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**With\_Gensyms Package**



# With\_Gensyms Package

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A Maxima Package  
for version \$WG\_VERSION, \$WG\_LAST\_UPDATED

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This manual documents the `with_gensyms` package (version `$WG_VERSION`, `$WG_LAST_UPDATED`), a user-level package for the Maxima computer algebra system.

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# 1 WITH\_GENSYMS

## 1.1 Introduction to WITH\_GENSYMS

WITH\_GENSYMS is a Maxima package that provides a user-level drop-in replacement for the function definition operator `:=`, and the macro definition operator `::=`.

In addition, it offers a macro, `with_gensyms`, as a general-purpose tool to re-write Maxima code using anonymous variable names, or gensyms.

## 1.2 Examples

Here is a sample of `with_gensyms`. Consider the following example where Maxima's scoping conventions introduce a difficult to understand bug.

```
(%i1) f(x,n) := x[n]          /* x is a local parameter to f */;
(%o1)          f(x, n) := x
                      n

(%i2) f(h,1);
(%o2)          h
              1

(%i3) f(x,3);
(%o3)          x
              3

(%i4) f(x,2);
(%o4)          x
              2

(%i5) x[2] : 2          /* x is now an undeclared array */;
(%o5)          2

(%i6) f(h,1);
(%o6)          x
              1

(%i7) f(x,3);
(%o7)          x
              3

(%i8) f(x,2);
(%o8)          2
```

The discrepancy in behavior is due to the creation of the undeclared array `x` in `%i5`. This introduces a global property on the symbol `x` that frustrates the expected behavior of `f`.

```
(%i1) load(with_gensyms)$
(%i2) x[2] : 2          /* x is now an undeclared array */;
(%o2)          2

(%i3) f(x,n) :> x[n]    /* :> function definition operator */;
(%o3)          f($x, $n) := $x
                      $n

(%i4) f(h,1);
(%o4)          h
              1

(%i5) f(x,3);
(%o5)          x
              3

(%i6) f(x,2);
(%o6)          2
```



## 1.5 Definitions for WITH\_GENSYMS

**wg\_reversealias** [User Option]

See the entry for [wg\_gensymize], page 2.

**gensym** [Feature]

A property of a symbol. Used by **wg\_gensymize** to ensure idempotency of that function. See the entry for [wg\_gensymize], page 2.

**wg\_make\_binding (undef)** [Function]

Creates a function of two variables, *x* and *y*, where *x* is an assignment *a*:*b*. If *y* = **undef**, then return *b*; otherwise return the binding *b*:*y*.

```
(%i8) map(wg_make_binding(undef), '[a:b,a:b], [undef,3]);
(%o8) [b, b : 3]
```

**wg\_check\_op (oper,expr)** [Function]

If *expr* is an atom or the operand of *expr* is not *oper*, signal an error; otherwise return *expr*.

**wg\_atom\_or\_quote (expr)** [Function]

If *expr* is an atom or the operand is **'**, return **true**; else return **false**.

**with\_gensyms (bindings, [body])** [Macro]

Replace the variables in *bindings* with gensyms, and substitute these into *body*.

```
(%i1) load(with_gensyms)$
(%i2) with_gensyms([x:1, y:2],
                  ['[x,y], [x,y]]);
(%o2) [[x, y], [1, 2]]
(%i3) with_gensyms([x,n], f(x) := a+x[n]);
(%o3) f(x) := a + $x
      $n
```

Here is an implementation of a lambda function using **with\_gensyms**:

```
(%i4) wg_lambda(vars,[body]) ::> buildq([vars:vars,body:body],
    with_gensyms(
        vars,
        lambda(vars,
            splice(body)))) $
(%i5) wg_lambda([x,y], if a=1 then x+1 else if a=2 then y+2 else a);
(%o5) lambda([$x, $y], if a = 1 then 1 + $x
    else (if a = 2 then 2 + $y else a))
(%i6) apply(%o5,'[u,v]);
(%o6) a
(%i7) apply(%o5,'[u,v]), a=1;
(%o7) u + 1
(%i8) apply(%o5,'[u,v]), a=2;
(%o8) v + 2
```

**wg\_listofvars (expr)** [Function]

Extract the list of variables appearing in *expr*, after removing constants (such as **%e**, **%pi**, etc.), dummy variables (such as **%r1**, etc.) and variables listed in **symbols**.



## Appendix A Code Listings

### A.1 SYMBOLS.LISP

```

;;/* -*- Mode: lisp -*- */
;;
;; $Id:$
;;
;; Author: Leo Butler (l_butler@users.sourceforge.net)
;;
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;;

(in-package :maxima)

(eval-when (:load-toplevel :compile-toplevel :execute)
  (defmacro defmmfun (f x &body body)
    '(progn (setf (get ',f 'source) (append (list 'defmfun ',f ',x) ',body))
      (defmfun ,f ,x ,@body))))

(defmmfun maxima-symbol-p (x)
  (let ((n (symbol-name x)))
    (and (or (> (length n) 2) (eq x t)))) ; single character symbols like $A should be discarded, but true=
  ; (or (char= (char n 0) #\$) (char= (char n 0) #\%))))

(declare (special $symbols))

(defmmfun $add_maxima_symbol (x &optional (s $symbols))
  (assert (or (symbolp x) ($listp x)))
  (cond ((symbolp x)
        (setf (gethash x s) t))
        (($listp x)
        (dolist (e (cdr x))
          ($add_maxima_symbol e s)))
        (t nil))
  '$done)

(defmvar $symbols
  (let ((s (make-hash-table :test #'eq)))
    (do-symbols (x :maxima)
      (if (maxima-symbol-p x) ($add_maxima_symbol x s))
    s))

```

```

(defmmfun $maxima_symbolp (x)
  (or (gethash x $symbols nil)
      (member x (mapcar #'caar (cdr $functions)) :test #'eq)))

(defmmfun $remove_maxima_symbols (x)
  (assert (listp x))
  (remove-if #'$maxima_symbolp x))

(defmmfun $delete_maxima_symbols (x)
  "Deletes 'x' from the hash-table of symbols '$symbols'. The input
may be a symbol or mlist of symbols."
  (assert (or ($listp x) (symbolp x)))
  (cond ((symbolp x)
         (remhash x $symbols))
        (($listp x)
         (dolist (e (cdr x)) (remhash e $symbols)))
        (t ;; never get here
         nil))
  '$done)

(defmmfun $maxima_symbols ()
  (let (s)
    (maphash (lambda (k v)
                (declare (ignore v))
                (push k s)) $symbols)
    (cons '(mlist simp) s)))

(defmmfun $wg_gensymize (x)
  (declare (special $wg_reversealias))
  (assert (symbolp x))
  ;; make function idempotent by returning a symbol produced by $wg_gensymize
  (cond ((mfuncall '$featurep x '$gensym)
         x)
        (t
         (let ((w (gensym (format nil "%~a_" (stripdollar x)))))
           (setf (get w 'reversealias) (if $wg_reversealias (make-symbol (format nil "%~a" x)) x))
           (mfuncall '$declare w '$gensym)
           w))))

;;/* end of symbols.lisp */

```

## A.2 WITH\_GENSYMS.MAC

```

/* -*- Mode: maxima; Package: MAXIMA -*- */
/*
 * $Id:$
 *
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 *
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*/

wg_reversealias : true $

load("symbols.lisp");
declare(gensym,feature) $

wg_make_binding(undef) := buildq([undef:undef],lambda([x,y],if is(y=undef) then rhs(x) else funmake(":",[rhs(x)
wg_check_op(oper,expr) := if atom(expr) or not(is(op(expr)=oper)) then error("a: expected operand ~a.",expr,o
wg_atom_or_quote(expr) := is(atom(expr) or op(expr)="'");

(
  with_gensyms(bindings,[body]) ::= block([vals,undef,simp:false],
    vals:map(lambda([x],if wg_atom_or_quote(x) then undef else rhs(wg_check_op(":",x))),bindings),
    bindings:map(lambda([x],if atom(x) then x else lhs(x)),bindings),
    bindings:map(lambda([x],funmake("=", [x,wg_gensymize(x)])),bindings),
    buildq([body:psubst(bindings,body),bindings:bindings,v:map(wg_make_binding(undef),bindings,vals)],
      block(v,splice(body))),
    /* bootstrap with_gensyms by using it to define itself! */
    apply(with_gensyms,['[bindings,body,vals,undef,x,v],%]))$

wg_listofvars(expr) := block([v,listconstvars:false,listdummyvars:false],
  v:unique(listofvars(expr)),
  for r in v do if not(atom(r)) then v:delete(r,v),
  v:remove_maxima_symbols(v),
  v)$
wg_funargs(expr) := block([listconstvars:true,listdummyvars:true],
  if atom(expr) then errcatch(wg_funargs(fundef(expr))) else
  if op(expr)=":=" or op(expr)="::=" then listofvars(part(expr,1)) else [] )$

/* substitutes for := and ::= */

kill(":>","::>") $
infix(":>",180,20) $
infix("::>",180,20) $
(x ::> y) ::= block([simp:false], buildq([v:unique(append(wg_listofvars(x),wg_funargs(x),wg_listofvars(y))),x:x
(x :> y) ::> block([simp:false], buildq([v:unique(append(wg_listofvars(x),wg_funargs(x),wg_listofvars(y))),x:x

(
  wg_redefun(fun,[vars]) := block([fd],
    fd:if atom(fun) then apply('fundef,[fun]) else if member(op(fun),[":=","::="]) then fun else error("argumen
    if vars=[] then vars:wg_listofvars(fd),
    apply('with_gensyms,[flatten(append(args(lhs(fd)),vars)),fd])),
    /* bootstrap wg_redefun by using it to define itself! */
    wg_redefun('wg_redefun,'fd));
  map(wg_redefun,['[wg_make_binding,wg_check_op,wg_atom_or_quote,"::>",wg_listofvars,wg_funargs]);

wg_lambda(vars,[body]) ::> buildq([vars:vars,body:body], with_gensyms(vars,lambda(vars,splice(body)))) $
wg_block(vars,[body]) ::> buildq([vars:vars,body:body], with_gensyms(vars,block (vars,splice(body)))) $

/* end of with_gensyms.mac */
1;

```

## Appendix B Function and Variable index

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