6_Functions

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```
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --

## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.6     v dplyr   1.0.8
## v tidyr   1.2.0     v stringr 1.4.0
## v readr   2.1.2     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

6. Functions

6.1 Introduction

Quiz

1. What are the three components of a function?

arguments, body, and environment

2. What does the following code return?

```
x <- 10
f1 <- function(x) {
  function() {
    x + 10
  }
}
f1(1)()
```

```
## [1] 11
```

3. How would you usually write this code?

```
`+`(1, `*`(2, 3))
```

```
## [1] 7
```

4. How could you make this call easier to read?

```
mean(, TRUE, x = c(1:10, NA))
```

```
## [1] 5.5
```

5. Does the following code throw an error when executed? Why or why not?

```
f2 <- function(a, b) {
  a * 10
}
f2(10, stop("This is an error!"))
```

```
## [1] 100
```

6. What is an infix function? How do you write it? What's a replacement function? How do you write it?
7. How do you ensure that cleanup action occurs regardless of how a function exits?

6.2 Function fundamentals

- Functions can be broken down into three components: arguments, body, and environment.
- Functions are objects, just as vectors are objects.

6.2.1 Function components

A function has three parts:

- The formals(), the list of arguments that control how you call the function.
- The body(), the code inside the function.
- The environment(), the data structure that determines how the function finds the values associated with the names.

```
f02 <- function(x, y) {
  # A comment
  x + y
}

formals(f02)
```

```
## $x
##
##
## $y
```

```
body(f02)
```

```
## {
##     x + y
## }
```

```
environment(f02)
```

```
## <environment: R_GlobalEnv>
```

```
attr(f02, "srcref")
```

```
## function(x, y) {
##   # A comment
##   x + y
## }
```

6.2.2 Primitive functions

```
sum
```

```
## function (..., na.rm = FALSE)  .Primitive("sum")
```

```
`[`
```

```
## .Primitive("[")
```

```
typeof(sum)
```

```
## [1] "builtin"
```

```
typeof(`[`)
```

```
## [1] "special"
```

```
formals(sum)
```

```
## NULL
```

```
body(sum)
```

```
## NULL
```

```
environment(sum)
```

```
## NULL
```

6.2.3 First-class functions

```r
f01 <- function(x) {
  sin(1 / x ^ 2)
}
```

```r
lapply(mtcars, function(x) length(unique(x)))
```

```
## $mpg
## [1] 25
##
## $cyl
## [1] 3
##
## $disp
## [1] 27
##
## $hp
## [1] 22
##
## $drat
## [1] 22
##
## $wt
## [1] 29
##
## $qsec
## [1] 30
##
## $vs
## [1] 2
##
## $am
## [1] 2
##
## $gear
## [1] 3
##
## $carb
## [1] 6
```

```r
Filter(function(x) !is.numeric(x), mtcars)
```

```
## data frame with 0 columns and 32 rows
```

```r
integrate(function(x) sin(x) ^ 2, 0, pi)
```

```
## 1.570796 with absolute error < 1.7e-14
```

```r
funs <- list(
  half = function(x) x / 2,
  double = function(x) x * 2
```

```
)

funs$double(10)
```

```
## [1] 20
```

6.2.4 Invoking a function

```
args <- list(1:10, na.rm = TRUE)
```

```
do.call(mean, args)
```

```
## [1] 5.5
```

6.2.5 Exercises

1. Given a name, like `"mean"`, `match.fun()` lets you find a function. Given a function, can you find its name? Why doesn't that make sense in R?

It's a lot easier to match a name then it is to match all the code in a function to a name

2. It's possible (although typically not useful) to call an anonymous function. Which of the two approaches below is correct? Why?

```
function(x) 3()
```

```
## function(x) 3()
```

```
(function(x) 3)()
```

```
## [1] 3
```

2nd?

3. A good rule of thumb is that an anonymous function should fit on one line and shouldn't need to use {}. Review your code. Where could you have used an anonymous function instead of a named function? Where should you have used a named function instead of an anonymous function?

Should have used an anonymous on smaller quick functions. Use named functions on larget multi line chunks that need comments

4. What function allows you to tell if an object is a function? What function allows you to tell if a function is a primitive function?

```
is.primitive(sum)
```

```
## [1] TRUE
```

```
is.function(mean)
```

```
## [1] TRUE
```

5. This code makes a list of all functions in the base package.

```
objs <- mget(ls("package:base", all = TRUE), inherits = TRUE)
funs <- Filter(is.function, objs)
```

a. Which base function has the most arguments?

```
sort(unlist((lapply(
  lapply(funs, FUN = formals), length
))), decreasing = T) %>% head()
```

```
##             scan   format.default           source          formatC
##               22               16               16               15
##          library merge.data.frame
##               13               13
```

b. How many base functions have no arguments? What's special about those functions?

```
a <- unlist((lapply(
  lapply(funs, FUN = formals), length
)))
sum(a == 0)
```

```
## [1] 253
```

```
head(a[a == 0])
```

```
##   -   !  !=   $ $<-  %%
##   0   0   0   0   0   0
```

```
is.primitive(`-`)
```

```
## [1] TRUE
```

```
is.primitive("scan")
```

```
## [1] FALSE
```

```
# Are primitive functions
```

c. How could you adapt the code to find all primitive functions?

```
objs <- mget(ls("package:base", all = TRUE), inherits = TRUE)
funs <- Filter(is.primitive, objs)
```

6. What are the three important components of a function?

Formals, Body, Environment

7. When does printing a function not show the environment it was created in?

Primitives and functions created in the global environment

6.3 Function composition

```
square <- function(x) x^2
deviation <- function(x) x - mean(x)
```

```
x <- runif(100)

sqrt(mean(square(deviation(x))))
```

```
## [1] 0.2798161
```

```
out <- deviation(x)
out <- square(out)
out <- mean(out)
out <- sqrt(out)
out
```

```
## [1] 0.2798161
```

```
library(magrittr)
```

```
##
## Attaching package: 'magrittr'

## The following object is masked from 'package:purrr':
##
##     set_names

## The following object is masked from 'package:tidyr':
##
##     extract
```

```
x %>%
  deviation() %>%
  square() %>%
  mean() %>%
  sqrt()
```

```
## [1] 0.2798161
```

6.4 Lexical scoping

```
x <- 10
g01 <- function() {
  x <- 20
  x
}

g01()
```

```
## [1] 20
```

R's lexical scoping follows four primary rules:

- Name masking
- Functions versus variables
- A fresh start
- Dynamic lookup

6.4.1 Name masking

```
x <- 10
y <- 20
g02 <- function() {
  x <- 1
  y <- 2
  c(x, y)
}
g02()
```

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

```
x <- 2
g03 <- function() {
  y <- 1
  c(x, y)
}
g03()
```

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

```
y
```

```
## [1] 20
```

```
x <- 1
g04 <- function() {
  y <- 2
  i <- function() {
    z <- 3
    c(x, y, z)
  }
  i()
}
g04()
```

```
## [1] 1 2 3
```

6.4.2 Functions versus variables

```
g07 <- function(x) x + 1
g08 <- function() {
  g07 <- function(x) x + 100
  g07(10)
}
g08()
```

```
## [1] 110
```

```
g09 <- function(x) x + 100
g10 <- function() {
  g09 <- 10
  g09(g09)
}
g10()
```

```
## [1] 110
```

6.4.3 A fresh start

```
g11 <- function() {
  if (!exists("a")) {
    a <- 1
  } else {
    a <- a + 1
  }
  a
}

g11()
```

```
##                          -                          -.Date
##                          1                               3
##                   -.POSIXt                               !
##                          3                               1
##                 !.hexmode                     !.octmode
##                          2                               2
##                         !=                               $
##                          1                               1
##                $.DLLInfo                $.package_version
##                          3                               3
##                       $<-                   $<-.data.frame
##                          1                               4
##                        %%                             %*%
##                          1                               1
##                       %/%                            %in%
##                          1                               3
##                       %o%                             %x%
##                          3                               3
##                         &                              &&
##                          1                               1
##                &.hexmode                     &.octmode
##                          3                               3
##                         (                               *
##                          1                               1
##              *.difftime                          ...elt
##                          3                               1
##             ...length                          ...names
##                          1                               1
##           ..getNamespace                    .__H__.cbind
##                          3                               3
##            .__H__.rbind                   .amatch_bounds
##                          3                               2
##           .amatch_costs                         .bincode
##                          2                               5
##                       .C                     .cache_class
##                          1                               1
##                  .Call                    .Call.graphics
##                          1                               1
##                 .class2                             .col
##                          1                               2
##              .colMeans                          .colSums
##                          5                               5
##                 .Date              .decode_numeric_version
##                          3                               2
##               .Defunct                    .deparseOpts
##                          4                               2
##            .Deprecated                          .detach
##                          5                               2
##              .difftime                       .doSortWrap
##                          4                               5
##               .doTrace                          .doWrap
##                          3                               5
##               .dynLibs              .encode_numeric_version
##                          2                               2
```

```
##             .expand_R_libs_env_var                          .External
##                                  2                                  1
##                .External.graphics                         .External2
##                                  1                                  1
##                        .First.sys                  .fixupGFortranStderr
##                                  1                                  1
##                .fixupGFortranStdout                         .format.zeros
##                                  1                                  6
##                           .Fortran                         .getNamespace
##                                  1                                  2
##                  .getNamespaceInfo                  .getRequiredPackages
##                                  3                                  5
##                .getRequiredPackages2                               .gt
##                                  5                                  4
##                               .gtn                    .handleSimpleError
##                                  3                                  4
##                          .Internal                  .isMethodsDispatchOn
##                                  1                                  1
##                           .isOpen                          .kappa_tri
##                                  2                                  6
##                         .kronecker                          .libPaths
##                                  6                                  3
##                .make_numeric_version                         .makeMessage
##                                  5                                  4
##                           .mapply                          .maskedMsg
##                                  4                                  4
##                .mergeExportMethods                 .mergeImportMethods
##                                  3                                  4
##                .NotYetImplemented                          .NotYetUsed
##                                  1                                  3
##                .OptRequireMethods                           .packages
##                                  1                                  3
##             .packageStartupMessage                          .POSIXct
##                                  3                                  4
##                           .POSIXlt                         .Primitive
##                                  4                                  1
##                         .primTrace                       .primUntrace
##                                  1                                  1
##                            .rmpkg                              .row
##                                  2                                  2
##                    .row_names_info                         .rowMeans
##                                  3                                  5
##                     .rowNamesDF<-                          .rowSums
##                                  4                                  5
##                          .S3method                          .Script
##                                  4                                  5
##                     .set_row_names                  .signalSimpleWarning
##                                  2                                  3
##                  .standard_regexps                          .subset
##                                  1                                  1
##                           .subset2                .TAOCP1997init
##                                  1                                  2
##                         .traceback                   .tryResumeInterrupt
##                                  3                                  1
```

```
##                     .valid.factor                                 /
##                                 2                                 1
##                        /.difftime                                 :
##                                 3                                 1
##                                ::                               :::
##                                 1                                 1
##                                 @                               @<-
##                                 1                                 1
##                                 [                           [.AsIs
##                                 1                                 4
##                       [.data.frame                             [.Date
##                                 5                                 4
##                         [.difftime                            [.Dlist
##                                 4                                 4
##                      [.DLLInfoList                            [.factor
##                                 3                                 4
##                          [.hexmode                            [.listof
##                                 3                                 4
##                          [.noquote                  [.numeric_version
##                                 3                                 4
##                          [.octmode                        [.POSIXct
##                                 3                                 4
##                          [.POSIXlt                     [.simple.list
##                                 5                                 4
##                            [.table                        [.warnings
##                                 6                                 3
##                                [[                       [[.data.frame
##                                 1                                 4
##                           [[.Date                           [[.factor
##                                 4                                 3
##                    [[.numeric_version                       [[.POSIXct
##                                 4                                 4
##                          [[.POSIXlt                              [[<-
##                                 4                                 1
##                      [[<-.data.frame                        [[<-.factor
##                                 5                                 4
##                   [[<-.numeric_version                      [[<-.POSIXlt
##                                 4                                 4
##                               [<-                     [<-.data.frame
##                                 1                                 5
##                           [<-.Date                       [<-.difftime
##                                 4                                 4
##                          [<-.factor                 [<-.numeric_version
##                                 4                                 5
##                        [<-.POSIXct                       [<-.POSIXlt
##                                 4                                 5
##                                 ^                                 {
##                                 1                                 1
##                                 |                        |.hexmode
##                                 1                                 3
##                          |.octmode                               ||
##                                 3                                 1
##                                 ~                                 +
##                                 1                                 1
```

```
##                           +.Date                           +.POSIXt
##                                3                                  3
##                                <                                 <-
##                                1                                  1
##                              <<-                                 <=
##                                1                                  1
##                                =                                 ==
##                                1                                  1
##                                >                                 >=
##                                1                                  1
##                       abbreviate                                abs
##                                8                                  1
##                             acos                              acosh
##                                1                                  1
##              activeBindingFunction                             addNA
##                                3                                  3
##                    addTaskCallback                             agrep
##                                4                                  9
##                             agrepl                             alist
##                                8                                  2
##                              all                          all.equal
##                                1                                  4
##                all.equal.character                 all.equal.default
##                                5                                  4
##              all.equal.environment             all.equal.envRefClass
##                                6                                  4
##                   all.equal.factor                 all.equal.formula
##                                5                                  4
##                 all.equal.function                all.equal.language
##                                5                                  4
##                    all.equal.list                 all.equal.numeric
##                                6                                  9
##                  all.equal.POSIXt                      all.equal.raw
##                                7                                  5
##                         all.names                          all.vars
##                                5                                  5
##                   allowInterrupts                               any
##                                2                                  1
##                     anyDuplicated                anyDuplicated.array
##                                4                                  6
##           anyDuplicated.data.frame             anyDuplicated.default
##                                5                                  5
##               anyDuplicated.matrix                             anyNA
##                                6                                  1
##                   anyNA.data.frame           anyNA.numeric_version
##                                3                                  3
##                     anyNA.POSIXlt                             aperm
##                                3                                  4
##                     aperm.default                       aperm.table
##                                5                                  6
##                            append                             apply
##                                4                                  6
##                               Arg                             array
##                                1                                  4
```

```
##                      arrayInd                      as.array
##                             5                             3
##             as.array.default                       as.call
##                             3                             1
##               as.character          as.character.condition
##                             1                             3
##            as.character.Date           as.character.default
##                             3                             3
##           as.character.error           as.character.factor
##                             3                             3
##         as.character.hexmode    as.character.numeric_version
##                             3                             3
##         as.character.octmode           as.character.POSIXt
##                             3                             3
##          as.character.srcref                      as.complex
##                             5                             1
##                as.data.frame           as.data.frame.array
##                             5                             5
##           as.data.frame.AsIs        as.data.frame.character
##                             5                             4
##         as.data.frame.complex       as.data.frame.data.frame
##                             6                             4
##            as.data.frame.Date          as.data.frame.default
##                             6                             3
##        as.data.frame.difftime          as.data.frame.factor
##                             6                             6
##         as.data.frame.integer            as.data.frame.list
##                             6                            10
##         as.data.frame.logical          as.data.frame.matrix
##                             6                             7
##    as.data.frame.model.matrix          as.data.frame.noquote
##                             6                             6
##         as.data.frame.numeric    as.data.frame.numeric_version
##                             6                             6
##         as.data.frame.ordered          as.data.frame.POSIXct
##                             6                             6
##         as.data.frame.POSIXlt             as.data.frame.raw
##                             5                             6
##           as.data.frame.table              as.data.frame.ts
##                             8                             3
##          as.data.frame.vector                       as.Date
##                             6                             3
##             as.Date.character              as.Date.default
##                             6                             3
##               as.Date.factor              as.Date.numeric
##                             3                             4
##              as.Date.POSIXct              as.Date.POSIXlt
##                             4                             3
##                 as.difftime                      as.double
##                             5                             1
##           as.double.difftime              as.double.POSIXlt
##                             4                             3
##               as.environment                as.expression
##                             1                             3
```

```
##              as.expression.default                         as.factor
##                                  3                                 2
##                        as.function                 as.function.default
##                                  3                                 4
##                         as.hexmode                         as.integer
##                                  2                                 1
##                            as.list                  as.list.data.frame
##                                  3                                 3
##                       as.list.Date                     as.list.default
##                                  3                                 3
##                   as.list.difftime                 as.list.environment
##                                  3                                 5
##                     as.list.factor                   as.list.function
##                                  3                                 3
##             as.list.numeric_version                    as.list.POSIXct
##                                  3                                 3
##                    as.list.POSIXlt                         as.logical
##                                  3                                 1
##                  as.logical.factor                          as.matrix
##                                  3                                 3
##                as.matrix.data.frame                  as.matrix.default
##                                  4                                 3
##                  as.matrix.noquote                  as.matrix.POSIXlt
##                                  3                                 3
##                           as.name                           as.null
##                                  2                                 3
##                    as.null.default                         as.numeric
##                                  3                                 1
##                  as.numeric_version                         as.octmode
##                                  2                                 2
##                        as.ordered                  as.package_version
##                                  2                                 2
##                       as.pairlist                         as.POSIXct
##                                  2                                 4
##                    as.POSIXct.Date                  as.POSIXct.default
##                                  3                                 4
##                  as.POSIXct.numeric                  as.POSIXct.POSIXlt
##                                  5                                 4
##                         as.POSIXlt                as.POSIXlt.character
##                                  4                                 7
##                    as.POSIXlt.Date                  as.POSIXlt.default
##                                  3                                 5
##                   as.POSIXlt.factor                  as.POSIXlt.numeric
##                                  3                                 5
##                  as.POSIXlt.POSIXct                              as.qr
##                                  4                                 2
##                             as.raw                         as.single
##                                  1                                 3
##                   as.single.default                         as.symbol
##                                  3                                 2
##                            as.table                     as.table.default
##                                  3                                 3
##                           as.vector                     as.vector.factor
##                                  3                                 3
```

```
##                      asin                     asinh
##                         1                         1
##               asNamespace                    asplit
##                         3                         3
##                      asS3                      asS4
##                         4                         4
##                    assign                      atan
##                         7                         1
##                     atan2                     atanh
##                         3                         1
##                    attach           attachNamespace
##                         5                         6
##                      attr            attr.all.equal
##                         1                         6
##                    attr<-                attributes
##                         1                         1
##              attributes<-                  autoload
##                         1                         5
##                autoloader                 backsolve
##                         4                         6
##                   baseenv                  basename
##                         1                         2
##                   besselI                   besselJ
##                         4                         3
##                   besselK                   besselY
##                         4                         3
##                      beta           bindingIsActive
##                         3                         3
##           bindingIsLocked             bindtextdomain
##                         3                         3
##                   bitwAnd                    bitwNot
##                         3                         2
##                    bitwOr                 bitwShiftL
##                         3                         3
##                bitwShiftR                    bitwXor
##                         3                         3
##                      body                     body<-
##                         2                         4
##                    bquote                     break
##                         4                         1
##                   browser          browserCondition
##                         1                         2
##           browserSetDebug               browserText
##                         2                         2
##                  builtins                        by
##                         2                         6
##            by.data.frame                by.default
##                         6                         6
##                    bzfile                         c
##                         5                         1
##                    c.Date                c.difftime
##                         3                         3
##                  c.factor                 c.noquote
##                         3                         3
```

```
##                 c.numeric_version                          c.POSIXct
##                                 3                                  3
##                         c.POSIXlt                          c.warnings
##                                 3                                  3
##                              call                             callCC
##                                 1                                  2
##                      capabilities                           casefold
##                                 3                                  3
##                               cat                              cbind
##                                 7                                  3
##                  cbind.data.frame                           ceiling
##                                 3                                  1
##                       char.expand                          character
##                                 4                                  2
##                         charmatch                          charToRaw
##                                 4                                  2
##                            chartr                       check_tzones
##                                 4                                  2
##                           chkDots                               chol
##                                 4                                  3
##                      chol.default                            chol2inv
##                                 6                                  4
##                            choose                              class
##                                 3                                  1
##                           class<-                       clearPushBack
##                                 1                                  2
##                             close                  close.connection
##                                 3                                  4
##                      close.srcfile                close.srcfilealias
##                                 3                                  3
##                 closeAllConnections                                col
##                                 1                                  3
##                           colMeans                           colnames
##                                 4                                  4
##                         colnames<-                            colSums
##                                 3                                  4
##                       commandArgs                            comment
##                                 2                                  2
##                         comment<-                            complex
##                                 3                                  6
##                   computeRestarts                      conditionCall
##                                 2                                  2
##             conditionCall.condition                    conditionMessage
##                                 2                                  2
##           conditionMessage.condition                       conflictRules
##                                 2                                  4
##                           conflicts                               Conj
##                                 3                                  1
##                       contributors                                cos
##                                 1                                  1
##                                cosh                              cospi
##                                 1                                  1
##                           crossprod                       Cstack_info
##                                 3                                  1
```

```
##                     cummax                     cummin
##                          1                          1
##                    cumprod                     cumsum
##                          1                          1
##              curlGetHeaders                        cut
##                          6                          3
##                   cut.Date                cut.default
##                          7                          9
##                  cut.POSIXt                 data.class
##                          7                          2
##                  data.frame                data.matrix
##                          7                          3
##                       date                      debug
##                          1                          5
##               debuggingState                  debugonce
##                          2                          5
##      default.stringsAsFactors               delayedAssign
##                          1                          5
##                    deparse                     deparse1
##                          6                          5
##                        det                     detach
##                          3                          6
##                 determinant           determinant.matrix
##                          4                          4
##                       dget                       diag
##                          3                          5
##                    diag<-                       diff
##                          3                          3
##                  diff.Date                diff.default
##                          5                          5
##               diff.difftime                diff.POSIXt
##                          3                          5
##                   difftime                    digamma
##                          5                          1
##                        dim                dim.data.frame
##                          1                          2
##                      dim<-                   dimnames
##                          1                          1
##          dimnames.data.frame                  dimnames<-
##                          2                          1
##         dimnames<-.data.frame                        dir
##                          3                          9
##                 dir.create                 dir.exists
##                          5                          2
##                    dirname                    do.call
##                          2                          5
##                  dontCheck                     double
##                          2                          2
##                       dput                     dQuote
##                          4                          3
##                       drop                 droplevels
##                          2                          3
##         droplevels.data.frame           droplevels.factor
##                          5                          4
```

```
##                          dump                     duplicated
##                             7                              4
##               duplicated.array          duplicated.data.frame
##                             6                              5
##             duplicated.default              duplicated.matrix
##                             6                              6
##      duplicated.numeric_version             duplicated.POSIXlt
##                             4                              4
##             duplicated.warnings                      dyn.load
##                             4                              5
##                    dyn.unload                        dynGet
##                             2                              5
##                         eapply                         eigen
##                             6                              5
##                       emptyenv                     enc2native
##                             1                              1
##                       enc2utf8                   encodeString
##                             1                              6
##                       Encoding                     Encoding<-
##                             2                              3
##                       endsWith                        enquote
##                             3                              2
##                    env.profile                    environment
##                             2                              2
##                  environment<-           environmentIsLocked
##                             1                              2
##                environmentName                errorCondition
##                             2                              5
##                           eval                   eval.parent
##                             4                              3
##                          evalq                        exists
##                             4                              7
##                            exp                   expand.grid
##                             1                              4
##                          expm1                    expression
##                             1                              1
##                 extSoftVersion                        factor
##                             1                              7
##                      factorial                          fifo
##                             2                              5
##                           file                   file.access
##                             7                              3
##                    file.append                   file.choose
##                             3                              2
##                      file.copy                   file.create
##                             7                              3
##                    file.exists                     file.info
##                             2                              3
##                      file.link                     file.mode
##                             3                              2
##                     file.mtime                     file.path
##                             2                              3
##                    file.remove                   file.rename
##                             2                              3
```

```
##                         file.show                         file.size
##                                 7                                 2
##                       file.symlink                            Filter
##                                 3                                 3
##                              Find                       find.package
##                                 5                                 5
##                       findInterval                      findPackageEnv
##                                 6                                 2
##                        findRestart                             floor
##                                 3                                 1
##                              flush                    flush.connection
##                                 2                                 2
##                                for                             force
##                                 1                                 2
##                       forceAndCall                           formals
##                                 1                                 3
##                          formals<-                            format
##                                 4                                 3
##                        format.AsIs                  format.data.frame
##                                 4                                 4
##                        format.Date                     format.default
##                                 3                                17
##                     format.difftime                      format.factor
##                                 3                                 3
##                     format.hexmode                         format.info
##                                 5                                 4
##                   format.libraryIQR             format.numeric_version
##                                 3                                 3
##                      format.octmode                 format.packageInfo
##                                 4                                 3
##                     format.POSIXct                     format.POSIXlt
##                                 6                                 5
##                        format.pval              format.summaryDefault
##                                 6                                 4
##                             formatC                           formatDL
##                                16                                 6
##                      forwardsolve                           function
##                                 6                                 1
##                             gamma                                gc
##                                 1                                 4
##                           gc.time                            gcinfo
##                                 1                                 2
##                        gctorture                         gctorture2
##                                 2                                 4
##                               get                               get0
##                                 6                                 6
##                   getAllConnections                      getCallingDLL
##                                 1                                 3
##                      getCallingDLLe                      getConnection
##                                 2                                 2
##           getDLLRegisteredRoutines getDLLRegisteredRoutines.character
##                                 3                                 3
##   getDLLRegisteredRoutines.DLLInfo                        getElement
##                                 3                                 3
```

```
##                  geterrmessage                  getExportedValue
##                              1                                 3
##                        getHook                     getLoadedDLLs
##                              2                                 1
##                     getNamespace                getNamespaceExports
##                              2                                 2
##                getNamespaceImports                   getNamespaceInfo
##                              2                                 3
##                   getNamespaceName                  getNamespaceUsers
##                              2                                 2
##                getNamespaceVersion                getNativeSymbolInfo
##                              2                                 5
##                        getOption                        getRversion
##                              3                                 1
##                      getSrcLines                getTaskCallbackNames
##                              4                                 1
##                          gettext                         gettextf
##                              3                                 4
##                            getwd                              gl
##                              1                                 6
##             globalCallingHandlers                        globalenv
##                              2                                 1
##                         gregexec                         gregexpr
##                              7                                 7
##                             grep                            grepl
##                              9                                 7
##                          grepRaw                         grouping
##                              9                                 2
##                             gsub                            gzcon
##                              8                                 5
##                           gzfile                                I
##                              5                                 2
##                            iconv                        iconvlist
##                              7                                 1
##                     icuGetCollate                    icuSetCollate
##                              2                                 2
##                        identical                         identity
##                              9                                 2
##                               if                           ifelse
##                              1                                 4
##                               Im                    importIntoEnv
##                              1                                 5
##                         infoRDS                          inherits
##                              2                                 4
##                         integer                       interaction
##                              2                                 5
##                     interactive                         intersect
##                              1                                 4
##                       intToBits                         intToUtf8
##                              2                                 4
##                     inverse.rle                         invisible
##                              3                                 1
##                     invokeRestart           invokeRestartInteractively
##                              3                                 2
```

```
##                       is.array                       is.atomic
##                              1                              1
##                        is.call                    is.character
##                              1                              1
##                     is.complex                   is.data.frame
##                              1                              2
##                      is.double                      is.element
##                              1                              3
##                  is.environment                   is.expression
##                              1                              1
##                      is.factor                      is.finite
##                              2                              1
##                    is.function                    is.infinite
##                              1                              1
##                     is.integer                    is.language
##                              1                              1
##                        is.list                      is.loaded
##                              1                              4
##                     is.logical                      is.matrix
##                              1                              1
##                          is.na                 is.na.data.frame
##                              1                              2
##             is.na.numeric_version                    is.na.POSIXlt
##                              2                              2
##                         is.na<-                  is.na<-.default
##                              3                              3
##                  is.na<-.factor           is.na<-.numeric_version
##                              3                              3
##                       is.name                         is.nan
##                              1                              1
##                       is.null                      is.numeric
##                              1                              1
##                  is.numeric.Date              is.numeric.difftime
##                              2                              2
##                is.numeric.POSIXt               is.numeric_version
##                              2                              2
##                       is.object                    is.ordered
##                              1                              2
##             is.package_version                    is.pairlist
##                              2                              1
##                   is.primitive                         is.qr
##                              2                              2
##                           is.R                        is.raw
##                              1                              1
##                   is.recursive                     is.single
##                              1                              1
##                     is.symbol                      is.table
##                              1                              2
##                   is.unsorted                     is.vector
##                              4                              3
##                           isa                        isatty
##                              3                              2
##                 isBaseNamespace                    isdebugged
##                              2                              3
```

```
##                    isFALSE                 isIncomplete
##                          2                            2
##                 isNamespace           isNamespaceLoaded
##                          2                            2
##                    ISOdate                  ISOdatetime
##                          8                            8
##                     isOpen                     isRestart
##                          3                            2
##                       isS4                   isSeekable
##                          1                            2
##                 isSymmetric           isSymmetric.matrix
##                          3                            5
##                     isTRUE                       jitter
##                          2                            4
##                     julian                  julian.Date
##                          3                            4
##               julian.POSIXt                        kappa
##                          4                            3
##               kappa.default                     kappa.lm
##                          6                            3
##                    kappa.qr                    kronecker
##                          3                            6
##                   l10n_info                       La.svd
##                          1                            4
##                  La_library                   La_version
##                          1                            1
##                      labels                labels.default
##                          3                            3
##                      lapply                     lazyLoad
##                          4                            4
##              lazyLoadDBexec              lazyLoadDBfetch
##                          4                            1
##                       lbeta                      lchoose
##                          3                            3
##                      length                length.POSIXlt
##                          1                            2
##                    length<-                 length<-.Date
##                          1                            3
##           length<-.difftime              length<-.factor
##                          3                            3
##            length<-.POSIXct              length<-.POSIXlt
##                          3                            3
##                     lengths                      levels
##                          3                            2
##               levels.default                    levels<-
##                          2                            1
##              levels<-.factor                   lfactorial
##                          3                            2
##                      lgamma                libcurlVersion
##                          1                            1
##                     library                 library.dynam
##                         14                            7
##           library.dynam.unload                     licence
##                          5                            1
```

```
##                      license                         list
##                            1                            1
##                    list.dirs                   list.files
##                            4                            9
##                      list2DF                     list2env
##                            3                            6
##                         load                loadedNamespaces
##                            4                            1
##          loadingNamespaceInfo                   loadNamespace
##                            1                            7
##                        local                   lockBinding
##                            3                            3
##              lockEnvironment                          log
##                            3                            1
##                        log10                        log1p
##                            1                            1
##                         log2                         logb
##                            1                            3
##                      logical                     lower.tri
##                            2                            3
##                           ls                    make.names
##                            7                            4
##                  make.unique           makeActiveBinding
##                            3                            4
##                          Map                       mapply
##                            3                            6
##                 margin.table                   marginSums
##                            3                            3
##                   mat.or.vec                        match
##                            3                            5
##                    match.arg                   match.call
##                            4                            5
##                    match.fun              Math.data.frame
##                            3                            3
##                    Math.Date                 Math.difftime
##                            3                            3
##                   Math.factor                  Math.POSIXt
##                            3                            3
##                       matrix                          max
##                            6                            1
##                      max.col                         mean
##                            3                            3
##                    mean.Date                mean.default
##                            3                            5
##                 mean.difftime                mean.POSIXct
##                            3                            3
##                  mean.POSIXlt                mem.maxNSize
##                            3                            2
##                  mem.maxVSize                  memCompress
##                            2                            3
##                 memDecompress              memory.profile
##                            4                            1
##                         merge             merge.data.frame
##                            4                           14
```

```
##                merge.default                      message
##                            4                            4
##                         mget                          min
##                            6                            1
##                      missing                          Mod
##                            1                            1
##                         mode                        mode<-
##                            2                            3
##                       months                   months.Date
##                            3                            3
##                  months.POSIXt                mostattributes<-
##                            3                            3
##                        names                   names.POSIXlt
##                            1                            2
##                      names<-                  names<-.POSIXlt
##                            1                            3
##              namespaceExport                namespaceImport
##                            3                            5
##         namespaceImportClasses           namespaceImportFrom
##                            5                            8
##         namespaceImportMethods                       nargs
##                            5                            1
##                        nchar                        ncol
##                            5                            2
##                         NCOL                       Negate
##                            2                            2
##                      new.env                         next
##                            4                            1
##                   NextMethod                     ngettext
##                            4                            5
##                      nlevels                      noquote
##                            2                            3
##                         norm                normalizePath
##                            3                            4
##                         nrow                         NROW
##                            2                            2
##                     nullfile                      numeric
##                            1                            2
##              numeric_version                    numToBits
##                            3                            2
##                    numToInts                       nzchar
##                            2                            1
##                      objects                     oldClass
##                            7                            1
##                   oldClass<-                   OlsonNames
##                            1                            2
##                      on.exit                         open
##                            1                            3
##             open.connection                open.srcfile
##                            5                            4
##           open.srcfilealias              open.srcfilecopy
##                            4                            4
##              Ops.data.frame                     Ops.Date
##                            3                            3
```

```
##                     Ops.difftime                       Ops.factor
##                                3                                3
##               Ops.numeric_version                      Ops.ordered
##                                3                                3
##                      Ops.POSIXt                          options
##                                3                                2
##                            order                          ordered
##                                5                                3
##                            outer                  package_version
##                                5                                3
##                     packageEvent                packageHasNamespace
##                                3                                3
##               packageNotFoundError             packageStartupMessage
##                                4                                4
##                          packBits                         pairlist
##                                3                                2
##                        parent.env                      parent.env<-
##                                2                                3
##                     parent.frame                            parse
##                                2                                8
##                parseNamespaceFile                            paste
##                                4                                5
##                           paste0                       path.expand
##                                4                                2
##                     path.package                       pcre_config
##                                3                                1
##                             pipe                             plot
##                                4                                4
##                           pmatch                             pmax
##                                5                                3
##                          pmax.int                             pmin
##                                3                                3
##                          pmin.int                         polyroot
##                                3                                2
##                        pos.to.env                           pretty
##                                1                                3
##                    pretty.default                        prettyNum
##                                9                               14
##                             print                        print.AsIs
##                                3                                3
##                          print.by                   print.condition
##                                4                                3
##                  print.connection                  print.data.frame
##                                3                                8
##                        print.Date                     print.default
##                                4                               11
##                    print.difftime                       print.Dlist
##                                4                                3
##                     print.DLLInfo                  print.DLLInfoList
##                                3                                3
##          print.DLLRegisteredRoutines                      print.eigen
##                                3                                3
##                       print.factor                     print.function
##                                6                                4
```

```
##                print.hexmode                print.libraryIQR
##                            3                               3
##                  print.listof          print.NativeRoutineList
##                            3                               3
##                print.noquote           print.numeric_version
##                            5                               4
##                print.octmode               print.packageInfo
##                            3                               3
##                print.POSIXct                  print.POSIXlt
##                            6                               6
##             print.proc_time                  print.restart
##                            3                               3
##                    print.rle               print.simple.list
##                            5                               3
##                print.srcfile                   print.srcref
##                            3                               4
##          print.summary.table         print.summary.warnings
##                            4                               3
##       print.summaryDefault                    print.table
##                            4                               9
##             print.warnings                       prmatrix
##                            5                               8
##                  proc.time                           prod
##                            1                               1
##                 prop.table                    proportions
##                            3                               3
##            provideDimnames                       psigamma
##                            5                               3
##                   pushBack                 pushBackLength
##                            5                               2
##                           q                              qr
##                            4                               3
##                    qr.coef                      qr.default
##                            3                               5
##                  qr.fitted                           qr.Q
##                            4                               4
##                     qr.qty                          qr.qy
##                            3                               3
##                      qr.R                        qr.resid
##                            3                               3
##                  qr.solve                           qr.X
##                            4                               4
##                  quarters                 quarters.Date
##                            3                               3
##           quarters.POSIXt                          quit
##                            3                               4
##                     quote                         R.home
##                            1                               2
##                R.Version                R_system_version
##                            1                               3
##                     range                   range.default
##                            1                               4
##                      rank                          rapply
##                            4                               7
```

```
##                       raw                rawConnection
##                         2                            3
##         rawConnectionValue                     rawShift
##                         2                            3
##                  rawToBits                    rawToChar
##                         2                            3
##                     rbind           rbind.data.frame
##                         3                            6
##                     rcond                           Re
##                         5                            1
##                  read.dcf                      readBin
##                         5                            7
##                  readChar                     readline
##                         4                            2
##                 readLines                      readRDS
##                         7                            3
##              readRenviron                       Recall
##                         2                            2
##                    Reduce                 reg.finalizer
##                         6                            4
##                   regexec                      regexpr
##                         7                            7
##           registerS3method              registerS3methods
##                         5                            4
##                 regmatches                   regmatches<-
##                         4                            5
##                    remove           removeTaskCallback
##                         6                            2
##                       rep                     rep.Date
##                         1                            3
##              rep.difftime                    rep.factor
##                         3                            3
##                   rep.int           rep.numeric_version
##                         3                            3
##                rep.POSIXct                   rep.POSIXlt
##                         3                            3
##                   rep_len                       repeat
##                         3                            1
##                   replace                    replicate
##                         4                            4
##                   require              requireNamespace
##                        10                            4
##         restartDescription                restartFormals
##                         2                            2
##                retracemem                       return
##                         1                            1
##               returnValue                          rev
##                         2                            2
##               rev.default                          rle
##                         2                            2
##                        rm                       RNGkind
##                         6                            4
##                RNGversion                        round
##                         2                            1
```

```
##                   round.Date                  round.POSIXt
##                            3                             3
##                          row                    row.names
##                            3                             2
##           row.names.data.frame               row.names.default
##                            2                             2
##                    row.names<-          row.names<-.data.frame
##                            3                             3
##            row.names<-.default                      rowMeans
##                            3                             4
##                     rownames                     rownames<-
##                            4                             3
##                       rowsum                rowsum.data.frame
##                            5                             6
##                rowsum.default                      rowSums
##                            6                             4
##                       sample                    sample.int
##                            5                             6
##                       sapply                          save
##                            6                            11
##                   save.image                      saveRDS
##                            6                             7
##                        scale                 scale.default
##                            4                             4
##                         scan                        search
##                           23                             1
##                   searchpaths                          seek
##                            1                             3
##                seek.connection                           seq
##                            6                             2
##                     seq.Date                   seq.default
##                            7                             7
##                      seq.int                    seq.POSIXt
##                            1                             7
##                     seq_along                       seq_len
##                            1                             1
##                      sequence                sequence.default
##                            3                             5
##                     serialize                   serverSocket
##                            7                             2
##                      set.seed                       setdiff
##                            5                             4
##                      setequal                       setHook
##                            4                             4
##                 setNamespaceInfo             setSessionTimeLimit
##                            4                             3
##                    setTimeLimit                         setwd
##                            4                             2
##                           shell                    shell.exec
##                            9                             2
##                 showConnections                       shQuote
##                            2                             3
##                            sign                signalCondition
##                               1                             2
```

```
##                    signif                simpleCondition
##                         1                              3
##               simpleError                 simpleMessage
##                         3                              3
##             simpleWarning                 simplify2array
##                         3                              3
##                       sin                         single
##                         1                              2
##                      sinh                           sink
##                         1                              5
##              sink.number                          sinpi
##                         2                              1
##              slice.index                   socketAccept
##                         3                              7
##           socketConnection                   socketSelect
##                         9                              4
##              socketTimeout                          solve
##                         3                              4
##              solve.default                       solve.qr
##                         6                              4
##                      sort                   sort.default
##                         4                              5
##                  sort.int                      sort.list
##                         7                              6
##               sort.POSIXlt                         source
##                         5                             17
##                     split                split.data.frame
##                         5                              5
##                split.Date                   split.default
##                         5                              7
##               split.POSIXct                         split<-
##                         5                              6
##          split<-.data.frame                 split<-.default
##                         6                              6
##                   sprintf                           sqrt
##                         3                              1
##                    sQuote                        srcfile
##                         3                              4
##              srcfilealias                    srcfilecopy
##                         3                              5
##                    srcref                standardGeneric
##                         3                              1
##               startsWith                         stderr
##                         3                              1
##                     stdin                         stdout
##                         1                              1
##                      stop                       stopifnot
##                         4                              5
##              storage.mode                storage.mode<-
##                         2                              1
##           str2expression                        str2lang
##                         2                              2
##                  strftime                        strptime
##                         6                              4
```

```
##                          strrep                          strsplit
##                               3                                 6
##                          strtoi                          strtrim
##                               3                                 3
##                       structure                          strwrap
##                               3                                 8
##                             sub                          subset
##                               8                                 3
##                  subset.data.frame                 subset.default
##                               6                                 4
##                      subset.matrix                      substitute
##                               6                                 1
##                          substr                         substr<-
##                               4                                 5
##                       substring                       substring<-
##                               4                                 5
##                             sum                           summary
##                               1                                 3
##                 summary.connection              summary.data.frame
##                               3                                 5
##                 Summary.data.frame                   summary.Date
##                               3                                 4
##                      Summary.Date                 summary.default
##                               3                                 5
##                   Summary.difftime                  summary.factor
##                               3                                 4
##                    Summary.factor                  summary.matrix
##                               3                                 3
##            Summary.numeric_version                 Summary.ordered
##                               3                                 3
##                    summary.POSIXct                 Summary.POSIXct
##                               4                                 3
##                    summary.POSIXlt                 Summary.POSIXlt
##                               4                                 3
##                 summary.proc_time                  summary.srcfile
##                               3                                 3
##                    summary.srcref                    summary.table
##                               4                                 3
##                  summary.warnings                suppressMessages
##                               3                                 3
##     suppressPackageStartupMessages                suppressWarnings
##                               2                                 3
##                 suspendInterrupts                             svd
##                               2                                 5
##                           sweep                          switch
##                               7                                 1
##                        sys.call                        sys.calls
##                               2                                 1
##                       Sys.chmod                         Sys.Date
##                               4                                 1
##                       sys.frame                        sys.frames
##                               2                                 1
##                    sys.function                        Sys.getenv
##                               2                                 4
```

```
##                  Sys.getlocale                      Sys.getpid
##                              2                               1
##                       Sys.glob                        Sys.info
##                              3                               1
##                   Sys.junction                  sys.load.image
##                              3                               3
##                 Sys.localeconv                      sys.nframe
##                              1                               1
##                    sys.on.exit                      sys.parent
##                              1                               2
##                    sys.parents                     Sys.readlink
##                              1                               2
##                  sys.save.image                      Sys.setenv
##                              2                               2
##                 Sys.setFileTime                    Sys.setlocale
##                              3                               3
##                       Sys.sleep                      sys.source
##                              2                               7
##                    sys.status                        Sys.time
##                              1                               1
##                   Sys.timezone                       Sys.umask
##                              2                               2
##                   Sys.unsetenv                       Sys.which
##                              2                               2
##                         system                     system.file
##                             11                               5
##                    system.time                         system2
##                              3                              12
##                              t                   t.data.frame
##                              2                               2
##                     t.default                           table
##                              2                               6
##                      tabulate                             tan
##                              3                               1
##                          tanh                            tanpi
##                              1                               1
##                         tapply                taskCallbackManager
##                              7                               4
##                     tcrossprod                         tempdir
##                              3                               2
##                      tempfile                     textConnection
##                              4                               6
##               textConnectionValue                        tolower
##                              2                               2
##                         topenv                        toString
##                              3                               3
##                  toString.default                         toupper
##                              4                               2
##                          trace                       traceback
##                              9                               3
##                       tracemem                    tracingState
##                              1                               2
##                      transform              transform.data.frame
##                              3                               3
```

```
##                transform.default                         trigamma
##                                3                                1
##                          trimws                            trunc
##                                4                                1
##                       trunc.Date                       trunc.POSIXt
##                                3                                4
##                         truncate                  truncate.connection
##                                3                                3
##                              try                          tryCatch
##                                4                                4
##                  tryInvokeRestart                           typeof
##                                3                                2
##                          unclass                          undebug
##                                1                                3
##                            union                           unique
##                                4                                4
##                     unique.array                  unique.data.frame
##                                6                                5
##                   unique.default                       unique.matrix
##                                6                                6
##            unique.numeric_version                      unique.POSIXlt
##                                4                                4
##                  unique.warnings                            units
##                                4                                2
##                   units.difftime                           units<-
##                                2                                3
##                 units<-.difftime                        unix.time
##                                3                                2
##                          unlink                           unlist
##                                5                                4
##                  unloadNamespace                     unlockBinding
##                                2                                3
##                          unname                        unserialize
##                                3                                3
##                          unsplit                          untrace
##                                4                                4
##                       untracemem                              unz
##                                1                                5
##                        upper.tri                              url
##                                3                                7
##                        UseMethod                       utf8ToInt
##                                1                                2
##                         validEnc                        validUTF8
##                                2                                2
##                           vapply                           vector
##                                6                                3
##                       Vectorize                          warning
##                                5                                6
##                  warningCondition                         warnings
##                                5                                2
##                         weekdays                     weekdays.Date
##                                3                                3
##                   weekdays.POSIXt                            which
##                                3                                4
```

```
##                         which.max                         which.min
##                                 2                                 2
##                             while                              with
##                                 1                                 4
##                       with.default                     withAutoprint
##                                 4                                10
##                  withCallingHandlers                            within
##                                 3                                 4
##                   within.data.frame                       within.list
##                                 4                                 5
##                       withRestarts                       withVisible
##                                 3                                 2
##                              write                         write.dcf
##                                 6                                 8
##                           writeBin                         writeChar
##                                 6                                 6
##                         writeLines                               xor
##                                 5                                 3
##                  xpdrows.data.frame                             xtfrm
##                                 4                                 1
##                        xtfrm.AsIs                   xtfrm.data.frame
##                                 2                                 2
##                       xtfrm.Date                      xtfrm.default
##                                 2                                 2
##                    xtfrm.difftime                       xtfrm.factor
##                                 2                                 2
##               xtfrm.numeric_version                      xtfrm.POSIXct
##                                 2                                 2
##                       xtfrm.POSIXlt                            xzfile
##                                 2                                 5
##                           zapsmall
##                                 3
```

```
g11()
```

```
##                                 -                                -.Date
##                                 1                                     3
##                           -.POSIXt                                     !
##                                 3                                     1
##                          !.hexmode                           !.octmode
##                                 2                                     2
##                                !=                                     $
##                                 1                                     1
##                          $.DLLInfo                   $.package_version
##                                 3                                     3
##                                $<-                      $<-.data.frame
##                                 1                                     4
##                                %%                                   %*%
##                                 1                                     1
##                                %/%                                  %in%
##                                 1                                     3
##                                %o%                                   %x%
##                                 3                                     3
##                                 &                                    &&
```

```
##                             1                             1
##                     &.hexmode                     &.octmode
##                             3                             3
##                             (                             *
##                             1                             1
##                   *.difftime                      ...elt
##                             3                             1
##                     ...length                     ...names
##                             1                             1
##                  ..getNamespace                  .__H__.cbind
##                             3                             3
##                   .__H__.rbind                .amatch_bounds
##                             3                             2
##                  .amatch_costs                      .bincode
##                             2                             5
##                             .C                  .cache_class
##                             1                             1
##                         .Call                .Call.graphics
##                             1                             1
##                        .class2                          .col
##                             1                             2
##                      .colMeans                     .colSums
##                             5                             5
##                         .Date          .decode_numeric_version
##                             3                             2
##                       .Defunct                  .deparseOpts
##                             4                             2
##                    .Deprecated                       .detach
##                             5                             2
##                      .difftime                    .doSortWrap
##                             4                             5
##                      .doTrace                       .doWrap
##                             3                             5
##                      .dynLibs          .encode_numeric_version
##                             2                             2
##             .expand_R_libs_env_var                     .External
##                             2                             1
##                .External.graphics                    .External2
##                             1                             1
##                    .First.sys                .fixupGFortranStderr
##                             1                             1
##              .fixupGFortranStdout                  .format.zeros
##                             1                             6
##                      .Fortran                  .getNamespace
##                             1                             2
##                 .getNamespaceInfo             .getRequiredPackages
##                             3                             5
##               .getRequiredPackages2                           .gt
##                             5                             4
##                           .gtn                .handleSimpleError
##                             3                             4
##                      .Internal             .isMethodsDispatchOn
##                             1                             1
##                        .isOpen                     .kappa_tri
```

```
##                                2                                6
##                       .kronecker                       .libPaths
##                                6                                3
##              .make_numeric_version                      .makeMessage
##                                5                                4
##                           .mapply                      .maskedMsg
##                                4                                4
##              .mergeExportMethods                .mergeImportMethods
##                                3                                4
##               .NotYetImplemented                        .NotYetUsed
##                                1                                3
##               .OptRequireMethods                        .packages
##                                1                                3
##             .packageStartupMessage                         .POSIXct
##                                3                                4
##                         .POSIXlt                       .Primitive
##                                4                                1
##                        .primTrace                     .primUntrace
##                                1                                1
##                             .rmpkg                             .row
##                                2                                2
##                   .row_names_info                        .rowMeans
##                                3                                5
##                    .rowNamesDF<-                         .rowSums
##                                4                                5
##                        .S3method                         .Script
##                                4                                5
##                    .set_row_names                .signalSimpleWarning
##                                2                                3
##                .standard_regexps                         .subset
##                                1                                1
##                         .subset2                  .TAOCP1997init
##                                1                                2
##                        .traceback                .tryResumeInterrupt
##                                3                                1
##                     .valid.factor                                /
##                                2                                1
##                       /.difftime                                :
##                                3                                1
##                               ::                              :::
##                                1                                1
##                                @                             @<-
##                                1                                1
##                                [                           [.AsIs
##                                1                                4
##                     [.data.frame                           [.Date
##                                5                                4
##                       [.difftime                           [.Dlist
##                                4                                4
##                     [.DLLInfoList                          [.factor
##                                3                                4
##                        [.hexmode                          [.listof
##                                3                                4
##                        [.noquote                  [.numeric_version
```

```
##                             3                             4
##                     [.octmode                     [.POSIXct
##                             3                             4
##                     [.POSIXlt                  [.simple.list
##                             5                             4
##                       [.table                     [.warnings
##                             6                             3
##                            [[                  [[.data.frame
##                             1                             4
##                       [[.Date                       [[.factor
##                             4                             3
##              [[.numeric_version                    [[.POSIXct
##                             4                             4
##                     [[.POSIXlt                          [[<-
##                             4                             1
##                [[<-.data.frame                    [[<-.factor
##                             5                             4
##             [[<-.numeric_version                  [[<-.POSIXlt
##                             4                             4
##                           [<-                 [<-.data.frame
##                             1                             5
##                      [<-.Date                   [<-.difftime
##                             4                             4
##                    [<-.factor              [<-.numeric_version
##                             4                             5
##                    [<-.POSIXct                   [<-.POSIXlt
##                             4                             5
##                             ^                             {
##                             1                             1
##                             |                      |.hexmode
##                             1                             3
##                     |.octmode                            ||
##                             3                             1
##                             ~                             +
##                             1                             1
##                        +.Date                        +.POSIXt
##                             3                             3
##                             <                            <-
##                             1                             1
##                           <<-                            <=
##                             1                             1
##                             =                            ==
##                             1                             1
##                             >                            >=
##                             1                             1
##                    abbreviate                           abs
##                             8                             1
##                          acos                         acosh
##                             1                             1
##            activeBindingFunction                       addNA
##                             3                             3
##                 addTaskCallback                       agrep
##                             4                             9
##                         agrepl                         alist
```

```
##                                8                                2
##                              all                        all.equal
##                                1                                4
##                all.equal.character                  all.equal.default
##                                5                                4
##               all.equal.environment              all.equal.envRefClass
##                                6                                4
##                   all.equal.factor                  all.equal.formula
##                                5                                4
##                  all.equal.function                 all.equal.language
##                                5                                4
##                     all.equal.list                  all.equal.numeric
##                                6                                9
##                   all.equal.POSIXt                      all.equal.raw
##                                7                                5
##                           all.names                         all.vars
##                                5                                5
##                    allowInterrupts                              any
##                                2                                1
##                      anyDuplicated                anyDuplicated.array
##                                4                                6
##           anyDuplicated.data.frame              anyDuplicated.default
##                                5                                5
##               anyDuplicated.matrix                            anyNA
##                                6                                1
##                    anyNA.data.frame              anyNA.numeric_version
##                                3                                3
##                      anyNA.POSIXlt                            aperm
##                                3                                4
##                      aperm.default                       aperm.table
##                                5                                6
##                             append                            apply
##                                4                                6
##                                Arg                            array
##                                1                                4
##                           arrayInd                         as.array
##                                5                                3
##                   as.array.default                          as.call
##                                3                                1
##                       as.character             as.character.condition
##                                1                                3
##                  as.character.Date               as.character.default
##                                3                                3
##                 as.character.error                as.character.factor
##                                3                                3
##               as.character.hexmode       as.character.numeric_version
##                                3                                3
##               as.character.octmode                as.character.POSIXt
##                                3                                3
##                as.character.srcref                          as.complex
##                                5                                1
##                      as.data.frame                as.data.frame.array
##                                5                                5
##                  as.data.frame.AsIs             as.data.frame.character
```

```
##                                5                                4
##             as.data.frame.complex          as.data.frame.data.frame
##                                6                                4
##                as.data.frame.Date             as.data.frame.default
##                                6                                3
##            as.data.frame.difftime              as.data.frame.factor
##                                6                                6
##             as.data.frame.integer                as.data.frame.list
##                                6                               10
##             as.data.frame.logical              as.data.frame.matrix
##                                6                                7
##         as.data.frame.model.matrix             as.data.frame.noquote
##                                6                                6
##             as.data.frame.numeric      as.data.frame.numeric_version
##                                6                                6
##             as.data.frame.ordered             as.data.frame.POSIXct
##                                6                                6
##             as.data.frame.POSIXlt                as.data.frame.raw
##                                5                                6
##               as.data.frame.table                 as.data.frame.ts
##                                8                                3
##              as.data.frame.vector                          as.Date
##                                6                                3
##                 as.Date.character                   as.Date.default
##                                6                                3
##                     as.Date.factor                   as.Date.numeric
##                                3                                4
##                   as.Date.POSIXct                   as.Date.POSIXlt
##                                4                                3
##                      as.difftime                         as.double
##                                5                                1
##                 as.double.difftime                  as.double.POSIXlt
##                                4                                3
##                     as.environment                      as.expression
##                                1                                3
##             as.expression.default                         as.factor
##                                3                                2
##                       as.function                as.function.default
##                                3                                4
##                       as.hexmode                         as.integer
##                                2                                1
##                          as.list                  as.list.data.frame
##                                3                                3
##                     as.list.Date                     as.list.default
##                                3                                3
##                   as.list.difftime                 as.list.environment
##                                3                                5
##                     as.list.factor                    as.list.function
##                                3                                3
##            as.list.numeric_version                    as.list.POSIXct
##                                3                                3
##                   as.list.POSIXlt                         as.logical
##                                3                                1
##                 as.logical.factor                         as.matrix
```

```
##                          3                          3
##  as.matrix.data.frame          as.matrix.default
##                          4                          3
##     as.matrix.noquote          as.matrix.POSIXlt
##                          3                          3
##               as.name                    as.null
##                          2                          3
##        as.null.default                 as.numeric
##                          3                          1
##      as.numeric_version                 as.octmode
##                          2                          2
##           as.ordered          as.package_version
##                          2                          2
##            as.pairlist                 as.POSIXct
##                          2                          4
##        as.POSIXct.Date          as.POSIXct.default
##                          3                          4
##      as.POSIXct.numeric          as.POSIXct.POSIXlt
##                          5                          4
##            as.POSIXlt        as.POSIXlt.character
##                          4                          7
##        as.POSIXlt.Date          as.POSIXlt.default
##                          3                          5
##       as.POSIXlt.factor          as.POSIXlt.numeric
##                          3                          5
##      as.POSIXlt.POSIXct                      as.qr
##                          4                          2
##                 as.raw                  as.single
##                          1                          3
##       as.single.default                  as.symbol
##                          3                          2
##              as.table            as.table.default
##                          3                          3
##             as.vector            as.vector.factor
##                          3                          3
##                   asin                       asinh
##                          1                          1
##             asNamespace                      asplit
##                          3                          3
##                   asS3                       asS4
##                          4                          4
##                 assign                       atan
##                          7                          1
##                  atan2                      atanh
##                          3                          1
##                 attach           attachNamespace
##                          5                          6
##                   attr            attr.all.equal
##                          1                          6
##                 attr<-               attributes
##                          1                          1
##           attributes<-                   autoload
##                          1                          5
##             autoloader                  backsolve
```

```
##                           4                           6
##                     baseenv                    basename
##                           1                           2
##                     besselI                     besselJ
##                           4                           3
##                     besselK                     besselY
##                           4                           3
##                        beta                bindingIsActive
##                           3                           3
##               bindingIsLocked                bindtextdomain
##                           3                           3
##                     bitwAnd                     bitwNot
##                           3                           2
##                      bitwOr                   bitwShiftL
##                           3                           3
##                  bitwShiftR                     bitwXor
##                           3                           3
##                        body                      body<-
##                           2                           4
##                      bquote                       break
##                           4                           1
##                     browser             browserCondition
##                           1                           2
##               browserSetDebug                 browserText
##                           2                           2
##                    builtins                          by
##                           2                           6
##                by.data.frame                 by.default
##                           6                           6
##                     bzfile                           c
##                           5                           1
##                     c.Date                   c.difftime
##                           3                           3
##                   c.factor                    c.noquote
##                           3                           3
##             c.numeric_version                    c.POSIXct
##                           3                           3
##                    c.POSIXlt                   c.warnings
##                           3                           3
##                        call                      callCC
##                           1                           2
##                capabilities                    casefold
##                           3                           3
##                         cat                       cbind
##                           7                           3
##              cbind.data.frame                    ceiling
##                           3                           1
##                   char.expand                   character
##                           4                           2
##                   charmatch                   charToRaw
##                           4                           2
##                      chartr                check_tzones
##                           4                           2
##                     chkDots                        chol
```

```
##                              4                              3
##                    chol.default                       chol2inv
##                              6                              4
##                         choose                          class
##                              3                              1
##                         class<-                     clearPushBack
##                              1                              2
##                          close                  close.connection
##                              3                              4
##                    close.srcfile              close.srcfilealias
##                              3                              3
##              closeAllConnections                            col
##                              1                              3
##                        colMeans                       colnames
##                              4                              4
##                     colnames<-                        colSums
##                              3                              4
##                     commandArgs                        comment
##                              2                              2
##                      comment<-                        complex
##                              3                              6
##                  computeRestarts                   conditionCall
##                              2                              2
##           conditionCall.condition                conditionMessage
##                              2                              2
##         conditionMessage.condition                   conflictRules
##                              2                              4
##                        conflicts                           Conj
##                              3                              1
##                     contributors                            cos
##                              1                              1
##                             cosh                           cospi
##                              1                              1
##                        crossprod                     Cstack_info
##                              3                              1
##                           cummax                         cummin
##                              1                              1
##                          cumprod                         cumsum
##                              1                              1
##                   curlGetHeaders                            cut
##                              6                              3
##                         cut.Date                    cut.default
##                              7                              9
##                       cut.POSIXt                     data.class
##                              7                              2
##                       data.frame                    data.matrix
##                              7                              3
##                             date                          debug
##                              1                              5
##                    debuggingState                     debugonce
##                              2                              5
##            default.stringsAsFactors                   delayedAssign
##                              1                              5
##                          deparse                        deparse1
```

```
##                                6                                5
##                              det                           detach
##                                3                                6
##                      determinant                 determinant.matrix
##                                4                                4
##                             dget                             diag
##                                3                                5
##                            diag<-                             diff
##                                3                                3
##                         diff.Date                     diff.default
##                                5                                5
##                     diff.difftime                      diff.POSIXt
##                                3                                5
##                         difftime                         digamma
##                                5                                1
##                              dim                    dim.data.frame
##                                1                                2
##                             dim<-                         dimnames
##                                1                                1
##                dimnames.data.frame                       dimnames<-
##                                2                                1
##               dimnames<-.data.frame                              dir
##                                3                                9
##                         dir.create                       dir.exists
##                                5                                2
##                            dirname                          do.call
##                                2                                5
##                         dontCheck                           double
##                                2                                2
##                             dput                            dQuote
##                                4                                3
##                             drop                       droplevels
##                                2                                3
##               droplevels.data.frame                 droplevels.factor
##                                5                                4
##                             dump                        duplicated
##                                7                                4
##                   duplicated.array              duplicated.data.frame
##                                6                                5
##                duplicated.default                duplicated.matrix
##                                6                                6
##          duplicated.numeric_version                duplicated.POSIXlt
##                                4                                4
##                duplicated.warnings                       dyn.load
##                                4                                5
##                         dyn.unload                          dynGet
##                                2                                5
##                              eapply                           eigen
##                                6                                5
##                           emptyenv                      enc2native
##                                1                                1
##                           enc2utf8                    encodeString
##                                1                                6
##                           Encoding                       Encoding<-
```

```
##                          2                          3
##                   endsWith                    enquote
##                          3                          2
##                env.profile                environment
##                          2                          2
##               environment<-           environmentIsLocked
##                          1                          2
##             environmentName                errorCondition
##                          2                          5
##                       eval                  eval.parent
##                          4                          3
##                      evalq                     exists
##                          4                          7
##                        exp                  expand.grid
##                          1                          4
##                      expm1                  expression
##                          1                          1
##             extSoftVersion                      factor
##                          1                          7
##                  factorial                        fifo
##                          2                          5
##                       file                 file.access
##                          7                          3
##                file.append                file.choose
##                          3                          2
##                  file.copy                file.create
##                          7                          3
##                file.exists                  file.info
##                          2                          3
##                  file.link                  file.mode
##                          3                          2
##                 file.mtime                  file.path
##                          2                          3
##                file.remove                file.rename
##                          2                          3
##                  file.show                  file.size
##                          7                          2
##               file.symlink                     Filter
##                          3                          3
##                       Find               find.package
##                          5                          5
##              findInterval             findPackageEnv
##                          6                          2
##               findRestart                      floor
##                          3                          1
##                     flush            flush.connection
##                          2                          2
##                       for                      force
##                          1                          2
##              forceAndCall                    formals
##                          1                          3
##                formals<-                     format
##                          4                          3
##               format.AsIs           format.data.frame
```

```
##                                4                                4
##                      format.Date                      format.default
##                                3                               17
##                   format.difftime                      format.factor
##                                3                                3
##                    format.hexmode                       format.info
##                                5                                4
##                  format.libraryIQR             format.numeric_version
##                                3                                3
##                    format.octmode                 format.packageInfo
##                                4                                3
##                    format.POSIXct                       format.POSIXlt
##                                6                                5
##                       format.pval                format.summaryDefault
##                                6                                4
##                           formatC                          formatDL
##                               16                                6
##                      forwardsolve                          function
##                                6                                1
##                             gamma                               gc
##                                1                                4
##                           gc.time                            gcinfo
##                                1                                2
##                          gctorture                        gctorture2
##                                2                                4
##                               get                              get0
##                                6                                6
##                  getAllConnections                      getCallingDLL
##                                1                                3
##                     getCallingDLLe                      getConnection
##                                2                                2
##           getDLLRegisteredRoutines getDLLRegisteredRoutines.character
##                                3                                3
##   getDLLRegisteredRoutines.DLLInfo                         getElement
##                                3                                3
##                       geterrmessage                   getExportedValue
##                                1                                3
##                             getHook                      getLoadedDLLs
##                                2                                1
##                       getNamespace                 getNamespaceExports
##                                2                                2
##                 getNamespaceImports                   getNamespaceInfo
##                                2                                3
##                    getNamespaceName                   getNamespaceUsers
##                                2                                2
##                 getNamespaceVersion                 getNativeSymbolInfo
##                                2                                5
##                          getOption                        getRversion
##                                3                                1
##                       getSrcLines                getTaskCallbackNames
##                                4                                1
##                             gettext                          gettextf
##                                3                                4
##                               getwd                               gl
```

```
##                             1                             6
##          globalCallingHandlers                    globalenv
##                             2                             1
##                       gregexec                     gregexpr
##                             7                             7
##                          grep                        grepl
##                             9                             7
##                       grepRaw                      grouping
##                             9                             2
##                          gsub                        gzcon
##                             8                             5
##                        gzfile                             I
##                             5                             2
##                         iconv                    iconvlist
##                             7                             1
##                  icuGetCollate                icuSetCollate
##                             2                             2
##                     identical                      identity
##                             9                             2
##                            if                      ifelse
##                             1                             4
##                            Im                importIntoEnv
##                             1                             5
##                       infoRDS                      inherits
##                             2                             4
##                       integer                   interaction
##                             2                             5
##                   interactive                     intersect
##                             1                             4
##                     intToBits                     intToUtf8
##                             2                             4
##                    inverse.rle                     invisible
##                             3                             1
##                  invokeRestart  invokeRestartInteractively
##                             3                             2
##                      is.array                    is.atomic
##                             1                             1
##                       is.call                  is.character
##                             1                             1
##                    is.complex                 is.data.frame
##                             1                             2
##                     is.double                    is.element
##                             1                             3
##                is.environment                 is.expression
##                             1                             1
##                      is.factor                     is.finite
##                             2                             1
##                    is.function                   is.infinite
##                             1                             1
##                    is.integer                   is.language
##                             1                             1
##                       is.list                     is.loaded
##                             1                             4
##                    is.logical                    is.matrix
```

```
##                             1                             1
##                         is.na                 is.na.data.frame
##                             1                             2
##           is.na.numeric_version                    is.na.POSIXlt
##                             2                             2
##                        is.na<-                  is.na<-.default
##                             3                             3
##                  is.na<-.factor           is.na<-.numeric_version
##                             3                             3
##                        is.name                          is.nan
##                             1                             1
##                        is.null                       is.numeric
##                             1                             1
##                  is.numeric.Date               is.numeric.difftime
##                             2                             2
##                is.numeric.POSIXt                is.numeric_version
##                             2                             2
##                       is.object                     is.ordered
##                             1                             2
##                  is.package_version                     is.pairlist
##                             2                             1
##                     is.primitive                          is.qr
##                             2                             2
##                             is.R                        is.raw
##                             1                             1
##                     is.recursive                     is.single
##                             1                             1
##                       is.symbol                      is.table
##                             1                             2
##                     is.unsorted                     is.vector
##                             4                             3
##                             isa                       isatty
##                             3                             2
##                  isBaseNamespace                    isdebugged
##                             2                             3
##                         isFALSE                   isIncomplete
##                             2                             2
##                     isNamespace                isNamespaceLoaded
##                             2                             2
##                         ISOdate                   ISOdatetime
##                             8                             8
##                          isOpen                     isRestart
##                             3                             2
##                             isS4                    isSeekable
##                             1                             2
##                     isSymmetric                isSymmetric.matrix
##                             3                             5
##                          isTRUE                        jitter
##                             2                             4
##                          julian                    julian.Date
##                             3                             4
##                    julian.POSIXt                         kappa
##                             4                             3
##                    kappa.default                       kappa.lm
```

```
##                              6                              3
##                      kappa.qr                      kronecker
##                              3                              6
##                     l10n_info                         La.svd
##                              1                              4
##                    La_library                     La_version
##                              1                              1
##                         labels                 labels.default
##                              3                              3
##                         lapply                       lazyLoad
##                              4                              4
##                  lazyLoadDBexec                 lazyLoadDBfetch
##                              4                              1
##                           lbeta                        lchoose
##                              3                              3
##                         length                   length.POSIXlt
##                              1                              2
##                       length<-                    length<-.Date
##                              1                              3
##                  length<-.difftime                length<-.factor
##                              3                              3
##                   length<-.POSIXct               length<-.POSIXlt
##                              3                              3
##                        lengths                         levels
##                              3                              2
##                   levels.default                       levels<-
##                              2                              1
##                    levels<-.factor                    lfactorial
##                              3                              2
##                         lgamma                   libcurlVersion
##                              1                              1
##                        library                    library.dynam
##                             14                              7
##                library.dynam.unload                        licence
##                              5                              1
##                        license                           list
##                              1                              1
##                      list.dirs                      list.files
##                              4                              9
##                        list2DF                        list2env
##                              3                              6
##                           load                 loadedNamespaces
##                              4                              1
##                loadingNamespaceInfo                   loadNamespace
##                              1                              7
##                          local                     lockBinding
##                              3                              3
##                lockEnvironment                            log
##                              3                              1
##                          log10                          log1p
##                              1                              1
##                           log2                           logb
##                              1                              3
##                        logical                      lower.tri
```

```
##                           2                           3
##                          ls                  make.names
##                           7                           4
##                 make.unique          makeActiveBinding
##                           3                           4
##                         Map                      mapply
##                           3                           6
##                margin.table                  marginSums
##                           3                           3
##                  mat.or.vec                       match
##                           3                           5
##                   match.arg                  match.call
##                           4                           5
##                   match.fun           Math.data.frame
##                           3                           3
##                   Math.Date             Math.difftime
##                           3                           3
##                Math.factor                Math.POSIXt
##                           3                           3
##                      matrix                         max
##                           6                           1
##                     max.col                        mean
##                           3                           3
##                   mean.Date              mean.default
##                           3                           5
##                mean.difftime              mean.POSIXct
##                           3                           3
##                mean.POSIXlt              mem.maxNSize
##                           3                           2
##                mem.maxVSize                memCompress
##                           2                           3
##                memDecompress             memory.profile
##                           4                           1
##                       merge           merge.data.frame
##                           4                          14
##                merge.default                     message
##                           4                           4
##                        mget                         min
##                           6                           1
##                     missing                         Mod
##                           1                           1
##                        mode                       mode<-
##                           2                           3
##                      months                 months.Date
##                           3                           3
##                months.POSIXt             mostattributes<-
##                           3                           3
##                       names              names.POSIXlt
##                           1                           2
##                     names<-             names<-.POSIXlt
##                           1                           3
##              namespaceExport              namespaceImport
##                           3                           5
##         namespaceImportClasses          namespaceImportFrom
```

```
##                             5                             8
##          namespaceImportMethods                          nargs
##                             5                             1
##                         nchar                          ncol
##                             5                             2
##                          NCOL                        Negate
##                             2                             2
##                       new.env                          next
##                             4                             1
##                    NextMethod                       ngettext
##                             4                             5
##                       nlevels                        noquote
##                             2                             3
##                          norm                  normalizePath
##                             3                             4
##                          nrow                          NROW
##                             2                             2
##                      nullfile                       numeric
##                             1                             2
##               numeric_version                     numToBits
##                             3                             2
##                     numToInts                        nzchar
##                             2                             1
##                       objects                       oldClass
##                             7                             1
##                    oldClass<-                    OlsonNames
##                             1                             2
##                       on.exit                          open
##                             1                             3
##                open.connection                  open.srcfile
##                             5                             4
##              open.srcfilealias                open.srcfilecopy
##                             4                             4
##                Ops.data.frame                     Ops.Date
##                             3                             3
##                  Ops.difftime                   Ops.factor
##                             3                             3
##           Ops.numeric_version                   Ops.ordered
##                             3                             3
##                    Ops.POSIXt                       options
##                             3                             2
##                         order                       ordered
##                             5                             3
##                         outer                package_version
##                             5                             3
##                  packageEvent           packageHasNamespace
##                             3                             3
##            packageNotFoundError         packageStartupMessage
##                             4                             4
##                      packBits                      pairlist
##                             3                             2
##                    parent.env                   parent.env<-
##                             2                             3
##                  parent.frame                         parse
```

```
##                              2                              8
##                parseNamespaceFile                          paste
##                              4                              5
##                          paste0                     path.expand
##                              4                              2
##                    path.package                     pcre_config
##                              3                              1
##                           pipe                           plot
##                              4                              4
##                          pmatch                           pmax
##                              5                              3
##                       pmax.int                           pmin
##                              3                              3
##                       pmin.int                       polyroot
##                              3                              2
##                     pos.to.env                         pretty
##                              1                              3
##                  pretty.default                      prettyNum
##                              9                             14
##                           print                      print.AsIs
##                              3                              3
##                       print.by                 print.condition
##                              4                              3
##                 print.connection                print.data.frame
##                              3                              8
##                      print.Date                   print.default
##                              4                             11
##                   print.difftime                      print.Dlist
##                              4                              3
##                    print.DLLInfo                print.DLLInfoList
##                              3                              3
##       print.DLLRegisteredRoutines                      print.eigen
##                              3                              3
##                     print.factor                    print.function
##                              6                              4
##                    print.hexmode                   print.libraryIQR
##                              3                              3
##                     print.listof              print.NativeRoutineList
##                              3                              3
##                    print.noquote               print.numeric_version
##                              5                              4
##                    print.octmode                   print.packageInfo
##                              3                              3
##                    print.POSIXct                      print.POSIXlt
##                              6                              6
##                  print.proc_time                      print.restart
##                              3                              3
##                         print.rle                   print.simple.list
##                              5                              3
##                    print.srcfile                       print.srcref
##                              3                              4
##               print.summary.table            print.summary.warnings
##                              4                              3
##              print.summaryDefault                      print.table
```

```
##                         4                         9
##          print.warnings                   prmatrix
##                         5                         8
##               proc.time                      prod
##                         1                         1
##              prop.table                 proportions
##                         3                         3
##          provideDimnames                   psigamma
##                         5                         3
##                  pushBack              pushBackLength
##                         5                         2
##                         q                        qr
##                         4                         3
##                   qr.coef                qr.default
##                         3                         5
##                qr.fitted                      qr.Q
##                         4                         4
##                   qr.qty                     qr.qy
##                         3                         3
##                    qr.R                   qr.resid
##                         3                         3
##                 qr.solve                      qr.X
##                         4                         4
##                 quarters              quarters.Date
##                         3                         3
##           quarters.POSIXt                      quit
##                         3                         4
##                   quote                   R.home
##                         1                         2
##               R.Version           R_system_version
##                         1                         3
##                   range              range.default
##                         1                         4
##                    rank                    rapply
##                         4                         7
##                     raw              rawConnection
##                         2                         3
##      rawConnectionValue                  rawShift
##                         2                         3
##              rawToBits                 rawToChar
##                         2                         3
##                   rbind           rbind.data.frame
##                         3                         6
##                   rcond                        Re
##                         5                         1
##                read.dcf                  readBin
##                         5                         7
##                readChar                  readline
##                         4                         2
##               readLines                  readRDS
##                         7                         3
##             readRenviron                   Recall
##                         2                         2
##                  Reduce              reg.finalizer
```

```
##                             6                             4
##                       regexec                       regexpr
##                             7                             7
##                registerS3method               registerS3methods
##                             5                             4
##                     regmatches                    regmatches<-
##                             4                             5
##                        remove                removeTaskCallback
##                             6                             2
##                           rep                      rep.Date
##                             1                             3
##                    rep.difftime                    rep.factor
##                             3                             3
##                        rep.int                rep.numeric_version
##                             3                             3
##                     rep.POSIXct                     rep.POSIXlt
##                             3                             3
##                        rep_len                        repeat
##                             3                             1
##                        replace                     replicate
##                             4                             4
##                        require                requireNamespace
##                            10                             4
##               restartDescription                restartFormals
##                             2                             2
##                     retracemem                        return
##                             1                             1
##                     returnValue                           rev
##                             2                             2
##                     rev.default                           rle
##                             2                             2
##                              rm                       RNGkind
##                             6                             4
##                     RNGversion                         round
##                             2                             1
##                     round.Date                    round.POSIXt
##                             3                             3
##                             row                     row.names
##                             3                             2
##              row.names.data.frame              row.names.default
##                             2                             2
##                     row.names<-          row.names<-.data.frame
##                             3                             3
##               row.names<-.default                     rowMeans
##                             3                             4
##                        rownames                    rownames<-
##                             4                             3
##                          rowsum               rowsum.data.frame
##                             5                             6
##                    rowsum.default                       rowSums
##                             6                             4
##                          sample                    sample.int
##                             5                             6
##                          sapply                          save
```

```
##                          6                         11
##                 save.image                    saveRDS
##                          6                          7
##                      scale              scale.default
##                          4                          4
##                       scan                     search
##                         23                          1
##                 searchpaths                       seek
##                          1                          3
##             seek.connection                        seq
##                          6                          2
##                   seq.Date                seq.default
##                          7                          7
##                    seq.int                 seq.POSIXt
##                          1                          7
##                 seq_along                    seq_len
##                          1                          1
##                   sequence              sequence.default
##                          3                          5
##                  serialize                serverSocket
##                          7                          2
##                   set.seed                    setdiff
##                          5                          4
##                   setequal                    setHook
##                          4                          4
##             setNamespaceInfo          setSessionTimeLimit
##                          4                          3
##                setTimeLimit                      setwd
##                          4                          2
##                      shell                 shell.exec
##                          9                          2
##              showConnections                    shQuote
##                          2                          3
##                       sign               signalCondition
##                          1                          2
##                     signif               simpleCondition
##                          1                          3
##                simpleError                simpleMessage
##                          3                          3
##              simpleWarning                simplify2array
##                          3                          3
##                        sin                      single
##                          1                          2
##                       sinh                        sink
##                          1                          5
##                 sink.number                      sinpi
##                          2                          1
##                slice.index                socketAccept
##                          3                          7
##             socketConnection                socketSelect
##                          9                          4
##               socketTimeout                       solve
##                          3                          4
##               solve.default                    solve.qr
```

```
##                             6                             4
##                          sort                 sort.default
##                             4                             5
##                      sort.int                     sort.list
##                             7                             6
##                   sort.POSIXlt                        source
##                             5                            17
##                         split                split.data.frame
##                             5                             5
##                    split.Date                   split.default
##                             5                             7
##                 split.POSIXct                        split<-
##                             5                             6
##               split<-.data.frame                 split<-.default
##                             6                             6
##                       sprintf                          sqrt
##                             3                             1
##                        sQuote                       srcfile
##                             3                             4
##                   srcfilealias                  srcfilecopy
##                             3                             5
##                        srcref                standardGeneric
##                             3                             1
##                    startsWith                        stderr
##                             3                             1
##                         stdin                        stdout
##                             1                             1
##                          stop                      stopifnot
##                             4                             5
##                  storage.mode                 storage.mode<-
##                             2                             1
##                 str2expression                       str2lang
##                             2                             2
##                      strftime                      strptime
##                             6                             4
##                        strrep                      strsplit
##                             3                             6
##                        strtoi                       strtrim
##                             3                             3
##                     structure                       strwrap
##                             3                             8
##                           sub                        subset
##                             8                             3
##                subset.data.frame                 subset.default
##                             6                             4
##                    subset.matrix                    substitute
##                             6                             1
##                        substr                       substr<-
##                             4                             5
##                     substring                    substring<-
##                             4                             5
##                           sum                       summary
##                             1                             3
##               summary.connection            summary.data.frame
```

```
##                                3                                5
##               Summary.data.frame                  summary.Date
##                                3                                4
##                     Summary.Date                 summary.default
##                                3                                5
##                  Summary.difftime                  summary.factor
##                                3                                4
##                    Summary.factor                  summary.matrix
##                                3                                3
##           Summary.numeric_version                 Summary.ordered
##                                3                                3
##                   summary.POSIXct                 Summary.POSIXct
##                                4                                3
##                   summary.POSIXlt                 Summary.POSIXlt
##                                4                                3
##                 summary.proc_time                 summary.srcfile
##                                3                                3
##                    summary.srcref                   summary.table
##                                4                                3
##                  summary.warnings                suppressMessages
##                                3                                3
##     suppressPackageStartupMessages                suppressWarnings
##                                2                                3
##                 suspendInterrupts                             svd
##                                2                                5
##                             sweep                           switch
##                                7                                1
##                          sys.call                        sys.calls
##                                2                                1
##                         Sys.chmod                         Sys.Date
##                                4                                1
##                         sys.frame                       sys.frames
##                                2                                1
##                      sys.function                        Sys.getenv
##                                2                                4
##                     Sys.getlocale                       Sys.getpid
##                                2                                1
##                          Sys.glob                         Sys.info
##                                3                                1
##                     Sys.junction                   sys.load.image
##                                3                                3
##                    Sys.localeconv                       sys.nframe
##                                1                                1
##                      sys.on.exit                       sys.parent
##                                1                                2
##                      sys.parents                     Sys.readlink
##                                1                                2
##                    sys.save.image                        Sys.setenv
##                                2                                2
##                  Sys.setFileTime                     Sys.setlocale
##                                3                                3
##                         Sys.sleep                       sys.source
##                                2                                7
##                      sys.status                          Sys.time
```

```
##                         1                         1
##          Sys.timezone                 Sys.umask
##                         2                         2
##          Sys.unsetenv                 Sys.which
##                         2                         2
##                system                 system.file
##                        11                         5
##           system.time                 system2
##                         3                        12
##                         t                 t.data.frame
##                         2                         2
##           t.default                 table
##                         2                         6
##           tabulate                 tan
##                         3                         1
##                tanh                 tanpi
##                         1                         1
##               tapply                 taskCallbackManager
##                         7                         4
##           tcrossprod                 tempdir
##                         3                         2
##            tempfile                 textConnection
##                         4                         6
##      textConnectionValue                 tolower
##                         2                         2
##               topenv                 toString
##                         3                         3
##      toString.default                 toupper
##                         4                         2
##                trace                 traceback
##                         9                         3
##             tracemem                 tracingState
##                         1                         2
##           transform                 transform.data.frame
##                         3                         3
##      transform.default                 trigamma
##                         3                         1
##              trimws                 trunc
##                         4                         1
##           trunc.Date                 trunc.POSIXt
##                         3                         4
##           truncate                 truncate.connection
##                         3                         3
##                try                 tryCatch
##                         4                         4
##      tryInvokeRestart                 typeof
##                         3                         2
##            unclass                 undebug
##                         1                         3
##              union                 unique
##                         4                         4
##         unique.array                 unique.data.frame
##                         6                         5
##       unique.default                 unique.matrix
```

```
##                           6                           6
##  unique.numeric_version                  unique.POSIXlt
##                           4                           4
##          unique.warnings                           units
##                           4                           2
##           units.difftime                         units<-
##                           2                           3
##         units<-.difftime                       unix.time
##                           3                           2
##                     unlink                      unlist
##                           5                           4
##          unloadNamespace                    unlockBinding
##                           2                           3
##                     unname                     unserialize
##                           3                           3
##                    unsplit                       untrace
##                           4                           4
##                 untracemem                         unz
##                           1                           5
##                  upper.tri                         url
##                           3                           7
##                  UseMethod                      utf8ToInt
##                           1                           2
##                   validEnc                      validUTF8
##                           2                           2
##                     vapply                      vector
##                           6                           3
##                  Vectorize                     warning
##                           5                           6
##           warningCondition                    warnings
##                           5                           2
##                    weekdays                 weekdays.Date
##                           3                           3
##           weekdays.POSIXt                       which
##                           3                           4
##                  which.max                     which.min
##                           2                           2
##                      while                        with
##                           1                           4
##              with.default                    withAutoprint
##                           4                          10
##         withCallingHandlers                      within
##                           3                           4
##           within.data.frame                   within.list
##                           4                           5
##               withRestarts                     withVisible
##                           3                           2
##                      write                      write.dcf
##                           6                           8
##                   writeBin                     writeChar
##                           6                           6
##                 writeLines                           xor
##                           5                           3
##           xpdrows.data.frame                        xtfrm
```

```
##                                 4                                 1
##                         xtfrm.AsIs                 xtfrm.data.frame
##                                 2                                 2
##                         xtfrm.Date                    xtfrm.default
##                                 2                                 2
##                     xtfrm.difftime                     xtfrm.factor
##                                 2                                 2
##              xtfrm.numeric_version                    xtfrm.POSIXct
##                                 2                                 2
##                      xtfrm.POSIXlt                           xzfile
##                                 2                                 5
##                           zapsmall
##                                 3
```

6.4.4 Dynamic lookup

```
g12 <- function() x + 1
x <- 15
g12()
```

```
## [1] 16
```

```
x <- 20
g12()
```

```
## [1] 21
```

```
codetools::findGlobals(g12)
```

```
## [1] "+" "x"
```

```
environment(g12) <- emptyenv()
g12()
```

```
## Error in x + 1: could not find function "+"
```

6.4.5 Exercises

1. What does the following code return? Why? Describe how each of the three c's is interpreted.

```
c <- 10
c(c = c)
```

```
##  c
## 10
```

Creates a vector with one named element "c" with a value of 10

2. What are the four principles that govern how R looks for values?

Name masking, Functions versus variables, A fresh start, Dynamic lookup

3. What does the following function return? Make a prediction before running the code yourself.

```
f <- function(x) {
  f <- function(x) {
    f <- function() {
      x ^ 2
    }
    f() + 1
  }
  f(x) * 2
}
f(10)
```

```
## [1] 202
```

202

6.5 Lazy evaluation

```
h01 <- function(x) {
  10
}
h01(stop("This is an error!"))
```

```
## [1] 10
```

6.5.1 Promises

```
y <- 10
h02 <- function(x) {
  y <- 100
  x + 1
}

h02(y)
```

```
## [1] 11
```

```
h02(y <- 1000)
```

```
## [1] 1001
```

```
y
```

```
## [1] 1000
```

```
double <- function(x) {
  message("Calculating...")
  x * 2
}

h03 <- function(x) {
  c(x, x)
}

h03(double(20))
```

```
## Calculating...

## [1] 40 40
```

6.5.2 Default arguments

```
h04 <- function(x = 1, y = x * 2, z = a + b) {
  a <- 10
  b <- 100

  c(x, y, z)
}

h04()
```

```
## [1]   1   2 110
```

```
h05 <- function(x = ls()) {
  a <- 1
  x
}

# ls() evaluated inside h05:
h05()
```

```
## [1] "a" "x"
```

```
# ls() evaluated in global environment:
h05(ls())
```

```
##  [1] "a"         "args"      "c"         "deviation" "double"    "f"
##  [7] "f01"       "f02"       "f1"        "f2"        "funs"      "g01"
## [13] "g02"       "g03"       "g04"       "g07"       "g08"       "g09"
## [19] "g10"       "g11"       "g12"       "h01"       "h02"       "h03"
## [25] "h04"       "h05"       "objs"      "out"       "square"    "x"
## [31] "y"
```

6.5.3 Missing arguments

```
h06 <- function(x = 10) {
  list(missing(x), x)
}
str(h06())
```

```
## List of 2
##  $ : logi TRUE
##  $ : num 10
```

```
str(h06(10))
```

```
## List of 2
##  $ : logi FALSE
##  $ : num 10
```

```
args(sample)
```

```
## function (x, size, replace = FALSE, prob = NULL)
## NULL
```

```
sample <- function(x, size = NULL, replace = FALSE, prob = NULL) {
  if (is.null(size)) {
    size <- length(x)
  }

  x[sample.int(length(x), size, replace = replace, prob = prob)]
}
```

```
`%||%` <- function(lhs, rhs) {
  if (!is.null(lhs)) {
    lhs
  } else {
    rhs
  }
}

sample <- function(x, size = NULL, replace = FALSE, prob = NULL) {
  size <- size %||% length(x)
  x[sample.int(length(x), size, replace = replace, prob = prob)]
}
```

6.5.4 Exercises

1. What important property of && makes x_ok() work?

```
x_ok <- function(x) {
  !is.null(x) && length(x) == 1 && x > 0
}

x_ok(NULL)
```

```
## [1] FALSE
```

```
x_ok(1)
```

```
## [1] TRUE
```

```
x_ok(1:3)
```

```
## [1] FALSE
```

Processed from left to right. Prevents error later on by requiring the first tests to work.

```
x_ok <- function(x) {
  !is.null(x) & length(x) == 1 & x > 0
}

x_ok(NULL)
```

```
## logical(0)
```

```
x_ok(1)
```

```
## [1] TRUE
```

```
x_ok(1:3)
```

```
## [1] FALSE FALSE FALSE
```

Runs each logical test, no control flow. Provide values to tests that should not accept them

2. What does this function return? Why? Which principle does it illustrate?

```
f2 <- function(x = z) {
  z <- 100
  x
}
f2()
```

```
## [1] 100
```

100, lazy evaluation

3. What does this function return? Why? Which principle does it illustrate?

```
y <- 10
f1 <- function(x = {y <- 1; 2}, y = 0) {
  c(x, y)
}
f1()
```

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

```
y
```

```
## [1] 10
```

(2, 1), 10. name masking

4. In hist(), the default value of xlim is range(breaks), the default value for breaks is “Sturges”, and

```
range("Sturges")
```

```
## [1] "Sturges" "Sturges"
```

Explain how hist() works to get a correct xlim value.

Sturges is a function called which calculates bins for you

5. Explain why this function works. Why is it confusing?

```
show_time <- function(x = stop("Error!")) {
  stop <- function(...) Sys.time()
  print(x)
}
show_time()
```

```
## [1] "2022-10-10 08:47:40 PDT"
```

The default value for x is run the function stop with the argument “Error!”. Which should stop and prevent an error message. The stop function is then redefined in the function to provide the system time instead. They evaluation is then applied to the value of x. Last x is print given its environmental value which is the system time. It’s confusing because we are masking functions and lazy evaluating calls.

6. How many arguments are required when calling library()?

None