, 119, 120, 122, 133, 134,
seek ....................................................... 112
self-backups .......................................... 104
SELinux ............................................... 95, 119, 188
SELinux context ....................................... 204
SELinux, context ....................................... 204
SELinux, restoring security context ............... 122
SELinux, setting/restoring security context ....... 110, 120, 133, 134
send a signal to processes .......................... 223
sentences and line-breaking ......................... 22
separator for numbers in seq .................... 231
seq ....................................................... 231
sequence of numbers ................................ 231
set-group-ID .......................................... 233
set-group-ID check ................................... 165
set-user-ID ............................................ 233
set-user-ID check .................................... 165
setgid .................................................... 233
setting permissions .................................. 235
setting the hostname ................................ 202
setting the time ...................................... 196
setuid .................................................... 233
setup for color ........................................ 103
sh syntax for color setup ............................ 103
sha1sum ............................................... 47
sha224sum ............................................. 48
sha256sum ............................................. 48
sha384sum ............................................. 48
sha512sum ............................................. 48
SHA-1 .................................................... 47
SHA-2 .................................................... 48
shebang arguments ................................... 211
shell utilities .......................................... 1
SHELL environment variable, and color ........... 97, 103
shred .................................................... 124
shuf ...................................................... 57
shuffling files ......................................... 57
SI output ............................................... 4, 95, 147, 151
signals, specifying .................................... 5
simple backup method ................................ 3
SIMPLE_BACKUP_SUFFIX ................................ 3
single quotes, and env -S ......................... 212
single-column output of files ...................... 96
size ....................................................... 186
size for main memory sorting ...................... 54
size of file to shred ................................ 126
size of files, reporting .............................. 94
size of files, sorting files by ...................... 95
skip ...................................................... 112
sleep ..................................................... 224
socket check ......................................... 164
software flow control ................................ 182
sort ...................................................... 49
sort field .............................................. 53
sort stability .......................................... 49, 54
sort's last-resort comparison ...................... 49, 54
sorted files, operations on ......................... 49
sorting files .......................................... 49
symbolic (soft) links, creating ........................................ 128
symbolic link check .................................................. 164
symbolic link to directory, controlling traversal of.................. 9
symbolic link to directory, never traverse 9, 139, 141, 204
symbolic link to directory, traverse each that is encountered .... 9, 139, 141, 204
symbolic link to directory, traverse if on the command line .... 9, 139, 141, 204
symbolic link, defined .............................................. 129
symbolic links and ln .............................................. 131
symbolic links and psd .............................................. 180
symbolic links, changing group .................................... 140
symbolic links, changing owner .................................... 138, 140
symbolic links, changing time ..................................... 143
symbolic links, copying ........................................... 105, 106
symbolic links, copying with ...................................... 109
symbolic links, dereferencing ..................................... 90, 91
symbolic links, dereferencing in du ................................ 150
symbolic links, dereferencing in stat ............................... 153
symbolic links, following ......................................... 115
symbolic links, permissions of .................................... 141
symbolic modes ........................................................ 234
symlinks, resolution .................................................. 177
sync ................................................................. 115, 157
sync (padding with ASCII NULs) ................................... 113
Synchronize cached writes to persistent storage ...................... 157
synchronize file system and memory ................................ 157
synchronized data and metadata I/O ................................ 115
synchronized data and metadata writes, before finishing .......... 114
synchronized data reads ............................................ 115
synchronized data writes, before finishing ......................... 114
system context ..................................................... 192
system information, printing ...................................... 200, 201
system name, printing .............................................. 202
System V sum ......................................................... 42

T

tab stops, setting .......................................................... 87
tabn .......................... 183
tabs ................................................................. 185
tabs to spaces, converting ............................................ 86
tac ................................................................. 13
tagged paragraphs .................................................. 22
tail ................................................................. 30
tandem .............................................................. 182
target directory ......... 7, 8, 109, 110, 119, 122, 131
tebibyte, definition of .............................................. 4
tee ................................................................. 170
telephone directory order .............................................. 50
temporary directory .................................................. 55
temporary files and directories ................................... 175
terabyte, definition of .............................................. 4
terminal check ......................................................... 164
<table>
<thead>
<tr>
<th>U</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>u, and disabling special characters</td>
<td></td>
<td>185</td>
</tr>
<tr>
<td>ucase, converting to</td>
<td></td>
<td>113</td>
</tr>
<tr>
<td>umask and modes</td>
<td></td>
<td>237</td>
</tr>
<tr>
<td>uname</td>
<td></td>
<td>201</td>
</tr>
<tr>
<td>unblock</td>
<td></td>
<td>113</td>
</tr>
<tr>
<td>unexpand</td>
<td></td>
<td>87</td>
</tr>
<tr>
<td>Unicode</td>
<td></td>
<td>161</td>
</tr>
<tr>
<td>uniq</td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>unique lines, outputting</td>
<td></td>
<td>61</td>
</tr>
<tr>
<td>uniqify files</td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>uniquifying output</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>Universal Time</td>
<td></td>
<td>198</td>
</tr>
<tr>
<td>unlink</td>
<td></td>
<td>136</td>
</tr>
<tr>
<td>unprintable characters, ignoring</td>
<td></td>
<td>51</td>
</tr>
<tr>
<td>unsorted directory listing</td>
<td></td>
<td>95</td>
</tr>
<tr>
<td>upper</td>
<td></td>
<td>84</td>
</tr>
<tr>
<td>uppercase, translating to lowercase</td>
<td></td>
<td>182</td>
</tr>
<tr>
<td>uptime</td>
<td></td>
<td>203</td>
</tr>
<tr>
<td>use time, changing</td>
<td></td>
<td>143</td>
</tr>
<tr>
<td>use time, printing or sorting files</td>
<td></td>
<td>95</td>
</tr>
<tr>
<td>use time, show the most recent</td>
<td></td>
<td>151</td>
</tr>
<tr>
<td>user IDs, disambiguating</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>user information, commands for</td>
<td></td>
<td>188</td>
</tr>
<tr>
<td>user name, printing</td>
<td></td>
<td>189</td>
</tr>
<tr>
<td>user names, disambiguating</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>usernames, printing current</td>
<td></td>
<td>189</td>
</tr>
<tr>
<td>users</td>
<td></td>
<td>189</td>
</tr>
<tr>
<td>UTC</td>
<td></td>
<td>198</td>
</tr>
<tr>
<td>utmp</td>
<td></td>
<td>189, 190</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>valid file names, checking for</td>
<td></td>
<td>174</td>
</tr>
<tr>
<td>variable-length records, converting</td>
<td></td>
<td>111</td>
</tr>
<tr>
<td>to fixed-length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vdir</td>
<td></td>
<td>102</td>
</tr>
<tr>
<td>verbose ls format</td>
<td></td>
<td>93</td>
</tr>
<tr>
<td>verifying checksums</td>
<td></td>
<td>45, 46</td>
</tr>
<tr>
<td>version number sort</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>version number, finding</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>version of kernel</td>
<td></td>
<td>202</td>
</tr>
<tr>
<td>version, sorting option for ls</td>
<td></td>
<td>96</td>
</tr>
<tr>
<td>version-control Emacs variable</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>VERSION_CONTROL</td>
<td></td>
<td>2, 105, 118, 121, 129</td>
</tr>
<tr>
<td>vertical sorted files in columns</td>
<td></td>
<td>96</td>
</tr>
<tr>
<td>vtn</td>
<td></td>
<td>183</td>
</tr>
</tbody>
</table>
Index

W
wc ...................................................... 41
week in date strings ............................. 246
werase .............................................. 185
who .................................................... 190
who am i ............................................ 190
whoami .............................................. 189
width, sorting option for ls ....................... 96
word count ........................................... 41
working context .................................... 180
working directory, printing ..................... 180
wrap data ............................................ 19
wrapping long input lines ....................... 27
writable file check ................................ 165
write permission .................................. 233
write permission, symbolic ...................... 235
write, allowed .................................... 191
wtmp .................................................. 189, 190

X
xcase .................................................... 183
xdigit .................................................. 84
xfs file system type ............................... 148
XON/XOFF flow control ........................... 182

Y
year in date strings ................................ 246
yes ..................................................... 162
yesterday ............................................ 196
yesterday in date strings ......................... 246
yottabyte, definition of .......................... 5
Youmans, B ........................................... 1

Z
zero-length string check .......................... 165
zettabyte, definition of ........................... 5