Package 'PolynomF'

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Type Package

Title Polynomials in R

Description Implements univariate polynomial operations in R, including polynomial arithmetic, finding zeros, plotting, and some operations on lists of polynomials.

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Imports stats, Rcpp, methods

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R topics documented:

`as.character.polynom` *Polynomial coercion to character*

Description

Produce a text representation of a polynomial object

Usage

```
## S3 method for class 'polynom'
as.character(x, variable = "x", decreasing = FALSE, ...)
```

Arguments

`x`	The polynomial object in question
`variable`	Character string: what variable name should be used?
`decreasing`	Logical: in decreasing powers or increasing powers?
`...`	Additional arguments (ignored as yet)

Value

A character string representation of the polynomial

Examples

```
p <- poly_from_zeros(-2:3)
as.character(p, "z", FALSE)
as.character(p, "z", TRUE)
parse(text = as.character(p, "z", TRUE))[[1]]
```

`as.function.polynom` *Coercion to function*

Description

PolynomF objects ARE functions, but this coercion method creates from a polynomial object a pure function with the coefficients fully exposed in the code and which evaluates the polynomial more efficiently.

Usage

```
## S3 method for class 'polynom'
as.function(x, variable = "x", ...)

## S3 method for class 'polylist'
as.function(x, ...)
```

Arguments

`x`	A polynomial object
`variable`	Character string: what variable name should be used?
`...`	Additional arguments

Value

An explicit R function evaluating the polynomial

Examples

```
p <- poly_from_zeros(-2:3)
p
as.function(p)
```

c.polynom *Concatenation of polynomial objects into lists*

Description

Concatenation of polynomial objects into lists

Usage

```
## S3 method for class 'polynom'
c(..., recursive = FALSE)

## S3 method for class 'polylist'
c(..., recursive = FALSE)
```

Arguments

...	Polynomial or polylist objects
recursive	Logical, should the concatenation flatten all component lists?

Value

A polylist object with all argumets included

change_origin *Change origin of a polynomial*

Description

Given a polynomial P(x) and a new origin o, find the polynomial Q(x) = P(x + o). I.e. Q(0) = P(o)

Usage

```
change_origin(p, o, ...)

## Default S3 method:
change_origin(p, o, ...)

## S3 method for class 'polynom'
change_origin(p, o, ...)

## S3 method for class 'polylist'
change_origin(p, o, ...)
```

Arguments

p	A polynom or polylist object
o	A single numeric quantity specifying the new x-origin
...	currently not used

Value

A polynom or polylist object with x measured from the new origin

---

coef.polynom *Polynomial coefficients*

Description

Extract polynomial coefficients

Usage

```
## S3 method for class 'polynom'
coef(object, ...)

## S3 method for class 'polylist'
coef(object, ...)
```

Arguments

object	A polynomial object or list thereof
...	Ignored

Value

A numeric vector of coefficients

Examples

```
p <- polynomial(1:3)*polynomial(5:1)
coef(p)
```

deriv.polynom *Polynomial Calculus*

Description

Find the derivative or indefinite integral of a polynomial object, or list thereof.

Usage

```
## S3 method for class 'polynom'
deriv(expr, ...)

integral(expr, ...)

## Default S3 method:
integral(expr, ...)

## S3 method for class 'polynom'
integral(expr, limits = NULL, ...)

## S3 method for class 'polylist'
deriv(expr, ...)

## S3 method for class 'polylist'
integral(expr, ...)
```

Arguments

expr	A polynomial object, or list thereof
...	Unused as yet
limits	Real limits of a definite integral

Value

A coeffieient vector, or list thereof

Examples

```
p <- poly_from_roots(-2:3)
p
deriv(p)
integral(p)
```

GCD *Greatest common divisor*

Description

Find a monic polynomial of maximal degree that divides each of a set of polynomials exactly

Usage

```
GCD(...)

greatest_common_divisor(...)

## S3 method for class 'polynom'
GCD(...)

## S3 method for class 'polylist'
GCD(...)
```

Arguments

...	A list of polynomials or polylist objects

Value

A polynomial giving the greatest common divisor, as defined above

Examples

```
p <- poly_calc(0:5)
r <- poly_calc(1:6)
greatest_common_divisor(p, r)
solve(greatest_common_divisor(p, r))
lowest_common_multiple(p, r)
solve(lowest_common_multiple(p, r))
```

GroupGenerics *Summary and Math methods for polynomials*

Description

These provide methods for the generic function Summary and Math for polynomial and polylist objects. For Summary only sum and prod members are implemented

Usage

```
## S3 method for class 'polynom'
Summary(..., na.rm = FALSE)

## S3 method for class 'polylist'
Summary(..., na.rm = FALSE)

## S3 method for class 'polynom'
Math(x, ...)

## S3 method for class 'polylist'
Math(x, ...)
```

Arguments

...	Additional arguments
na.rm	Logical: should missing values be removed?
x	a "polynom" or "polylist" objects.

Value

The result of the group generic operation

Examples

```
lis <- as_polylist(lapply(-2:3, function(x) polynomial() - x))
prod(lis)
sum(lis)
solve(prod(lis))
solve(sum(lis))
```

LCM *Lowest Common Multiple*

Description

For a list of polynomials, find the lowest degree monic polynomial into which each divides exactly

Usage

```
LCM(...)

lowest_common_multiple(...)

## S3 method for class 'polynom'
LCM(...)

## S3 method for class 'polylist'
LCM(...)
```

Arguments

...	A list of polynomials or polylist objects

Value

A polynomial giving the lowest common multiple

Examples

```
p <- poly_calc(0:5)
r <- poly_calc(1:6)
greatest_common_divisor(p, r)
solve(greatest_common_divisor(p, r))
lowest_common_multiple(p, r)
solve(lowest_common_multiple(p, r))
```

---

neville *Lagrange Interpolation Polynomials*

Description

Compute the Lagrange Interpolation Polynomial from a given set of x- and y-values, or, alterntively, compute the interpolated values at a set of given x-values. Two algorithms are provided, namely Neville's algorithm, or a more direct version based on the usual Lagrange formula. The latter is generally faster but the former can be more accurate numerically.

Usage

```
neville(x, y, x0 = polynomial())

lagrange(x, y, x0 = polynomial())
```

Arguments

x	A numeric vector of x-values
y	A numeric values of y-values corresponding to the x-values
x0	Either a polynomial object or a vector of x-values for which interpolated y-values are required.

Value

Either an interpolation polynomial object or a vector of interpolated y-values

Examples

```
set.seed(123)
x <- 1:5
y <- rnorm(x)
xout <- 0.5 + 1:4

p1 <- neville(x, y)
plot(p1, xlim = range(x), ylim = extendrange(y, f = 1), panel.first = grid())
points(x, y, col = 4)
points(xout, lagrange(x, y, xout), col = 2)
```

Ops.polynom *Polynomial arithmetic*

Description

Group generic function to implement arithmetic operations on polynomial objects

Usage

```
## S3 method for class 'polynom'
Ops(e1, e2)

## S3 method for class 'polylist'
Ops(e1, e2)
```

Arguments

e1, e2	A numeric vector of a polynomial object. At least one of e1 or e2 must be an object of class "polynom" or "polylist".

Value

A polynomial or polylist object representing the result of the operation.

Examples

```
x <- polynomial()
(p <- (x-1)^5 - 1)
(p1 <- (p + 1)/(x - 1)^2 - 1)
for(i in 0:10) cat(coef((x+1)^i), "\n")
```

plot.polylist *Plot method for polynomials*

Description

Plot methods for polynom or polylist objects

Usage

```
## S3 method for class 'polylist'
plot(
  x,
  xlim = 0:1,
  ylim = range(Px),
  type = "l",
  xlab = "x",
  ylab = "P(x)",
  ...,
  col = seq_along(x),
  lty = if (length(col) == 1) seq_along(x) else "solid",
  len = 1000,
  legend = FALSE
)

## S3 method for class 'polynom'
plot(
  x,
  xlim = 0:1,
  ylim = range(Px),
  type = "l",
  xlab = "x",
  ylab = "p(x)",
  ...,
  len = 1000,
  limits = pu[1:2]
)

## S3 method for class 'polynom'
lines(x, ..., len = 1000, limits = pu[1:2])

## S3 method for class 'polynom'
points(x, ..., len = 100, limits = pu[1:2])

## S3 method for class 'polylist'
lines(
  x,
  ...,
```

```
  len = 1000,
  limits = pu[1:2],
  col = seq_along(x),
  lty = if (length(col) == 1) seq_along(x) else "solid"
)

## S3 method for class 'polylist'
points(x, ..., len = 100)
```

Arguments

x	A polynom or polylist object to be plotted
xlim, ylim	as for graphics::plot
type	as for graphics::plot
xlab, ylab	as for graphics::plot
...	additional arguments passed on to methods
col, lty	Colour(s) and line type(s) as for graphics::plot
len	positive integer defining the point or curve resolution
legend	logical: for "polylist" objects, should a legend be drawn alongside the main plot?
limits	x-limits for the polynomial, default: the entire plot. For polylist objects this may be a two column matrix.

Value

Nothing of interest, invisibly

Examples

```
p <- poly_from_zeros((-3):4)
plot(p)
lines(deriv(p), col = "red")
```

---

polynom *Polynomial construction*

Description

Functions to construct polynomial objects and check class membership

Usage

```
polynom(a = c(0, 1), ..., eps = 0)

polynomial(a = c(0, 1), ..., eps = 0)

as_polynom(a)

is_polynom(a)

polylist(...)

is_polylist(x)

as_polylist(x)
```

Arguments

a	A polynom object, or a numeric vector of coefficients (in "power series" order) or a vector object which can be coerced to one.
...	Additional arguments, currently ignored.
eps	A small non-negative tolerance to check for zero components.
x	An object of class "polylist", at least potentially.

Value

A polynomial object.

Examples

```
(s <- polynomial())
(p <- polynomial(c(1, 5, 4, 1)/11))
oldPar <- par(mar = c(5,5,2,2)+0.1)
plot(p, xlim = 0:1, ylim = 0:1, type = "n", bty="n",
     xlab = "s", ylab = expression({P^(n)}(s)))
lines(s, limits = 0:1)
P <- p
for(j in 1:7) {
  lines(P, col = j+1, limits = 0:1)
  P <- p(P)
}
lines(P, limits = 0:1, col = 9)
(r <- Re(solve((p-s)/(1-s))))
arrows(r, p(r), r, par("usr")[3], lwd = 0.5,
       length = 0.125, angle = 15)
text(r, 0.025, paste("r =", format(r, digits = 3)))
leg <- sapply(0:8, function(x) bquote({P^(.(x))}(s)))
legend("topleft", legend = as.expression(leg),
       lty = "solid", col = 1:9, bty = "n", ncol=3)
par(oldPar)
rm(leg, oldPar, p, P, r, s, j)
```

poly_calc *Lagrange interpolation polynomial*

Description

Calculate the Lagrange interpolation polynomial, or list of polynomials, given a set of (x, y) points to fit

Usage

```
poly_calc(x, y, tol = sqrt(.Machine$double.eps), lab = dimnames(y)[[2]])

poly_from_zeros(...)

poly_from_roots(...)

poly_from_roots(...)

poly_from_values(x, y, tol = sqrt(.Machine$double.eps), lab = dimnames(y)[[2]])
```

Arguments

x	A numeric vector of x-points at which the y-values are specified.
y	Either a numeric vector of the same length as x or a numeric matrix with rows matching the length of x. If y is missing (not specified) then a polynomial with zero at x is returned.
tol	A numeric tolerance for duplicated x values.
lab	A character string vector of names for the list result when y is a matrix.
...	A list of specified zeros (for subsidiary functions)

Value

An interpolation polynomial, or list of interpolating polynomials.

Examples

```
(p <- poly_calc(0:5)) ## same as poly_from_zeros(0:5)
(p <- poly_calc(0:5, exp(0:5)))
plot(p)
curve(exp, add = TRUE, col = "red")
```

poly_orth *Simpl orthogonal polynomials*

Description

Generate a list of polynomials up to a specified degree, orthogonal with respect to the natural inner product on a discrete, finite set of x-values with equal weights.

Usage

```
poly_orth(x, degree = length(unique(x)) - 1, norm = TRUE)
```

Arguments

x	A numeric vector
degree	The desired maximum degree
norm	Logical: should polynomials be normalised to length one?

Value

A list of orthogonal polynomials as a polylist object

Examples

```
x <- c(0:3, 5)
P <- poly_orth(x)
plot(P, lty = "solid")
Pf <- as.function(P)
zap(crossprod(Pf(x)))
```

poly_orth_general *General Orthogonal Polynomials*

Description

Generate sets of polynomials orthogonal with respect to a general inner product. The inner product is specified by an R function of (at least) two polynomial arguments.

Usage

```
poly_orth_general(inner_product, degree, norm = FALSE, ...)

Hermite(p, q = p)

Legendre(p, q = p)

ChebyshevT(p, q = p)

ChebyshevU(p, q = p)

Jacobi(p, q = p, alpha = -0.5, beta = alpha)

Discrete(p, q = p, x, w = function(x, ...) 1, ...)
```

Arguments

inner_product	An R function of two "polynom" arguments with the second polynomial having a default value equal to the first. Additional arguments may be specified. See examples
degree	A non-negative integer specifying the maximum degree
norm	Logical: should the polynomials be normalized?
...	additional arguments passed on to the inner product function
p, q	Polynomials
alpha, beta	Family parameters for the Jacobi polynomials
x	numeric vector defining discrete orthogonal polynomials
w	a weight function for discrete orthogonal polynomials

Details

Discrete orthogonal polynomials, equally or unequally weighted, are included as special cases. See the Discrete inner product function.

Computations are done using the recurrence relation with computed coefficients. If the algebraic expressions for these recurrence relation coefficients are known the computation can be made much more efficient.

Value

A "polylist" object containing the orthogonal set

Examples

```
(P0 <- poly_orth(0:5, norm = FALSE))
(P1 <- poly_orth_general(Discrete, degree = 5, x = 0:5, norm = FALSE))
sapply(P0-P1, function(x) max(abs(coef(x))))  ## visual check for equality
(P0 <- poly_orth_general(Legendre, 5))
   ### should be same as P0, up to roundoff
```

```
(P1 <- poly_orth_general(Jacobi, 5, alpha = 0, beta = 0))
                ### check
sapply(P0-P1, function(x) max(abs(coef(x))))
```

`predict.polynom` *Evaluate a polynomial*

Description

Evaluate a polynomial, or polylist object components.

Usage

```
## S3 method for class 'polynom'
predict(object, newdata, ...)

## S3 method for class 'polylist'
predict(object, newdata, ...)
```

Arguments

`object`	A polynomial or polylist object
`newdata`	A target object at which to evaluate.
`...`	Not used

Value

If `newdata` is a numeric vector, a numeric vector of results. If `newdata` is a polynomial, then the composition is returned as a polynomial, or polylist object.

`print.polylist` *Print method for polynomial objects*

Description

Print method for polynomial objects

Usage

```
## S3 method for class 'polylist'
print(x, ...)
```

Arguments

`x`	A polynomial object or list thereof
`...`	Additional arguments passed on to methods

Value

The original object, invisibly.

`print.polynom` *Print method for polynomial objects*

Description

Standard method for printing polynomial objects

Usage

```
## S3 method for class 'polynom'
print(x, variable = "x", digits = getOption("digits"), decreasing = FALSE, ...)
```

Arguments

`x`	A polynomial object
`variable`	Character string: what variable name should be given?
`digits`	Integer: how many decimal degits to use?
`decreasing`	Logical: in descending powers, or ascending?
`...`	Additional arguments

Value

The original object `x`, invisibly

`rep.polylist` *Component repition*

Description

Repeat components of a polylist object

Usage

```
## S3 method for class 'polylist'
rep(x, times, ...)

## S3 method for class 'polynom'
rep(x, times, ...)
```

Arguments

x	A single polynom or polylist object
times, ...	As for the base package function rep.

Value

The resulting polylist object.

---

solve.polynom *Find Polynomial Zeros*

Description

Solve polynomial equations, a(x) = b(x), or alternatively find the zeros of the polynomial a(x) - b(x)

Usage

```
## S3 method for class 'polynom'
solve(a, b, ...)

## S3 method for class 'polylist'
solve(a, b, ...)
```

Arguments

a, b	Polynomials for the LHS and RHS respectively
...	Currently unused

Value

A vector of roots, usually complex

Examples

```
p <- poly_calc(0:5)
solve(p)
solve(p, 1)
```

summary.polynom *Polynomial summary*

Description

Provide a succinct summary of the critical points of a polynomial, or list thereof

Usage

```
## S3 method for class 'polynom'
summary(object, ...)

## S3 method for class 'polylist'
summary(object, ...)

## S3 method for class 'summary.polynom'
print(x, ...)
```

Arguments

object, x	A polynomial or polylist object
...	Currently unused

Value

A list giving the zeros, stationary points and points of inflexion of the polynomial(s)

Examples

```
p <- poly_calc(0:5)
summary(p)
```

tangent *Tangent lines*

Description

Find the tangent line to a polynomial at one or more x-points

Usage

```
tangent(p, x0)
```

Arguments

p	A polynomial object
x0	A numeric vector of values at which the tangent line(s) are required

Value

A linear polynomial giving the tangent line, or a list of such polynomials

Examples

```
p <- poly_from_zeros(c(0, 0:5, 4))
plot(p, xlab = expression(italic(x)), ylab = expression(italic(P(x))),
  main = parse(text = paste("italic(P(x) ==",
                            as.character(p, decreasing = TRUE),")")))
x0 <- solve(deriv(p))        ## stationary points
lines(tangent(p, x0), col = "dark green", lty = "solid",
      limits = cbind(x0-1/4, x0+1/4))
points(x0, p(x0), col = "dark green")

x0 <- solve(deriv(deriv(p))) ## points of inflexion
lines(tangent(p, x0), col = "red", lty = "solid", lwd = 2,
      limits = cbind(x0-1/4, x0+1/4))
points(x0, p(x0), col = "red")
legend("bottomleft", c("Stationary points", "Points of inflexion"),
       pch = 19, col = c("dark green", "red"), lty = "solid",
       cex = 0.7, bg = "beige", box.lwd = 0.25)
```

---

unique.polylist *Unique components*

Description

Remove duplicated polynomials in a polylist object

Usage

```
## S3 method for class 'polylist'
unique(x, incomparables = FALSE, ...)
```

Arguments

x	A polylist object
incomparables	Logical: as for the base function unique
...	As for the base function unique

Value

A polylist object with no duplicated components

zap *Remove minuscule coefficients*

Description

A convenience function for setting polynomial coefficients likely to be entirely round-off error to zero. The decision is relegated to the function `base::zapsmall`, to which this is a front-end.

Usage

```
zap(x, digits = getOption("digits"))

## Default S3 method:
zap(x, digits = getOption("digits"))

## S3 method for class 'polynom'
zap(x, digits = getOption("digits"))

## S3 method for class 'polylist'
zap(x, digits = getOption("digits"))

## S3 method for class 'list'
zap(x, digits = getOption("digits"))
```

Arguments

`x`	A polynomial or polylist object
`digits`	As for `base::zapsmall`

Value

A polynomial or polylist object with minuscule coefficients set to zero.

Examples

```
(P <- poly_orth(-2:2, norm = FALSE))
zap(35*P)
```

`[.polylist` *Extract components of a list of polynomials*

Description

Extract components of a list of polynomials

Usage

```
## S3 method for class 'polylist'
x[i]
```

Arguments

`x`	A polylist object
`i`	An index vector of any crongruent form

Value

A polylist object of the components

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