

# Package ‘Formula’

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**Title** Extended Model Formulas

**Description** Infrastructure for extended formulas with multiple parts on the right-hand side and/or multiple responses on the left-hand side (see <[doi:10.18637/jss.v034.i01](https://doi.org/10.18637/jss.v034.i01)>).

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Formula *Extended Formulas: Multiple Responses and Multiple Regressor Parts*

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## Description

The new class Formula extends the base class `formula` by allowing for multiple responses and multiple parts of regressors.

**Usage**

```

Formula(object)

## S3 method for class 'Formula'
formula(x, lhs = NULL, rhs = NULL,
        collapse = FALSE, update = FALSE, drop = TRUE, ...)

as.Formula(x, ...)
is.Formula(object)

```

**Arguments**

object, x	an object. For Formula it needs to be a formula object.
lhs, rhs	indexes specifying which elements of the left- and right-hand side, respectively, should be employed. NULL corresponds to all parts, 0 to none.
collapse	logical. Should multiple parts (if any) be collapsed to a single part (essentially by replacing the   operator by +)? collapse can be a vector of length 2, corresponding for different handling of left- and right-hand side respectively.
update	logical. Only used if all(collapse). Should the resulting formula be updated to remove possibly redundant terms occurring in multiple terms?
drop	logical. Should the Formula class be dropped? If TRUE (the default) a formula is returned, if FALSE the corresponding Formula is returned.
...	further arguments.

**Details**

Formula objects extend the basic formula objects. These extensions include multi-part formulas such as  $y \sim x_1 + x_2 \mid u_1 + u_2 + u_3 \mid v_1 + v_2$ , multiple response formulas  $y_1 + y_2 \sim x_1 + x_2 + x_3$ , multi-part responses such as  $y_1 \mid y_2 + y_3 \sim x$ , and combinations of these.

The Formula creates a Formula object from a formula which can have the | operator on the left-and/or right-hand side (LHS and/or RHS). Essentially, it stores the original formula along with attribute lists containing the decomposed parts for the LHS and RHS, respectively.

The main motivation for providing the Formula class is to be able to conveniently compute model frames and model matrices or extract selected responses based on an extended formula language. This functionality is provided by methods to the generics `model.frame`, and `model.matrix`. For details and examples, see their manual page: [model.frame.Formula](#).

In addition to these workhorses, a few further methods and functions are provided. By default, the `formula()` method switches back to the original formula. Additionally, it allows selection of subsets of the LHS and/or RHS (via `lhs`, and `rhs`) and collapsing multiple parts on the LHS and/or RHS into a single part (via `collapse`).

`is.Formula` checks whether the argument inherits from the Formula class.

`as.Formula` is a generic for coercing to Formula, the default method first coerces to `formula` and then calls `Formula`. The default and `formula` method also take an optional `env` argument, specifying the environment of the resulting Formula. In the latter case, this defaults to the environment of the formula supplied.

Methods to further standard generics `print`, `update`, and `length` are provided for Formula objects. The latter reports the number of parts on the LHS and RHS, respectively.

### Value

Formula returns an object of class Formula which inherits from formula. It is the original formula plus two attributes "lhs" and "rhs" that contain the parts of the decomposed left- and right-hand side, respectively.

### References

Zeileis A, Croissant Y (2010). Extended Model Formulas in R: Multiple Parts and Multiple Responses. *Journal of Statistical Software*, **34**(1), 1–13. doi:10.18637/jss.v034.i01

### See Also

[model.frame.Formula](#)

### Examples

```
## create a simple Formula with one response and two regressor parts
f1 <- y ~ x1 + x2 | z1 + z2 + z3
F1 <- Formula(f1)
class(F1)
length(F1)

## switch back to original formula
formula(F1)

## create formula with various transformations
formula(F1, rhs = 1)
formula(F1, collapse = TRUE)
formula(F1, lhs = 0, rhs = 2)

## put it together from its parts
as.Formula(y ~ x1 + x2, ~ z1 + z2 + z3)

## update the formula
update(F1, . ~ . + I(x1^2) | . - z2 - z3)
update(F1, . | y2 + y3 ~ .)

# create a multi-response multi-part formula
f2 <- y1 | y2 + y3 ~ x1 + I(x2^2) | 0 + log(x1) | x3 / x4
F2 <- Formula(f2)
length(F2)

## obtain various subsets using standard indexing
## no lhs, first/second rhs
formula(F2, lhs = 0, rhs = 1:2)
formula(F2, lhs = 0, rhs = -3)
formula(F2, lhs = 0, rhs = c(TRUE, TRUE, FALSE))
## first lhs, third rhs
```

```
formula(F2, lhs = c(TRUE, FALSE), rhs = 3)
```

---

model.frame.Formula    *Model Frame/Matrix/Response Construction for Extended Formulas*

---

## Description

Computation of model frames, model matrices, and model responses for extended formulas of class Formula.

## Usage

```
## S3 method for class 'Formula'
model.frame(formula, data = NULL, ...,
  lhs = NULL, rhs = NULL, dot = "separate")
## S3 method for class 'Formula'
model.matrix(object, data = environment(object), ...,
  lhs = NULL, rhs = 1, dot = "separate")
## S3 method for class 'Formula'
terms(x, ...,
  lhs = NULL, rhs = NULL, dot = "separate")

model.part(object, ...)
## S3 method for class 'Formula'
model.part(object, data, lhs = 0, rhs = 0,
  drop = FALSE, terms = FALSE, dot = NULL, ...)
```

## Arguments

formula, object, x	an object of class Formula.
data	a data.frame, list or environment containing the variables in formula. For model.part it needs to be the model.frame.
lhs, rhs	indexes specifying which elements of the left- and right-hand side, respectively, should be employed. NULL corresponds to all parts, 0 to none. At least one lhs or one rhs has to be specified.
dot	character specifying how to process formula parts with a dot (.) on the right-hand side. This can be: "separate" so that each formula part is expanded separately. "sequential" so that the parts are expanded sequentially conditional on all prior parts. "previous" so the part is expanded to the previous part.
drop	logical. Should the data.frame be dropped for single column data frames?
terms	logical. Should the "terms" attribute (corresponding to the model.part extracted) be added?
...	further arguments passed to the respective formula methods.

## Details

All three model computations leverage the corresponding standard methods. Additionally, they allow specification of the part(s) of the left- and right-hand side (LHS and RHS) that should be included in the computation.

The idea underlying all three model computations is to extract a suitable formula from the more general Formula and then calling the standard `model.frame`, `model.matrix`, and `terms` methods.

More specifically, if the Formula has multiple parts on the RHS, they are collapsed, essentially replacing `|` by `+`. If there is only a single response on the LHS, then it is kept on the LHS. Otherwise all parts of the formula are collapsed on the RHS (because formula objects can not have multiple responses). Hence, for multi-response Formula objects, the (non-generic) `model.response` does not give the correct results. To avoid confusion a new generic `model.part` with suitable formula method is provided which can always be used instead of `model.response`. Note, however, that it has a different syntax: It requires the Formula object in addition to the readily processed `model.frame` supplied in `data` (and optionally the `lhs`). Also, it returns either a `data.frame` with multiple columns or a single column (dropping the `data.frame` property) depending on whether multiple responses are employed or not.

If the the formula contains one or more dots (`.`), some care has to be taken to process these correctly, especially if the LHS contains transformations (such as `log`, `sqrt`, `cbind`, `Surv`, etc.). Calling the `terms` method with the original data (untransformed, if any) resolves all dots (by default separately for each part, otherwise sequentially) and also includes the original and updated formula as part of the terms. When calling `model.part` either the original untransformed data should be provided along with a dot specification or the transformed `model.frame` from the same formula without another dot specification (in which case the dot is inferred from the terms of the `model.frame`).

## References

Zeileis A, Croissant Y (2010). Extended Model Formulas in R: Multiple Parts and Multiple Responses. *Journal of Statistical Software*, **34**(1), 1–13. doi:10.18637/jss.v034.i01

## See Also

[Formula](#), [model.frame](#), [model.matrix](#), [terms](#), [model.response](#)

## Examples

```
## artificial example data
set.seed(1090)
dat <- as.data.frame(matrix(round(runif(21), digits = 2), ncol = 7))
colnames(dat) <- c("y1", "y2", "y3", "x1", "x2", "x3", "x4")
for(i in c(2, 6:7)) dat[[i]] <- factor(dat[[i]] > 0.5, labels = c("a", "b"))
dat$y2[1] <- NA
dat

#####
## single response and two-part RHS ##
#####

## single response with two-part RHS
F1 <- Formula(log(y1) ~ x1 + x2 | I(x1^2))
```

```

length(F1)

## set up model frame
mf1 <- model.frame(F1, data = dat)
mf1

## extract single response
model.part(F1, data = mf1, lhs = 1, drop = TRUE)
model.response(mf1)
## model.response() works as usual

## extract model matrices
model.matrix(F1, data = mf1, rhs = 1)
model.matrix(F1, data = mf1, rhs = 2)

#####
## multiple responses and multiple RHS ##
#####

## set up Formula
F2 <- Formula(y1 + y2 | log(y3) ~ x1 + I(x2^2) | 0 + log(x1) | x3 / x4)
length(F2)

## set up full model frame
mf2 <- model.frame(F2, data = dat)
mf2

## extract responses
model.part(F2, data = mf2, lhs = 1)
model.part(F2, data = mf2, lhs = 2)
## model.response(mf2) does not give correct results!

## extract model matrices
model.matrix(F2, data = mf2, rhs = 1)
model.matrix(F2, data = mf2, rhs = 2)
model.matrix(F2, data = mf2, rhs = 3)

#####
## Formulas with '.' ##
#####

## set up Formula with a single '.'
F3 <- Formula(y1 | y2 ~ .)
mf3 <- model.frame(F3, data = dat)
## without y1 or y2
model.matrix(F3, data = mf3)
## without y1 but with y2
model.matrix(F3, data = mf3, lhs = 1)
## without y2 but with y1
model.matrix(F3, data = mf3, lhs = 2)

## set up Formula with multiple '.'
F3 <- Formula(y1 | y2 | log(y3) ~ . - x3 - x4 | .)

```

```
## process both '.' separately (default)
mf3 <- model.frame(F3, data = dat, dot = "separate")
## only x1-x2
model.part(F3, data = mf3, rhs = 1)
## all x1-x4
model.part(F3, data = mf3, rhs = 2)

## process the '.' sequentially, i.e., the second RHS conditional on the first
mf3 <- model.frame(F3, data = dat, dot = "sequential")
## only x1-x2
model.part(F3, data = mf3, rhs = 1)
## only x3-x4
model.part(F3, data = mf3, rhs = 2)

## process the second '.' using the previous RHS element
mf3 <- model.frame(F3, data = dat, dot = "previous")
## only x1-x2
model.part(F3, data = mf3, rhs = 1)
## x1-x2 again
model.part(F3, data = mf3, rhs = 2)

#####
## Process multiple offsets ##
#####

## set up Formula
F4 <- Formula(y1 ~ x3 + offset(x1) | x4 + offset(log(x2)))
mf4 <- model.frame(F4, data = dat)
## model.part can be applied as above and includes offset!
model.part(F4, data = mf4, rhs = 1)
## additionally, the corresponding corresponding terms can be included
model.part(F4, data = mf4, rhs = 1, terms = TRUE)
## hence model.offset() can be applied to extract offsets
model.offset(model.part(F4, data = mf4, rhs = 1, terms = TRUE))
model.offset(model.part(F4, data = mf4, rhs = 2, terms = TRUE))
```

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