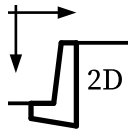


# Vector graphics with *Drawj2d*



Program documentation  
&  
function reference

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## 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).

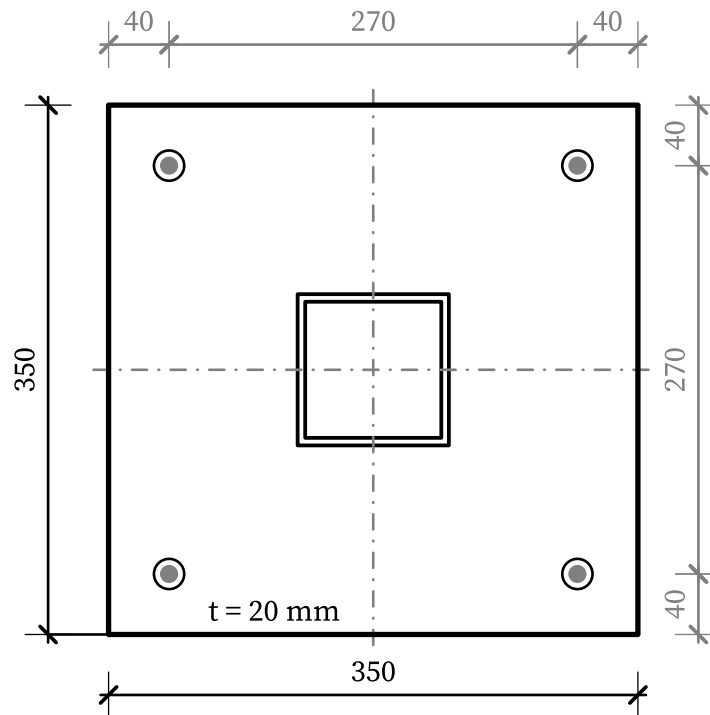


Figure 1: Drawing

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+*<sup>1</sup>. 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>

---

<sup>1</sup>GNU 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>
- Hershey fonts - (ref. to source code)  
Vector fonts the `L i n e s` font is based on.  
<https://emergent.unpythonic.net/software/hershey>

## **Licence of this program documentation**

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## **1.5 Program development**

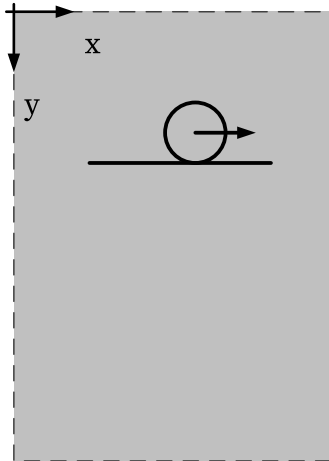
This manual is based on version: Drawj2d 1.24 (April 2021)

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
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>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</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, 2014-2021
Version 1.24
```

Usage:

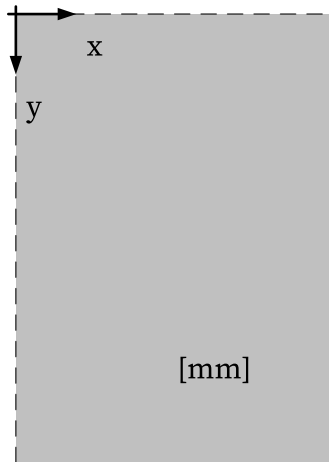
```
java -jar drawj2d.jar [-TWHcXYrfvqhV]
                    [-o OutputFile]
                    [InputFile] [arguments]
```

-T, --type	Output file type: pdf (default), svg, eps, png screen (displays the drawing) emf, dxf, tikz, bgd, hcl, rm, rmapi
-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 |  $\mu$ 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)

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

## SYNOPSIS

**here** *dx dy***here***dx dy* Relative 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*

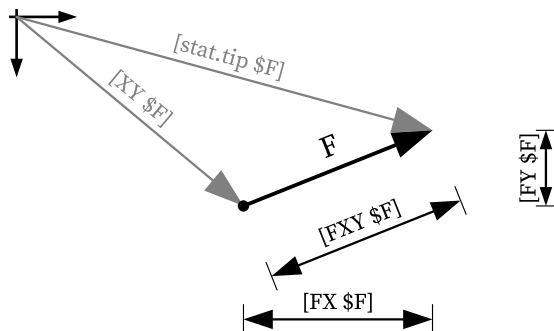
*F* force "x y Fx Fy"

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.

#### 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
pen 0x87431D;      # color hex values. r:87, g:43, b:1D (brown)
```

### 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 screen and png.

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 expression.

#### SYNOPSIS

**expr** *mathexpr*

*mathexpr* Mathematical expression. Angles are expected in degrees (this differs from tcl and from the hecl trigonometric functions!).

#### EXAMPLE

```

set D 4.4
puts [expr $D /2 * sin(30)]; # Prints 1.1.
                                # The space after variable $D is required!
# 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<sup>-11</sup>.

*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 =  $1.4 \times$  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  
linereel 0 25  
linereel {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*  $\alpha$

*dL* distance to current position  
 $\alpha$  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*  $\alpha$

**linemid** *L*

*L* line length  
 $\alpha$  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 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



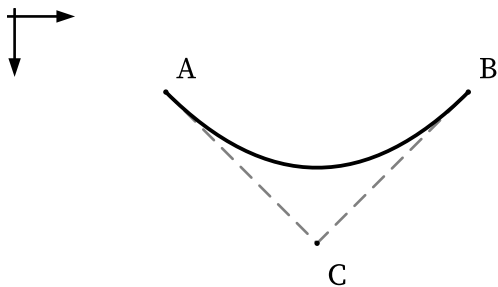
*pos1*            end point

#### 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

```



#### 3.3.13 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

```

<i>x0 y0</i>	starting point
<i>pos0</i>	Starting point. Current cursor position if omitted.
<i>x0Ctrl y0Ctrl</i>	first control point
<i>pos0Ctrl</i>	first control point
<i>x1Ctrl y1Ctrl</i>	second control point
<i>pos1Ctrl</i>	second control point
<i>x1 y1</i>	end point
<i>pos1</i>	end point.

#### EXAMPLE

```

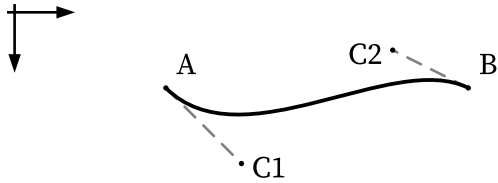
set A {20 10}; point $A; label A
set B {60 10}; point $B; label B
set C1 {30 20}
set C2 {50 5}
pen dashed 0.35 gray

```

```

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

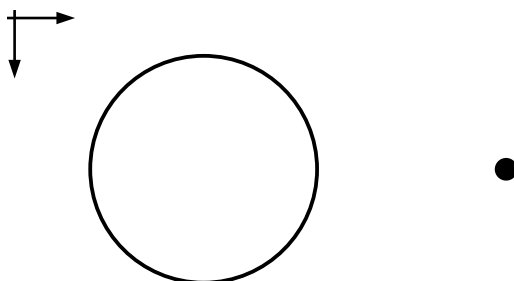
*radius*   radius

##### 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

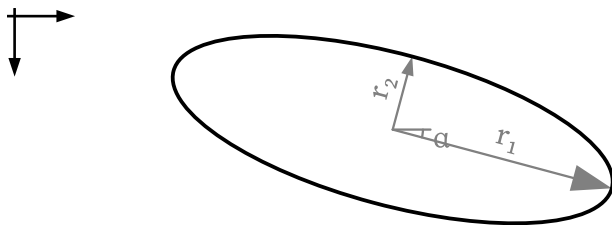
**ellipse** *x1 y1 radius1 radius2 angle1***ellipse** *radius1 radius2 angle1***ellipse** *radius1 radius2**x1 y1*      centre*radius1*    radius in first direction*radius2*    radius in second direction*angle1*    Angle in degrees between x-axis and first direction, clock-wise. 0° if omitted.

## 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

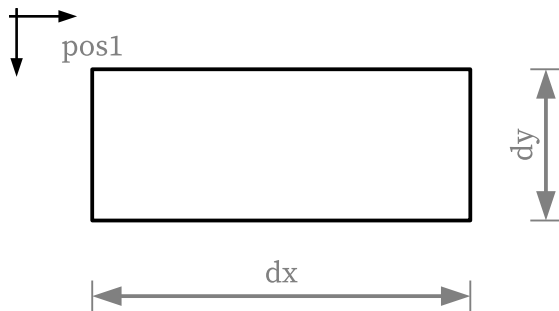
**rectangle** *x1 y1 dx dy***rectangle** *pos1 dx dy***rectangle** *dx dy**x1 y1*    Coordinates of a corner. If omitted current cursor position.*pos1*    Corner position (usually top left). If omitted current cursor position.*dx*      width*dy*      height

## 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
unithlength 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*

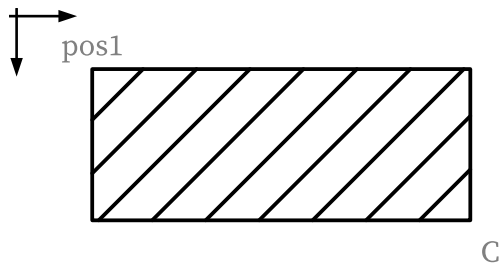
*x1 y1* First corner of the rectangle. Cursor position moves here.

*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.

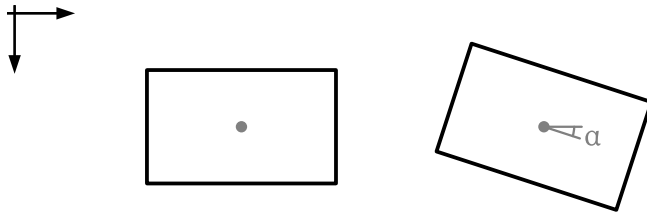
## SYNOPSIS

```
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  $\alpha$*

**rod** *x0 y0 L w*

**rod** *pos0 L w  $\alpha$*

**rod** *pos0 L w*

**rod** *L w  $\alpha$*

**rod** *L w*

*x0 y0* coordinates on rod axis

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

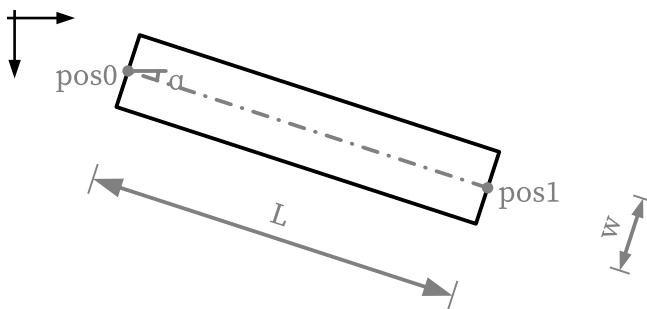
*L* length

*w* width

*$\alpha$*  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 .....*

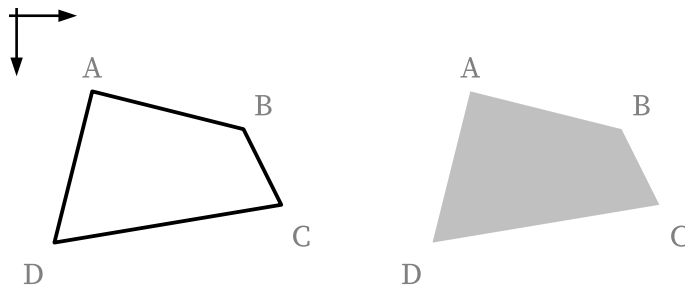
**polygon** *posA posB posC ...*

*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
  
```

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

## EXAMPLE

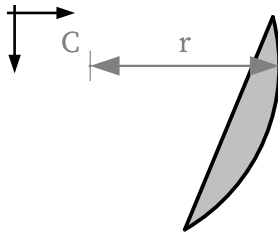
```

set C {10 7}
set r 25
set α -15
set β 60
pen lightgray
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*

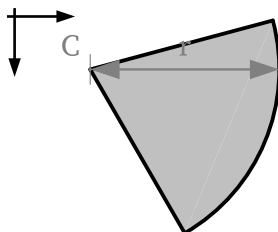
*x1 y1*            centre  
*pos1*            Centre. Current cursor position if omitted.  
*radius*           radius  
*startangle*      in degrees, clock-wise  
*endangle*        in degrees, clock-wise

#### 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.

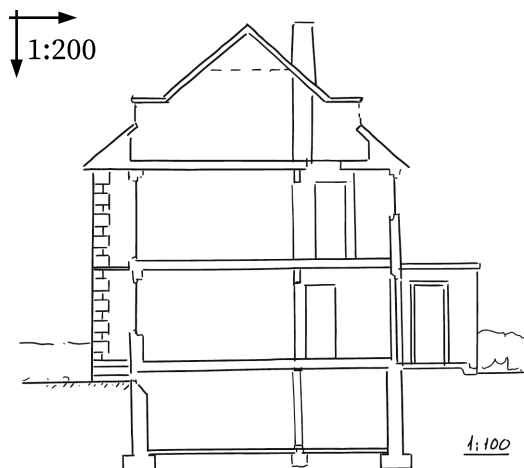
#### SYNOPSIS

```
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
```

<i>filename</i>	image file (*.png jpeg bmp svg)
<i>file.pdf</i>	portable document file (*.pdf)
<i>dpi</i>	Image resolution [dots per inch]. Default: 200 / 96 (svg)
<i>page</i>	Selected page. If omitted the first page.
<i>pxX pxY</i>	Pixel coordinates of insertion point. If omitted top left corner of the image.
<i>mmX mmY</i>	Coordinates [mm] of insertion point. If omitted top left corner of the pdf.
<i>1 : x</i>	Scale e.g. 100. If omitted or 0 the image will not be scaled to natural units.

#### EXAMPLE:

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



```
unittlength [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 |  $\mu$ 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*

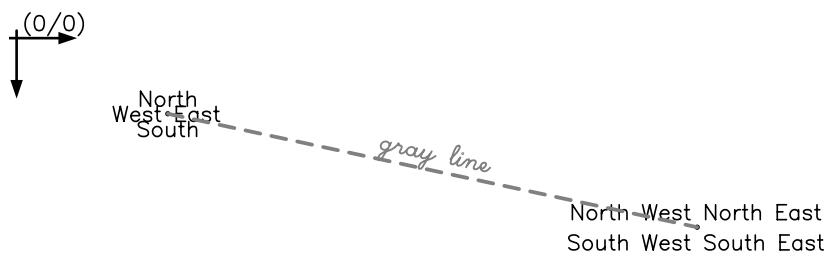
*xA yA* first point of imaginary line  
*xB yB* second point of imaginary line  
*posA* first point of imaginary line  
*posB* second point of imaginary line  
*lineAB* imaginary line "xA yA xB yB"  
*placement* The placement of the label: NE | BL | E | SE | S | SW | W | BW | NW | N | BC | C. BLC moves 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*

*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.

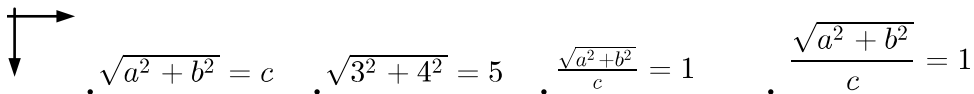
*Text* Label text using TeX syntax. If there is white space, enclose the text with curly brackets. If the text contains variables, use quotation marks instead. Within quotation marks any backslash must be escaped, thus a double backslash is required.

## 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}

```



$$\sqrt{a^2 + b^2} = c \quad \sqrt{3^2 + 4^2} = 5 \quad \frac{\sqrt{a^2 + b^2}}{c} = 1 \quad \frac{\sqrt{a^2 + b^2}}{c} = 1$$

## 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

```

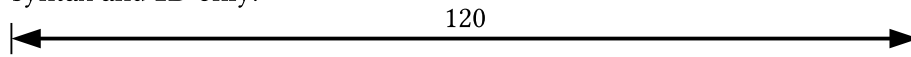
font "Linux Libertine O"
font bold 5
text {Description} [mm 120]
font plain 4
text; # Empty line
text {Drawj2d creates technical line drawings using a descriptive language. It
      writes pdf, svg, eps and emf vector graphics or png images. It runs on all
      platforms that run Java. It is inspired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

**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*

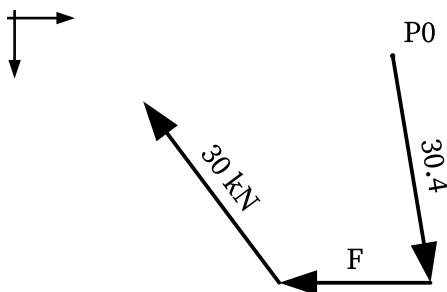
*x0 y0* force application point

*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*

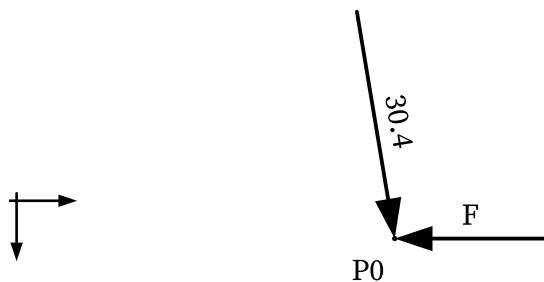
**force2** *Fx Fy Label*

**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. {%f 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 `dimlinereel` 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. "%f m".

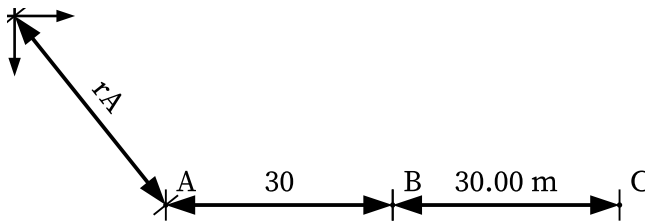


*decdigits*    Maximal number of decimal places to be written. This setting is used by any following dimension line command.

*style*        arrows | dots | ticks

## 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 dimlinereel

analogy: **texdimlinereel**

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

**dimlinereel** *dx dy Label*

**dimlinereel** *dx dy*

**dimlinereel** *vector Label*

**dimlinereel** *vector*

*dx dy*    coordinate increment

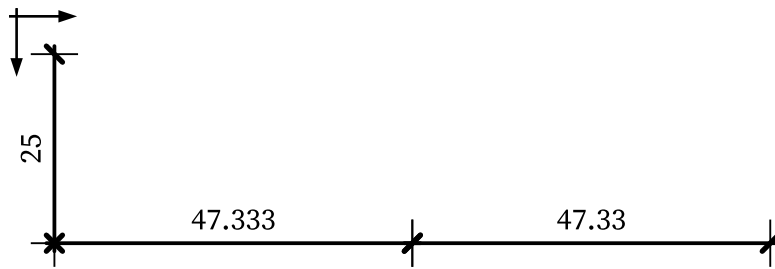
*vector*    vector of movement

*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.
dimlinereel 0 25.0;      # Writes 25
dimlinereel {47.333333 0}; # Writes 47.333

dimline 2;               # Sets the number of decimal digits to 2.
dimlinereel {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°.

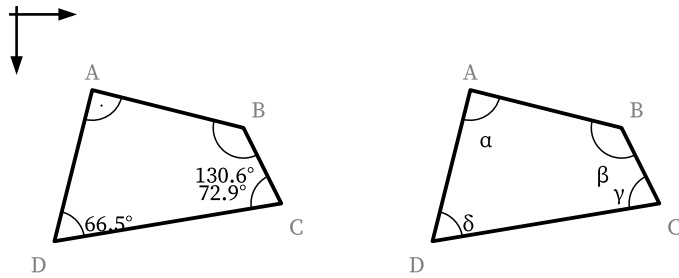
#### EXAMPLE

```
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  $\delta$ 

```

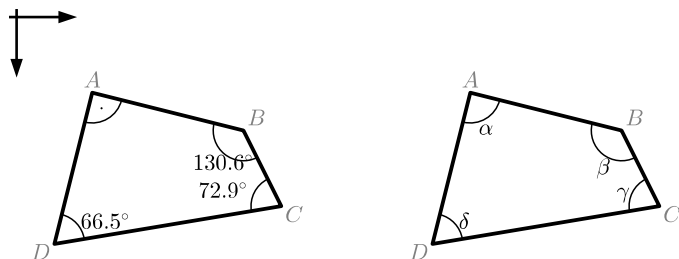


EXAMPLE using  $\text{\TeX}$  typesetting

```

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**

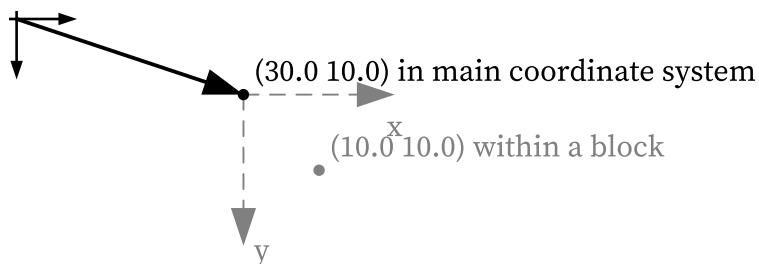
**endblock**

#### 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**  $\alpha$

$\alpha$  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

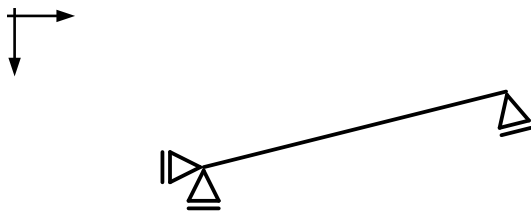
```

```

# 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.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
```

### 3.7.3 **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.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

```

### 3.7.9 **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

*xC yC* first point of line CD

*xD yD* 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

### 3.7.10 **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 below

**3.7.11 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

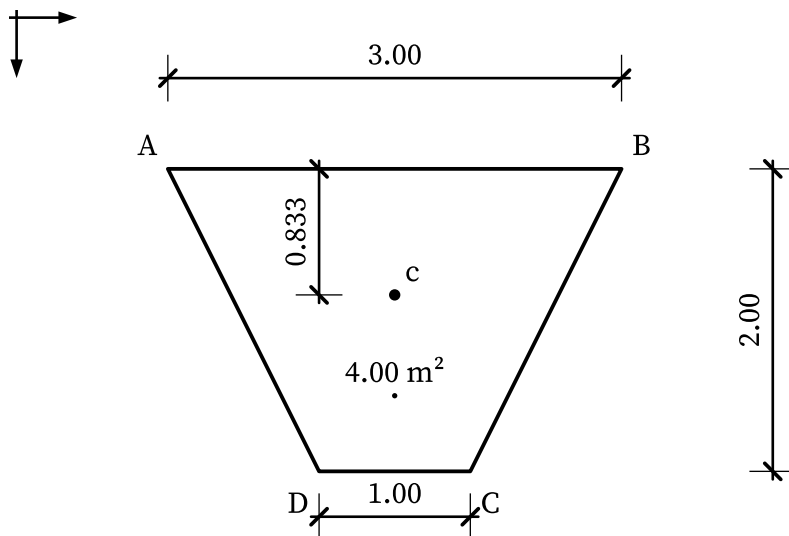
*posC* third point of polygon

**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

```



**3.7.12 geom.intersectlinepath**

Returns the first intersection point of the extensions of a line  $\overline{AB}$  with a path  $\overline{P_1P_2} \dots$ . If the extension of the line does not intersect the path, an exception is raised.

**SYNOPSIS**

**geom.intersectlinepath**  $x_A y_A x_B y_B x_1 y_1 x_2 y_2 \dots$

**geom.intersectlinepath**  $posA posB posP1 posP2 \dots$

$x_A y_A$  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

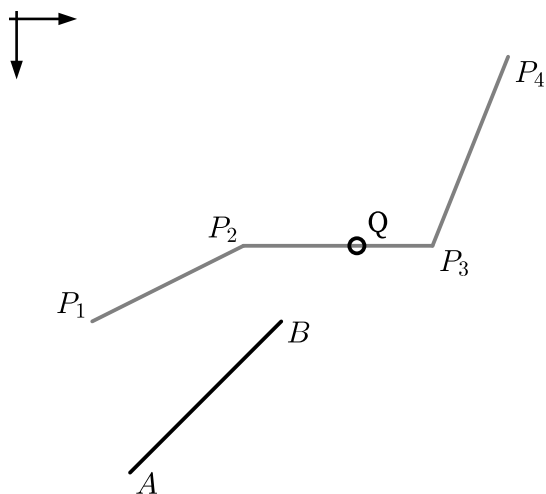
$posP2$  second point of path

**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

```



**3.7.13 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**  $x_A$   $y_A$   $r_A$   $x_B$   $y_B$   $r_B$   $nb$

**geom.intersectcircles**  $x_A$   $y_A$   $r_A$   $x_B$   $y_B$   $r_B$

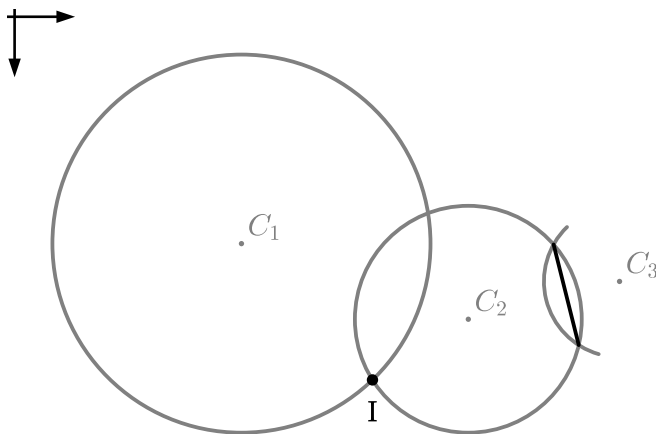
$x_A$   $y_A$   $r_A$  first circle (centre coordinates, radius)

$x_B$   $y_B$   $r_B$  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]
```

**3.7.14 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**  $x_M$   $y_M$   $r$   $x_A$   $y_A$   $x_B$   $y_B$   $nb$

**geom.intersectcircleline**  $x_M$   $y_M$   $r$   $x_A$   $y_A$   $x_B$   $y_B$

$x_M$   $y_M$   $r_M$  circle (centre coordinates, radius)

$x_A$   $y_A$   $x_B$   $y_B$  line (point A, point B)

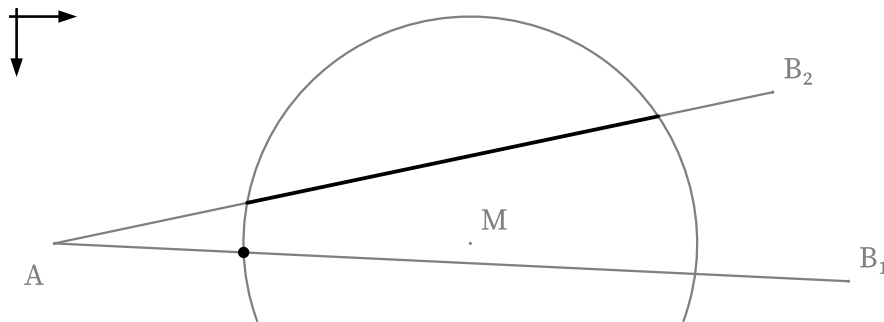
$nb$  requested number of intersection points. 2: both. 1: First intersection point in line direction (default). 0: Query only if there is a valid intersection point, returns true or false.

#### 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]

```



#### 3.7.15 geom.online

Returns the point on the line defined by " $x_0$   $y_0$   $x_1$   $y_1$ " a given fraction from  $x_0, y_0$ .

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**  $x_1$   $y_1$   $x_2$   $y_2$  *fraction*

**geom.online**  $posA$   $posB$  *fraction*

$x_1$   $y_1$  first point

$x_2$   $y_2$  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

```

**3.7.16 geom.angle**

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

**3.7.17 geom.anglerad**

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

## SYNOPSIS

**geom.anglerad** *xA yA xP yP xQ yQ*

**geom.anglerad** *posA posP posQ*

**geom.anglerad** *xP yP xQ yQ*

**geom.anglerad** *posP posQ*

**geom.anglerad** *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

**3.7.18 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
```

## 3.7.19 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
```

## 3.7.20 geom.rotate

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

## SYNOPSIS

**geom.rotate** *dx dy  $\theta$* **geom.rotate** *v  $\theta$* **geom.rotate** *v**dx dy* vector*v* vector *$\theta$*  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
```

**3.7.21 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*  $\alpha$

**geom.polar**  $\alpha$

*dL* length

$\alpha$  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
```

**3.7.22 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.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
```

#### 3.7.24 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

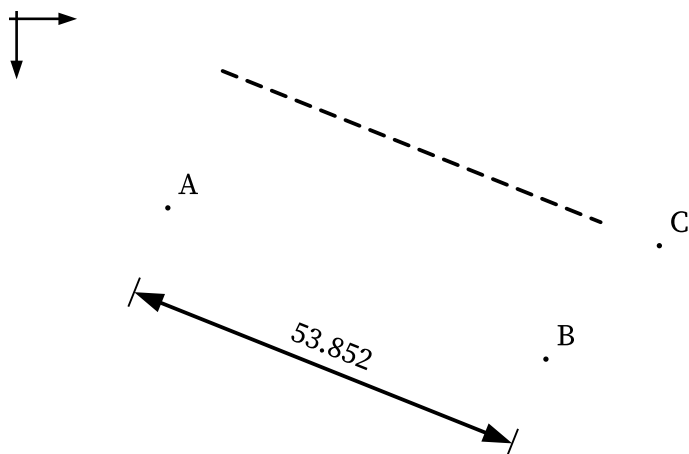
*pos1* first point of existing line

*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]
```



**3.7.25 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*

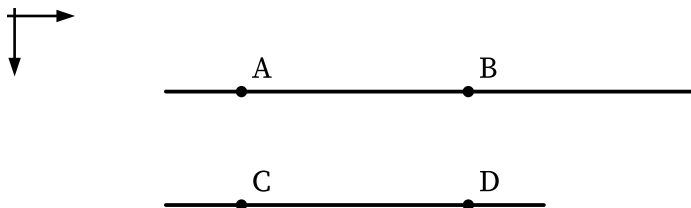
**geom.extend** *x1 y1 x2 y2 dL*

**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]
```

**3.7.26 geom.distance (geom.dist)**

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

**SYNOPSIS**

**geom.distance** *x1 y1 x2 y2*

**geom.distance** *pos1 pos2*

**geom.distance** *x1 y1*

**geom.distance** *pos1*

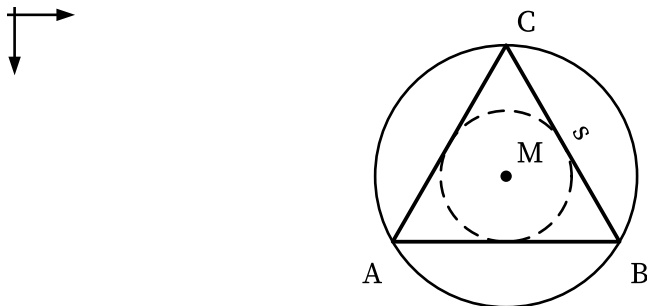
*x1 y1* first point of existing line or just point  
*x2 y2* second point of existing line  
*pos1* first point of existing line or just point  
*pos2* second point of existing line

## EXAMPLE

```

set s 30
set A {50 30}
set B [++ $A "$s 0"]
set C [++ $A "[expr $s /2] [expr -sqrt(3)*$s /2]"]
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]

```



## 3.7.27 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 ...

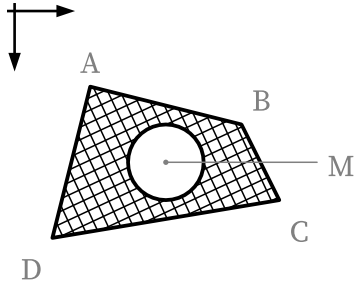
## EXAMPLE

```

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
```



### 3.8 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 ...*

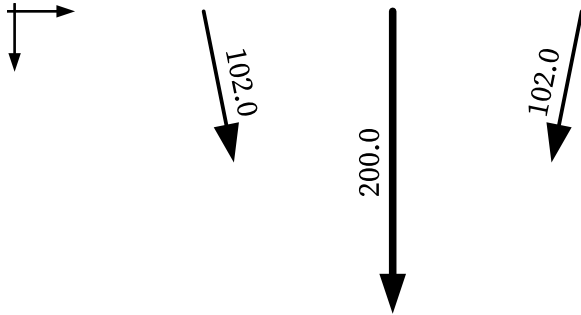
**+++** *F1 F2 ...*

*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  $AB$ .

## 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  $AB$ .

## 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

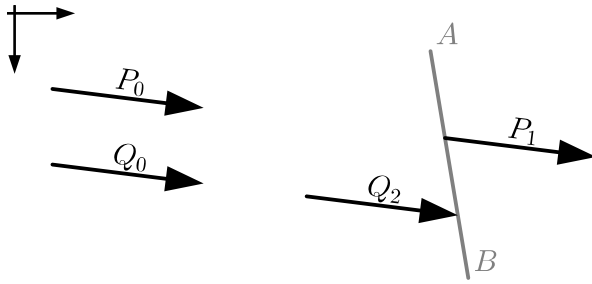
$posB$  second point of line AB

## 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

```

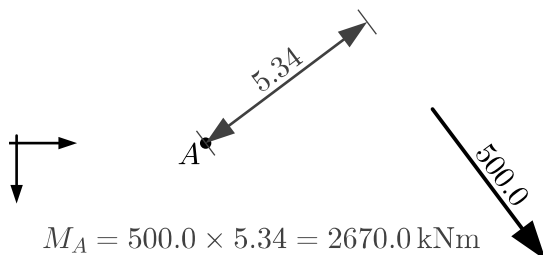


```

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**  $F1 F2 \dots$

$F1$  first force  
 $F2$  second force

## EXAMPLE

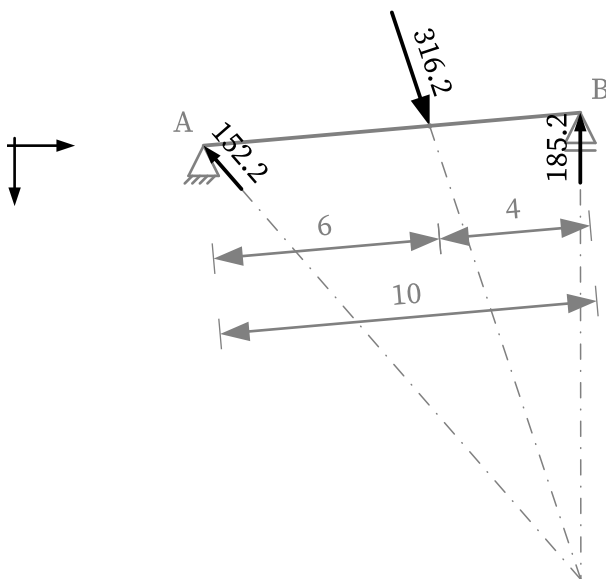
```

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 [geom.parallel $A $C [mm 15]]
dimlinerel [-- "$B" "$C"]
dimline [geom.parallel $A $B [mm 25]]
# 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  $F$   $\alpha$   $\beta$ ].

**SYNOPSIS**

**stat.fequi**  $F$   $\alpha$   $\beta$

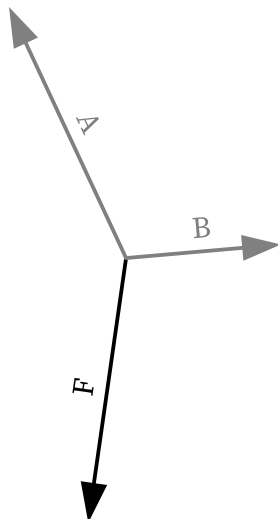
$F$  known force

$\alpha$  azimuth (in degrees) of searched force  $A$

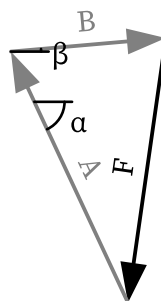
$\beta$  azimuth (in degrees) of force  $B$

**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

### 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

```

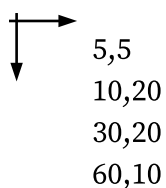
5,5
10,20
30,20
60,10

```

```

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

```



```

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

```

```

# Read the data of a csv file into a list
proc readcsv {file} {

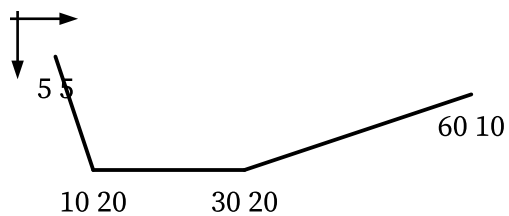
```



```
    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 ar-
row arrowrel arrows arrowsrel arrowsto arrowto asin assert atan atan2 bgerror block block.flip block.ro-
tate 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 fillseg-
ment filter float floor font for force force2 forceunitlength foreach format fu geom.abs geom.add geom.an-
gle geom.anglerad geom.area geom.azi geom.azimuth geom.centroid geom.crossproduct geom.dist
geom.distance geom.divide geom.dotproduct geom.extend geom.half geom.intersect geom.intersectcir-
cleline geom.intersectcircles geom.intersectlinepath geom.length geom.multiply geom.norm geom.on-
line geom.parallel geom.polar geom.rotate geom.subtract geom.topolygon 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 hget hkeys
hremove hset hypot if image incr int intro join kN l label lappend lb lindex line linemid linepolar
linerel lineto lineto lineto lineto linsert list llen llength lm log log10 log1p long lp lr lrange lset lx ly m
max min mm movepolar moverel moveto moveto moveto moveto 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 runtime.freememory runtime.totalmemory search sector segment set signum
sin sinh sort source split sqrt stat.abs stat.actionline 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 strange strep 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](http://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

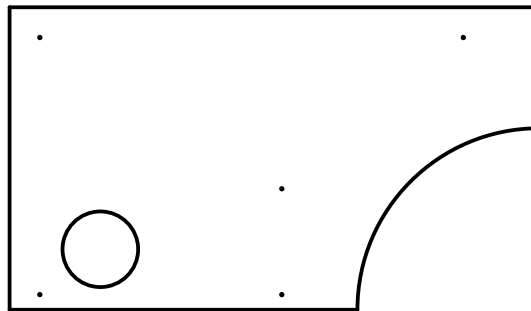
Line
3.5  0        ← start
3.5  0.8      ← end

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](http://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
```

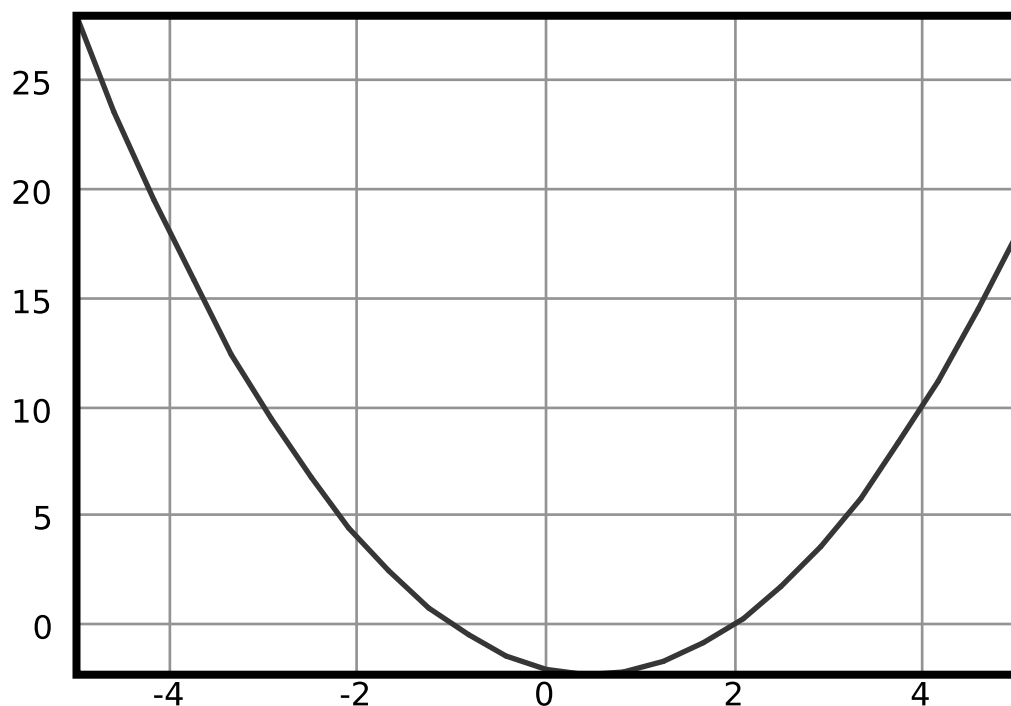


Figure 3: Draw yacas plot data:  $f(x)$

## 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).

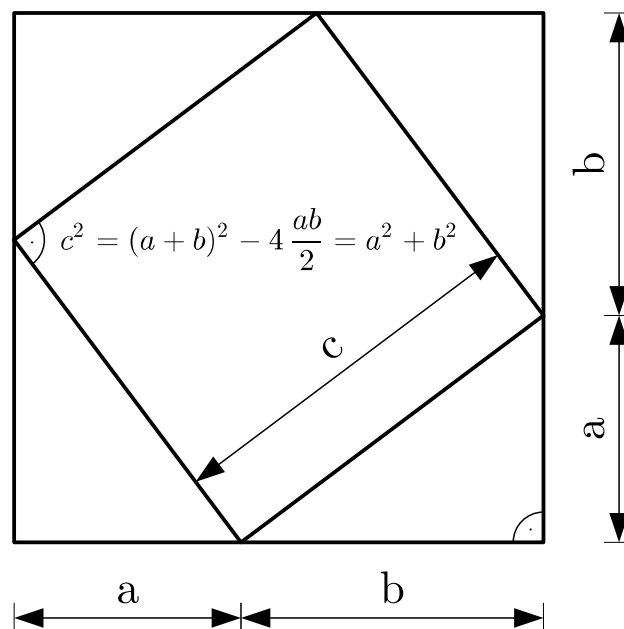


Figure 4: Pythagoras

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

```



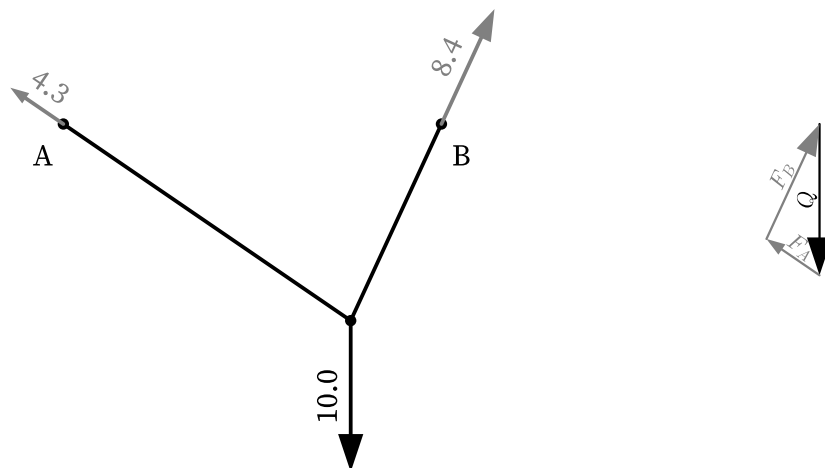


Figure 5: Cable equilibrium

```

# 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.

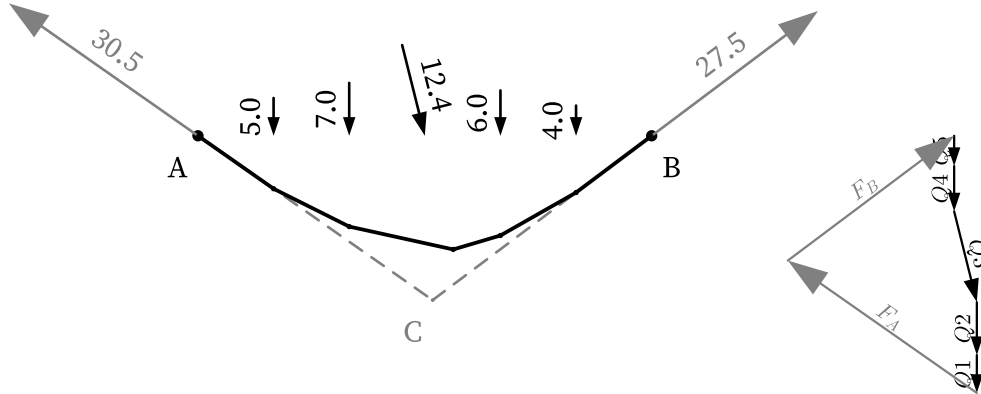


Figure 6: Cable shape

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}

```