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Math Cell

Syntax

Assignment including number with units:

$x = 10\,[m]$

Multiple assignments:

$y = 2\,[m]\,,\ z = 5\,[N]$

Query to evaluate expression:

$z \cdot (x \cdot y)^{-1} =$ $0.25\,[Pa]$

Specifying preferred units for a query result:

$z \cdot (x \cdot y)^{-1} = [psi]$ $= 3.63 \times 10^{-5}\,[psi]$

Combined assignment and query:

$Pressure = z \cdot (x \cdot y)^{-1} =$ $0.25\,[Pa]$

Predefined variables (cannot be redefined, type **pi** for π):

$\pi =$ 3.14159265358979 $e =$ 2.71828182845905 $i =$ $\sqrt{-1}$

Comment mode toggled with the quotation mark key:

$\sigma = \frac{M \cdot y}{I}$ Bending stress equation

The expression above can be called as a function:

$\sigma\,(M = 1\,[kN \cdot m]\,,\ y = 1\,[mm]\,,\ I = 1\,[m^4]) =$ $1\,[Pa]$

Math Field Keyboard Shortcuts

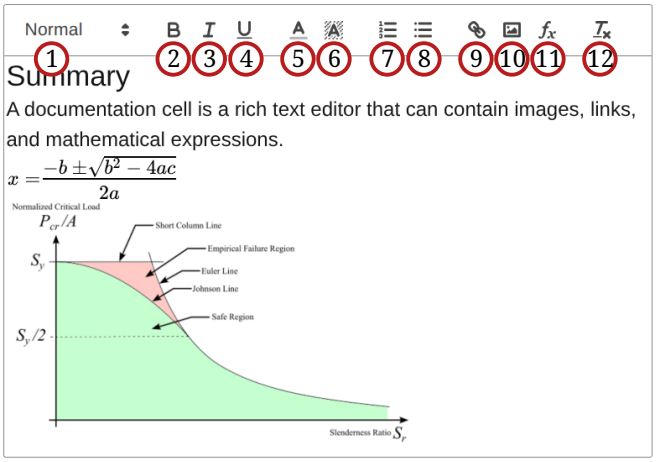
^	Add exponent
_	Add subscript
*	Multiply
/	Divide
Ctrl/Cmd + E	Insert scientific notation
Tab	Move out of exponent or subscript
"	Toggle comment mode
Type **sqrt**	Insert square root

Spell out a Greek character to insert (may be proceeded by \ to insert immediately): **alpha**, **beta**, **gamma**, **delta**, **epsilon**, **zeta**, **eta**, **theta**, **iota**, **kappa**, **lambda**, **mu**, **nu**, **xi**, **pi**, **rho**, **sigma**, **tau**, **phi**, **chi**, **psi**, **omega**, **Gamma**, **Delta**, **Theta**, **Lambda**, **Xi**, **Pi**, **Sigma**, **Upsilon**, **Phi**, **Psi**, and **Omega**

Type **\int**	Insert integral
Type **\der**	Insert derivative
Type **\dder**	Insert double derivative
Type **\tder**	Insert triple derivative
Type **\sum**	Insert summation notation
Type **\prod**	Insert product notation
Type **\hat**	Add hat accent to variable name
Type **\bar**	Add bar accent to variable name
Type **\vec**	Add vector accent to variable name
Type **\dot**	Add dot accent to variable name
Type **\ddot**	Add double dot accent to variable name
'	Add prime to variable name
← or → or ↓ or ↑	Navigate within math field

Live Tutorial

Documentation Cell



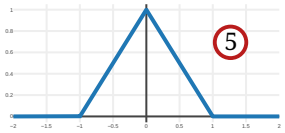
1. Set heading level
2. Toggle bold text — Ctrl/Cmd + B
3. Toggle italics text — Ctrl/Cmd + I
4. Toggle underline text — Ctrl/Cmd + U
5. Set text color
6. Set text background color
7. Insert numbered list
8. Insert bulleted list
9. Insert link — Ctrl/Cmd + K
10. Insert image (images may also be pasted)
11. Insert formula (uses LaTeX notation) — Ctrl/Cmd + E
12. Remove text formatting

Ctrl/Cmd + Z Undo edit in current field

Ctrl + Y or Cmd + Shift + Z Redo edit in current field

Piecewise Expression Cell

$$triangle = \begin{cases} x+1 & \text{if } -1 \le x \le 0 \\ -(x-1) & \text{if } 0 \le x \le 1 \\ 0 & \text{otherwise} \end{cases}$$



$triangle\,(x = -.5) =$ 0.5

1. Expression is assigned to this variable
2. Values that are assigned to the variable
3. Conditions (the first true condition is used)
4. Value used if no condition is true
5. The variable can be used like any other expression

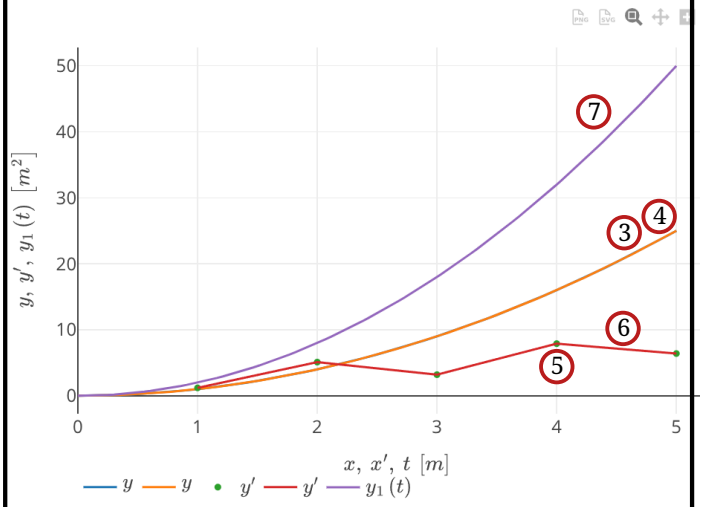
< then = inserts ≤ > then = inserts ≥

.pro Indicates an EngineeringPaper.pro exclusive feature

Plot Cell

$y = x^2$ (1)

$x' = [1 \quad 2 \quad 3 \quad 4 \quad 5] \cdot 1\,[m]\,,\ y' = [1.2 \quad 5.1 \quad 3.2 \quad 7.9 \quad 6.4] \cdot 1\,[m^2]$ (2)



log x | log y | 1:1 Ratio | Copy Data

$y\,(0\,[m] \le x \le 5\,[m]) =$ (3)

$y\,(0\,[m] \le x \le 5\,[m])\ with\ 200\ points =$ (4)

$(x', y') =$ (5)

$(x', y')\ as\ lines =$ (6)

$(t, 2 \cdot t^2)\ for\ (0\,[m] \le t \le 5\,[m]) =$ (7)

1. Function definition
2. Scatter points definition
3. Function plot
4. Function plot w/ num of points specified (default 51)
5. Scatter plot as points (default)
6. Scatter plot as lines
7. Parametric plot

< then = inserts ≤ > then = inserts ≥

Plotting Live Tutorial

Global Keyboard Shortcuts

Ctrl/Cmd + S	Save current sheet to file
Ctrl/Cmd + Shift + S	Save as .pro
Ctrl/Cmd + O	Open file
Ctrl/Cmd + N	Open new tab .pro
Ctrl/Cmd + Shift + E	Export as PDF/DOCX .pro
Ctrl/Cmd + W	Close current tab .pro
Ctrl/Cmd + Tab	Switch to next tab .pro
Ctrl/Cmd + Shift + Tab	Switch to previous tab .pro
Ctrl/Cmd + ↑	Select cell above current cell
Ctrl/Cmd + ↓	Select cell below current cell
Ctrl/Cmd + D	Delete current cell
Shift + Enter	Insert math cell below current cell
Ctrl/Cmd + Enter	Insert custom cell below current cell

System Solve Cell

Symbolic System Solve

System = $x^2 - 5 \cdot x + 6 = 0$ (1), $y + x + c = 10$

Solution = $x =$ 2 3; $y =$ $8 - c$ $7 - c$

Selected Solution: (3)

Solve for: x, y (2)

$y =$ $8 - c$ (6)

Numerical System Solve

System = $H = 10\,[m]$ (5), $L = 15\,[m]$ (5), $H = 2 \cdot a \cdot \ln\left(\frac{(h+a)}{a} + \sqrt{\left(\frac{h+a}{a}\right)^2 - 1}\right)$ (1), $L = 2 \cdot a \cdot \sinh\left(\frac{H}{2 \cdot a}\right)$

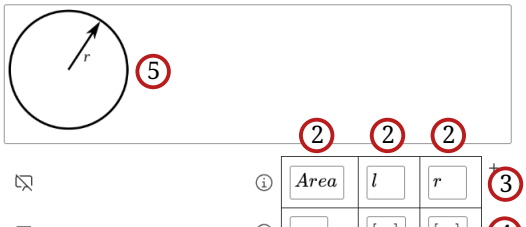
Solve for: $h \approx 3\,[m]\,, a \approx 2\,[m]\,,\ H \approx 10\,[m]\,,\ L \approx 15\,[m]$ (2) (4)

$h =$ $5.02633261648315\,[m]$ (6)

1. Specify system of equations
2. Specify variables to solve for
3. If more than one solution, choose desired solution
4. Initial guesses to trigger numerical solve (~ inserts ≈)
5. Define all variables needed by numerical solve
6. Results are available in the rest of the sheet

Equation Solving Live Tutorial

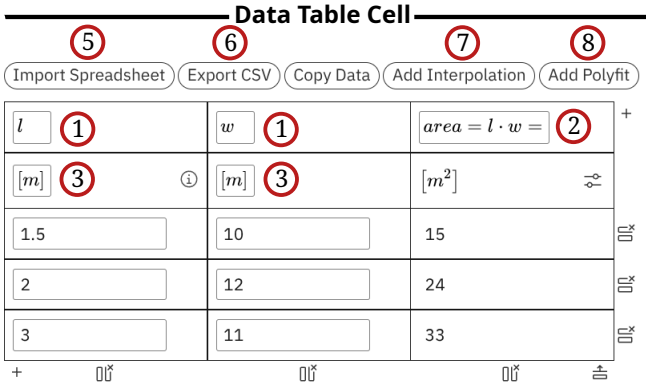
Selector Table Cell



$Area =$ $7.06858347057703\,[m^2]$ (6)

1. Selected row inserts variable values into rest of sheet
2. Each column sets the value for a variable
3. First row sets variable names
4. Units can optionally be specified in the units row
5. Row specific documentation can be added using
6. Column variables are available in the rest of the sheet

Data Table Cell



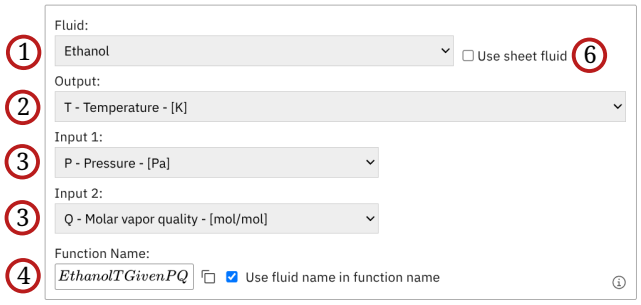
$l^{\mathrm{T}} =$ $[1.5\,[m] \quad 2\,[m] \quad 3\,[m]]$ 4

$area^{\mathrm{T}} =$ $[15\,[m^2] \quad 24\,[m^2] \quad 33\,[m^2]]$ 4

1. Input columns assign column contents to a variable
2. Output columns perform row-by-row calculations
3. Optional units may be specified for input columns
4. Input/output column variables become vectors
5. Data can be imported from files (CSV or XLSX)
6. Data can be exported as CSV files
7. Input columns can be interpolated
8. Polynomials can be fit to input columns

Data Table Live Tutorial

Fluid Properties Cell



5 $\mathrm{EthanolTGivenPQ}\,(1\,[bar], 0) = [degC]$ $= 78.0871426243792\,[degC]$

1. Select fluid
2. Select output
3. Select the 0, 2, or 3 inputs (0 for const., 3 for humid air)
4. Function or constant name used in the sheet
5. Function is called similarly to a built-in function
6. Use toggle to lock all fluid cells to the same fluid

Fluid Properties Live Tutorial

Insert Sheet Command

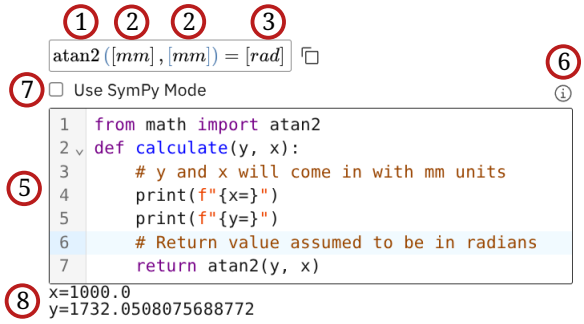
Click the insert sheet button to insert an existing sheet

Select the "Link Sheet" option to link to one or more external sheets .pro

Linked sheets are linked by relative file path and link will be preserved as long as files are kept together .pro

Code Cell

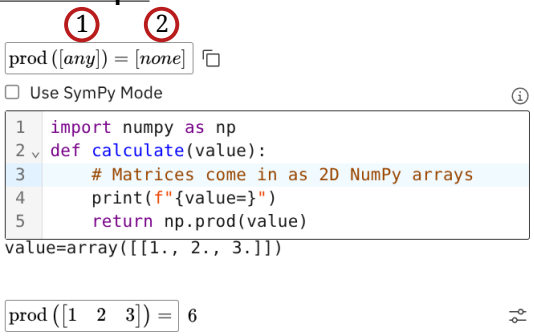
Scalar Example



4 $\mathrm{atan2}\left(\sqrt{3} \cdot 1\,[m], 1\,[m]\right) = [deg]$ $= 60\,[deg]$

1. Name of function that will be created
2. Units for inputs (will be converted before function call)
3. Units for output value within the function
4. Function can be called like built in functions
5. Function code, function must be named **`calculate`**
6. Click info button to see what packages are available
7. SymPy mode treats inputs and output as SymPy objects
8. Print function output appears below code

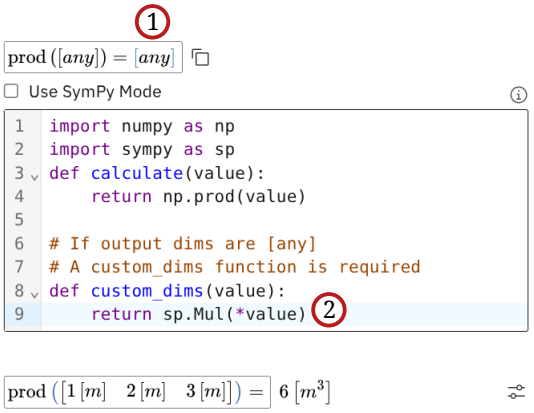
Matrix Example



$\mathrm{prod}\left(\begin{bmatrix}1 & 2 & 3\end{bmatrix}\right) =$ 6

1. Use [any] for inputs that can have any units
2. [none] indicates input or output will be unitless

Custom Units Example



$\mathrm{prod}\left(\begin{bmatrix}1\,[m] & 2\,[m] & 3\,[m]\end{bmatrix}\right) =$ $6\,[m^3]$

1. [any] for output unts requires a **`custom_dims`** function
2. **`custom_dims`** inputs are always SymPy objects

Code Cell Live Tutorial

Built-in Functions

General

$\sqrt{x}$	Square root, type **sqrt** to insert
x^y	Exponent, press ^ to insert
$\ln(x)$	Natural logarithm (base *e*)
$\log(x)$	Base 10 logarithm
$\log_b(x)$	Base *b* logarithm, type **log** then press _
$\lvert x\rvert$	Absolute value
$\text{round}(x)$	Round to nearest integer
$\text{ceil}(x)$	Round up to nearest integer
$\text{floor}(x)$	Round down to nearest integer
$n!$	Factorial

Trigonometry

$\sin(x)$	Sine, input unitless or angle
$\cos(x)$	Cosine, input unitless or angle
$\tan(x)$	Tangent, input unitless or angle
$\sec(x)$	Secant, input unitless or angle
$\cos(x)$	Cosecant, input unitless or angle
$\cot(x)$	Cotangent, input unitless or angle
$\arcsin(x)$	Inverse sine, input unitless, output angle
$\arccos(x)$	Inverse cosine, input unitless, output angle
$\arctan(x)$	Inverse tangent, input unitless, output angle
$\sinh(x)$	Hyperbolic sine, unitless input/output
$\cosh(x)$	Hyperbolic cosine, unitless input/output
$\tanh(x)$	Hyperbolic tangent, unitless input/output

Complex Numbers

$\text{real}(x)$	Real part of a complex number
$\text{imag}(x)$	Imaginary part of a complex number
$\text{angle}(x)$	Angle of a complex number
$\text{conj}(x)$	Complex conjugate of a complex number

Matrices and Vectors

$\text{numrows}(x)$ *or* $\text{numcols}(x)$	Number of rows or columns
$\min(x)$ *or* $\max(x)$	Min or max of list or vector
$\text{count}(x)$	Number of entries in a matrix/vector
$\text{sum}(x)$	Sum of values of list or matrix/vector
$\text{average}(x)$	Average of values of list or matrix/vector
$\text{stdev}(x)$ *or* $\text{stdevp}(x)$	Sample or population std. dev.
$\text{range}(n)$	Return vector of integers 1 to n
$\text{range}(m, n)$	Return vector of integers m to n
$\text{range}(m, n, s)$	Return vector of integers m to n, step s
$\lVert A\rVert$ *or* $\text{norm}(A)$	Euclidean norm
$\det(A)$	Determinant
$\text{dot}(v_1, v_2)$	Dot product
$v_1 \times v_2$	Cross product for 3 by 1 or 1 by 3, type @
A^{T}	Matrix transpose Ctrl/Cmd + '
A^{-1}	Matrix inverse
$A_{3,4}$ *or* $A_{1:end,4:2:12}$	Matrix indexing examples

Matrices and Vectors Live Tutorial

Calculus See function toolbar, $f(x)$, for calculus operators

Built-in Units

Units can be used in their long and short forms. Most units support long prefixes in their long form and short prefixes in their short form (e.g., kilogram or kg). Long form units generally support their singular and plural forms (e.g., meter or meters). Units may be combined as needed using exponents, multiplication, and division, as in: $\left[\frac{kg}{m^3}\right]$ or $\left[kg \cdot m^{-3}\right]$

Supported Units

Base	Unit
Length	meter (m), inch (in), foot (ft), yard (yd), mile (mi), link (li), rod (rd), chain (ch), angstrom, mil
Surface area	m2, sqin, sqft, sqyd, sqmi, sqrd, sqch, sqmil, acre, hectare
Volume	m3, litre (l, L, lt, liter), cc, cuin, cuft, cuyd, teaspoon, tablespoon
Liquid vol.	minim, fluiddram (fldr), fluidounce (floz), gill (gi), cup (cp), pint (pt), quart (qt), gallon (gal), beerbarrel (bbl), oilbarrel (obl), hogshead, drop (gtt)
Angles	rad (radian), deg (degree), grad (gradian), cycle, arcsec (arcsecond), arcmin (arcminute)
Time	second (s, secs, seconds), minute (min, mins, minutes), hour (h, hr, hrs, hours), day (days), week (weeks), month (months),s year (years), decade (decades), century (centuries), millennium (millennia)
Frequency	hertz (Hz)
Mass	gram(g), tonne, ton, grain (gr), dram (dr), ounce (oz), poundmass (lbm, lb, lbs), hundredweight (cwt), stick, stone
Elec. current	ampere (A)
Temperature	kelvin (K), celsius (degC), fahrenheit (degF), rankine (degR)
Amount sub.	mole (mol)
Luminous int.	candela (cd)
Force	newton (N), dyne (dyn), poundforce (lbf), kip, kilogramforce (kgf), gramforce (gf)
Energy	joule (J), erg, Wh, BTU (Btu), electronvolt (eV)
Power	watt (W), hp, tonrefrigeration (TR, RT, TOR, toncooling), boilerhp (BHP), MBH, MMBH
Pressure	Pa, psi, atm, torr, bar, mmHg, mmH2O, cmH2O, inHg, inH2O, ftH2O, kpsi (ksi), Mpsi
Elec. / Mag.	ampere (A), coulomb (C), watt (W), volt (V), ohm, farad (F), weber (Wb), tesla (T), henry (H), siemens (S), electronvolt (eV)
Viscosity	poise (P), reyn, ureyn, stokes (St)
Binary	bits (b), bytes (B)

Supported Unit Prefixes

Name	Abbr.	Value	Name	Abbr.	Value
deca	da	1e1	deci	d	1e-1
hecto	h	1e2	centi	c	1e-2
kilo	k	1e3	milli	m	1e-3
mega	M	1e6	micro	u	1e-6
giga	G	1e9	nano	n	1e-9
tera	T	1e12	pico	p	1e-12
peta	P	1e15	femto	f	1e-15
exa	E	1e18	atto	a	1e-18
zetta	Z	1e21	zepto	z	1e-21
yotta	Y	1e24	yocto	y	1e-24