Introduction

> 1 + 2;

$$3$$

> 1 + 3/2;

$$\frac{5}{2}$$

> 2 * (3 + 1/3)/(5/3-4/5);

$$\frac{100}{13}$$

> 2.8754/2;

$$1.437700000$$

> 1 + 1/2;

$$\frac{3}{2}$$

Numerical Computations

Integer Computations

> 100!;

$$933262154439441526816992388562667004907159682643816214685929638952175999932299156089414639761565182862536979208272237582511852109168\backslash$$

$$640000000000000000000000$$

> length('');

$$3$$

> ifactor(60);

$$(2)^2 (3) (5)$$

> igcd(123,45);

$$3$$

> iquo(25,3);

$$8$$

> isprime(18002676583);

$$true$$

Exact arithmetic
Rationals, Irrationals, and Constants

> 1/2 + 1/3;

$$\frac{5}{6}$$

> Pi;

$$\pi$$

> evalf(Pi,100);

3.14159265358979323846264338327950288419716939937 \
51058209749445923078164062862089986280348 \
25342117068

> 1/3;

$$\frac{1}{3}$$

> evalf(");

$$.3333333333$$

> 3/2*5;

$$\frac{15}{2}$$

> 1.5*5;

$$7.5$$

> sqrt(2);

$$\sqrt{2}$$

> sqrt(3)^2;

$$3$$

> Pi;

$$\pi$$

> sin(Pi);

$$0$$

> exp(1);

$$e$$

> ln(exp(5));

$$5$$

Floating-Point Approximations

> evalf(Pi);

$$3.141592654$$

> evalf(Pi,200);

$$3.14159265358979323846264338327950288419716939937510582097494459230781640628620899862803482534211706798214808651328230664709384460955058223172535940812848111745028410270193852110555964462294895493038$$

> 1/3 + 1/4 + 1/5.3;

$$.7720125786$$

> sin(0.2);

$$.1986693308$$

> Digits := 20;

$$Digits := 20$$

> sin(0.2);

$$.19866933079506121546$$

Arithmetic with Special Numbers

> (2 + 5*I) + (1 - I);

$$3 + 4\,I$$

> (1 + I)/(3 - 2*I);

$$\frac{1}{13} + \frac{5}{13}\,I$$

> convert(247,binary);

$$11110111$$

> convert(1023,hex);

$$3FF$$

> convert(17,base,3);

$$[2, 2, 1]$$

> 27 mod 4;

$$3$$

> mods(27,4);

$$-1$$

> modp(27,4);

$$3$$

Mathematical Functions

> sin(Pi/4);

$$\frac{1}{2}\sqrt{2}$$

> ln(1);

$$0$$

> ln(Pi);

$$\ln(\pi)$$

Basic Symbolic Computations

> (1 + x)^2;

$$(x + 1)^2$$

> (1 + x) * (3 - 2*x);

$$(x + 1)\,(3 - 2\,x)$$

> expand((1+x)^2);

$$x^2 + 2\,x + 1$$

> factor(");

$$(x + 1)^2$$

> Diff(sin(x),x);

$$\frac{\partial}{\partial x}\sin(x)$$

> value(");

$$\cos(x)$$

> diff(cos(x),x$2);

$$-\cos(x)$$

> int(1/sqrt(1-x^2),x);

$$\arcsin(x)$$

> Sum(n^2,n);

$$\sum_n n^2$$

> value(");

$$\frac{1}{3} n^3 - \frac{1}{2} n^2 + \frac{1}{6} n$$

> rem(x^3+x+1,x^2+x+1,x);

$$x + 2$$

> series(sin(x), x=0, 10);

$$x - \frac{1}{6} x^3 + \frac{1}{120} x^5 - \frac{1}{5040} x^7 + \frac{1}{362880} x^9 + \mathrm{O}(x^{10})$$

Assigning Names to Expressions

> var := x;

$$var := x$$

> term = x*y;

$$term = x\,y$$

> eqs := x = y + 2;

$$eqs := x = y + 2$$

> f := x -> 2*x^2 - 3*x + 4;

$$f := x \to 2\,x^2 - 3\,x + 4$$

> plot(f(x),x=-5..5);

> f := x -> x^2;

$$f := x \to x^2$$

> f(5);

25

> f(y+1);

$$(y+1)^2$$

> Pi := 3.14;

```
Error, attempting to assign to ‘Pi‘ which is protected
```

> set := {1, 2, 3};

```
Error, attempting to assign to ‘set‘ which is protected
```

More Basic Type of Maple Objects

Expression Sequences

> 1, 2, 3, 4;

$$1, 2, 3, 4$$

> x, y, z, w;

$$x, y, z, w$$

> a.b;

$$ab$$

> S := 1, 2, 3, 4;

$$S := 1, 2, 3, 4$$

> a.S;

$$a1, a2, a3, a4$$

Lists

> data_list := [1, 2, 3, 4, 5];

$$data_list := [1, 2, 3, 4, 5]$$

> polynomials := [x^2 + 3, x^2 + 3*x - 1, 2*x];

$$polynomials := [x^2 + 3, x^2 + 3\,x - 1, 2\,x]$$

> participants := [Kathy, Frank, Rene, Niklaus, Liz];

$$participants := [Kathy, Frank, Rene, Niklaus, Liz]$$

> [a, b, c], [b, c, a], [a, a, b, c, a];

$$[a, b, c], [b, c, a], [a, a, b, c, a]$$

> letters := [a, b, c];

$$letters := [a, b, c]$$

> letters[2];

$$b$$

> nops(letters);

$$3$$

> op(letters);

$$a, b, c$$

Sets

> data_set := {1, -1, 0, 10, 2};

$$data_set := \{2, 0, 10, -1, 1\}$$

> unknowns := {x, y, z};

$$unknowns := \{x, y, z\}$$

> {a, b, c}, {c, b, a}, {a, a, b, c, a};

$$\{a, b, c\}, \{a, b, c\}, \{a, b, c\}$$

> {1, 2, 2.0};

$$\{2.0, 2, 1\}$$

> {a,b,c} union {c,d,e};

$$\{a, b, c, d, e\}$$

> {1, 2, 3, a, b, c} intersect {1, a};

$$\{1, a\}$$

> nops(");

$$2$$

> op({1, 2, 3, a, b});

$$2, 3, 1, a, b$$

> numbers := {0, Pi/3, Pi/2, Pi};

$$numbers := \left\{0, \pi, \frac{1}{3}\pi, \frac{1}{2}\pi\right\}$$

> map(g, numbers);

$$\left\{g(0), g(\pi), g\left(\frac{1}{3}\pi\right), g\left(\frac{1}{2}\pi\right)\right\}$$

> map(sin, numbers);

$$\left\{0, 1, \frac{1}{2}\sqrt{3}\right\}$$

Operations on Sets and Lists

> participants := [Kate, Tom, Steve];

$$participants := [Kate, Tom, Steve]$$

> member(Tom,participants);

$$true$$

> data_set := {5, 6, 3, 7};

$$data_set := \{7, 6, 5, 3\}$$

> member(2, data_set);

$$false$$

> participants := [Kate, Tom, Steve];

$$participants := [Kate, Tom, Steve]$$

> participants[2];

$$Tom$$

> empty_set := {};

$$empty_set := \{\ \}$$

> empty_list := [];

$$empty_list := [\ ]$$

> old_set := {2, 3, 4} union {};

$$old_set := \{2, 4, 3\}$$

> new_set := old_set union {2, 5};

$$new_set := \{2, 5, 4, 3\}$$

> third_set := old_set minus{2,5};

$$third_set := \{4, 3\}$$

Arrays

> squares := array(1..3);

$$squares := \text{array}(1 .. 3, [\ ])$$

> squares[1] := 1; squares[2] := 2^2; squares[3] := 3^2;

$$squares_1 := 1$$

$$squares_2 := 4$$

$$squares_3 := 9$$

> cubes := array(1..3,[1,8,27]);

$$cubes := [1 \quad 8 \quad 27]$$

> squares[2];

$$4$$

> squares;

$$squares$$

> print(squares);

$$[1 \quad 4 \quad 9]$$

> pwrs := array(1..3,1..3);

$$pwrs := \text{array}(1 .. 3, 1 .. 3, [\ ])$$

> pwrs[1,1] := 1; pwrs[1,2] := 1; pwrs[1,3] := 1;

$$pwrs_{1,1} := 1$$

$$pwrs_{1,2} := 1$$

$$pwrs_{1,3} := 1$$

> pwrs[2,1] := 2: pwrs[2,2] := 4: pwrs[2,3] := 8:

> pwrs[3,1] := 3: pwrs[3,2] := 9: pwrs[3,3] := 27:
> print(pwrs);

$$\begin{bmatrix} 1 & 1 & 1 \\ 2 & 4 & 8 \\ 3 & 9 & 27 \end{bmatrix}$$

> pwrs[2,3];

$$8$$

> pwrs2 := array(1..3, 1..3 ,[[1,1,1], [2,4,8], [3,9,27]]);

$$pwrs2 := \begin{bmatrix} 1 & 1 & 1 \\ 2 & 4 & 8 \\ 3 & 9 & 27 \end{bmatrix}$$

> array3 := array(1..2, 1..2, 1..2,
> [[[1,2], [3,4]], [[5,6], [7,8]]]);

$$array3 := \text{array}(1 .. 2, 1 .. 2, 1 .. 2, [$$
$$(1, 1, 1) = 1$$
$$(1, 1, 2) = 2$$
$$(1, 2, 1) = 3$$
$$(1, 2, 2) = 4$$
$$(2, 1, 1) = 5$$
$$(2, 1, 2) = 6$$
$$(2, 2, 1) = 7$$
$$(2, 2, 2) = 8$$
$$])$$

> expr := z^2 + 3;

$$expr := z^2 + 3$$

> subs({z = x + y}, expr);

$$(x + y)^2 + 3$$

> subs({2=9}, pwrs);

$$pwrs$$

> subs({2=9}, evalm(pwrs));

$$\begin{bmatrix} 1 & 1 & 1 \\ 9 & 4 & 8 \\ 3 & 9 & 27 \end{bmatrix}$$

> evalm(pwrs);

$$\begin{bmatrix} 1 & 1 & 1 \\ 2 & 4 & 8 \\ 3 & 9 & 27 \end{bmatrix}$$

Tables

> translate := table([one=un, two=deux, three=trois]);

$$translate := \text{table}([$$
$$three = trois$$
$$two = deux$$
$$one = un$$
$$])$$

```
> translate[two];
```

$$deux$$

```
> earth_data := table( [mass = [5.976*10^24,kg],
>                       radius = [6.378164*10^6,m],
>                       circumference = [4.00752*10^7,m] ] );
```

$$earth_data := \mathrm{table}([\ mass = [\ .5976000000000000000\ 10^{25}, kg\ ],\ radius = [\ .6378164000000\ 10^{7}, m\ ],\ circumference = [\ .4007520000000\ 10^{8}, m\ ]\ ])$$

```
> Digits := 10;
```

$$Digits := 10$$

```
> earth_data[mass];
```

$$[\ .5976000000000000000\ 10^{25}, kg\ ]$$

EXPRESSION MANIPULATION

The simplify Command

```
> expr := cos(x)^5 + sin(x)^4 + 2*cos(x)^2
> - 2*sin(x)^2 - cos(2*x);
```

$$expr := \cos(x)^5 + \sin(x)^4 + 2\cos(x)^2 - 2\sin(x)^2 - \cos(2x)$$

```
> simplify(expr);
```

$$\cos(x)^5 + \cos(x)^4$$

> simplify(sin(x)^2 + ln(2*y) + cos(x)^2);

$$1 + \ln(2) + \ln(y)$$

> simplify(sin(x)^2 + ln(2*y) + cos(x)^2,'trig');

$$1 + \ln(2\,y)$$

> simplify(sin(x)^2 + ln(2*y) + cos(x)^2,'ln');

$$\sin(x)^2 + \ln(2) + \ln(y) + \cos(x)^2$$

> siderel := {sin(x)^2 + cos(x)^2 = 1};

$$siderel := \left\{ \sin(x)^2 + \cos(x)^2 = 1 \right\}$$

> trig_expr := sin(x)^3 - sin(x)*cos(x)^2 + 3*cos(x)^3;

$$trig_expr := \sin(x)^3 - \sin(x)\cos(x)^2 + 3\cos(x)^3$$

> simplify(trig_expr,siderel);

$$2\sin(x)^3 - 3\cos(x)\sin(x)^2 + 3\cos(x) - \sin(x)$$

The factor Command

> big_poly := x^5 - x^4 - 7*x^3 + x^2 + 6*x;

$$big_poly := x^5 - x^4 - 7\,x^3 + x^2 + 6\,x$$

> factor(big_poly);

$$x\,(x - 1)\,(x - 3)\,(x + 2)\,(x + 1)$$

> rat_expr := (x^3 - y^3) / (x^4 - y^4);

$$rat_expr := \frac{x^3 - y^3}{x^4 - y^4}$$

> factor(rat_expr);

$$\frac{x^2 + x\,y + y^2}{(x + y)\,(x^2 + y^2)}$$

The expand Command

> expand((x+1)*(x+2));

$$x^2 + 3\,x + 2$$

> expand(sin(x+y));

$$\sin(x)\cos(y) + \cos(x)\sin(y)$$

> expand(exp(a+ln(b)));

$$\mathrm{e}^{a}\,b$$

> expand((x+1)*(y+z),x+1);

$$(x + 1)\,y + (x + 1)\,z$$

The convert Command

> convert(cos(x),exp);

$$\frac{1}{2}\,\mathrm{e}^{(I\,x)} + \frac{1}{2}\,\frac{1}{\mathrm{e}^{(I\,x)}}$$

> convert(1/2*exp(x)+1/2*exp(-x),trig);

$$\cosh(x)$$

> A := array(1..2,1..2,[[a,b], [c,d]]);

$$A := \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

> convert(A,'listlist');

$$[[a, b], [c, d]]$$

> convert(A,'set');

$$\{a, b, c, d\}$$

> convert('',list);

$$[a, b, c, d]$$

The normal Command

> rat_expr_2 := (x^2 - y^2) / (x - y)^3;

$$rat_expr_2 := \frac{x^2 - y^2}{(x - y)^3}$$

> normal(rat_expr_2);

$$\frac{x + y}{(x - y)^2}$$

> normal(rat_expr_2,'expanded');

$$\frac{x + y}{x^2 - 2\,x\,y + y^2}$$

The combine Command

> combine(exp(x)^2*exp(y),exp);

$$e^{(2x+y)}$$

> combine((x^a)^2,power);

$$x^{(2a)}$$

> expr := (x +1)^(1/2)*(x+2)^(1/2);

$$expr := \sqrt{x+1}\,\sqrt{x+2}$$

> combine(expr);

$$\sqrt{x^2+3x+2}$$

The map Command

> map(g, [a, b, c]);

$$[\,g(a), g(b), g(c)\,]$$

> data_list := [0, Pi/2, 3*Pi/2, 2*Pi];

$$data_list := \left[0, \frac{1}{2}\pi, \frac{3}{2}\pi, 2\pi\right]$$

> map(sin,data_list);

$$[\,0, 1, -1, 0\,]$$

> map(g, [a,b,c], x, y);

$$[\,g(a,x,y), g(b,x,y), g(c,x,y)\,]$$

> fcn_list := [sin(x),ln(x),x^2];

$$fcn_list := [\,\sin(x), \ln(x), x^2\,]$$

> map(Diff,fcn_list,x);

$$\left[\frac{\partial}{\partial x}\sin(x), \frac{\partial}{\partial x}\ln(x), \frac{\partial}{\partial x}x^2\right]$$

> map(value,");

$$\left[\cos(x), \frac{1}{x}, 2\,x\right]$$

> map(x->x^2,[-1, 0, 1, 2, 3]);

$$[1, 0, 1, 4, 9]$$

The lhs and rhs Commands

> eqn1 := x + y = z + 3;

$$eqn1 := x + y = z + 3$$

> lhs(eqn1);

$$x + y$$

> rhs(eqn1);

$$z + 3$$

The numer and denom Commands

> numer(3/4);

$$3$$

> denom(1/(1 + x));

$$x + 1$$

The nops and op Commands

> nops(x^2);

$$2$$

> nops(x+y);

$$2$$

> op(x^2);

$$x, 2$$

> op(1,x^2);

$$x$$

> op(2,x^2);

$$2$$

> op(1..2,x+y+z+w);

$$x, y$$

Common Questions about Expression Manipulation

> expr := a^3 * b^2;

$$expr := a^3\, b^2$$

> subs(a*b = 5, expr);

$$a^3\, b^2$$

> simplify(expr,{a*b=5});

$$25\, a$$

> expr2 := cos(x) * (sec(x) - cos(x));

$$expr2 := \cos(x)\,(\sec(x) - \cos(x))$$

> simplify(expr2);

$$1 - \cos(x)^2$$

> simplify(",{1-cos(x)^2=sin(x)^2});

$$\sin(x)^2$$

> x^19 -x;

$$x^{19} - x$$

> factor(");

$$x\,(x - 1)\,(x^2 + x + 1)\,(x^6 + x^3 + 1)\,(x + 1)\,(1 - x + x^2)\,(1 - x^3 + x^6)$$

> 2 * (x + y);

$$2\,x + 2\,y$$

> expr3 := 2*(x + y);

$$expr3 := 2\,x + 2\,y$$

> subs(2=two, expr3);

$$x\,two + y\,two$$

> factor(");

$$two\,(x + y)$$

>