1 3D Tools

TikZ Library 3dtools

```
\usetikzlibrary{3dtools} % LaTeX and plain TeX
\usetikzlibrary[3dtools] % ConTeXt
```

This library provides additional tools to create 3d–like pictures.

TikZ has the `3d` and `tpp` libraries which deal with the projections of three–dimensional drawings. This library provides some means to manipulate the coordinates. It supports linear combinations of vectors, vector and scalar products.
Note: Hopefully this library is only temporary and its contents will be absorbed in slightly extended versions of the `3d` and `calc` libraries.

1.1 Coordinate computations

The 3dtools library has some options and styles for coordinate computations.

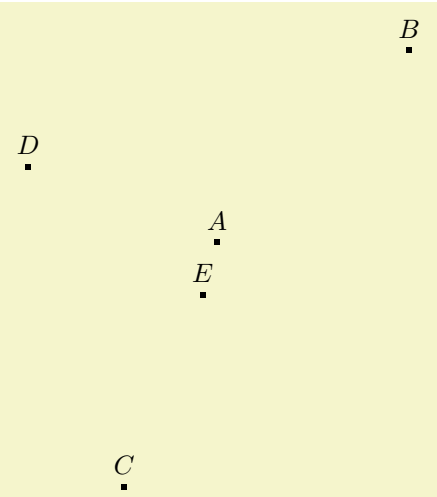
`/tikz/3d parse` (no value)

Parses and expression and inserts the result in form of a coordinate.

`/tikz/3d coordinate` (no value)

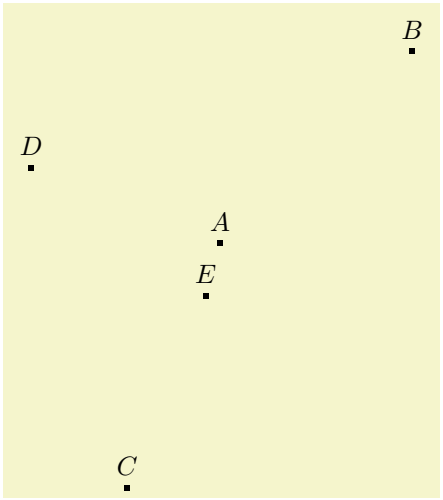
Allow one to define a 3d coordinate from other coordinates.

Both keys support both symbolic and explicit coordinates.




```
\begin{tikzpicture}
 \path (1,2,3) coordinate (A)
  (2,3,-1) coordinate (B)
  (-1,-2,1) coordinate (C)
  [3d parse={0.25*(1,2,3)x(B)}]
  coordinate(D)
  [3d parse={0.25*(C)x(B)}]
  coordinate(E);
 \path foreach \X in {A,...,E}
 {(\X) node[fill,inner sep=1pt,
 label=above:$\X$]{}};
\end{tikzpicture}
```

Notice that, as of now, only the syntax `\path (1,2,3) coordinate (A);` works, i.e. `\coordinate (A) at (1,2,3);` does *not* work, but leads to error messages.




```
\begin{tikzpicture}
 \path (1,2,3) coordinate (A)
  (2,3,-1) coordinate (B)
  (-1,-2,1) coordinate (C)
  [3d coordinate={(D)=0.25*(1,2,3)x(B)},
  3d coordinate={(E)=0.25*(C)x(B)}];
 \path foreach \X in {A,...,E}
 {(\X) node[fill,inner sep=1pt,
 label=above:$\X$]{}};
\end{tikzpicture}
```

The actual parsings are done by the function \pgfmathtdparse that allows one to parse 3d expressions. The supported vector operations are `+` (addition $+$), `-` (subtraction $-$), `*` (multiplication of the vector by a scalar), `x` (vector product $\times$) and `o` (scalar product).

\pgfmathtdparse{⟨x⟩}

Parses 3d expressions.

0.0,0.0,1.0

```
\pgfmathtdparse{(1,0,0)x(0,1,0)}\pgfmathresult
```

In order to pretty-print the result one may want to use \pgfmathprintvector, and use the math function `TD` for parsing.

\pgfmathprintvector{⟨x⟩}

Pretty-prints vectors.

$0.2\,\vec{A} - 0.3\,\vec{B} + 0.6\,\vec{C} = (-1, -1.7, 1.5)$

```
\pgfmathparse{TD("0.2*(A)
-0.3*(B)+0.6*(C)")}%
$0.2\,\vec A-0.3\,\vec B+0.6\,\vec C
=(\pgfmathprintvector\pgfmathresult)$
```

The alert reader may wonder why this works, i.e. how would Ti*k*Z "know" what the coordinates A, B and C are. It works because the coordinates in Ti*k*Z are global, so they get remembered from the above example.

$(1,0,0)^T \times (0,1,0)^T = (0,0,1)^T$

```
\pgfmathparse{TD("(1,0,0)x(0,1,0)")}%
$(1,0,0)^T\times(0,1,0)^T=
(\pgfmathprintvector\pgfmathresult)^T$
```

$\vec{A} \cdot \vec{B} = 5$

```
\pgfmathparse{TD("(A)o(B)")}%
$\vec A\cdot \vec B=
\pgfmathprintnumber\pgfmathresult$
```

Notice that, as of now, the only purpose of brackets `(...)` is to delimit vectors. Further, the addition `+` and subtraction `-` have a *higher* precedence than vector

products `x` and scalar products `o`. That is, `(A)+(B)o(C)` gets interpreted as $(\vec A+\vec B)\cdot\vec C$, and `(A)+(B)x(C)` as $(\vec A+\vec B)\times\vec C$.

$(\vec A+\vec B)\cdot\vec C=-11$

```
\pgfmathparse{TD("(A)+(B)o(C)")}%
$(\vec A+\vec B)\cdot\vec C=
\pgfmathprintnumber\pgfmathresult$
```

$(\vec A+\vec B)\times\vec C=(9,-5,-1)$

```
\pgfmathparse{TD("(A)+(B)x(C)")}%
$(\vec A+\vec B)\times\vec C=
(\pgfmathprintvector\pgfmathresult)$
```

Moreover, any expression can only have either one `o` or one `x`, or none of these. Expressions with more of these can be accidentally right.

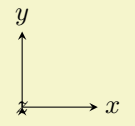
1.2 Orthonormal projections

This library can be used together with the `tikz-3dplot` package. It also has its own means to install orthonormal projections. Orthonormal projections emerge from subjecting 3-dimensional vectors to orthogonal transformations and projecting them to 2 dimensions. They are not to be confused with the perspective projections, which are more realistic and supported by the `tpp` library. Orthonormal projections may be thought of a limit of perspective projections at large distances, where large means that the distance of the observer is much larger than the dimensions of the objects that get depicted.

`/tikz/3d/install view` (no value)

Installs a 3d orthonormal projection.

The initial projection is such that x is right an y is up, as if we had no third direction.




```
\begin{tikzpicture}[3d/install view]
 \draw[-stealth] (0,0,0) -- (1,0,0)
  node[pos=1.2] {$x$};
 \draw[-stealth] (0,0,0) -- (0,1,0)
  node[pos=1.2] {$y$};
 \draw[-stealth] (0,0,0) -- (0,0,1)
  node[pos=1.2] {$z$};
\end{tikzpicture}
```

The 3d-like picture emerge by rotating the view. The conventions for the parametrization of the orthogonal rotations in terms of three rotation angles ϕ, ψ and θ are

$$O(\phi,\psi,\theta)=\begin{pmatrix} s_\phi\,c_\psi & s_\psi & -s_\phi\,c_\theta-c_\phi\,s_\psi\,s_\theta \\ c_\phi\,c_\theta-s_\phi\,s_\psi\,s_\theta & c_\psi\,s_\theta & s_\phi\,s_\theta-c_\phi\,c_\theta\,s_\psi \\ -s_\phi\,s_\psi\,c_\theta-c_\phi\,s_\theta & c_\psi\,c_\theta & c_\psi\,c_\theta \end{pmatrix}.$$

Here, $c_\phi:=\cos\phi$, $s_\phi:=\sin\phi$ and so on.

`/tikz/3d/phi` (initially `0`)

3d rotation angle.

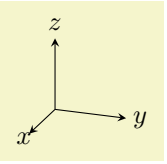
`/tikz/3d/psi` (initially `0`)

3d rotation angle.

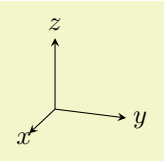
/tikz/3d/theta (initially 0)

3d rotation angle.

The rotation angles can be used to define the view. The conventions are chosen in such a way that they resemble those of the `tikz-3dplot` package, which gets widely used.




```
\begin{tikzpicture}[3d/install view={phi=110,psi=0,theta=70}]
 \draw[-stealth] (0,0,0) -- (1,0,0)
  node[pos=1.2] {$x$};
 \draw[-stealth] (0,0,0) -- (0,1,0)
  node[pos=1.2] {$y$};
 \draw[-stealth] (0,0,0) -- (0,0,1)
  node[pos=1.2] {$z$};
\end{tikzpicture}
```




```
\begin{tikzpicture}[3d/install view={phi=110,psi=0,theta=70}]
 \draw[-stealth] (0,0,0) -- (1,0,0)
  node[pos=1.2] {$x$};
 \draw[-stealth] (0,0,0) -- (0,1,0)
  node[pos=1.2] {$y$};
 \draw[-stealth] (0,0,0) -- (0,0,1)
  node[pos=1.2] {$z$};
\end{tikzpicture}
```

To do:

- transform to plane given by three non-degenerate coordinates
- transform to plane given by normal and one point
- maybe layering/visibility

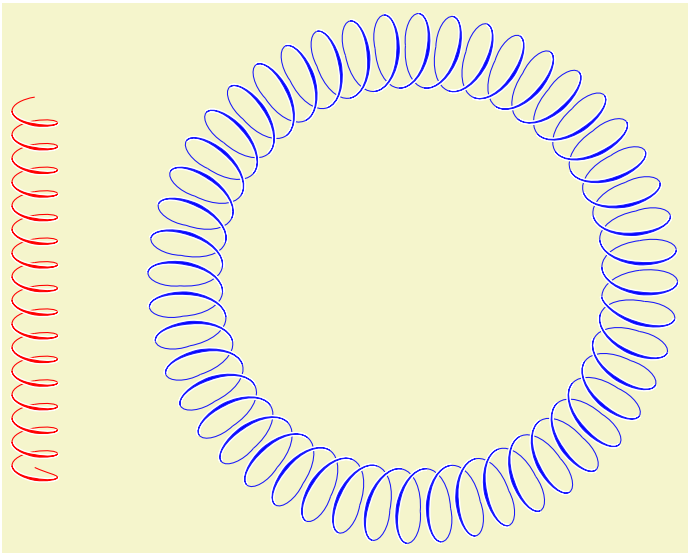
1.3 3D–like decorations

/tikz/decorations/3d complete coil (no value)

3d–like coil where the front is thicker than the back.

/tikz/decorations/3d coil closed (no value)

Indicates that the coil is closed.



```
\begin{tikzpicture}
\draw[decoration={3d coil color=red,aspect=0.35, segment length=3.1mm,
amplitude=3mm,3d complete  coil},
decorate] (0,1) -- (0,6);
\draw[decoration={3d coil color=blue,3d coil opacity=0.9,aspect=0.5,
segment length={2*pi*3cm/50}, amplitude=5mm,3d complete coil,
3d coil closed},
decorate] (5,3.5) circle[radius=3cm];
\end{tikzpicture}
```