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Contents

1	Command overview	1
2	Introduction	5
2.1	How to read this manual?	5
2.1.1	A few explanations	5
2.1.2	Additional help	5
2.2	Installation	6
2.3	Additional necessary packages	6
3	Elements	7
3.1	General information about the elements	7
3.1.1	Order	7
3.1.2	Input	7
3.2	The elements	8
3.2.1	Points	8
3.2.2	Beams and bars	8
3.2.3	Supports and Bearings	9
3.2.4	Joints and Hinges	10
3.2.5	Single load	11
3.2.6	Line loads	12
3.2.7	Temperatur	13
3.2.8	Internal forces	13
3.2.9	Dimensioning	14
3.2.10	Range of the influence line	15
3.2.11	Labeling and notation	15
3.2.12	Additional symbols	16
3.3	Useful <i>TikZ</i> commands	17
3.3.1	Orientation of text elements	17
3.3.2	Grouping	18
3.3.3	Scaling	18
3.3.4	Guides	19
4	Tutorial	21
4.1	Roof construction	21
4.1.1	Start of the consturction	21
4.1.2	First steps	22
4.1.3	Roof structure	22
4.1.4	Bearings and joints	23
4.1.5	Snow on the roof	23
4.1.6	Range of the influence line and roof dimensions	23
4.1.7	The finished roof	24
4.1.8	Roof construction with source code	25

1 Command overview

```
\macroname{obligatory}{obligatory}{obligatory}[optional][optional];
```

Scaling (see 3.3.3)

```
\scaling{scaling_value};
```

Points (see 3.2.1)

```
\point{name}{x-coordiante}{y-coordiante};
```

Beams and bars (see 3.2.2)

```
\beam{type}{initial point}{end point}[rounded initial point][rounded end point];

{1} bending beam with characteristic fiber
    \beam{1}{initial point}{end point}[rounded initial point][rounded end point];

{2} trussed
    \beam{2}{initial point}{end point}[rounded initial point][rounded end point];

{3} hidden bar
    \beam{3}{initial point}{end point};

{4} bending beam without characteristic fiber
    \beam{4}{initial point}{end point}[rounded initial point][rounded end point];
```

Supports and Bearings(see 3.2.3)

```
\support{type}{insertion point}[rotation];

{1} fixed bearing
    \support{1}{insertion point}[rotation];

{2} floating bearing
    \support{2}{insertion point}[rotation];

{3} fixed support
    \support{3}{insertion point}[rotation];

{4} support
    \support{4}{insertion point}[rotation];

{5} spring
    \support{5}{insertion point}[rotation];

{6} torsion spring
    \support{6}{insertion point}[rotation];
```

Joints and Hinges (siehe 3.2.4)

```
\hinge{type}{insertion point}[optional][optional][optional];

{1} full joint
    \hinge{1}{insertion point};

{2} half joint
    \hinge{2}{insertion point}[initial point][end point][orientation];

{3} shear joint
    \hinge{3}{insertion point}[rotation];

{4} normal force joint
    \hinge{4}{insertion point}[rotation];

{5} stiff corner
    \hinge{5}{insertion point}[initial point][end point];
```

Single loads (see 3.2.5)

```
\load{type}{insertion point}[rotation][length or included angle][loaddistance];

{1} single load
  \load{1}{insertion point}[rotation][length][loaddistance];

{2} moment clockwise
  \load{2}{insertion point}[rotation][included angle][moment distance];

{3} moment counter clockwise
  \load{3}{insertion point}[rotation][included angle][moment distance];
```

Line loads (siehe 3.2.6)

```
\lineload{type}{initial point}{end point}[optional][optional][optional][optional];

{1} line load normal to beam axis
  \lineload{1}{initial point}{end point}[initial force value][end force value]
    [force interval];

{2} line load normal to x-axis
  \lineload{2}{initial point}{end point}[initial force value][end force value]
    [force interval];

{3} line load projected on the beam
  \lineload{3}{initial point}{end point}[initial force value][end force value]
    [lineload_distance from initial point][force interval];

{4} line load along the beam axis
  \lineload{4}{initial point}{end point}[force interval][force length];
```

Temperature (see 3.2.7)

```
\temperature{initial point}{end point}{temperature_below}{temperature_above}
  [temperature_position][temperature_value_below][temperature_value_above]
  [text_orientation_below][text_orientation_above];
```

Internal forces (see 3.2.8)

```
\internalforces{initial point}{end point}{initial value}{end value}
  [parabola height][color][bend position];
```

Dimensioning (see 3.2.9)

```
\dimensioning{type}{initial point}{end point}{distance from point of origin}[measure];

{1} dimensioning horizontal
  \dimensioning{1}{initial point}{end point}{distance from point of origin}[measure]
    ];

{2} dimensioning vertical
  \dimensioning{2}{initial point}{end point}{distance from point of origin}[measure]
    ];

{3} dimensioning of a shift
  \dimensioning{3}{initial point}{end point}{distance from initial point}[measure];
```

Range of the influence line (see 3.2.10)

```
\influenceline{initial point}{end point}{distance from initial point}[arrow position];
```

Labeling and notation (see 3.2.11)

```
\notation{type}{insertion point}{ }[ ][ ][ ];

{1} label
  \notation{1}{insertion point}{labelling}[orientation];

{2} label with vertical mark
  \notation{2}{insertion point}{labelling}[orientation];

{3} label with mark orthogonal to a line
  \notation{3}{initial point}{end point}[labelling][position][orientation];

{4} label in a square
  \notation{4}{initial point}{end point}[labelling][position][orientation][text
    orientation];
```

```
{5} label of a line
  \notation{5}{initial point}{end point}[labelling][position][orientation][text
    orientation];
```

```
{6} label in a circle
  \notation{6}{insertion point}{labelling};
```

Additional symbols (siehe 3.2.12)

```
\addontype{insertion point}{}{[]};
```

```
{1} symbol for parallel lines
  \addont{1}{insertion point}{end point}{position};
```

```
{2} Symbol for orthogonal lines
  \addont{2}{insertion point}{initial point}{end point}[orientation];
```

```
{3} arc symbol
  \addont{3}{insertion point}{initial point}{end point}[orientation];
```


2 Introduction

The following work is a manual for a library of symbols for structural analysis. This library is based on the PGF/TikZ environment. Accordingly, commands from these packages are used. Nevertheless, comprehensive knowledge of TikZ is not necessary in order to use this library. If the referenced commands in this manual are not enough for the interested reader, the TikZ manual from Till Tantau is suggested.

2.1 How to read this manual?

This manual describes the use of the library for symbols for structural analysis. To ensure an easy use of the elements and to keep the clarity, this manual follows the structure of the “TikZ and PGF Manual” and starts with the essential components (command list, elements) and subsequently deals with the “whole schmear”. Finally, everything is repeated and summarized in form of a brief tutorial.

If the required packages have not yet been installed, you should read before starting, the installation chapter.

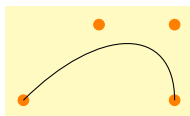
2.1.1 A few explanations

All images in this manual were created with TikZ or the element library. The code used for this, is specified for each image.



```
\begin{tikzpicture}
  \filldraw (-.2,.2) circle (2pt)
            (.2,.2) circle (2pt);
  \draw (0,0) circle (5mm)
        (-.3,-.1) .. controls (0,-.3) .. (.3,-.1);
\end{tikzpicture}
```

Special additions which are needed for a better understanding are shown in orange, but are not in the sample code available.



```
\begin{tikzpicture}
  \draw (0,0) .. controls (1,1) and (2,1) .. (2,0);
\end{tikzpicture}
```

2.1.2 Additional help

If the manual not enough, occur some ambiguities or some TikZ commands are unclear, please have a look in the “TikZ and PGF Manual” von Till Tantau.

Should you have any further questions, please do not hesitate to contact me.

2.2 Installation

Actually, we can hardly speak of an installation since only the necessary package `\usepackage{structuralanalysis}` must be installed.

Is the package installed or the style file is stored in the main file folder, so the library can be imported by `\usepackage{structuralanalysis}`, as a following example shows:

```
%-----  
% header  
%  
\documentclass[  
  a4paper,           % defines the paper size: a4paper (default), a5paper  
  B5OR20mm,         % correction  
  twoside,           % changes to a two-page-layout (alternatively: oneside)  
  halfparskip,       % insert an empty line between two paragraphs (alternatively: parskip,  
    ...)             %  
  openright,         % chapter starts on the right page  
{scrreprt}  
  
%-----  
% packages  
%  
\usepackage{structuralanalysis}
```

2.3 Additional necessary packages

To use all commands and options of *TikZ*, possibly some packages need to be reloaded. These missing files (or their names) appear in the error log, when you convert the file. However, for the package described in this manual, it is sufficient to use the library and the *TikZ* standard commands.

3 Elements

3.1 General information about the elements

3.1.1 Order

The library provides a number of standard elements available to the user. For example, bearings, joints, forces, etc. Since *TikZ* displays those elements at the bottom which are entered first, it must be ensured that the element insert in the correct order. The following order is recommended:

1. Points `\point`
2. Beams and bars `\beam`
3. Supports and bearings `\support`
4. Joints `\hinge`
5. Force and temperature `\load` respectively `\lineload` and `\temperature`
6. Internal forces `\internalforces`
7. Dimensioning `\dimensioning`
8. Range of the influence line `\influenceline`
9. Labeling `\notation`
10. Additional symbols `\addon`

3.1.2 Input

In addition to the correct order also the correct input for the elements matters.

Basically, one can distinguish between the mandatory input `{ }` and the optional input `[]`. The first values must be entered compulsory. By contrast, nothing has to be entered for the optional input. Additional features (eg. rotation) can be activated when entering optional parameters.

For illustration a small example of a single force

```
\load{type}{insertion point}[rotation][length or included angle][loaddistance];
```

When entering size values the base unit is always predefined in $[cm]$. Percentage values % are always specified as decimal values; for example, $100\% = 1.0$ and 10% corresponds to 0.1 .

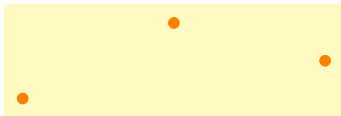
Another important note is, that every *TikZ* command has to be completed with an semicolon “;”. If this semicolon is not set, the command can not be performed, this leads finally to an error message by the compilation.

3.2 The elements

3.2.1 Points

```
\point{name}{x-coordiante}{y-coordiante};
```

In order to be able, to place elements, points must be defined previously. For the labeling a short and precise name should be chosen. Because other elements will reference back to these points, in the later stages of the construction. Since TikZ uses Cartesian coordinates, this must be entered in accordance with the coordinate system. This means that is first entry corresponds to the x-coordinate and the second to the y-coordinate.



```
\begin{tikzpicture}
  \point{a}{0}{0};
  \point{b}{2}{1};
  \point{c}{4}{.5};
\end{tikzpicture}
```

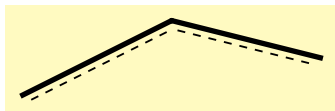
3.2.2 Beams and bars

```
\beam{type}{initial point}{end point}[rounded initial point][rounded end point];
```

The library includes several types of beams and bars. These are determined by the type. To construct such a beam or bar, two points must first be defined, the starting point and the end point. Furthermore, is an optional available to round the ends of the bars. [0] or no entry means the corresponding end of the beam is not rounded, [1] the end is rounded. This option is especially needed when multiple bars meet with different angles.

```
\beam{1}{initial point}{end point}[rounded initial point][rounded end point];
```

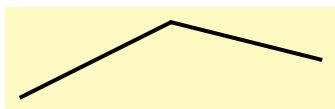
Type 1 is a bending beam with characteristic fiber¹. Thereby, the characteristic fiber is always below the bar, when you follow the input convention mentioned above (start point - end point).



```
\begin{tikzpicture}
  \point{a}{0}{0};
  \point{b}{2}{1};
  \point{c}{4}{.5};
  \beam{1}{a}{b}[0][1];
  \beam{1}{b}{c}[1];
\end{tikzpicture}
```

```
\beam{2}{initial point}{end point}[rounded initial point][rounded end point];
```

Type 2 describes a truss rod. Accordingly there is no characteristic fiber. This means, that order of the input points (starting point - end point) does not matter.

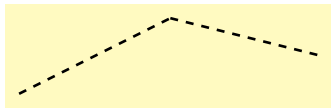


```
\begin{tikzpicture}
  \point{a}{0}{0};
  \point{b}{2}{1};
  \point{c}{4}{.5};
  \beam{2}{a}{b}[0][1];
  \beam{2}{b}{c}[1];
\end{tikzpicture}
```

```
\beam{3}{initial point}{end point};
```

¹The characteristic fiber acts as a local coordinate system of the beam.

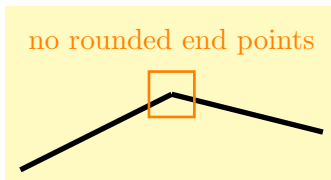
Here (type 3) is an invisible bar or beam. Since this is plotted as a dashed lines, there is no option to round the ends.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\point{c}{4}{.5};
\beam{3}{a}{b};
\beam{3}{b}{c};
\end{tikzpicture}
```

`\beam{4}{initial point}{end point}[rounded initial point][rounded end point];`

Type 4 has the same look and the same properties as type 1, but no characteristic fiber. This corresponds to a bending beam without characteristics fiber.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\point{c}{4}{.5};
\beam{4}{a}{b};
\beam{4}{b}{c};
\end{tikzpicture}
```

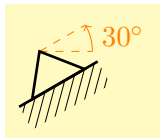
3.2.3 Supports and Bearings

`\support{type}{insertion point}[rotation];`

In the library the most common types of bearings and springs are available. Similar to all remaining elements the type can be changed by the type variable. Similarly, an insertion point is required to initialize a bearing or a spring. As an optional parameter the rotation is available. Here the angle is counted from the x-axis.

`\support{1}{insertion point}[rotation];`

Type 1 is a fixed bearing, which can absorb both horizontal and vertical forces, but no moments.



```
\begin{tikzpicture}
\point{a}{0}{0};
\support{1}{a}[30];
\end{tikzpicture}
```

`\support{2}{insertion point}[rotation];`

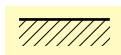
Type 2 is a floating bearing, which can absorb forces only in one direction and no moments.



```
\begin{tikzpicture}
\point{a}{0}{0};
\support{2}{a};
\end{tikzpicture}
```

`\support{3}{insertion point}[rotation];`

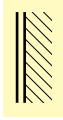
Type 3 is a fixed support which can absorb all forces and moments.



```
\begin{tikzpicture}
\point{a}{0}{0};
\support{3}{a};
\end{tikzpicture}
```

`\support{4}{insertion point}[rotation];`

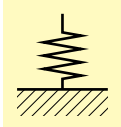
Type 4 is also a fixed support. However, these can only absorb forces in one direction and moments.



```
\begin{tikzpicture}
\point{a}{0}{0};
\support{4}{a}[90];
\end{tikzpicture}
```

`\support{5}{insertion point}[rotation];`

Type 5 describes a spring.



```
\begin{tikzpicture}
\point{a}{0}{0};
\support{5}{a};
\end{tikzpicture}
```

`\support{6}{insertion point}[rotation];`

Type 6 describes a torsion spring.



```
\begin{tikzpicture}
\point{a}{0}{0};
\support{6}{a}[-45];
\end{tikzpicture}
```

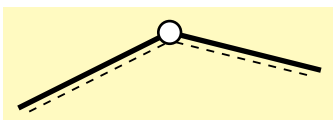
3.2.4 Joints and Hinges

`\hinge{type}{insertion point}[optional][optional][optional];`

The above described bearings might be combined with the following joints. The library contains different types of joints. Beside the insertion point, several other parameters are available. However, the optional parameter are mainly dependent on the type of joint.

`\hinge{1}{insertion point};`

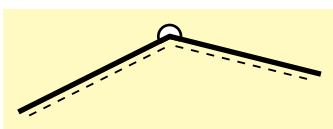
The basic version of a joint is the type 1. This is a full joint, which requires only an insertion point.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{.5};
\beam{1}{a}{b}[0][1]; \beam{1}{b}{c}[1];
\hinge{1}{b};
\end{tikzpicture}
```

`\hinge{2}{insertion point}[initial point][end point][orientation];`

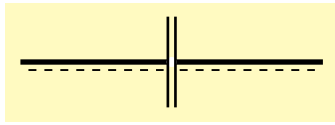
In addition to the insertion point, for type 2 - the half-hinge - the start and end point have to be specify, for the purpose of orientation. This information is marked as optional by `[]`, but must be completed in order to generate such a half-hinge. The joint is inserted at the insertion point and stretches between the start and the end point. The input `[0]` or no input in the orientation means that the half-hinge on the lower side, ie on the side of the characteristic fiber. A `[1]` in contrast means the exact opposite.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{.5};
\beam{1}{a}{b}[0][1]; \beam{1}{b}{c}[1];
\hinge{2}{b}[a][c][1];
\end{tikzpicture}
```

`\hinge{3}{insertion point}[rotation];`

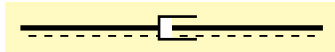
Type 3 describes a shear hinge. There is an additional option for rotating the hinge. The rotation works similar to the rotation of the supports.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{0}; \point{c}{4}{0};
\beam{1}{a}{b}; \beam{1}{b}{c};
\hinge{3}{b};
\end{tikzpicture}
```

`\hinge{4}{insertion point}[rotation];`

For Type 4, the normal force hinge, applies the same as for the shear hinge.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{0}; \point{c}{4}{0};
\beam{1}{a}{b}; \beam{1}{b}{c};
\hinge{4}{b};
\end{tikzpicture}
```

`\hinge{5}{insertion point}[initial point][end point];`

To achieve a stiffening of a corner, the Type 5 is applied. In addition to the insertion point, type 5 requires the input of the start and the end point, similar to the half hinge. This information is marked as optional, by [], but must be completed in order to generate such a stiff corner.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{.5};
\beam{1}{a}{b}[0][1]; \beam{1}{b}{c}[1];
\hinge{5}{b}[a][c];
\end{tikzpicture}
```

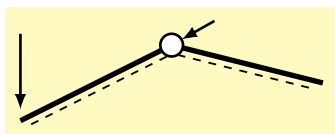
3.2.5 Single load

`\load{type}{insertion point}[rotation][length or included angle][loaddistance];`

The single load command includes both individual forces and moments. To place such an element it is necessary to define an insertion point. The moments can be plotted in a clockwise or counter clockwise directional. As an optional parameter the rotation is available. Here the angle is counted from the x-axis.

`\load{1}{insertion point}[rotation][length][loaddistance];`

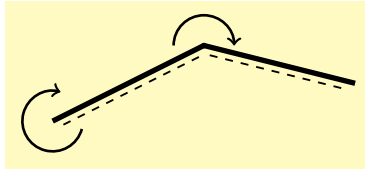
The first type describes a single force. In addition to the optional parameter of rotation, there is a parameter to change the length of the force, as well as an optional parameter which regulates the distance to the beam axis. Per default the distance to the beam axis is the radius of a joint.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{.5};
\beam{1}{a}{b}[0][1]; \beam{1}{b}{c}[1];
\hinge{1}{b};
\load{1}{b}[29.5][.5];
\load{1}{a};
\end{tikzpicture}
```

`\load{2}{insertion point}[rotation][included angle][loaddistance];`

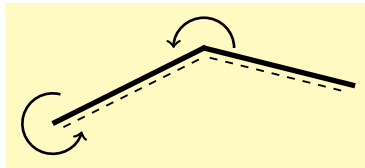
Type 2, describes a moment that is oriented clockwise. In addition to the optional parameter rotation there is further parameter to specify the included angle and the radius of the moment.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{.5};
\beam{1}{a}{b}[0][1]; \beam{1}{b}{c}[1];
\load{2}{b}[0][180];
\load{2}{a}[75];
\end{tikzpicture}
```

`\load{3}{insertion point}{rotation}[included angle][loaddistance];`

Type 3 describes a moment that is oriented counterclockwise. Otherwise, the same conditions apply as for type 2.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{.5};
\beam{1}{a}{b}[0][1]; \beam{1}{b}{c}[1];
\load{3}{b}[0][180];
\load{3}{a}[75];
\end{tikzpicture}
```

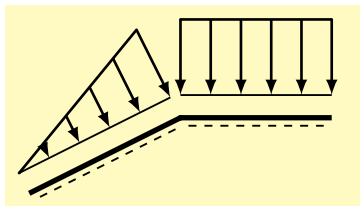
3.2.6 Line loads

`\lineload{type}{initial point}{end point}[optional][optional][optional][optional];`

In the library four types of line loads are available. These are determined by their type. Two points (start and end point) must be defined in advance, similar as with the beam and bar elements. The optional properties are mainly dependent on the type of the line load.

`\lineload{1}{initial point}{end point}[initial force value][end force value][force interval];`

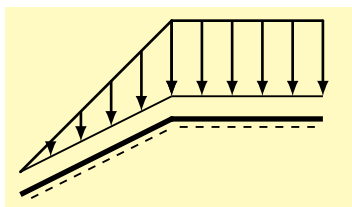
Type 1 is a linear load that is normal to the beam axis. Optionally, the sizes of the initial force and the final force can be adjusted. If one of the parameters is set to [0], the result is a triangular load. The last parameter controls the distance between the individual forces.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\lineload{1}{a}{b}[0];
\lineload{1}{b}{c};
\end{tikzpicture}
```

`\lineload{2}{initial point}{end point}[initial force value][end force value][force interval];`

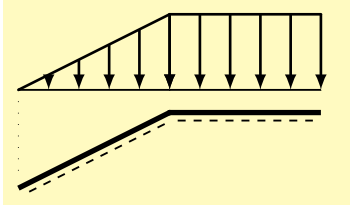
For type 2, the forces are parallel to the y-axis. The optional parameters are the same as for type 1.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\lineload{2}{a}{b}[0];
\lineload{2}{b}{c};
\end{tikzpicture}
```

`\lineload{3}{initial point}{end point}[initial force value][end force value][force interval];`

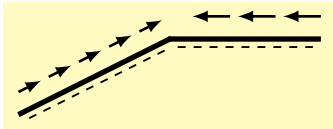
Type 3 is a projection of the forces on the beam. In addition to the start and end force size, the vertical distance to the starting point can also be specified optionally.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\lineload{3}{a}{b}[0][1][1];
\lineload{3}{b}{c};
\end{tikzpicture}
```

`\lineload{4}{initial point}{end point}[force interval][force length];`

A line load along the bar axis is described by type 4. In addition to the start and end points, the number of forces and its length can be changed optionally. This line load is always located above the bar. To change the direction, start and end points must be exchanged.

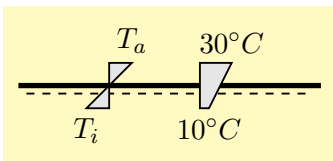


```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\lineload{4}{a}{b};
\lineload{4}{c}{b}[-.3][.25];
\end{tikzpicture}
```

3.2.7 Temperatur

```
\temperature{initial point}{end point}{temperature_below}{temperature_above}
[temperature_position][temperature_value_below][temperature_value_above]
[text_orientation_below][text_orientation_above];
```

The load temperature is described in its own command, because several optional settings can be made (see above). Same as with the line loads, the starting point and the end point of the bar has to be entered, where the temperature load act on. This is followed by the obligatory declaration of the temperature input variables, starting with the temperature at the bottom side of the bar. Optionally, the position of the temperature can be changed. By default, the temperature will be positioned at the center of the beam. Furthermore, there is also the possibility of labeling the temperature. The entries of the text are equal to a \LaTeX input. As a further optional input, the alignment of the text can be modified. Here, \TikZ commands must be used, these are in section 3.3.1 described.



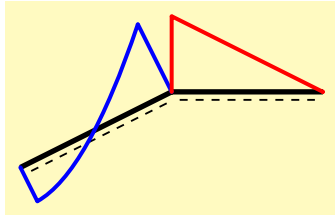
```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{4}{0};
\beam{1}{a}{b};
\temperature{a}{b}{-.5}{.5}[-.3][\$T_i\$][\$T_a\$];
\temperature{a}{b}{.2}{.7}[-.6][\$10^\circ\text{C}\$][\$30^\circ\text{C}\$];
\end{tikzpicture}
```

3.2.8 Internal forces

```
\internalforces{initial point}{end point}{initial value}{end value}[parabola height][color][bend position];
```

Same as with the temperature, there are no different types of internal forces. With this function, linear and quadratic curves internal forces can be displayed. The entries are made as repeatedly shown above. First, the start and end points must be determined. Thereafter, the start and end values must be entered. Optional the parabola down can be enter. If there is no entry or the entry is equal to [0], than it is a linear function. Also optionally, the color can be determined. Here the most common colors are available and addressed with the color name. The last optional

parameter is used to edit the parabola down and if necessary to adapt the plot to another function.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\internalforces{a}{b}{.5}{-1}[-.4][blue];
\internalforces{b}{c}{-1}{0};
\end{tikzpicture}
```

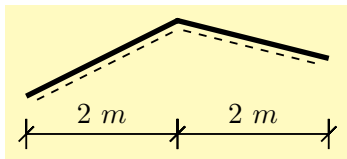
3.2.9 Dimensioning

`\dimensioning{type}{initial point}{end point}{distance from point of origin}[measure];`

Basically, three kinds of dimensions can be distinguished in the program, the horizontal and vertical dimension and a dimension of a shift. As with the line loads, also here the the start and end point is required. However, the distance between the the dimension line and the the corresponding points is not entered directly, but the dimension line refers to the coordinate origin. Optional a label can be inserted at any dimension line.

`\dimensioning{1}{initial point}{end point}{distance from point of origin}[measure];`

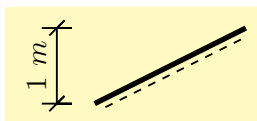
The first type describes the horizontal dimension.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{.5};
\beam{1}{a}{b}[0][1]; \beam{1}{b}{c}[1];
\dimensioning{1}{a}{b}{-.5}[$2~m$];
\dimensioning{1}{b}{c}{-.5}[$2~m$];
\end{tikzpicture}
```

`\dimensioning{2}{initial point}{end point}{distance from point of origin}[measure];`

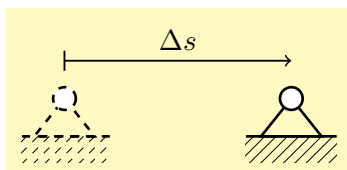
Type 2 describe the vertical dimension.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\beam{1}{a}{b};
\dimensioning{2}{a}{b}{-.5}[$1~m$];
\end{tikzpicture}
```

`\dimensioning{3}{initial point}{end point}{distance from initial point}[measure];`

With type 3, a shift is marked. Unlike type 1 and 2 the distance is not determined from the origin, but from the initial point.

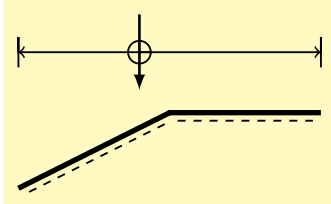


```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1};
\begin{scope}[dashed]
\support{1}{a};
\hinge{1}{a};
\end{scope}
\support{1}{b}; \hinge{1}{b};
\dimensioning{3}{a}{b}{.5}[$\Delta s$];
\end{tikzpicture}
```

3.2.10 Range of the influence line

`\influence``line`{initial point}{end point}{distance from initial point}[arrow position];

A special case of dimension is the range of the influence line. In addition to the start or end point of the vertical distance from the starting point must be specified. Optionally the position of the arrow symbol can be moved.



```
\begin{tikzpicture}
\point{a}{0}{0};
\point{b}{2}{1};
\point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\influence{a}{c}{1.5}[,4];
\end{tikzpicture}
```

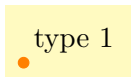
3.2.11 Labeling and notation

`\notation`{type}{insertion point}{ } { } { };

With the element `\notation` various kinds of labels can be insert. Because different input parameters are require, these are explained in detail for the individual types. Furthermore, in all types the optional parameters `orientation` is used. Here, the *TikZ* commands must be used, these are described in Section 3.3.1.

`\notation`{1}{insertion point}{labelling}[orientation];

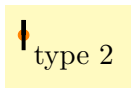
Type 1 is a normal labeling. Only the insertion point and the corresponding text must be specified. The optional parameter `orientation` can be changed. The default setting is above right, which means top right.



```
\begin{tikzpicture}
\point{a}{0}{0};
\notation{1}{a}{type 1};
\end{tikzpicture}
```

`\notation`{2}{insertion point}{labelling}[orientation];

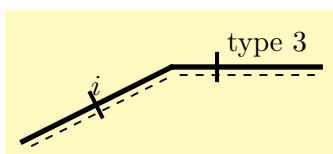
Type 2 has besides the label additional a line to mark the appropriate place. This line is always parallel to the y-axis.



```
\begin{tikzpicture}
\point{a}{0}{0};
\notation{2}{a}{type 2}[below right];
\end{tikzpicture}
```

`\notation`{3}{initial point}{end point}[labelling][position][orientation];

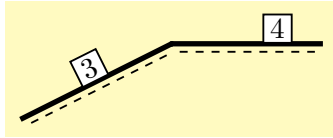
Type 3 is an extension of type 2. As with the other line elements the start point and end point must be specified. The mark is located in the middle of the two points. An optional parameter is the position of the mark which can be changed.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\notation{3}{a}{b}[$i$];
\notation{3}{b}{c}[type 3][.3][above right];
\end{tikzpicture}
```

```
\notation{4}{initial point}{end point}[labelling][position][orientation][text orientation];
```

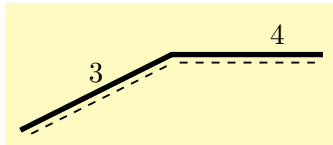
Type 4 is placed on a line, like type 3. Instead of a mark, the text is enclosed in a square. The other parameters are the same as in type 3. In addition, with the last parameter, the text alignment can be changed. If the parameter is equal to [1], the text is placed parallel to the x-axis.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\notation{4}{a}{b}[$3$];
\notation{4}{b}{c}[$4$][.7];
\end{tikzpicture}
```

```
\notation{5}{initial point}{end point}[labelling][position][orientation][text orientation];
```

Type 5 corresponds to the types 3 and 4, but here only the text is displayed and no additional symbols. Thus, the same requirements as in the previous type can be applied.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1}; \point{c}{4}{1};
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1];
\notation{5}{a}{b}[$3$][.5][above][1];
\notation{5}{b}{c}[$4$][.7];
\end{tikzpicture}
```

```
\notation{6}{insertion point}{labelling};
```

The last type 6, is similar to the type 1. Only in this case, the text is framed by a circle. Furthermore, no orientation of the text can be made.



```
\begin{tikzpicture}
\point{a}{0}{0};
\notation{6}{a}{+};
\end{tikzpicture}
```

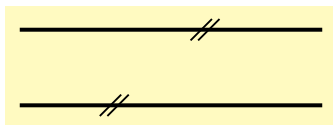
3.2.12 Additional symbols

```
\addon{type}{insertion point}{-}{-};
```

Among these elements fall all symbols that you can not assign to the above introduced elements. Since these types of items require different input parameters, these are explained in detail for each individual types.

```
\addon{1}{insertion point}{end point}{position};
```

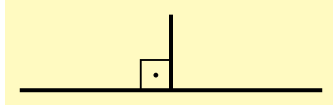
Type 1 is a symbol for parallel bars. First the start and end points of the bar must be specified and then the positioning of the symbol must be set.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{4}{0};
\point{c}{0}{1}; \point{d}{4}{1};
\beam{2}{a}{b}; \beam{2}{c}{d};
\addon{1}{a}{b}{.3};
\addon{1}{c}{d}{.6};
\end{tikzpicture}
```

```
\addon{2}{insertion point}{initial point}{end point}[orientation];
```

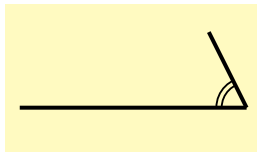
Type 2 represents the symbol of two originally bars. Here, also the insertion point must be specified in addition to the start and end points. The orientation of the symbol can be changed, by setting an optional parameter to $[-1]$



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{0}; \point{c}{4}{0};
\point{d}{2}{1};
\beam{2}{a}{c};
\beam{2}{b}{d};
\addon{2}{b}{a}{d}[-1];
\end{tikzpicture}
```

`\addon{3}{insertion point}{initial point}{end point}[orientation];`

Type 3 is the symbol for an arbitrary angle. The same approaches as for Type 2 can be applied. With the optional parameter it can be distinguished between an acute angle or an obtuse angle. Depending on the case the parameter has to be changed to $[-1]$.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{3}{0}; \point{c}
{2.5}{1};
\beam{2}{a}{b};
\beam{2}{b}{c};
\addon{3}{b}{a}{c}[-1];
\end{tikzpicture}
```

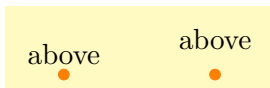
3.3 Useful TikZ commands

3.3.1 Orientation of text elements

TikZ provides some useful commands for labels, especially in the context of “nodes”. These commands can be used in the same way for some labeling elements in this library.

`/tikz/above=<offset>`

With `above` the text is placed above a corresponding point. The offset distance can be specified optional. If no `<offset>` is specified, the system default values are used.



```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{0};
\notation{1}{a}{above}[above];
\notation{1}{b}{above}[above=2mm];
\end{tikzpicture}
```

`/tikz/below=<offset>`

`below` positions the text below a selected point, otherwise the same properties as `above` can be used.

`/tikz/left=<offset>`

`left` positions the text left to a selected point, otherwise the same properties as `above` can be used.

`/tikz/right=<offset>`

`right` positions the text right to a selected point, otherwise the same properties as `above` can be used.

`/tikz/above left=<offset>`

A combination of `above` and `left` places the text to the top left over a corresponding point. Similarly, the offset distance can be specified as an option again. If no `<offset>` specified, the system defaults are used.

above left

```
\begin{tikzpicture}
\point{a}{0}{0};
\notation{1}{a}{above left}[above left];
\end{tikzpicture}
```

`/tikz/above right=<offset>`

The same as `above left` just in the right direction.

above right

```
\begin{tikzpicture}
\point{a}{0}{0};
\notation{1}{a}{above right}[above right];
\end{tikzpicture}
```

`/tikz/below left=<offset>`

There is an arrangement at the bottom left.

`/tikz/below right=<offset>`

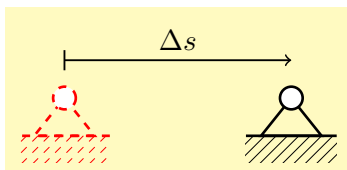
There is an arrangement at the bottom right.

3.3.2 Grouping

To group objects and assign features, there is the environment `scope`.

```
\begin{scope}[<options>]
<environment contents>
\end{scope}
```

All `<options>` are locally limited to those elements that are within the scope.



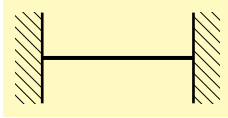
```
\begin{tikzpicture}
\point{a}{0}{0}; \point{b}{2}{1};
\begin{scope}[dashed,color=red]
\support{1}{a};
\hinge{1}{a};
\end{scope}
\support{1}{b}; \hinge{1}{b};
\dimensioning{3}{a}{b}{.5}[$\Delta s$];
\end{tikzpicture}
```

3.3.3 Scaling

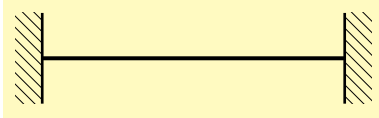
This command is not provided in the `TikZ` package, but it was written for the library to accordingly scale the lengths.

`/tikz/structuralanalysis/scaling{scalingParameter};`

This command only scales the length of the system, i.e. scaling the distances between individual points. This enables the user to create larger system, but still be printable on paper without reducing to symbols size.



```
\begin{tikzpicture}
  \scaling{.5};
  \point{a}{0}{0}; \point{b}{4}{0};
  \beam{2}{a}{b};
  \support{3}{a}[-90]; \support{3}{b}[90];
\end{tikzpicture}
```

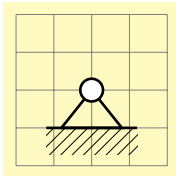


```
\begin{tikzpicture}
  \point{a}{0}{0}; \point{b}{4}{0};
  \beam{2}{a}{b};
  \support{3}{a}[-90]; \support{3}{b}[90];
\end{tikzpicture}
```

3.3.4 Guides

`\draw[help lines,<options>] (<coordinates>)grid (<coordinates>);`

To simplify the construction, it is often useful to insert appropriate guides. The distances between the grid lines can be changed with the command `step=<offset>`.



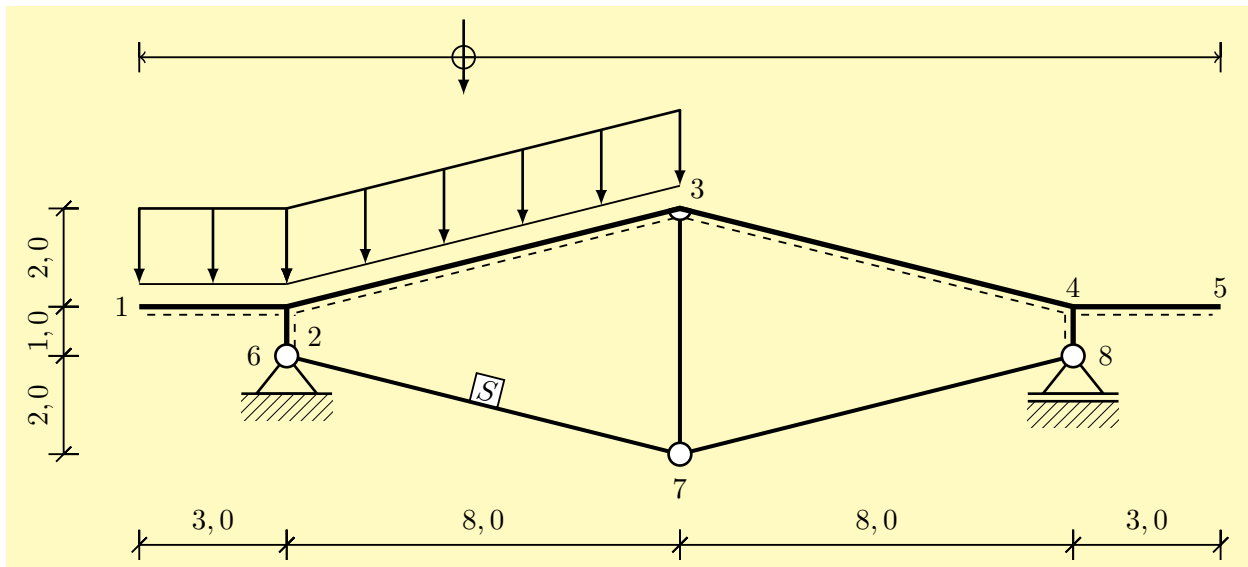
```
\begin{tikzpicture}
  \draw[help lines,step=.5] (-1,-1) grid (1,1);
  \point{a}{0}{0};
  \support{1}{a};
  \hinge{1}{a};
\end{tikzpicture}
```


4 Tutorial

In the following tutorial, the program code is only shown for the currently treated aspects, because of the limited space. However, at the end the full code is provided.

4.1 Roof construction

In this tutorial, the basic principles of designing with `TikZ` and “structuralanalysis” are treated. Step by Step, a roof structure should be created. The final result is shown below.



4.1.1 Start of the consturction

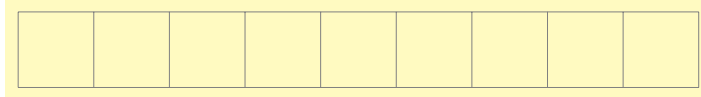
In order to create the desired roof structure, a file has to be created first. In this example, it is a `LaTeX` file. However, the library can also be used with `TeX` and `ConTeXt` files.

```
\documentclass{scrreprt} % say
\usepackage{structuralanalysis}

\begin{document}
  \begin{tikzpicture}
    % here we construct our structure
  \end{tikzpicture}
\end{document}
```

4.1.2 First steps

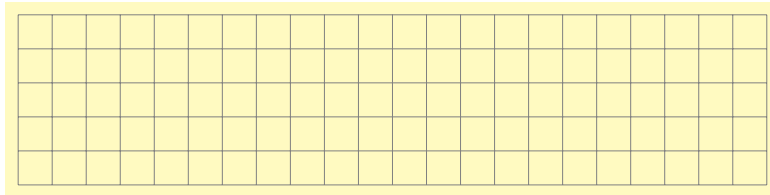
First, we have to specify corresponding points with the command `\point`. On this basis, the remaining library elements are placed. Since the points are not shown in the graph, it is recommended to create a helping grid, to predict the distances and sizes. The basic size of a grid element is 1 *cm* by 1 *cm*.



```
\begin{tikzpicture}
\draw[help lines]
(0,0) grid (9,1);
\end{tikzpicture}
```

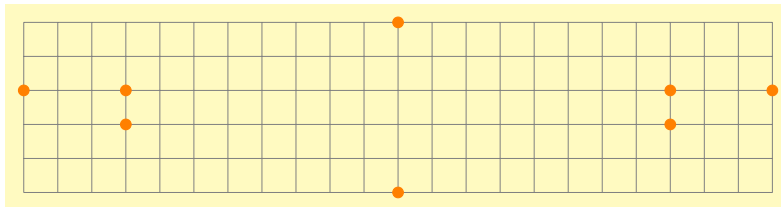
Here, it is obvious that the roof structure with a width of 22 *cm* does not fit on this page. In order not to change all the dimensions recalculating all distances, the command `scaling` can be used. Hereby, the distances are scaled depending on the desired scaling factor. However, the symbols and the entries remain unchanged.

Note, since the help grid is a function of *TikZ*, the scaling command can not be used for the guides. If we recalculate the size of the grid we get following situation:



```
\begin{tikzpicture}
\scaling{.45};
\draw[help lines,step=.45]
(0,-.9) grid (9.9,1.35);
\end{tikzpicture}
```

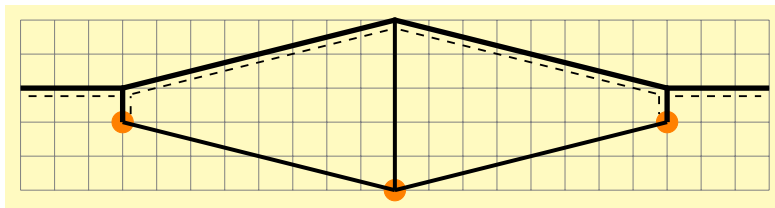
Now the points of the structure can be easily entered. Since the points, as mentioned above, are not visible, they are identified by illustration as orange dots.



```
\point{a}{0}{1};
\point{b}{3}{1};
\point{c}{11}{3};
\point{d}{19}{1};
\point{e}{22}{1};
\point{f}{3}{0};
\point{g}{11}{-2};
\point{h}{19}{0};
```

4.1.3 Roof structure

After the foundation stone was laid by the points, we can start to connect the points with beams and bars. In the library bars are with or without characteristics fiber available. With the command `\beam` they can be brought to “paper”.

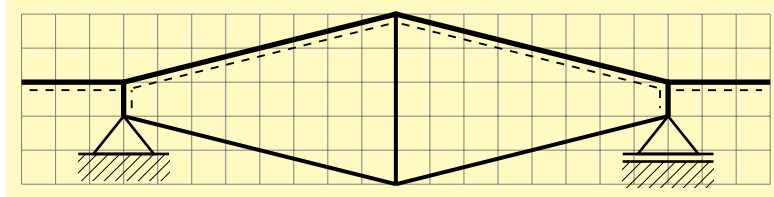


```
\beam{1}{a}{b}[0][1];
\beam{1}{b}{c}[1][1];
\beam{1}{c}{d}[1][1];
\beam{1}{d}{e}[1][0];
\beam{1}{f}{b};
\beam{1}{d}{h};
\beam{2}{f}{g};
\beam{2}{g}{h};
\beam{2}{g}{c};
```

If the edges are not rounded, as it has been happened above, there is no smooth transition of the beams (see orange dots). However, at these points it does not matter, because in a later phase joints are placed above.

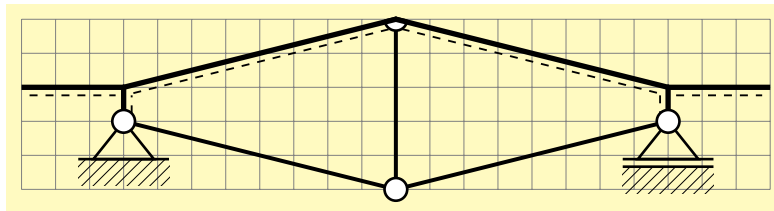
4.1.4 Bearings and joints

In order to provide more flexibility, and to keep the number of macros as low as possible, there are own commands available for the bearings and the joints. Bearings are built with the command `\support`. However, the corresponding joint must independently created with the command `\hinge`. This allows to combine different bearings with different joints. The important thing is always that the bearing has to be created first and only then the joints should be implemented. This is necessary, because TikZ puts the recently drawn figures on the top.



```
\support{1}{f};
\support{2}{h};
```

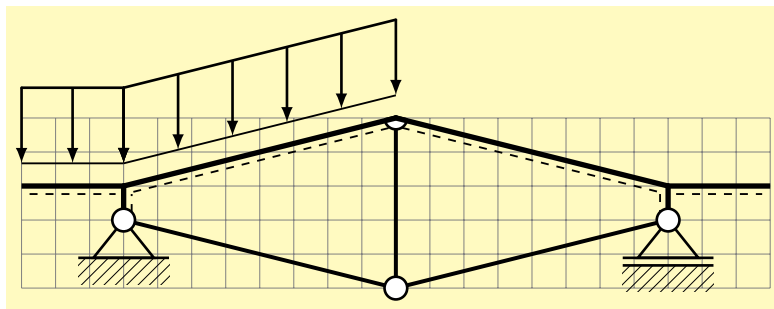
After the bearings are created, we can start with drawing the joints. As with most elements the library provides a set of different types of joints. For instance, the point *c* is described by a half-joint.



```
\hinge{1}{f};
\hinge{1}{h};
\hinge{1}{g};
\hinge{2}{c}{b}{d};
```

4.1.5 Snow on the roof

With the insertion of the joints, the construction is completed and can now be loaded. Besides single loads `\load` are line loads `\lineload` and temperature loads `\temperature` available.



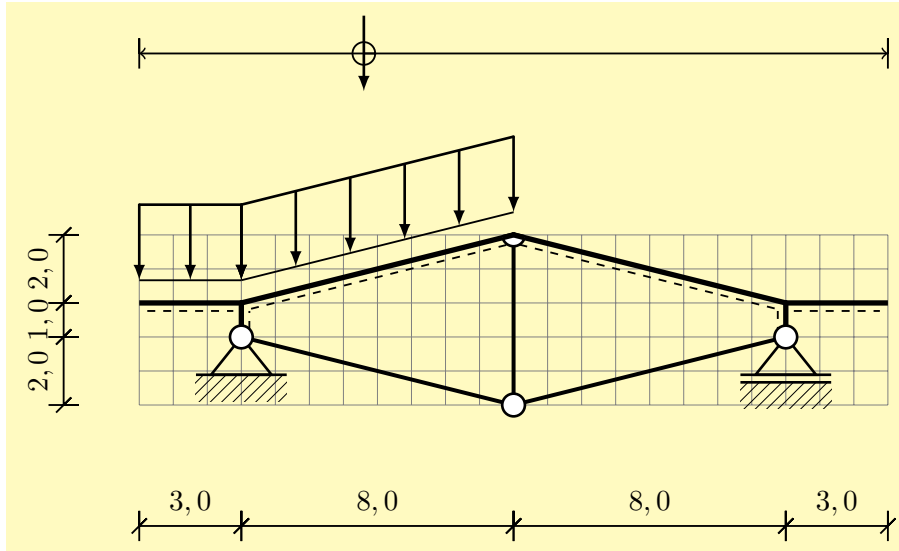
```
\lineload{2}{a}{b}{1}{1}{.5};
\lineload{2}{b}{c};
```

4.1.6 Range of the influence line and roof dimensions

Actually, the roof is already finished and ready for use. However, for the purpose of an overview, we can include the corresponding measures with the command `\dimensioning`. Similarly, the range of influence line can be defined.

```
\dimensioning{1}{a}{b}{-2.5}[$3,0$];
\dimensioning{1}{b}{c}{-2.5}[$8,0$];
\dimensioning{1}{c}{d}{-2.5}[$8,0$];
\dimensioning{1}{d}{e}{-2.5}[$3,0$];
\dimensioning{2}{f}{a}{-1}[$1,0$];
\dimensioning{2}{g}{f}{-1}[$2,0$];
\dimensioning{2}{a}{c}{-1}[$2,0$];

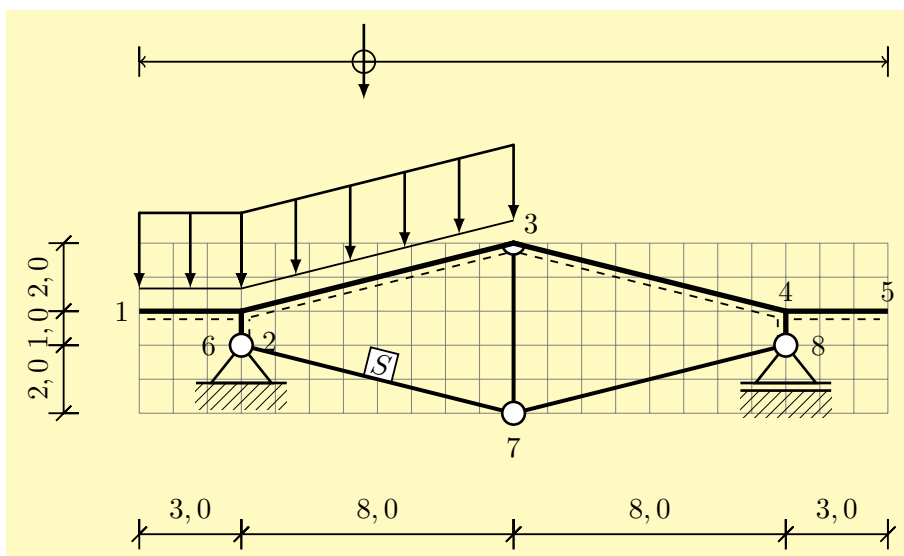
\influenceline{a}{e}{3} [.3];
```



4.1.7 The finished roof

Now the only missing parts are the names of nodes and bars, then roof construction is completed. To achieve the best possible appearance of the labels, can the labels (`\notation`) the position can be shifted with an optional parameter.

```
\notation{1}{a}{{1$}}[left];
\notation{1}{b}{{2$}}[below right=2mm];
\notation{1}{c}{{3$}};
\notation{1}{d}{{4$}}[above];
\notation{1}{e}{{5$}}[above];
\notation{1}{f}{{6$}}[left=2mm];
\notation{1}{g}{{7$}}[below=2mm];
\notation{1}{h}{{8$}}[right=2mm];
\notation{4}{f}{g}{{S$}};
```



Now the guides can be deleted and the scaling factor can be chosen so that the entire page is filled.

