

Command Line

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)cd <pathname>
)clear all -- clear workspace
)display op <function> -- function arguments
)set message autoload off -- quietly load algebra
)set message bottom on -- show selection process
)set stream calculate 20 -- number of terms to calculate
)show <domain> -- list all functions
)spool <filename> -- start save session
)spool -- close spool file
)trace <domain> )math -- trace execution
)quit -- exit Axiom
)read <filename>[.input] -- evaluate a file
)sys <command line> -- execute command
_ continues input lines or escapes chars a_ b = "a b"
% is last value
%%(n) is nth value
-- and ++ start comment lines

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Programming

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assignment: var := value
            x:=3
conditional: if <pred> then <truecase> else <falsecase>
            if (2 > 4) then 4 else 5
loop: for <pred> repeat (block)
      for i in 1..5 repeat print i
      while i < 3 repeat (print i ; i:=i+1)
function: f(x) = x^2
          f(x)==x^2
anon. function: g:=x --> x+1    g(3) -> 4
Indentation is significant:
          f(x)==(x > 3 => x ; 0)
          f(x)==
              x > 3 => x
              0

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Basic constants and functions

π = %pi e = %e i = %i ∞ = %infinity
 $+\infty$ = %plusInfinity $-\infty$ = %minusInfinity
 numeric(%pi) = 3.1415926535 897932385
 Functions: sin cos tan sec csc cot sinh cosh tanh

sech csch coth log ln exp
 $a^b = \mathbf{a}^*\mathbf{b}$ $\frac{a}{b} = \mathbf{a}/\mathbf{b}$ $a^b = \mathbf{a}^{\wedge}\mathbf{b}$ $\sqrt{x} = \mathbf{sqrt}(x)$
 $\sqrt[n]{x} = \mathbf{x}^{\wedge}(1/\mathbf{n})$ $|x| = \mathbf{abs}(x)$ $\log_b(x) = \mathbf{log}(x)/\mathbf{log}(b)$

Operations on expressions

factor(...) expand(...) simplify(...)

Symbolic equations: f(x)=g(x)

Solve $f(x) = g(x)$: solve(f(x)=g(x),x)

solve([x^2*y-1,x*y^2-2],.01)
 → [[y = 1.5859375, x = 0.79296875]]

complexSolve([x^2*y-1,x*y^2-2],1/1000)

radicalSolve([x^2/a+a*y^3-1,a*y+a+1],[x,y])

$\sum_{i=k}^n f(i) = \mathbf{reduce}(+,[f(i) \text{ for } i \text{ in } k..n])$

$\prod_{i=k}^n f(i) = \mathbf{reduce}(*,[f(i) \text{ for } i \text{ in } k..n])$

Pattern Matching

logrule:=rule log(x)+log(y) == log(x*y) →
 log(y)+log(x)+%B==log(x y)+%B

f:=log sin x + log x → log(sin(x))+log(x)

logrule f → log(x sin(x))

Calculus

$\lim_{x \rightarrow a} f(x) = \mathbf{limit}(f(x), x=a)$

$\lim_{x \rightarrow a^-} f(x) = \mathbf{limit}(f(x), x=a, \text{"left"})$

$\lim_{x \rightarrow a^+} f(x) = \mathbf{limit}(f(x), x=a, \text{"right"})$

$\lim_{x \rightarrow \infty} f(x) = \mathbf{limit}(f(x), x=\%plusInfinity)$

$\mathbf{limit}(\sin(x)/x, x=\%plusInfinity) \rightarrow 0$

$\mathbf{complexLimit}(\sin(x)/x, x=\%infinity) \rightarrow \text{"failed"}$

$\frac{d}{dx}(f(x)) = \mathbf{D}(f(x), x)$

$\frac{\partial}{\partial x}(f(x, y)) = \mathbf{D}(f(x, y), x)$

$\int f(x)dx = \mathbf{integrate}(f(x), x)$

$\int_a^b f(x)dx = \mathbf{integrate}(f(x), x=a..b)$

Series

x:=series 'x

y:=sin(x) → $x - \frac{1}{6}x^3 + \frac{1}{120}x^5 - \frac{1}{5040}x^7 + O(x^9)$

coefficient(y,3) → $-\frac{1}{6}$

taylor(f(x),x=a)

laurent(x/log(x),x=1)

puiseux(sqrt(sec(x)),x=3*%pi/2)

2D graphics

draw(cos(5*t/8),t=0..16*%pi,coordinates==polar)

f(t:SF):SF == sin(3*t/5)

g(t:SF):SF == sin(t)

draw(curve(f,g),0..%pi)

draw(x^2+y^3-1=0,x,y,range==[-1..1,-1..1])

v1:=draw(Gamma(i),i=-4.2..4,adaptive==true)

v2:=draw(1/Gamma(i),i=-4.2..4,adaptive==true)

putGraph(v2,getGraph(v1,1),2)

makeViewport2D(v2)

options: adaptive clip toScale curveColor pointColor

unit range coordinates

3D graphics

m(u:SF,v:SF):SF == 1

draw(m,0..2*%pi,0..%pi,coordinates==spherical)

options: title style colorFunction coordinates tubeRadius

tubePoints var1Steps var2Steps space

Discrete math

$\lfloor x \rfloor = \mathbf{floor}(x)$ $\lceil x \rceil = \mathbf{ceiling}(x)$

Remainder of n divided by $k = \mathbf{rem}(n,k)$, $k|n$ iff $\mathbf{n}\%k==0$

$n! = \mathbf{factorial}(n)$ $\binom{x}{m} = \mathbf{binomial}(x,m)$

$\phi(n) = \mathbf{eulerPhi}(n)$ Tuples: (1,'Hello,x)

Type Conversions

$r := (2/3)*x^2 - y + 4/5 \rightarrow -y + \frac{2}{3}x^2 + \frac{4}{5}$

Type: Polynomial Fraction Integer

$r::\mathbf{FRAC POLY INT} \rightarrow \frac{-15y+10x^2+12}{15}$

Type: Fraction Polynomial Integer

$s := (3+4*i)/(7+3*i) \rightarrow \frac{33}{58} + \frac{19}{58}i$

$s::\mathbf{FRAC COMPLEX INT} \rightarrow \frac{3+4%i}{7+3%i}$

Equation

eq1:=3*x+4*y=5 → $4y + 3x = 5$

eq2:=2*x+2*y=3 → $2y + 2x = 3$

lhs eq1 → $4y + 3x$

rhs eq1 → 5

eq1+eq2 → $6y + 5x = 8$

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| Factored |
| g:=factor(4312) → 2 ³ 7 ² 11 |
| unit g → 1 |
| numberOfFactors g → 3 |
| nthFactor(g,2) → 7 |
| nthExponent(g,2) → 2 |
| nthFlag(g,2) → "prime" |
| map(factor,55739/2520) → $\frac{139}{2^3} \frac{401}{3^2} \frac{7}{5} \frac{7}{7}$ |

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| List |
| a:=[1,2,3,4] → [1, 2, 3, 4] |
| b:=[3,4,5,6] → [3, 4, 5, 6] |
| append(a,b) → [1, 2, 3, 4, 3, 4, 5, 6] |
| cons(10,a) → [10, 1, 2, 3, 4] |
| empty? a → false |
| a.2 → 2 |
| a.2 := 99 → [1, 99, 3, 4] |
| reverse b → [6, 5, 4, 3] |

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| MakeFunction |
| expr :=(x + a) ³ → $x^3 + 3ax^2 + 3a^2x + a^3$ |
| function(expr,f,x) → f |
| f(2) → $a^3 + 6a^2 + 12a + 8$ |
| function(expr,g,a) → g |
| g(2) → $x^3 + 6x^2 + 12x + 8$ |

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| Matrix |
| A:=matrix([[1,2],[3,4]]) → $\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ |
| determinant A → -2 |
| v:=vector([1,2]) → [1, 2] |
| A*v → [5, 11] |
| A ⁻¹ → $\begin{bmatrix} \frac{2}{3} & \frac{1}{2} \\ \frac{3}{2} & \frac{1}{2} \end{bmatrix}$ |
| transpose(A) → $\begin{bmatrix} 1 & 3 \\ 2 & 4 \end{bmatrix}$ |
| nrows A → 2 |
| ncols A → 2 |
| nullity A → 0 |
| rank A → 2 |
| trace A → 5 |

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| Polynomial |
| x+1 yields Type Polynomial Integer |
| z-2.3 yields Type Polynomial Float |
| y ² -z+3/4 yields Type Polynomial Fraction Integer |
| p :=(y -1) ² * x * z → $(xy^2 - 2xy + x)z$ |
| q :=(y -1)* x *(z +5) → $(xy - x)z + 5xy - 5x$ |
| gcd(p,q) → $xy - x$ |
| mainVariable p → z |
| variables p → [z, y, x] |
| degree(p,y) → 2 |
| totaldegree p → 4 |
| eval(p,x,w) → $(wy^2 - 2wy + w)z$ |
| D(p,x) → $(y^2 - 2y + 1)z$ |
| integrate(p,x) → $(\frac{1}{2}x^2y^2 - x^2y + \frac{1}{2}x^2)z$ |

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| PrimeField |
| x:PrimeField(7):=5 → 5 |
| x ³ → 6 |
| 1/x → 3 |

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| Set |
| s :=brace([1,2,3,4,5]) → {1, 2, 3, 4, 5} |
| t :=brace([2,3,5,7]) → {2, 3, 5, 7} |
| intersect(s,t) → {2, 3, 5} |
| union(s,t) → {1, 2, 3, 4, 5, 7} |
| difference(s,t) → {1, 4} |
| insert!(7,s) → {1, 2, 3, 4, 5, 7} |
| remove!(7,s) → {1, 2, 3, 4, 5} |
| {1, 2, 1, <i>a</i> } = brace([1,2,1,'a]) (= {1, 2, <i>a</i> }) |
| { <i>f</i> (<i>x</i>) : <i>x</i> ∈ <i>X</i> , <i>x</i> > 0} ≈brace([f(x) for x in X x>0]) |

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| Special Functions |
| [fibonacci(k) for k in 0..] → [0,1,1,2,3,5,...] |
| [legendre(i,11) for i in 0..5] → [0,1,- 1,1,1,1] |
| [jacobi(i,15) for i in 0.5] → [0,1,1,0,1,0] |
| [eulerPhi i for i in 1..] → [1,1,2,2,4,2,...] |
| [moebiusMu i for i in 1..] → [1,- 1,- 1,0,- 1,1,...] |
| E1(0.01) → 4.0379295765381134 |
| Gamma(0.01) → 99.432585119150588 |

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| Stream |
|)set streams calculate 6 |
| ints := [i for i in 1..] → [1,2,3,4,5,6,...] |
| ints.20 → 20 |
| [i for i in ints odd? i] → [1,3,5,7,9,11,...] |

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| String |
| creation: s:= "Hello" |
| concatenate "He" "llo" → "Hello" |
| s(1)='H' s.1='H' s(2..3)='el' s(4..)= 'lo' |
| split("hi there",char " ") → ["hi","there"] |
| prefix?("He","Hello") → true |
| substring?("ll","Hello",3) → true |

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| TwoDimensionalArray |
| creation: arr :ARRAY2 INT:=new(2,3,0) → $\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ |
| nrows arr → 2 |
| ncols arr → 3 |
| setelt(arr,1,1,17) → $\begin{bmatrix} 17 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$ |
| arr(1,1) → 17 |

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| Univariate Polynomial |
| creation: p :UP(x,INT):=(3*x-1) ² *(2*x+8) |
| q :UP(x,INT):=(1-6*x+9*x ²) ² |
| leadingCoefficient p → 18 |
| degree p → 3 |
| reductum p → $60x^2 - 46x + 8$ |
| gcd(p,q) → $9x^2 - 6x + 1$ |
| lcm(p,q) → $162x^5 + 432x^4 - 756x^3 + 408x^2 - 94x + 8$ |
| resultant(p,q) → 0 |
| p(2) → 300 (used as function) |
| D(p) → $54x^2 + 120x - 46$ (derivative) |

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| Vector |
| creation: v := vector([1,2,3,4,5]) → [1, 2, 3, 4, 5] |
| length: #v → 5 |
| access: v.2 → 2 |
| add: v+v → [2, 4, 6, 8, 10] |
| multiply: 5*v → [5, 10, 15, 20, 25] |
| assign: v.2 := 7 → [1, 7, 3, 4, 5] |