NAME
mksh, sh – MirBSD Korn shell

SYNOPSIS
mksh [−+abCefhiklmnrUtXx][−T [!]|tty| −][−o option][−c string | −s | file [argument ...]]
builtin-name [argument ...]

DESCRIPTION
mksh is a command interpreter intended for both interactive and shell script use. Its command language is
a superset of the sh(C) shell language and largely compatible to the original Korn shell. At times, this man-
ual page may give scripting advice; while it sometimes does take portable shell scripting or various stan-
dards into account all information is first and foremost presented with mksh in mind and should be taken as
such.

I use Android, OS/2, etc. so what...?
Please refer to: http://www.mirbsd.org/mksh-faq.htm#sowhatismksh

Invocation
Most builtins can be called directly, for example if a link points from its name to the shell; not all make
sense, have been tested or work at all though.

The options are as follows:
−c string
mksh will execute the command(s) contained in string.
−i
Interactive shell. A shell that reads commands from standard input is “interactive” if this op-
tion is used or if both standard input and standard error are attached to a tty(4). An interac-
tive shell has job control enabled, ignores the SIGINT, SIGQUIT and SIGTERM signals, and prints
prompts before reading input (see the PS1 and PS2 parameters). It also processes the ENV pa-
rameter or the mkshrc file (see below). For non-interactive shells, the trackall option is on by
default (see the set command below).
−l
Login shell. If the basename the shell is called with (i.e. argv[0]) starts with ‘-’ or if this option
is used, the shell is assumed to be a login shell; see Startup files below.
−p
Privileged shell. A shell is “privileged” if the real user ID or group ID does not match the effec-
tive user ID or group ID (see getuid(2) and getgid(2)). Clearing the privileged option causes
the shell to set its effective user ID (group ID) to its initial real user ID (group ID). For further
implications, see Startup files. If the shell is privileged and this flag is not explicitly set, the
“privileged” option is cleared automatically after processing the startup files.
−r
Restricted shell. A shell is “restricted” if this option is used. The following restrictions come in-
to effect after the shell processes any profile and ENV files:
• The cd (and chdir) command is disabled.
• The SHELL, ENV and PATH parameters cannot be changed.
• Command names can’t be specified with absolute or relative paths.
• The −p option of the built-in command command can’t be used.
• Redirections that create files can’t be used (i.e. “>”, “>|”, “>>”, “<>”).
−s
The shell reads commands from standard input; all non-option arguments are positional pa-
rameters.
-T name  Spawn mksh on the tty(4) device given. The paths name, /dev/ttyCname and /dev/ttynname are attempted in order. Unless name begins with an exclamation mark (‘!’), this is done in a subshell and returns immediately. If name is a dash (‘-’), detach from controlling terminal (daemonise) instead.

In addition to the above, the options described in the set built-in command can also be used on the command line: both [−+abcefhkmnuvXX] and [−+o option] can be used for single letter or long options, respectively.

If neither the −c nor the −s option is specified, the first non-option argument specifies the name of a file the shell reads commands from. If there are no non-option arguments, the shell reads commands from the standard input. The name of the shell (i.e. the contents of $0) is determined as follows: if the −c option is used and there is a non-option argument, it is used as the name; if commands are being read from a file, the file is used as the name; otherwise, the basename the shell was called with (i.e. argv[0]) is used.

The exit status of the shell is 127 if the command file specified on the command line could not be opened, or non-zero if a fatal syntax error occurred during the execution of a script. In the absence of fatal errors, the exit status is that of the last command executed, or zero if no command is executed.

Startup files
For the actual location of these files, see FILES. A login shell processes the system profile first. A privileged shell then processes the suid profile. A non-privileged login shell processes the user profile next. A non-privileged interactive shell checks the value of the ENV parameter after subjecting it to parameter, command, arithmetic and tilde (‘~’) substitution; if unset or empty, the user mkshrc profile is processed; otherwise, the basename the shell was called with (i.e. argv[0]) is used.

The exit status of the shell is 127 if the command file specified on the command line could not be opened, or non-zero if a fatal syntax error occurred during the execution of a script. In the absence of fatal errors, the exit status is that of the last command executed, or zero if no command is executed.

Command syntax
The shell begins parsing its input by removing any backslash-newline combinations, then breaking it into words. Words (which are sequences of characters) are delimited by unquoted whitespace characters (space, tab and newline) or meta-characters (‘<’, ‘>’, ‘|’, ‘;’, ‘(’, ‘)’ and ‘&’). Aside from delimiting words, spaces and tabs are ignored, while newlines usually delimit commands. The meta-characters are used in building the following tokens: “<”, “<&”, “<<”, “<<<”, “>”, “>&”, “">”, “&>>”, etc. are used to specify redirections (see Input/output redirection below); “[]” is used to create pipelines; “|” is used to create co-processes (see Co-processes below); “;” is used to separate commands; “&” is used to create asynchronous pipelines; “&&” and “||” are used to specify conditional execution; “;”, “; &” and “; |” are used in case statements; “(( . . . ))” is used in arithmetic expressions; and lastly, “( . . . )” is used to create subshells.

Whitespace and meta-characters can be quoted individually using a backslash (‘\’), or in groups using double (“”’) or single (‘’’) quotes. Note that the following characters are also treated specially by the shell and must be quoted if they are to represent themselves: ‘\’, ‘”’, ‘’’, ‘#’, ‘$’, ‘’’, ‘~’, ‘(’, ‘)’, ‘*’, ‘?’ and ‘[’.

The first three of these are the above mentioned quoting characters (see Quoting below); ‘#’, if used at the beginning of a word, introduces a comment – everything after the ‘#’ up to the nearest newline is ignored; ‘$’ is used to introduce parameter, command and arithmetic substitutions (see Substitution below); ‘”’ introduces an old-style command substitution (see Substitution below); ‘~’ begins a directory expansion (see Tilde expansion below); ‘(‘ and ‘)’ delimit csh(1)-style alternations (see Brace expansion below); and finally, ‘[‘ and ‘]’ are used in file name generation (see File name patterns below).

As words and tokens are parsed, the shell builds commands, of which there are two basic types: simple-commands, typically programmes that are executed, and compound-commands, such as for and if statements, grouping constructs and function definitions.
A simple-command consists of some combination of parameter assignments (see Parameters below), input/output redirections (see Input/output redirections below) and command words; the only restriction is that parameter assignments come before any command words. The command words, if any, define the command that is to be executed and its arguments. The command may be a shell built-in command, a function or an external command (i.e. a separate executable file that is located using the PATH parameter; see Command execution below). Note that all command constructs have an exit status: for external commands, this is related to the status returned by wait(2) (if the command could not be found, the exit status is 127; if it could not be executed, the exit status is 126); the exit status of other command constructs (built-in commands, functions, compound-commands, pipelines, lists, etc.) are all well-defined and are described where the construct is described. The exit status of a command consisting only of parameter assignments is that of the last command substitution performed during the parameter assignment or 0 if there were no command substitutions.

Commands can be chained together using the “|” token to form pipelines, in which the standard output of each command but the last is piped (see pipe(2)) to the standard input of the following command. The exit status of a pipeline is that of its last command, unless the pipefail option is set (see there). All commands of a pipeline are executed in separate subshells; this is allowed by POSIX but differs from both variants of AT&T UNIX ksh, where all but the last command were executed in subshells; see the read builtin’s description for implications and workarounds. A pipeline may be prefixed by the “!” reserved word which causes the exit status of the pipeline to be logically complemented: if the original status was 0, the complemented status will be 1; if the original status was not 0, the complemented status will be 0.

Lists of commands can be created by separating pipelines by any of the following tokens: “&&”, “||”, “&”, “|&” and “;”. The first two are for conditional execution: “cmd1 && cmd2” executes cmd2 only if the exit status of cmd1 is zero; “||” is the opposite – cmd2 is executed only if the exit status of cmd1 is non-zero. “&&” and “||” have equal precedence which is higher than that of “&”, “[&” and “;”, which also have equal precedence. Note that the “&&” and “||” operators are "left-associative". For example, both of these commands will print only "bar":

```
$ false && echo foo || echo bar
$ true || echo foo && echo bar
```

The “&” token causes the preceding command to be executed asynchronously; that is, the shell starts the command but does not wait for it to complete (the shell does keep track of the status of asynchronous commands; see Job control below). When an asynchronous command is started when job control is disabled (i.e. in most scripts), the command is started with signals SIGINT and SIGQUIT ignored and with input redirected from /dev/null (however, redirections specified in the asynchronous command have precedence). The “[&” operator starts a co-process which is a special kind of asynchronous process (see Co-processes below). Note that a command must follow the “&&” and “||” operators, while it need not follow “&”, “[&” or “;”;”. The exit status of a list is that of the last command executed, with the exception of asynchronous lists, for which the exit status is 0.

Compound commands are created using the following reserved words. These words are only recognised if they are unquoted and if they are used as the first word of a command (i.e. they can't be preceded by parameter assignments or redirections):

```
case    else    function    then    !    {  
do     esac    if     time    [[    (  
done    fi     in     until    {  
elif    for    select    while    }  
```

In the following compound command descriptions, command lists (denoted as list) that are followed by reserved words must end with a semicolon, a newline or a (syntactically correct) reserved word. For example, the following are all valid:
$ { echo foo; echo bar; }
$ { echo foo; echo bar <newline>}
$ ( { echo foo; echo bar; } )

This is not valid:

$( echo foo; echo bar )

(list)
Execute list in a subshell. There is no implicit way to pass environment changes from a subshell back to its parent.

{ list; }
Compound construct; list is executed, but not in a subshell. Note that “{” and “}” are reserved words, not meta-characters.

case word in [[() pattern [() pattern] ...] list terminator] ... esac
The case statement attempts to match word against a specified pattern; the list associated with the first successfully matched pattern is executed. Patterns used in case statements are the same as those used for file name patterns except that the restrictions regarding ‘.’ and ‘/’ are dropped. Note that any unquoted space before and after a pattern is stripped; any space within a pattern must be quoted. Both the word and the patterns are subject to parameter, command and arithmetic substitution, as well as tilde substitution.

For historical reasons, open and close braces may be used instead of in and esac e.g. case $foo { * echo bar ; ; }.

The list terminators are:

“;;” Terminate after the list.

“;|” Fall through into the next list.

“|” Evaluate the remaining pattern-list tuples.

The exit status of a case statement is that of the executed list; if no list is executed, the exit status is zero.

for name [in word ...]; do list; done
For each word in the specified word list, the parameter name is set to the word and list is executed. If in is not used to specify a word list, the positional parameters ($1, $2, etc.) are used instead. For historical reasons, open and close braces may be used instead of do and done e.g. for i; { echo $i; }. The exit status of a for statement is the last exit status of list; if list is never executed, the exit status is zero.

if list; then list; [elif list; then list;] ... [else list;] fi
If the exit status of the first list is zero, the second list is executed; otherwise, the list following the elif, if any, is executed with similar consequences. If all the lists following the if and elifs fail (i.e. exit with non-zero status), the list following the else is executed. The exit status of an if statement is that of non-conditional list that is executed; if no non-conditional list is executed, the exit status is zero.

select name [in word ...]; do list; done
The select statement provides an automatic method of presenting the user with a menu and selecting from it. An enumerated list of the specified word(s) is printed on standard error, followed by a prompt (PS3: normally “#?”). A number corresponding to one of the enumerated words is then read from standard input, name is set to the selected word (or unset if the selection is not valid), REPLY is set to what was read (leading/trailing space is stripped), and list is executed. If a blank line (i.e. zero or more IFS octets) is entered, the menu is reprinted without executing list.
When `list` completes, the enumerated list is printed if `REPLY` is empty, the prompt is printed, and so on. This process continues until an end-of-file is read, an interrupt is received, or a `break` statement is executed inside the loop. If “in word ...” is omitted, the positional parameters are used (i.e. `$1`, `$2`, etc.). For historical reasons, open and close braces may be used instead of `do` and `done` e.g. `select 1; { echo $1; }`. The exit status of a `select` statement is zero if a `break` statement is used to exit the loop, non-zero otherwise.

```
until list; do list; done
```

This works like `while`, except that the body is executed only while the exit status of the first `list` is non-zero.

```
while list; do list; done
```

A `while` is a pre-checked loop. Its body is executed as often as the exit status of the first `list` is zero. The exit status of a `while` statement is the last exit status of the `list` in the body of the loop; if the body is not executed, the exit status is zero.

```
function name { list; }
```

Defines the function `name` (see Functions below). Note that redirections specified after a function definition are performed whenever the function is executed, not when the function definition is executed.

```
name() command
```

Mostly the same as `function` (see Functions below). Whitespace (space or tab) after `name` will be ignored most of the time.

```
function name() { list; }
```

The same as `name()` (bashism). The `function` keyword is ignored.

```
time [-p][pipeline]
```

The Command execution section describes the `time` reserved word.

```
(( expression ))
```

The arithmetic expression `expression` is evaluated; equivalent to “let "expression"” (see Arithmetic expressions and the `let` command, below) in a compound construct.

```
[ [ expression ] ]
```

Similar to the `test` and `[ ... ]` commands (described later), with the following exceptions:

- Field splitting and file name generation are not performed on arguments.
- The `-a` (AND) and `-o` (OR) operators are replaced with “&&” and “||”, respectively.
- Operators (e.g. “-f”, “=”, “!”) must be unquoted.
- Parameter, command and arithmetic substitutions are performed as expressions are evaluated and lazy expression evaluation is used for the “&&” and “||” operators. This means that in the following statement, `$(<foo)` is evaluated if and only if the file `foo` exists and is readable:

```
$ [ [ -r foo && $(<foo) = b*r ] ]
```

- The second operand of the “!=” and “=” expressions are a subset of patterns (e.g. the comparison `[[ foobar = f*r ]]` succeeds). This even works indirectly:

```
$ bar=foobar; baz='f*r'
$ [[ $bar = $baz ]]; echo $?
$ [[ $bar = "$baz" ]]; echo $?
```

Perhaps surprisingly, the first comparison succeeds, whereas the second doesn’t. This does not apply to all extglob metacharacters, currently.
Quoting

Quoting is used to prevent the shell from treating characters or words specially. There are three methods of quoting. First, ‘\’ quotes the following character, unless it is at the end of a line, in which case both the ‘\’ and the newline are stripped. Second, a single quote (‘”’) quotes everything up to the next single quote (this may span lines). Third, a double quote (’”’) quotes all characters, except ‘$’, ‘\’ and ‘‘’, up to the next unescaped double quote. ‘$’ and ‘‘’ inside double quotes have their usual meaning (i.e. parameter, arithmetic or command substitution) except no field splitting is carried out on the results of double-quoted substitutions, and the old-style form of command substitution has backslash-quoting for double quotes enabled. If a ‘\’ inside a double-quoted string is followed by ‘’’, ‘$’, ‘\’ or ‘‘’, only the ‘\’ is removed, i.e. the combination is replaced by the second character; if it is followed by a newline, both the ‘\’ and the newline are stripped; otherwise, both the ‘\’ and the character following are unchanged.

If a single-quoted string is preceded by an unquoted ‘$’, C style backslash expansion (see below) is applied (even single quote characters inside can be escaped and do not terminate the string then); the expanded result is treated as any other single-quoted string. If a double-quoted string is preceded by an unquoted ‘$’, the ‘$’ is simply ignored.

Backslash expansion

In places where backslashes are expanded, certain C and AT&T UNIX ksh or GNU bash style escapes are translated. These include “\a”, “\b”, “\f”, “\n”, “\r”, “\t”, “\U####”, “\u##” and “\v”. For “\U#####” and “\u####”, ‘#’ means a hexadecimal digit (up to 4 or 8); these translate a Universal Coded Character Set codepoint to UTF-8 (see CAVEATS on UCS limitations). Furthermore, “\E” and “\e” expand to the escape character.

In the print builtin mode, octal sequences must have the optional up to three octal digits ‘#’ prefixed with the digit zero (“\0###”); hexadecimal sequences “\x##” are limited to up to two hexadecimal digits ‘#’; both octal and hexadecimal sequences convert to raw octets; “\%”, where ‘%’ is none of the above, translates to % (backslashes are retained).

In C style mode, raw octet-yielding octal sequences “\###” must not have the one up to three octal digits prefixed with the digit zero; hexadecimal sequences “\x##” greedily eat up as many hexadecimal digits ‘#’ as they can and terminate with the first non-xdigit; below x100 these produce raw octets; above, they are equivalent to “\U#”. The sequence “\c%”, where ‘%’ is any octet, translates to Ctrl-%, that is, “c?” becomes DEL, everything else is bitwise ANDed with 0x9F. “\%”, where ‘%’ is none of the above, translates to %: backslashes are trimmed even before newlines.

Aliases

There are two types of aliases: normal command aliases and tracked aliases. Command aliases are normally used as a short hand for a long or often used command. The shell expands command aliases (i.e. substitutes the alias name for its value) when it reads the first word of a command. An expanded alias is re-processed to check for more aliases. If a command alias ends in a space or tab, the following word is also checked for alias expansion. The alias expansion process stops when a word that is not an alias is found, when a quoted word is found, or when an alias word that is currently being expanded is found. Aliases are specifically an interactive feature: while they do happen to work in scripts and on the command line in some cases, aliases are expanded during lexing, so their use must be in a separate command tree from their definition; otherwise, the alias will not be found. Noticeably, command lists (separated by semicolon, in command substitutions also by newline) may be one same parse tree.

The following command aliases are defined automatically by the shell:

```
autoload='\builtin typeset -fu'
functions='\builtin typeset -f'
hash='\builtin alias -t'
history='\builtin fc -l'
```
integer='\builtin typeset -i'
local='\builtin typeset'
login='\builtin exec login'
nameref='\builtin typeset -n'
nohup='nohup '
r='\builtin fc -e '
type='\builtin whence -v'

Tracked aliases allow the shell to remember where it found a particular command. The first time the shell
does a path search for a command that is marked as a tracked alias, it saves the full path of the command.
The next time the command is executed, the shell checks the saved path to see that it is still valid, and if so,
avoids repeating the path search. Tracked aliases can be listed and created using alias -t. Note that
changing the PATH parameter clears the saved paths for all tracked aliases. If the trackall option is set (i.e.
set -ot trackall or set -h), the shell tracks all commands. This option is set automatically for non-in-
teractive shells. For interactive shells, only the following commands are automatically tracked: cat(1),
cc(1), chmod(1), cp(1), date(1), ed(1), emacs(1), grep(1), ls(1), make(1), mv(1), pr(1), rm(1), sed(1), sh(1),
vi(1) and who(1).

Substitution
The first step the shell takes in executing a simple-command is to perform substitutions on the words of the
command. There are three kinds of substitution: parameter, command and arithmetic. Parameter substitu-
tions, which are described in detail in the next section, take the form $\{name\} or ${\ldots}; command substitu-
tions take the form $(command) or (deprecated) `command` or (executed in the current environment)
${command}; and strip trailing newlines; and arithmetic substitutions take the form $(expression).
Parsing the current-environment command substitution requires a space, tab or newline after the opening
brace and that the closing brace be recognised as a keyword (i.e. is preceded by a newline or semicolon).
They are also called funsubs (function substitutions) and behave like functions in that local and return
work, and in that exit terminates the parent shell; shell options are shared.

Another variant of substitution are the valsubs (value substitutions) ${|command|} which are also executed
in the current environment, like funsubs, but share their I/O with the parent; instead, they evaluate to
whatever the, initially empty, expression-local variable REPLY is set to within the
command.

If a substitution appears outside of double quotes, the results of the substitution are generally subject to
word or field splitting according to the current value of the IFS parameter. The IFS parameter specifies
a list of octets which are used to break a string up into several words; any octets from the set space, tab and
newline that appear in the IFS octets are called “IFS whitespace”. Sequences of one or more IFS whitespace
octets, in combination with zero or one non-IFS whitespace octets, delimit a field. As a special case,
leading and trailing IFS whitespace is stripped (i.e. no leading or trailing empty field is created by it); leading-
or trailing non-IFS whitespace does create an empty field.

Example: If IFS is set to “<space>” and VAR is set to “<space>A<space>:<space><space>B:<space>:D”, the sub-
stitution for $VAR results in four fields: “A”, “B”, “” (an empty field) and “D”. Note that if the IFS parameter
is set to the empty string, no field splitting is done; if it is unset, the default value of space, tab and newline
is used.

Also, note that the field splitting applies only to the immediate result of the substitution. Using the previ-
ous example, the substitution for $VAR:E results in the fields: “A”, “B”, “” and “D:E”, not “A”, “B”, “” “D” and
“E”. This behavior is POSIX compliant, but incompatible with some other shell implementations which do
field splitting on the word which contained the substitution or use IFS as a general whitespace delimiter.

The results of substitution are, unless otherwise specified, also subject to brace expansion and file name ex-
ansion (see the relevant sections below).
A command substitution is replaced by the output generated by the specified command which is run in a subshell. For `${command}` and `$(command)` and `$(command)` substitutions, normal quoting rules are used when command is parsed; however, for the deprecated `'command` form, a `' followed by any of `$`, `\` or `\` is stripped (as is `''` when the substitution is part of a double-quoted string); a backslash `\` followed by any other character is unchanged. As a special case in command substitutions, a command of the form `file` is interpreted to mean substitute the contents of file. Note that `$<foo>` has the same effect as `$(cat foo)`. Note that some shells do not use a recursive parser for command substitutions, leading to failure for certain constructs; to be portable, use workaround “x=$(cat) <<<EOF” (or the newline-keeping “x=<EOF” extension) instead to merely slurp the string. IEEE Std 1003.1 ("POSIX.1") recommends using case statements of the form x=$(case $foo in (bar) echo $bar ;; (* echo $baz ;; esac) instead, which would work but not serve as example for this portability issue.

```
x=$(case $foo in (bar) echo $bar ;; (* echo $baz ;; esac)
# above fails to parse on old shells; below is the workaround
x=$(eval $(cat)) <<<EOF
  case $foo in (bar) echo $bar ;; (* echo $baz ;; esac
EOF
```

Arithmetic substitutions are replaced by the value of the specified expression. For example, the command `print $((2+3))` displays 14. See Arithmetic expressions for a description of an expression.

Parameters

Parameters are shell variables; they can be assigned values and their values can be accessed using a parameter substitution. A parameter name is either one of the special single punctuation or digit character parameters described below, or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter). The latter form can be treated as arrays by appending an array index of the form `arraynamenumber` or a letter followed by zero or more letters or digits (’_’ counts as a letter).

Parameter substitutions take the form `$name`, `${name}` or `${name[expr]}` where name is a parameter name. Substitutions of an an array in scalar context, i.e. without an expr in the latter form mentioned above, expand the element with the key “0”. Substitution of all array elements with `${name[*]}` and `${name[@]}` works equivalent to `$*` and `$@` for positional parameters. If substitution is performed on a parameter (or an array parameter element) that is not set, an empty string is substituted unless the nounset option (`set -u`) is set, in which case an error occurs.

Parameters can be assigned values in a number of ways. First, the shell implicitly sets some parameters like “#”, “PWD” and “$”; this is the only way the special single character parameters are set. Second, parameters are imported from the shell’s environment at startup. Third, parameters can be assigned values on the command line: for example, `FOO=bar` sets the parameter “FOO” to “bar”; multiple parameter assignments can be given on a single command line and they can be followed by a simple-command, in which case the assignments are in effect only for the duration of the command (such assignments are also exported; see below for the implications of this). Note that both the parameter name and the ‘=’ must be unquoted for the shell to recognise a parameter assignment. The construct `FOO+=baz` is also recognised; the old and new values are string-concatenated with no separator. The fourth way of setting a parameter is with the `export`, `global`, `readonly` and `typeset` commands; see their descriptions in the Command execution section. Fifth, `for` and `select` loops set parameters as well as the `getopts`, `read` and `set -A` commands. Lastly, parameters can be assigned values using assignment operators inside arithmetic expressions (see Arithmetic expressions below) or using the `${name=value}` form of the parameter substitution (see below).

Parameters with the export attribute (set using the `export` or `typeset -x` commands, or by parameter assignments followed by simple commands) are put in the environment (see `environ()`) of commands run by the shell as `name=value` pairs. The order in which parameters appear in the environment of a command
is unspecified. When the shell starts up, it extracts parameters and their values from its environment and automatically sets the export attribute for those parameters.

Modifiers can be applied to the \$\{name\} form of parameter substitution:

\$\{name:-word\}
  If \textit{name} is set and not empty, it is substituted; otherwise, \textit{word} is substituted.

\$\{name:+word\}
  If \textit{name} is set and not empty, \textit{word} is substituted; otherwise, nothing is substituted.

\$\{name:=word\}
  If \textit{name} is set and not empty, it is substituted; otherwise, it is assigned \textit{word} and the resulting value of \textit{name} is substituted.

\$\{name:?word\}
  If \textit{name} is set and not empty, it is substituted; otherwise, \textit{word} is printed on standard error (preceded by \textit{name}:) and an error occurs (normally causing termination of a shell script, function, or a script sourced using the "." built-in). If \textit{word} is omitted, the string "parameter null or not set" is used instead.

Note that, for all of the above, \textit{word} is actually considered quoted, and special parsing rules apply. The parsing rules also differ on whether the expression is double-quoted: \textit{word} then uses double-quoted rules, except for the double quote itself (""') and the closing brace, which, if backslash escaped, gets quote removal applied.

In the above modifiers, the `:` can be omitted, in which case the conditions only depend on \textit{name} being set (as opposed to set and not empty). If \textit{word} is needed, parameter, command, arithmetic and tilde substitution are performed on it; if \textit{word} is not needed, it is not evaluated.

The following forms of parameter substitution can also be used:

\$\{#name\}
  The number of positional parameters if \textit{name} is "@", "*" or not specified; otherwise the length (in characters) of the string value of parameter \textit{name}.

\$\{#name[*]\}
\$\{#name[@]\}
  The number of elements in the array \textit{name}.

\$\{%name\}
  The width (in screen columns) of the string value of parameter \textit{name}, or -1 if \$\{name\} contains a control character.

\$\{name\}
  The name of the variable referred to by \textit{name}. This will be \textit{name} except when \textit{name} is a name reference (bound variable), created by the \texttt{nameref} command (which is an alias for \texttt{typeset -n}). \textit{name} cannot be one of most special parameters (see below).

\$\{name[*]\}
\$\{name[@]\}
  The names of indices (keys) in the array \textit{name}.

\$\{name#pattern\}
\$\{name##pattern\}
  If \textit{pattern} matches the beginning of the value of parameter \textit{name}, the matched text is deleted from the result of substitution. A single "#" results in the shortest match, and two of them result in the longest match.
$\{name\%pattern\}$
$\{name\%pattern\}$

Like $\{...#...\}$ but deletes from the end of the value.

$\{name/\text{pattern}/\text{string}\}$
$\{name/#\text{pattern}/\text{string}\}$
$\{name/\%\text{pattern}/\text{string}\}$
$\{name//\text{pattern}/\text{string}\}$

The longest match of \text{pattern} in the value of parameter \text{name} is replaced with \text{string} (deleted if \text{string} is empty; the trailing slash (' /') may be omitted in that case). A leading slash followed by ‘#’ or ‘%’ causes the pattern to be anchored at the beginning or end of the value, respectively; empty unanchored \text{patterns} cause no replacement; a single leading slash or use of a \text{pattern} that matches the empty string causes the replacement to happen only once; two leading slashes cause all occurrences of matches in the value to be replaced. May be slow on long strings.

$\{name@/\text{pattern}/\text{string}\}$

The same as $\{name//\text{pattern}/\text{string}\}$, except that both \text{pattern} and \text{string} are expanded anew for each iteration. Use with KSH\_MATCH.

$\{name:\text{pos}:\text{len}\}$

The first \text{len} characters of \text{name}, starting at position \text{pos}, are substituted. Both \text{pos} and \text{:len} are optional. If \text{pos} is negative, counting starts at the end of the string; if it is omitted, it defaults to 0. If \text{len} is omitted or greater than the length of the remaining string, all of it is substituted. Both \text{pos} and \text{len} are evaluated as arithmetic expressions.

$\{name@#\}$

The hash (using the BAFH algorithm) of the expansion of \text{name}. This is also used internally for the shell’s hashtables.

$\{name@Q\}$

A quoted expression safe for re-entry, whose value is the value of the \text{name} parameter, is substituted.

Note that \text{pattern} may need extended globbing pattern (@(...) ), single (‘...’) or double ("...") quote escaping unless \text{−o sh} is set.

The following special parameters are implicitly set by the shell and cannot be set directly using assignments:

! Process ID of the last background process started. If no background processes have been started, the parameter is not set.

# The number of positional parameters ($1, $2, etc.).

$ The PID of the shell or, if it is a subshell, the PID of the original shell. Do NOT use this mechanism for generating temporary file names; see mktemp(1) instead.

− The concatenation of the current single letter options (see the \text{set} command below for a list of options).

? The exit status of the last non-asynchronous command executed. If the last command was killed by a signal, $? is set to 128 plus the signal number, but at most 255.

0 The name of the shell, determined as follows: the first argument to \text{mksh} if it was invoked with the \text{−c} option and arguments were given; otherwise the \text{file} argument, if it was supplied; or else the basename the shell was invoked with (i.e. argv[0]). $0 is also set to the name of the current script or the name of the current function, if it was defined with the \text{function} keyword (i.e. a Korn shell style function).
The first nine positional parameters that were supplied to the shell, function, or script sourced using the “." built-in. Further positional parameters may be accessed using $\{number\}.

All positional parameters (except 0), i.e. $1, $2, $3, ...
If used outside of double quotes, parameters are separate words (which are subjected to word splitting); if used within double quotes, parameters are separated by the first character of the IFS parameter (or the empty string if IFS is unset).

Same as $\ast$, unless it is used inside double quotes, in which case a separate word is generated for each positional parameter. If there are no positional parameters, no word is generated. "@" can be used to access arguments, verbatim, without losing empty arguments or splitting arguments with spaces (IFS, actually).

The following parameters are set and/or used by the shell:

- When an external command is executed by the shell, this parameter is set in the environment of the new process to the path of the executed command. In interactive use, this parameter is also set in the parent shell to the last word of the previous command.

BASHPID The PID of the shell or subshell.

CDPATH Like PATH, but used to resolve the argument to the cd built-in command. Note that if CDPATH is set and does not contain "." or an empty string element, the current directory is not searched. Also, the cd built-in command will display the resulting directory when a match is found in any search path other than the empty path.

COLUMNS Set to the number of columns on the terminal or window. If never unset and not imported, always set dynamically; unless the value as reported by stty(1) is non-zero and sane enough (minimum is 12x3), defaults to 80; similar for LINES. This parameter is used by the interactive line editing modes and by the select, set -o and kill -l commands to format information columns. Importing from the environment or unseting this parameter removes the binding to the actual terminal size in favour of the provided value.

ENV If this parameter is found to be set after any profile files are executed, the expanded value is used as a shell startup file. It typically contains function and alias definitions.

EPOCHREALTIME Time since the epoch, as returned by gettimeofday(2), formatted as decimal tv_sec followed by a dot (\.') and tv_usec padded to exactly six decimal digits.

EXECSHELL If set, this parameter is assumed to contain the shell that is to be used to execute commands that execve(2) fails to execute and which do not start with a "#! shell" sequence.

FCEDIT The editor used by the fc command (see below).

FPATH Like PATH, but used when an undefined function is executed to locate the file defining the function. It is also searched when a command can't be found using PATH. See Functions below for more information.

HISTFILE The name of the file used to store command history. When assigned to or unset, the file is opened, history is truncated then loaded from the file; subsequent new commands (possibly consisting of several lines) are appended once they successfully compiled. Also, several invocations of the shell will share history if their HISTFILE parameters all point to the same file.

Note: If HISTFILE is unset or empty, no history file is used. This is different from AT&T UNIX ksh.
HISTSIZE  The number of commands normally stored for history. The default is 2047. The maximum is 65535.

HOME  The default directory for the cd command and the value substituted for an unqualified ~ (see Tilde expansion below).

IFS  Internal field separator, used during substitution and by the read command, to split values into distinct arguments; normally set to space, tab and newline. See Substitution above for details.

Note: This parameter is not imported from the environment when the shell is started.

KSHEGID  The effective group id of the shell at startup.

KSHGID  The real group id of the shell at startup.

KSHUID  The real user id of the shell at startup.

KSH_MATCH  The last matched string. In a future version, this will be an indexed array, with indexes 1 and up capturing matching groups. Set by string comparisons (= and !=} in double-bracket test expressions when a match is found (when != returns false), by case when a match is encountered, and by the substitution operations ${x#pat}$, ${x#pat}$, ${x%pat}$, ${x%pat}$, ${x@/pat/rpl}$, and ${x@/pat/rpl}$. See the end of the Emacs editing mode documentation for an example.

KSH_VERSION  The name and version of the shell (read-only). See also the version commands in Emacs editing mode and Vi editing mode sections, below.

LINENO  The line number of the function or shell script that is currently being executed.

LINES  Set to the number of lines on the terminal or window. Defaults to 24; always set, unless imported or unset. See COLUMNS.

OLDPWD  The previous working directory. Unset if cd has not successfully changed directories since the shell started or if the shell doesn’t know where it is.

OPTARG  When using getopt, it contains the argument for a parsed option, if it requires one.

OPTIND  The index of the next argument to be processed when using getopt. Assigning 1 to this parameter causes getopt to process arguments from the beginning the next time it is invoked.

PATH  A colon (semicolon on OS/2) separated list of directories that are searched when looking for commands and files sourced using the "." command (see below). An empty string resulting from a leading or trailing (semi)colon, or two adjacent ones, is treated as a "." (the current directory).

PATHSEP  A colon (semicolon on OS/2), for the user’s convenience.

PGRP  The process ID of the shell’s process group leader.

PIPESTATUS  An array containing the errorlevel (exit status) codes, one by one, of the last pipeline run in the foreground.

PPID  The process ID of the shell’s parent.

PS1  The primary prompt for interactive shells. Parameter, command and arithmetic substitutions are performed, and ‘!’ is replaced with the current command number (see the fc command below). A literal ‘!’ can be put in the prompt by placing “!!” in PS1.

The default prompt is “$ ” for non-root users, “# ” for root. If mksh is invoked by root and PS1 does not contain a ‘#’ character, the default value will be used even if PS1 already exists
in the environment.

The `mksh` distribution comes with a sample dot.mkshrc containing a sophisticated example, but you might like the following one (note that `$HOSTNAME:=$(hostname)` and the root-vs-user distinguishing clause are (in this example) executed at `PS1` assignment time, while the `$USER` and `$PWD` are escaped and thus will be evaluated each time a prompt is displayed):

```
PS1="${USER:=$(id -un)}"@${HOSTNAME:=$(hostname)}:~$PWD $(
    if (( USER_ID )); then print \$; else print \#; fi) 
"
```

Note that since the command-line editors try to figure out how long the prompt is (so they know how far it is to the edge of the screen), escape codes in the prompt tend to mess things up. You can tell the shell not to count certain sequences (such as escape codes) by prefixing your prompt with a character (such as Ctrl-A) followed by a carriage return and then delimiting the escape codes with this character. Any occurrences of that character in the prompt are not printed. By the way, don't blame me for this hack; it's derived from the original ksh88(1), which did print the delimiter character so you were out of luck if you did not have any non-printing characters.

Since backslashes and other special characters may be interpreted by the shell, to set `PS1` either escape the backslash itself or use double quotes. The latter is more practical. This is a more complex example, avoiding to directly enter special characters (for example with `^V` in the emacs editing mode), which embeds the current working directory, in reverse video (colour would work, too), in the prompt string:

```
x=$(print \001) # otherwise unused char
PS1="$x$(print \r)$x$(tput so)$x\$PWD$x$(tput se)$x> "
```

Due to a strong suggestion from David G. Korn, `mksh` now also supports the following form:

```
PS1=$'\1\1\1\1[e7m]$PWD$'\1\1[e0m]$'
```

**PS2**

Secondary prompt string, by default “> “, used when more input is needed to complete a command.

**PS3**

Prompt used by the `select` statement when reading a menu selection. The default is “#? “.

**PS4**

Used to prefix commands that are printed during execution tracing (see the `set` `-x` command below). Parameter, command and arithmetic substitutions are performed before it is printed. The default is “+ “. You may want to set it to “[$EPOCHREALTIME] “ instead, to include timestamps.

**PWD**

The current working directory. May be unset or empty if the shell doesn't know where it is.

**RANDOM**

Each time `RANDOM` is referenced, it is assigned a number between 0 and 32767 from a Linear Congruential PRNG first.

**REPLY**

Default parameter for the `read` command if no names are given. Also used in `select` loops to store the value that is read from standard input.

**SECONDS**

The number of seconds since the shell started or, if the parameter has been assigned an integer value, the number of seconds since the assignment plus the value that was assigned.

**TMOUT**

If set to a positive integer in an interactive shell, it specifies the maximum number of seconds the shell will wait for input after printing the primary prompt (`PS1`). If the time is exceeded, the shell exits.

**TMPDIR**

The directory temporary shell files are created in. If this parameter is not set or does not contain the absolute path of a writable directory, temporary files are created in `/tmp`. 
USER_ID  The effective user id of the shell at startup.

Tilde expansion

Tilde expansion, which is done in parallel with parameter substitution, is applied to words starting with an unquoted ‘~’. In parameter assignments (such as those preceding a simple-command or those occurring in the arguments of a declaration utility), tilde expansion is done after any assignment (i.e. after the equals sign) or after an unquoted colon (‘:’); login names are also delimited by colons. The Korn shell, except in POSIX mode, always expands tildes after unquoted equals signs, not just in assignment context (see below), and enables tab completion for tildes after all unquoted colons during command line editing.

The characters following the tilde, up to the first ‘/’, if any, are assumed to be a login name. If the login name is empty, ‘+’ or ‘−’, the simplified value of the HOME, PWD or OLDPWD parameter is substituted, respectively. Otherwise, the password file is searched for the login name, and the tilde expression is substituted with the user’s home directory. If the login name is not found in the password file or if any quoting or parameter substitution occurs in the login name, no substitution is performed.

The home directory of previously expanded login names are cached and re-used. The alias -d command may be used to list, change and add to this cache (e.g. alias -d fac=/usr/local/facilities; cd ~fac/bin).

Brace expansion (alternation)

Brace expressions take the following form:

```
prefix{str1,...,strN}suffix
```

The expressions are expanded to N words, each of which is the concatenation of prefix, str and suffix (e.g. “a{c,b{X,Y},d}e” expands to four words: “ace”, “abxe”, “abye” and “ade”). As noted in the example, brace expressions can be nested and the resulting words are not sorted. Brace expressions must contain an unquoted comma (‘,’) for expansion to occur (e.g. {} and {foo} are not expanded). Brace expansion is carried out after parameter substitution and before file name generation.

File name patterns

A file name pattern is a word containing one or more unquoted ‘?’, ‘*’, ‘+', ‘@’ or ‘!’ characters or “[... ]” sequences. Once brace expansion has been performed, the shell replaces file name patterns with the sorted names of all the files that match the pattern (if no files match, the word is left unchanged). The pattern elements have the following meaning:

- ? Matches any single character.
- * Matches any sequence of octets.
- [...] Matches any of the octets inside the brackets. Ranges of octets can be specified by separating two octets by a ‘−’ (e.g. “[a0−9]” matches the letter ‘α’ or any digit). In order to represent itself, a ‘−’ must either be quoted or the first or last octet in the octet list. Similarly, a ‘]’ must be quoted or the first octet in the list if it is to represent itself instead of the end of the list. Also, a ‘!’ appearing at the start of the list has special meaning (see below), so to represent itself it must be quoted or appear later in the list.
- [!... ] Like […], except it matches any octet not inside the brackets.
- *(pattern)...*(pattern) Matches any string of octets that matches zero or more occurrences of the specified patterns. Example: The pattern *(foo|bar) matches the strings “”, “foo”, “bar”, “foobarfoo”, etc.
Matches any string of octets that matches one or more occurrences of the specified patterns. Example: The pattern `+(foo|bar)` matches the strings “foo”, “bar”, “foobar”, etc.

Matches the empty string or a string that matches one of the specified patterns. Example: The pattern `?(foo|bar)` only matches the strings “”, “foo” and “bar”.

Matches a string that matches one of the specified patterns. Example: The pattern `@(foo|bar)` only matches the strings “foo” and “bar”.

Matches any string that does not match one of the specified patterns. Examples: The pattern `!(foo|bar)` matches all strings except “foo” and “bar”; the pattern `!(?*)` matches all strings (think about it).

Note that complicated globbing, especially with alternatives, is slow; using separate comparisons may (or may not) be faster.

Note that `mksh` (and `pdksh`) never matches “.” and “..”, but AT&T UNIX `ksh`, Bourne `sh` and GNU `bash` do.

Note that none of the above pattern elements match either a period (‘.’) at the start of a file name or a slash (‘/’), even if they are explicitly used in a [...] sequence; also, the names “.” and “..” are never matched, even by the pattern “.*”.

If the `markdirs` option is set, any directories that result from file name generation are marked with a trailing ‘/’.

### Input/output redirection

When a command is executed, its standard input, standard output and standard error (file descriptors 0, 1 and 2, respectively) are normally inherited from the shell. Three exceptions to this are commands in pipelines, for which standard input and/or standard output are those set up by the pipeline, asynchronous commands created when job control is disabled, for which standard input is initially set to `/dev/null`, and commands for which any of the following redirections have been specified:

- `> file` Standard output is redirected to file. If file does not exist, it is created; if it does exist, is a regular file, and the `noclobber` option is set, an error occurs; otherwise, the file is truncated. Note that this means the command `cmd <foo >foo` will open foo for reading and then truncate it when it opens it for writing, before `cmd` gets a chance to actually read `foo`.

- `>| file` Same as >, except the file is truncated, even if the `noclobber` option is set.

- `>> file` Same as >, except if file exists it is appended to instead of being truncated. Also, the file is opened in append mode, so writes always go to the end of the file (see `open`).

- `< file` Standard input is redirected from file, which is opened for reading.

- `= file` Same as <, except the file is opened for reading and writing.

- `<< marker` After reading the command line containing this kind of redirection (called a “here document”), the shell copies lines from the command source into a temporary file until a line matching `marker` is read. When the command is executed, standard input is redirected from the temporary file. If `marker` contains no quoted characters, the contents of the temporary file are processed as if enclosed in double quotes each time the command is executed, so parameter, command and arithmetic substitutions are performed, along with backslash (‘\’) escapes for ‘$’, ‘\’, ‘\’ and “newline”, but not for ‘‘’. If multiple here documents are used on the same command line, they are saved in order.
If no `marker` is given, the here document ends at the next `<<` and substitution will be performed. If `marker` is only a set of either single “‘” or double “‘” quotes with nothing in between, the here document ends at the next empty line and substitution will not be performed.

`<<-marker` Same as `<<`, except leading tabs are stripped from lines in the here document.

`<<<word` Same as `<<`, except that `word` is the here document. This is called a here string.

`<&fd` Standard input is duplicated from file descriptor `fd`. `fd` can be a single digit, indicating the number of an existing file descriptor; the letter ‘p’, indicating the file descriptor associated with the output of the current co-process; or the character ‘−’, indicating standard input is to be closed.

`>&fd` Same as `<&`, except the operation is done on standard output.

`&>file` Same as `>file 2>&1`. This is a deprecated (legacy) GNU `bash` extension supported by `mksh` which also supports the preceding explicit fd digit, for example, `3>&file` is the same as `>file 2>&3` in `mksh` but a syntax error in GNU `bash`.

`&>|file, &>>file, &>&fd` Same as `>file, >>file or >&fd`, followed by `2>&1`, as above. These are `mksh` extensions.

Arithmetic expressions

Integer arithmetic expressions can be used with the `let` command, inside `$((...))` expressions, inside array references (e.g. `name[expr]`), as numeric arguments to the `test` command, and as the value of an assignment to an integer parameter. **Warning:** This also affects implicit conversion to integer, for example as done by the `let` command. *Never* use unchecked user input, e.g. from the environment, in an arithmetic context.

Expressions are calculated using signed arithmetic and the `mksh_arit` type (a 32-bit signed integer), unless they begin with a sole ‘#’ character, in which case they use `mksh_uari_t` (a 32-bit unsigned integer).

Expressions may contain alpha-numeric parameter identifiers, array references and integer constants and may be combined with the following C operators (listed and grouped in increasing order of precedence):

Unary operators:

```
+  -  !  ~  ++  --
```

Binary operators:

```
,  =  +=  -=  *=  /=  %=  <<=  >>=  ^=  &=  ^=  |=
||

```
&&
|
^&
== !=
<< >>= ^< ^>
+ -
* / %

Ternary operators:
?: (precedence is immediately higher than assignment)

Grouping operators:
( )

Integer constants and expressions are calculated using an exactly 32-bit wide, signed or unsigned, type with silent wraparound on integer overflow. Integer constants may be specified with arbitrary bases using the notation `base#number`, where `base` is a decimal integer specifying the base (up to 36), and `number` is a number in the specified base. Additionally, base-16 integers may be specified by prefixing them with “0x” (case-insensitive) in all forms of arithmetic expressions, except as numeric arguments to the `test` built-in utility. Prefixing numbers with a sole digit zero (“0”) does not cause interpretation as octal (except in POSIX mode, as required by the standard), as that’s unsafe to do.

As a special `mksh` extension, numbers to the base of one are treated as either (8-bit transparent) ASCII or Universal Coded Character Set codepoints, depending on the shell’s `utf8-mode` flag (current setting). The AT&T UNIX ksh93 syntax of ‘x’ instead of ‘1#x’ is also supported. Note that NUL bytes (integral value of zero) cannot be used. An unset or empty parameter evaluates to 0 in integer context. If ‘x’ isn’t comprised of exactly one valid character, the behaviour is undefined (usually, the shell aborts with a parse error, but rarely, it succeeds, e.g. on the sequence C2 20); users of this feature (as opposed to `read -a`) must validate the input first. See CAVEATS for UTF-8 mode handling.

The operators are evaluated as follows:

- **unary +**
  - Result is the argument (included for completeness).

- **unary -**
  - Negation.

- **!**
  - Logical NOT; the result is 1 if argument is zero, 0 if not.

- **~**
  - Arithmetic (bit-wise) NOT.

- **++**
  - Increment; must be applied to a parameter (not a literal or other expression). The parameter is incremented by 1. When used as a prefix operator, the result is the incremented value of the parameter; when used as a postfix operator, the result is the original value of the parameter.

- **--**
  - Similar to `++`, except the parameter is decremented by 1.

- **,**
  - Separates two arithmetic expressions; the left-hand side is evaluated first, then the right. The result is the value of the expression on the right-hand side.

- **=**
  - Assignment; the variable on the left is set to the value on the right.
Assignment operators. `<var><op><expr>` is the same as `<var><expr>` with any operator precedence in `<expr>` preserved. For example, "`var1 *= 5 + 3`" is the same as specifying "`var1 = var1 * (5 + 3)`".

`||` Logical OR; the result is 1 if either argument is non-zero, 0 if not. The right argument is evaluated only if the left argument is zero.

`&&` Logical AND; the result is 1 if both arguments are non-zero, 0 if not. The right argument is evaluated only if the left argument is non-zero.

`|` Arithmetic (bit-wise) OR.

`^` Arithmetic (bit-wise) XOR (exclusive-OR).

`&` Arithmetic (bit-wise) AND.

`==` Equal; the result is 1 if both arguments are equal, 0 if not.

`!=` Not equal; the result is 0 if both arguments are equal, 1 if not.

`<` Less than; the result is 1 if the left argument is less than the right, 0 if not.

`<=` Greater than or equal.

`>=` Less than or equal, greater than, greater than or equal. See `<`.

`<<` Shift left (right); the result is the left argument with its bits arithmetically (signed operation) or logically (unsigned expression) shifted left (right) by the amount given in the right argument.

`^<` Rotate left (right); the result is similar to shift, except that the bits shifted out at one end are shifted in at the other end, instead of zero or sign bits.

`+-*/` Addition, subtraction, multiplication and division.

`%` Remainder; the result is the symmetric remainder of the division of the left argument by the right. To get the mathematical modulus of "`a mod b`", use the formula "`(a % b + b) % b`".

`<arg1>-<arg2>:<arg3>`

If `<arg1>` is non-zero, the result is `<arg2>`; otherwise the result is `<arg3>`. The non-result argument is not evaluated.

Co-processes

A co-process (which is a pipeline created with the "`&`" operator) is an asynchronous process that the shell can both write to (using `print -p`) and read from (using `read -p`). The input and output of the co-process can also be manipulated using `>p` and `<p` redirections, respectively. Once a co-process has been started, another can’t be started until the co-process exits, or until the co-process’s input has been redirected using an `exec n>p` redirection. If a co-process’s input is redirected in this way, the next co-process to be started will share the output with the first co-process, unless the output of the initial co-process has been redirected using an `exec n<p` redirection.

Some notes concerning co-processes:

- The only way to close the co-process’s input (so the co-process reads an end-of-file) is to redirect the input to a numbered file descriptor and then close that file descriptor: `exec 3>p; exec 3<&-

- In order for co-processes to share a common output, the shell must keep the write portion of the output pipe open. This means that end-of-file will not be detected until all co-processes sharing the co-process’s output have exited (when they all exit, the shell closes its copy of the pipe). This can be avoided by redirecting the output to a numbered file descriptor (as this also causes the shell to close its copy).
Note that this behaviour is slightly different from the original Korn shell which closes its copy of the write portion of the co-process output when the most recently started co-process (instead of when all sharing co-processes) exits.

- **print** `-p` will ignore SIGPIPE signals during writes if the signal is not being trapped or ignored; the same is true if the co-process input has been duplicated to another file descriptor and **print** `-uN` is used.

### Functions

Functions are defined using either Korn shell `function function-name` syntax or the Bourne/POSIX shell `function-name()` syntax (see below for the difference between the two forms). Functions are like `. -scripts` (i.e. scripts sourced using the `"."` built-in) in that they are executed in the current environment. However, unlike `. -scripts`, shell arguments (i.e. positional parameters `$1`, `$2`, etc.) are never visible inside them. When the shell is determining the location of a command, functions are searched after special built-in commands, before builtins and the `PATH` is searched.

An existing function may be deleted using `unset -f function-name`. A list of functions can be obtained using `typeset +f` and the function definitions can be listed using `typeset -f`. The `autoload` command (which is an alias for `typeset -fu`) may be used to create undefined functions: when an undefined function is executed, the shell searches the path specified in the `FPATH` parameter for a file with the same name as the function which, if found, is read and executed. If after executing the file the named function is found to be defined, the function is executed; otherwise, the normal command search is continued (i.e. the shell searches the regular built-in command table and `PATH`). Note that if a command is not found using `PATH`, an attempt is made to autoload a function using `FPATH` (this is an undocumented feature of the original Korn shell).

Functions can have two attributes, “trace” and “export”, which can be set with `typeset -ft` and `typeset -fx`, respectively. When a traced function is executed, the shell’s `xtrace` option is turned on for the function’s duration. The “export” attribute of functions is currently not used.

Since functions are executed in the current shell environment, parameter assignments made inside functions are visible after the function completes. If this is not the desired effect, the `typeset` command can be used inside a function to create a local parameter. Note that AT&T UNIX `ksh93` uses static scoping (one global scope, one local scope per function) and allows local variables only on Korn style functions, whereas `mksh` uses dynamic scoping (nested scopes of varying locality). Note that special parameters (e.g. `$$, `$$`) can’t be scoped in this way.

The exit status of a function is that of the last command executed in the function. A function can be made to finish immediately using the `return` command; this may also be used to explicitly specify the exit status. Note that when called in a subshell, `return` will only exit that subshell and will not cause the original shell to exit a running function (see the `while...read` loop FAQ).

Functions defined with the `function` reserved word are treated differently in the following ways from functions defined with the `()` notation:

- The `$0` parameter is set to the name of the function (Bourne-style functions leave `$0` untouched).
- `OPTIND` is saved/reset and restored on entry and exit from the function so `getopts` can be used properly both inside and outside the function (Bourne-style functions leave `OPTIND` untouched, so using `getopts` inside a function interferes with using `getopts` outside the function).
- Shell options (`set -o`) have local scope, i.e. changes inside a function are reset upon its exit.

In the future, the following differences may also be added:
• A separate trap/signal environment will be used during the execution of functions. This will mean that traps set inside a function will not affect the shell’s traps and signals that are not ignored in the shell (but may be trapped) will have their default effect in a function.
• The EXIT trap, if set in a function, will be executed after the function returns.

Command execution
After evaluation of command-line arguments, redirections and parameter assignments, the type of command is determined: a special built-in command, a function, a normal builtin or the name of a file to execute found using the PATH parameter. The checks are made in the above order. Special built-in commands differ from other commands in that the PATH parameter is not used to find them, an error during their execution can cause a non-interactive shell to exit, and parameter assignments that are specified before the command are kept after the command completes. Regular built-in commands are different only in that the PATH parameter is not used to find them.

The original ksh and POSIX differ somewhat in which commands are considered special or regular.

POSIX special built-in utilities:
.. :: break, continue, eval, exec, exit, export, readonly, return, set, shift, times, trap, unset

Additional mksh commands keeping assignments:
global, source, typeset

Builtins that are not special:
[. alias, bg, bind, builtin, cat, cd, command, echo, false, fc, fg, getopts, jobs, kill, let, print, pwd, read, realpath, rename, sleep, suspend, test, true, ulimit, umask, unalias, wait, whence

Once the type of command has been determined, any command-line parameter assignments are performed and exported for the duration of the command.

The following describes the special and regular built-in commands and builtin-like reserved words:

. file [arg ...]
   This is called the “dot” command. Execute the commands in file in the current environment. The file is searched for in the directories of PATH. If arguments are given, the positional parameters may be used to access them while file is being executed. If no arguments are given, the positional parameters are those of the environment the command is used in.

: [...]  
The null command. Exit status is set to zero.

[ expression ]
   See test.

alias [-d | -t [-r]|+-x][-p][+][name=[-value] ...]
   Without arguments, alias lists all aliases. For any name without a value, the existing alias is listed. Any name with a value defines an alias; see Aliases above. [A-Za-z0-9_!%+,.@:] are valid in names, except they may not begin with a plus or hyphen-minus, and [] is not a valid alias name.

   When listing aliases, one of two formats is used. Normally, aliases are listed as name=value, where value is quoted. If options were preceded with ‘+’, or a lone ‘+’ is given on the command line, only name is printed.

   The –d option causes directory aliases which are used in tilde expansion to be listed or set (see Tilde expansion above).
If the `-p` option is used, each alias is prefixed with the string “alias “.

The `-t` option indicates that tracked aliases are to be listed/set (values specified on the command line are ignored for tracked aliases). The `-r` option indicates that all tracked aliases are to be reset.

The `-x` option sets (+x clears) the export attribute of an alias, or, if no names are given, lists the aliases with the export attribute (exporting an alias has no effect).

**bg [job ...]**

Resume the specified stopped job(s) in the background. If no jobs are specified, `%+` is assumed. See Job control below for more information.

**bind [-l]**

The current bindings are listed. If the `-l` flag is given, `bind` instead lists the names of the functions to which keys may be bound. See Emacs editing mode for more information.

**bind [-m] string=[substitute] ...**

**bind string=[editing-command] ...**

The specified editing command is bound to the given `string`, which should consist of a control character optionally preceded by one of the two prefix characters and optionally succeeded by a tilde character. Future input of the `string` will cause the editing command to be immediately invoked. If the `-m` flag is given, the specified input `string` will afterwards be immediately replaced by the given `substitute` string which may contain editing commands but not other macros. If a tilde postfix is given, a tilde trailing the one or two prefixed and the control character is ignored, any other trailing character will be processed afterwards.

Control characters may be written using caret notation i.e. `^X` represents Ctrl-X. The caret itself can be escaped by a backslash, which also escapes itself. Note that although only three prefix characters (usually ESC, `^X` and `NUL`) are supported, some multi-character sequences can be supported.

The following default bindings show how the arrow keys, the home, end and delete key on a BSD wsvt25, xterm-xfree86 or GNU screen terminal are bound (of course some escape sequences won’t work out quite this nicely):

```
bind '^[=prefix-2
bind '^[=prefix-2
bind '^[A=up-history
bind '^[B=down-history
bind '^[C=forward-char
bind '^[D=backward-char
bind '^[1~=beginning-of-line
bind '^[7~=beginning-of-line
bind '^[H=beginning-of-line
bind '^[4~=end-of-line
bind '^[8~=end-of-line
bind '^[F=end-of-line
bind '^[3~=delete-char-forward
```

**break [level]**

Exit the `level`th inner-most `for`, `select`, `until` or `while` loop. `level` defaults to 1.

**builtin [--] command [arg ...]**

Execute the built-in command `command`.

**\builtin command [arg ...]**

Same as `builtin`. Additionally acts as declaration utility forwarder, i.e. this is a declaration utility (see Tilde expansion) iff `command` is a declaration utility.
cat \([-u]\)[file ...]
Read files sequentially, in command line order, and write them to standard output. If a file is a single dash ("-") or absent, read from standard input. For direct builtin calls, the POSIX \(-u\) option is supported as a no-op. For calls from shell, if any options are given, an external cat(1) utility is preferred over the builtin.

cd \([-L]\)[dir]
cd \(-P\) \([-e]\)[dir]
chdir \([-eLP]\)[dir]
Set the working directory to \textit{dir}. If the parameter CDPATH is set, it lists the search path for the directory containing \textit{dir}. An unset or empty path means the current directory. If \textit{dir} is found in any component of the CDPATH search path other than an unset or empty path, the name of the new working directory will be written to standard output. If \textit{dir} is missing, the home directory HOME is used. If \textit{dir} is "-", the previous working directory is used (see the OLDPWD parameter).

If the \(-L\) option (logical path) is used or if the \textit{physical} option isn't set (see the set command below), references to ".." in \textit{dir} are relative to the path used to get to the directory. If the \(-P\) option (physical path) is used or if the \textit{physical} option is set, ".." is relative to the filesystem directory tree. The PWD and OLDPWD parameters are updated to reflect the current and old working directory, respectively. If the \(-e\) option is set for physical filesystem traversal and PWD could not be set, the exit code is 1; greater than 1 if an error occurred, 0 otherwise.

cd \([-eLP]\) old new
chdir \([-eLP]\) old new
The string \textit{new} is substituted for \textit{old} in the current directory, and the shell attempts to change to the new directory.

\textbf{command} \([-pVv]\) cmd[\textit{arg ...}]
If neither the \(-v\) nor \(-V\) option is given, cmd is executed exactly as if command had not been specified, with two exceptions: firstly, cmd cannot be a shell function; and secondly, special built-in commands lose their specialness (i.e. redirection and utility errors do not cause the shell to exit, and command assignments are not permanent). The declaration utility property is not reset.

If the \(-p\) option is given, a default search path is used instead of the current value of PATH, the actual value of which is system dependent.

If the \(-v\) option is given, instead of executing cmd, information about what would be executed is given (and the same is done for \textit{arg ...}). For builtins, functions and keywords, their names are simply printed; for aliases, a command that defines them is printed; for utilities found by searching the PATH parameter, the full path of the command is printed. If no command is found (i.e. the path search fails), nothing is printed and command exits with a non-zero status. The \(-V\) option is like the \(-v\) option, except it is more verbose.

\textbf{continue} \([\textit{level}]\)
Jumps to the beginning of the \textit{level}th inner-most for, select, until or while loop. level defaults to 1.

ehco \([-Een]\)[\textit{arg ...}]
Warning: this utility is not portable; use the Korn shell builtin \textit{print} instead.

Prints its arguments (separated by spaces) followed by a newline, to the standard output. The newline is suppressed if any of the arguments contain the backslash sequence "\c". See the \textit{print} command below for a list of other backslash sequences that are recognised.

The options are provided for compatibility with BSD shell scripts. The \(-n\) option suppresses the trailing newline, \(-e\) enables backslash interpretation (a no-op, since this is normally done), and \(-E\) suppresses backslash interpretation.
If the **posix** or **sh** option is set or this is a direct builtin call or **print** -R, only the first argument is treated as an option, and only if it is exactly “−n”. Backslash interpretation is disabled.

**eval** **command** ...  
The arguments are concatenated (with spaces between them) to form a single string which the shell then parses and executes in the current environment.

**exec** [-a **argv0**] [-c] [**command** [arg ...]]  
The command is executed without forking, replacing the shell process. This is currently absolute, i.e. **exec** never returns, even if the **command** is not found. The -a option permits setting a different **argv[0]** value, and -c clears the environment before executing the child process, except for the _ variable and direct assignments.

If no command is given except for I/O redirection, the I/O redirection is permanent and the shell is not replaced. Any file descriptors greater than 2 which are opened or dup(2)'d in this way are not made available to other executed commands (i.e. commands that are not built-in to the shell). Note that the Bourne shell differs here; it does pass these file descriptors on.

**exit** [**status**]  
The shell or subshell exits with the specified exit status. If **status** is not specified, the exit status is the current value of the $? parameter.

**export** [-p] [**parameter**=[value]]  
Sets the export attribute of the named parameters. Exported parameters are passed in the environment to executed commands. If values are specified, the named parameters are also assigned. This is a declaration utility.

If no parameters are specified, all parameters with the export attribute set are printed one per line; either their names, or, if a “−” with no option letter is specified, name=value pairs, or, with -p, **export** commands suitable for re-entry.

**false**  
A command that exits with a non-zero status.

**fc** [-e **editor** | -l [−n]] [−r] [**first** [**last**]]  
**first** and **last** select commands from the history. Commands can be selected by history number (negative numbers go backwards from the current, most recent, line) or a string specifying the most recent command starting with that string. The -l option lists the command on standard output, and -n inhibits the default command numbers. The -r option reverses the order of the list. Without -l, the selected commands are edited by the editor specified with the -e option or, if no -e is specified, the editor specified by the FCEDIT parameter (if this parameter is not set, /bin/ed is used), and then executed by the shell.

**fc** -e − | -s [−g] [old=new] [prefix]  
Re-execute the selected command (the previous command by default) after performing the optional substitution of old with new. If -g is specified, all occurrences of old are replaced with new. The meaning of -e - and -s is identical: re-execute the selected command without invoking an editor. This command is usually accessed with the predefined: alias r='fc -e -'

**fg** [**job** ...]  
Resume the specified job(s) in the foreground. If no jobs are specified, %+ is assumed. See Job control below for more information.

**getopts** **optstring** **name** [arg ...]  
Used by shell procedures to parse the specified arguments (or positional parameters, if no arguments are given) and to check for legal options. **optstring** contains the option letters that **getopts** is to recognise. If a letter is followed by a colon, the option is expected to have an argument. Options that do not take arguments may be grouped in a single argument. If an option takes
an argument and the option character is not the last character of the argument it is found in, the re-
mainder of the argument is taken to be the option’s argument; otherwise, the next argument is the
option’s argument.

Each time `getopts` is invoked, it places the next option in the shell parameter `name` and the index
of the argument to be processed by the next call to `getopts` in the shell parameter `OPTIND`. If the
option was introduced with a ‘+’, the option placed in `name` is prefixed with a ‘+’. When an option
requires an argument, `getopts` places it in the shell parameter `OPTARG`.

When an illegal option or a missing option argument is encountered, a question mark or a colon is
placed in `name` (indicating an illegal option or missing argument, respectively) and `OPTARG` is set to
the option character that caused the problem. Furthermore, if `optstring` does not begin with a
colon, a question mark is placed in `name`, `OPTARG` is unset, and an error message is printed to stan-
dard error.

When the end of the options is encountered, `getopts` exits with a non-zero exit status. Options end
at the first (non-option argument) argument that does not start with a ‘−’, or when a “−−” argument
is encountered.

Option parsing can be reset by setting `OPTIND` to 1 (this is done automatically whenever the shell or
a shell procedure is invoked).

Warning: Changing the value of the shell parameter `OPTIND` to a value other than 1 or parsing differ-
ent sets of arguments without resetting `OPTIND` may lead to unexpected results.

global [+aglpntux] [+L[n] | +R[n] | +Z[n] ][ +i[n] ][name[=value] ...]
See `typeset` −g. Deprecated, will be removed from a future version of `mksh`.

hash [−r] [name ...]
Without arguments, any hashed executable command pathnames are listed. The `−r` option causes
all hashed commands to be removed from the hash table. Each `name` is searched as if it were a com-
mand name and added to the hash table if it is an executable command.

jobs [−lnp] [job ...]
Display information about the specified job(s); if no jobs are specified, all jobs are displayed. The `−n`
option causes information to be displayed only for jobs that have changed state since the last notifi-
cation. If the `−l` option is used, the process ID of each process in a job is also listed. The `−p` option
causes only the process group of each job to be printed. See Job control below for the format of `job`
and the displayed job.

kill [−s signame | −signum | −signame]{ job | pid | pgrp } ... Send the specified signal to the specified jobs, process IDs or process groups. If no signal is specified, the TERM
signal is sent. If a job is specified, the signal is sent to the job’s process group. See Job
control below for the format of `job`.

kill −l [exit-status ...]
Print the signal name corresponding to `exit-status`. If no arguments are specified, a list of all
the signals with their numbers and a short description of each are printed.

let [expression ...]
Each expression is evaluated (see Arithmetic expressions above). If all expressions are successfully
evaluated, the exit status is 0 (1) if the last expression evaluated to non-zero (zero). If an error oc-
urs during the parsing or evaluation of an expression, the exit status is greater than 1. Since expres-
sions may need to be quoted, `(( expr ))` is syntactic sugar for:
{ \builtin let `expr'; }

mknod [-m mode] name b|c major minor
mknod [-m mode] name p

Create a device special file. The file type may be b (block type device), c (character type device) or p (named pipe, FIFO). The file created may be modified according to its mode (via the -m option), major (major device number), and minor (minor device number). This is not normally part of mksh; however, distributors may have added this as builtin as a speed hack.

print [-AcelNnprs][ -R [-n]] [argument ...]

Print the specified argument(s) on the standard output, separated by spaces, terminated with a newline. The escapes mentioned in Backslash expansion above, as well as "\c", which is equivalent to using the -n option, are interpreted.

The options are as follows:
- A Each argument is arithmetically evaluated; the character corresponding to the resulting value is printed. Empty arguments separate input words.
- c The output is printed columnised, line by line, similar to how the rs(1) utility, tab completion, the kill -l built-in utility and the select statement do.
- e Restore backslash expansion after a previous -r.
- l Change the output word separator to newline.
- N Change the output word and line separator to ASCII NUL.
- n Do not print the trailing line separator.
- p Print to the co-process (see Co-processes above).
- r Inhibit backslash expansion.
- s Print to the history file instead of standard output.
- u[n] Print to the file descriptor n (defaults to 1 if omitted) instead of standard output.

The -R option mostly emulates the BSD echo(1) command which does not expand backslashes and interprets its first argument as option only if it is exactly "-n" (to suppress the trailing newline).

pwd [-LP]

Print the present working directory. If the -L option is used or if the physical option isn’t set (see the set command below), the logical path is printed (i.e. the path used to cd to the current directory). If the -P option (physical path) is used or if the physical option is set, the path determined from the filesystem (by following ".." directories to the root directory) is printed.

read [-A | -a][-d x][-N z | -n z][-p | -u[n]][-t n][ -rs][p ...]

Reads a line of input, separates the input into fields using the IFS parameter (see Substitution above), and assigns each field to the specified parameters p. If no parameters are specified, the REPLY parameter is used to store the result. With the -A and -a options, only no or one parameter is accepted. If there are more parameters than fields, the extra parameters are set to the empty string or 0; if there are more fields than parameters, the last parameter is assigned the remaining fields (including the word separators).

The options are as follows:
- A Store the result into the parameter p (or REPLY) as array of words.
- a Store the result without word splitting into the parameter p (or REPLY) as array of characters (wide characters if the utf8-mode option is enacted, octets otherwise); the codepoints are encoded as decimal numbers by default.
−d x  Use the first byte of x, NUL if empty, instead of the ASCII newline character as input line delimiter.

−N z  Instead of reading till end-of-line, read exactly Z bytes. Upon EOF, a partial read is returned with exit status 1. After timeout, a partial read is returned with an exit status as if SIGALRM were caught.

−n z  Instead of reading till end-of-line, read up to Z bytes but return as soon as any bytes are read, e.g. from a slow terminal device, or if EOF or a timeout occurs.

−p  Read from the currently active co-process, see Co-processes above for details on this.

−u[n]  Read from the file descriptor n (defaults to 0, i.e. standard input). The argument must immediately follow the option character.

−t n  Interrupt reading after n seconds (specified as positive decimal value with an optional fractional part). The exit status of read is the same as if SIGALRM were caught if the timeout occurred, but partial reads may still be returned.

−r  Normally, the ASCII backslash character escapes the special meaning of the following character and is stripped from the input; read does not stop when encountering a backslash-newline sequence and does not store that newline in the result. This option enables raw mode, in which backslashes are not processed.

−s  The input line is saved to the history.

If the input is a terminal, both the −N and −n options set it into raw mode; they read an entire file if −1 is passed as Z argument.

The first parameter may have a question mark and a string appended to it, in which case the string is used as a prompt (printed to standard error before any input is read) if the input is a tty(4) (e.g. read nfoo? 'number of foos: ').

If no input is read or a timeout occurred, read exits with a non-zero status.

readonly [-p] [parameter [=value] ...]
Sets the read-only attribute of the named parameters. This is a declaration utility. If values are given, parameters are set to them before setting the attribute. Once a parameter is made read-only, it cannot be unset and its value cannot be changed.

If no parameters are specified, the names of all parameters with the read-only attribute are printed one per line, unless the −p option is used, in which case readonly commands defining all read-only parameters, including their values, are printed.

realpath [−−] name
Prints the resolved absolute pathname corresponding to name. If name ends with a slash (‘/’), it’s also checked for existence and whether it is a directory; otherwise, realpath returns 0 if the pathname either exists or can be created immediately, i.e. all but the last component exist and are directories. For calls from the shell, if any options are given, an external realpath(1) utility is preferred over the builtin.

rename [−−] from to
Renames the file from to. Both must be complete pathnames and on the same device. An external utility is preferred over this builtin, which is intended for emergency situations (where /bin/mv becomes unusable) and directly calls rename(2).
**return** \([\text{status}]\)

Returns from a function or script, with exit status \(\text{status}\). If no \(\text{status}\) is given, the exit status of the last executed command is used. If used outside of a function or script, it has the same effect as \text{exit}. Note that mksh treats both profile and ENV files as scripts, while the original Korn shell only treats profiles as scripts.

**set** \([+-abcEfhiklmprsuvxX][+-o \text{option}][+-\text{A name}][--][\text{arg} ...]\)

The **set** command can be used to set (-) or clear (+) shell options, set the positional parameters, or set an array parameter. Options can be changed using the **+-o option** syntax, where \text{option} is the long name of an option, or using the **+-letter** syntax, where \text{letter} is the option's single letter name (not all options have a single letter name). The following table lists both option letters (if they exist) and long names along with a description of what the option does:

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-A name</td>
<td>Sets the elements of the array parameter \text{name} to \text{arg} ... If -A is used, the array is reset (i.e. emptied) first; if +A is used, the first N elements are set (where N is the number of arguments); the rest are left untouched.</td>
</tr>
<tr>
<td>-a</td>
<td>-o allexport</td>
</tr>
<tr>
<td>-b</td>
<td>-o notify</td>
</tr>
<tr>
<td>-C</td>
<td>-o noclobber</td>
</tr>
<tr>
<td>-e</td>
<td>-o errexit</td>
</tr>
<tr>
<td>-f</td>
<td>-o noglob</td>
</tr>
<tr>
<td>-h</td>
<td>-o trackall</td>
</tr>
<tr>
<td>-i</td>
<td>-o interactive</td>
</tr>
<tr>
<td>-k</td>
<td>-o keyword</td>
</tr>
<tr>
<td>-l</td>
<td>-o login</td>
</tr>
</tbody>
</table>

An alternative syntax for the command **set** -A foo -- a b c which is compatible to GNU bash and also supported by AT&T UNIX ksh93 is: foo=(a b c); foo+=(d e)

- **A name**
  - Sets the elements of the array parameter \text{name} to \text{arg} ...
- **-o allowexport**
  - All new parameters are created with the export attribute.
- **-b | -o notify**
  - Print job notification messages asynchronously, instead of just before the prompt. Only used if job control is enabled (-m).
- **-C**
  - Prevent > redirection from overwriting existing files. Instead, >| must be used to force an overwrite. Note that this is not safe to use for creation of temporary files or lockfiles due to a TOCTOU in a check allowing one to redirect output to /dev/null or other device files even in noclobber mode.
- **-e**
  - Exit (after executing the ERR trap) as soon as an error occurs or a command fails (i.e. exits with a non-zero status). This does not apply to commands whose exit status is explicitly tested by a shell construct such as \text{if, until, while} or \text{!} statements. For && or ||, only the status of the last command is tested.
- **-f**
  - Do not expand file name patterns.
- **-h**
  - Create tracked aliases for all executed commands (see Aliases above). Enabled by default for non-interactive shells.
- **-i**
  - The shell is an interactive shell. This option can only be used when the shell is invoked. See above for a description of what this means.
- **-k**
  - Parameter assignments are recognised anywhere in a command.
- **-l**
  - The shell is a login shell. This option can only be used when the shell is invoked. See above for a description of what this means.
-m | -o monitor
Enable job control (default for interactive shells).

-n | -o noexec
Do not execute any commands. Useful for checking the syntax of scripts (ignored if interactive).

-p | -o privileged
The shell is a privileged shell. It is set automatically if, when the shell starts, the real UID or GID does not match the effective UID (EUID) or GID (EGID), respectively. See above for a description of what this means.

If the shell is privileged, setting this flag after startup files have been processed let it go full setuid and/or setgid. Clearing this flag makes the shell drop privileges. Changing this flag resets the groups vector.

-r | -o restricted
The shell is a restricted shell. This option can only be used when the shell is invoked. See above for a description of what this means.

-s | -o stdin
If used when the shell is invoked, commands are read from standard input. Set automatically if the shell is invoked with no arguments.

When -s is used with the set command it causes the specified arguments to be sorted before assigning them to the positional parameters (or to array name, if -A is used).

-U | -o utf8-mode
Enable UTF-8 support in the Emacs editing mode and internal string handling functions. This flag is disabled by default, but can be enabled by setting it on the shell command line; is enabled automatically for interactive shells if requested at compile time, your system supports setlocale(LC_CTYPE, "") and optionally nl_langinfo(CODESET), or the LC_ALL, LC_CTYPE or LANG environment variables, and at least one of these returns something that matches "UTF-8" or “utf8” case-insensitively; for direct builtin calls depending on the aforementioned environment variables; or for stdin or scripts, if the input begins with a UTF-8 Byte Order Mark.

In near future, locale tracking will be implemented, which means that set -U is changed whenever one of the POSIX locale-related environment variables changes.

-u | -o nounset
Referencing of an unset parameter, other than “$@” or “$*”, is treated as an error, unless one of the ‘-’, ‘+’ or ‘=’ modifiers is used.

-v | -o verbose
Write shell input to standard error as it is read.

-X | -o markdown
Mark directories with a trailing ‘/’ during file name generation.

-x | -o xtrace
Print command trees when they are executed, preceded by the value of PS4.

-o bgnice
Background jobs are run with lower priority.

-o braceexpand
Enable brace expansion (a.k.a. alternation). This is enabled by default.
-o emacs
Enable BRL emacs-like command-line editing (interactive shells only); see Emacs editing mode.

-o gmacs
Enable gmacs-like command-line editing (interactive shells only). Currently identical to emacs editing except that transpose-chars (^T) acts slightly differently.

- o ignoreeof
The shell will not (easily) exit when end-of-file is read; exit must be used. To avoid infinite loops, the shell will exit if EOF is read 13 times in a row.

- o inherit-xtrace
Do not reset -o xtrace upon entering functions. This is enabled by default.

- o nohup
Do not kill running jobs with a SIGHUP signal when a login shell exits. Currently set by default, but this may change in the future to be compatible with AT&T UNIX ksh, which doesn’t have this option, but does send the SIGHUP signal.

- o nolog
No effect. In the original Korn shell, this prevents function definitions from being stored in the history file.

- o physical
Causes the cd and pwd commands to use “physical” (i.e. the filesystem’s) “..” directories instead of “logical” directories (i.e. the shell handles “..”, which allows the user to be oblivious of symbolic links to directories). Clear by default. Note that setting this option does not affect the current value of the PWD parameter; only the cd command changes PWD. See the cd and pwd commands above for more details.

- o pipefail
Make the exit status of a pipeline (before logically complementing) the rightmost non-zero errorlevel, or zero if all commands exited with zero.

- o posix
Behave closer to the standards (see POSIX mode for details). Automatically enabled if the basename of the shell invocation begins with “sh” and this autodetection feature is compiled in (not in MirBSD). As a side effect, setting this flag turns off the braceexpand and utf8-mode flags, which can be turned back on manually, and sh mode (unless both are enabled at the same time).

- o sh
Enable /bin/sh (kludge) mode (see SH mode). Automatically enabled if the basename of the shell invocation begins with “sh” and this autodetection feature is compiled in (not in MirBSD). As a side effect, setting this flag turns off braceexpand mode, which can be turned back on manually, and posix mode (unless both are enabled at the same time).

- o vi
Enable vi(1)-like command-line editing (interactive shells only). See Vi editing mode for documentation and limitations.

- o vi-esccomplete
In vi command-line editing, do command and file name completion when escape (^I) is entered in command mode.
−o vi−tabcomplete
In vi command−line editing, do command and file name completion when tab (^I) is entered in insert mode. This is the default.

−o viraw
No effect. In the original Korn shell, unless viraw was set, the vi command−line mode would let the tty(4) driver do the work until ESC (^[) was entered. mksh is always in viraw mode.

These options can also be used upon invocation of the shell. The current set of options (with single letter names) can be found in the parameter "$−o". set −o with no option name will list all the options and whether each is on or off; set +o will print the long names of all options that are currently on. In a future version, set +o will behave POSIX compliant and print commands to restore the current options instead.

Remaining arguments, if any, are positional parameters and are assigned, in order, to the positional parameters (i.e. $1, $2, etc.). If options end with “−−” and there are no remaining arguments, all positional parameters are cleared. If no options or arguments are given, the values of all names are printed. For unknown historical reasons, a lone “−” option is treated specially – it clears both the −v and −x options.

shift [number]
The positional parameters number+1, number+2, etc. are renamed to 1, 2, etc. number defaults to 1.

sleep seconds
Suspends execution for a minimum of the seconds specified as positive decimal value with an optional fractional part. Signal delivery may continue execution earlier.

source file [arg ...]
Like . ("dot"), except that the current working directory is appended to the search path (GNU bash extension).

suspend
Stops the shell as if it had received the suspend character from the terminal. It is not possible to suspend a login shell unless the parent process is a member of the same terminal session but is a member of a different process group. As a general rule, if the shell was started by another shell or via su(1), it can be suspended.

test expression
[ expression ]
test evaluates the expression and returns zero status if true, 1 if false, or greater than 1 if there was an error. It is normally used as the condition command of if and while statements. Symbolic links are followed for all file expressions except −h and −L.

The following basic expressions are available:

−a file file exists.
−b file file is a block special device.
−c file file is a character special device.
−d file file is a directory.
−e file file exists.
−f file file is a regular file.
-G file  
  file's group is the shell's effective group ID.

-g file  
  file's mode has the setgid bit set.

-H file  
  file is a context dependent directory (only useful on HP-UX).

-h file  
  file is a symbolic link.

-k file  
  file's mode has the sticky(8) bit set.

-L file  
  file is a symbolic link.

-O file  
  file's owner is the shell's effective user ID.

-p file  
  file is a named pipe (FIFO).

-r file  
  file exists and is readable.

-S file  
  file is a unix(4)-domain socket.

-s file  
  file is not empty.

-t fd  
  File descriptor fd is a tty(4) device.

-u file  
  file's mode has the setuid bit set.

-w file  
  file exists and is writable.

-x file  
  file exists and is executable.

file1 -nt file2  
  file1 is newer than file2 or file1 exists and file2 does not.

file1 -ot file2  
  file1 is older than file2 or file2 exists and file1 does not.

file1 -ef file2  
  file1 is the same file as file2.

string  
  string has non-zero length.

-n string  
  string is not empty.

-z string  
  string is empty.

-v name  
  The shell parameter name is set.

-o option  
  Shell option is set (see the set command above for a list of options). As a non-standard extension, if the option starts with a ‘!’ , the test is negated; the test always fails if option doesn’t exist (so [ -o foo -o -o !foo ] returns true if and only if option foo exists). The same can be achieved with [ -o ?foo ] like in AT&T UNIX ksh93. option can also be the short flag led by either ‘−’ or ‘+’ (no logical negation), for example “−x” or “+x” instead of “xtrace”.

string = string  
  Strings are equal. If the right-hand side is not quoted, pattern matching occurs.

string == string  
  Same as ‘=’ (deprecated).

string > string  
  First string operand is greater than second string operand.
string < string  First string operand is less than second string operand.
string != string  Strings are not equal. See ‘=’ regarding pattern matching.
number -eq number  Numbers compare equal.
number -ne number  Numbers compare not equal.
number -ge number  Numbers compare greater than or equal.
number -gt number  Numbers compare greater than.
number -le number  Numbers compare less than or equal.
number -lt number  Numbers compare less than.

The above basic expressions, in which unary operators have precedence over binary operators, may
be combined with the following operators (listed in increasing order of precedence):

expr -o expr  Logical OR.
expr -a expr  Logical AND.
! expr  Logical NOT.
(expr )  Grouping.

Note that a number actually may be an arithmetic expression, such as a mathematical term or the
name of an integer variable:

x=1; [ "x" -eq 1 ]  evaluates to true

Note that some special rules are applied (courtesy of POSIX) if the number of arguments to test or inside
the brackets [ . . . ] is less than five: if leading “!” arguments can be stripped such that only one to three arg-
ments remain, then the lowered comparison is executed; (thanks to XSI) parentheses \( . . . \) lower four-
and three-argument forms to two- and one-argument forms, respectively; three-argument forms ultimately
prefer binary operations, followed by negation and parenthesis lowering; two- and four-argument forms prefer
negation followed by parenthesis; the one-argument form always implies -n.

Note: A common mistake is to use “if [ $foo = bar ]” which fails if parameter “foo” is empty or unset, if it
has embedded spaces (i.e. IFS octets) or if it is a unary operator like “!” or “-n”. Use tests like “if [ x"foo"
= x"bar" ]” instead, or the double-bracket operator “if [[ $foo = bar ]]” or, to avoid pattern matching
(see [[ above]): “if [[ $foo = "$bar" ]]”

The [[ . . . ]] construct is not only more secure to use but also often faster.

time [-p] [pipeline]
If a pipeline is given, the times used to execute the pipeline are reported. If no pipeline is given, then the
user and system time used by the shell itself, and all the commands it has run since it was started, are reported.
The times reported are the real time (elapsed time from start to finish), the user CPU time (time spent running
in user mode), and the system CPU time (time spent running in kernel mode). Times are reported to standard
error; the format of the output is:

0m0.03s real  0m0.02s user  0m0.01s system
If the `-p` option is given the output is slightly longer:

```
real  0.03
user  0.02
sys   0.01
```

It is an error to specify the `-p` option unless `pipeline` is a simple command.

Simple redirections of standard error do not affect the output of the `time` command:

```
$ time sleep 1 2>afile
$ ( time sleep 1; ) 2>afile
```

Times for the first command do not go to "afile", but those of the second command do.

### times

Print the accumulated user and system times used both by the shell and by processes that the shell started which have exited. The format of the output is:

```
0m0.01s 0m0.00s
0m0.04s 0m0.02s
```

### trap

```
trap n [signal ...]
```

If the first operand is a decimal unsigned integer, this resets all specified signals to the default action, i.e. is the same as calling `trap` with a dash ("-"), as `handler`, followed by the arguments `{ n [signal ...]}`, all of which are treated as signals.

```
trap [handler signal ...]
```

Sets a trap handler that is to be executed when any of the specified `signals` are received. `handler` is either an empty string, indicating the signals are to be ignored, a dash ("-"), indicating that the default action is to be taken for the signals (see `signal(3)`), or a string containing shell commands to be executed at the first opportunity (i.e. when the current command completes or before printing the next PS1 prompt) after receipt of one of the signals. `signal` is the name of a signal (e.g. `PIPE` or `ALRM`) or the number of the signal (see the `kill -l` command above).

There are two special signals: `EXIT` (also known as 0), which is executed when the shell is about to exit, and `ERR`, which is executed after an error occurs; an error is something that would cause the shell to exit if the `set -e` or `set -o errexit` option were set. `EXIT` handlers are executed in the environment of the last executed command.

Note that, for non-interactive shells, the trap handler cannot be changed for signals that were ignored when the shell started.

With no arguments, the current state of the traps that have been set since the shell started is shown as a series of `trap` commands. Note that the output of `trap` cannot be usefully piped to another process (an artifact of the fact that traps are cleared when subprocesses are created).

The original Korn shell’s `DEBUG` trap and the handling of `ERR` and `EXIT` traps in functions are not yet implemented.

### true

A command that exits with a zero value.

```
typeset [+aglnprtuux][−L[n] | −R[n] | −Z[n]][−i[n]][name[=value] ...]
typeset −f [−tux][name ...]
```

Display or set parameter attributes. This is a declaration utility. With no `name` arguments, parameter attributes are displayed; if no options are used, the current attributes of all parameters are printed as `typeset` commands; if an option is given (or "-" with no option letter), all parameters and their values with the specified attributes are printed; if options are introduced with '*', parameter values are not printed.
If *name* arguments are given, the attributes of the named parameters are set (-) or cleared (+); inside a function, this will cause the parameters to be created (with no value) in the local scope (but see -g). Values for parameters may optionally be specified. For *name[+]*, the change affects all elements of the array, and no value may be specified.

When -f is used, `typeset` operates on the attributes of functions. As with parameters, if no *name* arguments are given, functions are listed with their values (i.e. definitions) unless options are introduced with ‘+’, in which case only the function names are reported.

- `-a` Indexed array attribute.
- `-f` Function mode. Display or set functions and their attributes, instead of parameters.
- `-g` Do not cause named parameters to be created in the local scope when called inside a function.
- `-i[n]` Integer attribute. *n* specifies the base to use when displaying the integer (if not specified, the base given in the first assignment is used). Parameters with this attribute may be assigned values containing arithmetic expressions.
- `-L[n]` Left justify attribute. *n* specifies the field width. If *n* is not specified, the current width of a parameter (or the width of its first assigned value) is used. Leading whitespace (and zeros, if used with the -Z option) is stripped. If necessary, values are either truncated or space padded to fit the field width.
- `-l` Lower case attribute. All upper case ASCII characters in values are converted to lower case. (In the original Korn shell, this parameter meant “long integer” when used with the -i option.)
- `-n` Create a bound variable (name reference): any access to the variable *name* will access the variable *value* in the current scope (this is different from AT&T UNIX ksh93!) instead. Also different from AT&T UNIX ksh93 is that *value* is lazily evaluated at the time *name* is accessed. This can be used by functions to access variables whose names are passed as parameters, instead of using `eval`.
- `-p` Print complete `typeset` commands that can be used to re-create the attributes and values of parameters.
- `-R[n]` Right justify attribute. *n* specifies the field width. If *n* is not specified, the current width of a parameter (or the width of its first assigned value) is used. Trailing whitespace is stripped. If necessary, values are either stripped of leading characters or space padded to make them fit the field width.
- `-r` Read-only attribute. Parameters with this attribute may not be assigned to or unset. Once this attribute is set, it cannot be turned off.
- `-t` Tag attribute. Has no meaning to the shell; provided for application use.

For functions, `-t` is the trace attribute. When functions with the trace attribute are executed, the `xtrace` `-x` shell option is temporarily turned on.

- `-U` Unsigned integer attribute. Integers are printed as unsigned values (combine with the -i option). This option is not in the original Korn shell.
- `-u` Upper case attribute. All lower case ASCII characters in values are converted to upper case. (In the original Korn shell, this parameter meant “unsigned integer” when used with the -i option which meant upper case letters would never be used for bases greater than 10. See -U above.)

For functions, `-u` is the undefined attribute. See Functions above for the implications of this.

- `-x` Export attribute. Parameters are placed in the environment of any executed commands. Functions cannot be exported for security reasons (“shellshock”).
−Z[n]  Zero fill attribute. If not combined with −L, this is the same as −R, except zero padding is used instead of space padding. For integers, the number is padded, not the base.

If any of the −i, −L, −l, −R, −U, −u or −Z options are changed, all others from this set are cleared, unless they are also given on the same command line.

ulimit [-aBCdefHilMmnOPpqrSsTtVvwx] [value]
Display or set process limits. If no options are used, the file size limit (−f) is assumed. value, if specified, may be either an arithmetic expression or the word “unlimited”. The limits affect the shell and any processes created by the shell after a limit is imposed. Note that some systems may not allow limits to be increased once they are set. Also note that the types of limits available are system dependent – some systems have only the −f limit, or not even that, or can set only the soft limits

−a  Display all limits; unless −H is used, soft limits are displayed.
−B n  Set the socket buffer size to n kibibytes.
−C n  Set the number of cached threads to n.
−c n  Impose a size limit of n blocks on the size of core dumps.
−d n  Impose a size limit of n kibibytes on the size of the data area.
−e n  Set the maximum niceness to n.
−f n  Impose a size limit of n blocks on files written by the shell and its child processes (files of any size may be read).
−H  Set the hard limit only (the default is to set both hard and soft limits).
−i n  Set the number of pending signals to n.
−l n  Impose a limit of n kibibytes on the amount of locked (wired) physical memory.
−M n  Set the AIO locked memory to n kibibytes.
−m n  Impose a limit of n kibibytes on the amount of physical memory used.
−n n  Impose a limit of n file descriptors that can be open at once.
−O n  Set the number of AIO operations to n.
−P n  Limit the number of threads per process to n.

This option mostly matches AT&T UNIX ksh93’s −T; on AIX, see −r (as used by its ksh) though.
−p n  Impose a limit of n processes that can be run by the user at any one time.
−q n  Limit the size of POSIX message queues to n bytes.
−r n  (AIX) Limit the number of threads per process to n.
     (Linux ) Set the maximum real-time priority to n.
−S  Set the soft limit only (the default is to set both hard and soft limits).
−s n  Impose a size limit of n kibibytes on the size of the stack area.
−T n  Impose a time limit of n real seconds to be used by each process.
−t n  Impose a time limit of n CPU seconds spent in user mode to be used by each process.
−V n Set the number of vnode monitors on Haiku to n.

−v n Impose a limit of n kibibytes on the amount of virtual memory (address space) used.

−w n Impose a limit of n kibibytes on the amount of swap space used.

−x n Set the maximum number of file locks to n.

As far as ulimit is concerned, a block is 512 bytes.

umask [−S][mask]
Display or set the file permission creation mask or umask (see umask(2)). If the −S option is used, the mask displayed or set is symbolic; otherwise, it is an octal number.

Symbolic masks are like those used by chmod(1). When used, they describe what permissions may be made available (as opposed to octal masks in which a set bit means the corresponding bit is to be cleared). For example, “ug=rwx,o=” sets the mask so files will not be readable, writable or executable by “others”, and is equivalent (on most systems) to the octal mask “007”.

unalias [−adt][name ...]
The aliases for the given names are removed. If the −a option is used, all aliases are removed. If the −t or −d options are used, the indicated operations are carried out on tracked or directory aliases, respectively.

unset [−fv] parameter ...
Unset the named parameters (−v, the default) or functions (−f). With parameter[*], attributes are kept, only values are unset.

The exit status is non-zero if any of the parameters have the read-only attribute set, zero otherwise.

wait [job ...]
Wait for the specified job(s) to finish. The exit status of wait is that of the last specified job; if the last job is killed by a signal, the exit status is 128 + the number of the signal (see kill −l exit−status above); if the last specified job can’t be found (because it never existed or had already finished), the exit status of wait is 127. See Job control below for the format of job. wait will return if a signal for which a trap has been set is received or if a SIGHUP, SIGINT or SIGQUIT signal is received.

If no jobs are specified, wait waits for all currently running jobs (if any) to finish and exits with a zero status. If job monitoring is enabled, the completion status of jobs is printed (this is not the case when jobs are explicitly specified).

whence [−pv][name ...]
Without the −v option, it is the same as command −v, except aliases are not printed as alias command. With the −v option, it is exactly the same as command −V. In either case, the −p option differs: the search path is not affected in whence, but the search is restricted to the path.

Job control
Job control refers to the shell’s ability to monitor and control jobs which are processes or groups of processes created for commands or pipelines. At a minimum, the shell keeps track of the status of the background (i.e. asynchronous) jobs that currently exist; this information can be displayed using the jobs commands. If job control is fully enabled (using set −m or set −o monitor), as it is for interactive shells, the processes of a job are placed in their own process group. Foreground jobs can be stopped by typing the suspend character from the terminal (normally ‘^Z’); jobs can be restarted in either the foreground or background using the commands fg and bg.

Note that only commands that create processes (e.g. asynchronous commands, subshell commands and non-built-in, non-function commands) can be stopped; commands like read cannot be.
When a job is created, it is assigned a job number. For interactive shells, this number is printed inside “[... “, followed by the process IDs of the processes in the job when an asynchronous command is run. A job may be referred to in the `bg`, `fg`, `jobs`, `kill` and `wait` commands either by the process ID of the last process in the command pipeline (as stored in the `$!` parameter) or by prefixing the job number with a percent sign (‘%’). Other percent sequences can also be used to refer to jobs:

- `%+` | `%-% | %` The most recently stopped job or, if there are no stopped jobs, the oldest running job.
- `%−` The job that would be the `%+` job if the latter did not exist.
- `%n` The job with job number `n`.
- `%%string` The job with its command containing the string `string` (an error occurs if multiple jobs are matched).
- `%string` The job with its command starting with the string `string` (an error occurs if multiple jobs are matched).

When a job changes state (e.g. a background job finishes or foreground job is stopped), the shell prints the following status information:

```
[number] flag status command
```

where...

- `number` is the job number of the job;
- `flag` is the ‘+’ or ‘−’ character if the job is the `%+` or `%−` job, respectively, or space if it is neither;
- `status` indicates the current state of the job and can be:
  - `Done [number]` The job exited. `number` is the exit status of the job which is omitted if the status is zero.
  - `Running` The job has neither stopped nor exited (note that running does not necessarily mean consuming CPU time – the process could be blocked waiting for some event).
  - `Stopped [signal]` The job was stopped by the indicated `signal` (if no signal is given, the job was stopped by SIGTSTP).
    - `signal-description` [“core dumped”] The job was killed by a signal (e.g. memory fault, hangup); use `kill -l` for a list of signal descriptions. The “core dumped” message indicates the process created a core file.

- `command` is the command that created the process. If there are multiple processes in the job, each process will have a line showing its `command` and possibly its `status`, if it is different from the status of the previous process.

When an attempt is made to exit the shell while there are jobs in the stopped state, the shell warns the user that there are stopped jobs and does not exit. If another attempt is immediately made to exit the shell, the stopped jobs are sent a SIGHUP signal and the shell exits. Similarly, if the `nohup` option is not set and there are running jobs when an attempt is made to exit a login shell, the shell warns the user and does not exit. If another attempt is immediately made to exit the shell, the running jobs are sent a SIGHUP signal and the shell exits.
Terminal state
The state of the controlling terminal can be modified by a command executed in the foreground, whether or not job control is enabled, but the modified terminal state is only kept past the job’s lifetime and used for later command invocations if the command exits successfully (i.e. with an exit status of 0). When such a job is momentarily stopped or restarted, the terminal state is saved and restored, respectively, but it will not be kept afterwards. In interactive mode, when line editing is enabled, the terminal state is saved before being reconfigured by the shell for the line editor, then restored before running a command.

POSIX mode
Entering `set -o posix` mode will cause `mksh` to behave even more POSIX compliant in places where the defaults or opinions differ. Note that `mksh` will still operate with unsigned 32-bit arithmetic; use `lksh` if arithmetic on the host `long` data type, complete with ISO C Undefined Behaviour, is required; refer to the `lksh(1)` manual page for details. Most other historic, AT&T UNIX `ksh`-compatible or opinionated differences can be disabled by using this mode; these are:

- The incompatible GNU `bash` I/O redirection `&> FILE` is not supported.
- File descriptors created by I/O redirections are inherited by child processes.
- Numbers with a leading digit zero are interpreted as octal.
- The `echo` builtin does not interpret backslashes and only supports the exact option `-n`.
- Alias expansion with a trailing space only reruns on command words.
- Tilde expansion follows POSIX instead of Korn shell rules.
- The exit status of `fg` is always 0.
- `kill -l` only lists signal names, all in one line.
- `getopts` does not accept options with a leading `+`.
- `exec` skips builtins, functions and other commands and uses a PATH search to determine the utility to execute.

SH mode
Compatibility mode; intended for use with legacy scripts that cannot easily be fixed; the changes are as follows:

- The incompatible GNU `bash` I/O redirection `&> FILE` is not supported.
- File descriptors created by I/O redirections are inherited by child processes.
- The `echo` builtin does not interpret backslashes and only supports the exact option `-n`, unless built with `-DMKSH_MIDNIGHTBSD01ASH_COMPAT`.
- The substitution operations `${x#PAT}`, `${x##PAT}`, `${x%PAT}`, and `${x%%PAT}` wrongly do not require a parenthesis to be escaped and do not parse extglobs.
- The `getopt` construct from `lksh(1)` passes through the `errorlevel`.
- sh `-c` eats a leading `--` if built with `-DMKSH_MIDNIGHTBSD01ASH_COMPAT`.

Interactive input line editing
The shell supports three modes of reading command lines from a `tty(4)` in an interactive session, controlled by the `emacs`, `gmacs` and `vi` options (at most one of these can be set at once). The default is `emacs`. Editing modes can be set explicitly using the `set` built-in. If none of these options are enabled, the shell simply reads lines using the normal `tty(4)` driver. If the `emacs` or `gmacs` option is set, the shell allows emacs-like editing of the command; similarly, if the `vi` option is set, the shell allows vi-like editing of the command.
These modes are described in detail in the following sections.

In these editing modes, if a line is longer than the screen width (see the COLUMNS parameter), a ‘>’, ‘+’ or ‘<’ character is displayed in the last column indicating that there are more characters after, before and after, or before the current position, respectively. The line is scrolled horizontally as necessary.

Completed lines are pushed into the history, unless they begin with an IFS octet or IFS white space or are the same as the previous line.

Emacs editing mode

When the emacs option is set, interactive input line editing is enabled. Warning: This mode is slightly different from the emacs mode in the original Korn shell. In this mode, various editing commands (typically bound to one or more control characters) cause immediate actions without waiting for a newline. Several editing commands are bound to particular control characters when the shell is invoked; these bindings can be changed using the bind command.

The following is a list of available editing commands. Each description starts with the name of the command, suffixed with a colon; an \[n\] (if the command can be prefixed with a count); and any keys the command is bound to by default, written using caret notation e.g. the ASCII ESC character is written as ^[. These control sequences are not case sensitive. A count prefix for a command is entered using the sequence ^[n, where \(n\) is a sequence of 1 or more digits. Unless otherwise specified, if a count is omitted, it defaults to 1.

Note that editing command names are used only with the bind command. Furthermore, many editing commands are useful only on terminals with a visible cursor. The user’s tty(4) characters (e.g. ERASE) are bound to reasonable substitutes and override the default bindings; their customary values are shown in parentheses below. The default bindings were chosen to resemble corresponding Emacs key bindings:

abort: INTR (^C), ^G

Abort the current command, save it to the history, empty the line buffer and set the exit state to interrupted.

auto-insert: \[n\]

Simply causes the character to appear as literal input. Most ordinary characters are bound to this.

backward-char: \[n\] ^B, ^XD, ANSI-CurLeft, PC-CurLeft

Moves the cursor backward \(n\) characters.

backward-word: \[n\] ^[b, ANSI-Ctrl-CurLeft, ANSI-Alt-CurLeft

Moves the cursor backward to the beginning of the word; words consist of alphanumerics, underscore (‘_’) and dollar sign (‘$’) characters.

beginning-of-history: ^[<

Moves to the beginning of the history.


Moves the cursor to the beginning of the edited input line.

capitalise-word: \[n\] ^[C, ^[c

Uppercase the first ASCII character in the next \(n\) words, leaving the cursor past the end of the last word.

clear-screen: ^[L

Prints a compile-time configurable sequence to clear the screen and home the cursor, redraws the last line of the prompt string and the currently edited input line. The default sequence works for almost all standard terminals.
comment: ^[#
If the current line does not begin with a comment character, one is added at the beginning of the
line and the line is entered (as if return had been pressed); otherwise, the existing comment char-
acters are removed and the cursor is placed at the beginning of the line.

complete: ^[^
Automatically completes as much as is unique of the command name or the file name containing
the cursor. If the entire remaining command or file name is unique, a space is printed after its
completion, unless it is a directory name in which case ‘/’ is appended. If there is no command or
file name with the current partial word as its prefix, a bell character is output (usually causing a
beep to be sounded).

complete-command: ^X[^
Automatically completes as much as is unique of the command name having the partial word up to
the cursor as its prefix, as in the complete command above.

complete-file: ^[^X
Automatically completes as much as is unique of the file name having the partial word up to the
cursor as its prefix, as in the complete command described above.

complete-list: ^[I, ^[=
Complete as much as is possible of the current word and list the possible completions for it. If only
one completion is possible, match as in the complete command above. Note that ^I is usually gen-
erated by the TAB (tabulator) key.

delete-char-backward: [n] ERASE (^[H), ^?, ^H
Deletes n characters before the cursor.

delete-char-forward: [n] ANSI-Del, PC-Del
Deletes n characters after the cursor.

delete-word-backward: [n] Pfxc1+ERASE (^[^[H), WERASE (^W), ^^[?, ^^[H, ^[[h
Deletes n words before the cursor.

delete-word-forward: [n] ^[d
Deletes characters after the cursor up to the end of n words.

down-history: [n] ^N, ^XB, ANSI-CurDown, PC-CurDown
Scrolls the history buffer forward n lines (later). Each input line originally starts just after the last
entry in the history buffer, so down-history is not useful until either search-history,
search-history-up or up-history has been performed.

downcase-word: [n] ^[L, ^[l
Lowercases the next n words.

edit-line: [n] ^Xe
Edit line n or the current line, if not specified, interactively. The actual command executed is fc
-e $({VISUAL:=${EDITOR:-vi}}) n.

end-of-history: ^>
Moves to the end of the history.

end-of-line: ^E, ANSI-End, PC-End
Moves the cursor to the end of the input line.

eot: ^_ Acts as an end-of-file; this is useful because edit-mode input disables normal terminal input canoni-
calisation.
eot-or-delete: [n] EOF (^[D)
    If alone on a line, same as eot, otherwise, delete-char-forward.

error: (not bound)
    Error (ring the bell).

evaluate-region: ^[E
    Evaluates the text between the mark and the cursor position (the entire line if no mark is set) as function substitution (if it cannot be parsed, the editing state is unchanged and the bell is rung to signal an error); $? is updated accordingly.

exchange-point-and-mark: ^X^X
    Places the cursor where the mark is and sets the mark to where the cursor was.

expand-file: ^[*
    Appends a ‘∗’ to the current word and replaces the word with the result of performing file globbing on the word. If no files match the pattern, the bell is rung.

forward-char: [n] ^F, ^XC, ANSI-CurRight, PC-CurRight
    Moves the cursor forward n characters.

forward-word: [n] ^[f, ANSI-Ctrl-CurRight, ANSI-Alt-CurRight
    Moves the cursor forward to the end of the nth word.

goto-history: [n] ^[g
    Goes to history number n.

kill-line: KILL (^[U)
    Deletes the entire input line.

kill-region: ^W
    Deletes the input between the cursor and the mark.

kill-to-eol: [n] ^[k
    Deletes the input from the cursor to the end of the line if n is not specified; otherwise deletes characters between the cursor and column n.

list: ^[?
    Prints a sorted, columnated list of command names or file names (if any) that can complete the partial word containing the cursor. Directory names have ‘/’ appended to them.

list-command: ^X?
    Prints a sorted, columnated list of command names (if any) that can complete the partial word containing the cursor.

list-file: ^X^Y
    Prints a sorted, columnated list of file names (if any) that can complete the partial word containing the cursor. File type indicators are appended as described under list above.

newline: ^J, ^M
    Causes the current input line to be processed by the shell. The current cursor position may be anywhere on the line.

newline-and-next: ^O
    Causes the current input line to be processed by the shell, and the next line from history becomes the current line. This is only useful after an up-history, search-history or search-history-up.

no-op: QUIT (^\)
    This does nothing.
prefix-1: ^[  
Introduces a 2-character command sequence.

prefix-2: ^X, ^[, ^[O  
Introduces a multi-character command sequence.

prev-hist-word: [n] ^[, ^[_  
The last word or, if given, the n-th word (zero-based) of the previous (on repeated execution, second-last, third-last, etc.) command is inserted at the cursor. Use of this editing command trashes the mark.

quote: ^^, ^V  
The following character is taken literally rather than as an editing command.

redraw: ^L  
Reprints the last line of the prompt string and the current input line on a new line.

search-characterbackward: [n] ^[^  
Search backward in the current line for the n-th occurrence of the next character typed.

search-character-forward: [n] ^]  
Search forward in the current line for the n-th occurrence of the next character typed.

search-history: ^R  
Enter incremental search mode. The internal history list is searched backwards for commands matching the input. An initial ‘^’ in the search string anchors the search. The escape key will leave search mode. Other commands, including sequences of escape as prefix-1 followed by a prefix-1 or prefix-2 key will be executed after leaving search mode. The abort (^G) command will restore the input line before search started. Successive search-history commands continue searching backward to the next previous occurrence of the pattern. The history buffer retains only a finite number of lines; the oldest are discarded as necessary.

search-history-up: ANSI-PgUp, PC-PgUp  
Search backwards through the history buffer for commands whose beginning match the portion of the input line before the cursor. When used on an empty line, this has the same effect as up-history.

search-history-down: ANSI-PgDn, PC-PgDn  
Search forwards through the history buffer for commands whose beginning match the portion of the input line before the cursor. When used on an empty line, this has the same effect as down-history. This is only useful after an up-history, search-history or search-history-up.

set-mark-command: ^[<space>  
Set the mark at the cursor position.

transpose-chars: ^T  
If at the end of line or, if the gmacs option is set, this exchanges the two previous characters; otherwise, it exchanges the previous and current characters and moves the cursor one character to the right.

up-history: [n] ^P, ^XA, ANSI-CurUp, PC-CurUp  
Scrolls the history buffer backward n lines (earlier).

upcase-word: [n] ^U, ^[u  
Uppercase the next n words.
version: ^{^V}
Display the version of mksh. The current edit buffer is restored as soon as a key is pressed. The restoring keypress is processed, unless it is a space.

yank: ^Y
Inserts the most recently killed text string at the current cursor position.

yank-pop: ^[y
Immediately after a yank, replaces the inserted text string with the next previously killed text string.

The tab completion escapes characters the same way as the following code:

```
print -nr "\"${x@/\"$\&-\*?:?\[\\`\{\}${IFS$' \t\n'}]/\$KSH_MATCH}\"
```

**Vi editing mode**

*Note:* The vi command-line editing mode has not yet been brought up to the same quality and feature set as the emacs mode. It is 8-bit clean but specifically does not support UTF-8 or MBCS.

The vi command-line editor in mksh has basically the same commands as the vi(1) editor with the following exceptions:

- You start out in insert mode.
- There are file name and command completion commands: =, \, *, ^X, ^E, ^F and, optionally, <tab> and <esc>.
- The _ command is different (in mksh, it is the last argument command; in vi(1) it goes to the start of the current line).
- The / and G commands move in the opposite direction to the j command.
- Commands which don’t make sense in a single line editor are not available (e.g. screen movement commands and ex(1)-style colon (: ) commands).

Like vi(1), there are two modes: “insert” mode and “command” mode. In insert mode, most characters are simply put in the buffer at the current cursor position as they are typed; however, some characters are treated specially. In particular, the following characters are taken from current tty(4) settings (see stty(1)) and have their usual meaning (normal values are in parentheses): kill (^U), erase (^?), werase (^W), eof (^D), intr (^C) and quit (^\). In addition to the above, the following characters are also treated specially in insert mode:

- Command and file name enumeration (see below).
- Command and file name completion (see below). If used twice in a row, the list of possible completions is displayed; if used a third time, the completion is undone.
- Erases previous character.
- End of line. The current line is read, parsed and executed by the shell.
- Literal next. The next character typed is not treated specially (can be used to insert the characters being described here).
- Command and file name expansion (see below).
- Puts the editor in command mode (see below).
- Optional file name and command completion (see ^F above), enabled with set -o vi-tabcomplete.
In command mode, each character is interpreted as a command. Characters that don’t correspond to commands, are illegal combinations of commands, or are commands that can’t be carried out, all cause beeps. In the following command descriptions, an \[n\] indicates the command may be prefixed by a number (e.g. \[10l\] moves right 10 characters); if no number prefix is used, \[n\] is assumed to be 1 unless otherwise specified. The term “current position” refers to the position between the cursor and the character preceding the cursor. A “word” is a sequence of letters, digits and underscore characters or a sequence of non-letter, non-digit, non-underscore and non-whitespace characters (e.g. “ab2*&^” contains two words) and a “big-word” is a sequence of non-whitespace characters.

Special \texttt{mksh} vi commands:

The following commands are not in, or are different from, the normal vi file editor:

\begin{itemize}
\item \[n\]_ Insert a space followed by the \[n\]th big-word from the last command in the history at the current position and enter insert mode; if \[n\] is not specified, the last word is inserted.
\item \# Insert the comment character (’#’) at the start of the current line and return the line to the shell (equivalent to \texttt{I#^J}).
\item \[n\]g Like \texttt{G}, except if \[n\] is not specified, it goes to the most recent remembered line.
\item \[n\]v Edit line \[n\] using the \texttt{vi(1)} editor; if \[n\] is not specified, the current line is edited. The actual command executed is \texttt{fc -e$\{VISUAL:-$\{EDITOR:-vi\}\} n}.
\item \^ and \^X Command or file name expansion is applied to the current big-word (with an appended ‘*’ if the word contains no file globbing characters) – the big-word is replaced with the resulting words. If the current big-word is the first on the line or follows one of the characters ’;’, ’|’, ’&’, ’(’ or ’)’ and does not contain a slash (’/’), then command expansion is done; otherwise file name expansion is done. Command expansion will match the big-word against all aliases, functions and built-in commands as well as any executable files found by searching the directories in the \texttt{PATH} parameter. File name expansion matches the big-word against the files in the current directory. After expansion, the cursor is placed just past the last word and the editor is in insert mode.
\item \[n\]\, \[n\]^F, \[n\]<tab>, and \[n\]<esc> Command/file name completion. Replace the current big-word with the longest unique match obtained after performing command and file name expansion. \texttt{<tab>} is only recognised if the \texttt{vi-tabcomplete} option is set, while \texttt{<esc>} is only recognised if the \texttt{vi-esccomplete} option is set (see \texttt{set -o}). If \[n\] is specified, the \[n\]th possible completion is selected (as reported by the command/file name enumeration command).
\item \^ and \^E Command/file name enumeration. List all the commands or files that match the current big-word.
\item \^V Display the version of \texttt{mksh}. The current edit buffer is restored as soon as a key is pressed. The restoring keypress is ignored.
\item \@c Macro expansion. Execute the commands found in the alias \texttt{_c}.
\end{itemize}

Intra-line movement commands:

\begin{itemize}
\item \[n\]h and \[n\]^H Move left \[n\] characters.
\item \[n\]l and \[n\]<space> Move right \[n\] characters.
\end{itemize}
Move to column 0.
Move to the first non-whitespace character.
Move to column \n.
Move to the last character.
Move back \n words.
Move back \n big-words.
Move forward to the end of the word, \n times.
Move forward to the end of the big-word, \n times.
Move forward \n words.
Move forward \n big-words.
Find match. The editor looks forward for the nearest parenthesis, bracket or brace and then moves the cursor to the matching parenthesis, bracket or brace.
Move forward to the \n th occurrence of the character \c.
Move backward to the \n th occurrence of the character \c.
Move forward to just before the \n th occurrence of the character \c.
Move backward to just before the \n th occurrence of the character \c.
Repeats the last \f, \F, \t or \T command.
Repeats the last \f, \F, \t or \T command, but moves in the opposite direction.
Inter-line movement commands:
Move to the \n th next line in the history.
Move to the \n th previous line in the history.
Move to line \n in the history; if \n is not specified, the number of the first remembered line is used.
Like \G, except if \n is not specified, it goes to the most recent remembered line.
Search backward through the history for the \n th line containing \string; if \string starts with '\^%', the remainder of the string must appear at the start of the history line for it to match.
Search forward through the history.
Search for the \n th occurrence of the last search string; the direction of the search is the same as the last search.
Search for the \n th occurrence of the last search string; the direction of the search is the opposite of the last search.
Take the characters from the beginning of the line to the current cursor position as search string and do a history search, backwards, for lines beginning with this string; keep the cursor position. This works only in insert mode and keeps it enabled.
ANSI-CurDown, PC-PgDn
Take the characters from the beginning of the line to the current cursor position as search string and do a history search, forwards, for lines beginning with this string; keep the cursor position. This works only in insert mode and keeps it enabled.

Edit commands

[n]a Append text n times; goes into insert mode just after the current position. The append is only replicated if command mode is re-entered i.e. <esc> is used.

[n]A Same as a, except it appends at the end of the line.

[n]i Insert text n times; goes into insert mode at the current position. The insertion is only replicated if command mode is re-entered i.e. <esc> is used.

[n]I Same as i, except the insertion is done just before the first non-blank character.

[n]s Substitute the next n characters (i.e. delete the characters and go into insert mode).

S Substitute whole line. All characters from the first non-blank character to the end of the line are deleted and insert mode is entered.

[n]cmd Change from the current position to the position resulting from n move-cmds (i.e. delete the indicated region and go into insert mode); if move-cmd is c, the line starting from the first non-blank character is changed.

C Change from the current position to the end of the line (i.e. delete to the end of the line and go into insert mode).

[n]x Delete the next n characters.

[n]X Delete the previous n characters.

D Delete to the end of the line.

[n]dmov-cmd Delete from the current position to the position resulting from n move-cmds; move-cmd is a movement command (see above) or d, in which case the current line is deleted.

[n]rc Replace the next n characters with the character c.

[r]R Replace. Enter insert mode but overwrite existing characters instead of inserting before existing characters. The replacement is repeated n times.

[n]~ Change the case of the next n characters.

[n]ymov-cmd Yank from the current position to the position resulting from n move-cmds into the yank buffer; if move-cmd is y, the whole line is yanked.

Y Yank from the current position to the end of the line.

[n]p Paste the contents of the yank buffer just after the current position, n times.

[p]p Same as p, except the buffer is pasted at the current position.

Miscellaneous vi commands

^J and ^M
The current line is read, parsed and executed by the shell.
^L and ^R
Redraw the current line.

[n]. Redo the last edit command n times.

u Undo the last edit command.

U Undo all changes that have been made to the current line.

PC Home, End, Del and cursor keys
They move as expected, both in insert and command mode.

intr and quit
The interrupt and quit terminal characters cause the current line to be removed to the history and a new prompt to be printed.

FILES

~/.mkshrc User mkshrc profile (non-privileged interactive shells); see Startup files. The location can be changed at compile time (e.g. for embedded systems); AOSP Android builds use /system/etc/mkshrc.

~/.profile User profile (non-privileged login shells); see Startup files near the top of this manual.

/etc/profile System profile (login shells); see Startup files.

/etc/shells Shell database.

/etc/suid_profile Privileged shells’ profile (sugid); see Startup files.

Note: On Android, /system/etc/ contains the system and suid profile.

SEE ALSO

awk(1), cat(1), ed(1), getopt(1), lksh(1), sed(1), sh(1), stty(1), dup(2), execve(2), getgid(2), getuid(2), mkms(2), mkfifo(2), open(2), pipe(2), rename(2), wait(2), getopt(3), nl_langinfo(3), setlocale(3), signal(3), system(3), tty(4), shells(5), environ(7), script(7), utf−8(7), mkms(8)

The FAQ at http://www.mirbsd.org/mksh−faq.htm or in the mksh.faq file.

http://www.mirbsd.org/ksh−chan.htm


AUTHORS

The MirBSD Korn Shell is developed by mirabilos <m@mirbsd.org> as part of The MirOS Project. This shell is based on the public domain 7th edition Bourne shell clone by Charles Forsyth, who kindly agreed to, in countries where the Public Domain status of the work may not be valid, grant a copyright licence to the general public to deal in the work without restriction and permission to sublicence derivatives under the terms of any (OSI approved) Open Source licence, and parts of the BRL shell by Doug A. Gwyn, Doug Kingston, Ron Natalie, Arnold Robbins, Lou Salkind and others. The first release of pdksh was created by Eric Gisin, and it was subsequently maintained by John R. MacMillan, Simon J. Gerraty and Michael Rendell. The effort of several projects, such as Debian and OpenBSD, and other contributors including our users, to improve the shell is appreciated. See the documentation, website and source code (CVS) for details.

mksh-os2 is developed by KO Myung-Hun <komh@chollian.net>.

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The BSD daemon is Copyright © Marshall Kirk McKusick. The complete legalese is at: http://www.mirbsd.org/TaC-mksh.txt

CAVEATS

mksh provides a consistent, clear interface normally. This may deviate from POSIX in historic or opinionated places. set −o posix (see POSIX mode for details) will make the shell more conformant, but mind the FAQ (see SEE ALSO), especially regarding locales. mksh (but not lksh) provides a consistent 32-bit integer arithmetic implementation, both signed and unsigned, with sign of the result of a remainder operation and wraparound defined, even (defying POSIX) on 36-bit and 64-bit systems.

mksh currently uses OPTU-16 internally, which is the same as UTF-8 and CESU-8 with 0000..FFFD being valid codepoints; raw octets are mapped into the PUA range EF80..EFFF, which is assigned by CSUR for this purpose.

BUGS

Suspending (using ^Z) pipelines like the one below will only suspend the currently running part of the pipeline; in this example, “fubar” is immediately printed on suspension (but not later after an fg).

$ /bin/sleep 666 && echo fubar

The truncation process involved when changing HISTFILE does not free old history entries (leaks memory) and leaks old entries into the new history if their line numbers are not overwritten by same-number entries from the persistent history file; truncating the on-disc file to HISTSIZE lines has always been broken and prone to history file corruption when multiple shells are accessing the file; the rollover process for the in-memory portion of the history is slow, should use memmove(3).

This document attempts to describe mksh R58 and up, compiled without any options impacting functionality, such as MKSH_SMALL, when not called as /bin/sh which, on some systems only, enables set −o posix or set −o sh automatically (whose behaviour differs across targets), for an operating environment supporting all of its advanced needs.

Please report bugs in mksh to the public development mailing list at <miros−mksh@mirbsd.org> (please note the EU−DSGVO/GDPR notice on http://www.mirbsd.org/rss.htm#lists and in the SMTP banner!) or in the #!/bin/mksh (or #ksh) IRC channel at irc.freenode.net (Port 6697 SSL, 6667 unencrypted), or at: https://launchpad.net/mksh