

Third-party maxima software

John Lapeyre

December 16, 2012

Contents

1 Array Representation For Expressions

Maxima expressions are normally implemented internally as lisp lists, but they may also be represented by lisp arrays. Each representation has advantages.

2 Attributes

A function may possess a list of attributes. The attributes control how the arguments to the function are evaluated and how errors are handled.

- `attributes`
- `set_match_form`
- `set_nowarn`
- `unset_match_form`
- `unset_nowarn`

2.1 Function: `attributes`

`attributes`(*name*)

Description Returns a list of the ‘attributes’ of function *name*.

Arguments `attributes` requires one argument *name*, which must be a string or a symbol.

See also `unset_match_form`, `set_match_form`, `set_nowarn`, and `unset_nowarn`.

2.2 Function: `set_match_form`

`set_match_form`(*names*)

Description Set the ‘match_form’ attribute for function(s) *names*. If the argument checks for a function call fail, and the attribute ‘match_form’ is set, then rather than signaling an error, the unevaluated form is returned. Furthermore, if the attribute ‘nowarn’ is not set, then a warning message is printed.

Arguments `set_match_form` requires one argument *names*, which must be a string, a symbol, or a list of strings or symbols.

See also `unset_match_form`, `set_nowarn`, `unset_nowarn`, and `attributes`.

2.3 Function: `set_nowarn`

`set_nowarn(names)`

Description Set the ‘nowarn’ attribute for function(s) *names*. If the argument checks for a function call fail, and the attribute ‘match_form’ is set, and the attribute ‘nowarn’ is set, then rather than signaling an error, the unevaluated form is returned and no warning message is printed.

Arguments `set_nowarn` requires one argument *names*, which must be a string, a symbol, or a list of strings or symbols.

See also `unset_match_form`, `set_match_form`, `unset_nowarn`, and `attributes`.

2.4 Function: `unset_match_form`

`unset_match_form(names)`

Description Unset the ‘match_form’ attribute for function(s) *names*. If the argument checks for a function call fail, and the attribute ‘match_form’ is set, then rather than signaling an error, the unevaluated form is returned. Furthermore, if the attribute ‘nowarn’ is not set, then a warning message is printed.

Arguments `unset_match_form` requires one argument *names*, which must be a string, a symbol, or a list of strings or symbols.

See also `set_match_form`, `set_nowarn`, `unset_nowarn`, and `attributes`.

2.5 Function: `unset_nowarn`

`unset_nowarn(names)`

Description Unset the ‘nowarn’ attribute for function(s) *names*. If the argument checks for a function call fail, and the attribute ‘match_form’ is set, and the attribute ‘nowarn’ is set, then rather than signaling an error, the unevaluated form is returned and no warning message is printed.

Arguments `unset_nowarn` requires one argument *names*, which must be a string, a symbol, or a list of strings or symbols.

See also `unset_match_form`, `set_match_form`, `set_nowarn`, and `attributes`.

3 Functions and Variables for Array Representation for Expressions

These functions operate on the the array expression data structure.

- `aeop`
- `aex`
- `aex_cp`
- `aex_get`
- `aex_new`
- `aex_set`
- `aex_shift`
- `aex.unshift`

- `aexg`
- `aexs`
- `copy_aex_type`
- `iapply`
- `ilength`
- `ipart`
- `ipart_set`
- `ireverse`
- `lex`

3.1 Function: `aeop`

`aeop(expr)`
 next package: `aex`

Description `op` function for `aex`. returns `op` if e is not an `aex`.

Arguments `aeop` requires one argument $expr$, which must be non-atomic.

3.2 Function: `aex`

`aex(:optional x)`
 next package: `aex`

Calling

`aex(e)` Converts expression e to an array representation. The input expression e is returned unchanged if it is already an array expression or is a symbol or number or specially represented maxima expression. This function converts only at the first level.

Arguments `aex` requires either zero or one arguments.

Options `aex` takes options with default values: `adj->true`.

3.3 Function: `aex_cp`

`aex_cp(e :optional $head$)`
 next package: `aex`

Calling

`aex_cp(e)` Returns an `aex` form copy of e . e may be in either `lex` or `aex` form. Conversion to `aex` representation occurs only on the first level.

Arguments `aex_cp` requires either one or two arguments. The first argument e must be non-atomic.

Options `aex_cp` takes options with default values: `adj->true`.

3.4 Function: aex_get

Description Returns the n th part of aexpr e . A value of 0 for n is not allowed. This is more efficient than `aexg`, which allows n equal to zero.

Examples

```
(%i1) a : aex([5,6,7]), aex_get(a,2);  
(%o1) 7
```

3.5 Function: aex_new

`aex_new(n : optional head)`

next package: aex

Arguments `aex_new` requires either one or two arguments. The first argument n must be a non-negative integer.

3.6 Function: aex_set

Description Destructively sets the n th part of aexpr e to value v . A value of 0 for n is not allowed. This is more efficient than `aexs`. No argument checking is done.

Examples

Destructively assign to a part of an expression.

```
(%i1) a : aex([1,2,3]), aex_set(a,1,x), a;  
(%o1) <[1,x,3]>
```

See also `aexs` and `ipart`.

3.7 Function: aex_shift

`aex_shift(e)`

next package: aex

Description destructively removes an element from the end of e . For array representation of expressions we use the words ‘push’ and ‘pop’ for the beginning of and expression, and ‘shift’ and ‘unshift’ for the end of an expression, whether the representation is an array or a list. This is consistent with maxima, but the reverse of the meaning of the terms in perl.

Arguments `aex_shift` requires one argument e , which must be an adjustable array expression.

Examples

```
(%i1) a : lrange(10,0t->ar);  
(%o1) <[1,2,3,4,5,6,7,8,9,10]>  
(%i1) b : aex_shift(a);  
(%o1) 10  
(%i2) a;  
(%o2) <[1,2,3,4,5,6,7,8,9]>
```

3.8 Function: aex_unshift

aex_unshift(*v*, *e*)
next package: aex

Description Destructively pushes an element *v* onto the end of *e*. The return value is *v*. For array representation of expressions we use the words ‘push’ and ‘pop’ for the beginning of and expression, and ‘shift’ and ‘unshift’ for the end of an expression, whether the representation is an array or a list. This is consistent with maxima, but the reverse of the meaning of the terms in perl.

Arguments **aex_unshift** requires two arguments. The second argument *e* must be an adjustable array expression.

Examples

```
(%i1) a : lrange(10,ot->ar), aex_unshift("dog",a), a;  
(%o1) <[1,2,3,4,5,6,7,8,9,10,"dog"]>
```

3.9 Function: aexg

Description **aexg**(*e*,*n*) returns the *n*th part of aexpr *e*. If *n* is 0, the head of *e* is returned. No argument checking is performed.

See also **aex_get**, **ipart**, **inpart**, and **part**.

3.10 Function: aexs

Description destructively sets the *n*th part of aexpr *e* to value *v*. A value of 0 for *n* returns the head (or op) of *e*.

3.11 Function: copy_aex_type

copy_aex_type(*ein*)
next package: aex

Description Create a new aex with same head,length,adjustability,etc. but contents of expression are not copied.

Arguments **copy_aex_type** requires one argument *ein*, which must be an array-representation expression.

3.12 Function: iapply

iapply(*fun*, *arg*)
next package: aex

Description **iapply** is like maxima **apply**, but it supports aex lists. *arg* is converted to an ml if it is an aex expression. By default, output is ml regardless of the input representation.

Arguments **iapply** requires two arguments. The first argument *fun* must be a function. The second argument *arg* must be non-atomic.

Options **iapply** takes options with default values: **adj->true**, **ot->ml**.

Examples

```
(%i1) iapply(%ff,lrange(4));
(%o1) %ff(1,2,3,4)
```

```
(%i1) iapply(%ff,lrange(4,[ot->ar]));
(%o1) %ff(1,2,3,4)
```

```
(%i1) iapply(%ff,lrange(4,[ot->ar]), [ot->ar] );
(%o1) %ff<1,2,3,4>
```

```
(%i1) iapply(%ff,lrange(4), [ot->ar] );
(%o1) %ff<1,2,3,4>
```

3.13 Function: ilength

ilength(*e*)

next package: aex

Description Returns the length of the expression *e*. This is like maxima **length**, but here, *e* can be either an aex or a lex.

Arguments **ilength** requires one argument *e*, which must be a subscripted variable or non-atomic.

3.14 Function: ipart

Calling

ipart(*e, ind1, ind2, ...*) Returns the part of expression *e* specified by indices. *e* may be a mixed (lex and aex) representation expression. When used as an lvalue, ipart can be used to assign to a part of an expression. If an index is negative, then it counts from the end of the list. If *e* is an ordinary maxima list (lex), then using a negative index is potentially slower than using a positive index because the entire list must first be traversed in order to determine it's length. If *e* is in aex representation, then this inefficiency is not present.

Examples

Destructively assign to a part of an expression.

```
(%i1) (a : [1,2,3], ipart(a,1) : 7, a);
(%o1) [7,2,3]
```

Implementation Some tests were performed with large lists of numbers. If we set **a:lrange(10⁷)**, then the times required for **ipart(a,10⁷)**, **ipart(a,-1)**, **ipart(a,10⁷)**, and **part(a,10⁷)** were 30, 60, 90, and 90 ms.

3.15 Function: ipart_set

Calling

ipart_set(*e, val, ind1, ind2, ...*) Set part of *e* specified by the final arguments to *val*. *e* is a mixed representation expression.

3.16 Function: ireverse

ireverse(*e*)

next package: aex

Description ireverse is like maxima reverse, but it works on both aex and list objects. ireverse tries to be identical to maxima reverse for a non-aex argument.

Arguments ireverse requires one argument *e*, which must be non-atomic.

Options ireverse takes options with default values: `adj->true`, `ot->ml`.

Examples

```
(%i1) ireverse(lrange(4));  
(%o1) [4,3,2,1]
```

```
(%i1) ireverse(lrange(4), [ot->ar] );  
(%o1) <[4,3,2,1]>
```

```
(%i1) ireverse(lrange(4, [ot->ar]) );  
(%o1) <[4,3,2,1]>
```

```
(%i1) ireverse(lrange(4, [ot->ar]), [ot->ml] );  
(%o1) [4,3,2,1]
```

3.17 Function: lex

Calling

lex(*e*) converts the aex expression *e* to lex. If *e* is not an aex expression, *e* is returned. Conversion is only done on the first level.

4 Functions and Variables for Combinatorics

- `ae_random.permutation`
- `cycles_to_perm`
- `inverse_permutation`
- `perm_to_cycles`
- `perm_to_transpositions`
- `permutation_p`
- `permutation_p1`
- `random_cycle`
- `random_permutation_sym`
- `signature_permutation`
- `transpositions_to_perm`

4.1 Function: `ae_random_permutation`

`ae_random_permutation(a)`

next package: `discrete_aex`

Description returns *a* with subexpressions permuted randomly.

Arguments `ae_random_permutation` requires one argument *a*, which must be non-atomic.

Options `ae_random_permutation` takes options with default values: `adj->true`, `ot->m1`.

See also `random_cycle`, `random_permutation_sym`, `signature_permutation`, `perm_to_cycles`, and `cycles_to_perm`.

4.2 Function: `cycles_to_perm`

`cycles_to_perm(cycles)`

next package: `discrete_aex`

Description Returns a permutation from its cycle decomposition *cycles*, which is a list of lists. Here ‘permutation’ means a permutation of a list of the integers from 1 to some number *n*. The default output representation is `aex`.

Arguments `cycles_to_perm` requires one argument *cycles*, which must be a list (lex or `aex`).

Options `cycles_to_perm` takes options with default values: `adj->true`, `ot->m1`.

See also `random_cycle`, `random_permutation_sym`, `ae_random_permutation`, `signature_permutation`, and `perm_to_cycles`.

4.3 Function: `inverse_permutation`

`inverse_permutation(perm)`

next package: `discrete_aex`

Description Returns the inverse permutation of *perm*.

Arguments `inverse_permutation` requires one argument *perm*, which must be a list (lex or `aex`).

Options `inverse_permutation` takes options with default values: `adj->true`, `ot->m1`.

Examples

```
(%i1) inverse_permutation([5,1,4,2,6,8,7,3,10,9]);
(%o1) <[2,4,8,3,1,5,7,6,10,9]>
(%i1) inverse_permutation(inverse_permutation([5,1,4,2,6,8,7,3,10,9]),ot->m1);
(%o1) [5,1,4,2,6,8,7,3,10,9]
```

4.4 Function: `perm_to_cycles`

`perm_to_cycles(ain)`

next package: `discrete_aex`

Description Returns a cycle decomposition of the input permutation *ain*. The input must be a permutation of *n* integers from 1 through *n*.

Arguments `perm_to_cycles` requires one argument *ain*, which must be a list (lex or `aex`).

Options `perm_to_cycles` takes options with default values: `adj->true`, `ot->m1`.

Examples


```
(%i1) perm_to_cycles([5,4,3,2,1,10,6,7,8,9]);  
(%o1) [[7,8,9,10,6],[3],[4,2],[5,1]]
```

See also `random_cycle`, `random_permutation_sym`, `ae_random_permutation`, `signature_permutation`, and `cycles_to_perm`.

4.5 Function: perm_to_transpositions

perm_to_transpositions(*ain*)

next package: discrete_aex

Description Returns a list representing the permutation *ain* as a product of transpositions. The output representation type is applied at both levels.

Arguments `perm_to_transpositions` requires one argument *ain*, which must be a list (lex or aex).

Options `perm_to_transpositions` takes options with default values: `adj->true`, `ot->m1`.

4.6 Function: permutation_p

permutation_p(*ain*)

next package: discrete_aex

Calling

permutation_p(*list*) Returns true if the list *list* of length *n* is a permutation of the integers from 1 through *n*. Otherwise returns false.

Arguments `permutation_p` requires one argument.

Implementation Separate routines for aex and lex input are used.

4.7 Function: permutation_p1

permutation_p1(*ain*)

next package: discrete_aex

Description This is the same as `permutation_p`, but, if the input is a list, it assumes all elements in the input list are fixnum integers, while `permutation_p` does not.

Arguments `permutation_p1` requires one argument.

Implementation Some variables are declared fixnum, but this does not seem to improve performance with respect to `permutationp`.

4.8 Function: random_cycle

random_cycle(*n*)

next package: discrete_aex

Calling

random_cycle(*n*) Returns a random cycle of length *n*. The return value is a list of the integers from 1 through *n*, representing an element of the symmetric group S_n that is a cycle.

Arguments `random_cycle` requires one argument n , which must be a positive integer.

Options `random_cycle` takes options with default values: `adj->true`, `ot->ml`.

See also `random_permutation_sym`, `ae_random_permutation`, `signature_permutation`, `perm_to_cycles`, and `cycles_to_perm`.

Implementation This function uses Sattolo's algorithm.

4.9 Function: `random_permutation_sym`

`random_permutation_sym(n)`

next package: `discrete_aex`

Calling

`random_permutation_sym(n)` Returns a random permutation of the integers from 1 through n . This represents a random element of the symmetric group S_n .

Arguments `random_permutation_sym` requires one argument n , which must be a positive integer.

Options `random_permutation_sym` takes options with default values: `adj->true`, `ot->ml`.

See also `random_cycle`, `ae_random_permutation`, `signature_permutation`, `perm_to_cycles`, and `cycles_to_perm`.

4.10 Function: `signature_permutation`

`signature_permutation(ain)`

next package: `discrete_aex`

Calling

`signature_permutation($list$)` returns the sign, or signature, of the symmetric permutation $list$, which must be represented by a permutation the integers from 1 through n , where n is the length of the list.

Arguments `signature_permutation` requires one argument ain , which must be a list (lex or aex).

See also `random_cycle`, `random_permutation_sym`, `ae_random_permutation`, `perm_to_cycles`, and `cycles_to_perm`.

4.11 Function: `transpositions_to_perm`

`transpositions_to_perm(ain)`

next package: `discrete_aex`

Description Returns the permutation specified by the list of transpositions ain .

Arguments `transpositions_to_perm` requires one argument ain , which must be a list (lex or aex).

Options `transpositions_to_perm` takes options with default values: `adj->true`, `ot->ml`.

Implementation Input is converted to lex on both levels. Default output is aex.

5 Functions and Variables for Documentation

- `doc_system_list`
- `maxdoc`
- `maxdoc_author`

- `maxdoc_copyright`
- `maxdoc_examples`
- `maxdoc_set_cur_sec`
- `maxdoc_set_mext_package`
- `maxdoc_split_text`
- `mext_package_record`
- `print_entry_latex`
- `print_maxdoc_entry`
- `print_maxdoc_sections`
- `print_sections_latex`
- `read_docs_with_pager`
- `set_all_doc_systems`
- `simple_doc_add`
- `simple_doc_delete`
- `simple_doc_get`
- `simple_doc_init`
- `simple_doc_print`

5.1 Variable: `doc_system_list`

Description A list of the documentatation system that will be searched by `?` and `??`. This can be set to all available systems with the function `set_all_doc_systems`. Also, if this variable is false, then all documentation is enabled.

5.2 Function: `maxdoc`

`maxdoc(name, docs)`
 next package: `defunfun1`

Description Add maxdoc documentation entry for item *name* specified by *docs*.

Arguments `maxdoc` requires two arguments. The first argument *name* must be a string.

Attributes `maxdoc` has attributes: `[hold_all]`

5.3 Function: `maxdoc_author`

`maxdoc_author(name, author)`
 next package: `defunfun1`

Description Set the author(s) for the documentation item *name*.

Arguments `maxdoc_author` requires two arguments. The first argument *name* must be a string. The second argument *author* must be a string or a list of strings.

5.4 Function: `maxdoc_copyright`

`maxdoc_copyright`(*name*, *copyright*)

mext package: `defmfun1`

Description Set the copyright information for the documentation item *name*. *copyright* should typically be a list whose first element is an integer (the year), with the remaining strings naming the copyright holder. This copyright information will not be printed with documentation, unless *print_copyrights* is true.

Arguments `maxdoc_copyright` requires two arguments. The first argument *name* must be a string.

5.5 Function: `maxdoc_examples`

`maxdoc_examples`(*name* :rest *examples*)

mext package: `defmfun1`

Description Add maxdoc examples entry for item *name* specified by *examples*.

Arguments `maxdoc_examples` requires one or more arguments. The first argument *name* must be a string.

Attributes `maxdoc_examples` has attributes: `[hold_all]`

5.6 Function: `maxdoc_set_cur_sec`

`maxdoc_set_cur_sec`(*shortname*)

mext package: `defmfun1`

Description Set the current section for maxdoc to *shortname*. This section will be used by functions such as `maxdoc`, and `maxdoc_author`.

Arguments `maxdoc_set_cur_sec` requires one argument *shortname*, which must be a string.

5.7 Function: `maxdoc_set_mext_package`

`maxdoc_set_mext_package`(*packagename*)

mext package: `defmfun1`

Description Set the current mext package name for maxdoc to *packagename*. This name will be used by functions specifying documentation for functions until the name is set to another value. When documenting functions written in maxima code, calling `mext_record_package` is probably more useful.

Arguments `maxdoc_set_mext_package` requires one argument *packagename*, which must be a string.

5.8 Function: `maxdoc_split_text`

`maxdoc_split_text`(*text*)

mext package: `defmfun1`

Description Split the string *text* into a list of strings, using a sequence of one or more spaces as the delimiter. Single newlines are removed.

Arguments `maxdoc_split_text` requires one argument *text*, which must be a string.

5.9 Function: `mext_package_record`

`mext_package_record(docitem, packagename)`
mext package: defmfun1

Description Set the mext packagename for the function or variable *docitem* to *packagename*. This name will be used when displaying documentation. The function `maxdoc_set_mext_package` is useful for setting the package name of a group of functions, but there is currently no maxima hook for doing this.

Arguments `mext_package_record` requires two arguments. The first argument *docitem* must be a string or a symbol. The second argument *packagename* must be a string.

5.10 Function: `print_entry_latex`

`print_entry_latex(item)`
mext package: defmfun1

Arguments `print_entry_latex` requires one argument *item*, which must be a string.

5.11 Function: `print_maxdoc_entry`

`print_maxdoc_entry(item)`
mext package: defmfun1

Arguments `print_maxdoc_entry` requires one argument *item*, which must be a string.

5.12 Function: `print_maxdoc_sections`

`print_maxdoc_sections()`
mext package: defmfun1

Description Print all sections of maxdoc documentation. This does not include other documentation databases, such as the main maxima documentation.

Arguments `print_maxdoc_sections` requires zero arguments.

5.13 Function: `print_sections_latex`

`print_sections_latex(:optional filename)`
mext package: defmfun1

Description Print all sections of maxdoc documentation currently loaded in latex format to the file *filename*. This does not include other documentation databases, such as the main maxima documentation.

Arguments `print_sections_latex` requires either zero or one arguments. If present, the argument *filename* must be a string.

5.14 Option variable: `read_docs_with_pager`

default value `true`.

Description If `read_docs_with_pager` is true then documentation printed by `describe()` or `?` or `??` is read with a pager. This will most likely only work with a command line interface under linux/unix with certain lisp implementations.

5.15 Function: `set_all_doc_systems`

`set_all_doc_systems()`
next package: `defmfun1`

Description Enable all documentation databases for `describe`, `?` and `??`. This sets `doc_system_list` to a list of all doc systems.

Arguments `set_all_doc_systems` requires zero arguments.

5.16 Function: `simple_doc_add`

`simple_doc_add(name, content)`
next package: `defmfun1`

Description Adds documentation string *content* for item *name*. These documentation strings are accessible via `'?'` and `'??'`.

Arguments `simple_doc_add` requires two arguments. The first argument *name* must be a string. The second argument *content* must be a string.

See also `simple_doc_init`, `simple_doc_delete`, `simple_doc_get`, and `simple_doc_print`.

5.17 Function: `simple_doc_delete`

`simple_doc_delete(name)`
next package: `defmfun1`

Description Deletes the `simple_doc` documentation string for item *name*.

Arguments `simple_doc_delete` requires one argument *name*, which must be a string.

See also `simple_doc_init`, `simple_doc_add`, `simple_doc_get`, and `simple_doc_print`.

5.18 Function: `simple_doc_get`

`simple_doc_get(name)`
next package: `defmfun1`

Description Returns the `simple_doc` documentation string for item *name*.

Arguments `simple_doc_get` requires one argument *name*, which must be a string.

See also `simple_doc_init`, `simple_doc_add`, `simple_doc_delete`, and `simple_doc_print`.

5.19 Function: `simple_doc_init`

`simple_doc_init()`
next package: `defmfun1`

Description Initialize the `simple_doc` documentation database.

Arguments `simple_doc_init` requires zero arguments.

See also `simple_doc_add`, `simple_doc_delete`, `simple_doc_get`, and `simple_doc_print`.

5.20 Function: simple_doc_print

simple_doc_print(*name*)

next package: defmfun1

Description Prints the simple-doc documentation string for item *name*.

Arguments `simple_doc_print` requires one argument *name*, which must be a string.

See also `simple_doc_init`, `simple_doc_add`, `simple_doc_delete`, and `simple_doc_get`.

6 Functions and Variables for Equations

- `alt_eigen`

6.1 Function: alt_eigen

next package: `alt_eigen`

Description `alt_eigen(mat, ['var=x, 'maxdegree=n, 'orthogonal=boolean])`

Express the eigenvectors of the matrix *mat* as a polynomial in the eigenvalue *var*. When the degree of a factor of the characteristic polynomial has degree *maxdegree* or less, the code attempts to find all the roots of the factor. The optional variables *var*, *maxdegree* (default 1), and *orthogonal* (default false) can be in any order. When the dimension of an eigenspace is greater than one and *orthogonal* is true, the list of eigenvectors is orthogonal.

Examples The eigenvectors of `matrix([1,2],[4,5])`, are

```
(%i1) alt_eigen(matrix([1,2],[4,5]),'var=z);  
(%o1) [z^2=6*z+3,[matrix([2],[z-1])]]
```

Substituting the two roots of $z^2=6z+3$ in to the column vector `matrix([2],[z-1])` gives the two eigenvectors. To find explicit expressions for these eigenvectors, set *maxdegree* to 2; thus

```
(%i2) alt_eigen(matrix([1,2],[4,5]),'var=z, 'maxdegree=2);  
(%o2) [z=2*sqrt(3)+3,[matrix([2],[2*sqrt(3)+2])],z=3-2*sqrt(3),  
      [matrix([2],[2-2*sqrt(3)])]]
```

Here is a matrix with a degenerate eigenvalue:

```
(%i3) m : matrix([5,6,5,6,5,6],[6,5,6,5,6,5],[5,6,5,6,5,6],[6,5,6,5,6,5],  
      [5,6,5,6,5,6],[6,5,6,5,6,5])$  
(%i4) alt_eigen(m,'var=z);  
(%o4) [z=-3,[matrix([-1],[1],[-1],[1],[-1],[1])],z=0,[matrix([0],[-1],[0],[1],[0],[0]),  
      matrix([0],[0],[0],[-1],[0],[1]), matrix([0],[0],[1],[0],[-1],[0]),  
      matrix([1],[0],[-1],[0],[0],[0])],z=33,[matrix([-1],[-1],[-1],[-1],[-1],[-1])]]
```

There are four eigenvectors with eigenvalue 0. To find an orthogonal basis for this eigenspace, set the optional variable *orthogonal* to true; thus

```
(%i5) alt_eigen(m,'var=z, 'orthogonal=true);  
(%o5) [z=-3,[matrix([-1],[1],[-1],[1],[-1],[1])],z=0,[matrix([1],[0],[-1/2],[0],  
      [-1/2],[0]), matrix([0],[0],[1],[0],[-1],[0]),matrix([0],[-1/2],[0],[-1/2],[0],[1]),  
      matrix([0],[-1],[0],[1],[0],[0])],z=33,[matrix([-1],[-1],[-1],[-1],[-1],[-1])]]
```

Author Barton Willis.

7 Functions and Variables for Function Definition

- `comp_load`
- `compile_file1`

7.1 Function: `comp_load`

`comp_load`(*fname* :optional *pathlist*)
next package: aex

Description Compile and load a lisp file. Maxima does not load it by default with `compile_file`. If the input filename does not end with “.lisp”, it will be appended. If *pathlist* is specified, then *fname* is only searched for in directories in *pathlist*.

Arguments `comp_load` requires either one or two arguments. The first argument *fname* must be a string. The second argument *pathlist* must be a string or a list of strings.

7.2 Function: `compile_file1`

`compile_file1`(*input-file* :optional *bin-file*, *translation-output-file*)
next package: aex

Description This is copied from maxima `compile_file`, with changes. Sometimes a loadable binary file is apparently compiled, but an error flag is set and `compile_file` returns false for the output binary filename. Here we return the binary filename in any case.

Arguments `compile_file1` requires between one and three arguments. The first argument *input-file* must be a string.

8 Functions and Variables for Input and Output

- `pager_command`
- `pager_string`

8.1 Option variable: `pager_command`

default value `/usr/bin/less`.

Description The pathname to the pager program used for reading paged output, eg for documentation.

See also `read_docs_with_pager`.

8.2 Function: `pager_string`

`pager_string`(*s*)
next package: aex

Description Read the string *s* in the pager given by the maxima variable `pager_command`. This works at least with `gcl` under linux.

Arguments `pager_string` requires one argument *s*, which must be a string.

9 Functions and Variables for Lists

These functions manipulate lists. They build lists, take them apart, select elements, etc.

- `aelistp`
- `constant_list`
- `count`
- `drop_while`
- `every1`
- `fold`
- `fold_list`
- `icons`
- `imap`
- `length_while`
- `lrange`
- `nest`
- `nest_list`
- `nest_while`
- `nreverse`
- `partition_list`
- `select`
- `sequence specifier`
- `table`
- `take`
- `take_while`
- `tuples`

9.1 Function: `aelistp`

Description Returns true if e is a list, either ml or ar representation.

Examples

```
(%i1) aelistp([1,2,3]);  
(%o1) true  
(%i1) aelistp( aex([1,2,3]));  
(%o1) true  
(%i2) aelistp(3);  
(%o2) false
```

```
(%i3) aelisp(x);
(%o3) false
(%i4) x:lrangle(10),aelisp(x);
(%o4) true
(%i5) aelisp(%f(y));
(%o5) false
(%i6) aelisp( aex( %f(y) ));
(%o6) false
```

9.2 Function: constant_list

constant_list(*expr*, *list*)

next package: lists_aex

Description Returns a list of n elements, each of which is an independent copy of *expr*. **constant_list**(*expr*, [*n*,*m*,...]) returns a nested list of dimensions n,m,\dots where each leaf is an independent copy of *expr* and the copies of each list at each level are independent. If a third argument is given, then it is used as the op, rather than 'list', at every level.

Arguments **constant_list** requires either two or three arguments. The second argument *spec* must be a positive integer or a list of positive integers.

Options **constant_list** takes options with default values: *adj*->true, *ot*->ml.

See also **makelist**, **lrangle**, and **table**.

9.3 Function: count

count(*expr*, *item*)

next package: lists_aex

Description Counts the number of items in *expr* matching *item*. If *item* is a lambda function then *compile* must be true.

Arguments **count** requires two arguments. The first argument *expr* must be non-atomic and either aex or represented by a lisp list.

Options **count** takes options with default values: *compile*->true.

Examples

```
(%i1) count([1,2,"dog"], 'numberp);
(%o1) 2
(%i1) count([1,2,"dog"], "dog");
(%o1) 1
(%i2) count(lrangle(10^4), lambda([x], is(mod(x,3) = 0)));
(%o2) 3333
(%i3) count( %ff(1,2,"dog"), "dog");
(%o3) 1
(%i4) count(lrangle(100,ot->ar), 'evenp);
(%o4) 50
```

9.4 Function: drop_while

drop_while(*expr*, *test*)

next package: lists_aex

Calling

drop_while(*expr*, *test*) Tests the elements of *expr* in order, dropping them until *test* fails. The remaining elements are returned in an expression with the same op as that *expr*.

Arguments **drop_while** requires two arguments. The first argument *expr* must be non-atomic and represented by a lisp list.

Options **drop_while** takes options with default values: `adj->true`, `ot->ml`, `compile->true`.

Examples

Drop elements as long as they are negative.

```
(%i1) drop_while([-3,-10,-1,3,6,7,-4], lambda([x], is(x<0)));  
(%o1) [3,6,7,-4]
```

9.5 Function: every1

every1(*expr*, *test*)

next package: lists_aex

Calling

every1(*expr*, *test*) Returns true if *test* is true for each element in *expr*. Otherwise, false is returned. This is like **every** but allow a test that takes only one argument. For some inputs, **every1** is much faster than **every**.

Arguments **every1** requires two arguments. The first argument *expr* must be non-atomic and represented by a lisp list.

Options **every1** takes options with default values: `compile->true`.

9.6 Function: fold

next package: lists_aex

Description **fold**(*f*, *x*, [*a*, *b*, *c*]) returns `f(f(f(x,a),b),c)`.

Arguments **fold** requires three arguments. The third argument *v* must be non-atomic.

Options **fold** takes options with default values: `adj->true`, `ot->ml`, `compile->true`.

See also **fold_list** and **nest**.

9.7 Function: fold_list

next package: lists_aex

Description **fold_list**(*f*, *x*, [*a*, *b*, *c*]) returns `[f(x,a),f(f(x,a),b),f(f(f(x,a),b),c)]`.

Arguments **fold_list** requires three arguments. The third argument *v* must be non-atomic.

Options **fold_list** takes options with default values: `adj->true`, `ot->ml`, `compile->true`.

See also **fold** and **nest**.

9.8 Function: icons

icons(*x*, *e*)

Description **icons** is like maxima **cons**, but less general, and much, much faster. *x* is a maxima object. *e* is a maxima list or list-like object, such as **[a]**, or **f(a)**. It is suitable at a minimum, for pushing a number or list or string onto a list of numbers, or strings or lists. If you find **icons** gives buggy behavior that you are not interested in investigating, use **cons** instead.

Implementation In a function that mostly only does icons in a loop, icons defined with **defmfund** rather than **defmfund1** runs almost twice as fast. So icons is defined with **defmfund** rather than **defmfund1**. icons does no argument checking.

9.9 Function: imap

imap(*f*, *expr*)

next package: lists_aex

Description Maps functions of a single argument. I guess that **map** handles more types of input without error. But **imap** can be much faster for some inputs.

Arguments **imap** requires two arguments. The second argument *expr* must be non-atomic.

Options **imap** takes options with default values: **compile->true**.

Examples

Map sqrt efficiently over a list of floats

```
(%i1) (a : lrange(1.0,4),  
      imap(lambda([x],modeddeclare(x,float),sqrt(x)),a));  
(%o1) [1.0,1.414213562373095,1.732050807568877,2.0]
```

With aex expression, no conversions to lex are done.

```
(%i1) (a : lrange(1.0,4,ot->ar),  
      imap(lambda([x],modeddeclare(x,float),sqrt(x)),a));  
(%o1) <[1.0,1.414213562373095,1.732050807568877,2.0]>
```

9.10 Function: length_while

length_while(*expr*, *test*)

next package: lists_aex

Description Computes the length of *expr* while *test* is true.

Arguments **length_while** requires two arguments. The first argument *expr* must be non-atomic and represented by a lisp list.

Options **length_while** takes options with default values: **compile->true**.

Examples

```
(%i1) length_while([-3,-10,-1,3,6,7,-4], lambda([x], is(x<0)));  
(%o1) 3
```

9.11 Function: lrange

next package: lists_aex

Calling

`lrange(stop)` returns a list of numbers from 1 through *stop*.

`lrange(start, stop)` returns a list of expressions from *start* through *stop*.

`lrange(start, stop, incr)` returns a list of expressions from *start* through *stop* in steps of *incr*.

Description `lrange` is much more efficient than `makelist` for creating ranges, particularly for large lists (e.g. 10^5 or more items.) Functions for creating a list of numbers, in order of decreasing speed, are: `lrange`, `table`, `create_list`, `makelist`.

Arguments `lrange` requires between one and three arguments. The third argument *incr* must be an expression that is not zero.

Options `lrange` takes options with default values: `adj->true`, `ot->ml`.

Examples

```
(%i1) lrange(6);
(%o1) [1,2,3,4,5,6]
(%i1) lrange(2,6);
(%o1) [2,3,4,5,6]
(%i2) lrange(2,6,2);
(%o2) [2,4,6]
(%i3) lrange(6,1,-1);
(%o3) [6,5,4,3,2,1]
(%i4) lrange(6,1,-2);
(%o4) [6,4,2]
(%i5) lrange(6,ot->ar);
(%o5) <[1,2,3,4,5,6]>
```

The type of the first element and increment determine the type of the elements.

```
(%i1) lrange(1.0,6);
(%o1) [1.0,2.0,3.0,4.0,5.0,6.0]
(%i1) lrange(1.0b0,6);
(%o1) [1.0b0,2.0b0,3.0b0,4.0b0,5.0b0,6.0b0]
(%i2) lrange(1/2,6);
(%o2) [1/2,3/2,5/2,7/2,9/2,11/2]
(%i3) lrange(6.0,1,-1);
(%o3) [6.0,5.0,4.0,3.0,2.0,1.0]
```

Symbols can be used for limits or increments.

```
(%i1) lrange(x,x+4);
(%o1) [x,x+1,x+2,x+3,x+4]
(%i1) lrange(x,x+4*a,a);
(%o1) [x,x+a,x+2*a,x+3*a,x+4*a]
```

See also `makelist`, `table`, and `constant_list`.

9.12 Function: nest

next package: lists_aex

Description `nest(f,x,n)` returns $f(\dots f(f(f(x)))\dots)$ where there are n nested calls of f .

Arguments `nest` requires three arguments. The first argument f must be a function. The third argument n must be a non-negative integer.

Options `nest` takes options with default values: `adj->true`, `ot->ml`, `compile->true`.

9.13 Function: nest_list

`nest_list(f, x, n)`

next package: lists_aex

Arguments `nest_list` requires three arguments. The third argument n must be a non-negative integer.

Options `nest_list` takes options with default values: `adj->true`, `ot->ml`, `compile->true`.

Examples

Find the first 10 primes after 100.

```
(%i1) nest_list(next_prime,100,10);  
(%o1) [101,103,107,109,113,127,131,137,139,149]
```

See also `nest`, `fold`, and `fold_list`.

9.14 Function: nest_while

`nest_while(f, x, test :optional min, max)`

next package: lists_aex

Calling

`nest_while(f, x, test)` applies f to x until $test$ fails to return true when called on the nested result.

`nest_while(f, x, test, min)` applies f at least min times.

`nest_while(f, x, test, min, max)` applies f not more than max times.

Arguments `nest_while` requires between three and five arguments. The fourth argument min must be a non-negative integer. The fifth argument max must be a non-negative integer.

Options `nest_while` takes options with default values: `adj->true`, `ot->ml`, `compile->true`.

Implementation This should be modified to allow applying test to more than just the most recent result.

9.15 Function: nreverse

`nreverse(e)`

next package: lists_aex

Description Destructively reverse the arguments of expression e . This is more efficient than using `reverse`.

Arguments `nreverse` requires one argument e , which must be non-atomic.

Examples

Be careful not to use a after applying `nreverse`. Do assign the result to another variable.

```
(%i1) a : lrange(10), b : nreverse(a);
(%o1) [10,9,8,7,6,5,4,3,2,1]
(%i1) a : lrange(10,ot->ar), b : nreverse(a);
(%o1) <[10,9,8,7,6,5,4,3,2,1]>
```

See also `reverse`.

9.16 Function: `partition_list`

`partition_list`(*e*, *nlist* : optional *dlist*)

next package: `lists_aex`

Calling

`partition_list`(*e*, *n*) partitions *e* into sublists of length *n*

`partition_list`(*e*, *n*, *d*) partitions *e* into sublists of length *n* with offsets *d*.

Description Omitting *d* is equivalent to giving *d* equal to *n*. *e* can be any expression, not only a list. If *n* is a list, then `partition_list` partitions at successively deeper levels with elements of *n*. If *n* and *d* are lists, the first elements of *n* and *d* apply at the highest level and so on. If *n* is a list and *d* is a number, then the offset *d* is used with each of the *n*.

Arguments `partition_list` requires either two or three arguments. The first argument *e* must be non-atomic. The second argument *nlist* must be an integer or a list of integers. The third argument *dlist* must be an integer or a list of integers.

Examples

Partition the numbers from 1 through 10 into pairs.

```
(%i1) partition_list([1,2,3,4,5,6,7,8,9,10],2);
(%o1) [[1,2],[3,4],[5,6],[7,8],[9,10]]
```

9.17 Function: `select`

`select`(*expr*, *test* : optional *n*)

next package: `lists_aex`

Description Returns a list of all elements of *expr* for which *test* is true. *expr* may have any op. If *n* is supplied, then at most *n* elements are examined.

Arguments `select` requires either two or three arguments. The first argument *expr* must be non-atomic and represented by a lisp list. The third argument *n* must be a positive integer.

Options `select` takes options with default values: `adj->true`, `ot->ml`, `compile->true`.

Examples

Select elements less than 3

```
(%i1) select([1,2,3,4,5,6,7], lambda([x], is(x<3)));
(%o1) [1,2]
```

9.18 Argument type: sequence specifier

Description A sequence specification specifies a subsequence of the elements in an expression. A single positive number n means the first n elements. $-n$ means the last n elements. A list of three numbers $[i1,i2,i3]$ means the $i1$ th through the $i2$ th stepping by $i3$. If $i1$ or $i2$ are negative, they count from the end. If $i3$ is negative, stepping is down and $i1$ must be greater than or equal to $i2$. If $i3$ is omitted, it is taken to be 1. A sequence specifier can also be one of 'all' 'none' or 'reverse', which mean all elements, no elements or all elements in reverse order respectively.

See also `take` and `string_take`.

9.19 Function: table

next package: `lists_aex`

Calling

table(*expr*, [*n*]) Evaluates expression *number* times. If *number* is not an integer or a floating point number, then `float` is called. If we have a floating point number, it is truncated into an integer. This type of iterator is the fastest, since no variable is bound.

table(*expr*, [*variable*, *initial*, *end*, *step*]) Returns a list of evaluated expressions where *variable* (a symbol) is set to a value. The first element of the returned list is *expression* evaluated with *variable* set to *initial*. The i -th element of the returned list is *expression* evaluated with *variable* set to $initial + (i - 1)step$. The iteration stops once the value is greater (if *step* is positive) or smaller (if *step* is negative) than *end*. Requirement: The difference between *end* and *initial* must return a **numberp** number. *step* must be a nonzero **numberp** number. This allows for iterators of rather general forms like `[i, %i - 2, %i, 0.1b0]` ...

table(*expr*, [*variable*, *initial*, *end*]) This iterator uses a step of 1 and is equal to `[variable,initial,end,1]`.

Arguments `table` requires two or more arguments. The second argument *iterator1* must be a list. Each of the remaining arguments must be a list.

Options `table` takes options with default values: `adj->true`, `ot->m1`.

Attributes `table` has attributes: `[hold_all]`

Examples

Make a list of function values

```
(%i1) table(sin(x),[x,0,2*pi,%pi/4]);
(%o1) [0,1/sqrt(2),1,1/sqrt(2),0,-1/sqrt(2),-1,-1/sqrt(2),0]
```

Make a nested list.

```
(%i1) table( x^y, [x,1,2], [y,1,2]);
(%o1) [[1,1],[2,4]]
```

See also `makelist`, `lrange`, and `constant_list`.

Author Ziga Lenarcic.

9.20 Function: take

take(*e* :rest *v*)
next package: lists_aex

Calling

take(*e*, *n*) returns a list of the first *n* elements of list or expression *e*.

take(*e*, [*n1*, *n2*]) returns a list of the *n1*th through *n2*th elements of list or expression *e*.

take(*e*, [*n1*, *n2*, *step*]) returns a list of the *n1*th through *n2*th elements stepping by *step* of list or expression *e*.

take(*e*, -*n*) returns the last *n* elements.

take(*e*, *spec1*, *spec2*, ...) applies the sequence specifications at successively deeper levels in *e*.

Description *e* can have mixed lex and aex expressions on different levels. If more sequence specifications are given, they apply to successively deeper levels in *e*.

Arguments **take** requires one or more arguments. The first argument *e* must be non-atomic. Each of the remaining arguments must be a sequence specification.

Examples

Take the first 3 elements of a list.

```
(%i1) take([a,b,c,d,e],3);  
(%o1) [a,b,c]
```

Take the last 3 elements of a list.

```
(%i1) take([a,b,c,d,e],-3);  
(%o1) [c,d,e]
```

Take the second through third elements of a list.

```
(%i1) take([a,b,c,d,e],[2,3]);  
(%o1) [b,c]
```

Take the second through tenth elements of a list counting by two.

```
(%i1) take([1,2,3,4,5,6,7,8,9,10],[2,10,2]);  
(%o1) [2,4,6,8,10]
```

Take the last through first elements of a list counting backwards by one.

```
(%i1) take([a,b,c,d],[-1,1,-1]);  
(%o1) [d,c,b,a]
```

Shorthand for the previous example is 'reverse.

```
(%i1) take([a,b,c,d],'reverse);  
(%o1) [d,c,b,a]
```

Take the second through third elements at the first level and the last 2 elements at the second level.

```
(%i1) take([[a,b,c],[d,e,f],[g,h,i]],[2,3],-2);  
(%o1) [[e,f],[h,i]]
```

9.21 Function: take_while

take_while(*expr*, *test*)

next package: lists_aex

Calling

take_while(*expr*, *test*) collects the elements in *expr* until *test* fails on one of them. The op of the returned expression is the same as the op of *expr*.

Arguments **take_while** requires two arguments. The first argument *expr* must be non-atomic and represented by a lisp list.

Options **take_while** takes options with default values: **adj**->**true**, **ot**->**ml**, **compile**->**true**.

Examples

Take elements as long as they are negative.

```
(%i1) take_while([-3,-10,-1,3,6,7,-4], lambda([x], is(x<0)));  
(%o1) [-3,-10,-1]
```

9.22 Function: tuples

tuples(*list-or-lists* :optional *n*)

next package: lists_aex

Calling

tuples(*list*, *n*) Return a list of all lists of length *n* whose elements are chosen from *list*.

tuples([*list1*, *list2*, ...]) Return a list of all lists whose *i*-th element is chosen from *listi*.

Arguments **tuples** requires either one or two arguments. The first argument *list-or-lists* must be non-atomic and represented by a lisp list. The second argument *n* must be a non-negative integer.

Options **tuples** takes options with default values: **adj**->**true**, **ot**->**ml**.

Examples

Make all three letter words in the alphabet 'a,b'.

```
(%i1) tuples([a,b],3);  
(%o1) [[a,a,a],[a,a,b],[a,b,a],[a,b,b],[b,a,a],[b,a,b],[b,b,a],[b,b,b]]
```

Take all pairs chosen from two lists.

```
(%i1) tuples([ [0,1] , [x,y,z] ]);  
(%o1) [[0,x],[0,y],[0,z],[1,x],[1,y],[1,z]]
```

tuples works for expressions other than lists.

```
(%i1) tuples(f(0,1),3);  
(%o1) [f(0,0,0),f(0,0,1),f(0,1,0),f(0,1,1),f(1,0,0),f(1,0,1),f(1,1,0),f(1,1,1)]
```

10 Functions and Variables for Number Theory

- `abundant_p`
- `aliquot_sequence`
- `aliquot_sum`
- `amicable_p`
- `catalan_number`
- `divisor_function`
- `divisor_summatory`
- `from_digits`
- `integer_digits`
- `integer_string`
- `oeis_A092143`
- `perfect_p`
- `prime_pi_soe`
- `primes1`

10.1 Function: `abundant_p`

`abundant_p`(n)

next package: `discrete.aex`

Description Returns true if n is an abundant number. Otherwise, returns false.

Arguments `abundant_p` requires one argument n , which must be a positive integer.

Examples

The abundant numbers between 1 and 100

```
(%i1) select(lrange(100),abundant_p);  
(%o1) [12,18,20,24,30,36,40,42,48,54,56,60,66,70,72,78,80,84,88,90,96,100]
```

See also `divisor_function`, `aliquot_sum`, `aliquot_sequence`, `divisor_summatory`, and `perfect_p`.

10.2 Function: `aliquot_sequence`

`aliquot_sequence`(k , n)

next package: `discrete.aex`

Description The aliquot sequence is a recursive sequence in which each term is the sum of the proper divisors of the previous term. This function returns the first n elements (counting from zero) in the aliquot sequence whose first term is k . The sequence is truncated at an element if it is zero or repeats the previous element.

Arguments `aliquot_sequence` requires two arguments. The first argument k must be a positive integer. The second argument n must be a non-negative integer.

Examples

Perfect numbers give a repeating sequence of period 1.

```
(%i1) imap(lambda([x], aliquot_sequence(x,100)), [6,28,496,8128]);
(%o1) [[6],[28],[496],[8128]]
```

Aspiring numbers are those which are not perfect, but terminate with a repeating perfect number.

```
(%i1) imap(lambda([x], aliquot_sequence(x,100)), [25, 95, 119, 143, 417, 445, 565, 608, 650, 652, 675, 688, 722, 761, 812, 815, 854, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000]);
(%o1) [[25,6],[95,25,6],[119,25,6],[143,25,6],[417,143,25,6],[445,95,25,6],[565,119,25,6],[608,652,496]]
```

See also `divisor_function`, `aliquot_sum`, `divisor_summatory`, `perfect_p`, and `abundant_p`.

10.3 Function: aliquot_sum

aliquot_sum(n)

next package: `discrete_aex`

Description Returns the aliquot sum of n . The aliquot sum of n is the sum of the proper divisors of n .

Arguments `aliquot_sum` requires one argument n , which must be a positive integer.

Attributes `aliquot_sum` has attributes: `[match_form]`

See also `divisor_function`, `aliquot_sequence`, `divisor_summatory`, `perfect_p`, and `abundant_p`.

10.4 Function: amicable_p

amicable_p(n, m)

next package: `discrete_aex`

Description Returns true if n and m are amicable, and false otherwise.

Arguments `amicable_p` requires two arguments. The first argument n must be a positive integer. The second argument m must be a positive integer.

Examples

The first few amicable pairs.

```
(%i1) map(lambda([x], amicable_p(first(x), second(x))), [[220, 284],
[1184, 1210], [2620, 2924], [5020, 5564], [6232, 6368]]);
(%o1) [true,true,true,true,true]
```

10.5 Function: catalan_number

catalan_number(n)

next package: `discrete_aex`

Description Returns the n th catalan number.

Arguments `catalan_number` requires one argument.

Examples

The catalan number for n from 1 through 12.

```
(%i1) map(catalan_number, lrange(12));
(%o1) [1,2,5,14,42,132,429,1430,4862,16796,58786,208012]
```

The n'th catalan number.

```
(%i1) catalan_number(n);  
(%o1) binomial(2*n,n)/(n+1)
```

OEIS number: A000108.

10.6 Function: divisor_function

divisor_function(*n* :optional *x*)

next package: discrete_aex

Description Returns the divisor function, or sum of positive divisors function

$$\sigma_x(n) = \sum_{d|n} d^x,$$

where $d|x$ means d divides n . If x is omitted it takes the default value 0. Currently, complex values for x are not supported. After writing this, I noticed that the function is implemented in the maxima core and is called `divsum`.

Arguments `divisor_function` requires either one or two arguments. The first argument n must be a non-negative integer. The second argument x must be a number.

Attributes `divisor_function` has attributes: [match_form]

OEIS number: A000005 for $x=0$ and A000203 for $x=1$.

See also `aliquot_sum`, `aliquot_sequence`, `divisor_summatory`, `perfect_p`, and `abundant_p`.

10.7 Function: divisor_summatory

divisor_summatory(*x*)

next package: discrete_aex

Description Returns the divisor summatory function $D(x)$ for x . The `divisor_function` $\sigma_0(n)$ counts the number of unique divisors of the natural number n . $D(x)$ is the sum of $\sigma_0(n)$ over $n \leq x$.

Arguments `divisor_summatory` requires one argument x , which must be a non-negative number.

Attributes `divisor_summatory` has attributes: [match_form]

Examples

$D(n)$ for n from 1 through 12

```
(%i1) map(divisor_summatory, lrange(12));  
(%o1) [1,3,5,8,10,14,16,20,23,27,29,35]
```

OEIS number: A006218.

See also `divisor_function`, `aliquot_sum`, `aliquot_sequence`, `perfect_p`, and `abundant_p`.

10.8 Function: from_digits

from_digits(*digits* :optional *base*)

next package: discrete_aex

Calling

from_digits(*digits*) returns the integer represented by the decimal digits in the list *digits*.

from_digits(*digits*, *base*) returns the integer represented by the base *base* digits in the list *digits*.

Description *base* need not be number, but may be, for instance, a symbol. If *base* is a number it must be an integer between 2 and 36. *digits* may be a string rather than a list.

Arguments **from_digits** requires either one or two arguments. The first argument *digits* must be a list (lex or aex) or a string.

See also **integer_digits** and **integer_string**.

10.9 Function: integer_digits

integer_digits(*n* :optional *base*, *len*)

next package: discrete_aex

Calling

integer_digits(*n*) returns a list of the base 10 digits of *n*.

integer_digits(*n*, *base*) returns a list of the base *base* digits of *n*.

integer_digits(*n*, *base*, *len*) returns a list of the base *base* digits of *n* padded with 0's so that the total length of the list is *len*.

Arguments **integer_digits** requires between one and three arguments. The first argument *n* must be an integer. The second argument *base* must be a valid radix (an integer between 2 and 36). The third argument *len* must be a non-negative integer.

Options **integer_digits** takes options with default values: **adj**->**true**, **ot**->**ml**.

See also **from_digits** and **integer_string**.

Implementation gcl is much faster than the others. **integer_digits**(2^(10⁶)): typical times for lisps: ccl-1.7-r15184M = 65s, sbcl-1.0.52.0.debian = 1.5s, allegro-8.2 = 23s, Mma-3.0 = 5s, gcl-2.6.7 = 0.11s, Mma-8 = 0.04s. The base is limited to 36 only because we call write-to-string.

10.10 Function: integer_string

integer_string(*n* :optional *base*, *pad*)

next package: discrete_aex

Calling

integer_string(*n*) returns a string containing the decimal digits of the integer *n*.

integer_string(*n*, *base*) returns a string containing the base *base* digits of the integer *n*.

integer_string(*n*, *base*, *pad*) pads the string on the left with 0's so that the length of the string is *pad*.

integer_string(*n*, "roman") returns a string containing the roman-numeral form of the integer *n*.

integer_string(*n*, "cardinal") returns a string containing the english word form of the integer (cardinal number) *n*.

integer_string(*n*, "ordinal") returns a string containing the english word form of the ordinal (counting) number *n*.

Arguments `integer_string` requires between one and three arguments. The first argument n must be an integer. The second argument $base$ must be a valid radix (an integer between 2 and 36) or a string. The third argument pad must be a positive integer.

See also `integer_digits` and `from_digits`.

10.11 Function: `oeis_A092143`

`oeis_A092143`(n)

next package: `discrete_aex`

Description Returns the cumulative product of all divisors of integers from 1 to n .

Arguments `oeis_A092143` requires one argument n , which must be a positive integer.

10.12 Function: `perfect_p`

`perfect_p`(n)

next package: `discrete_aex`

Description Returns true if n is a perfect number. Otherwise, returns false.

Arguments `perfect_p` requires one argument n , which must be a positive integer.

See also `divisor_function`, `aliquot_sum`, `aliquot_sequence`, `divisor_summatory`, and `abundant_p`.

Implementation This function computes divisors. It would be far more efficient to use a table of known perfect numbers, as very few of them are accessible by current computer hardware.

10.13 Function: `prime_pi_soe`

`prime_pi_soe`(n)

next package: `discrete_aex`

Description The prime counting function. The algorithm is the sieve of Eratosthenes. Internally an array of n bits is used.

Arguments `prime_pi_soe` requires one argument n , which must be a non-negative integer.

See also `prime_pi`, `next_prime`, and `prev_prime`.

Implementation This is not the most efficient way to compute primes.

10.14 Function: `primes1`

`primes1`($n1$:optional $n2$)

next package: `discrete_aex`

Calling

`primes1`(max) returns a list of the primes less than or equal to max .

`primes1`(min , max) returns a list of the primes between min and max .

Description The algorithm is the sieve of Eratosthenes. This is not an efficient algorithm.

Arguments `primes1` requires either one or two arguments. The first argument $n1$ must be a non-negative integer. The second argument $n2$ must be a non-negative integer.

Options `primes1` takes options with default values: `adj->true`, `ot->ml`.

11 Functions and Variables for Numerics

These are mathematical functions— cos,sin,etc. —that accept only numerical arguments. Tests of loops in untranslated code show that these are much more efficient than using the standard maxima versions. But, for most applications, the standard maxima versions are probably ok.

- `n_abs`
- `n_acos`
- `n_acosh`
- `n_asin`
- `n_asinh`
- `n_atan`
- `n_atanh`
- `n_cos`
- `n_cosh`
- `n_exp`
- `n_expt`
- `n_log`
- `n_sin`
- `n_sinh`
- `n_sqrt`
- `n_tan`
- `n_tanh`

11.1 Function: `n_abs`

Description `n_abs` calls the lisp numeric function `?abs`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_abs` may be considerably faster in some code, particularly untranslated code.

11.2 Function: `n_acos`

Description `n_acos` calls the lisp numeric function `?acos`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_acos` may be considerably faster in some code, particularly untranslated code.

11.3 Function: `n_acosh`

Description `n_acosh` calls the lisp numeric function `?acosh`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_acosh` may be considerably faster in some code, particularly untranslated code.

11.4 Function: `n_asin`

Description `n_asin` calls the lisp numeric function `?asin`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_asin` may be considerably faster in some code, particularly untranslated code.

11.5 Function: `n_asinh`

Description `n_asinh` calls the lisp numeric function `?asinh`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_asinh` may be considerably faster in some code, particularly untranslated code.

11.6 Function: `n_atan`

Description `n_atan` calls the lisp numeric function `?atan`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_atan` may be considerably faster in some code, particularly untranslated code.

11.7 Function: `n_atanh`

Description `n_atanh` calls the lisp numeric function `?atanh`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_atanh` may be considerably faster in some code, particularly untranslated code.

11.8 Function: `n_cos`

Description `n_cos` calls the lisp numeric function `?cos`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_cos` may be considerably faster in some code, particularly untranslated code.

11.9 Function: `n_cosh`

Description `n_cosh` calls the lisp numeric function `?cosh`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_cosh` may be considerably faster in some code, particularly untranslated code.

11.10 Function: `n_exp`

Description `n_exp` calls the lisp numeric function `?exp`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_exp` may be considerably faster in some code, particularly untranslated code.

11.11 Function: `n_expt`

Description `n_expt` calls the lisp numeric function `?expt`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_expt` may be considerably faster in some code, particularly untranslated code.

11.12 Function: `n_log`

Description `n_log` calls the lisp numeric function `?log`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_log` may be considerably faster in some code, particularly untranslated code.

11.13 Function: `n_sin`

Description `n_sin` calls the lisp numeric function `?sin`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_sin` may be considerably faster in some code, particularly untranslated code.

11.14 Function: `n_sinh`

Description `n_sinh` calls the lisp numeric function `?sinh`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_sinh` may be considerably faster in some code, particularly untranslated code.

11.15 Function: `n_sqrt`

Description `n_sqrt` calls the lisp numeric function `?sqrt`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_sqrt` may be considerably faster in some code, particularly untranslated code.

11.16 Function: `n_tan`

Description `n_tan` calls the lisp numeric function `?tan`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_tan` may be considerably faster in some code, particularly untranslated code.

11.17 Function: `n_tanh`

Description `n_tanh` calls the lisp numeric function `?tanh`. This function accepts only float or integer arguments from maxima (lisp complex and rationals, as well.). `n_tanh` may be considerably faster in some code, particularly untranslated code.

12 Functions and Variables for Predicates

- `cmplength`
- `length0p`
- `length1p`
- `length_eq`
- `type_of`

12.1 Function: `cmplength`

`cmplength`(*e*, *n*)
next package: aex

Description return the smaller of *n* and `length(e)`. This is useful if *e* is very large and *n* is small, so that computing the entire length of *e* is inefficient. Expression *e* can be either a list or an array.

Arguments `cmplength` requires two arguments. The second argument *n* must be a non-negative integer.

See also `length0p`, `length_eq`, and `length1p`.

Implementation `cmplength` is implemented with `defmfun1`, which slows things down a bit. So be cautious using it in a tight loop.

12.2 Function: `length0p`

`length0p`(*e*)
next package: aex

Description Returns true if *e* is of length 0, false otherwise. This implementation traverse no more elements of *e* than necessary to return the result.

Arguments `length0p` requires one argument *e*, which must be a string or non-atomic.

See also `cmplength`, `length_eq`, and `length1p`.

Implementation `length0p` is implemented with `defmfun1`, which slows things down a bit. So be cautious using it in a tight loop.

12.3 Function: `length1p`

`length1p`(*e*)
next package: aex

Description Returns true if *e* is of length 1, false otherwise. This implementation traverse no more elements of *e* than necessary to return the result.

Arguments `length1p` requires one argument *e*, which must be a string or non-atomic.

See also `length0p`, `cmplength`, and `length_eq`.

Implementation `length1p` is implemented with `defmfun1`, which slows things down a bit. So be cautious using it in a tight loop.

12.4 Function: `length_eq`

`length_eq`(*e*, *n*)
next package: aex

Description Returns true if *e* is of length *n*, false otherwise. This implementation traverses no more elements of *e* than necessary to return the result.

Arguments `length_eq` requires two arguments. The first argument *e* must be a string or non-atomic. The second argument *n* must be a non-negative integer.

See also `length0p`, `cmplength`, and `length1p`.

Implementation `length_eq` is implemented with `defmfun1`, which slows things down a bit. So be cautious using it in a tight loop.

12.5 Function: type_of

type_of(*e* : optional *verbose*)

next package: aex

Description Return something like the ‘type’ of a maxima expression. This is a bit ill defined currently. `type_of` uses the lisp function `type-of`.

Arguments `type_of` requires either one or two arguments.

Examples

```
(%i1) type_of(1);
(%o1) ?bit
(%i1) type_of(1.0);
(%o1) ?double\~float
(%i2) type_of(1.0b0);
(%o2) ?bfloat
(%i3) type_of(1/3);
(%o3) /
(%i4) type_of("dog");
(%o4) ?string
(%i5) type_of([1,2,3]);
(%o5) [
(%i6) type_of(aex([1,2,3]));
(%o6) [
(%i7) type_of(%e);
(%o7) ?symbol
(%i8) type_of(%i);
(%o8) ?symbol
(%i9) type_of(%i+1);
(%o9) +
```

`type_of` returns the type of the lisp struct corresponding to a maxima object.

```
(%i1) load(graphs)$
(%i2) type_of(new_graph());
(%o2) graph
```

13 Functions and Variables for Program Flow

- `error_str`

13.1 Function: error_str

error_str()

next package: aex

Description Returns the last error message as a string.

Arguments `error_str` requires zero arguments.

See also `error` and `errormsg`.

14 Functions and Variables for Quicklisp

15 Functions and Variables for Runtime Environment

- `chdir`
- `dir_exists`
- `dirstack`
- `dont_kill`
- `dont_kill_share`
- `get_dont_kill`
- `mext_clear`
- `mext_info`
- `mext_list`
- `mext_test`
- `popdir`
- `probe_file`
- `pwd`
- `require`
- `trueename`

15.1 Function: `chdir`

`chdir`(:optional *dir*)
mext package: `mext.defmfun1`

Calling

`chdir`() Set the working directory to the value it had when `mext` was loaded.

`chdir`(*dir*) Set the working directory to *dir*.

Description Set the working directory for `maxima/lisp`. With some lisps, such as `cmu lisp` the system directory is changed as well. This should be made uniform across lisp implementations.

Arguments `chdir` requires either zero or one arguments. If present, the argument *dir* must be a string.

15.2 Function: `dir_exists`

`dir_exists`(*dir*)
mext package: `mext.defmfun1`

Description Returns the pathname as a string if *dir* exists, and `false` otherwise.

Arguments `dir_exists` requires one argument *dir*, which must be a string.

15.3 Function: `dirstack`

dirstack()

mext package: `mext.defmfun1`

Description Return a list of the directories on the directory stack. This list is manipulated with `chdir`, `updir`, and `popdir`.

Arguments `dirstack` requires zero arguments.

15.4 Function: `dont_kill`

dont_kill(:rest *item*)

mext package: `mext.defmfun1`

Description Add the *items* to the list of symbols that are not killed by `kill(all)`. This facility is part of the maxima core, but is apparently unused. Maybe putting a property in the symbol's property list would be better.

Arguments `dont_kill` requires zero or more arguments.

Attributes `dont_kill` has attributes: `[hold_all]`

15.5 Function: `dont_kill_share`

dont_kill_share(*package*)

mext package: `mext.defmfun1`

Description Prevent symbols in maxima share package *package* from being killed by `kill`.

Arguments `dont_kill_share` requires one argument *package*, which must be a string or a symbol.

15.6 Function: `get_dont_kill`

get_dont_kill()

mext package: `mext.defmfun1`

Description Returns the list of symbols that are not killed by `kill(all)`. Items are added to this list with `dont_kill`.

Arguments `get_dont_kill` requires zero arguments.

15.7 Function: `mext_clear`

mext_clear()

mext package: `mext.defmfun1`

Description Clears the list of me`x`t packages that have been loaded with `require`. Subsequent calls to `require` will reload the packages.

Arguments `mext_clear` requires zero arguments.

15.8 Function: `mext_info`

mext_info(*distname*)

mext package: `mext.defmfun1`

Description Print information about installed mext distribution *distname*. The list of installed distributions is built by calling `mext_list`.

Arguments `mext_info` requires one argument *distname*, which must be a string or a symbol.

15.9 Function: `mext_list`

`mext_list()`

mext package: `mext.defmfun1`

Description Returns a list of all installed mext distributions.

Arguments `mext_list` requires zero arguments.

15.10 Function: `mext_test`

`mext_test(:optional dists)`

mext package: `mext.defmfun1`

Description Run the test suites for a mext distribution or list of distributions. With no argument, a subfolder named `rtests` is searched for in the current directory.

Arguments `mext_test` requires either zero or one arguments. If present, the argument *dists* must be a string, a symbol, or a list of strings or symbols.

15.11 Function: `popdir`

`popdir(:optional n)`

mext package: `mext.defmfun1`

Description Pop a value from the current directory stack and `chdir` to this value. If *n* is given, pop *n* values and `chdir` to the last value popped.

Arguments `popdir` requires either zero or one arguments. If present, the argument *n* must be a non-negative integer.

15.12 Function: `probe_file`

Calling

`probe_file(filespec)` returns a string representing a canonical pathname to the file specified by *filespec*. False is returned if the file can't be found.

Description `Probe_File` tries to find a canonical pathname for a file specified by the string *filespec*.

Examples

```
(%i1) probe_file("a/b.txt");  
(%o1) "/home/username/c/a/b.txt"
```

15.13 Function: `pwd`

`pwd()`

mext package: `mext.defmfun1`

Description Return the current working directory.

Arguments `pwd` requires zero arguments.

15.14 Function: `require`

require(*distname* :optional *force*)
next package: `next.defmfun1`

Description Load the next package *distname* and register that it has been loaded. `require('all')` will load all installed next packages. If *force* is true, then *distname* is loaded even if it has been loaded previously.

Arguments `require` requires either one or two arguments. The first argument *distname* must be a string or a symbol.

15.15 Function: `truename`

Calling

`truename(filespec)` returns a string representing a canonical pathname to the file specified by *filespec*

Description `TrueName` tries to find a canonical pathanme for a file specified by the string *filespec*.

16 Functions and Variables for Strings

- `string_drop`
- `string_reverse`
- `string_take`
- `with_output_to_string`

16.1 Function: `string_drop`

string_drop(*s*, *spec*)
next package: `lists.aex`

Arguments `string_drop` requires two arguments. The first argument *s* must be a string. The second argument *spec* must be a sequence specification.

Examples

```
(%i1) string_drop("abracadabra",1);  
(%o1) bracadabra
```

```
(%i1) string_drop("abracadabra",-1);  
(%o1) abracadabr
```

```
(%i1) string_drop("abracadabra",[2,10]);  
(%o1) aa
```


16.2 Function: string_reverse

`string_reverse(s)`
next package: lists_aex

Calling

`string_reverse(s)` returns a copy of string *s* with the characters in reverse order.

Arguments `string_reverse` requires one argument *s*, which must be a string.

16.3 Function: string_take

`string_take(s, spec)`
next package: lists_aex

Calling

`string_take(s, n)` returns a string of the first *n* characters of the string *s*.

`string_take(s, -n)` returns a string of the last *n* characters of *s*.

Arguments `string_take` requires two arguments. The first argument *s* must be a string. The second argument *spec* must be a sequence specification.

Examples

```
(%i1) string_take("dog-goat-pig-zebra",[5,12]);  
(%o1) goat-pig
```

16.4 Function: with_output_to_string

Description Evaluates *expr_1*, *expr_2*, *expr_3*, ...

Examples

```
(%i1) sreverse(with_output_to_string(for i:5 thru 10 do print("i! for i=",i,i!)));  
(%o1)  
0088263 01 =i rof !i  
088263 9 =i rof !i  
02304 8 =i rof !i  
0405 7 =i rof !i  
027 6 =i rof !i  
021 5 =i rof !i
```

See also `with_stdout`.

17 Miscellaneous Functions

- `examples`
- `examples_add`

17.1 Function: examples

examples(*item*)

next package: defmfun1

Calling

examples(*item*) Print examples for the topic *item*. Note these examples are different from those extracted from the maxima manual with the command **example**.

Arguments **examples** requires one argument *item*, which must be a string or a symbol.

17.2 Function: examples_add

examples_add(*item*, *text*, *protected-var-list*, *code*)

next package: defmfun1

Calling

examples_add(*item*, *text*, *protected-var-list*, *code*) Add an example for item *item*. *text* will be printed before the example is displayed. *protected-var-list* is string giving a list of variables such as "[x,y]" that appear in the example code. The example code will be wrapped in a block that makes *protected-var-list* local. *code* may be a string or list of strings that is/are the example code.

Arguments **examples_add** requires four arguments. The first argument *item* must be a string or a symbol. The second argument *text* must be a string. The third argument *protected-var-list* must be a string. The fourth argument *code* must be a string or a list of strings.

Examples

Add an example for the function 'last'.

```
(%i1) examples_add("last", "Return the last item in a list.", "[a,b,c,d]", "last([a,b,c,d])") ;  
(%o1) done
```

18 Miscellaneous utilities

19 Options

Options to a function in the aex-maxima distribution are passed as follows:

funcname(x,y, [optname -i optval, optname2 -i optval2]) or funcname(x,y, optname -i optval, optname2 -i optval2)

The standard options described in this section are some options that are supported by many functions in the aex-maxima distribution.

- adj
- compile
- foptions
- ot

19.1 Option: adj

Description This option takes values of `true` or `false`. If `true`, then the output aex expression is adjustable, that is, the underlying array can be extended in size. If `false`, then the output aex expression is not adjustable. The non-adjustable array may have some advantages in efficiency, but I have not observed them, and this may be lisp-implementation dependent.

19.2 Option: compile

Description If this option is true, then lambda functions passed as arguments to a function will be automatically translated or compiled. If it is false they will be used as interpreted maxima code. Compiling lambda functions usually greatly decreases the execution time of the function if the lambda function is called many times.

19.3 Function: foptions

`foptions(name)`

Description Return a list of allowed options to `defmfun1` function *name*. I would prefer to call this `options`, but that name is taken by an unused, undocumented function.

Arguments `foptions` requires one argument *name*, which must be a string or a symbol.

19.4 Option: ot

Description With a value `ar` this option causes the function to return an array-representation expression. With a value `ml` a standard lisp list representation is returned. The array-representation is not a maxima array, but rather a more-or-less arbitrary maxima expression that is stored internally as an array. For certain operations, such as random access to elements of the expression, an array representation is faster than the standard list representation. One disadvantage of the array representations is that creating an array is relatively slow. For instance, execution time may be large if a function returns an expression with many small subexpressions that are in the array-representation. The majority of the maxima system does not understand array-representation, so conversion back to list-representation may be necessary.