HW1-R

Introduction to R HW1

PART II

To check the R version installed in your system use the following code

```
R.version
```

```
               _
platform       x86_64-pc-linux-gnu
arch           x86_64
os             linux-gnu
system         x86_64, linux-gnu
status
major          4
minor          3.1
year           2023
month          06
day            16
svn rev        84548
language       R
version.string R version 4.3.1 (2023-06-16)
nickname       Beagle Scouts
```

To install Packages in R use the following code

#here we are installing DMwR2 package which is used in data mining

####{r} ####install.packages("DMwR2") ####

We will use help() to see what is in the package

```
help(package="DMwR2")
```

If we want to use a function from the installed library we need to use library() function.

```
library(DMwR2)
```

```
Registered S3 method overwritten by 'quantmod':
  method            from
  as.zoo.data.frame zoo
```

As we have now loaded the package we can use any function from it example -

```
data(algae)
algae
```

```
# A tibble: 200 x 18
   season size  speed   mxPH  mnO2    Cl    NO3   NH4  oPO4   PO4  Chla    a1
   <fct>  <fct> <fct>  <dbl> <dbl> <dbl>  <dbl> <dbl> <dbl> <dbl> <dbl> <dbl>
 1 winter small medium  8      9.8  60.8  6.24  578   105   170   50      0
 2 spring small medium  8.35   8    57.8  1.29  370   429.  559.   1.3    1.4
 3 autumn small medium  8.1   11.4  40.0  5.33  347.  126.  187.  15.6    3.3
 4 spring small medium  8.07   4.8  77.4  2.30   98.2  61.2 139.   1.4    3.1
 5 autumn small medium  8.06   9    55.4 10.4   234.   58.2  97.6 10.5    9.2
 6 winter small high    8.25  13.1  65.8  9.25  430    18.2  56.7 28.4   15.1
 7 summer small high    8.15  10.3  73.2  1.54  110    61.2 112.   3.2    2.4
 8 autumn small high    8.05  10.6  59.1  4.99  206.   44.7  77.4  6.9   18.2
 9 winter small medium  8.7    3.4  22.0  0.886 103.   36.3  71    5.54  25.4
10 winter small high    7.93   9.9   8    1.39    5.8  27.2  46.6  0.8   17
# i 190 more rows
# i 6 more variables: a2 <dbl>, a3 <dbl>, a4 <dbl>, a5 <dbl>, a6 <dbl>,
#   a7 <dbl>
```

to find rows with too many nans

```
manyNAs(algae)
```

```
[1]  62 199
```

To get list of packages installed in different libraries use

```
library()
```

The following command will show the packages loaded in the session

```
(.packages())
```

```
[1] "DMwR2"     "stats"     "graphics"  "grDevices" "utils"     "datasets"
[7] "methods"   "base"
```

#Another way to see the packages installed

```
installed.packages()
```

```
               Package          LibPath
askpass        "askpass"        "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
base64enc      "base64enc"      "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
bit            "bit"            "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
bit64          "bit64"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
bslib          "bslib"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
cachem         "cachem"         "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
cli            "cli"            "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
clipr          "clipr"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
cpp11          "cpp11"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
crayon         "crayon"         "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
credentials    "credentials"    "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
curl           "curl"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
DBI            "DBI"            "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
desc           "desc"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
digest         "digest"         "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
```

```
DMwR2          "DMwR2"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
dplyr          "dplyr"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
ellipsis       "ellipsis"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
evaluate       "evaluate"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
fansi          "fansi"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
fastmap        "fastmap"        "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
fontawesome    "fontawesome"    "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
fs             "fs"             "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
generics       "generics"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
gert           "gert"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
gh             "gh"             "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
gitcreds       "gitcreds"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
glue           "glue"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
highr          "highr"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
hms            "hms"            "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
htmltools      "htmltools"      "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
httr2          "httr2"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
ini            "ini"            "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
jquerylib      "jquerylib"      "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
jsonlite       "jsonlite"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
knitr          "knitr"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
lifecycle      "lifecycle"      "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
magrittr       "magrittr"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
memoise        "memoise"        "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
mime           "mime"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
openssl        "openssl"        "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
palmerpenguins "palmerpenguins" "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
pillar         "pillar"         "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
pkgconfig      "pkgconfig"      "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
prettyunits    "prettyunits"    "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
progress       "progress"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
purrr          "purrr"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
quantmod       "quantmod"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
R6             "R6"             "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
rappdirs       "rappdirs"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
readr          "readr"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
rlang          "rlang"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
rmarkdown      "rmarkdown"      "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
rprojroot      "rprojroot"      "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
rstudioapi     "rstudioapi"     "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
sass           "sass"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
stringi        "stringi"        "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
stringr        "stringr"        "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
```

```
sys             "sys"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
tibble          "tibble"        "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
tidyselect      "tidyselect"    "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
tinytex         "tinytex"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
TTR             "TTR"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
tzdb            "tzdb"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
usethis         "usethis"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
utf8            "utf8"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
vctrs           "vctrs"         "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
vroom           "vroom"         "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
whisker         "whisker"       "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
withr           "withr"         "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
xfun            "xfun"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
xts             "xts"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
yaml            "yaml"          "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
zip             "zip"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
zoo             "zoo"           "/cloud/lib/x86_64-pc-linux-gnu-library/4.3"
base            "base"          "/opt/R/4.3.1/lib/R/library"
boot            "boot"          "/opt/R/4.3.1/lib/R/library"
class           "class"         "/opt/R/4.3.1/lib/R/library"
cluster         "cluster"       "/opt/R/4.3.1/lib/R/library"
codetools       "codetools"     "/opt/R/4.3.1/lib/R/library"
compiler        "compiler"      "/opt/R/4.3.1/lib/R/library"
datasets        "datasets"      "/opt/R/4.3.1/lib/R/library"
foreign         "foreign"       "/opt/R/4.3.1/lib/R/library"
graphics        "graphics"      "/opt/R/4.3.1/lib/R/library"
grDevices       "grDevices"     "/opt/R/4.3.1/lib/R/library"
grid            "grid"          "/opt/R/4.3.1/lib/R/library"
KernSmooth      "KernSmooth"    "/opt/R/4.3.1/lib/R/library"
lattice         "lattice"       "/opt/R/4.3.1/lib/R/library"
MASS            "MASS"          "/opt/R/4.3.1/lib/R/library"
Matrix          "Matrix"        "/opt/R/4.3.1/lib/R/library"
methods         "methods"       "/opt/R/4.3.1/lib/R/library"
mgcv            "mgcv"          "/opt/R/4.3.1/lib/R/library"
nlme            "nlme"          "/opt/R/4.3.1/lib/R/library"
nnet            "nnet"          "/opt/R/4.3.1/lib/R/library"
parallel        "parallel"      "/opt/R/4.3.1/lib/R/library"
rpart           "rpart"         "/opt/R/4.3.1/lib/R/library"
spatial         "spatial"       "/opt/R/4.3.1/lib/R/library"
splines         "splines"       "/opt/R/4.3.1/lib/R/library"
stats           "stats"         "/opt/R/4.3.1/lib/R/library"
stats4          "stats4"        "/opt/R/4.3.1/lib/R/library"
survival        "survival"      "/opt/R/4.3.1/lib/R/library"
```

```
tcltk          "tcltk"          "/opt/R/4.3.1/lib/R/library"
tools          "tools"          "/opt/R/4.3.1/lib/R/library"
utils          "utils"          "/opt/R/4.3.1/lib/R/library"
               Version    Priority
askpass        "1.1"      NA
base64enc      "0.1-3"    NA
bit            "4.0.5"    NA
bit64          "4.0.5"    NA
bslib          "0.5.1"    NA
cachem         "1.0.8"    NA
cli            "3.6.1"    NA
clipr          "0.8.0"    NA
cpp11          "0.4.6"    NA
crayon         "1.5.2"    NA
credentials    "1.3.2"    NA
curl           "5.0.2"    NA
DBI            "1.1.3"    NA
desc           "1.4.2"    NA
digest         "0.6.33"   NA
DMwR2          "0.0.2"    NA
dplyr          "1.1.2"    NA
ellipsis       "0.3.2"    NA
evaluate       "0.21"     NA
fansi          "1.0.4"    NA
fastmap        "1.1.1"    NA
fontawesome    "0.5.2"    NA
fs             "1.6.3"    NA
generics       "0.1.3"    NA
gert           "1.9.3"    NA
gh             "1.4.0"    NA
gitcreds       "0.1.2"    NA
glue           "1.6.2"    NA
highr          "0.10"     NA
hms            "1.1.3"    NA
htmltools      "0.5.6"    NA
httr2          "0.2.3"    NA
ini            "0.3.1"    NA
jquerylib      "0.1.4"    NA
jsonlite       "1.8.7"    NA
knitr          "1.43"     NA
lifecycle      "1.0.3"    NA
magrittr       "2.0.3"    NA
memoise        "2.0.1"    NA
```

```
mime            "0.12"     NA
openssl         "2.1.0"    NA
palmerpenguins "0.1.1"    NA
pillar          "1.9.0"    NA
pkgconfig       "2.0.3"    NA
prettyunits     "1.1.1"    NA
progress        "1.2.2"    NA
purrr           "1.0.2"    NA
quantmod        "0.4.25"   NA
R6              "2.5.1"    NA
rappdirs        "0.3.3"    NA
readr           "2.1.4"    NA
rlang           "1.1.1"    NA
rmarkdown       "2.24"     NA
rprojroot       "2.0.3"    NA
rstudioapi      "0.15.0"   NA
sass            "0.4.7"    NA
stringi         "1.7.12"   NA
stringr         "1.5.0"    NA
sys             "3.4.2"    NA
tibble          "3.2.1"    NA
tidyselect      "1.2.0"    NA
tinytex         "0.46"     NA
TTR             "0.24.3"   NA
tzdb            "0.4.0"    NA
usethis         "2.2.2"    NA
utf8            "1.2.3"    NA
vctrs           "0.6.3"    NA
vroom           "1.6.3"    NA
whisker         "0.4.1"    NA
withr           "2.5.0"    NA
xfun            "0.40"     NA
xts             "0.13.1"   NA
yaml            "2.3.7"    NA
zip             "2.3.0"    NA
zoo             "1.8-12"   NA
base            "4.3.1"    "base"
boot            "1.3-28.1" "recommended"
class           "7.3-22"   "recommended"
cluster         "2.1.4"    "recommended"
codetools       "0.2-19"   "recommended"
compiler        "4.3.1"    "base"
datasets        "4.3.1"    "base"
```

```
foreign        "0.8-84"   "recommended"
graphics       "4.3.1"    "base"
grDevices      "4.3.1"    "base"
grid           "4.3.1"    "base"
KernSmooth     "2.23-21"  "recommended"
lattice        "0.21-8"   "recommended"
MASS           "7.3-60"   "recommended"
Matrix         "1.5-4.1"  "recommended"
methods        "4.3.1"    "base"
mgcv           "1.8-42"   "recommended"
nlme           "3.1-162"  "recommended"
nnet           "7.3-19"   "recommended"
parallel       "4.3.1"    "base"
rpart          "4.1.19"   "recommended"
spatial        "7.3-16"   "recommended"
splines        "4.3.1"    "base"
stats          "4.3.1"    "base"
stats4         "4.3.1"    "base"
survival       "3.5-5"    "recommended"
tcltk          "4.3.1"    "base"
tools          "4.3.1"    "base"
utils          "4.3.1"    "base"
               Depends
askpass        NA
base64enc      "R (>= 2.9.0)"
bit            "R (>= 2.9.2)"
bit64          "R (>= 3.0.1), bit (>= 4.0.0), utils, methods, stats"
bslib          "R (>= 2.10)"
cachem         NA
cli            "R (>= 3.4)"
clipr          NA
cpp11          "R (>= 3.5.0)"
crayon         NA
credentials    NA
curl           "R (>= 3.0.0)"
DBI            "methods, R (>= 3.0.0)"
desc           "R (>= 3.4)"
digest         "R (>= 3.3.0)"
DMwR2          "R(>= 3.0), methods"
dplyr          "R (>= 3.5.0)"
ellipsis       "R (>= 3.2)"
evaluate       "R (>= 3.0.2)"
fansi          "R (>= 3.1.0)"
```

```
fastmap         NA
fontawesome     "R (>= 3.3.0)"
fs              "R (>= 3.4)"
generics        "R (>= 3.2)"
gert            NA
gh              "R (>= 3.4)"
gitcreds        "R (>= 3.4)"
glue            "R (>= 3.4)"
highr           "R (>= 3.3.0)"
hms             NA
htmltools       "R (>= 2.14.1)"
httr2           "R (>= 3.4)"
ini             NA
jquerylib       NA
jsonlite        "methods"
knitr           "R (>= 3.3.0)"
lifecycle       "R (>= 3.4)"
magrittr        "R (>= 3.4.0)"
memoise         NA
mime            NA
openssl         NA
palmerpenguins "R (>= 2.10)"
pillar          NA
pkgconfig       NA
prettyunits     NA
progress        NA
purrr           "R (>= 3.5.0)"
quantmod        "R (>= 3.2.0), xts(>= 0.9-0), zoo, TTR(>= 0.2), methods"
R6              "R (>= 3.0)"
rappdirs        "R (>= 3.2)"
readr           "R (>= 3.5)"
rlang           "R (>= 3.5.0)"
rmarkdown       "R (>= 3.0)"
rprojroot       "R (>= 3.0.0)"
rstudioapi      NA
sass            NA
stringi         "R (>= 3.1)"
stringr         "R (>= 3.3)"
sys             NA
tibble          "R (>= 3.4.0)"
tidyselect      "R (>= 3.4)"
tinytex         NA
TTR             NA
```

```
tzdb           "R (>= 3.5.0)"
usethis        "R (>= 3.6)"
utf8           "R (>= 2.10)"
vctrs          "R (>= 3.5.0)"
vroom          "R (>= 3.4)"
whisker        NA
withr          "R (>= 3.2.0)"
xfun           NA
xts            "R (>= 3.6.0), zoo (>= 1.7-12)"
yaml           NA
zip            NA
zoo            "R (>= 3.1.0), stats"
base           NA
boot           "R (>= 3.0.0), graphics, stats"
class          "R (>= 3.0.0), stats, utils"
cluster        "R (>= 3.5.0)"
codetools      "R (>= 2.1)"
compiler       NA
datasets       NA
foreign        "R (>= 4.0.0)"
graphics       NA
grDevices      NA
grid           NA
KernSmooth     "R (>= 2.5.0), stats"
lattice        "R (>= 4.0.0)"
MASS           "R (>= 4.0), grDevices, graphics, stats, utils"
Matrix         "R (>= 3.5.0), methods"
methods        NA
mgcv           "R (>= 3.6.0), nlme (>= 3.1-64)"
nlme           "R (>= 3.5.0)"
nnet           "R (>= 3.0.0), stats, utils"
parallel       NA
rpart          "R (>= 2.15.0), graphics, stats, grDevices"
spatial        "R (>= 3.0.0), graphics, stats, utils"
splines        NA
stats          NA
stats4         NA
survival       "R (>= 3.5.0)"
tcltk          NA
tools          NA
utils          NA
               Imports
askpass        "sys (>= 2.1)"
```

```
base64enc      NA
bit            NA
bit64          NA
bslib          "base64enc, cachem, grDevices, htmltools (>= 0.5.4), jquerylib\n(>= 0.1.3), js
cachem         "rlang, fastmap (>= 1.1.1)"
cli            "utils"
clipr          "utils"
cpp11          NA
crayon         "grDevices, methods, utils"
credentials    "openssl (>= 1.3), sys (>= 2.1), curl, jsonlite, askpass"
curl           NA
DBI            NA
desc           "cli, R6, rprojroot, utils"
digest         "utils"
DMwR2          "xts (>= 0.9-7), zoo (>= 1.7-10), class (>= 7.3-14), rpart (>=\n4.1-10), quant
dplyr          "cli (>= 3.4.0), generics, glue (>= 1.3.2), lifecycle (>=\n1.0.3), magrittr (>
ellipsis       "rlang (>= 0.3.0)"
evaluate       "methods"
fansi          "grDevices, utils"
fastmap        NA
fontawesome    "rlang (>= 1.0.6), htmltools (>= 0.5.1.1)"
fs             "methods"
generics       "methods"
gert           "askpass, credentials (>= 1.2.1), openssl (>= 2.0.3),\nrstudioapi (>= 0.11), s
gh             "cli (>= 3.0.1), gitcreds, httr2, ini, jsonlite, rlang (>=\n1.0.0)"
gitcreds       NA
glue           "methods"
highr          "xfun (>= 0.18)"
hms            "lifecycle, methods, pkgconfig, rlang (>= 1.0.2), vctrs (>=\n0.3.8)"
htmltools      "utils, digest, grDevices, base64enc, rlang (>= 0.4.12),\nfastmap (>= 1.1.0),
httr2          "cli (>= 3.0.0), curl, glue, magrittr, openssl, R6, rappdirs,\nrlang (>= 1.0.0
ini            NA
jquerylib      "htmltools"
jsonlite       NA
knitr          "evaluate (>= 0.15), highr, methods, tools, xfun (>= 0.39),\nyaml (>= 2.1.19)"
lifecycle      "cli (>= 3.4.0), glue, rlang (>= 1.0.6)"
magrittr       NA
memoise        "rlang (>= 0.4.10), cachem"
mime           "tools"
openssl        "askpass"
palmerpenguins NA
pillar         "cli (>= 2.3.0), fansi, glue, lifecycle, rlang (>= 1.0.2), utf8\n(>= 1.1.0), u
pkgconfig      "utils"
```

```
prettyunits    NA
progress       "hms, prettyunits, R6, crayon"
purrr          "cli (>= 3.6.1), lifecycle (>= 1.0.3), magrittr (>= 1.5.0),\nrlang (>= 1.1.1)
quantmod       "curl, jsonlite(>= 1.1)"
R6             NA
rappdirs       NA
readr          "cli (>= 3.2.0), clipr, crayon, hms (>= 0.4.1), lifecycle (>=\n0.2.0), methods
rlang          "utils"
rmarkdown      "bslib (>= 0.2.5.1), evaluate (>= 0.13), fontawesome (>=\n0.5.0), htmltools (>
rprojroot      NA
rstudioapi     NA
sass           "fs (>= 1.2.4), rlang (>= 0.4.10), htmltools (>= 0.5.1), R6,\nrappdirs"
stringi        "tools, utils, stats"
stringr        "cli, glue (>= 1.6.1), lifecycle (>= 1.0.3), magrittr, rlang\n(>= 1.0.0), stri
sys            NA
tibble         "fansi (>= 0.4.0), lifecycle (>= 1.0.0), magrittr, methods,\npillar (>= 1.8.1)
tidyselect     "cli (>= 3.3.0), glue (>= 1.3.0), lifecycle (>= 1.0.3), rlang\n(>= 1.0.4), vct
tinytex        "xfun (>= 0.29)"
TTR            "xts (>= 0.10-0), zoo, curl"
tzdb           NA
usethis        "cli (>= 3.0.1), clipr (>= 0.3.0), crayon, curl (>= 2.7), desc\n(>= 1.4.2), fs
utf8           NA
vctrs          "cli (>= 3.4.0), glue, lifecycle (>= 1.0.3), rlang (>= 1.1.0)"
vroom          "bit64, cli (>= 3.2.0), crayon, glue, hms, lifecycle (>=\n1.0.3), methods, rla
whisker        NA
withr          "graphics, grDevices, stats"
xfun           "stats, tools"
xts            "methods"
yaml           NA
zip            NA
zoo            "utils, graphics, grDevices, lattice (>= 0.20-27)"
base           NA
boot           NA
class          "MASS"
cluster        "graphics, grDevices, stats, utils"
codetools      NA
compiler       NA
datasets       NA
foreign        "methods, utils, stats"
graphics       "grDevices"
grDevices      NA
grid           "grDevices, utils"
KernSmooth     NA
```

```
lattice        "grid, grDevices, graphics, stats, utils"
MASS           "methods"
Matrix         "graphics, grid, lattice, stats, utils"
methods        "utils, stats"
mgcv           "methods, stats, graphics, Matrix, splines, utils"
nlme           "graphics, stats, utils, lattice"
nnet           NA
parallel       "tools, compiler"
rpart          NA
spatial        NA
splines        "graphics, stats"
stats          "utils, grDevices, graphics"
stats4         "graphics, methods, stats"
survival       "graphics, Matrix, methods, splines, stats, utils"
tcltk          "utils"
tools          NA
utils          NA
               LinkingTo
askpass        NA
base64enc      NA
bit            NA
bit64          NA
bslib          NA
cachem         NA
cli            NA
clipr          NA
cpp11          NA
crayon         NA
credentials    NA
curl           NA
DBI            NA
desc           NA
digest         NA
DMwR2          NA
dplyr          NA
ellipsis       NA
evaluate       NA
fansi          NA
fastmap        NA
fontawesome    NA
fs             NA
generics       NA
gert           NA
```

```
gh              NA
gitcreds        NA
glue            NA
highr           NA
hms             NA
htmltools       NA
httr2           NA
ini             NA
jquerylib       NA
jsonlite        NA
knitr           NA
lifecycle       NA
magrittr        NA
memoise         NA
mime            NA
openssl         NA
palmerpenguins NA
pillar          NA
pkgconfig       NA
prettyunits     NA
progress        NA
purrr           "cli"
quantmod        NA
R6              NA
rappdirs        NA
readr           "cpp11, tzdb (>= 0.1.1)"
rlang           NA
rmarkdown       NA
rprojroot       NA
rstudioapi      NA
sass            NA
stringi         NA
stringr         NA
sys             NA
tibble          NA
tidyselect      NA
tinytex         NA
TTR             "xts"
tzdb            "cpp11 (>= 0.4.2)"
usethis         NA
utf8            NA
vctrs           NA
vroom           "cpp11 (>= 0.2.0), progress (>= 1.2.1), tzdb (>= 0.1.1)"
```

```
whisker         NA
withr           NA
xfun            NA
xts             "zoo"
yaml            NA
zip             NA
zoo             NA
base            NA
boot            NA
class           NA
cluster         NA
codetools       NA
compiler        NA
datasets        NA
foreign         NA
graphics        NA
grDevices       NA
grid            NA
KernSmooth      NA
lattice         NA
MASS            NA
Matrix          NA
methods         NA
mgcv            NA
nlme            NA
nnet            NA
parallel        NA
rpart           NA
spatial         NA
splines         NA
stats           NA
stats4          NA
survival        NA
tcltk           NA
tools           NA
utils           NA
                Suggests
askpass         "testthat"
base64enc       NA
bit             "testthat (>= 0.11.0), roxygen2, knitr, rmarkdown,\nmicrobenchmark, bit64 (>=
bit64           NA
bslib           "bsicons, curl, fontawesome, ggplot2, knitr, magrittr,\nrappdirs, rmarkdown (>
cachem          "testthat"
```

```
cli             "callr, covr, crayon, digest, glue (>= 1.6.0), grDevices,\nhtmltools, htmlwidg
clipr           "covr, knitr, rmarkdown, rstudioapi (>= 0.5), testthat (>=\n2.0.0)"
cpp11           "bench, brio, callr, cli, covr, decor, desc, ggplot2, glue,\nknitr, lobstr, mo
crayon          "mockery, rstudioapi, testthat, withr"
credentials     "testthat, knitr, rmarkdown"
curl            "spelling, testthat (>= 1.0.0), knitr, jsonlite, rmarkdown,\nmagrittr, httpuv
DBI             "blob, covr, DBItest, dbplyr, downlit, dplyr, glue, hms,\nknitr, magrittr, RMa
desc            "callr, covr, gh, spelling, testthat, whoami, withr"
digest          "tinytest, simplermarkdown"
DMwR2           NA
dplyr           "bench, broom, callr, covr, DBI, dbplyr (>= 2.2.1), ggplot2,\nknitr, Lahman, l
ellipsis        "covr, testthat"
evaluate        "covr, ggplot2, lattice, rlang, testthat (>= 3.0.0), withr"
fansi           "unitizer, knitr, rmarkdown"
fastmap         "testthat (>= 2.1.1)"
fontawesome     "covr, dplyr (>= 1.0.8), knitr (>= 1.31), testthat (>= 3.0.0),\nrsvg"
fs              "covr, crayon, knitr, pillar (>= 1.0.0), rmarkdown, spelling,\ntestthat (>= 3
generics        "covr, pkgload, testthat (>= 3.0.0), tibble, withr"
gert            "spelling, knitr, rmarkdown, testthat"
gh              "covr, knitr, mockery, rmarkdown, rprojroot, spelling,\ntestthat (>= 3.0.0), w
gitcreds        "codetools, covr, knitr, mockery, oskeyring, rmarkdown,\ntestthat (>= 3.0.0),
glue            "covr, crayon, DBI, dplyr, forcats, ggplot2, knitr, magrittr,\nmicrobenchmark
highr           "knitr, markdown, testit"
hms             "crayon, lubridate, pillar (>= 1.1.0), testthat (>= 3.0.0)"
htmltools       "markdown, testthat, withr, Cairo, ragg, shiny"
httr2           "askpass, bench, clipr, covr, docopt, httpuv, jose, jsonlite,\nknitr, purrr, r
ini             "testthat"
jquerylib       "testthat"
jsonlite        "httr, vctrs, testthat, knitr, rmarkdown, R.rsp, sf"
knitr           "bslib, codetools, DBI (>= 0.4-1), digest, formatR, gifski,\ngridSVG, htmlwidg
lifecycle       "covr, crayon, knitr, lintr, rmarkdown, testthat (>= 3.0.1),\ntibble, tidyvers
magrittr        "covr, knitr, rlang, rmarkdown, testthat"
memoise         "digest, aws.s3, covr, googleAuthR, googleCloudStorageR, httr,\ntestthat"
mime            NA
openssl         "curl, testthat (>= 2.1.0), digest, knitr, rmarkdown,\njsonlite, jose, sodium"
palmerpenguins "knitr, rmarkdown, tibble, ggplot2, dplyr, tidyr, recipes"
pillar          "bit64, DBI, debugme, DiagrammeR, dplyr, formattable, ggplot2,\nknitr, lubrida
pkgconfig       "covr, testthat, disposables (>= 1.0.3)"
prettyunits     "codetools, covr, testthat"
progress        "Rcpp, testthat, withr"
purrr           "covr, dplyr (>= 0.7.8), httr, knitr, lubridate, rmarkdown,\ntestthat (>= 3.0
quantmod        "DBI,RMySQL,RSQLite,timeSeries,xml2,downloader"
R6              "testthat, pryr"
```

```
rappdirs       "roxygen2, testthat (>= 3.0.0), covr, withr"
readr          "covr, curl, datasets, knitr, rmarkdown, spelling, stringi,\ntestthat (>= 3.1
rlang          "cli (>= 3.1.0), covr, crayon, fs, glue, knitr, magrittr,\nmethods, pillar, rm
rmarkdown      "digest, dygraphs, fs, rsconnect, downlit (>= 0.4.0), katex\n(>= 1.4.0), sass
rprojroot      "covr, knitr, lifecycle, mockr, rmarkdown, testthat (>=\n3.0.0), withr"
rstudioapi     "testthat, knitr, rmarkdown, clipr, covr"
sass           "testthat, knitr, rmarkdown, withr, shiny, curl"
stringi        NA
stringr        "covr, htmltools, htmlwidgets, knitr, rmarkdown, testthat (>=\n3.0.0)"
sys            "unix (>= 1.4), spelling, testthat"
tibble         "bench, bit64, blob, brio, callr, cli, covr, crayon (>=\n1.3.4), DiagrammeR, c
tidyselect     "covr, crayon, dplyr, knitr, magrittr, rmarkdown, stringr,\ntestthat (>= 3.1.
tinytex        "testit, rstudioapi"
TTR            "RUnit"
tzdb           "covr, testthat (>= 3.0.0)"
usethis        "covr, knitr, magick, pkgload, rmarkdown, roxygen2 (>= 7.1.2),\nspelling (>=
utf8           "cli, covr, knitr, rlang, rmarkdown, testthat (>= 3.0.0),\nwithr"
vctrs          "bit64, covr, crayon, dplyr (>= 0.8.5), generics, knitr,\npillar (>= 1.4.4),
vroom          "archive, bench (>= 1.1.0), covr, curl, dplyr, forcats, fs,\nggplot2, knitr,
whisker        "markdown"
withr          "callr, covr, DBI, knitr, lattice, methods, rlang, rmarkdown\n(>= 2.12), RSQL
xfun           "testit, parallel, codetools, rstudioapi, tinytex (>= 0.30),\nmime, markdown
xts            "timeSeries, timeDate, tseries, chron, tinytest"
yaml           "RUnit"
zip            "covr, processx, R6, testthat, withr"
zoo            "AER, coda, chron, ggplot2 (>= 3.0.0), mondate, scales,\nstinepack, strucchang
base           "methods"
boot           "MASS, survival"
class          NA
cluster        "MASS, Matrix"
codetools      NA
compiler       NA
datasets       NA
foreign        NA
graphics       NA
grDevices      "KernSmooth"
grid           NA
KernSmooth     "MASS, carData"
lattice        "KernSmooth, MASS, latticeExtra, colorspace"
MASS           "lattice, nlme, nnet, survival"
Matrix         "MASS, expm"
methods        "codetools"
mgcv           "parallel, survival, MASS"
```

```
nlme            "Hmisc, MASS, SASmixed"
nnet            "MASS"
parallel        "methods"
rpart           "survival"
spatial         "MASS"
splines         "Matrix, methods"
stats           "MASS, Matrix, SuppDists, methods, stats4"
stats4          NA
survival        NA
tcltk           NA
tools           "codetools, methods, xml2, curl, commonmark, knitr, xfun, mathjaxr, V8"
utils           "methods, xml2, commonmark, knitr"
                Enhances
askpass         NA
base64enc       "png"
bit             NA
bit64           NA
bslib           NA
cachem          NA
cli             NA
clipr           NA
cpp11           NA
crayon          NA
credentials     NA
curl            NA
DBI             NA
desc            NA
digest          NA
DMwR2           NA
dplyr           NA
ellipsis        NA
evaluate        NA
fansi           NA
fastmap         NA
fontawesome     NA
fs              NA
generics        NA
gert            NA
gh              NA
gitcreds        NA
glue            NA
highr           NA
hms             NA
```

```
htmltools      "knitr"
httr2          NA
ini            NA
jquerylib      NA
jsonlite       NA
knitr          NA
lifecycle      NA
magrittr       NA
memoise        NA
mime           NA
openssl        NA
palmerpenguins NA
pillar         NA
pkgconfig      NA
prettyunits    NA
progress       NA
purrr          NA
quantmod       NA
R6             NA
rappdirs       NA
readr          NA
rlang          "winch"
rmarkdown      NA
rprojroot      NA
rstudioapi     NA
sass           NA
stringi        NA
stringr        NA
sys            NA
tibble         NA
tidyselect     NA
tinytex        NA
TTR            "quantmod"
tzdb           NA
usethis        NA
utf8           NA
vctrs          NA
vroom          NA
whisker        NA
withr          NA
xfun           NA
xts            NA
yaml           NA
```

```
zip             NA
zoo             NA
base            NA
boot            NA
class           NA
cluster         NA
codetools       NA
compiler        NA
datasets        NA
foreign         NA
graphics        NA
grDevices       NA
grid            NA
KernSmooth      NA
lattice         "chron"
MASS            NA
Matrix          "MatrixModels, SparseM, graph, igraph, maptools, sfsmisc, sp,\nspdep"
methods         NA
mgcv            NA
nlme            NA
nnet            NA
parallel        "snow, Rmpi"
rpart           NA
spatial         NA
splines         NA
stats           NA
stats4          NA
survival        NA
tcltk           NA
tools           NA
utils           NA
                License                                 License_is_FOSS
askpass         "MIT + file LICENSE"                    NA
base64enc       "GPL-2 | GPL-3"                         NA
bit             "GPL-2 | GPL-3"                         NA
bit64           "GPL-2 | GPL-3"                         NA
bslib           "MIT + file LICENSE"                    NA
cachem          "MIT + file LICENSE"                    NA
cli             "MIT + file LICENSE"                    NA
clipr           "GPL-3"                                 NA
cpp11           "MIT + file LICENSE"                    NA
crayon          "MIT + file LICENSE"                    NA
credentials     "MIT + file LICENSE"                    NA
```

```
curl           "MIT + file LICENSE"                NA
DBI            "LGPL (>= 2.1)"                     NA
desc           "MIT + file LICENSE"                NA
digest         "GPL (>= 2)"                        NA
DMwR2          "GPL (>= 2)"                        NA
dplyr          "MIT + file LICENSE"                NA
ellipsis       "MIT + file LICENSE"                NA
evaluate       "MIT + file LICENSE"                NA
fansi          "GPL-2 | GPL-3"                     NA
fastmap        "MIT + file LICENSE"                NA
fontawesome    "MIT + file LICENSE"                NA
fs             "MIT + file LICENSE"                NA
generics       "MIT + file LICENSE"                NA
gert           "MIT + file LICENSE"                NA
gh             "MIT + file LICENSE"                NA
gitcreds       "MIT + file LICENSE"                NA
glue           "MIT + file LICENSE"                NA
highr          "GPL"                               NA
hms            "MIT + file LICENSE"                NA
htmltools      "GPL (>= 2)"                        NA
httr2          "MIT + file LICENSE"                NA
ini            "GPL-3"                             NA
jquerylib      "MIT + file LICENSE"                NA
jsonlite       "MIT + file LICENSE"                NA
knitr          "GPL"                               NA
lifecycle      "MIT + file LICENSE"                NA
magrittr       "MIT + file LICENSE"                NA
memoise        "MIT + file LICENSE"                NA
mime           "GPL"                               NA
openssl        "MIT + file LICENSE"                NA
palmerpenguins "CC0"                               NA
pillar         "MIT + file LICENSE"                NA
pkgconfig      "MIT + file LICENSE"                NA
prettyunits    "MIT + file LICENSE"                NA
progress       "MIT + file LICENSE"                NA
purrr          "MIT + file LICENSE"                NA
quantmod       "GPL-3"                             NA
R6             "MIT + file LICENSE"                NA
rappdirs       "MIT + file LICENSE"                NA
readr          "MIT + file LICENSE"                NA
rlang          "MIT + file LICENSE"                NA
rmarkdown      "GPL-3"                             NA
rprojroot      "MIT + file LICENSE"                NA
```

```
rstudioapi     "MIT + file LICENSE"                    NA
sass           "MIT + file LICENSE"                    NA
stringi        "file LICENSE"                          "yes"
stringr        "MIT + file LICENSE"                    NA
sys            "MIT + file LICENSE"                    NA
tibble         "MIT + file LICENSE"                    NA
tidyselect     "MIT + file LICENSE"                    NA
tinytex        "MIT + file LICENSE"                    NA
TTR            "GPL (>= 2)"                            NA
tzdb           "MIT + file LICENSE"                    NA
usethis        "MIT + file LICENSE"                    NA
utf8           "Apache License (== 2.0) | file LICENSE" NA
vctrs          "MIT + file LICENSE"                    NA
vroom          "MIT + file LICENSE"                    NA
whisker        "GPL-3"                                 NA
withr          "MIT + file LICENSE"                    NA
xfun           "MIT + file LICENSE"                    NA
xts            "GPL (>= 2)"                            NA
yaml           "BSD_3_clause + file LICENSE"           NA
zip            "MIT + file LICENSE"                    NA
zoo            "GPL-2 | GPL-3"                         NA
base           "Part of R 4.3.1"                       NA
boot           "Unlimited"                             NA
class          "GPL-2 | GPL-3"                         NA
cluster        "GPL (>= 2)"                            NA
codetools      "GPL"                                   NA
compiler       "Part of R 4.3.1"                       NA
datasets       "Part of R 4.3.1"                       NA
foreign        "GPL (>= 2)"                            NA
graphics       "Part of R 4.3.1"                       NA
grDevices      "Part of R 4.3.1"                       NA
grid           "Part of R 4.3.1"                       NA
KernSmooth     "Unlimited"                             NA
lattice        "GPL (>= 2)"                            NA
MASS           "GPL-2 | GPL-3"                         NA
Matrix         "GPL (>= 2) | file LICENCE"             NA
methods        "Part of R 4.3.1"                       NA
mgcv           "GPL (>= 2)"                            NA
nlme           "GPL (>= 2)"                            NA
nnet           "GPL-2 | GPL-3"                         NA
parallel       "Part of R 4.3.1"                       NA
rpart          "GPL-2 | GPL-3"                         NA
spatial        "GPL-2 | GPL-3"                         NA
```

```
splines        "Part of R 4.3.1"                    NA
stats          "Part of R 4.3.1"                    NA
stats4         "Part of R 4.3.1"                    NA
survival       "LGPL (>= 2)"                        NA
tcltk          "Part of R 4.3.1"                    NA
tools          "Part of R 4.3.1"                    NA
utils          "Part of R 4.3.1"                    NA
               License_restricts_use OS_type MD5sum NeedsCompilation Built
askpass        NA                    NA      NA     "yes"            "4.3.0"
base64enc      NA                    NA      NA     "yes"            "4.3.0"
bit            NA                    NA      NA     "yes"            "4.3.0"
bit64          NA                    NA      NA     "yes"            "4.3.0"
bslib          NA                    NA      NA     "no"             "4.3.0"
cachem         NA                    NA      NA     "yes"            "4.3.0"
cli            NA                    NA      NA     "yes"            "4.3.0"
clipr          NA                    NA      NA     "no"             "4.3.0"
cpp11          NA                    NA      NA     "no"             "4.3.0"
crayon         NA                    NA      NA     "no"             "4.3.0"
credentials    NA                    NA      NA     "no"             "4.3.0"
curl           NA                    NA      NA     "yes"            "4.3.0"
DBI            NA                    NA      NA     "no"             "4.3.0"
desc           NA                    NA      NA     "no"             "4.3.0"
digest         NA                    NA      NA     "yes"            "4.3.0"
DMwR2          NA                    NA      NA     "no"             "4.3.0"
dplyr          NA                    NA      NA     "yes"            "4.3.0"
ellipsis       NA                    NA      NA     "yes"            "4.3.0"
evaluate       NA                    NA      NA     "no"             "4.3.0"
fansi          NA                    NA      NA     "yes"            "4.3.0"
fastmap        NA                    NA      NA     "yes"            "4.3.0"
fontawesome    NA                    NA      NA     "no"             "4.3.0"
fs             NA                    NA      NA     "yes"            "4.3.0"
generics       NA                    NA      NA     "no"             "4.3.0"
gert           NA                    NA      NA     "yes"            "4.3.0"
gh             NA                    NA      NA     "no"             "4.3.0"
gitcreds       NA                    NA      NA     "no"             "4.3.0"
glue           NA                    NA      NA     "yes"            "4.3.0"
highr          NA                    NA      NA     "no"             "4.3.0"
hms            NA                    NA      NA     "no"             "4.3.0"
htmltools      NA                    NA      NA     "yes"            "4.3.0"
httr2          NA                    NA      NA     "no"             "4.3.0"
ini            NA                    NA      NA     "no"             "4.3.0"
jquerylib      NA                    NA      NA     "no"             "4.3.0"
jsonlite       NA                    NA      NA     "yes"            "4.3.0"
```

knitr	NA	NA	NA	"no"	"4.3.0"
lifecycle	NA	NA	NA	"no"	"4.3.0"
magrittr	NA	NA	NA	"yes"	"4.3.0"
memoise	NA	NA	NA	"no"	"4.3.0"
mime	NA	NA	NA	"yes"	"4.3.0"
openssl	NA	NA	NA	"yes"	"4.3.0"
palmerpenguins	NA	NA	NA	"no"	"4.3.0"
pillar	NA	NA	NA	"no"	"4.3.0"
pkgconfig	NA	NA	NA	"no"	"4.3.0"
prettyunits	NA	NA	NA	"no"	"4.3.0"
progress	NA	NA	NA	"no"	"4.3.0"
purrr	NA	NA	NA	"yes"	"4.3.0"
quantmod	NA	NA	NA	"no"	"4.3.0"
R6	NA	NA	NA	"no"	"4.3.0"
rappdirs	NA	NA	NA	"yes"	"4.3.0"
readr	NA	NA	NA	"yes"	"4.3.0"
rlang	NA	NA	NA	"yes"	"4.3.0"
rmarkdown	NA	NA	NA	"no"	"4.3.0"
rprojroot	NA	NA	NA	"no"	"4.3.0"
rstudioapi	NA	NA	NA	"no"	"4.3.0"
sass	NA	NA	NA	"yes"	"4.3.0"
stringi	NA	NA	NA	"yes"	"4.3.0"
stringr	NA	NA	NA	"no"	"4.3.0"
sys	NA	NA	NA	"yes"	"4.3.0"
tibble	NA	NA	NA	"yes"	"4.3.0"
tidyselect	NA	NA	NA	"no"	"4.3.0"
tinytex	NA	NA	NA	"no"	"4.3.0"
TTR	NA	NA	NA	"yes"	"4.3.0"
tzdb	NA	NA	NA	"yes"	"4.3.0"
usethis	NA	NA	NA	"no"	"4.3.0"
utf8	NA	NA	NA	"yes"	"4.3.0"
vctrs	NA	NA	NA	"yes"	"4.3.0"
vroom	NA	NA	NA	"yes"	"4.3.0"
whisker	NA	NA	NA	"no"	"4.3.0"
withr	NA	NA	NA	"no"	"4.3.0"
xfun	NA	NA	NA	"yes"	"4.3.0"
xts	NA	NA	NA	"yes"	"4.3.0"
yaml	NA	NA	NA	"yes"	"4.3.0"
zip	NA	NA	NA	"yes"	"4.3.0"
zoo	NA	NA	NA	"yes"	"4.3.0"
base	NA	NA	NA	NA	"4.3.1"
boot	NA	NA	NA	"no"	"4.3.1"
class	NA	NA	NA	"yes"	"4.3.1"

```
cluster        NA                    NA      NA     "yes"           "4.3.1"
codetools      NA                    NA      NA     "no"            "4.3.1"
compiler       NA                    NA      NA     NA              "4.3.1"
datasets       NA                    NA      NA     NA              "4.3.1"
foreign        NA                    NA      NA     "yes"           "4.3.1"
graphics       NA                    NA      NA     "yes"           "4.3.1"
grDevices      NA                    NA      NA     "yes"           "4.3.1"
grid           NA                    NA      NA     "yes"           "4.3.1"
KernSmooth     NA                    NA      NA     "yes"           "4.3.1"
lattice        NA                    NA      NA     "yes"           "4.3.1"
MASS           NA                    NA      NA     "yes"           "4.3.1"
Matrix         NA                    NA      NA     "yes"           "4.3.1"
methods        NA                    NA      NA     "yes"           "4.3.1"
mgcv           NA                    NA      NA     "yes"           "4.3.1"
nlme           NA                    NA      NA     "yes"           "4.3.1"
nnet           NA                    NA      NA     "yes"           "4.3.1"
parallel       NA                    NA      NA     "yes"           "4.3.1"
rpart          NA                    NA      NA     "yes"           "4.3.1"
spatial        NA                    NA      NA     "yes"           "4.3.1"
splines        NA                    NA      NA     "yes"           "4.3.1"
stats          NA                    NA      NA     "yes"           "4.3.1"
stats4         NA                    NA      NA     NA              "4.3.1"
survival       NA                    NA      NA     "yes"           "4.3.1"
tcltk          NA                    NA      NA     "yes"           "4.3.1"
tools          NA                    NA      NA     "yes"           "4.3.1"
utils          NA                    NA      NA     "yes"           "4.3.1"
```

Use following code to see if installed packages have newer version

```
old.packages()
```

```
           Package      LibPath                       Installed Built
KernSmooth "KernSmooth" "/opt/R/4.3.1/lib/R/library" "2.23-21" "4.3.1"
Matrix     "Matrix"     "/opt/R/4.3.1/lib/R/library" "1.5-4.1" "4.3.1"
mgcv       "mgcv"       "/opt/R/4.3.1/lib/R/library" "1.8-42"  "4.3.1"
nlme       "nlme"       "/opt/R/4.3.1/lib/R/library" "3.1-162" "4.3.1"
spatial    "spatial"    "/opt/R/4.3.1/lib/R/library" "7.3-16"  "4.3.1"
survival   "survival"   "/opt/R/4.3.1/lib/R/library" "3.5-5"   "4.3.1"
           ReposVer  Repository
KernSmooth "2.23-22" "http://rspm/default/__linux__/focal/latest/src/contrib"
Matrix     "1.6-1"   "http://rspm/default/__linux__/focal/latest/src/contrib"
```

```
mgcv       "1.9-0"   "http://rspm/default/__linux__/focal/latest/src/contrib"
nlme       "3.1-163" "http://rspm/default/__linux__/focal/latest/src/contrib"
spatial    "7.3-17"  "http://rspm/default/__linux__/focal/latest/src/contrib"
survival   "3.5-7"   "http://rspm/default/__linux__/focal/latest/src/contrib"
```

To update all the packages to newer version

####{r} ####update.packages() ####

Use following to update all the insatalled packages without the confirmation

####{r} ####update.packages(ask=FALSE) ####

To find namespace/package a function belongs in your installed package, just type function name

```
mean
```

```
function (x, ...)
UseMethod("mean")
<bytecode: 0x55755bd2bf68>
<environment: namespace:base>
```

To find help on a function

```
help(mean)
```

If package we want to use has already been made

```
RSiteSearch('neural networks')
```

```
A search query has been submitted to https://search.r-project.org
The results page should open in your browser shortly
```

Project and Session Management

Utilize the Project feature for effective management of your R scripts and data.

In RStudio, navigate to File > New Project to establish a new folder on your computer dedicated to your project.

Within the project folder, you can create and store multiple scripts alongside the data you're working with.

To continue your work within a project, go to File > Open Project, which restores your previous workspace.

Your project folder functions as your current working directory, where you can conveniently save your .R and .RData files.

However, it's worth noting that a .R file can also exist independently outside of a project or project folder.

Closing a Project in RStudio will shut down the current project while keeping the session active, allowing you to keep the RStudio interface open.

On the other hand, selecting Quit Session closes the current RStudio window entirely.

When dealing with long and intricate commands in the console, it can be constraining.

A more efficient approach is to input all your commands into a text file, save it, and then either:

1. Execute the series of commands using [1] source('path_to_mycode.R').

2. Open mycode.R in RStudio's script tab and execute your commands from there using the Run or Source button.

- Run: Execute the code line by line.

- Source: Execute the entire script at once.

Frequently, you may need to save substantial data objects or functions for future use.

```
####{r} ####save(my.function, mydataset, file="path_to_mysession.RData")
####load("path_to_mysession.RData") ####
```

Save all objects

All objects are saved in .RData file for you to load ahead in future

```
save.image()
```

use getwd() and show() in RStudio Console for current working Directory and set working directory.

R Objects and Variables

variables are fundamental components used to store and manipulate data. They serve as named containers or identifiers for holding values, which can be numbers, text, objects, or other data types. e.g. assigning number 3 to a variable.

```
var <- 3
```

To see what the var variable holds

```
var
```

```
[1] 3
```

To print variable while assigning use ()

```
(var <- 3)
```

```
[1] 3
```

More Example For Same

```
x <- 10
y <- var*x
y
```

```
[1] 30
```

To list the current alive variables

```
ls() # we can also use
```

```
[1] "algae"           "algae.sols"      "has_annotations" "test.algae"
[5] "var"             "x"               "y"
```

```
objects()
```

```
[1] "algae"           "algae.sols"      "has_annotations" "test.algae"
[5] "var"             "x"               "y"
```

Using the following command we can remove variable from the memory

```
rm(var)
```

R Functions

In R, functions are blocks of reusable code that perform specific tasks or operations. Functions are a fundamental concept in R and play a central role in data analysis, statistical modeling, and programming.

Here are some examples

```
max(10, 30, 20, 11)
```

```
[1] 30
```

```
mean(10,20,30,40,50)
```

```
[1] 10
```

```
mean(sample(1:100, 30))
```

```
[1] 46.83333
```

```r
set.seed(1) #In the context of R, functions represent segments of code that can be reused

rnorm(1)
```

```
[1] -0.6264538
```

```r
rnorm(1)
```

```
[1] 0.1836433
```

We employ the set.seed() function to ensure that when running a program that involves generating random samples multiple times, we obtain consistent results for the purpose of debugging.

To initiate the creation of a new function called 'se' (representing the standard error of means), the initial step is to verify whether 'se' already exists within our present environment.

```r
exists("se")
```

```
[1] FALSE
```

Now we will create the function that computes the standard error of a sample.

```r
se <- function(x){
  variance <- var(x)
  n <-length(x)
  return (sqrt(variance/n))
}
```

```r
exists("se")
```

```
[1] TRUE
```

Same way, we can create a function to convert meters to inches,feet,yards and miles.

```r
convMeters <- function (x, to="inch"){
  factor = switch(to, inch=39.3701, foot=3.28084, yard=1.09361, mile=0.000621371, NA)
  if(is.na(factor)) stop ("unknown target unit")
  else return (x*factor)
}
convMeters(40, "foot")
```

```
[1] 131.2336
```

#Note is no argument is used above 'inch' is used

Factors

In R, factor variables are a data type used to represent categorical data. Categorical data consists of distinct categories or groups and is often used to label or group data into meaningful subsets. Factor variables are essential for tasks like statistical modeling and data analysis.

We can use factor() to create factor

```r
g <-c('f', 'm', 'f', 'f', 'f', 'm', 'm', 'f')
g <- factor(g)
```

using levels

```r
other.g <-factor(c('m', 'm', 'm', 'm'), levels= c('f', 'm'))
other.g
```

```
[1] m m m m
Levels: f m
```

We can use factor for illustrating concept of marginal frequencies or marginal distributions.

```r
g <- factor(c('f', 'm', 'f', 'f', 'f', 'm', 'm', 'f'))
table(g)
```

```
g
f m
5 3
```

```
a <- factor(c('adult', 'juvenile','adult', 'juvenile','adult', 'juvenile','juvenile', 'juv
table(a, g)
```

```
          g
a          f m
  adult    3 0
  juvenile 2 3
```

```
a <- factor(c('adult', 'juvenile','adult', 'juvenile','adult', 'juvenile','juvenile', 'juv
t <- table(a, g)
t
```

```
          g
a          f m
  adult    3 0
  juvenile 2 3
```

```
a <- factor(c('adult', 'juvenile','adult', 'juvenile','adult', 'juvenile','juvenile', 'juv
t <- table(a, g)
t
```

```
          g
a          f m
  adult    3 0
  juvenile 2 3
```

Find marginal frequency of a factor

```
margin.table(t, 1)#1 refers to the first factor, a (age)
```

```
a
   adult juvenile
       3        5
```

```
margin.table(t, 2)# now find the marginal freq of the second factor g
```

```
g
f m
5 3
```

To find relative frequency

```
prop.table(t, 1) #use the margin generated for the 1st factor a
```

```
          g
a            f   m
  adult    1.0 0.0
  juvenile 0.4 0.6
```

```
prop.table(t, 2)
```

```
          g
a            f   m
  adult    0.6 0.0
  juvenile 0.4 1.0
```

```
prop.table(t) #overall
```

```
          g
a              f     m
  adult    0.375 0.000
  juvenile 0.250 0.375
```

```
prop.table(t) * 100
```

```
          g
a             f    m
  adult    37.5  0.0
  juvenile 25.0 37.5
```

R Data Structures

Vectors

In R, a vector is one of the fundamental data structures used to store and manipulate collections of data. Vectors are a versatile and important concept in R programming.

To create a vector

```
v <- c(2, 5, 3, 4)
length(v)
```

```
[1] 4
```

To know the data type of a vector

```
mode(v)
```

```
[1] "numeric"
```

If Strings and numbers are mixed it will show data type as character.

```
v <- c(2, 5, 3, 4, 'me')
mode(v)
```

```
[1] "character"
```

```
v
```

```
[1] "2"  "5"  "3"  "4"  "me"
```

Boolean Vector

```
vec <- c(TRUE,TRUE,NA,FALSE)
mode(vec)
```

```
[1] "logical"
```

```
vec
```

```
[1]  TRUE  TRUE    NA FALSE
```

In vector elements are indexed starting from 1

```
vec[4]
```

```
[1] FALSE
```

We can update a vector to a specific index

```
vec[4] <- TRUE
vec
```

```
[1] TRUE TRUE   NA TRUE
```

Even we can add any values anywhere at any index as vectors are elastic.

```
vec[7] <- TRUE
vec
```

```
[1] TRUE TRUE   NA TRUE   NA   NA TRUE
```

we can create a empty vector

```
e <-vector()
mode(e)
```

```
[1] "logical"
```

```
e <- c()
mode(e)
```

```
[1] "NULL"
```

```
length(e)
```

```
[1] 0
```

Using a vector element we can create another vector

```
vec2 <-c(vec[1], vec[3], vec[5])
vec2
```

```
[1] TRUE   NA   NA
```

To find square root of all elements

```
v <- c(10,20,30,40,50)
sqrt(v)
```

```
[1] 3.162278 4.472136 5.477226 6.324555 7.071068
```

Vector Arithmetic

```
v1 <- c(3, 6, 9)
v2 <- c(1, 4, 8)
v1+v2 #addition
```

```
[1]  4 10 17
```

```
v1*v2 #dot product
```

```
[1]  3 24 72
```

```
v1-v2 #subtraction
```

```
[1] 2 2 1
```

```
v1/v2 #divsion
```

```
[1] 3.000 1.500 1.125
```

#In vectors arithmetic operations with different vector size is allowed.

```
v3 <- c(1, 4)
v1+v3#the recycling rule makes v3 [1, 4, 1]
```

```
Warning in v1 + v3: longer object length is not a multiple of shorter object
length
```

```
[1]  4 10 10
```

a single value is vector too

```
2*v1
```

```
[1]  6 12 18
```

PART II

If we know the distribution we can generate vectors.

```
(x <-1:10)
```

```
 [1]  1  2  3  4  5  6  7  8  9 10
```

```
(x <-10:1)
```

```
 [1] 10  9  8  7  6  5  4  3  2  1
```

#Note : operator have higher precedence tahn arithmetic operator

```
  10:15-1
```

```
[1]  9 10 11 12 13 14
```

```
  (seq(from=1, to=5, length=4)) # 4 values between 1 and 5 inclusive, even intervals/steps
```

```
[1] 1.000000 2.333333 3.666667 5.000000
```

```
  (seq(length=10, from=-2, by=0.5)) #10 values, starting from 2, interval/step = 0.5
```

```
 [1] -2.0 -1.5 -1.0 -0.5  0.0  0.5  1.0  1.5  2.0  2.5
```

```
  (rep(5, 10))
```

```
 [1] 5 5 5 5 5 5 5 5 5 5
```

```
  (rep("hi", 3))
```

```
[1] "hi" "hi" "hi"
```

```
  (rep(1:2, 3))
```

```
[1] 1 2 1 2 1 2
```

```
  (rep(TRUE:FALSE, 3))
```

```
[1] 1 0 1 0 1 0
```

```
  (rep(1:2, each=3))
```

```
[1] 1 1 1 2 2 2
```

```
gl(3, 5) #three levels, each repeat 5 times
```

```
 [1] 1 1 1 1 1 2 2 2 2 2 3 3 3 3 3
Levels: 1 2 3
```

```
gl(2, 5, labels= c('female', 'male'))#two levels, each level repeat 5 times
```

```
 [1] female female female female female male   male   male   male   male
Levels: female male
```

```
#first argument 2 says two levels.
#second argument 1 says repeat once
#third argment 20 says generate 20 values
gl(2, 1, 20, labels=c('female', 'male'))#10 alternating female and male pairs, a total of
```

```
 [1] female male   female male   female male   female male   female male
[11] female male   female male   female male   female male   female male
Levels: female male
```

We can use factor() to convert number sequence to factor level labels.

```
n <- rep(1:2, each=3)
(n <- factor(n,
             levels = c(1, 2),
             labels = c('female','male')
             ))
```

```
[1] female female female male   male   male
Levels: female male
```

```
n
```

```
[1] female female female male   male   male
Levels: female male
```

generating random number using rnorm

```
(rnorm(10, mean=10, sd=3))
```

```
 [1]  7.493114 14.785842 10.988523  7.538595 11.462287 12.214974 11.727344
 [8]  9.083835 14.535344 11.169530
```

```
(rt(10, df=5)) #10 values following a Student T distribution with degree of freedom of 5
```

```
 [1] -3.20099075 -0.42241451 -0.86409523 -1.50276529  0.85199410 -1.82436807
 [7] -0.06641194 -1.41288461 -0.32612422  0.44183505
```

Exercise:

(1) Generate a random sample of `normally distributed` data of `size 100`, with a `mean of` 20 and `standard deviation 4`

```
(rnorm(100, mean=20, sd=4))
```

```
  [1] 24.60765 23.96864 18.28195 24.95322 18.88261 27.03161 22.24298 18.18886
  [9] 16.67183 15.33372 15.73764 13.74487 24.62615 23.32819 19.09069 21.06455
 [17] 18.49319 29.76546 16.81864 19.78049 21.00057 22.47297 19.30951 11.10440
 [25] 14.94554 21.43492 19.95582 16.23740 19.53670 16.74013 20.96905 14.29961
 [33] 21.46376 20.99365 20.26115 20.07663 21.02935 17.40396 19.52332 22.65654
 [41] 24.40388 20.57509 19.52899 16.35173 14.24966 16.81164 25.01633 23.08857
 [49] 19.12194 18.30076 18.32408 23.98795 18.89689 25.02408 22.58670 25.19725
 [57] 16.50695 20.03348 16.47651 22.38504 20.47887 18.87130 25.82395 20.91608
 [65] 23.98618 23.12744 16.89289 17.53604 20.18632 15.47846 22.30688 14.87700
 [73] 26.50179 17.99721 26.71319 18.34992 16.11085 20.10153 20.10990 13.27927
 [81] 24.21500 15.52160 21.34247 21.97918 20.55221 19.52483 20.79074 15.72523
 [89] 16.78715 15.54494 26.32037 25.99128 21.05058 15.06840 19.98511 26.04669
 [97] 18.09721 23.19167 16.10399 22.75749
```

```
dataset <- (rnorm(100, mean=20, sd=4))
len <- length(dataset)
sem <- dataset/ sqrt(len)
sem
```

```
  [1] 1.617664 1.507317 1.617243 1.652087 1.635728 2.296511 2.027405 1.870500
  [9] 1.565399 1.593628 1.692884 1.552112 1.820730 2.188695 1.527804 2.588103
 [17] 1.475432 1.961390 2.947888 2.356251 1.899127 1.653694 2.233034 1.994988
 [25] 1.850058 2.127154 1.804478 3.063463 2.672111 2.311834 2.285296 1.782847
 [33] 2.354311 1.860562 1.596778 2.753273 1.628412 1.882321 1.754020 1.621170
 [41] 2.239590 1.390554 1.917524 1.770282 1.443934 1.971833 1.827648 1.763110
 [49] 2.392446 2.212964 1.963818 2.062596 1.705075 1.919464 2.440871 1.993301
 [57] 2.064715 2.809905 1.718522 2.384317 2.716194 1.574334 2.007055 1.844037
 [65] 1.803667 1.581713 1.641515 2.507755 2.237536 2.310254 2.622948 1.853839
 [73] 2.326623 1.975746 1.799449 2.370425 2.014775 1.573520 1.904617 2.598089
 [81] 2.468863 1.416917 2.038022 2.339066 1.350254 2.563425 1.783296 2.111466
 [89] 1.922411 2.630463 1.409781 1.942157 1.618719 2.162617 2.891705 1.394201
 [97] 1.975317 1.941092 2.616637 1.607258
```

Sub-Setting

```
x <- c(0, -3, 4, -1, 45, 90, -5)
#select all elements that is greater than 0
(gtzero <- x[x>0])
```

```
[1]  4 45 90
```

```
x <- c(0, -3, 4, -1, 45, 90, -5)
(x[x<=-2 | x>5])
```

```
[1] -3 45 90 -5
```

```
(x[x>40 & x<100])
```

```
[1] 45 90
```

```
x <- c(0, -3, 4, -1, 45, 90, -5)
(x[c(4, 6)])#select the 4th and 6th elements in the vector
```

```
[1] -1 90
```

```
(y<-c(4,6)) #same as above
```

```
[1] 4 6
```

```
(x[y])
```

```
[1] -1 90
```

```
(x[1:3]) #select the 1st to the 3rd elements in the vector
```

```
[1]  0 -3  4
```

```
x <- c(0, -3, 4, -1, 45, 90, -5)
(x[-1]) #select all but the first element
```

```
[1] -3  4 -1 45 90 -5
```

```
(x[-c(4, 6)])
```

```
[1]  0 -3  4 45 -5
```

```
(x[-(1:3)])
```

```
[1] -1 45 90 -5
```

Named Elements

We can assign names to vector elements

```
x <- c(0, -3, 4, -1, 45, 90, -5)
names(x) <- c('s1', 's2', 's3', 's4', 's5', 's6', 's7')
x
```

```
s1 s2 s3 s4 s5 s6 s7
 0 -3  4 -1 45 90 -5
```

```
(pH <- c(area1=4.5, area2=5.7, area3=9.8, mud=7.2))
```

```
area1 area2 area3   mud
  4.5   5.7   9.8   7.2
```

```
pH['mud']
```

```
mud
7.2
```

```
pH[c('area1', 'mud')]
```

```
area1   mud
  4.5   7.2
```

#Note we can not use elements directly to exclude

eg # x[-"s1"] results in error

Empty index means to select all

```
pH[]
```

```
area1 area2 area3   mud
  4.5   5.7   9.8   7.2
```

```
pH
```

```
area1 area2 area3   mud
  4.5   5.7   9.8   7.2
```

We can reset a vector using following

```
pH[] <- 0
pH
```

```
area1 area2 area3   mud
    0     0     0     0
```

```
pH<- 0
pH
```

```
[1] 0
```

More R Data Structures

Matrices and Array

A matrix is a two-dimensional data structure in R, similar to a table or spreadsheet. It consists of rows and columns, and all elements within a matrix must be of the same data type

An array is a multi-dimensional data structure in R that extends beyond the two dimensions of a matrix. It can have multiple dimensions, making it suitable for storing and analyzing data with higher complexity.

Creating a Matrix

```
m <- c(45, 23, 66, 77, 33, 44, 56, 12, 78, 23)
is.vector(m)
```

```
[1] TRUE
```

```
is.matrix(m)
```

```
[1] FALSE
```

```
is.array(m)
```

```
[1] FALSE
```

```
dim(m) <-c(2, 5)#make the vector a 2 by 5 matrix, 2x5 must = lenght of the vector
m
```

```
     [,1] [,2] [,3] [,4] [,5]
[1,]   45   66   33   56   78
[2,]   23   77   44   12   23
```

```
is.vector(m)
```

```
[1] FALSE
```

```
is.matrix(m)
```

```
[1] TRUE
```

```
is.array(m)
```

```
[1] TRUE
```

Exercise

Create a matrix with two columns:

First columns hold age data for a group of students `11, 11, 12, 13, 14, 9, 8`, and second columns hold grades `5, 5, 6, 7, 8, 4, 3`.

```
test <-matrix(c(11, 11, 12, 13, 14, 9, 8, 5, 5, 6, 7, 8, 4, 3), 7, 2)
test
```

```
     [,1] [,2]
[1,]   11    5
[2,]   11    5
[3,]   12    6
[4,]   13    7
[5,]   14    8
[6,]    9    4
[7,]    8    3
```

```r
m <- c(45, 23, 66, 77, 33, 44, 56, 12, 78, 23)
#then 'organize' the vector as a matrix
dim(m) <- c(2, 5)#make the vector a 2 by 5 matrix, 2x5 must = lenght of the vector
m
```

```
     [,1] [,2] [,3] [,4] [,5]
[1,]   45   66   33   56   78
[2,]   23   77   44   12   23
```

```r
m[2, 3]#the element at row 2 and column 3
```

```
[1] 44
```

```r
(s<- m[2, 1]) # select one value
```

```
[1] 23
```

```r
(m<- m [c(1,2), -c(3, 5)]) #select 1st row and 1st, 2nd, and 4th columns: result is a vect
```

```
     [,1] [,2] [,3]
[1,]   45   66   56
[2,]   23   77   12
```

```r
(m [1, ]) #select complete row or column: 1st row, result is a vector
```

```
[1] 45 66 56
```

```r
(m [1, ]) #select complete row or column: 1st row, result is a vector
```

```
[1] 45 66 56
```

```r
is.vector(m)
```

```
[1] FALSE
```

```r
is.matrix(m)
```

```
[1] TRUE
```

```r
is.vector(v)
```

```
[1] TRUE
```

```r
is.matrix(v)
```

```
[1] FALSE
```

To keep results as matrix use drop = FALSE

```r
m <- matrix(c(45, 23, 66, 77, 33, 44, 56, 12, 78, 23), 2, 5)
(m<-m [, 2, drop = FALSE])
```

```
     [,1]
[1,]   66
[2,]   77
```

```r
is.matrix(m)
```

```
[1] TRUE
```

```r
is.vector(m)
```

```
[1] FALSE
```

```
  cbind (c(1,2,3), c(4, 5, 6))
```

```
     [,1] [,2]
[1,]    1    4
[2,]    2    5
[3,]    3    6
```

```
  rbind (c(1,2,3), c(4, 5, 6))
```

```
     [,1] [,2] [,3]
[1,]    1    2    3
[2,]    4    5    6
```

```
  m <- matrix(c(45, 23, 66, 77, 33, 44, 56, 12, 78, 23), 2, 5)
  (a <- rbind (c(1,2,3,4,5), m))
```

```
     [,1] [,2] [,3] [,4] [,5]
[1,]    1    2    3    4    5
[2,]   45   66   33   56   78
[3,]   23   77   44   12   23
```

```
  is.array(a)
```

```
[1] TRUE
```

```
  is.matrix(a)
```

```
[1] TRUE
```

Exercise

```r
#m1 <- matrix(rep(10, 9), 3, 3)
#m2 <- cbind (c(1,2,3), c(4, 5, 6))
#m3 <- cbind (m1[,1], m2[2,])
#m4 <- cbind (m1[,1], m2[,2])
# Gives Error
```

```r
sales <- matrix(c(10, 30, 40, 50, 43, 56, 21, 30), 2, 4, byrow=TRUE)
colnames(sales) <- c('1qrt', '2qrt', '3qrt', '4qrt')
rownames(sales) <- c('store1', 'store2')
sales
```

```
       1qrt 2qrt 3qrt 4qrt
store1   10   30   40   50
store2   43   56   21   30
```

Exercise

```r
sales['store1', '1qrt']
```

```
[1] 10
```

```r
sales['store2', c('1qrt', '4qrt')]
```

```
1qrt 4qrt
  43   30
```

Arrays

```r
a <- array(1:48, dim= c(4, 3, 2))
a
```

```
, , 1

     [,1] [,2] [,3]
[1,]    1    5    9
```

```
[2,]    2    6   10
[3,]    3    7   11
[4,]    4    8   12

, , 2

     [,1] [,2] [,3]
[1,]   13   17   21
[2,]   14   18   22
[3,]   15   19   23
[4,]   16   20   24
```

```
a [1, 3, 2]
```

```
[1] 21
```

```
a [1, , 2]
```

```
[1] 13 17 21
```

```
a [1, , 2, drop=FALSE]
```

```
, , 1

     [,1] [,2] [,3]
[1,]   13   17   21
```

```
a [4, 3, ]
```

```
[1] 12 24
```

```
a [c(2, 3), , -2]
```

```
     [,1] [,2] [,3]
[1,]    2    6   10
[2,]    3    7   11
```

Assigning Names To Dimentions of array

```
dimnames(a)[[1]] <-c("1qrt", "2qrt", "3qrt", "4qrt")
dimnames(a)[[2]] <-c("store1", "store2", "store3")
dimnames(a)[[3]] <-c("2017", "2018")
a
```

```
, , 2017

     store1 store2 store3
1qrt      1      5      9
2qrt      2      6     10
3qrt      3      7     11
4qrt      4      8     12

, , 2018

     store1 store2 store3
1qrt     13     17     21
2qrt     14     18     22
3qrt     15     19     23
4qrt     16     20     24
```

```
ar <- array(data     = 1:27,
            dim      = c(3, 3, 3),
            dimnames = list(c("a", "b", "c"),
ar
```

```
, , g

  d e f
a 1 4 7
b 2 5 8
c 3 6 9

, , h
```

```
   d  e  f
a 10 13 16
b 11 14 17
c 12 15 18

, , i

   d  e  f
a 19 22 25
b 20 23 26
c 21 24 27
```

Splitting array into matrices

```
matrix1 <- ar[,,g]
```

```
matrix1 <- ar[,,'g']
matrix1
```

```
  d e f
a 1 4 7
b 2 5 8
c 3 6 9
```

```
matrix2 <- ar[,,'h']
matrix2
```

```
   d  e  f
a 10 13 16
b 11 14 17
c 12 15 18
```

```
sum <-matrix1 + matrix2
sum
```

```
   d  e  f
a 11 17 23
b 13 19 25
c 15 21 27
```

```
matrix1*3
```

```
  d  e  f
a 3 12 21
b 6 15 24
c 9 18 27
```

```
matrix1
```

```
  d e f
a 1 4 7
b 2 5 8
c 3 6 9
```

```
matrix1*c(2, 3)
```

```
Warning in matrix1 * c(2, 3): longer object length is not a multiple of shorter
object length
```

```
  d  e  f
a 2 12 14
b 6 10 24
c 6 18 18
```

```
matrix1*c(2,3,2,3,2,3,2,3,2)
```

```
  d  e  f
a 2 12 14
b 6 10 24
c 6 18 18
```

```
matrix1*c(1, 2, 3)
```

```
  d  e  f
a 1  4  7
b 4 10 16
c 9 18 27
```

```
matrix1/c(1, 2, 3)
```

```
  d   e f
a 1 4.0 7
b 1 2.5 4
c 1 2.0 3
```

```
matrix1/c(1, 2, 3, 1, 2, 3, 1, 2, 3)
```

```
  d   e f
a 1 4.0 7
b 1 2.5 4
c 1 2.0 3
```

Lists

A list is a versatile and flexible data structure used to store a collection of different data types (such as vectors, matrices, other lists, or even functions) within a single object. Lists provide a way to organize and manipulate heterogeneous data.

```
mylist <- list(stud.id=34453,
               stud.name="John",
               stud.marks= c(13, 3, 12, 15, 19)
               )

mylist$stud.id
```

```
[1] 34453
```

```
  mylist[1]
```

```
$stud.id
[1] 34453
```

```
  mylist[[1]]
```

```
[1] 34453
```

```
  mylist["stud.id"]
```

```
$stud.id
[1] 34453
```

#Note [is used to extract subset

#Note [[is used to extract one item

#Note $ is a special case of [[

```
  mylist <- list(stud.id=34453,
                 stud.name="John",
                 stud.marks= c(13, 3, 12, 15, 19)
                 )
  mylist$stud.marks
```

```
[1] 13  3 12 15 19
```

```
  mylist$stud.marks[2]
```

```
[1] 3
```

```
  names(mylist)
```

```
[1] "stud.id"    "stud.name"  "stud.marks"
```

```r
names(mylist) <- c('id','name','marks')

names(mylist)
```

```
[1] "id"    "name"  "marks"
```

```r
mylist
```

```
$id
[1] 34453

$name
[1] "John"

$marks
[1] 13  3 12 15 19
```

Adding a new component

```r
mylist$parents.names <- c('Ana', "Mike")
mylist
```

```
$id
[1] 34453

$name
[1] "John"

$marks
[1] 13  3 12 15 19

$parents.names
[1] "Ana"  "Mike"
```

To concatinate two list use c()

```
newlist <- list(age=19, sex="male");
expandedlist <-c(mylist, newlist)
expandedlist
```

```
$id
[1] 34453

$name
[1] "John"

$marks
[1] 13  3 12 15 19

$parents.names
[1] "Ana"  "Mike"

$age
[1] 19

$sex
[1] "male"
```

```
length(expandedlist)
```

```
[1] 6
```

Exercise

```
expandedlist <- expandedlist[-5]
expandedlist <- expandedlist[c(-1,-5)]
expandedlist$parents.names <- NULL
expandedlist[['marks']] <- NULL
```

```
mylist
```

```
$id
[1] 34453

$name
[1] "John"

$marks
[1] 13  3 12 15 19

$parents.names
[1] "Ana"  "Mike"
```

```
unlist(mylist)
```

```
           id           name         marks1         marks2         marks3
     "34453"         "John"           "13"            "3"           "12"
      marks4         marks5 parents.names1 parents.names2
        "15"           "19"          "Ana"         "Mike"
```

```
mode(mylist)
```

```
[1] "list"
```

```
mode(unlist(mylist))
```

```
[1] "character"
```

```
is.vector(unlist(mylist)) #atomic list with names
```

```
[1] TRUE
```

```
is.list(mylist)
```

```
[1] TRUE
```

```r
is.atomic(mylist)
```

```
[1] FALSE
```

```r
is.list(unlist(mylist))
```

```
[1] FALSE
```

Data Frames

A data frame is a fundamental data structure used to store and manipulate structured data in a tabular format, similar to a spreadsheet or database table. Data frames are especially useful for handling real-world data, where you have rows representing observations or cases and columns representing variables or attributes.

#Creating a Data Frame

```r
my.dataframe <- data.frame(site=c('A', 'B', 'A','A', 'B'),
                           season=c('winter', 'summer', 'summer', 'spring', 'fall'),
my.dataframe
```

```
  site season  ph
1    A winter 7.4
2    B summer 6.3
3    A summer 8.6
4    A spring 7.2
5    B   fall 8.9
```

Exercise

```r
my.dataframe <- data.frame(site=c('A', 'B', 'A','A', 'B'),
                           season=c('winter', 'summer', 'summer', 'spring', 'fall'),
my.dataframe[3, 2]
```

```
[1] "summer"
```

```
my.dataframe[['site']]
```

```
[1] "A" "B" "A" "A" "B"
```

```
my.dataframe['site']
```

```
  site
1    A
2    B
3    A
4    A
5    B
```

```
my.dataframe[my.dataframe$ph>7, ]
```

```
  site season  ph
1    A winter 7.4
3    A summer 8.6
4    A spring 7.2
5    B   fall 8.9
```

```
my.dataframe[my.dataframe$ph>7, c('site', 'ph')]
```

```
  site  ph
1    A 7.4
3    A 8.6
4    A 7.2
5    B 8.9
```

For quering a data frame

```
subset(my.dataframe, ph>7)
```

```
  site season  ph
1    A winter 7.4
3    A summer 8.6
4    A spring 7.2
5    B   fall 8.9
```

```
subset(my.dataframe, ph>7, c("site", "ph"))
```

```
  site  ph
1    A 7.4
3    A 8.6
4    A 7.2
5    B 8.9
```

```
subset(my.dataframe[1:2,], ph>7, c(site, ph))
```

```
  site  ph
1    A 7.4
```

```
my.dataframe[my.dataframe$season=='summer', 'ph'] <- my.dataframe[my.dataframe$season=='su
                                                                  my.dataframe[my.datafram
```

```
[1] 7.3 9.6
```

```
my.dataframe[my.dataframe$season=='summer' & my.dataframe$ph>8, 'ph'] <- my.dataframe[my.d

my.dataframe[my.dataframe$season=='summer', 'ph']
```

```
[1]  7.3 10.6
```

#Add a column

```
my.dataframe$NO3 <- c(234.5, 123.4, 456.7, 567.8, 789.0)
my.dataframe
```

```
  site season   ph   NO3
1    A winter  7.4 234.5
2    B summer  7.3 123.4
3    A summer 10.6 456.7
4    A spring  7.2 567.8
5    B   fall  8.9 789.0
```

```
#my.dataframe$NO3<-NULL
my.dataframe <- my.dataframe[, -4]
my.dataframe
```

```
  site season   ph
1    A winter  7.4
2    B summer  7.3
3    A summer 10.6
4    A spring  7.2
5    B   fall  8.9
```

```
str(my.dataframe)
```

```
'data.frame':   5 obs. of  3 variables:
 $ site  : chr  "A" "B" "A" "A" ...
 $ season: chr  "winter" "summer" "summer" "spring" ...
 $ ph    : num  7.4 7.3 10.6 7.2 8.9
```

```
nrow(my.dataframe)
```

```
[1] 5
```

```
ncol(my.dataframe)
```

```
[1] 3
```

```
dim(my.dataframe)
```

```
[1] 5 3
```

#“‘{r} # edit(my.dataframe) #this brings up a data editor

View(my.dataframe) #this brings up a uneditable tab that display #the data for you to view.

#“‘

```r
names(my.dataframe)
```

```
[1] "site"   "season" "ph"
```

```r
names(my.dataframe) <- c('area', 'season', 'P.h.')
my.dataframe
```

```
  area season P.h.
1    A winter  7.4
2    B summer  7.3
3    A summer 10.6
4    A spring  7.2
5    B   fall  8.9
```

```r
names(my.dataframe)[3] <- 'ph'
my.dataframe
```

```
  area season   ph
1    A winter  7.4
2    B summer  7.3
3    A summer 10.6
4    A spring  7.2
5    B   fall  8.9
```

Tibbles

a tibble is a modern data frame implementation introduced by the tidyverse.

```
install.packages("tibble")
```

```
Installing package into '/cloud/lib/x86_64-pc-linux-gnu-library/4.3'
(as 'lib' is unspecified)
```

```
library(tibble)
```

#Creating a Tibble

```
my.tibble <- tibble(TempCels = sample(-10:40, size=100, replace=TRUE),
                    TempFahr = TempCels*9/5+32,
                    Location = rep(letters[1:2], each=50))
my.tibble
```

```
# A tibble: 100 x 3
   TempCels TempFahr Location
      <int>    <dbl> <chr>
 1       -6     21.2 a
 2       31     87.8 a
 3       33     91.4 a
 4       24     75.2 a
 5       12     53.6 a
 6       18     64.4 a
 7       24     75.2 a
 8       25     77   a
 9       -2     28.4 a
10       24     75.2 a
# i 90 more rows
```

Using Dataset

```
install.packages("palmerpenguins")
```

```
Installing package into '/cloud/lib/x86_64-pc-linux-gnu-library/4.3'
(as 'lib' is unspecified)
```

```
library(palmerpenguins)
data(penguins)
dim(penguins)
```

```
[1] 344   8
```

```
class(penguins)
```

```
[1] "tbl_df"     "tbl"        "data.frame"
```

```
penguins
```

```
# A tibble: 344 x 8
   species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
   <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
 1 Adelie  Torgersen           39.1          18.7               181        3750
 2 Adelie  Torgersen           39.5          17.4               186        3800
 3 Adelie  Torgersen           40.3          18                 195        3250
 4 Adelie  Torgersen           NA            NA                  NA          NA
 5 Adelie  Torgersen           36.7          19.3               193        3450
 6 Adelie  Torgersen           39.3          20.6               190        3650
 7 Adelie  Torgersen           38.9          17.8               181        3625
 8 Adelie  Torgersen           39.2          19.6               195        4675
 9 Adelie  Torgersen           34.1          18.1               193        3475
10 Adelie  Torgersen           42            20.2               190        4250
# i 334 more rows
# i 2 more variables: sex <fct>, year <int>
```

Converting data frame to tibble

```
pe <-as_tibble(penguins)
class(pe)
```

```
[1] "tbl_df"     "tbl"        "data.frame"
```

```
pe
```

```
# A tibble: 344 x 8
   species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
   <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
 1 Adelie  Torgersen           39.1          18.7               181        3750
 2 Adelie  Torgersen           39.5          17.4               186        3800
 3 Adelie  Torgersen           40.3          18                 195        3250
 4 Adelie  Torgersen           NA            NA                  NA          NA
 5 Adelie  Torgersen           36.7          19.3               193        3450
 6 Adelie  Torgersen           39.3          20.6               190        3650
 7 Adelie  Torgersen           38.9          17.8               181        3625
 8 Adelie  Torgersen           39.2          19.6               195        4675
 9 Adelie  Torgersen           34.1          18.1               193        3475
10 Adelie  Torgersen           42            20.2               190        4250
# i 334 more rows
# i 2 more variables: sex <fct>, year <int>
```

Mode and Class

The mode function returns the internal storage mode of an R object. It indicates how the data is stored in memory.The modes in R include "numeric," "character," "logical," "complex," "raw," and "list," among others.

The class function returns the class or data type of an R object. It indicates how R treats and interacts with the data. In R, an object can belong to one or more classes, which defines its behavior in various operations and functions.

```
x <- 1:16
mode(x)
```

```
[1] "numeric"
```

```
dim(x) <- c(4,4)
class(x)
```

```
[1] "matrix" "array"
```

```
is.numeric(x)
```

```
[1] TRUE
```

```
mode(x) <- "character"
mode(x)
```

```
[1] "character"
```

```
class(x)
```

```
[1] "matrix" "array"
```

Even if mode changes class remains same

```
x <- factor(x)
class(x)
```

```
[1] "factor"
```

```
mode(x)
```

```
[1] "numeric"
```

```
is.array(x)
```

```
[1] FALSE
```

```
is.list(x)
```

```
[1] FALSE
```

```
  is.data.frame(x)
```

```
[1] FALSE
```

```
  is.matrix(x)
```

```
[1] FALSE
```

```
  is_tibble(x)
```

```
[1] FALSE
```

```
  is.vector(x)
```

```
[1] FALSE
```

```
  typeof(x)
```

```
[1] "integer"
```

Subsetting a tibble in smaller tibble

```
  class(pe[1:15, c("bill_length_mm", "bill_depth_mm")])
```

```
[1] "tbl_df"     "tbl"        "data.frame"
```

```
  class(penguins[1:15, c("bill_length_mm", "bill_depth_mm")])
```

```
[1] "tbl_df"     "tbl"        "data.frame"
```

```
  class(pe[1:15, c("bill_length_mm")])
```

```
[1] "tbl_df"     "tbl"        "data.frame"
```

```
  class(penguins[1:15, c("bill_length_mm")])
```

```
[1] "tbl_df"     "tbl"        "data.frame"
```

#Note filter() and select()

```
  install.packages("dplyr")
```

```
Installing package into '/cloud/lib/x86_64-pc-linux-gnu-library/4.3'
(as 'lib' is unspecified)
```

```
  library(dplyr)
```

```
Attaching package: 'dplyr'

The following objects are masked from 'package:stats':

    filter, lag

The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

```
  select(filter(pe, species=="Adelie"), bill_length_mm, bill_depth_mm)
```

```
# A tibble: 152 x 2
   bill_length_mm bill_depth_mm
            <dbl>         <dbl>
 1           39.1          18.7
 2           39.5          17.4
 3           40.3          18
 4           NA            NA
 5           36.7          19.3
 6           39.3          20.6
 7           38.9          17.8
 8           39.2          19.6
 9           34.1          18.1
10           42            20.2
# i 142 more rows
```

```
  filter(select(pe, bill_length_mm, bill_depth_mm, species), species=="Adelie")
```

```
# A tibble: 152 x 3
   bill_length_mm bill_depth_mm species
            <dbl>         <dbl> <fct>
 1           39.1          18.7 Adelie
 2           39.5          17.4 Adelie
 3           40.3          18   Adelie
 4           NA            NA   Adelie
 5           36.7          19.3 Adelie
 6           39.3          20.6 Adelie
 7           38.9          17.8 Adelie
 8           39.2          19.6 Adelie
 9           34.1          18.1 Adelie
10           42            20.2 Adelie
# i 142 more rows
```

Exercise

```
  pe
```

```
# A tibble: 344 x 8
   species island    bill_length_mm bill_depth_mm flipper_length_mm body_mass_g
   <fct>   <fct>              <dbl>         <dbl>             <int>       <int>
```

```
 1 Adelie  Torgersen           39.1          18.7                181        3750
 2 Adelie  Torgersen           39.5          17.4                186        3800
 3 Adelie  Torgersen           40.3          18                  195        3250
 4 Adelie  Torgersen           NA            NA                   NA          NA
 5 Adelie  Torgersen           36.7          19.3                193        3450
 6 Adelie  Torgersen           39.3          20.6                190        3650
 7 Adelie  Torgersen           38.9          17.8                181        3625
 8 Adelie  Torgersen           39.2          19.6                195        4675
 9 Adelie  Torgersen           34.1          18.1                193        3475
10 Adelie  Torgersen           42            20.2                190        4250
# i 334 more rows
# i 2 more variables: sex <fct>, year <int>
```

```
pe[pe$species=='Adelie', c("bill_length_mm", "bill_depth_mm")]
```

```
# A tibble: 152 x 2
   bill_length_mm bill_depth_mm
            <dbl>         <dbl>
 1           39.1          18.7
 2           39.5          17.4
 3           40.3          18
 4           NA            NA
 5           36.7          19.3
 6           39.3          20.6
 7           38.9          17.8
 8           39.2          19.6
 9           34.1          18.1
10           42            20.2
# i 142 more rows
```

```
subset(pe, pe$species=='Adelie', c("bill_length_mm", "bill_depth_mm"))
```

```
# A tibble: 152 x 2
   bill_length_mm bill_depth_mm
            <dbl>         <dbl>
 1           39.1          18.7
 2           39.5          17.4
 3           40.3          18
 4           NA            NA
```

```
 5           36.7          19.3
 6           39.3          20.6
 7           38.9          17.8
 8           39.2          19.6
 9           34.1          18.1
10           42            20.2
# i 142 more rows
```

```
  select(pe, bill_length_mm, bill_depth_mm, species) |> filter(species=="Adelie")
```

```
# A tibble: 152 x 3
   bill_length_mm bill_depth_mm species
            <dbl>         <dbl> <fct>
 1           39.1          18.7 Adelie
 2           39.5          17.4 Adelie
 3           40.3          18   Adelie
 4           NA            NA   Adelie
 5           36.7          19.3 Adelie
 6           39.3          20.6 Adelie
 7           38.9          17.8 Adelie
 8           39.2          19.6 Adelie
 9           34.1          18.1 Adelie
10           42            20.2 Adelie
# i 142 more rows
```

Exercise

```
  filter(pe, species=="Adelie") |> select(bill_length_mm, bill_depth_mm, species)
```

```
# A tibble: 152 x 3
   bill_length_mm bill_depth_mm species
            <dbl>         <dbl> <fct>
 1           39.1          18.7 Adelie
 2           39.5          17.4 Adelie
 3           40.3          18   Adelie
 4           NA            NA   Adelie
 5           36.7          19.3 Adelie
 6           39.3          20.6 Adelie
 7           38.9          17.8 Adelie
```

```
 8           39.2          19.6 Adelie
 9           34.1          18.1 Adelie
10           42            20.2 Adelie
# i 142 more rows
```

Create a data object to hold student names (`Judy`, `Max`, `Dan`) and their grades (‘78,85,99) `Convert number grades to letter grades`:90-100:A;80-89:B;70-79:C; \<70:F‘

```
students <- list(names=c("Judy", "Max", "Dan"),
                 grades=c(78, 85, 99))
print ("before:")
```

```
[1] "before:"
```

```
students
```

```
$names
[1] "Judy" "Max"  "Dan"

$grades
[1] 78 85 99
```

```
gradeConvertor<- function (grade){
  grade = as.numeric(grade)
  if(grade > 100 | grade < 0) print ("grade out of the range")
  else if(grade >= 90 & grade <= 100) return ("A")
  else if(grade >= 80 & grade < 90) return ("B")
  else if(grade >= 70 & grade < 80) return ("C")
  else return ("F")
}

#students$grades <-sapply(students$grades, gradeConvertor)

for(i in 1:length(students$grades)){
  students$grades[i] = gradeConvertor(students$grades[i])
}

print ("after:")
```

```
[1] "after:"
```

```
  students
```

```
$names
[1] "Judy" "Max"  "Dan"

$grades
[1] "C" "B" "A"
```