**solve** - Solve Equations

**Calling Sequence:**

```
solve(eqn, var)
```

```
solve(eqns, vars)
```

**Parameters:**

- `eqn` - an equation, inequality or procedure
- `eqns` - a set of equations or inequalities
- `var` - (optional) a name (unknown to solve for)
- `vars` - (optional) a set of names (unknowns to solve for)

**Description:**

- The solution to a single equation `eqn` solved for a single unknown `var` is returned as an expression. To solve a system of equations for some unknowns the system is specified as a set of equations `eqns` and a set of unknowns `vars`. The solutions for `vars` are returned as a set of equations.

- The output from `solve` in general is a sequence of solutions. In the case of multiple solutions, you should put the solutions in a list or set before manipulating them further. When `solve` is unable to find any solutions, the empty sequence NULL is returned. This means that either there are no solutions, or simply that `solve` was unable to find the solutions. If `solve` was unable to find some solutions, it will set the global variable `_SolutionsMayBeLost` to true.

- Two shortcuts for the input of equations and unknowns are provided. Wherever an equation is expected, if an expression `expr` is specified then the equation `expr = 0` is understood. If `vars` is not specified, Maple will solve for all the variables that appear in `eqns`, i.e. `indets(eqns,name)` is used in place of `vars`.

- In general, explicit solutions in terms of radicals for polynomial equations of degree greater than 4 do not exist. In these cases, implicit solutions are given in terms of `RootOfs`. Note that explicit solutions for the general quartic polynomial equation are not by default given because they are too complicated and messy to be of use. By setting the global variable `_EnvExplicit` to true then `solve` will return explicit solutions for quartic polynomials in all cases. By setting `_EnvExplicit` to false, all solutions which are not rational will be reported as `RootOfs`.

- The number of solutions found can be controlled by changing the value of the global variable `_MaxSols`. If an integer is assigned to `_MaxSols`, only those many solutions will be computed and returned. The variable `_EnvAllSolutions`, if set to true, will force all inverse transcendental functions to return the entire set of solutions. This usually requires additional, system created, variables, which take integer values. Normally such variables are named with prefix `_Z` for integer values, `_NN` for non-negative integer...
values and _B for binary values (0 and 1).

- A single quadratic equation with constant coefficients in one variable is solved directly by substitution into the quadratic formula. However, if _EnvTryHard is set to true, Maple will try to express solutions in the common radical basis. This may lead to a nicer answer, but can take a long time.

- When abs is used in the context of solve, solve assumes that the argument to abs is real-valued.

- For solving differential equations, use dsolve. For purely floating-point solutions use fsolve. Use isolve to solve for integer solutions, msolve to solve modulo a prime; rsolve for recurrences, and linalg[linsolve] to solve matrix equations.

- Further information is available for the subtopics solve[subtopic] where subtopic is one of

  float    function    identity    ineq    linear
  radical  scalar     series     system

- For systems of polynomial equations, the function Groebner[gsolve] which uses a Grobner-basis approach may be useful.

**Examples:**

```plaintext
> solve( f=m*a, a );

f
m

> solve( {f=m*a}, {a} );

{ a = f
m

> f := proc(x) x-cos(x) end proc:
solve( f(x),x );

RootOf(_Z - cos(_Z))

> eq := x^4-5*x^2+6*x=2;

eq := x^4 - 5 x^2 + 6 x = 2

> solve(eq,x);

1, 1, \sqrt{3} - 1, -1 - \sqrt{3}

> sols := [solve(eq,x)];
```
\[ \text{sols} := [1, 1, \sqrt{3} - 1, -1 - \sqrt{3}] \]

\[ \text{sols[1]}; \]

\[ 1 \]

\[ \text{evalf(sols)}; \]

\[ [1., 1., .732050808, -2.732050808] \]

\[ \text{sols := \{solve(eq,x)\}}; \]

\[ \text{sols} := \{1, -1 - \sqrt{3}, \sqrt{3} - 1\} \]

\[ \text{sols[1]}; \]

\[ 1 \]

\[ \text{subs( x=sols[1], eq ));} \]

\[ 2 = 2 \]

\[ \text{solve(x^4+x+1,x)}; \]

\[ \text{RootOf}(-_Z^4 + _Z + 1, \text{index} = 1), \text{RootOf}(-_Z^4 + _Z + 1, \text{index} = 2), \]

\[ \text{RootOf}(-_Z^4 + _Z + 1, \text{index} = 3), \text{RootOf}(-_Z^4 + _Z + 1, \text{index} = 4) \]

\[ \text{evalf\{\%\}}; \]

\[ \.7271360845 - .9340992895 \text{I}, -.7271360845 - .4300142883 \text{I}, \]

\[ -.7271360845 + .4300142883 \text{I}, .7271360845 + .9340992895 \text{I} \]

Manipulating Solutions: solve for u,v,w

\[ \text{eqns := \{u+v+w=1, 3*u+v=3, u-2*v-w=0\}}; \]

\[ \text{eqns} := \{3 \text{ u + v = 3, u - 2 v - w = 0, u + v + w = 1\}} \]

\[ \text{sols := solve( eqns )}; \]

\[ \text{sols} := \{v = \frac{3}{5}, w = \frac{-2}{5}, u = \frac{4}{5}\} \]

check solutions

\[ \text{subs( sols, eqns )}; \]
pick off one solution

> subs( sols, u );

\[ \frac{4}{5} \]

assign all solutions

> assign( sols );

\[ u; \]

\[ \frac{4}{5} \]

Other Examples

> solve( cos(x)+y = 9, x );

\[ \pi - \arccos(y - 9) \]

> solve( x^2+x>5, x );

\[ \left( \begin{array}{c}
\text{RealRange}(-\infty, \text{Open}\left(-\frac{1}{2} - \frac{1}{2} \sqrt{21}\right)) \\
\text{RealRange}\left(\text{Open}\left(-\frac{1}{2} + \frac{1}{2} \sqrt{21}\right), \infty\right)
\end{array} \right) \]

> solve( x^6-2*x^2+2*x, x );

\[ 0, \text{RootOf}(\_Z^5 - 2 \_Z + 2, \text{index} = 1), \text{RootOf}(\_Z^5 - 2 \_Z + 2, \text{index} = 2), \]
\[ \text{RootOf}(\_Z^5 - 2 \_Z + 2, \text{index} = 3), \text{RootOf}(\_Z^5 - 2 \_Z + 2, \text{index} = 4), \]
\[ \text{RootOf}(\_Z^5 - 2 \_Z + 2, \text{index} = 5) \]

> solve( \{x^2*y^2=0, x-y=1\} );

\[ \{ y = 0, x = 1 \}, \{ y = 0, x = 1 \}, \{ x = 0, y = -1 \}, \{ x = 0, y = -1 \} \]

> solve( \{x^2*y^2=0, x-y=1, x<>0\} );

\[ \{ y = 0, x = 1 \}, \{ y = 0, x = 1 \} \]

> solve( \{x^2*y^2-b, x^2-y^2-a\}, \{x,y\} );

\[ \{ y = \text{RootOf}(\_Z^4 + \_Z^2 a - b), x = \text{RootOf}(\_Z^2 - \text{RootOf}(\_Z^4 + \_Z^2 a - b)^2 - a) \} \]
> _EnvAllSolutions := true:
solve( sin(x)=cos(x)-1, x );

\[ -\frac{1}{2}\pi + 2\pi _Z1, 2\pi _Z2 \]

> r := solve(cos(x),x);

\[ r := \frac{1}{2}\pi + \pi _Z3~ \]

> subs(op(indets(r))=3, r);   # substitute 3 for _Z3~ in r

\[ \frac{7}{2}\pi \]

See Also:
RootOf, allvalues, dsolve, fsolve, isolve, msolve, rsolve, assign, invfunc, isolate, match, linalg[linsolve], simplex, Groebner