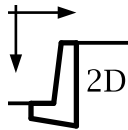


Vector graphics with *Drawj2d*



Program documentation
&
function reference

Adrian Vontobel

4th March 2022

Contents

1	The program Drawj2D	5
1.1	Purpose	5
1.2	Features	5
1.3	Difference to other programs	6
1.4	Licence	6
1.5	Program development	8
2	How to use the program	9
2.1	Installation	9
2.2	Basic usage	10
2.3	Viewer	10
2.4	Output file types	10
2.5	Command line options	11
3	Drawj2D Function Reference	12
3.1	Utility commands: coordinates and units	12
3.1.1	unitlength (unitsize)	12
3.1.2	forceunitlength	12
3.1.3	offset	13
3.1.4	here (r), herepolar (rp)	13
3.1.5	mm	14
3.1.6	fu (kN)	14
3.1.7	X, Y	14
3.1.8	FX, FY	15
3.1.9	XY, FXY	15
3.2	Utility commands: pen, font and mathematical expressions	16
3.2.1	pen	16
3.2.2	font	16
3.2.3	hatch	17
3.2.4	opacity	17
3.2.5	today	17
3.2.6	nf	18
3.2.7	format	18
3.2.8	expr	19
3.2.9	exprinput	19
3.2.10	assert	20
3.3	Drawing commands: points and lines	20
3.3.1	moveto (m)	20
3.3.2	movetox (mx), movetoy (my)	20
3.3.3	moverel (mr)	21
3.3.4	movepolar (mp)	21
3.3.5	point (pt), dot	22
3.3.6	line (l), lineto (l)	22
3.3.7	linetox (lx), linetoy (ly)	22
3.3.8	linerel (lr)	23
3.3.9	linepolar (lp)	23
3.3.10	linemid (lm)	23
3.3.11	arc	24

3.3.12	arc2	24
3.3.13	quadcurve (parabola)	25
3.3.14	cubiccurve	26
3.4	Drawing commands: shapes and fills	27
3.4.1	circle, fillcircle, hatchcircle	27
3.4.2	ellipse, fillellipse, hatchellipse	27
3.4.3	rectangle (rect)	28
3.4.4	fillrectangle (fillrect), hatchrectangle (hatchrect)	28
3.4.5	box, fillbox, hatchbox	29
3.4.6	rectmid, fillrectmid, hatchrectmid	30
3.4.7	rod, fillrod, hatchrod	30
3.4.8	polygon, fillpolygon, hatchpolygon	31
3.4.9	segment, fillsegment, hatchsegment	32
3.4.10	sector, fillsector, hatchsector	32
3.4.11	image	33
3.4.12	dxf	34
3.5	Drawing commands: labels and arrows	35
3.5.1	label (lb)	35
3.5.2	texlabel (tlb)	36
3.5.3	text	37
3.5.4	arrow, arrowto	37
3.5.5	arrows, arrowsto	38
3.5.6	arrowrel	38
3.5.7	arrowsrel	39
3.5.8	force	39
3.5.9	force2	40
3.5.10	dimline, dimlineto	40
3.5.11	dimlinerel	41
3.5.12	dimangle	42
3.6	Utility commands: blocks	44
3.6.1	block, endblock	44
3.6.2	block.rotate	45
3.6.3	block.flip	46
3.6.4	block.scale	46
3.7	Geometry commands	46
3.7.1	geom.vector (geom.v)	46
3.7.2	geom.polar (p)	47
3.7.3	geom.add (++)	47
3.7.4	geom.subtract (--)	47
3.7.5	geom.multiply (**)	48
3.7.6	geom.divide (//)	48
3.7.7	geom.half ($\frac{1}{2}$)	48
3.7.8	geom.norm	49
3.7.9	geom.rotate	49
3.7.10	geom.online	49
3.7.11	geom.tox (tx), geom.toy (ty)	50
3.7.12	geom.intersect	50
3.7.13	geom.intersectlinepath	51
3.7.14	geom.intersectcircles	52
3.7.15	geom.intersectcircleline	53
3.7.16	geom.centroid	54

3.7.17	geom.extend	55
3.7.18	geom.parallel	55
3.7.19	geom.topolygon	56
3.7.20	geom.topolyline	57
3.7.21	geom.azimuth (geom.azi)	58
3.7.22	geom.length (geom.abs)	58
3.7.23	geom.area	58
3.7.24	geom.angle	59
3.7.25	geom.crossproduct	59
3.7.26	geom.dotproduct	60
3.7.27	geom.distance (geom.dist)	60
3.8	Statics commands	61
3.8.1	stat.add (+++)	61
3.8.2	stat.subtract (---)	62
3.8.3	stat.multiply (***)	62
3.8.4	stat.move	63
3.8.5	stat.move2	63
3.8.6	stat.actionline	64
3.8.7	stat.tip	64
3.8.8	stat.abs	64
3.8.9	stat.distance (stat.dist)	65
3.8.10	stat.moment	65
3.8.11	stat.mequi	66
3.8.12	stat.equi	66
3.8.13	stat.fequi	68
3.9	Programming commands	69
3.9.1	Variables: set, \$	69
3.9.2	External script: source	69
3.9.3	Math commands	70
3.9.4	Conditions: if	70
3.9.5	Loops: for, foreach, while	70
3.9.6	Procedures: proc, rename	72
3.9.7	Hash tables	72
3.9.8	Read data from file: open	73
3.10	Complete command list	75
4	Additional functionality	76
4.1	Support for spread sheet csv data and Fachwerk background drawings bgd	76
4.2	Support for Yacas plot data	78
5	Drawj2d Input Examples	79
5.1	Drawings	79
5.2	Statics	81

1 The program Drawj2D

1.1 Purpose

DRAWJ2D creates technical line drawings using a descriptive language. It is implemented in java, thus requires the Java Runtime Environment JRE (1.8 or above).

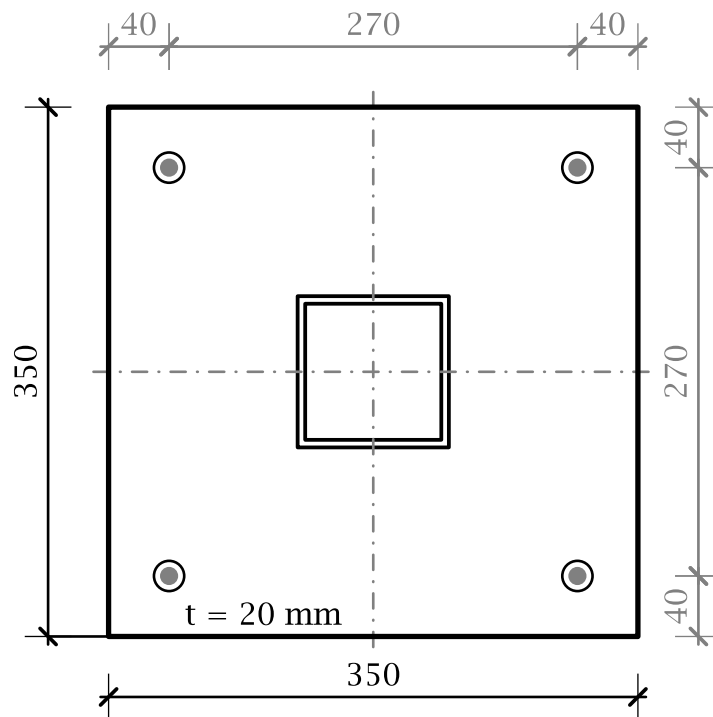


Figure 1: Drawing

The example in Figure 1 shows a drawing created by Drawj2d. The corresponding input file is printed in section 5.

```
drawj2d --type pdf --width 150 --height 120 --center drawing.hcl
```

1.2 Features

- easy to learn vector graphics language
Descriptive vector graphics language, easy (tcl-like) syntax.
- reusable drawings
Drawings can be parametrised using variables.
- draw to scale
1:50, 1:100, 1:20

- different output formats
Vector formats: pdf, svg, eps, emf. Bitmap formats png, bmp. Intermediate formats: dxf, tikz, hcl.
- platform independent
Drawj2d runs on every platform which runs *Java*: Linux, Windows, Mac OS X, Unix
- programming language
Built in tcl-like scripting language allows advanced features and extensibility.
- viewer
Built in viewer for the Drawj2d input files (*.hcl).

Additional functionality

- Yacas plot data
Drawj2d can draw the 2D plot data generated by the computer algebra system Yacas (see chapter 4.2).
- Spread sheet csv data
Drawj2d can draw points of a csv file (see chapter 4.1).
- Fachwerk background drawings
Drawj2d can read the simple text based *bgd* format Fachwerk uses (see chapter 4.1).

1.3 Difference to other programs

DRAWJ2D is inspired by ASYMPTOTE, but it does 2D line drawing only. Both provide a programming syntax: Asymptote is C++-like, Drawj2d is tcl-like. Drawj2d benefits from its limits though: less dependencies, no installation required. Drawj2d is easier, programming experience is not necessary.

Drawj2d is not a CAD program, it provides no graphical user interface!

1.4 Licence

DRAWJ2D is subject to the *GNU General Public License Version 3+*¹. The licence disclaims all liability of the author.

The program uses several libraries. They come with their own compatible open source licences. The text of the licences is distributed together with the program source code.

- Drawj2d core - GPL 2+
The core of the drawj2d program.
<https://sourceforge.net/projects/drawj2d>
- Hecl - Apache License 2
The drawj2d vector graphics language uses and extends the Hecl scripting language.
<http://www.hecl.org>

¹GNU General Public License Version 2+ is applicable provided the optional extensions OrsonPDF and JFreeSVG are dropped.

- java-getopt - LGPL 2
Command line option parser.
<http://www.urbanophile.com/arenn/hacking/getopt>
- EvalEx - MIT License (X11 License)
Java expression evaluator used for the `expr` command.
<https://udojava.com/category/open-source/expression-evaluator>
- FreeHEP Graphics2D - LGPL 2.1 or Apache License 2
Graphical back-end for pdf, svg, emf. Fall-back mode for eps.
<https://freehep.github.io/freehep-vectorgraphics>
- EpsGraphics - GPL 2+
Graphical back-end for eps.
<https://sourceforge.net/projects/epsgraphics>
- JTikZ - LGPL 2.1
Graphical back-end for tikz (TikZ/PGF). Extended for dxf, bgd, hcl and rm.
<https://sourceforge.net/projects/jtikz>
- OrsonPDF - GPL 3+
Graphical back-end for pdf (fall-back mode).
<https://github.com/jfree/orsonpdf>
- JFreeSVG - GPL 3+
Graphical back-end for svg (fall-back mode).
<https://github.com/jfree/jfreesvg>
- JLaTeXMath - GPL 2+ with linking exception
LaTeX rendering for command `tex\label`.
<https://github.com/opencollab/jlatexmath>
- G-library - LGPL 2.1+
Geometry functions for some commands `geom.*`.
<http://geosoft.no/graphics>
- Tcdxf-library - disclaimer (ref. to source code)
Dxf drawing parser for the `dxf` command.
<http://www.oocities.org/tunegov/products/tcldxf4java.htm>
- PDFRenderer - LGPL 2.1+
Pdf interpreter for the `image` command.
<https://github.com/katjas/PDFrenderer>
- svgSalamander - BSD or LGPL 3
Svg interpreter for the `image` command.
<https://github.com/blackears/svgSalamander>
- Yacas Grapher - LGPL 2.1+
Plotter front-end for yacas plot data.
<https://sourceforge.net/projects/yacas>
- JTar - Apache License 2
Tar library for `rmn`.
<https://github.com/kamranzafar/jtar>

- Hershey fonts - (ref. to source code)
Vector fonts the Lines font is based on.
<https://emergent.unpythonic.net/software/hershey>

Licence of this program documentation

This work is licensed under the Creative Commons Attribution-ShareAlike 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/4.0/> or send a letter to Creative Commons, PO Box 1866, Mountain View, CA 94042, USA.

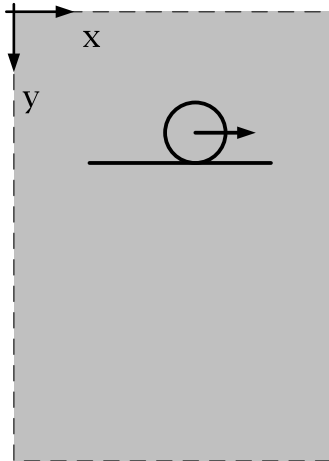
1.5 Program development

This manual is based on version: Drawj2d 1.31 (March 2022)

Changes in syntax and functionality are to be expected. It is recommended to check the website <https://drawj2d.sourceforge.io> for a new version from time to time.

2 How to use the program

DRAWJ2D is a command line program. There is no visible program window. Instead a text editor is used for the input and a shell (terminal, cmd/DOS-window, console) for running drawj2d.



First open a text editor and write the description of the drawing. The syntax is explained in the next chapter, for basic strokes it is straight forward. Save the file as normal UTF-8 encoded text, choosing a name with the suffix *hcl*.

drawing.hcl

```
moveto 50 100
lineto 170 100
moveto 120 80
circle 20
arrowrel 40 0
```

Now open the command line terminal, cd into the drawing directory and start drawj2d. It will read the input file and draw into a *pdf* file called out-drawing.pdf.

```
drawj2d drawing.hcl
```

2.1 Installation

No installation needed.

It is recommended though to add the drawj2d program directory to the path.

Alternatively create a batch file which calls "java -jar drawj2d.jar" and put it in a folder which is in the path. Windows: echo %PATH%, Linux & Mac: echo \$PATH.

- Windows "drawj2d.bat":
java -jar C:\PROGRAMDIRECTORY\drawj2d.jar %*
- Linux & Mac "drawj2d":
java -jar /PROGRAMDIRECTORY/drawj2d.jar \$@

2.2 Basic usage

```
drawj2d drawing.hcl
```

or

```
drawj2d --type pdf drawing.hcl
drawj2d --type pdf --width 150 --height 100 --center drawing.hcl
drawj2d -T pdf -W 150 -H 100 -c drawing.hcl
drawj2d -T pdf -W 150 -H 100 drawing.hcl
drawj2d -T pdf -W 150 -H 100 -X 50 -Y 50 drawing.hcl
drawj2d -T svg -W 150 -H 100 -c drawing.hcl
drawj2d -T pdf -o drawing.pdf drawing.hcl
```

2.3 Viewer

Preview the drawing using the screen type argument.

```
drawj2d -Tscr drawing.hcl
drawj2d -T screen -W 297 -H 210 drawing.hcl
```

To redraw press F5. This will parse the input file again. Thus the viewer can stay open, while you edit the input file in an editor. Pressing F5 will refresh the drawing. To close the window type ESC.

2.4 Output file types

Vector formats

<i>pdf</i>	Portable Document Format (Acrobat Reader, pdfLaTeX) backend mode Freehep, fallback mode JFree
<i>svg</i>	Scalable Vector Graphics (Browser, OpenOffice/LibreOffice) backend mode Freehep, fallback mode JFree
<i>eps</i>	Encapsulated PostScript (LaTeX) backend mode EpsGraphics, fallback mode Freehep
<i>emf</i>	Enhanced Metafile (Microsoft Word) backend mode Freehep

Raster graphics image file formats

<i>png</i>	Portable Network Graphics. Supports transparency. backend mode Freehep, fallback mode JRE
<i>wpng</i>	Portable Network Graphics. No transparency, white background. backend mode JRE
<i>bmp</i>	Bitmap Image backend mode Freehep, fallback mode JRE

Intermediate formats

<i>tikz</i>	PGF/TikZ graphics (...LaTeX) backend mode JTikZ
<i>bgd</i>	Background Drawing (Fachwerk). Single colour. Recommended scale 1:50 backend mode JTikZ
<i>rm, rmapi, rmn</i>	ReMarkable paper tablet. Monochrome line drawing backend mode JTikZ
<i>dxg</i>	Drawing Exchange Format (QCAD, AutoCAD) backend mode JTikZ
<i>hcl</i>	Drawj2d drawing backend mode JTikZ

2.5 Command line options

For help type

```
java -jar drawj2d.jar --help
```

The program will print the command line parameters.

```
Welcome to Drawj2d
Copyright (c) A. Vontobel, 2014-2022
Version 1.31
```

Usage:

```
java -jar drawj2d.jar [-TWHcXYrfvqhV]
                    [-o OutputFile]
                    [InputFile] [arguments]
```

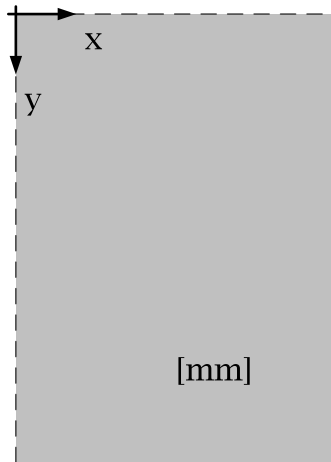
```
-T, --type           Output file type: pdf (default), svg, eps, png, wpng
                    screen (displays the drawing)
                    emf, dxf, tikz, bgd, hcl, rm, rmapi, rmn

-W, --width          Graphics width (default 210mm)
-H, --height         Graphics height (default 297mm)
-c, --center         Set origin to center of sheet, instead of top left
-X, --originx        Offset origin right (default 0mm)
-Y, --originy        Offset origin down (default 0mm)
-r, --resolution     Resolution of images (default 200dpi), svg (96dpi)
-f, --fallback       Fallback mode
-F, --frontend       Input file type: hcl (default), bgd, ypd
-v, --verbose        Verbose output
-q, --quiet          No messages to stdout
-h, --help           Usage information; this help screen
-V, --version        Display version
-o --outfile OutputFile  OutputFile name (default: out-filename)
InputFile           InputFile or - (stdin). If omitted reads from stdin
arguments           Arguments passed to the drawing in the variable $argv
```

3 Drawj2D Function Reference

3.1 Utility commands: coordinates and units

The Drawj2d coordinate system is shown below. The y-axis points downwards!



The sheet unit is *mm*. The drawing unit is not predefined, the scale can be set. Initially the drawing unit is assumed to be *mm* (scale 1:1). The scale for arrows representing forces can be set separately.

3.1.1 unitlength (unitsize)

Set the scale.

SYNOPSIS

unitlength *scale unit*

unitlength *mm*

unitlength

scale scaling factor, e.g. [/ 1. 100.]

unit mm | cm | meter, m | km | μ m | nm | inch, in | foot, ft | yard, yd | mile | point, pt | number in mm. Default: mm

mm the length (in mm) on the sheet for one drawing unit

EXAMPLE

```
unitlength [/ 1. 50.] m; # Scale 1:50, assuming the input units are in m
puts [unitlength];      # Prints 20.0 (1000mm/50 = 20.0mm)
```

3.1.2 forceunitlength

Force unit length.

SYNOPSIS

forceunitlength *mm decdigits***forceunitlength** *mm***forceunitlength***mm* the length (in mm) on the sheet for one force unit (usually kN)*decdigits* Number of decimal places. If omitted: 1

EXAMPLE

```

forceunitlength 5.0 1; # 1kN is drawn 5.0mm, assuming the input unit
                        # is kN. Force values are written with one
                        # decimal after the point, e.g.
                        # 10.333kN will be written 10.3.
forceunitlength;      # Equivalent to: forceunitlength 1.0 1

```

3.1.3 offset

Offset the origin (0/0) coordinate. Offset is relative to the previous origin position.

SYNOPSIS

offset *dX dY**dX* offset to the right, measured in drawing units*dY* offset downwards, measured in drawing units

EXAMPLE

```

offset 1 1
offset [mm 1 1]

```

3.1.4 here (r), herepolar (rp)

Get the current position. Or a position relative to the current one.

SYNOPSIS

here *dx dy***here****herepolar** *dL α***herepolar***dx dy* Relative coordinates from the current position. "0 0" if omitted.*dL α* Relative polar coordinates from the current position. "0 0" if omitted.

EXAMPLE

```

set pos [here]
puts $pos;      # Prints the coordinates of the current position.

```

3.1.5 mm

mm to unit length conversion.

SYNOPSIS

mm *length1 length2 ...*

mm *length*

length length measured in mm

EXAMPLE

```
moverel [mm 0 10]; # Moves the cursor 10mm downwards.
```

3.1.6 fu (kN)

Force unit to unit length conversion.

SYNOPSIS

fu *forcevalue1 forcevalue2 ...*

fu *forcevalue*

forcevalue force value measured in force unit, usually kN

EXAMPLE

```
arrowrel [kN 0 10]; # Draws an arrow 10kN downwards.
```

3.1.7 X, Y

Get the X (or Y) coordinate of a position {x y}.

X is equivalent to: [lindex \$pos 0]. Y is equivalent to: [lindex \$pos 1].

SYNOPSIS

X *pos*

Y *pos*

pos coordinate pair

EXAMPLE

```
set pos {120 300}  
puts [X $pos]; # Prints 120  
puts [Y $pos]; # Prints 300
```

3.1.8 FX, FY

Get the FX (or FY) component of a force {x y Fx Fy}.

FX is equivalent to: [index \$F 2]. FY is equivalent to: [index \$F 3].

SYNOPSIS

FX *F*

FY *F*

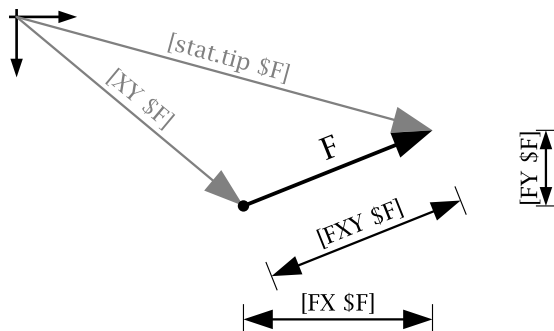
F force "x y Fx Fy"

EXAMPLE

```
set F {10 0 20 100}
puts [FX $F]; # Prints 20
puts [FY $F]; # Prints 100
```

3.1.9 XY, FXY

Get the application point "x y" or the components "Fx Fy" of a force {x y Fx Fy}.



XY is equivalent to: "[index \$F 0] [index \$F 1]".

FX is equivalent to: "[index \$F 2] [index \$F 3]".

SYNOPSIS

XY *F*

FX *F*

F force "x y Fx Fy"

EXAMPLE

```
set F {10 0 20 100}
puts [XY $F]; # Prints 10 0
puts [FX $F]; # Prints 20 100
```

3.2 Utility commands: pen, font and mathematical expressions

3.2.1 pen

The pen defines the current colour, line stroke width and line type. The command returns the previous pen settings.

SYNOPSIS

pen [*color*] [*linewidth*] [*linetype*]

pen *color*

pen *linewidth*

pen *linetype*

pen

color black, k | blue, b | cyan, c | darkgray, d | gray, a | green, g | lightgray, l | magenta, m | orange, o | pink, p | red, r | white, w | yellow, y | brown | darkorange | darkgreen | violet | purple | 0xrrggbb (hexadecimal values for red, green, blue)

linewidth Line stroke width in mm. Default: 0.5 mm

linetype dashed | dotted | dashdotted | solid

(*none*) equal to: pen black 0.5 solid

EXAMPLE

```
pen red dashdotted
line 0 0 100 0
set prevpen [pen 0x87431D];      # color hex values. r:87, g:43, b:1D (brown)
puts $prevpen;                  # Prints red dashdotted 0.5
pen $prevpen;                   # Applies the stored attributes
```

3.2.2 font

Set the font. Choose a truetype (outline) font or the line font Lines. The line font is useful for output types (e.g. rm) not supporting fill.

SYNOPSIS

font [*fontname*] [*style*] [*size*]

font *fontname*

font *style*

font *size*

font

fontname Serif | SansSerif | Monospaced | TeX | Lines or font name

style plain, up | bold, bf | italic, it

size font height in mm. 0.1 mm steps.

(*none*) equivalent to: font Serif plain 4

EXAMPLE

font Serif italic	« <i>Tout est pour le mieux dans le meilleur des mondes</i> »
font Lines plain	« Il faut cultiver notre jardin »
font Lines italic	« <i>Vouloir nous brûle et pouvoir nous détruit; mais savoir laisse notre faible organisation dans un perpétuel état de calme</i> »
font "Linux Libertine O" plain	« Je me sentais un monstre. Hélas, jamais je ne deviendrais rhinocéros: je ne pouvais plus changer. »

3.2.3 hatch

Set the hatch pattern.

SYNOPSIS

hatch *angle spacing*

hatch *angle*

hatch

angle hatch pattern angle in degrees. Default -45°.

spacing hatch pattern spacing in drawing units. If omitted or set to 0, the spacing is 5 mm.

EXAMPLE

```
hatch 75 [mm 2]
```

3.2.4 opacity

Set the opacity. Output modes supporting transparency are -T screen and -T png (and fallback modes -Tpdf -f and -Tsvg -f).

SYNOPSIS

opacity *value*

opacity

value float value from 0 to 1. 1.0 is opaque. If omitted the value is set to 1.0 (opaque).

3.2.5 today

Returns the current date.

SYNOPSIS

today *style locale*

today *style*

today

style full | long | short | medium, default

locale language or language-country code, e.g. de or en-GB. If omitted the language is taken from the computer settings.

EXAMPLE

```
puts [today medium en-GB]; # Prints 14-Mar-2017, if run that day.
puts [today medium de];   # Prints 14.03.2017
puts [today];              # Prints 14.03.2017 in DE or 14-Mar-2017 in GB
```

3.2.6 nf

Returns a formatted number.

SYNOPSIS

nf *number decdigits*

nf *number*

number the number to be formatted

decdigits Amount of digits beyond point. If omitted the value set by `dimline` (default 3) is used.

EXAMPLE

```
set L 4.6666667
puts [nf $L 2]; # Prints 4.67
puts [nf $L];   # Prints 4.667, unless default value has been changed.
```

3.2.7 format

Returns a formatted string in the style of `printf`. Customizes formatting of float numbers (place-holders %f, %e, %g) and integer numbers (%d) or inserts a string (%s) into a text template.

SYNOPSIS

format *text&placeholders value ...locale*

format *text&placeholders value ...*

text&placeholders Text containing place-holders %f, %e, %g, %d, %s, %c.
%10.3f means ten characters in width, right justified, with three places after decimal point. For details refer to the *java.String.format* documentation.

value number (integer or float) or string to be inserted

locale language-country code, e.g. de-CH. Affects the way numbers are formatted (decimal dot or comma).

EXAMPLE

```
set L 4.67
format %.3f $L;           # --> "4.670"
format %7.3f $L;          # --> " 4.670"
set m 12; set h [* 24 365]
puts [format "%d mo = %,d h" $m $h de-CH]; # Prints 12 mo = 8'760 h
```

3.2.8 **expr**

Calculates the value of a mathematical or boolean expression. Functions are case insensitive. Angles are expected in degrees (this differs from tcl and from the hecl trigonometric functions!) unless the function has a trailing R. Boolean operators always result in a value of 1 or 0 (zero), any non-zero value is treated as a true value.

SYNOPSIS

expr *mathexpr*

expr *boolexpr*

mathexpr Mathematical expression.

Supported operators: + - * / %(remainder) ^ (or **)

Trigonometric functions: SIN COS TAN COT SEC CSC ASIN ACOS ATAN ACOT ATAN2(y,x)

or in radians: SINR COSR TANR COTR SECR CSCR ASINR ACOSR ATANR ACOTR ATAN2R(y,x)

Hyperbolic functions: SINH COSH TANH COTH SECH CSCH ASINH ACOSH ATANH

Functions: LOG LOG10 SQRT EXP RAD DEG FACT RANDOM() ABS FLOOR CEILING

ROUND(expression,precision) MIN(e1,e2, ...) MAX(e1,e2, ...)

Constants: e PI NULL

boolexpr Boolean expression.

Supported operators: = (or ==) ~= != (or <>) < <= > >= && ||

Boolean functions: NOT(expression) IF(condition,value_if_true,value_if_false)

Constants: TRUE (value one) FALSE (value zero)

EXAMPLE

```
set D 4.4
puts [expr $D / 2 * sin(30)];      # Prints 1.1.
                                   # The space after variable $D is required!

# or in radians
puts [expr $D / 2 * sinr(PI / 6)]
# Equivalent in pure hecl
puts [* [/ $D 2.] [sin [/ $pi 6.]]]
```

3.2.9 **exprinput**

Returns the mathematical expression. Useful to check what the command expr would get as input.

SYNOPSIS

exprinput *mathexpr*

mathexpr mathematical expression

EXAMPLE

```
set D 4.4
puts [exprinput $D / 2 * sin(30)]; # Prints 4.4 / 2 * sin(30)
```

3.2.10 assert

Verifies that an assertion is fulfilled. Actually a mathematical expression is evaluated. If the return value is other than 1 (`== true`), an exception is raised.

SYNOPSIS

assert *condition message*

assert *condition*

condition A condition that is expected to be true. For comparisons use `<`, `>`, `<=`, `>=`, `=` or `~=`. The operator `~=` tests whether both sides are approximately equal (up to 11 significant digits). "`$val ~= 0`" is assumed to be true for $|val| < 10^{-11}$.

message optional message that helps to identify the assertion in case of failure

EXAMPLE

```
set h 250
# The program will abort if an assertion turns out to be wrong
assert "$h > 200" InputCheck
```

3.3 Drawing commands: points and lines**3.3.1 moveto (m)**

Move the cursor to a new position. The new position is given by its coordinates.

SYNOPSIS

moveto *x1 y1*

moveto *pos1*

x1 y1 new position

pos1 new position

EXAMPLE

```
set pos {50 0}
moveto $pos
```

3.3.2 movetox (mx), movetoy (my)

Move the cursor to a new x-coordinate while keeping the y-coordinate. Or move the cursor to a new y-coordinate while keeping the x-coordinate.

SYNOPSIS

movetox *x1*

movetox *posP*

x1 new x-coordinate
posP Position "x1 yP". The x-coordinate is used only.

EXAMPLE

```
moveto 50 0
movetox {60 45}
puts [here]; # Prints 60 0.
movetoy 30
puts [here]; # Prints 60 30.
```

3.3.3 moverel (mr)

Move the cursor relative to the actual position.

SYNOPSIS

moverel *dx dy*
moverel *vector*

dx dy coordinate increment
vector vector of movement

EXAMPLE

```
moveto 50 0
moverel 10 30
puts [here]; # Prints 60 30.
```

3.3.4 movepolar (mp)

Move the cursor in polar direction relative to the actual position.

SYNOPSIS

movepolar *dL α*

dL distance to current position
α azimuth (angle to x-axis, in degrees, clock-wise)

EXAMPLE

```
moveto 5.0 0.0
movepolar 2.0 60
puts [here]; # Prints 6.0 1.732
```

3.3.5 point (pt), dot

Mark a point at the given coordinate. Moves the cursor there. The point command draws a small circle (diameter = $1.4 \times \text{linewidth}$), the dot command a larger one (diameter 1.5 mm).

SYNOPSIS

point *x1 y1*

point *pos1*

point

x1 y1 point coordinates

pos1 point position

EXAMPLE

```
dot 50 0;           # Draws a dot.
point 70 0; label P; # Marks another point and names it P.
```

3.3.6 line (l), lineto (l)

Draw a line from the first coordinate to the second one. Or draw a line from the actual cursor position to the given coordinate. Sets the cursor to the end of the line (second coordinate *x1 y1*).

SYNOPSIS

line *x0 y0 x1 y1 ...*

line *pos0 pos1 ...*

lineto *x1 y1*

lineto *pos1*

x0 y0 Beginning position of the line. Current position if omitted.

x1 y1 ending position of the line

pos0 Beginning position of the line. Current position if omitted.

pos1 ending position of the line

EXAMPLE

```
line 5 5 5 30
lineto 30 30
set TR {30 5}
lineto $TR
```

3.3.7 linetox (lx), linetoy (ly)

Draw a horizontal line to a new x-coordinate. Or draw a vertical line to a new y-coordinate. Equivalent to commands "lineto [geom.tox \$posP]".

SYNOPSIS

linetox *x1***linetox** *posP**x1* new x-coordinate*posP* Position "x1 yP". The x-coordinate is used only.**3.3.8 linerel (lr)**

Draw a line from the actual cursor position to the given relative position. Sets the cursor to the end of the line.

SYNOPSIS

linerel *dx dy***linerel** *vector**dx dy* coordinate increment*vector* vector of movement

EXAMPLE

```
moveto 5 5
linerel 0 25
linerel {25 0}
```

3.3.9 linepolar (lp)

Draw a line given its length and direction relative to the actual position. Sets the cursor to the end of the line.

SYNOPSIS

linepolar *dL α**dL* distance to current position*α* azimuth (angle to x-axis, in degrees, clock-wise)

EXAMPLE

```
moveto 5.0 0.0
linepolar 2.0 60
puts [here]; # Prints 6.0 1.732
```

3.3.10 linemid (lm)

Draw a line given its length and direction. The middle of the line is set at the cursor position. The cursor does not move.

SYNOPSIS

linemid *L* α **linemid** *L**L* line length α Orientation of the line. Horizontal ($\alpha = 0$) if omitted.

EXAMPLE

```

moveto 17.5 5
linemid 25

```

3.3.11 arc

Draw an arc. Zero angle is where the x-axis points to. Clock-wise, consistent with the coordinate system. Sets the cursor to the centre.

SYNOPSIS

arc *x1 y1 radius startangle endangle***arc** *pos1 radius startangle endangle***arc** *radius startangle endangle**x1 y1* centre*pos1* Centre. Current cursor position if omitted.*radius* radius*startangle* in degrees, clock-wise*endangle* in degrees, clock-wise

EXAMPLE

```

set hour1 -60; set hour3 0
# Draw an arc from one-o-clock to three-o-clock
arc 50 0 20 $hour1 $hour3

```



3.3.12 arc2

Draw an arc. It is defined by the starting point, a control point and the end point. The control point is on the tangent at the starting point. Sets the cursor to the last point.

SYNOPSIS

arc2 *x0 y0 xCtrl yCtrl x1 y1***arc2** *xCtrl yCtrl x1 y1***quadcurve** *pos0 posCtrl pos1***quadcurve** *posCtrl pos1**x0 y0* starting point*pos0* Starting point. Current cursor position if omitted.*xCtrl yCtrl* control point*posCtrl* Control point. On tangent at starting point.*x1 y1* end point*pos1* end point**3.3.13 quadcurve (parabola)**

Draw a parabola. It is defined by the starting point, a control point and the end point. The control point is the intersection point of the tangents at starting and end points. Sets the cursor to the last point.

SYNOPSIS

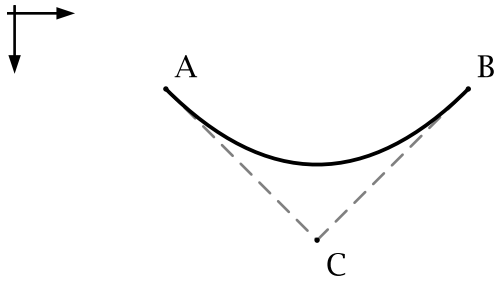
quadcurve *x0 y0 xCtrl yCtrl x1 y1***quadcurve** *xCtrl yCtrl x1 y1***quadcurve** *pos0 posCtrl pos1***quadcurve** *posCtrl pos1**x0 y0* starting point*pos0* Starting point. Current cursor position if omitted.*xCtrl yCtrl* control point*posCtrl* Control point. Intersection of tangents.*x1 y1* end point*pos1* end point

EXAMPLE

```

set A {20 10}; point $A; label A
set B {60 10}; point $B; label B
set C {40 30}
pen dashed 0.35 gray
line $A $C $B;                                # Tangents
pen
point $C; label C SE
quadcurve $A $C $B;                            # Parabola

```



3.3.14 cubiccurve

Draw a cubic parabola. It is defined by the starting point, two control points and the end point. The control points are on the tangents at the starting and end points. Sets the cursor to the last point.

SYNOPSIS

cubiccurve *x0 y0 x0Ctrl y0Ctrl x1Ctrl y1Ctrl x1 y1*

cubiccurve *x0Ctrl y0Ctrl x1Ctrl y1Ctrl x1 y1*

cubiccurve *pos0 pos0Ctrl pos1Ctrl pos1*

cubiccurve *pos0Ctrl pos1Ctrl pos1*

x0 y0 starting point

pos0 Starting point. Current cursor position if omitted.

x0Ctrl y0Ctrl first control point

pos0Ctrl first control point

x1Ctrl y1Ctrl second control point

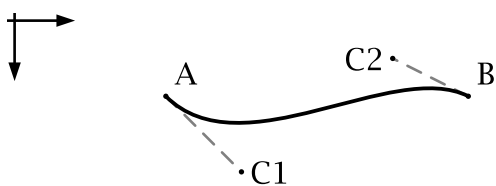
pos1Ctrl second control point

x1 y1 end point

pos1 end point.

EXAMPLE

```
set A {20 10}; point $A; label A
set B {60 10}; point $B; label B
set C1 {30 20}
set C2 {50 5}
pen dashed 0.35 gray
line $A $C1;           # tangents
line $B $C2
pen
point $C1; label C1 E
point $C2; label C2 W
cubiccurve $A $C1 $C2 $B; # cubic parabola
```



3.4 Drawing commands: shapes and fills

3.4.1 circle, fillcircle, hatchcircle

Draw or fill a circle. Sets the cursor to the centre.

SYNOPSIS

circle *x1 y1 radius*

circle *pos1 radius*

circle *radius*

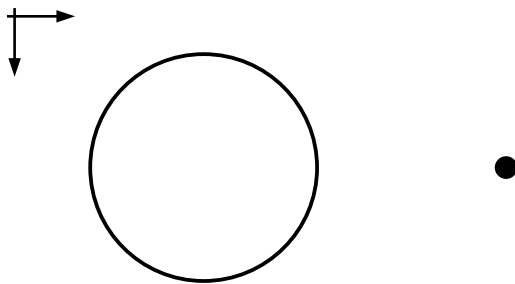
x1 y1 centre

pos1 centre

radius radius

EXAMPLE

```
unitlength 10
circle 2.5 2.0 1.5;           # Radius 1.5 drawing units,
                               # thus equivalent to 15 mm
fillcircle 6.5 2.0 [mm 1.5]; # Radius 1.5 mm
```



3.4.2 ellipse, fillellipse, hatchellipse

Draw or fill an ellipse. Sets the cursor to the centre.

SYNOPSIS

ellipse *x1 y1 radius1 radius2 angle1*

ellipse *radius1 radius2 angle1*

ellipse *radius1 radius2*

x1 y1 centre

radius1 radius in first direction

radius2 radius in second direction

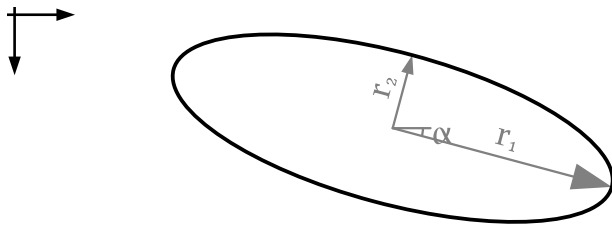
angle1 Angle in degrees between x-axis and first direction, clock-wise. 0° if omitted.

EXAMPLE

```

moveto 50 15
ellipse 30 10 15

```



3.4.3 rectangle (rect)

Draw a rectangle defined by its width and height. See also box and rod commands. The cursor position remains at (or moves to) the starting corner pos1.

SYNOPSIS

rectangle *x1 y1 dx dy*

rectangle *pos1 dx dy*

rectangle *dx dy*

x1 y1 Coordinates of a corner. If omitted current cursor position.

pos1 Corner position (usually top left). If omitted current cursor position.

dx width

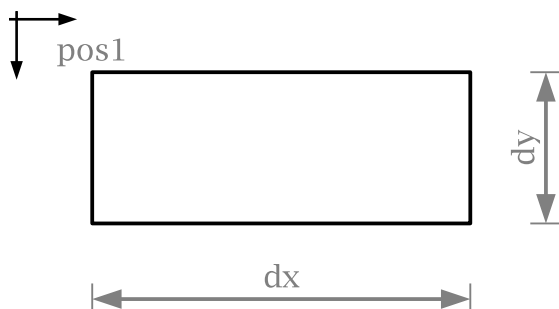
dy height

EXAMPLE

```

moveto 10 7
rectangle 50 20

```



3.4.4 fillrectangle (fillrect), hatchrectangle (hatchrect)

Fill a rectangle defined by its width and height. The current position remains at (or moves to) the starting corner pos1. Use the command to set the background colour.

SYNOPSIS

fillrectangle *x1 y1 dx dy*

fillrectangle *pos1 dx dy*
fillrectangle *dx dy*

x1 y1 Coordinates of a corner. If omitted current cursor position.
pos1 Corner position (usually top left). If omitted current cursor position.
dx width
dy height

EXAMPLE: For png image output, fill the sheet background with white colour (instead of transparent background).

```
pen white
fillrect 210 297; # Fill A4 sheet
pen;             # Reset pen to black
unitlength 10;   # Set the scale: length in mm of a drawing unit
line 2.0 0 5.0 0
```

3.4.5 box, fillbox, hatchbox

Draw or fill a rectangle defined by two diagonal corner points. The current position remains at (or moves to) the starting corner *pos1*.

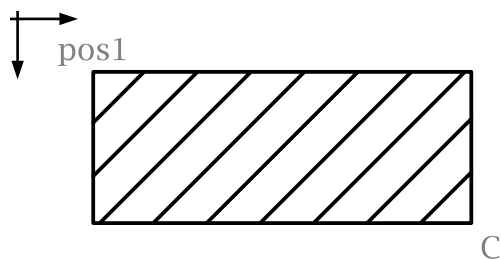
SYNOPSIS

box *x1 y1 x2 y2*
box *pos1 posC*
box *x2 y2*
box *posC*

x1 y1 First corner of the rectangle. Cursor position moves here.
pos1 First corner of the rectangle. Cursor position moves here. If omitted current cursor position.
x2 y2 diagonal corner of the rectangle
posC diagonal corner of the rectangle

EXAMPLE

```
moveto 10 7; # first corner (here top left, but not necessarily)
hatchbox 60 27
box 60 27; # diagonal corner
```



3.4.6 rectmid, fillrectmid, hatchrectmid

Draw or fill a rectangle defined by its centre, width and height. The current position remains at (or moves to) the centre.

SYNOPSIS

rectmid *x1 y1 dx dy α*

rectmid *pos1 dx dy α*

rectmid *x1 y1 dx dy*

rectmid *pos1 dx dy*

rectmid *dx dy α*

rectmid *dx dy*

x1 y1 centre

pos1 Centre. If omitted current cursor position.

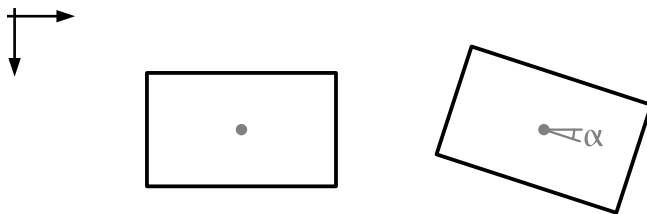
dx width

dy height

α Orientation of the rectangle. $\alpha = 0$ if omitted.

EXAMPLE

```
moveto 30 15
rectmid 25 15
moverel 40 0
rectmid 25 15 18
```

**3.4.7 rod, fillrod, hatchrod**

Draw or fill a rectangle defined by its axis (starting point and orientation), length and width. Sets the cursor to the end point on the axis, L from the starting point.

SYNOPSIS

rod *x0 y0 L w α*

rod *x0 y0 L w*

rod *pos0 L w α*

rod *pos0 L w*

rod *L w α*

rod *L w*

x0 y0 coordinates on rod axis

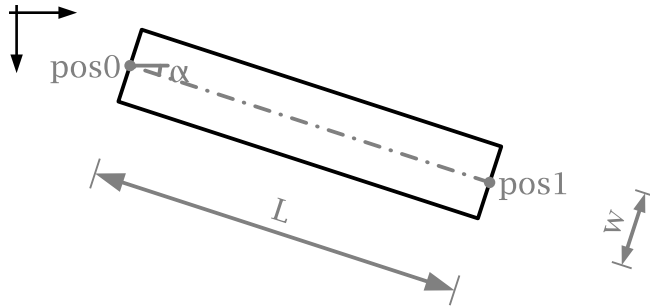
pos0 Coordinates on rod axis. If omitted current cursor position.

L length
 w width
 α orientation, in degrees, clock-wise

EXAMPLE

```

moveto 15 7
rod 50 10 18
  
```



3.4.8 polygon, fillpolygon, hatchpolygon

Draw a polygon defined by at least three vertices. The current position moves to the starting vertex A. The command `polygon $A $B $C` is equivalent to "line \$A \$B; lineto \$C; lineto \$A".

SYNOPSIS

polygon $x1\ y1\ x2\ y2\ x3\ y3\ \dots$

polygon $posA\ posB\ posC\ \dots$

$x1\ y1$ First vertex of the polygon. Cursor position moves here.

$posA$ First vertex of the polygon. Cursor position moves here.

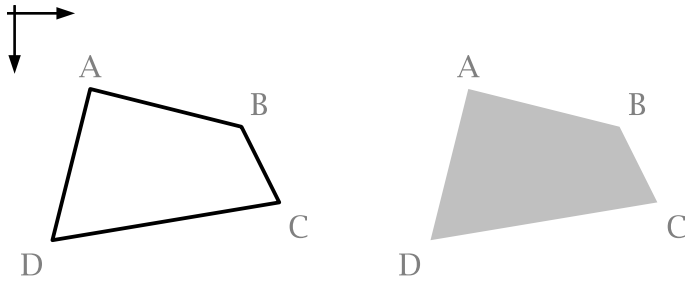
$x2\ y2\ x3\ y4$ further vertices

$posB\ posC$ further vertices

EXAMPLE

```

set A {10 10}
set B {30 15}
set C {35 25}
set D { 5 30}
polygon $A $B $C $D
offset 50 0
pen lightgray
fillpolygon $A $B $C $D
  
```



3.4.9 segment, fillsegment, hatchsegment

Draw or fill a segment of a circle. Zero angle is where the x-axis points to. Clock-wise, consistent with the coordinate system. Sets the cursor to the centre.

SYNOPSIS

segment *x1 y1 radius startangle endangle*

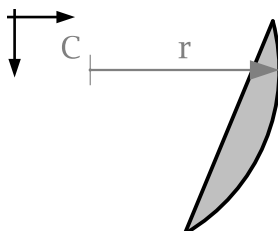
segment *pos1 radius startangle endangle*

segment *radius startangle endangle*

<i>x1 y1</i>	centre
<i>pos1</i>	Centre. Current cursor position if omitted.
<i>radius</i>	radius
<i>startangle</i>	in degrees, clock-wise
<i>endangle</i>	in degrees, clock-wise

EXAMPLE

```
set C {10 7}
set r 25
set α -15
set β 60
pen lightgray
fillsegment $C $r $α $β
pen black
segment $r $α $β
```



3.4.10 sector, fillsector, hatchsector

Draw or fill a sector. Zero angle is where the x-axis points to. Clock-wise, consistent with the coordinate system. Sets the cursor to the centre.

SYNOPSIS

sector *x1 y1 radius startangle endangle***sector** *pos1 radius startangle endangle***sector** *radius startangle endangle*

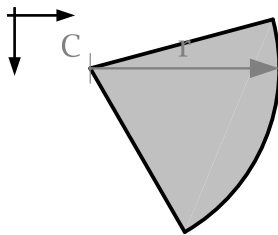
x1 y1 centre
pos1 Centre. Current cursor position if omitted.
radius radius
startangle in degrees, clock-wise
endangle in degrees, clock-wise

EXAMPLE

```

set C {10 7}
set r 25
set α -15
set β 60
pen lightgray
fillsector $C $r $α $β
pen black
sector $r $α $β

```



3.4.11 image

Insert an image. The cursor position does not move. Pdf files are interpreted, a subset of the specification is implemented. Pdf files created by scanners or by drawj2d usually work, complex pdf with embedded fonts often do not.

SYNOPSIS

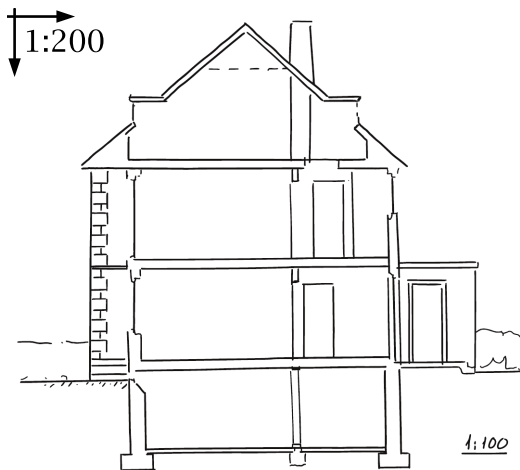
image *filename dpi pxX pxY 1 : x***image** *filename dpi pxX pxY***image** *filename dpi***image** *filename***image** *file.pdf page mmX mmY 1 : x***image** *file.pdf page mmX mmY***image** *file.pdf page***image** *file.pdf*

filename image file (*.png|jpeg|bmp|svg)
file.pdf portable document file (*.pdf)
dpi Image resolution [dots per inch]. Default: 200 / 96 (svg)

page Selected page. If omitted the first page.
pxX pxY Pixel coordinates of insertion point. If omitted top left corner of the image.
mmX mmY Coordinates [mm] of insertion point. If omitted top left corner of the pdf.
1 : x Scale e.g. 100. If omitted or 0 the image will not be scaled to natural units.

EXAMPLE:

```
unilength [expr 1/200] m
image section.png 200 0 0 100; # drawing 1:100 scanned at 200dpi
label {1:200} SE
```



```
unilength [expr 1/200] m
image section.pdf 1 0 0 100; # drawing 1:100 scanned to pdf
label {1:200} SE
```

3.4.12 dxf

Insert a vector line drawing, e.g. a CAD dxf file. The cursor position does not move. Colour, line width, line style and font are taken from the current drawj2d context (dxf style attributes are neglected). Repeat the command to apply different pen styles to different dxf layers. Many elementary dxf entities are supported, including blocks (single inserts only).

SYNOPSIS

dxf *filename unit dX dY options*

dxf *filename unit dX dY*

dxf *filename unit*

dxf *filename*

filename vector drawing file (*.dxf|bgd|bgd.gz|csv)

unit mm | cm | meter, m | km | μ m | nm | inch, in | foot, ft | yard, yd | mile | point, pt | number in mm. Default: mm

dX dY Drawing coordinates of insertion point. If omitted origin 0/0.

options Layer names (if omitted all visible layers will be drawn, use prefix <> to exclude a layer) or flags :doText (default) | :noText | :doInsert (default) | :noInsert | :verbose. Options shall be separated by commas.

EXAMPLE:

```

unittlength [expr 1/20] m
pen black 0.2
dxf section.dxf m 0.2 -2.0 {Section, Elevation}
pen red dashdotted
dxf section.dxf m 0.2 -2.0 Axes

```

3.5 Drawing commands: labels and arrows

3.5.1 label (lb)

Label the position of the cursor. Or align a label in the middle of two points.

SYNOPSIS

label *Text* *xA* *yA* *xB* *yB*

label *Text* *posA* *posB*

label *Text* *lineAB*

label *Text* *placement*

label *Text*

xA *yA* first point of imaginary line

xB *yB* second point of imaginary line

posA first point of imaginary line

posB second point of imaginary line

lineAB imaginary line "*xA* *yA* *xB* *yB*"

placement The placement of the label: NE | BL | E | SE | S | SW | W | BW | NW | N | BC | C. BLC moves the cursor forward. If omitted NE.

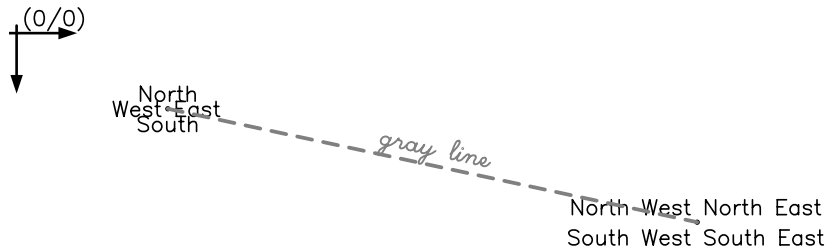
Text Label text. Unicode chars shall be UTF-8 formatted or escaped using *escu* and the hexadecimal index (e.g. *escu00b7* for the middle dot · unicode char U+00B7).

EXAMPLE

```

font Lines 3;                # Set font type and size
label "(0/0)"
point 20 10; set A [here]
label North N
label East E
label South S
label West W
point 90 25; set B [here]
label "North East" NE
label "South East" SE
label "South West" SW
label "North West" NW
set color gray
pen $color; pen dashed
line $A $B
# Note the label argument below: "$color" evaluates variable, {$color} would not.
font Lines italic 4
label "$color line" $A $B

```



3.5.2 texlabel (tlb)

Label the position of the cursor using TeX math syntax. Or align a label in the middle of two points.

SYNOPSIS

texlabel *Text* *xA yA xB yB*

texlabel *Text posA posB*

texlabel *Text lineAB*

texlabel *Text placement*

texlabel *Text*

<i>xA yA</i>	first point of imaginary line
<i>xB yB</i>	second point of imaginary line
<i>posA</i>	first point of imaginary line
<i>posB</i>	second point of imaginary line
<i>lineAB</i>	imaginary line "xA yA xB yB"
<i>placement</i>	The placement of the label: NE BL E SE S SW W BW NW N BC C. BLC moves the cursor forward. If omitted NE.
<i>Text</i>	Label text using TeX syntax. If there is white space, enclose the text with curly brackets. If the text contains variables, use quotation marks instead. Within quotation marks any backslash must be escaped, thus a double backslash is required.

EXAMPLE

```
point 20 10
texlabel {\sqrt{a^2+b^2} = c}; # Curly brackets
point 40 10
set a 3; set b 4
texlabel "\\sqrt{$a^2+$b^2}=5"; # Double backslash
point 70 10
texlabel {\frac{\sqrt{a^2+b^2}}{c} = 1}
point 100 10
texlabel {\displaystyle \frac{\sqrt{a^2+b^2}}{c} = 1}
```

The diagram shows a coordinate system with a vertical arrow pointing down and a horizontal arrow pointing right, labeled (0/0) at the origin. A dashed gray line connects two points. The first point is labeled with compass directions: North, West, East, South. The second point is labeled with compass directions: North, West, North, East, South, West, South, East.

3.5.3 text

Write some text. The words are wrapped if necessary. Sets the cursor a linefeed lower.

SYNOPSIS

text *Text* [*width*] [*alignment*]

text *Text*

text

width The available width for the text in drawing units. Words are wrapped if necessary. If omitted the last used width, initially 150 mm.

alignment *left* | *justify*. If omitted the last used alignment, initially left.

Text Text. Unicode chars shall be UTF-8 formatted or escaped using *escu* and the hexadecimal index (e.g. *escu00b7* for the middle dot · unicode char U+00B7).

EXAMPLE

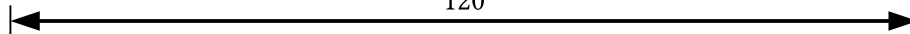
```
font "Linux Libertine O"
font bold 5
text {Description} [mm 120]
font plain 4
text;          # Empty line
text {Drawj2d creates technical line drawings using a descriptive language. It
      writes pdf, svg, eps and emf vector graphics or png images. It runs on all
      platforms that run Java. It is inspired by Asymptote but with a tcl-like syntax
      and 2D only.}

dimlinere1 [mm 120 0]
```

Description

Drawj2d creates technical line drawings using a descriptive language. It writes pdf, svg, eps and emf vector graphics or png images. It runs on all platforms that run Java. It is inspired by Asymptote but with a tcl-like syntax and 2D only.

120



3.5.4 arrow, arrowto

Draw an arrow from the first coordinate to the second one. Or draw an arrow from the actual cursor position to the given coordinate. Sets the cursor to the arrow head.

SYNOPSIS

arrow *x0 y0 x1 y1*

arrow *pos0 pos1*

arrowto *x1 y1*

arrowto *pos1*

x0 y0 Beginning position of the arrow. Current position if omitted.

x1 y1 ending position of the arrow (arrow head)
pos0 Beginning position of the arrow. Current position if omitted.
pos1 ending position of the arrow (arrow head)

EXAMPLE

```
arrow 5 5 5 30
arrowto 30 30
set TR {30 5}
arrowto $TR
```

3.5.5 **arrows, arrowsto**

Draw a double headed arrow from the first coordinate to the second one. Or draw a double headed arrow from the actual cursor position to the given coordinate. Sets the cursor to the new position.

SYNOPSIS

```
arrows x0 y0 x1 y1
arrows pos0 pos1
arrowsto x1 y1
arrowsto pos1
```

x0 y0 Beginning position of the double headed arrow. Current position if omitted.
x1 y1 ending position of the double headed arrow
pos0 Beginning position of the double headed arrow. Current position if omitted.
pos1 ending position of the double headed arrow

EXAMPLE

```
arrows 5 5 5 30
arrowsto 30 30
set TR {30 5}
arrowsto $TR
```

3.5.6 **arrowrel**

Draw an arrow from the actual cursor position to the given relative position. Sets the cursor to the arrow head.

SYNOPSIS

```
arrowrel dx dy
arrowrel vector
```

dx dy coordinate increment
vector vector of movement

EXAMPLE

```

moveto 5 5
arrowrel 0 25
arrowrel {25 0}

```

3.5.7 arrowsrel

Draw a double headed arrow from the actual cursor position to the given relative position. Sets the cursor to the new position.

SYNOPSIS

arrowsrel *dx dy*

arrowsrel *vector*

dx dy coordinate increment

vector vector of movement

EXAMPLE

```

moveto 5 5
arrowsrel 0 25
arrowsrel {25 0}

```

3.5.8 force

analogy: **texforce**

Draw a force arrow (pointing away from the cursor). The label is either its absolute force value or any text. The command sets the cursor to the arrow head. The command does not do anything if the absolute force value is zero. See `forceunitlength`.

SYNOPSIS

force *x0 y0 Fx Fy Label*

force *x0 y0 Fx Fy*

force *Fx Fy Label*

force *Fx Fy*

x0 y0 force application point

Fx Fy force components

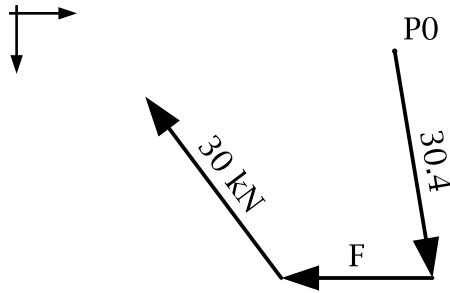
Label Label. If omitted the absolute force value is written. Use {} or "" to suppress any labelling. The place-holder %f inserts the absolute value, e.g. {%f kN}.

EXAMPLE

```

point 50 5; label P0
force 5 30;           # Writes 30.4. The cursor moves to the tip.
force -20 0 F;        # Writes F
force -18 -24 {%f kN}; # Writes 30 kN

```



3.5.9 force2

analogy: **texforce2**

Draw a force arrow (pointing to the cursor). The label is either its absolute force value or any text. The command sets the cursor to the arrow head. The command does not do anything if the absolute force value is zero. See `forceunitlength`.

SYNOPSIS

force2 *x1 y1 Fx Fy Label*

force2 *x1 y1 Fx Fy*

force2 *Fx Fy Label*

force2 *Fx Fy*

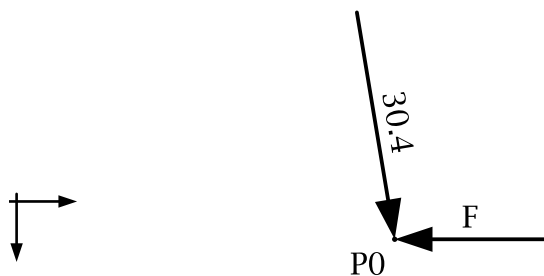
x1 y1 force application point

Fx Fy force components

Label Label. If omitted the absolute force value is written. Use `{}` or `""` to suppress any labelling. The place-holder `%f` inserts the absolute value, e.g. `{%.1f kN}`.

EXAMPLE

```
point 50 5; label P0 SW
force2 5 30;           # Writes 30.4
force2 -20 0 F;        # Writes F
```



3.5.10 dimline, dimlineto

analogy: **texdimline**, **texdimlineto**

Draw a dimension line (e.g. double headed arrow). The label is either its length (in drawing units) or

any text. Sets the cursor to the new position (last coordinate x1/y1).

The command followed by just a natural number sets the number of decimal digits (see `dimlinere1` for an example).

SYNOPSIS

dimline *x0 y0 x1 y1 Label*

dimline *x0 y0 x1 y1*

dimline *pos0 pos1 Label*

dimline *pos0 pos1*

dimline *decdigits*

dimline *style*

dimlineto *x1 y1 Label*

dimlineto *x1 y1*

dimlineto *pos1 Label*

dimlineto *pos1*

x0 y0 Beginning position of the dimension line. Current position if omitted.

x1 y1 ending position of the dimension line

pos0 Beginning position of the dimension line. Current position if omitted.

pos1 ending position of the dimension line

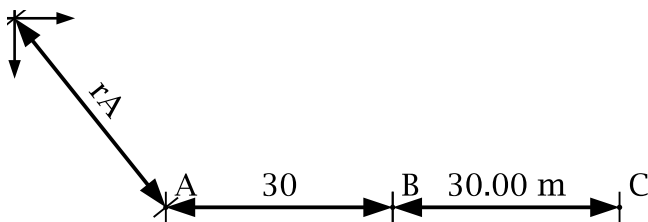
Label Text. If omitted the length measured in drawing units is written. Use quotation marks if the label contains white space. The place-holder %f inserts the length value, e.g. "%.2f m".

decdigits Maximal number of decimal places to be written. This setting is used by any following dimension line command.

style arrows | dots | ticks | arrow | none

EXAMPLE

```
set A {20 25}; point $A; label A
set B {50 25}; point $B; label B
set C {80 25}; point $C; label C
dimline {0 0} $A rA;           # Writes rA
dimlineto $B;                  # Writes 30
dimlineto $C "%.2f m";         # Writes 30.00 m
```



3.5.11 dimlinere1

analogy: **texdimlinere1**

Draw a dimension line (double headed arrow) from the cursor position to a relative position. The label

is either its length (in drawing units) or any text. Sets the cursor to the new position.

SYNOPSIS

dimlinerel *dx dy Label*

dimlinerel *dx dy*

dimlinerel *vector Label*

dimlinerel *vector*

dx dy coordinate increment

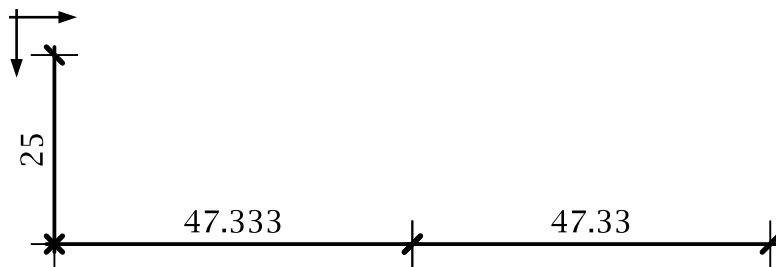
vector vector of movement

Label Text. If omitted the length measured in drawing units is written. Use quotation marks if the label contains white space. The place-holder %f inserts the length value, e.g. "%.2f m".

EXAMPLE

```
moveto 5 5
dimline ticks;           # Sets the dimension line style.
dimlinerel 0 25.0;       # Writes 25
dimlinerel {47.333333 0}; # Writes 47.333

dimline 2;               # Sets the number of decimal digits to 2.
dimlinerel {47.333333 0}; # Writes 47.33
```



3.5.12 dimangle

analogy: **texdimangle**

Draw a dimension arc at a vertex. The label is either its angle in degrees or any text. Clock-wise. The **texdimangle** command uses $\TeX$ typesetting is used. Sets the cursor to the vertex (*pos0*).

SYNOPSIS

dimangle *x0 y0 xP yP xQ yQ Label*

dimangle *pos0 posP posQ Label*

dimangle *x0 y0 xP yP xQ yQ*

dimangle *pos0 posP posQ*

dimangle *xP yP xQ yQ Label*

dimangle *posP posQ Label*

dimangle *xP yP xQ yQ*

dimangle *posP posQ*

dimangle *dirP dirQ Label*

dimangle *dirP dirQ***dimangle** *decdigits*

x0 y0 Vertex. If omitted the current cursor position is assumed.

pos0 Vertex. If omitted the current cursor position is assumed.

xP yP adjacent vertex

posP adjacent vertex

xQ yQ adjacent vertex

posQ adjacent vertex

dirP azimuth to vertex

dirQ azimuth to vertex

decdigits Maximal number of decimal places to be written. This setting is used by any following dimension arc (**dimangle**/**texdimangle**) command.

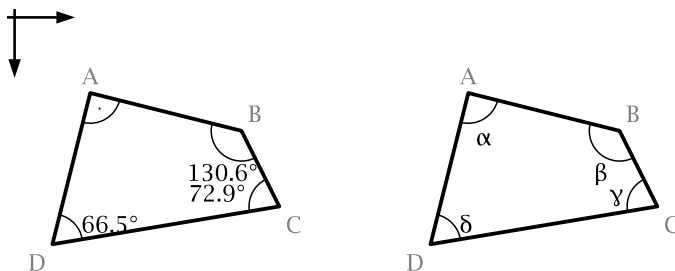
Label Text. If omitted the angle measured in degrees is written. A "." will draw the right angle sign (whether the angle is 90° or not). The place-holder %f inserts the angle value, e.g. %.2f°.

EXAMPLE

```

polygon $A $B $C $D
pen 0.2; font 3
dimangle $A $B $D
dimangle $B $C $A
dimangle $C $D $B
dimangle $D $A $C
offset 50 0; pen; # Drawing to the right
polygon $A $B $C $D
pen 0.2
dimangle $A $B $D  $\alpha$ 
dimangle $B $C $A  $\beta$ 
dimangle $C $D $B  $\gamma$ 
dimangle $D $A $C  $\delta$ 

```

EXAMPLE using T_EX typesetting

```

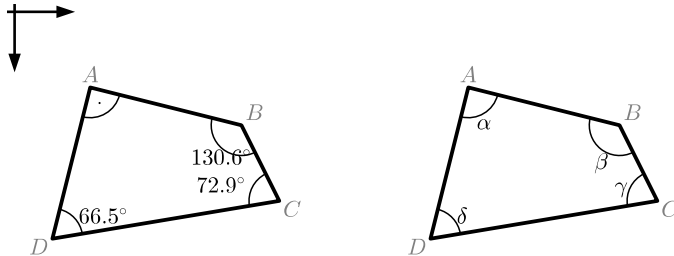
polygon $A $B $C $D
pen 0.2; font 3
texdimangle $A $B $D
texdimangle $B $C $A
texdimangle $C $D $B
texdimangle $D $A $C
offset 50 0; pen; # Drawing to the right

```

```

polygon $A $B $C $D
pen 0.2
texdimangle $A $B $D {\alpha}
texdimangle $B $C $A {\beta}
texdimangle $C $D $B \gamma
texdimangle $D $A $C \delta

```



3.6 Utility commands: blocks

A block is an invisible frame in the drawing that has its own coordinate system. It is useful to insert part drawings from a library. A block can be rotated or mirrored, without influencing the main coordinate system.

3.6.1 block, endblock

The block command starts its own coordinate system. Its origin is at the current location. The endblock command puts back the previous coordinate system and the cursor is placed where it was when the block command was called. A block also encapsulates the commands `unitlength` or `forceunitlength`. Blocks may be nested.

SYNOPSIS

block

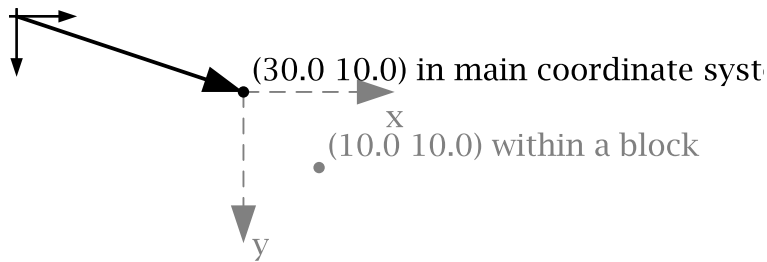
endblock

EXAMPLE

```

arrowto 30 10
pen dashed 0.25 gray
block
    arrow 0 0 20 0; label x S
    arrow 0 0 0 20; label y E
    dot 10 10
    label "([here]) within a block"
endblock
pen
dot
label "([here]) in main coordinate system"

```



The block coordinate system can be manipulated using the commands `block.rotate`, `block.flip`, `block.scale` or `offset`.

3.6.2 `block.rotate`

Rotate the block's coordinate system. The cursor stays at its absolute position.

SYNOPSIS

block.rotate α

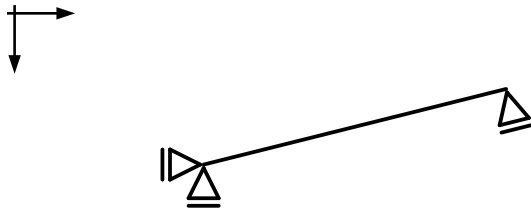
α azimuth (angle to global x-axis, in degrees, clock-wise)

Blocks are useful for inserting drawing blocks, e.g from a separate file (block; source externaldrawing.hcl; endblock). In the example below a typical part is wrapped in a procedure (see chapter 3.9).

EXAMPLE

```
# The procedure could be put in a file library.hcl
# and then loaded by the command: source library.hcl
proc bearing {rot} {
    block
    block.rotate $rot
    set bl [mm 4]; # baselength
    set ofs [+ [mm 0.25] [* 0.05 $bl]]; # offset
    set ofl [+ [mm 0.25] [* 1.3 $bl]]; # line offset
    moveto 0 $ofs
    linerel [½ -$bl] $bl
    linerel $bl 0
    lineto 0 $ofs
    moveto [½ -$bl] $ofl
    linerel $bl 0
    endblock
}

set A {25 20}
set B {65 10}
set β [geom.azimuth $A $B]
moveto $A
bearing 0
bearing 90
lineto $B
bearing $β
```



3.6.3 block.flip

Flip the block's coordinate system. Thus the local y-axis points upwards instead of downwards. Be aware that labels will be mirrored too. The cursor stays at its absolute position.

SYNOPSIS

block.flip

3.6.4 block.scale

Scale the local axes. These scale factors are applied to the previous scale. Be aware that everything will be scaled, e.g. line widths and labels too.

SYNOPSIS

block.scale *sx sy*

block.scale *s*

sx scale factor for local x-axis

sy scale factor for local y-axis

s scale factor for both axes

3.7 Geometry commands

The geometry commands `geom.*` are utility commands for calculations with vectors "x y". The commands do not draw.

3.7.1 geom.vector (geom.v)

Constructs the vector specified by two points. Equivalent to [-- \$posB \$posA].

SYNOPSIS

geom.vector *x1 y1 x2 y2*

geom.vector *posA posB*

geom.vector *x2 y2*

geom.vector *posB*

x1 y1 First point. If omitted the current cursor position is assumed.

x2 y2 second point

posA First point. If omitted the current cursor position is assumed.
posB second point

EXAMPLE

```
puts [geom.vector 10 10 37 20]; # Writes 27.0 10.0
```

3.7.2 geom.polar (p)

Returns a vector that is rotated by an angle (in degrees) from the x-axis. If the length is omitted the unit vector {1 0} is assumed to be rotated, otherwise {dL 0}.

SYNOPSIS

geom.polar *dL* α

geom.polar α

dL length

α azimuth (angle to x-axis, in degrees, clock-wise)

EXAMPLE

```
puts [geom.polar 2.0 60]; # Prints 1.000 1.732
puts [geom.polar 60];    # Prints 0.500 0.866
```

3.7.3 geom.add (++)

Computes the vector sum.

SYNOPSIS

geom.add *v1 v2 ...*

++ *v1 v2 ...*

v1 first vector or point

v2 second vector

EXAMPLE

```
puts [++ {3.0 0.5} {2 2}]; # Writes 5.0 2.5
```

3.7.4 geom.subtract (--)

Computes the vector subtraction.

SYNOPSIS

geom.subtract *v1 v2 ...*

-- *v1 v2 ...*

v1 first vector or point

v2 second vector

EXAMPLE

```
puts [-- {3.0 0.5} {2 2}];      # Writes 1.0 -1.5
puts [-- {12 37} {3 12} {2 4}]; # Writes 7.0 21.0
```

3.7.5 **geom.multiply** (**)

Computes a vector scaled by multiplication.

SYNOPSIS

geom.multiply *factor vector*
 ** *factor vector*

factor scaling factor

vector vector "dx dy"

EXAMPLE

```
puts [** 1.5 {2 3}]; # Writes 3.0 4.5
```

3.7.6 **geom.divide** (//)

Computes a vector scaled by division.

SYNOPSIS

geom.divide *vector quotient*
 // *vector quotient*

vector vector "dx dy"

quotient scaling quotient

EXAMPLE

```
puts [// {3.0 4.5} 1.5]; # Writes 2.0 3.0
```

3.7.7 **geom.half** (½)

Computes a vector or scalar scaled by the factor $\frac{1}{2}$.

SYNOPSIS

geom.half *dx dy*
geom.half *vector*
geom.half *scalar*

vector vector "dx dy"
dx number

EXAMPLE

```
puts [½ 3.0 4.5]; # Writes 1.5 2.25
```

3.7.8 geom.norm

Returns a unit length vector with the same direction as the input vector.

SYNOPSIS

geom.norm *dx dy*
geom.norm *v*

dx dy vector
v vector

EXAMPLE

```
puts [geom.norm 30 40]; # Writes 0.6 0.8
```

3.7.9 geom.rotate

Returns a vector that is rotated by an angle (in degrees) compared to the input vector.

SYNOPSIS

geom.rotate *dx dy θ*
geom.rotate *v θ*
geom.rotate *v*

dx dy vector
v vector
θ Angle in degrees. If omitted 90°

EXAMPLE

```
puts [geom.rotate {1 0} 30]; # Writes 0.866 5.0  

puts [geom.rotate 1 0];      # Writes 0.0 1.0
```

3.7.10 geom.online

Returns the point on the line defined by "x0 y0 x1 y1" a given fraction from x0,y0.

E.g. [geom.online \$A \$B 0.5] returns the position in the middle of the two points, while [geom.online \$A \$B 0] returns the position of \$A and [geom.online \$A \$B 1] the position of \$B.

SYNOPSIS

geom.online *x1 y1 x2 y2 fraction***geom.online** *posA posB fraction**x1 y1* first point*x2 y2* second point*posA* first point*posB* second point*fraction* fraction of the distance AB

EXAMPLE

```
puts [geom.online 10 10 24 10 0.6]; # Writes 18.4 10.0
```

3.7.11 **geom.tox (tx), geom.toy (ty)**

Returns the position with a given x coordinate that is horizontally aligned with the cursor position. Or returns the position with a given y coordinate that is vertically aligned with the cursor position.

SYNOPSIS

geom.tox *posP***geom.tox** *x1**posP* position "x1 yP"*x1* x-coordinate

EXAMPLE

```
moveto {5.0 1.2}
set P {9.0 3.5}
puts [tx 8.5]; # Writes 8.5 1.2
puts [tx $P]; # Writes 9.0 1.2
puts [ty 3.0]; # Writes 5.0 3.0
puts [ty $P]; # Writes 5.0 3.5
```

3.7.12 **geom.intersect**

Returns the intersection point of the extensions of two lines $\overline{AB}$ and $\overline{CD}$. If the lines are parallel the command raises an exception.

SYNOPSIS

geom.intersect *xA yA xB yB xC yC xD yD***geom.intersect** *posA posB posC posD**xA yA* first point of line AB*xB yB* second point of line AB

x_C y_C first point of line CD
 x_D y_D second point of line CD
 $posA$ first point of line AB
 $posB$ second point of line AB
 $posC$ first point of line CD
 $posD$ second point of line CD

EXAMPLE
see below

3.7.13 geom.intersectlinepath

Returns the first intersection point of the extensions of a line $\overline{AB}$ with a path $\overline{P_1 P_2 \dots}$. If the extension of the line does not intersect the path, an exception is raised.

SYNOPSIS

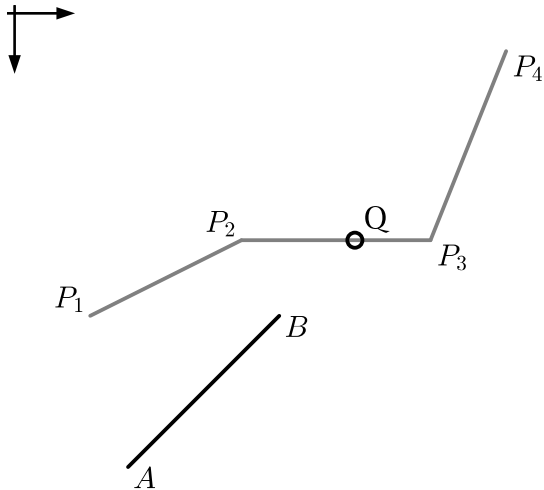
geom.intersectlinepath x_A y_A x_B y_B x_1 y_1 x_2 y_2 ...
geom.intersectlinepath $posA$ $posB$ $posP1$ $posP2$...

x_A y_A first point of line AB
 x_B y_B second point of line AB
 x_1 y_1 first point of path
 x_2 y_2 second point of path
 $posA$ first point of line AB
 $posB$ second point of line AB
 $posP1$ first point of path
 $posP2$ second point of path

EXAMPLE

```

unitlength 10
set A {1.5 6.0}; m $A; tlb A SE
set B {3.5 4.0}; m $B; tlb B SE
set P1 {1.0 4.0}; m $P1; tlb P_1 NW
set P2 {3.0 3.0}; m $P2; tlb P_2 NW
set P3 {5.5 3.0}; m $P3; tlb P_3 SE
set P4 {6.5 0.5}; m $P4; tlb P_4 SE
pen gray
l $P1 $P2 $P3 $P4
pen black
l $A $B
circle [geom.intersectlinepath $A $B $P1 $P2 $P3 $P4] [mm 1]
label Q
  
```



3.7.14 `geom.intersectcircles`

Returns the intersection point(s) of two circles. If the circles do not intersect or if they are coincident, an exception is raised.

SYNOPSIS

`geom.intersectcircles` *xA yA rA xB yB rB nb*

`geom.intersectcircles` *xA yA rA xB yB rB*

xA yA rA first circle (centre coordinates, radius)

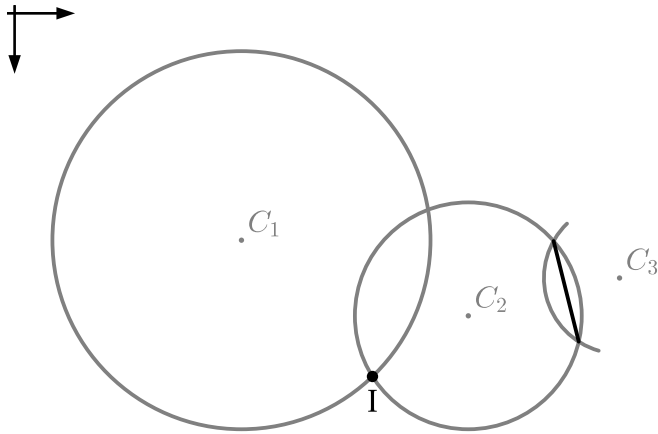
xB yB rB second circle

nb requested number of intersection points. 2: both. 1: Right intersection point, seen from the centre of the first circle looking to the centre of the second circle (default).

0: Query only if there is a valid intersection point, returns true or false.

EXAMPLE

```
pen gray
set c1 {30 30 25}; circle $c1;      pt; tlb C_1
set c2 {60 40 15}; circle $c2;      pt; tlb C_2
set c3 {80 35 10}; arc $c3 106 -134; pt; tlb C_3
pen black
dot [geom.intersectcircles $c1 $c2 ]; label I S
line [geom.intersectcircles $c3 $c2 2]
```



3.7.15 geom.intersectcircleline

Returns the intersection point(s) of a circle and a line $\overline{AB}$ or its extensions. If the line does not intersect the circle, an exception is raised.

SYNOPSIS

geom.intersectcircleline xM yM r xA yA xB yB nb

geom.intersectcircleline xM yM r xA yA xB yB

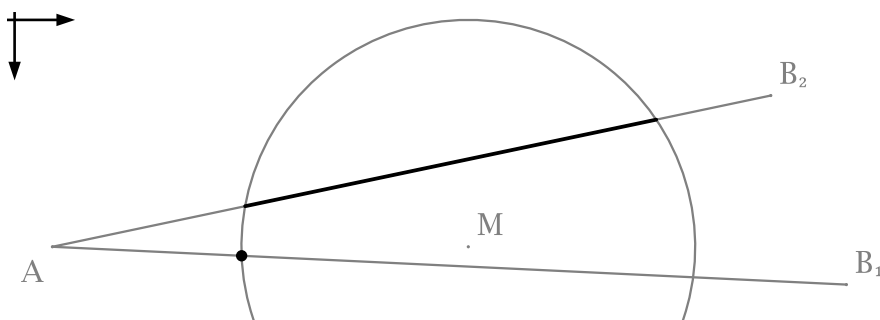
xM yM rM circle (centre coordinates, radius)

xA yA xB yB line (point A, point B)

nb requested number of intersection points. 2: both. 1: First intersection point in line direction (default). 0: Query only if there is a valid intersection point, returns true or false.

EXAMPLE

```
pen gray 0.3
set c {60 30 30}; arc $c 160 20; pt;      lb M
set A {5 30};                pt $A;      lb A SW
set B1 {110 35};              pt $B1;     lb B1
set B2 {100 10};              pt $B2;     lb B2
line $A $B1
line $A $B2
pen
dot [geom.intersectcircleline $c $A $B1]
line [geom.intersectcircleline $c $A $B2 2]
```



3.7.16 geom.centroid

Returns the centre of gravity of an area (surrounded by a polygon).

SYNOPSIS

geom.centroid *xA yA xB yB xC yC ...*

geom.centroid *posA posB posC ...*

xA yA first point of polygon

xB yB second point of polygon

xC yC third point of polygon

posA first point of polygon

posB second point of polygon

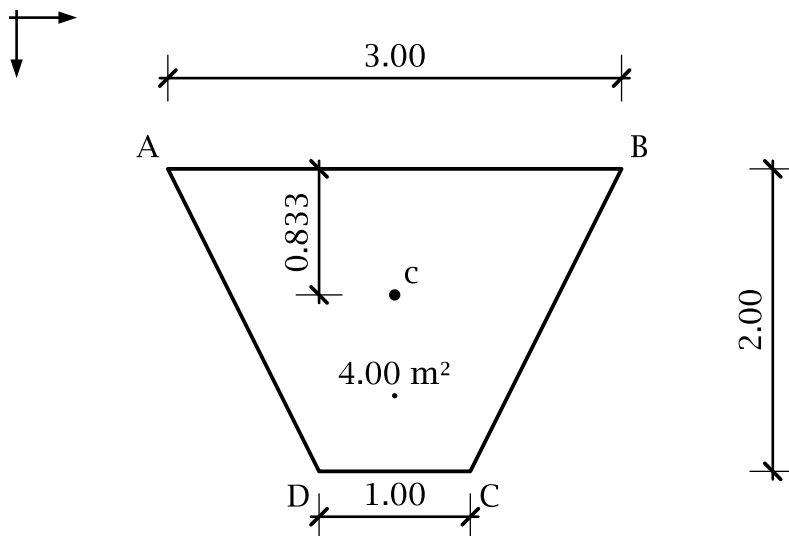
posC third point of polygon

EXAMPLE

```

unitlength 20
dimline ticks
set A {1 1}; m $A; lb A NW
set B {4 1}; m $B; lb B NE
set C {3 3}; m $C; lb C SE
set D {2 3}; m $D; lb D SW
polygon $A $B $C $D
set area [geom.area $A $B $C $D]
pt [geom.intersect "$A $C" "$B $D"]
label "[nf $area 2] m2" N
set c [geom.centroid $A $B $C $D]; # centroid: 2.5 1.8333333333333333
dot $c; lb c
pen 0.35; dimline 5 [Y $A] 5 [Y $D] %.2f
dimline 2 [Y $A] 2 [Y $c]
dimline [X $A] 0.4 [X $B] 0.4 %.2f
dimline [X $C] 3.3 [X $D] 3.3 %.2f

```



3.7.17 geom.extend

Returns an extended line defined by two points.

SYNOPSIS

geom.extend *x1 y1 x2 y2 dLA dLB*

geom.extend *pos1 pos2 dLA dLB*

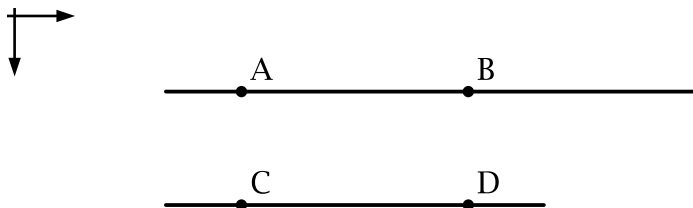
geom.extend *x1 y1 x2 y2 dL*

geom.extend *pos1 pos2 dL*

x1 y1 first point of existing line
x2 y2 second point of existing line
pos1 first point of existing line
pos2 second point of existing line
dLA dLB extension values
dL extension value at both sides

EXAMPLE

```
set A {30 10}; dot $A; label A
set B {60 10}; dot $B; label B
line [geom.extend $A $B 10 30]
set C {30 25}; dot $C; label C
set D {60 25}; dot $D; label D
line [geom.extend $C $D 10]
```

**3.7.18 geom.parallel**

Returns a parallel line defined by two points.

SYNOPSIS

geom.parallel *x1 y1 x2 y2 distance*

geom.parallel *pos1 pos2 distance*

geom.parallel *x1 y1 x2 y2*

geom.parallel *pos1 pos2*

x1 y1 first point of existing line
x2 y2 second point of existing line
pos1 first point of existing line
pos2 second point of existing line

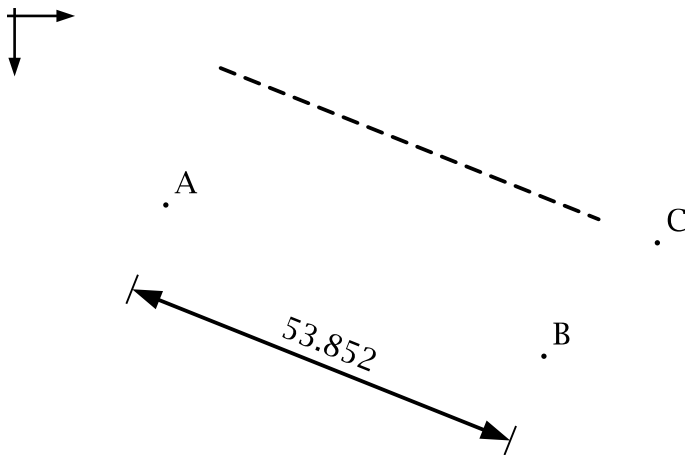
distance Distance. If omitted new parallel line goes through the current cursor position.

EXAMPLE

```

set A {20 25}; point $A; label A
set B {70 45}; point $B; label B
set C {85 30}; point $C; label C
# Draw a dimension line at 12mm distance to AB
dimline [geom.parallel $A $B [mm 12]]
pen dashed
# Draw a parallel line through C (current cursor position)
moveto $C
line [geom.parallel $A $B]

```



3.7.19 geom.topolygon

Returns a closed polygon (approximation) for shapes.

SYNOPSIS

geom.topolygon rectangle (rect) ...

geom.topolygon box ...

geom.topolygon rectmid ...

geom.topolygon rod ...

geom.topolygon circle ...

geom.topolygon ellipse ...

EXAMPLE

```

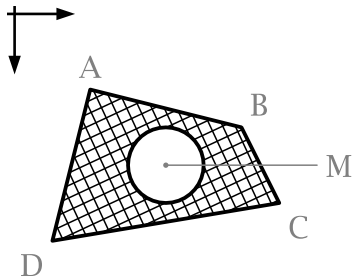
set A {10 10}
set B {30 15}
set C {35 25}
set D { 5 30}
set M {20 20}
set opening [geom.topolygon circle $M 5]
# hatch
pen 0.2
hatch 65 1.5
hatchpolygon $A $B $C $D $A $opening
hatch [+ 65 90] 1.5

```

```

hatchpolygon $A $B $C $D $A $opening
# outline
pen
polygon $A $B $C $D
polygon $opening

```



3.7.20 geom.topolyline

Returns a polyline (approximation) for curves. The subcommand *reverse* changes the order of a list, starting by the last point.

SYNOPSIS

geom.topolygon quadcurve (parabola) ...

geom.topolygon cubiccurve ...

geom.topolygon arc ...

geom.topolygon arc2 ...

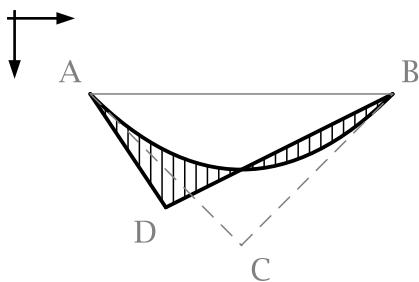
geom.topolygon reverse ...

EXAMPLE

```

offset 10 10
set A { 0 0 }
set B {40 0}
set C {20 20}
set D {10 15}
# outline
quadcurve $A $C $B
line $A $D $B
# hatch
pen 0.2
hatch 90 1.5
hatchpolygon [geom.topolyline quadcurve $A $C $B] $D

```



3.7.21 geom azimuth (geom.azi)

Computes the azimuth (in degrees) from point A to point B.

SYNOPSIS

geom.azimuth *x1 y1 x2 y2*

geom.azimuth *posA posB*

geom.azimuth *x2 y2*

geom.azimuth *posB*

x1 y1 First point. If omitted the current cursor position is assumed.

x2 y2 second point

posA First point. If omitted the current cursor position is assumed.

posB second point

EXAMPLE

```
puts [geom.azimuth 10 10 30 30]; # Writes 45.0
```

3.7.22 geom.length (geom.abs)

Computes the length of a vector. Thus returns the hypotenuse of two catheti in a right-angled triangle.

SYNOPSIS

geom.length *xA yA xB yB*

geom.length *posA posB*

geom.length *dx dy*

geom.length *v*

xA yA xB yB vector $\overline{AB}$

posA posB vector $\overline{AB}$

dx dy vector

v vector

EXAMPLE

```
puts [geom.length 30 40]; # Writes 50.0
```

3.7.23 geom.area

Computes the area within a polygon. The command always returns a positive value.

SYNOPSIS

geom.area *xA yA xB yB xC yC ...*

geom.area *posA posB posC ...*

xA yA first point of polygon
xB yB second point of polygon
xC yC third point of polygon
posA first point of polygon
posB second point of polygon
posC third point of polygon

EXAMPLE
 see above

3.7.24 **geom.angle**

analogy: **geom.anglerad**

Computes the angle (in degrees) between three points. A is the centre point. If the argument is a vector its direction (azimuth) is computed.

SYNOPSIS

geom.angle *xA yA xP yP xQ yQ*
geom.angle *posA posP posQ*
geom.angle *xP yP xQ yQ*
geom.angle *posP posQ*
geom.angle *vector*

xA yA Centre point. If omitted the current cursor position is assumed.
xP yP first distant point
xQ yQ second distant point
posA Centre point. If omitted the current cursor position is assumed.
posP first distant point
posQ second distant point
vector vector

3.7.25 **geom.crossproduct**

Computes the cross product of two vectors. The command returns the scalar z component of the resulting vector.

SYNOPSIS

geom.crossproduct *dx1 dy1 dx2 dy2*
geom.crossproduct *v1 v2*

dx1 dy1 first vector
dx2 dy2 second vector
v1 first vector
v2 second vector

EXAMPLE

```
puts [geom.crossproduct 3 0.5 2 2]; # Writes 5.0
```

3.7.26 geom.dotproduct

Computes the (scalar) dot product of two vectors.

SYNOPSIS

geom.dotproduct *dx1 dy1 dx2 dy2*

geom.dotproduct *v1 v2*

dx1 dy1 first vector

dx2 dy2 second vector

v1 first vector

v2 second vector

EXAMPLE

```
puts [geom.dotproduct 3 0.5 2 2]; # Writes 7.0
```

3.7.27 geom.distance (geom.dist)

Computes the distance of a line (or point) to the current position.

SYNOPSIS

geom.distance *x1 y1 x2 y2*

geom.distance *pos1 pos2*

geom.distance *x1 y1*

geom.distance *pos1*

x1 y1 first point of existing line or just point

x2 y2 second point of existing line

pos1 first point of existing line or just point

pos2 second point of existing line

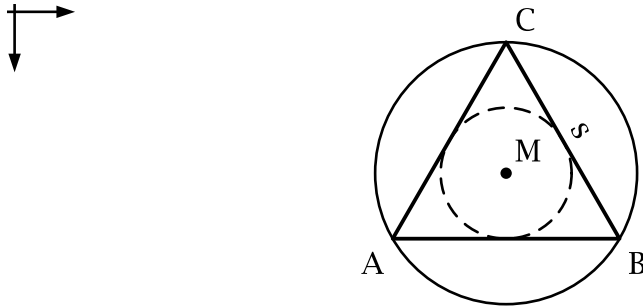
EXAMPLE

```
set s 30
set A {50 30}
set B [++ $A "$s 0"]
set C [++ $A [p $s -60]]
m $A; label A SW
m $B; label B SE
m $C; label C
label s $B $C
polygon $A $B $C; # cursor now is at $A
```

```

moverel [expr $s /2] [expr -sqrt(3)*$s /6]
dot; label M
pen 0.35
circle [geom.distance $A]
pen dashed
circle [geom.distance $A $B]

```



3.8 Statics commands

The statics commands `stat.*` are utility commands, that do calculations with forces "`x y Fx Fy`". The commands do not draw.

3.8.1 `stat.add (+++)`

Computes the force vector sum and a valid application point.

SYNOPSIS

stat.add *F1 F2 ...*

+++ *F1 F2 ...*

F1 first force

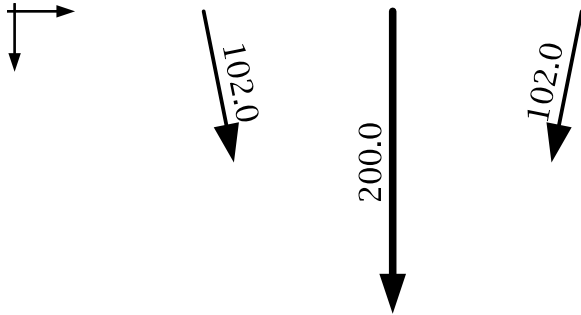
F2 second force

EXAMPLE

```

set F1 {5.0 0.0 20 100}
set F2 {15.0 0.0 -20 100}
force $F1
force $F2
pen 1.0
set R [stat.add $F1 $F2]
force $R
puts $R;           # Writes 10.0 0.0 0.0 200.0

```



3.8.2 `stat.subtract` (---)

Computes the force vector subtraction and a valid application point.

SYNOPSIS

stat.subtract *F1 F2 ...*

--- *F1 F2 ...*

F1 first force (sum)

F2 second force (to be subtracted from sum)

EXAMPLE

```
set F1 { 5.0 0.0    0 100}
set F2 {15.0 0.0  -20 100}
set R  [stat.add $F1 $F2]
puts [stat.subtract $R $F2]; # Writes 5.0 0.0 0.0 100.0
```

3.8.3 `stat.multiply` (***)

Computes a force scaled by multiplication. The application point does not change.

SYNOPSIS

stat.multiply *factor force*

*** *factor force*

factor scaling factor

force force "x0 y0 Fx Fy"

EXAMPLE

```
puts [*** 1.5 {5.00 0.00 20 30}]; # Writes 5.0 0.0 30.0 45.0
```

3.8.4 stat.move

Returns an equivalent force to the input force. The application point is moved along the action line of the force, until it intersects the extension of a line $\overline{AB}$.

SYNOPSIS

stat.move $x0\ y0\ Fx\ Fy\ xA\ yA\ xB\ yB$

stat.move $F\ posA\ posB$

$x0\ y0$ application point of input force

$Fx\ Fy$ components of input force

$xA\ yA$ first point of line AB

$xB\ yB$ second point of line AB

F input force " $x0\ y0\ Fx\ Fy$ "

$posA$ first point of line AB

$posB$ second point of line AB

EXAMPLE

see below

3.8.5 stat.move2

Returns an equivalent force to the input force. The application point is moved along the action line of the force, until the arrow head touches the extension of a line $\overline{AB}$.

SYNOPSIS

stat.move2 $x0\ y0\ Fx\ Fy\ xA\ yA\ xB\ yB$

stat.move2 $F\ posA\ posB$

$x0\ y0$ application point of input force

$Fx\ Fy$ components of input force

$xA\ yA$ first point of line AB

$xB\ yB$ second point of line AB

F input force " $x0\ y0\ Fx\ Fy$ "

$posA$ first point of line AB

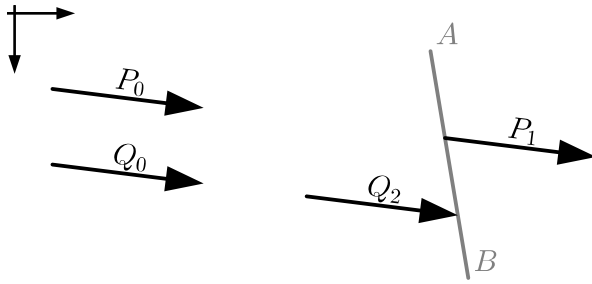
$posB$ second point of line AB

EXAMPLE

```

unitlength 10; forceunitlength 0.5
pen gray
set A {5.5 0.5}; m $A; tlb A
set B {6.0 3.5}; m $B; tlb B
l $A $B
pen
set P0 {0.5 1.0 40 5}; texforce $P0 P_0
set Q0 {0.5 2.0 40 5}; texforce $Q0 Q_0
texforce [stat.move $P0 $A $B] P_1
texforce [stat.move2 $Q0 $A $B] Q_2

```



3.8.6 stat.actionline

Returns two points on the action line of a force.

SYNOPSIS

stat.actionline *x0 y0 Fx Fy fA fB*

stat.actionline *F fA fB*

stat.actionline *x0 y0 Fx Fy f*

stat.actionline *F f*

stat.actionline *x0 y0 Fx Fy*

stat.actionline *F*

x0 y0 application point of input force

Fx Fy components of input force

F input force "x0 y0 Fx Fy"

fA fB extension factors (left, right), analogue to geom.online

f extension factor

EXAMPLE

see below

3.8.7 stat.tip

Returns the tip position of the force arrow.

SYNOPSIS

stat.tip *x0 y0 Fx Fy*

stat.tip *F*

x0 y0 application point of input force

Fx Fy components of input force

F input force "x0 y0 Fx Fy"

3.8.8 stat.abs

Computes the absolute value of a force: $\sqrt{F_x^2 + F_y^2}$.

SYNOPSIS

stat.abs *x0 y0 Fx Fy***stat.abs** *F**Fx Fy* force components*x0 y0* Application point. Does not influence the result.*F* force "*x0 y0 Fx Fy*"

EXAMPLE

see below

3.8.9 stat.distance (stat.dist)

Computes the distance of a force to the current position.

SYNOPSIS

stat.distance *x0 y0 Fx Fy***stat.distance** *F**x0 y0* application point of force*Fx Fy* components of force*F* force "*x0 y0 Fx Fy*"

EXAMPLE

see below

3.8.10 stat.moment

Computes the moment of a force relative to the current position. If several forces are given, the sum of the moments is calculated.

SYNOPSIS

stat.moment *x0 y0 Fx Fy***stat.moment** *F ...**x0 y0* application point of force*Fx Fy* components of force*F* force "*x0 y0 Fx Fy*"

EXAMPLE

```

unitlength [/ 1. 200.] m
forceunitlength [/ 5. 100.]
set A { 5.0 0}
set F {11.0 -0.90 300 400}
puts [stat.abs $F];           # Writes 500.0

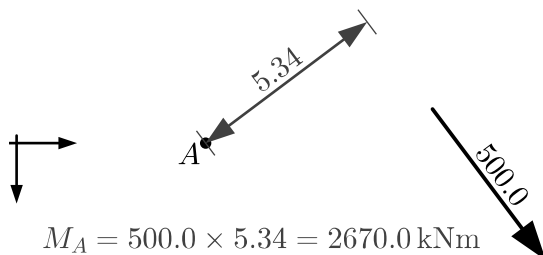
```

```

moveto $A
set r [stat.distance $F]; puts $r; # Writes 5.34
set M [stat.moment $F]; puts $M;   # Writes 2670.0

# Draw the point A, the force F and distance A-F
dot $A; tlb A SW
texforce $F
pen 0.35 darkgray
m $A; texdimlinere1 [geom.rotate [** $r [geom.norm [FXY $F]]] -90]
# Write the moment M_A of the force F
moveto 0.5 3.0
texlabel "M_A = [stat.abs $F] \\times $r = $M \\,\\,\\text{kNm}"

```



3.8.11 stat.mequi

Scales an input force until moment equilibrium is fulfilled. Moment equilibrium is done around the current cursor position.

SYNOPSIS

stat.mequi x_B y_B F_{xB} F_{yB} x_0 y_0 F_x F_y

stat.mequi FB F

stat.mequi FB M

x_B y_B	position of sliding bearing
F_{xB} F_{yB}	force components indicating direction of support (absolute value has no influence)
FB	support force, absolute value has no influence
F	force " x_0 y_0 F_x F_y " to be equilibrated
M	moment to be equilibrated

EXAMPLE

see below

3.8.12 stat.equi

Returns the force (components and application point) that is required to complete equilibrium. Equivalent to `[*** -1 [+++ $F1 $F2]]`.

SYNOPSIS

stat.equi $F1$ $F2$...

$F1$ first force
 $F2$ second force

EXAMPLE

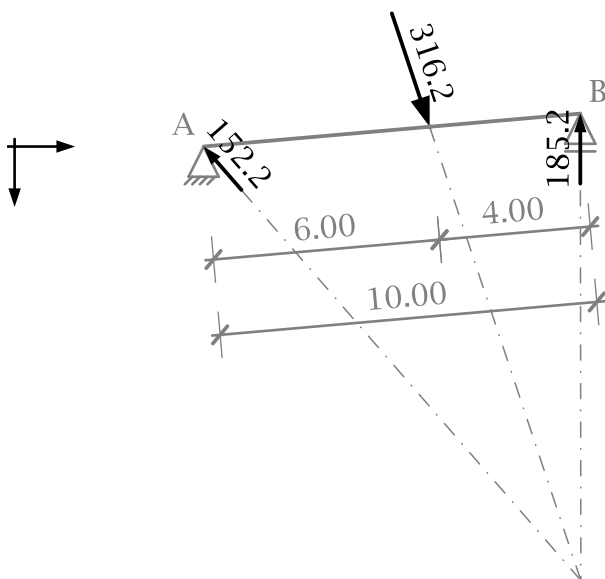
```

unitlength [/ 1. 200.] m
forceunitlength [/ 5. 100.]
set A {5 0}
set B "[++ $A [geom.rotate {10 0} -5]]"
set C [geom.online $A $B 0.6]
set F "$C 100 300"
force2 $F

# Draw beam, points, bearings (not shown), dimension lines
pen gray; moveto $A; label A NW
lineto $B; label B; point $C
dimline ticks
dimline [geom.parallel $A $C [mm 15]] %.2f
dimlinerel [-- "$B" "$C"] %.2f
dimline [geom.parallel $A $B [mm 25]] %.2f
# graphical statics
pen gray dashdotted 0.2
line [stat.actionline $F 1 4]
line $B [here]
lineto $A

# Calculate reaction forces
pen solid red 0.5
moveto $A; # moment equilibrium at pos. A in order to get force FB
set FB "$B 0 1"
set FB [stat.mequi $fB $F]
force2 $FB
set FA [stat.equi $F $FB]; # equilibrium to get force FA
set FA [stat.move $FA $A $B]
force2 $FA

```



3.8.13 stat.fequi

Equilibrates a known force F by two other forces A and B , of which the azimuths are known. The command returns the force A . Equilibrium is defined $F + A + B = 0$. Then B is [stat.equi F α β].

SYNOPSIS

stat.fequi F α β

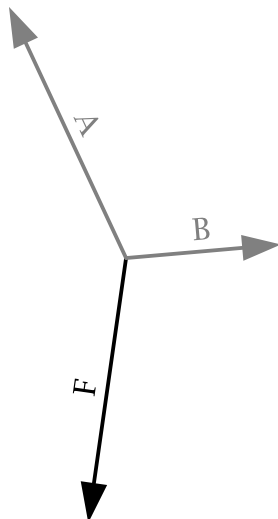
F known force

α azimuth (in degrees) of searched force A

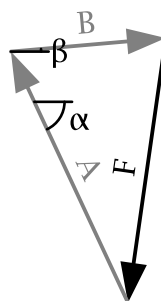
β azimuth (in degrees) of force B

EXAMPLE

```
forceunitlength [/ 1. 10.]
set F {40 35 -50 350}
force $F F
set A [stat.fequi $F 65 -5]
set B [stat.equi $F $A]
pen gray
force $A A
force $B B
pen black; # Draw the force polygon
m 100 25; lb {force polygon:} NW
moveto 100 35
force [FXY $F] F
pen gray
force [FXY $A] A
force [FXY $B] B
assert "[X [here]] == 100 && [Y [here]] == 35" "Force polygon not closed"
```



force polygon:



3.9 Programming commands

For a programming introduction check the hecl tutorial <http://hecl.org/docs/tutorial.html>.

For a complete reference, check the hecl command reference <http://hecl.org/docs/commands.html>.

3.9.1 Variables: set, \$

set — Set a variable.

SYNOPSIS

set *varname* [*value*]

Description

The set command sets the *value* of a variable *varname* to value *value*. If *value* is not provided, returns the value of *varname*.

EXAMPLE

```
set foo "bar"  
set bee bop  
puts "foo is $foo and bee is $bee"
```

Produces: foo is bar and bee is bop

The variable *\$argv* contains the list of eventual command line arguments, *\$argc* the number of arguments passed to the drawing script.

EXAMPLE drawj2d mydrawing.hcl Arg1 Arg2 Arg3

```
puts "The first of $argc arguments is: [lindex $argv 0]"
```

Produces: The first of 3 arguments is: Arg1

3.9.2 External script: source

The source command evaluates the Hecl script located in file *filename*. Calling the source command from within a procedure prevents unintended overwriting of global variables.

SYNOPSIS

source *filename.hcl*

EXAMPLE

```
# Variable foo is defined as "Hello world" in foo.hcl  
source foo.hcl  
puts $foo
```

Produces: Hello world

3.9.3 Math commands

Floating point math commands. See also **expr**. Angles are expected in radians (this differs from the **expr** command!).

abs acos asin atan atan2 cbrt ceil cos cosh exp expm1 floor hypot log log10 log1p pow random round signum sin sinh sqrt tan tanh toDegrees toRadians

SYNOPSIS

command number [number]

3.9.4 Conditions: if

if — Conditionally execute code.

SYNOPSIS

if *test code* [**elseif** | *test* | *code* ...] [**else** | *code*]

Description

The **if** command executes Hecl code conditionally. In its most basic form, it executes a test. If the results are not 0, then it executes code. If not, no further actions take place. **if** may take any number of **elseif** clauses, which have their own test and code. Finally, if none of the conditions has matched, it is also possible to supply an **else** clause that will be executed if the results of the **if** and **elseif** tests were all false.

EXAMPLE

```
if { > 0 1 } {
    puts "true"
} else {
    puts "false"
}
```

Produces: false

EXAMPLE

```
set numberOne 7; set numberTwo 8
if {expr $numberOne > 5 || $numberTwo > 10} {
    puts {numberOne > 5 OR numberTwo > 10}
}
```

3.9.5 Loops: for, foreach, while

for — For loop.

SYNOPSIS

for *initialization test step body*

Description

The **for** command is like in many other languages like C and Java. As arguments, it takes an *initialization* option, which is often used to set a variable to some initial value, a *test* to determine whether to continue

running, a *step* script option which is run at each iteration of the body (to increment a variable, for example), and the body itself.

EXAMPLE

```
set out {}
for {set i 0} {< $i 10} {incr $i} {
    append $out $i
}
puts $out
```

Produces: 0123456789

foreach — Iterate over elements in a list.

SYNOPSIS

foreach *varname list body*

foreach *varlist list body*

Description

The **foreach** command iterates over a list. For each element of the *list*, *varname* is set to a new element of the *list*, and then *body* is run.

EXAMPLE

```
set lst {a b c d e}
set res {}
foreach el $lst {
    append $res $el
}
puts $res
```

Produces: abcde

while — While loop.

SYNOPSIS

while *condition body*

Description

The **while** command continues to evaluate *body* while *condition* is true.

EXAMPLE

```
set i 0
while { < $i 3 } {
    puts "i is $i"
    incr $i
}
```

Produces: i is 0| i is 1| i is 2

3.9.6 Procedures: **proc**, **rename**

The **proc** command creates new procedures, which are virtually indistinguishable from built-in Hecl commands. By default, Hecl variables are always local. Global variables are not visible from within procedures. The **global** command makes global variable *varname* visible within a procedure.

SYNOPSIS

proc [*name*] *arglist body*
global *varname* [*varname...*]

EXAMPLE

```
set debug false
proc ignore {command} {
    global debug
    foreach cmd $command {
        proc $cmd {args} {global debug; if {$debug} {puts "command ignored"
        }}
        if {$debug} {puts "Ignore command: $cmd"}
    }
}
# ignore list
ignore {model geomTransf uniaxialMaterial}
ignore {eigen timeSeries pattern load loadConst rayleigh}
ignore {constraints numberer system test}
ignore {algorithm integrator analysis analyze}
ignore {open close recorder wipeAnalysis wipe}
```

rename — Rename a command

rename *cmdname newcmdname*

EXAMPLE

```
rename expr exprhecl
proc expr {args} {return $args}
```

3.9.7 Hash tables

hash — Create and manipulate hash tables.

SYNOPSIS

hash *list*
hget *hash key*
hset *hash key value*
hcontains *hash key*
hclear *hash*
hkeys *hash*
hremove *hash key*

Description

The **hash** command takes an even-numbered list and creates a hash table from it, using the even elements as keys, and odd elements as values. A new hash table is returned. The **hget** and **hset**

commands operate on hash tables. Both take a hash table as their first argument. `hget` also takes a key, and returns the corresponding value, or an error if no key by that name exists. To determine whether a given key exists, use the **hcontains** command, which returns true or false depending on whether the key exists in the hash table.

The **hkeys** command returns the keys of the hash table, as a list.

The **hclear** command clears an entire hash table, whereas **hremove** removes the value associated with a given key.

EXAMPLE

```
set foo [hash {a b c d}]
hset $foo a 42
puts [hget $foo a]
```

Produces: 42

EXAMPLE

```
set nd [hash {}]; # Hash list nd saves node coordinates.
proc node {number x y} {
    global nd
    set Y [* -1 $y]; # Opensees y coordinate points upwards, drawj2d downwards.
    hset $nd $number "$x $Y"
    circle $x $Y [mm 0.4]
    if {>= $x 0} {label $number NE} else {label $number NW}
}
```

3.9.8 Read data from file: open

The `open` command gives read access to external files.

SYNOPSIS

```
set f [open filename.txt]
$f hasnext
set s [$f readln]
set s [$f read bytes ]
set s [$f read]
$f close
```

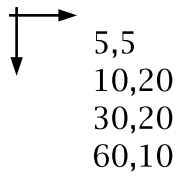
EXAMPLE

data.csv

```
5,5
10,20
30,20
60,10
```

```
moveto 10 5
set f [open data.csv]
while {$f hasnext} {
    text [$f readln]
```

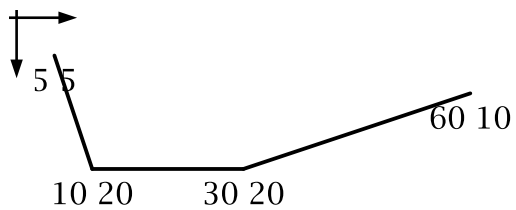
```
}
```



```
# Read the data of a csv file into a list
proc readcsv {file} {
    set f [open $file]
    set s [$f read]
    $f close
    set s [strtrim $s]
    set s [strreplace {, " "} $s]
    return [split $s "\n"]
}

set DATA [readcsv data.csv]

set i 0
foreach DP $DATA {
    incr $i
    if {< $i 2} {moveto $DP} else {lineto $DP}
    label $DP S
}
```



3.10 Complete command list

To get the list of all available commands type:

```
puts [sort [intro commands]]
```

```
!= % * ** *** + ++ +++ - -- --- / // 1+ 1- < <= = > >= FX FXY FY X XY Y abs acos after alias and
append arc arc2 arrow arrowrel arrows arrowsrel arrowsto arrowto asin assert atan atan2 berror
block block.flip block.rotate block.scale box break catch cbrt ceil circle classof clock continue copy
cos cosh cubiccurve dimangle dimline dimlinerel dimlineto dot double dxf ellipse endblock eq eval
exit exp expm1 expr exprinput false file.readable fillbox fillcircle fillellipse fillpolygon fillrect
fillrectangle fillrectmid fillrod fillsector fillsegment filter float floor font for force force2 forceunitlength
foreach format fu geom.abs geom.add geom.angle geom.anglerad geom.area geom.azi geom.azimuth
geom.centroid geom.crossproduct geom.dist geom.distance geom.divide geom.dotproduct geom.ex-
tend geom.half geom.intersect geom.intersectcircleline geom.intersectcircles geom.intersectlinepath
geom.length geom.multiply geom.norm geom.online geom.parallel geom.polar geom.rotate geom.sub-
tract geom.topolygon geom.topolyline geom.tox geom.toy geom.v geom.vector global hasclass hash
hatch hatchbox hatchcircle hatchellipse hatchpolygon hatchrect hatchrectangle hatchrectmid hatchrod
hatchsector hatchsegment hclear hcontains here herepolar hget hkeys hremove hset hypot if image incr
int intro join kN l label lappend lb lindex line linemid linepolar linerel lineto linetox linetoy linsert list
llen llength lm log log10 log1p long lp lr lrange lset lx ly m max min mm movepolar moverel moveto
movetox movetoy mp mr mx my ne nf not offset opacity open or p parabola pen point polygon pow proc
pt puts quadcurve r random rect rectangle rectmid rename return rod round rp runtime.freememory
runtime.totalmemory search sector segment set signum sin sinh sort source split sqrt stat.abs stat.ac-
tionline stat.add stat.dist stat.distance stat.equi stat.fequi stat.mequi stat.moment stat.move stat.move2
stat.multiply stat.subtract stat.tip strbytelen strcmp strfind strindex strlast strlen strlower strrange
strrep strreplace strtrim strtriml strtrimr strupper system.gc system.getProperty system.hasproperty
tan tanh texdimangle texdimline texdimlinerel texdimlineto texforce texforce2 texlabel text thisinterp
throw time tlb tnotify toDegrees toRadians today true twait tx ty unitlength unitsize unset upeval while
½
```

4 Additional functionality

4.1 Support for spread sheet csv data and Fachwerk background drawings bgd

Use the Drawj2d command line parameter *--frontend bgd* or *-F bgd*.

csv (spread sheet)

A list of point coordinates can be created in a spread sheet application. The list has to be saved as comma separated file with the ending *csv*. Drawj2d displays the points. The scale is automatically chosen (1:5, 1:10, 1:20, 1:50, ...).

```
drawj2d -T pdf -F bgd --width 150 --height 100 points.csv
```

bgd (text file)

The program Fachwerk for structural engineers (fachwerk.sourceforge.net) supports a simple text based drawing format called bgd for background drawings. These can be exported by Drawj2d to pdf, svg or other vector formats.

```
drawj2d -T pdf -F bgd --width 150 --height 80 doku.bgd
```

Bgd drawings are created using a text editor, similar to the Drawj2d native *hcl* format. The file has to be saved with the suffix *bgd*. Figure 2 shows an example of such a text file and the drawing as it would be displayed by Fachwerk.

The numbers in a row can be separated by space, tabulator or comma. The order of the commands (Point, Line, Circle, Arc) does not matter. For example the file may start with commands for lines, continue with points and then list a line command again. Only the first character of a command is required (Circle: *C* or *K* for Kreis (German), Arc: *A* or *B* for Bogen). Rows starting with *#* or *//* or with the word *rem* indicate comments. Fachwerk accepts coordinates in both *x,z* and *x,y,z* formats. In Fachwerk2D mode and Drawj2D the y-value is not used.

The bgd extension is an example for programmers how to access the Drawj2d java API.

```

Points
0.2  0.2      ← x, z - coordinates 1. point
0.2  1.9      ← x, z - coordinates 2. point
1.8  1.2
1.8  1.9
3.0  0.2

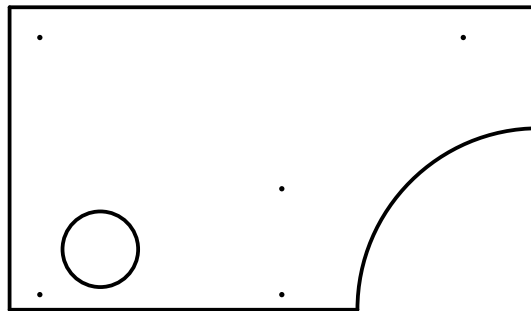
Line
3.5  0        ← start
3.5  0.8      ← end

Line
2.3  2.0      ← start
0    2.0
0    0
3.5  0        ← end

Circle
0.6  1.6      ← centre
0.25      ← radius

Arc
3.5  2.0      ← centre
1.2, 90, 180  ← radius, start angle, end angle (anti-clockwise)

```



1:50.0

Figure 2: Input text file *.bgd* and resulting drawing

4.2 Support for Yacas plot data

The computer algebra system Yacas (yacas.org) uses Gnuplot for plotting. If gnuplot is not available, yacas can prepare plot data using the Plot2D option *output=java*. Drawj2d can read the plot data and draw rudimentary plots.

Use the Drawj2d command line parameter *--frontend ypd* or *-F ypd*.

Start Yacas (`yacas-gui`, `yacas`, `java -jar yacas.jar` or alternatively `mavscript-yacas`) and type:

```
f(x) := x^2-x-2      ← The function to plot
g(x) := x^2          ← A second function to plot
```

Write a yacas plot data (ypd) file.

```
ToFile("plot-f.ypd") Plot2D(f(x),x=-5:5,output=java)
```

Multiple functions can be written in one plot data file:

```
ToFile("plot-fg.ypd") Plot2D({f(x),g(x)},x=-5:5,output=java)
```

Call Drawj2d directly out of Yacas to produce a plot (see Figure 3):

```
SystemCall("drawj2d -F ypd -W150 -H100 plot-f.ypd")
```

Drawj2d can also be called from the command line.

```
drawj2d -T pdf -F ypd --width 150 --height 100 plot-fg.ypd
```

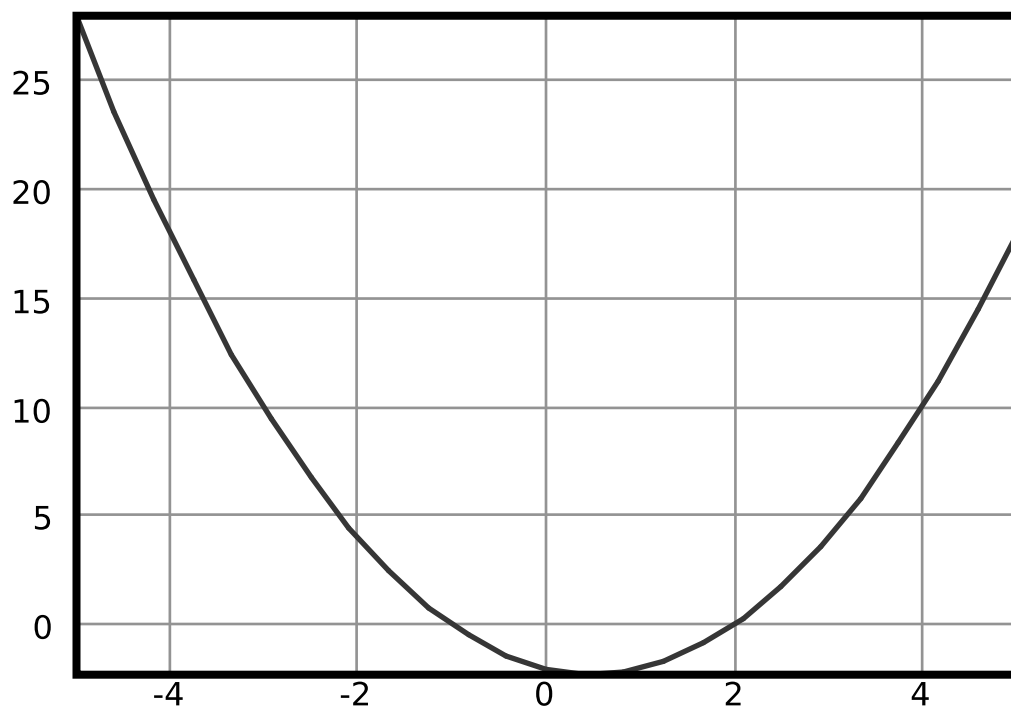


Figure 3: Draw yacas plot data: $f(x)$

5 Drawj2d Input Examples

5.1 Drawings

Anchor plate

Input of the drawing Figure 1.

drawing.hcl

```

#! drawj2d -T pdf -W 150 -H 120 -c drawing.hcl

# Nullpunkt ist Plattenmittelpunkt
# SI-Einheiten: mm, kN
unitlength 0.2 mm;    # Das heisst Massstab 1:5, Einheit Millimeter

# Eingaben
# -----
set b    350;    # Plattenbreite
set h    350;    # Plattenhöhe
set t     20;    # Plattenstärke
set d     12;    # zu zeichnender Dübeldurchmesser im Durchgangsloch
set df    20;    # Durchgangsloch in Ankerplatte
set c     40;    # nomineller Randabstand Dübel

# Profil zeichnen
box -50 -50  50 50
box -45 -45  45 45

# Eingabekontrollen
assert "$b > 4*$c"      {Eingabekontrolle Plattenbreite}
assert "$h > 4*$c"      {Eingabekontrolle Plattenhöhe}
assert "$t >= 8"        {Eingabekontrolle Plattenstärke}
assert "$d > 5"         {Eingabekontrolle Dübeldurchmesser}
assert "$df > 5"        {Eingabekontrolle Durchgangsloch}

# Zeichnen der Achsen
set ueberstand 10; # Achsüberstand
pen gray dashdotted 0.35
m 0 0
linemid [expr $b + 2 * $ueberstand] 0
linemid [expr $h + 2 * $ueberstand] 90

# Zeichnen der Ankerplatte
set TL [// "-$b -$h" 2]; set TR [// "$b -$h" 2]
set BL [// "-$b $h" 2]; set BR [// "$b $h" 2]
pen black solid 0.7;
box $TL $BR

# Zeichnen des Dübels
set DbTL [++ $TL "$c $c"];    set DbTR [++ $TR "-$c $c"]
set DbBL [++ $BL "$c -$c"];   set DbBR [-- $BR "$c $c"]
pen gray 0.5;
fillcircle $DbTL [/ $d 2.];   fillcircle $DbTR [/ $d 2.]
fillcircle $DbBL [/ $d 2.];   fillcircle $DbBR [/ $d 2.]

```

```

pen 0.35 black
circle $DbTL [/ $df 2.];      circle $DbTR [/ $df 2.]
circle $DbBL [/ $df 2.];      circle $DbBR [/ $df 2.]

# Vermassung
dimline ticks
set xdim [mm 8]
# Ankerplatte
pen 0.35
dimline [geom.parallel $BL $BR $xdim]
dimline [geom.parallel $TL $BL $xdim]
p 150 60; lr [mm 40 0]; label "t = $t mm" NW
# Dübel
pen gray
m $TR; mr $xdim 0
dimlinereel 0 $c
dimlineto [ty $DbBR]
dimlineto [ty $BR]
m $TL; mr 0 -$xdim
dimlineto [tx $DbTL]
dimlineto [tx $DbTR]
dimlineto [tx $TR]

```

Pythagoras

Pythagoras $a^2 + b^2 = c^2$ (Figure 4).

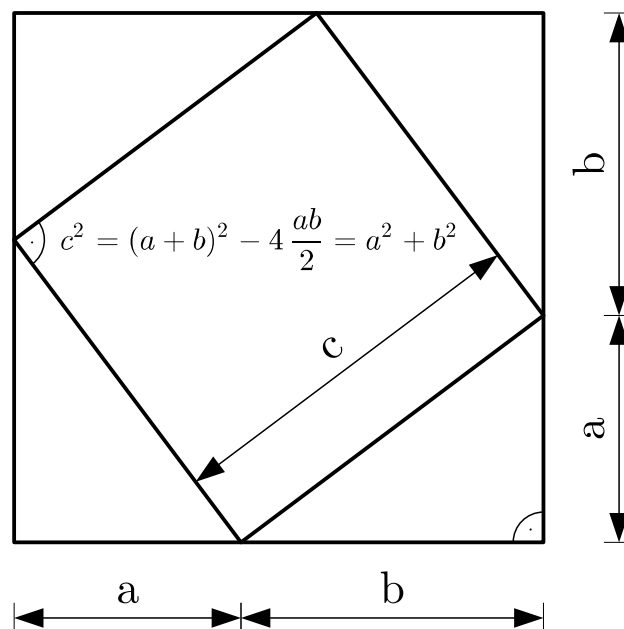


Figure 4: Pythagoras

pythagoras.hcl

```

#! drawj2d -W 100 -H 90 pythagoras.hcl

```

```

# original example from asymptote gallery
offset 80 75
unitlength 10

set a 3
set b 4

# vertices
set ML "-[+ $a $b] -$b" ; # middle left
set BM "-$b 0"           ; # bottom middle
set BL "-[+ $a $b] 0"    ; # bottom left

# draw squares
m 0 0; rectangle -[+ $a $b] -[+ $a $b];
m $BM; lr $b -$a; lr -$a -$b; lr -$b $a; l $BM;

# draw dimension lines
pen black 0.2
font tex 6; # Sets font to computer modern, 6mm
set d [mm 10]
m [++ $BL "0 $d"]
dimlinereel $a 0 a
dimlinereel $b 0 b
dimline [geom.parallel "0 -$a" $BM $d] c
m "$d 0"
dimlinereel 0 -$a a
dimlinereel 0 -$b b

# draw perpendicular sign
pen black
dimangle $ML [++ $ML "$b -$a"] $BM
m "0 0"; dimangle 180 270

# write equation
m $ML; mr [mm 4 4]; font
texlabel {\displaystyle c^2 = (a+b)^2 - 4 \frac{a b}{2} = a^2 + b^2}

```

5.2 Statics

Drawj2d has built in support for basic statics, see 3.8. It is useful for geotechnical tasks, e.g. earth pressure and retaining walls. The examples below are about cable equilibrium.

Cable equilibrium

For a given geometry the cable forces are calculated (Figure 5).

cable.hcl

```

#! drawj2d -W 150 -H 80 -X 20 -Y 20 cable.hcl

unitlength [/ 1. 50.] m
forceunitlength 2

```

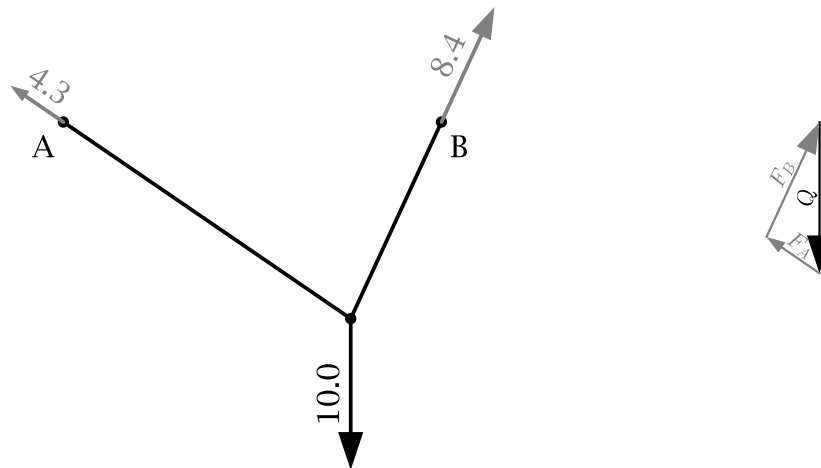


Figure 5: Cable equilibrium

```

# cable
set A {0 0}; dot $A; lb A SW
set B {2.5 0}; dot $B; lb B SE
set C {1.9 1.3}; dot $C
line $A $C $B

# weight (10 kN)
set Q "$C 0 10"
force $Q

# calculate reaction forces
pen gray
# moment equilibrium at pos. A in order to get force FB
moveto $A
set fB "$B [geom.vector $C $B]"
set FB [stat.mequi $fB $Q]
force $FB
# equilibrium to get force FA
set FA [stat.equi $Q $FB]
set FA [stat.move $FA $A $B]; # move along action line
force $FA

# force polygon
moveto 5 0
set posPolygon [here]
pen black 0.3; font 3
texforce [FXY $Q] Q
pen gray
texforce [FXY $FA] F_A
texforce [FXY $FB] F_B
# verify the force polygon is closed
assert "[geom.distance $posPolygon] ~= 0" {equilibrium check}

```

Cable shape

In this example the cable shape is calculated for multiple external forces (Figure 6). The bearing points and the initial cable angle (at point A) are given.

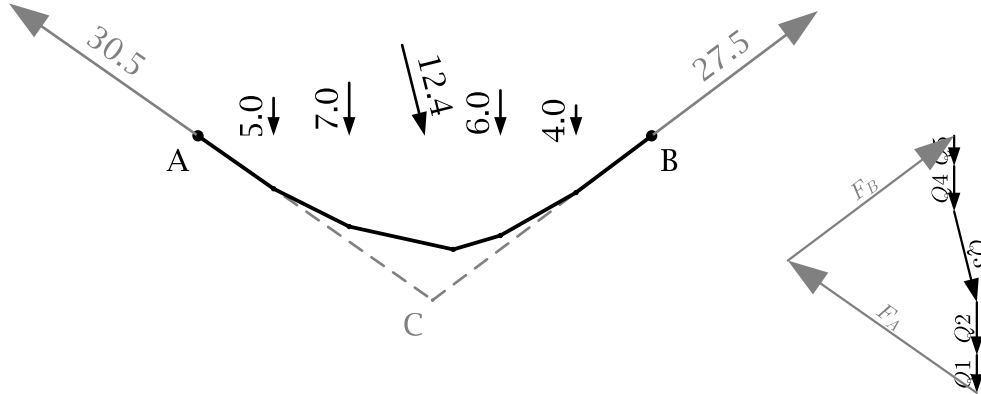


Figure 6: Cable shape

cable2.hcl

```

#! drawj2d -W 150 -H 60 -X 30 -Y 20 cable2.hcl

unitlength [/ 1. 50.] m
forceunitlength 1

# bearings
set A {0 0}; dot $A; lb A SW
set B {3.0 0}; dot $B; lb B SE
# cable angle at A
set alpha 35

# forces acting on the cable
pen 0.35
set Q1 "0.5 0 0 5"; force2 $Q1
set Q2 "1.0 0 0 7"; force2 $Q2
set Q3 "1.5 0 3 12"; force2 $Q3
set Q4 "2.0 0 0 6"; force2 $Q4
set Q5 "2.5 0 0 4"; force2 $Q5

# resultant
set R [stat.add $Q1 $Q2 $Q3 $Q4 $Q5]
set C [XY [stat.move $R $A [++ $A [geom.polar $alpha]]]]
pen dashed gray
point $C; lb C SW
line $A $C $B

# global moment equilibrium at pos. B in order to get force FA
pen solid gray
moveto $B
set fA "$A [geom.polar $alpha]"
set FA [stat.mequi $fA $R]
force $FA

```

```

# equilibrium to get force FB
set FB [stat.equi $R $FA]
set FB [stat.move $FB $A $B]; # move along action line
force $FB

# cable geometry
pen
set F1 [stat.equi $FA $Q1]
set F2 [--- $F1 $Q2]
set F3 [--- $F2 $Q3]
set F4 [--- $F3 $Q4]
set F5 [--- $F4 $Q5]
set C1 [XY [stat.move $Q1 [XY $FA] [stat.tip $FA]]]; point $C1
set C2 [XY [stat.move $Q2 [XY $F1] [stat.tip $F1]]]; point $C2
set C3 [XY [stat.move $Q3 [XY $F2] [stat.tip $F2]]]; point $C3
set C4 [XY [stat.move $Q4 [XY $F3] [stat.tip $F3]]]; point $C4
set C5 [XY [stat.move $Q5 [XY $F4] [stat.tip $F4]]]; point $C5
line $A $C1 $C2 $C3 $C4 $C5 $B
moveto $A; # verify the forces F5 and FB are equal
assert "[stat.moment $F5] ~= [stat.moment $FB]" {moment check F5 = FB}
assert "[stat.abs $F5] ~= [stat.abs $FB]" {check F5 = FB}

# force polygon
moveto 5 0; set posPolygon [here]
pen black 0.3; font 3
texforce [FXY $Q5] Q5
texforce [FXY $Q4] Q4
texforce [FXY $Q3] Q3
texforce [FXY $Q2] Q2
texforce [FXY $Q1] Q1
pen gray
texforce [FXY $FA] F_A
texforce [FXY $FB] F_B
# verify the force polygon is closed
assert "[geom.distance $posPolygon] ~= 0" {equilibrium check}

```