tikzphysics

TikZ-native physics diagrams

Version 1.3.0

Vaibhav Blayer
vaibhavblayer@gmail.com

2026-09-13

Abstract

`tikzphysics` extends TikZ with reusable shapes and geometric anchors for classical-physics diagrams. It provides continuous contact surfaces, straight and circular ramps, inclined planes, blocks, springs, pulleys, concave and convex mirrors, convex and concave lenses, slabs, and prisms. Mechanics primitives include particles, disks, supports, vectors, and pendulums. Diagrams use ordinary TikZ nodes, paths, and named pics.

In one line: `\node[wedge, wedge angle=30] (W) {};`

Contents

1 Start here

1.1 Your first diagram in five minutes

Install the package normally, or upload the generated single-file `output/overleaf/tikzphysics.sty` beside an Overleaf document. Compile this complete document with pdfLaTeX. No shell escape is needed to use the package.

```
\documentclass[tikz,border=5mm]{standalone}
\usepackage{tikzphysics}
\begin{document}
\begin{tikzpicture}
  \node[block] (B) at (3,0) {$m$};
  \draw[spring] (0,0) -- node[above] {$k$} (B.west);
\end{tikzpicture}
\end{document}
```

Read this as: create a `block`, name it `B`, and connect a `spring` to its `west` anchor. Change `(3,0)` to move the block; change `minimum width` to resize it. The spring follows its endpoints.

1.2 How to explore this manual

Your next task	Where to go
Choose defaults for a whole worksheet	Section 1.5
Build the spring–block–pulley example	Section 4.1
Find anchors while drawing	Section 6.3
Draw supports, vectors, or pendulums	Section 4.7
Look up every feature's keys and anchors	Section 8
Troubleshoot placement or transformations	Section 6.4

The examples directory contains complete documents. Its `README.md` provides a learning route and explains what each example demonstrates.

1.3 Loading

Load every module with the package wrapper:

```
\usepackage{tikzphysics}
```

For smaller documents, load only the required TikZ libraries:

```
\usepackage{tikz}
\usetikzlibrary{tikzphysics.surface, tikzphysics.mechanics}
```

The available libraries are `tikzphysics.surface`, `tikzphysics.ramps`, `tikzphysics.mechanics`, `tikzphysics.optics`, and `tikzphysics.core`. Each feature library loads `tikzphysics.core` automatically.

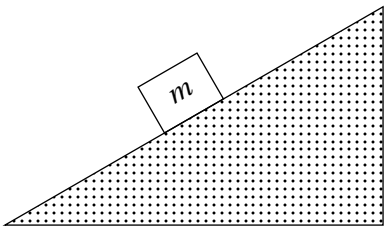
1.4 The design model

1. Choose a node style such as `wedge`, `block`, `convex-lens`, `concave-lens`, `slab`, or `prism`.
2. Use familiar TikZ sizing keys where they apply, and `physics ...` keys for shape-specific geometry or as unit-aware conveniences.
3. Give each node a name and compose the diagram through its anchors; draw a spring directly between any two such coordinates.

Short style names are the normal user interface. The longer forms remain available when another package or the surrounding document already defines a generic TikZ style such as `block`.

Short style	Collision-safe style	Object
`platform`	`physicsplatform-both`	General platform with two configurable walls
`platform-left` / `platform-right` / `platform-both`	`physicsplatform-left` / `physicsplatform-right` / `physicsplatform-both`	Explicit platform variants
`platform-left-up` / `platform-right-up`	`physicsplatform-left-up` / `physicsplatform-right-up`	One-wall presets with `wall angle=90`
`wedge`	`physicswedge`	Inclined plane
`ramp` / `ramp-left`	`physicsramp`	Continuous wall–floor–linear-incline body
`curved-ramp` / `curved-ramp-left`	`physicscurvedramp`	Circular contact ramp with a filled body
`ground` / `ceiling`	`physicsground` / `physicsceiling`	Horizontal contact strips
`wall-left` / `wall-right`	`physicswall-left` / `physicswall-right`	Vertical contact strips
`block` / `pulley`	`physicsblock` / `physicspulley`	Mechanics nodes
`spring`	`physics spring` / `physicsspring`	Coil decoration for `\draw` paths
`concave-mirror` / `convex-mirror`	`physicsconcavemirror` / `physicsconvexmirror`	Curved mirrors
`convex-lens`	`physicsconvexlens`	Symmetric biconvex lens
`concave-lens`	`physicsconcavelens`	Symmetric biconcave lens
`slab`	`physicsslab`	Parallel-sided rectangular slab
`prism`	`physicsprism`	Isosceles triangular prism

```
\begin{tikzpicture}
  \node[wedge, wedge width=5, wedge angle=30] (W) at (0,0) {};
  \node[block, minimum width=0.9cm, minimum height=0.7cm,
        rotate=30, anchor=south] at (W.slope-mid) {$m$};
\end{tikzpicture}
```



1.5 Set defaults once

The default block is a 1 cm square and the default pulley diameter is 1 cm. Simple names are the public interface: `spring`, `block`, `pulley`, and `wedge`. No slash-prefixed style is required. Each node or path style offers an `every <name>` hook:

```
\tikzset{
  every block/.style={minimum width=1cm,minimum height=1cm,fill=white},
  every spring/.style={pre length=3mm,post length=3mm,amplitude=2mm},
  every pulley/.style={minimum size=1cm}
}
\node[block] (A) {};
\node[block,minimum width=2cm] (B) at (3,0) {};
\draw[spring] (A.east) -- (B.west);
```

For node and path styles, the order is built-in settings, the shared hook, the feature hook, then later options on your node or path. This means a local `minimum width=2cm` overrides `every block` when placed after `block`. A scope contains its own settings without changing later pictures. A bare `minimum width` set at picture level may still be replaced by the object's built-in dimensions; use `every block` for object-wide sizing.

`every physics object` applies to package node styles; `every physics connection` applies to package path styles. `every platform` covers all platform variants; the other node/path hooks use the short feature name. The collision-safe hook `every physics block` is called by the initial definition of `every block`; redefining the short hook replaces that forwarding style. Do not put `block` inside `every block`, since that would call the hook recursively.

You can also use `spring/.append style={...}`. Hooks are a convenient, explicit place to keep preferences while retaining the short drawing syntax. Built-in defaults are not the same as a key's missing-value default: `show anchors` means `show anchors=true`, whereas geometric keys such as `wedge angle` require a value. An omitted geometry key keeps its inherited or built-in setting.

1.6 Dimensions

TikZ's native sizing keys are fully supported and are often the most familiar choice. Use explicit units with them, for example `minimum width=1.2cm`, `minimum height=8mm`, or `minimum size=0.7cm`. Package convenience keys may be used instead. They accept explicit dimensions and also interpret a bare value as centimetres, so `block width=1.2` and `minimum width=1.2cm` produce the same block size requirement.

Native TikZ (preferred)	Package convenience	Applies to
`minimum width / height`	`block width / height`	`block`
`minimum size`	`pulley diameter`	`pulley`
`minimum width / height`	`platform width / depth`	Bent platforms
`minimum width / height`	`ground width / depth`	`ground`
`minimum width / height`	`ceiling width / depth`	`ceiling`
`minimum width / height`	`wall thickness / height`	Left and right walls
`minimum width`	`wedge width`	`wedge` width only
`minimum width`	`--`	`ramp` overall horizontal width
`minimum width / height`	`slab width / height`	`slab`
`minimum width / height`	`prism width / height`	`prism`

The alternatives in each row set the same underlying TikZ size requirement. If both are supplied, normal TikZ option ordering applies: the last value wins. Put the shape style first, then the desired sizing keys, for example `block, minimum width=1.2cm`. These are minimum dimensions; a node may grow to contain

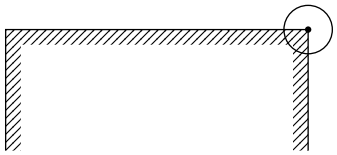
wider or taller text.

Shape-specific keys remain necessary when they control more than a native node size. In particular, use `wedge height` rather than `minimum height` when the height should determine wedge geometry. Keys such as `wall angle`, `strip width`, `convex lens radius`, and `prism apex angle` have no native TikZ sizing equivalent. All package size keys require positive values. Each concise wedge key also has a collision-safe form prefixed by `physics`, as listed in the wedge section.

1.7 Complete copy-paste examples

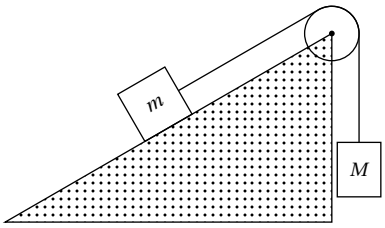
Each example below includes the document class, package loading, document environment, and complete TikZ picture. The first shows the basic composition pattern: name a node, then place another node at one of its anchors.

```
\documentclass[tikz, border=6mm]{standalone}
\usepackage{tikzphysics}

\begin{document}
\begin{tikzpicture}
  \node[platform, minimum width=5cm, minimum height=2cm]
    (platform) at (0,0) {};

  \node[pulley, minimum size=8mm]
    (pulley) at (platform.north east) {};
\end{tikzpicture}
\end{document}
```



The next complete document composes an inclined plane, two blocks, a pulley, and one exactly tangent string.

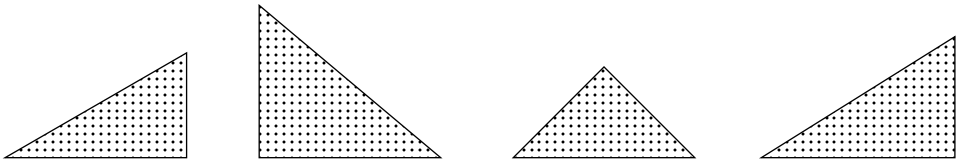
```
\documentclass[tikz, border=6mm]{standalone}
\usepackage{tikzphysics}

\begin{document}
\begin{tikzpicture}
  \node[wedge, minimum width=6cm, wedge angle=30]
    (plane) at (0,0) {};

  \node[block, minimum width=1cm, minimum height=1cm,
        rotate=30, anchor=south]
    (surface-block) at (plane.slope-mid) {$m$};

  \node[pulley] (pulley) at (plane.top) {};

  \node[block, minimum width=8mm, minimum height=1cm]
    (load) at ($(pulley.east)+(0,-2.5)$) {$M$};

  \physicsstringoverpulley{surface-block.east}{pulley}{load.north}
\end{tikzpicture}
\end{document}
```



Wedge key variants

This complete document demonstrates angle-driven and height-driven geometry, both width interfaces, and every value of `wedge right angle at`.

```
\documentclass[tikz, border=6mm]{standalone}
\usepackage{tikzphysics}

\begin{document}
\begin{tikzpicture}[font=\small]
  \node[wedge, minimum width=3cm, wedge angle=30,
        anchor=base-mid]
    (angle-br) at (0,0) {};
  \node[align=center] at (0,-0.65)
    {angle 30\textdegree\\right angle at br};

  \node[wedge, wedge width=3, wedge angle=40,
        wedge right angle at=bl, anchor=base-mid]
    (angle-bl) at (4.2,0) {};
  \node[align=center] at (4.2,-0.65)
    {width 3cm, angle 40\textdegree\\right angle at bl};

  \node[wedge, minimum width=3cm, wedge angle=45,
        wedge right angle at=top, anchor=base-mid]
    (angle-top) at (8.4,0) {};
  \node[align=center] at (8.4,-0.65)
    {angle 45\textdegree\\right angle at top};

  \node[wedge, minimum width=3.2cm, wedge height=2cm,
        anchor=base-mid]
    (height-driven) at (12.6,0) {};
  \node[align=center] at (12.6,-0.65)
    {height 2cm\\angle derived};
\end{tikzpicture}
\end{document}
```



angle 30°
right angle at br

width 3cm, angle 40°
right angle at bl

angle 45°
right angle at top

height 2cm
angle derived

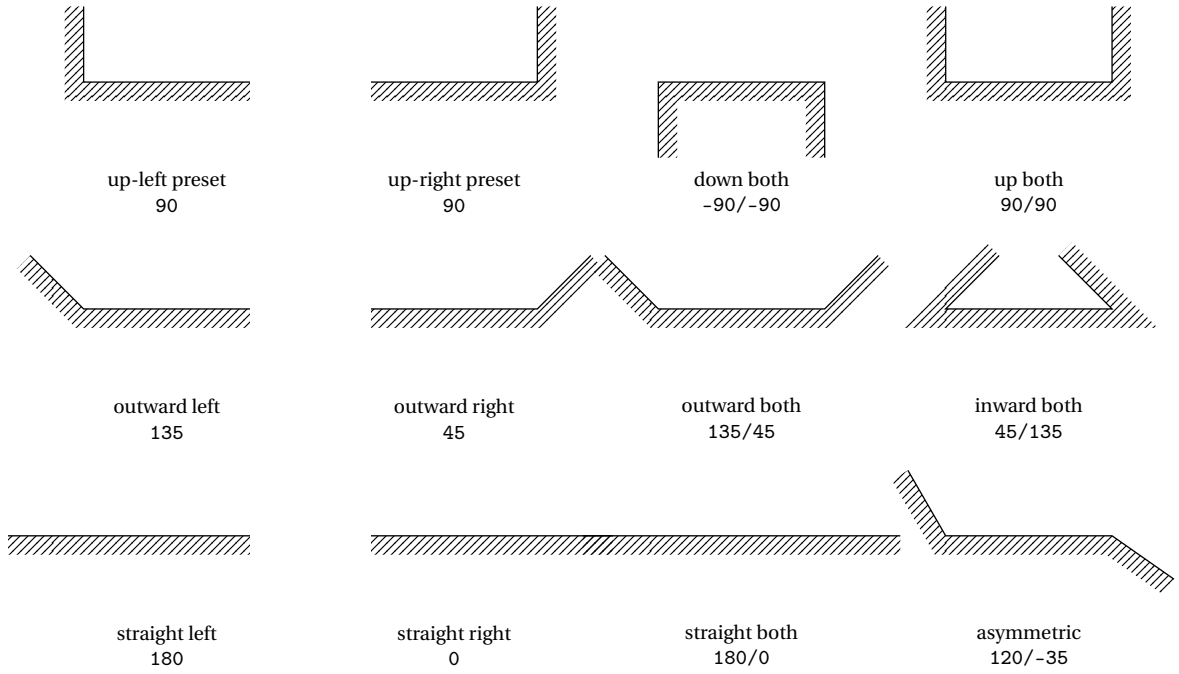
2 Contact surfaces and wedges

2.1 Bent platforms

The three underlying platform shapes share a horizontal floor strip. The left and right variants extend that strip through one bent wall; the general `platform` style uses the two-wall shape and is equivalent to the explicit `platform-both` style. Each node is rendered as one continuous platform, without a hinge mark or seam. Wall direction is continuous rather than limited to presets, so the gallery below covers every distinct configuration class; intermediate angles use the same keys.

Style	Configuration
`platform`	General two-wall platform; equivalent to `platform-both`.
`platform-left`	One wall at the left floor corner.
`platform-right`	One wall at the right floor corner.
`platform-left-up`	Left-wall preset with `wall angle=90`.
`platform-right-up`	Right-wall preset with `wall angle=90`.
`platform-both`	Two walls; set both with `wall angle`, or set them independently with `left wall angle` and `right wall angle`.

Variant gallery

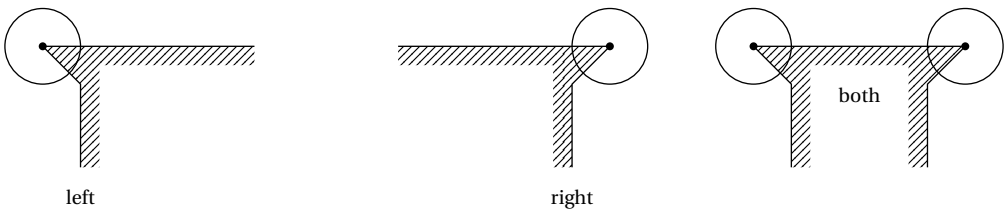


Concise key	Collision-safe alias	Meaning and default
`minimum width / platform width`	`physics platform width`	Overall floor width; default `5cm`.
`minimum height / platform depth`	`physics platform depth`	Wall length and nominal vertical extent; default `2cm`.
`strip width`	`physics strip width`	Thickness of the floor and walls; default `0.25cm`.
`wall angle`	`physics wall angle`	Direction of every wall, measured counter-clockwise from the positive x-axis; default `-90`.
`left wall angle`	`physics left wall angle`	Left-wall override for `platform-both`.
`right wall angle`	`physics right wall angle`	Right-wall override for `platform-both`.
`wall inset`	`physics wall inset`	Horizontal distance from each projecting floor tip to its wall root; default `0cm`.
`wall drop`	`physics wall drop`	Downward distance from each projecting floor tip to its wall root; default `0cm`.
`left/right wall inset`	`physics left/right wall inset`	Independent inset overrides for `platform-both`.
`left/right wall drop`	`physics left/right wall drop`	Independent drop overrides for `platform-both`.

Continuous pulley edges

The `pulley edge` preset adds the tapered corner found in many textbook pulley diagrams. It sets `wall inset=0.5cm` and `wall drop=0.5cm`, half the default pulley diameter in each direction. The floor, diagonal transition, and wall remain one closed, patterned path. There is no separately overlaid bracket.

```
\node[platform-right, pulley edge, platform width=5] (S) {};
\node[pulley] (P) at (S.pulley-center) {};

\node[platform, pulley edges] (Both) {};
\node[pulley] at (Both.left-pulley-center) {};
\node[pulley] at (Both.right-pulley-center) {};
```

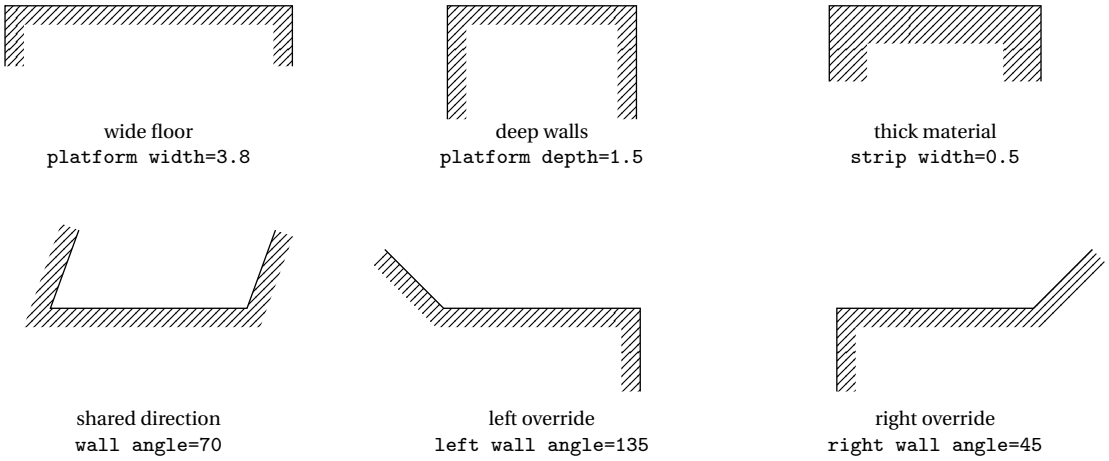


On a one-wall platform, `corner` and `pulley-center` coincide at the projecting tip. The `wall-root` anchor marks the end of the transition; `transition-mid` and `transition-0..100` address points along it. For `platform-both`, prefix these anchors with `left-` or `right-`. The styles `left pulley edge` and `right pulley edge` enable one side independently. Shared and side-specific inset/drop keys accept bare centimetre values or explicit TeX dimensions. Both values default to zero, so existing platform drawings retain their original geometry. The length set by `platform depth` remains the wall length from the wall root; the transition drop adds to the complete vertical extent.

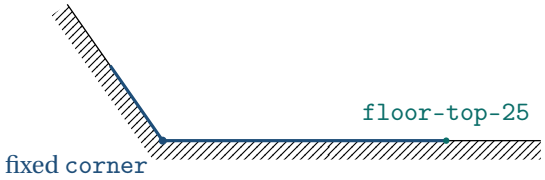
Use `show anchors` with the `transition` family to inspect points on the diagonal. The complete in-picture reference card also lists every new key and anchor. See `examples/debug-pulley-edge.tex` for a standalone example.

Key-by-key variants

Each public platform key can be varied independently and combined with any configuration from the preceding gallery. These examples isolate the original sizing and direction controls; the pulley-edge controls are shown above.



With zero inset and drop, the floor and wall contact lines meet at the fixed `corner`. With either transition dimension set, that corner remains the projecting floor tip and the wall begins at `wall-root`. The complete body is still one closed polygon with exact inner miters. The two-wall style exposes `left-corner` and `right-corner`; these lie on the same continuous geometry. Angles may vary continuously; only a left wall at 0° and a right wall at 180° (modulo 360°) are excluded because they retrace the floor and have no finite miter.



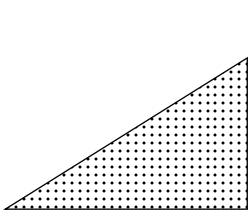
Platform anchors

Family	Available anchors
`Surface corner`	`corner`; for the two-wall style, `left-corner` and `right-corner`.
`Pulley placement`	`pulley-center`; for the two-wall style, `left-pulley-center` and `right-pulley-center`.
`Transition`	`wall-root`, `transition-mid`, and `transition-0..100`; use left/right prefixes on a two-wall platform.
`Floor corners`	`floor-tl`, `floor-tr`, `floor-br`, `floor-bl`.
`Floor midpoints`	`floor-top-mid`, `floor-bottom-mid`, `floor-left-mid`, `floor-right-mid`, `floor-center`.
`Wall corners`	`wall-A`, `wall-B`, `wall-C`, `wall-D`, ordered as outer-near, inner-miter, inner-far, outer-far.
`Wall midpoints`	`wall-outer-mid`, `wall-inner-mid`, `wall-near-mid`, `wall-far-mid`, `wall-center`.
`Two-wall prefixes`	Use `left-wall-...` and `right-wall-...` for wall corners, midpoints, and numeric wall edges.

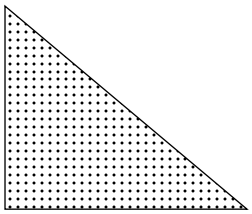
Every floor and wall edge also provides integer anchors from 0 through 100, for example `floor-top-25`, `transition-50`, `wall-outer-50`, and `right-wall-inner-75`.

2.2 Wedges

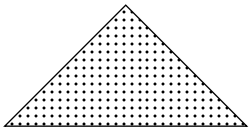
wedge creates a right triangle for inclined-plane diagrams. Its material uses TikZ's dots pattern by default; a later pattern=... option can replace it normally.



right angle at br



right angle at bl



right angle at top

Concise key	Collision-safe alias	Meaning and default
wedge width	physics wedge width	Base width; default 4cm.
wedge height	physics wedge height	Explicit height when no angle is supplied.
wedge angle	physics wedge angle	Authoritative acute angle; default is 30 degrees for bl/br, and 45 degrees for top.
wedge right angle at	physics wedge right angle at	One of br (default), bl, or top.

Geometry precedence is wedge angle, then wedge height, then the mode default. The principal anchors are bl, br, top, base-mid, right-mid, slope-mid, slope-right-mid, and centroid. Numeric edge families are base-0..100, right-0..100, and slope-0..100.

Attach to the usable incline

Prefer surface-0..100 when positioning an object on the contact face. Unlike the older CCW edge names, this family selects the actual incline in all three modes and always runs left to right. In top mode it selects the left face; right-surface-0..100 selects the right face. In the other two modes the right family refers to the same incline.

```
\node[wedge,wedge right angle at=bl,wedge angle=30] (W) {};
\path (W.tangent-before-50) -- (W.tangent-after-50)
  node[midway,sloped,block,anchor=south] (B) {$m$};
\draw[force] (W.surface-25) -- (W.normal-25);
```

The endpoint names are surface-start and surface-end. The following guides are saved per node:

Anchor or key	Meaning
tangent-before-T, tangent-after-T	Two points straddling the contact point.
normal-T	A point outside the wedge, along its normal.
surface guide length	Tangent separation and normal length; initially 0.5cm.
right-tangent-before-T, right-tangent-after-T	Corresponding guides on the right face in top mode.
right-normal-T	Normal guide for that face.

Nonuniform scaling changes perpendicularity; use rigid transformations or uniform scaling for physical normals.

Named geometry values

Every named wedge snapshots its resolved scalar geometry. Query the value owned by node `W` with

```
\geometryvalue{W}{property}
```

The collision-safe command `\tikzphysicsgeometryvalue{W}{property}` has the same result. The wedge must be named and its node command must finish before either command is used. Because the result is a fixed literal, it can appear directly inside `rotate=...`, a PGF calculation, or a label.

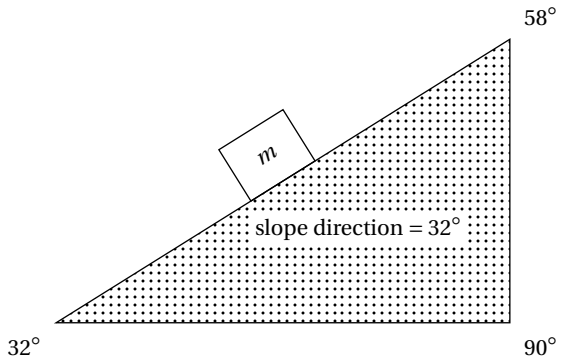
Property	Meaning
`left angle`	Interior angle at `bl`, in degrees
`right angle`	Interior angle at `br`, in degrees
`top angle`	Interior angle at `top`, in degrees
`base direction`	Direction from `bl` to `br`
`left edge direction`	Rising direction from `bl` to `top`
`right edge direction`	Rising direction from `br` to `top`
`slope angle, slope direction, surface angle`	Placement rotation for the surface at `slope-mid`
`right slope angle`	Placement rotation for the surface at `slope-right-mid`
`base angle, right edge angle`	Aliases for `base direction` and `right edge direction`
`width, height`	Resolved TeX dimensions
`right angle at`	The text value `bl`, `br`, or `top`

Angles and directions are returned as numbers without a degree symbol. Directions use degrees counterclockwise from the wedge's local positive x-axis. The placement rotations for all wedge modes are:

right angle at	left angle	right angle	top angle	slope angle
br	θ	90	$90-\theta$	θ
bl	90	θ	$90-\theta$	$-\theta$
top	θ	$90-\theta$	90	θ

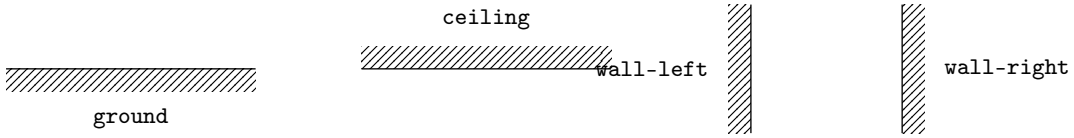
Here `slope angle` follows the contact surface selected by `slope-mid`; it is therefore the property normally wanted for a block. In `top` mode this is the left face. Use `right slope angle`, equal to $\theta - 90$, with `slope-right-mid` for the right face.

```
\node[wedge, minimum width=6cm, wedge angle=32] (W) at (0,0) {};

\node[block, minimum width=1cm, minimum height=0.8cm,
      rotate=\geometryvalue{W}{slope angle}, anchor=south]
  (B) at (W.slope-mid) {$m$};

\node at (W.bl)
  {$\pgfmathprintnumber{\geometryvalue{W}{left angle}}^\circ$};
```



These direction values describe the untransformed wedge. They work directly when the wedge and attached object share the same transformed scope. If the wedge has its own independent rotation or a nonuniform scale, orient the attached object from edge anchors with TikZ's `sloped` placement instead; that follows the final rendered edge. The complete copy-ready source is `examples/wedge-geometry-values.tex`.

2.3 Ground, ceiling, and walls



The sizing keys are grouped by shape:

`ground`	`ground width`, `ground depth`
`ceiling`	`ceiling width`, `ceiling depth`
`wall-left`, `wall-right`	`wall thickness`, `wall height`

Each shape exposes four corners, four edge midpoints, `center`, and `surface`. Numeric anchors are available as `top-`*T*, `right-`*T*, `bottom-`*T*, and `left-`*T*, where $T = 0, \ldots, 100$.

3 Straight and curved ramps

The tikzphysics.ramps library provides two comparatively unusual mechanics surfaces as genuine TikZ node shapes. They are not collections of overlaid lines: each ramp body is one closed path that receives the node's fill or pattern, and each usable contact surface is drawn once as a continuous line.

The default direction is right: parameter 0 is the low end and parameter 100 is the high end. Use ramp direction=left, or the convenience styles ramp-left and curved-ramp-left, to mirror the body. The parameter direction still runs from low to high, so algorithms and annotations do not need to reverse their anchor numbers.

3.1 Straight ramp geometry

The straight ramp combines a vertical wall, a horizontal floor, and a linear incline. The floor-to-incline meeting point is a mathematically sharp vertex; no rounding, joint circle, or seam is inserted. minimum width is the horizontal distance from the wall contact line to the high end. The ramp run occupies the final part of that width, so the flat length is

$$L_{\text{flat}} = \texttt{minimum width} - \texttt{ramp run}.$$

When ramp angle is supplied it is authoritative and the rise is $h = L_{\text{run}} \tan\theta$. Otherwise an explicit ramp rise determines the angle. With neither key, the default angle is 30°. Use \physicsrampangle{R}{label} after the node to draw the dashed reference ray, acute angle arc, and label at the exact ramp-foot. The command also works for ramp-left; its optional argument accepts ordinary TikZ angle-pic options.

Concise key	Collision-safe alias	Meaning and default
minimum width	--	Overall horizontal width; default 8.6cm.
ramp run	physics ramp run	Horizontal run of the incline; default 2.6cm.
ramp angle	physics ramp angle	Incline angle; default 30 degrees.
ramp rise	physics ramp rise	Explicit rise when no angle is supplied.
ramp wall height	physics ramp wall height	Contact-wall height; default 1.5cm.
ramp wall width	physics ramp wall width	Material behind the wall; default 0.25cm.
ramp depth	physics ramp depth	Material below the baseline; default 0.25cm.
ramp direction	physics ramp direction	right (default) or left.
ramp guide length	physics ramp guide length	Length used by tangent/normal guide anchors; default 0.5cm.

The following is a complete copy-paste document reproducing a wall, spring, block, floor, and rising end as a single ramp node.

```
\documentclass[tikz,border=6mm]{standalone}
\usepackage{tikzphysics}
\begin{document}
\begin{tikzpicture}[>=stealth]
  \node[ramp, minimum width=8.6cm, ramp run=2.6cm,
        ramp rise=1.5cm, ramp wall height=1.5cm] (R) at (0,0) {};

  \node[block, minimum width=1cm, minimum height=0.75cm,
        anchor=south] (B) at (R.floor-mid) {$m$};
  \coordinate (A) at (R.wall-mid |- B.west);
  \draw[spring] (A) -- node[above=3pt] {$k$} (B.west);
  \draw[->,thick] (B.east) -- ++(1.2,0) node[right] {$v$};
  \physicsrampangle{R}{$30^\circ$}
\end{tikzpicture}
\end{document}
```

3.2 Circular curved ramp geometry

`curved-ramp` begins with a horizontal floor extending left, then enters a circular arc tangentially at $(0,0)$; it is not an arbitrary Bézier curve. For radius R, sweep angle α, and circular-arc parameter $t = T/100$, the right-facing `curve-T` point is

$$x(T) = R\sin(t\alpha), \qquad y(T) = R\bigl(1-\cos(t\alpha)\bigr).$$

Thus a 90-degree sweep ends at (R,R) with a vertical tangent, exactly matching the common quarter-circle ramp. The floor-to-curve transition has a common horizontal tangent, so it contains no corner or visible joint. The body continues horizontally by `curved ramp back extension`, then closes down to the baseline. The supported sweep range is greater than 0 and at most 90 degrees; this keeps the filled body single-valued and prevents it folding back over itself.

Concise key	Collision-safe alias	Meaning and default
`curved ramp floor length`	`physics curved ramp floor length`	Horizontal floor before the arc; default `2.5cm`.
`curved ramp radius`	`physics curved ramp radius`	Circular radius; default `4cm`.
`curved ramp angle`	`physics curved ramp angle`	Sweep angle; default 90 degrees.
`curved ramp back extension`	`physics curved ramp back extension`	Horizontal body after the arc; default `1cm`.
`ramp depth`	`physics ramp depth`	Material below the low endpoint; default `0.25cm`.
`ramp direction`	`physics ramp direction`	`right` or `left`.
`ramp guide length`	`physics ramp guide length`	Tangent/normal guide length; default `0.5cm`.

3.3 Surface, tangent, and normal anchors

Both ramp shapes expose `surface-0` through `surface-100`. The short forms `.0` through `.100` name exactly the same points. On the straight ramp the parameter follows arc length over the floor and then the incline; it deliberately excludes the vertical wall. On the curved ramp it follows arc length over the new horizontal floor and then the circular arc. Use `curve-0..100` when a fraction of the circular portion alone is needed.

At every integer T, three orientation helpers are available:

Anchor	Meaning
tangent-before-T	Half a guide length before surface-T along the local tangent.
tangent-after-T	Half a guide length after surface-T along the local tangent.
normal-T	One guide length outward from surface-T, perpendicular to the surface.
curve-tangent-before-T	Half a guide length before curve-T.
curve-tangent-after-T	Half a guide length after curve-T.
curve-normal-T	Outward normal at curve-T only.

The tangent pair is symmetric about surface-T. Consequently TikZ can position and rotate a block without manually calculating its angle:

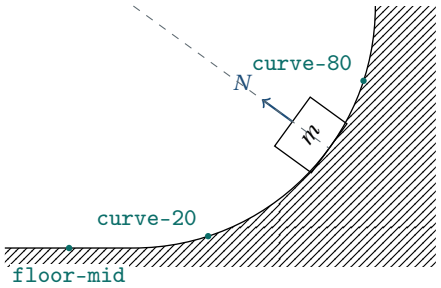
```
\path (R.tangent-before-60) -- (R.tangent-after-60)
  node[midway,sloped,block,anchor=south] (B) {$m$};
\draw[->] (B.north) --
  ($(B.north)+(R.normal-60)-(R.surface-60)$) node[above left] {$N$};
```

Named anchors provide the structural points:

Shape	Named anchors
Both	center, surface-start, surface-mid, surface-end, base-start, base-end.
Straight ramp	floor-start, floor-mid, floor-end, ramp-foot, ramp-mid, ramp-top, wall-top, wall-mid, wall-bottom, angle-baseline, angle-label.
Curved ramp	floor-start, floor-mid, floor-end, curve-start, curve-mid, curve-end, curve-center, back-top, back-bottom.

Here is a complete curved-ramp document. The dashed radius is perpendicular to the tangent. The blue force arrow uses the exact outward-normal vector, translated to begin at the block's north anchor so it does not cross the body.

```
\documentclass[tikz,border=6mm]{standalone}
\usepackage{tikzphysics}
\begin{document}
\begin{tikzpicture}[>=stealth]
  \node[curved-ramp, curved ramp radius=4cm,
        curved ramp angle=90,
        curved ramp back extension=1cm] (R) at (0,0) {};

  \path (R.curve-tangent-before-60) -- (R.curve-tangent-after-60)
    node[midway,sloped,block,minimum width=1cm,
         minimum height=0.75cm,anchor=south] (B) {$m$};
  \draw[->,blue,thick] (B.north) --
    ($(B.north)+(R.curve-normal-60)-(R.curve-60)$)
    node[above left] {$N$};
  \draw[dashed] (R.curve-center) -- (R.curve-60)
    node[midway,left] {$r$};
\end{tikzpicture}
\end{document}
```



3.4 Styling and debug use

The body follows ordinary TikZ styling. Place the shape style first, then override `pattern`, `pattern color`, `fill`, or `draw` in the usual option order. The contact line is always emitted once by the shape. For example, `curved-ramp, pattern=grid, pattern color=gray` changes the material rendering without changing anchors.

Debug overlays are especially useful for unfamiliar ramp geometry:

```
\node[curved-ramp, curved ramp floor length=1.5cm,
      curved ramp radius=2.5cm,
      curved ramp angle=70,
      physics debug/anchors=true,
      physics debug/keys=true] (R) {};
```

The key panel presents `minimum width` before package-specific sizing on the straight ramp. Anchor overlays show a compact representative set rather than all 101 samples. Use explicit `surface-T`, tangent, and normal anchors when inspecting a particular value.

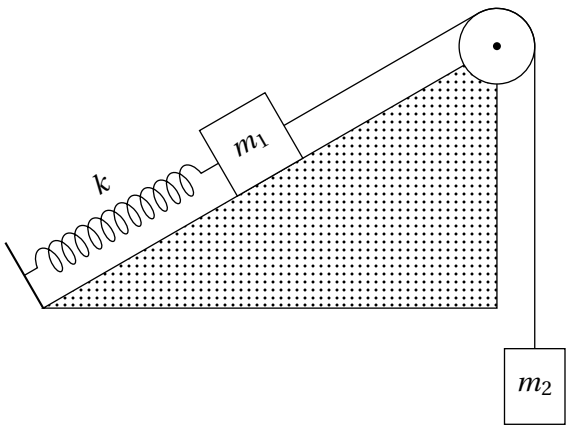
4 Blocks, springs, and pulleys

The `tikzphysics.mechanics` library supplies block and pulley nodes, a spring path style, and tangent pulley strings. They accept ordinary TikZ styling such as `draw`, `line width`, and `scale`.

4.1 Complete spring–block–pulley system

This example combines reusable defaults, a surface tangent, and the native `to[over pulley=P]` connection. Copy the complete document below.

```
\documentclass[tikz,border=6mm]{standalone}
\usepackage{tikzphysics}
\tikzset{
  every block/.style={minimum width=1cm,minimum height=1cm,fill=white},
  every pulley/.style={minimum size=1cm,fill=white},
  every spring/.style={pre length=3mm,post length=3mm,
    amplitude=2mm,segment length=2mm}
}
\begin{document}
\begin{tikzpicture}
  \node[wedge,minimum width=6cm,wedge angle=30] (W) {};
  % The contact anchors select the actual incline in every wedge mode.
  \path (W.tangent-before-50) -- (W.tangent-after-50)
    node[midway,sloped,block,anchor=south] (B) {$m_1$};
  \edef\InclineAngle{\geometryvalue{W}{slope angle}}
  \draw[thick] (W.surface-start) -- ++({\InclineAngle+90}:10mm);
  \coordinate (S) at ($(W.surface-start)+({\InclineAngle+90}:5mm)$);
  \draw[spring] (S) -- node[above=3mm,sloped] {$k$} (B.west);
  \node[pulley] (P) at (W.top) {};
  \node[block,minimum width=8mm,anchor=north] (H) at ($(P.east)+(0,-4cm)$) {$m_2$};
  \draw[rope] (B.east) to[over pulley=P] (H.north);
\end{tikzpicture}
\end{document}
```



The 10 mm block height matches the 10 mm pulley diameter. The hanging block has a local 8 mm width for readability; the package default remains a 1 cm square. With the pulley centred at the top vertex, the incoming rope is parallel to the incline. The support's attachment is half the block height above the surface, so the spring is parallel too. Changing one of these dimensions independently requires adjusting the placement. This example is specifically the rising `br` wedge arrangement; contact anchors support the other modes, but a complete pulley layout must still be chosen for the intended route.

4.2 Native rope connections

```
\draw[rope] (A) to[over pulley=P] (B);
\draw[rope,string route=under,red]
  (A) to[over pulley=P] node[right] {$T$} (B);
```

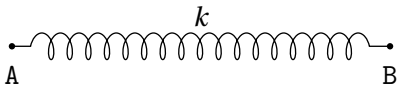
Both endpoints must lie outside the pulley. Use a circular pulley, without nonuniform scaling. The `to` segment computes both tangencies and the contact arc; its labels belong to the final straight segment. Place labels on another segment explicitly when that is what your diagram requires. The compatibility command uses the same route:

```
\physicsstringoverpulley[string route=under]{A}{P}{B}
```

Both forms now respect scoped route settings. `shortest` selects the shorter arc for the current tangent pair, not the globally shortest path over every possible tangent combination. The safe path names are `physics string` and `physics over pulley`.

4.3 Spring path

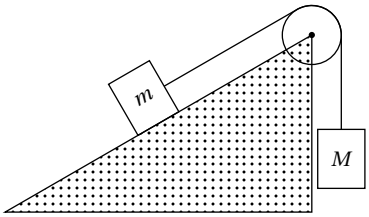
`spring` is a drawing style used directly between two coordinates. The path endpoints determine its complete length and direction, so horizontal, vertical, and inclined springs all use the same syntax. Zero-length leads are supported. Straight leads of `pre length` and `post length` surround the coil; the remaining keys map directly to TikZ's standard `coil` decoration parameters. Use explicit units for typographic sizes such as `5pt`; bare convenience-key values are interpreted as centimetres.



The spring has no node or private anchors: use the path endpoints and ordinary TikZ nodes placed along the path. For a wall–spring–block system, draw directly from a chosen wall coordinate to the block anchor:

```
\documentclass[tikz,border=5mm]{standalone}
\usepackage{tikzphysics}
\begin{document}
\begin{tikzpicture}[>=stealth]
  \node[platform-left, minimum width=6cm, minimum height=2cm,
        anchor=floor-top-mid] (P) at (0,0) {};
  \node[block, minimum width=1cm, minimum height=0.8cm,
        anchor=south] (B) at (P.floor-top-25) {$m$};
  \coordinate (A) at ($(B.west)+(-4cm,0)$);
  \draw[spring,
        pre length=5pt, post length=5pt,
        amplitude=4.5pt, segment length=4.5pt]
    (A) -- node[above=3pt] {$k$} (B.west);
  \draw[->,thick] (B.east) -- ++(1.1,0) node[right] {$v$};
\end{tikzpicture}
\end{document}
```

4.4 Blocks, pulleys, and tangent strings

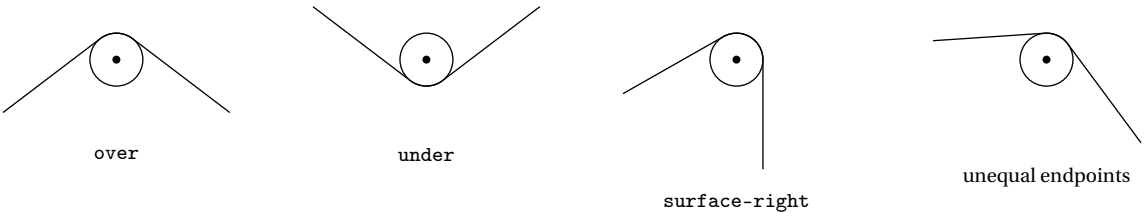


The pulley centre is exactly `W.top`. Its default diameter is `1cm`; matching the surface block's height to that diameter places `B.east` one radius above the slope, so the approaching tangent remains exactly parallel to the incline.

`\physicsstringoverpulley{start}{pulley}{end}` draws a single physical string. Both straight portions meet the circular pulley tangentially, and the intervening portion follows the pulley arc. The default `surface-right` route matches the layout shown above: the pulley is just beyond the incline's right end, the first string portion is parallel to the slope, the contact arc passes over the upper rim, and the second portion descends vertically on the right.

4.5 String-routing variants

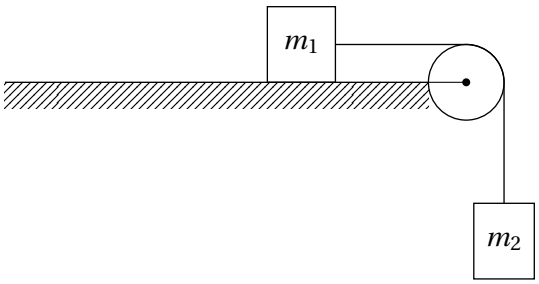
The endpoint coordinates may be placed at any unequal positions outside the pulley. The named routes below include two common left-to-right wraps and the default surface-to-right-hanging turn. `shortest` keeps the selected tangent pair and chooses the shorter contact arc. For other endpoint orderings, select tangent solutions and wrap direction explicitly.



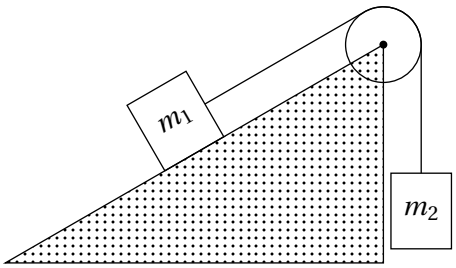
Concise key	Collision-safe alias	Meaning and default
`block width`	`physics block width`	Convenience alias for `minimum width`; default `1cm`.
`block height`	`physics block height`	Convenience alias for `minimum height`; default `1cm`.
`pre length / post length`	`physics spring pre length / physics spring post length`	Straight attachment leads; each defaults to `5pt`.
`amplitude`	`physics spring amplitude`	Coil half-height; default `4.5pt`.
`segment length`	`physics spring segment length`	Axial length of one repeated coil segment; default `4.5pt`.
`aspect`	`physics spring aspect`	Coil projection factor; default `0.5`.
`pulley diameter`	`physics pulley diameter`	Convenience alias for `minimum size`; default `1cm`.
`pulley axle radius`	`physics pulley axle radius`	Axle-dot radius; default `1.5pt`. Use `none` to hide the dot.
`pulley axle color`	`physics pulley axle color`	Axle-dot colour; default `black`.
`string start solution`	`physics string start solution`	Start-side tangent, `1` or `2`; default `2`.
`string end solution`	`physics string end solution`	End-side tangent, `1` or `2`; default `1`.
`string route`	`physics string route`	`surface-right` (default), `over`, `under`, or `shortest`.
`string wrap`	`physics string wrap`	`clockwise` (default), `counterclockwise`, or `shortest`.

4.6 Complete pulley systems

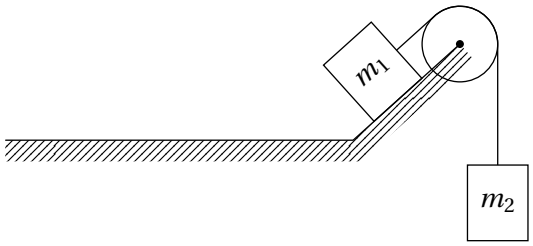
The mechanics shapes compose directly with every surface family. In each diagram below, one call to `\physicsstringoverpulley` draws both straight tangent portions and the circular contact arc; no pulley compass anchor is used as a substitute for the contact point. All four diagrams omit a pulley sizing key and therefore use the documented default `minimum size=1cm`. The inclined and bent systems place the pulley centre directly at the endpoint anchors `W.top` and `S.wall-outer-100`. Their `block height=1cm` makes `B.east` exactly one pulley radius from the supporting surface, so the incoming tangent is surface-parallel.



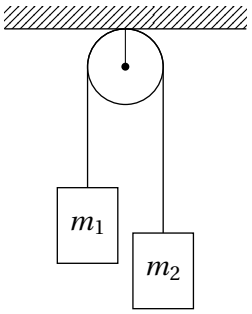
Horizontal plane



Inclined plane



Continuous bent platform



Two hanging masses

Copy-ready standalone sources are included in the `examples` directory:

- `mechanics-pulley-flat-plane.tex` and `mechanics-block-pulley.tex`;
- `mechanics-pulley-bent-platform.tex` and `mechanics-pulley-two-masses.tex`;
- `mechanics-spring-block.tex`, a complete wall–spring–block system;
- `mechanics-pulley-string-variants.tex`, a gallery of six endpoint and wrapping arrangements.

4.7 Bodies, forces and named assemblies

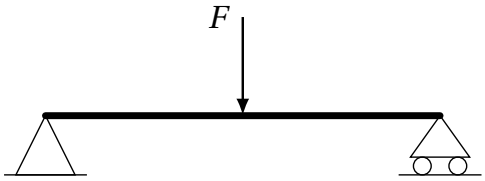
Feature	Use and defaults
`particle`	Filled circular node, diameter 3 mm.
`disk`, `ring`	Circular nodes, diameter 15 mm. Disk has a white fill; ring is unfilled with a thicker outline.
`force`, `velocity`, `acceleration`	Arrow path styles; you choose origin, direction, length, and labels.
`torque`	Arrow style for an arc you specify.
`rod`	Straight or curved path with a 2 pt stroke and round caps.
`pin-support`, `roller-support`	Named pics, controlled by `support size` (6 mm). The pic origin is the pivot.
`pendulum`	Named pic with a particle bob. Length defaults to 2 cm, angle to 30 degrees from downward vertical, positive towards the right.

Circular bodies have ordinary compass and angular anchors. Use `D.center` for an axle and `D.south` for bottom contact in an unrotated disk. These are two-dimensional diagram symbols, not automatic mass-distribution or rigid-body solvers.

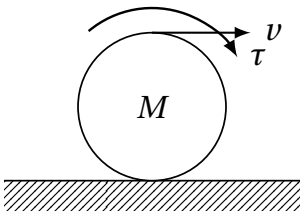
```
\pic (A) {pin-support};
\pic (B) at (4,0) {roller-support};
\draw[rod] (A-pivot) -- (B-pivot);
\draw[force] (2,1) -- (2,0) node[pos=0,left] {$F$};
\pic[pendulum length=2cm,pendulum angle=25] (P) at (6,1) {pendulum};
\draw[force] (P-bob.south) -- ++(0,-1) node[below] {$mg$};
```

Support coordinates are `A-pivot`, `A-base`, `A-left`, and `A-right`; `base` is the ground line's midpoint, while left/right are the triangle's bottom corners. A pendulum exposes `P-pivot` and a real bob node `P-bob`. Its specified length is pivot to bob centre; the rope stops at the bob's border. Rotate or shift a pic using normal TikZ options. Pic coordinates use a hyphen after the pic name, unlike a node's `B.west` anchor syntax.

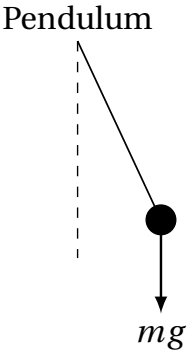
`every support` and `every pendulum` are applied when the pic type is expanded. As with TikZ pics generally, type styles are processed after options preceding the type; avoid conflicting geometric values in these hooks and the pic options. Use the hooks for shared appearance or set `support size` and `pendulum length` in the surrounding scope. The collision-safe pic types are `physics pin-support`, `physics roller-support`, and `physics pendulum`. See `examples/mechanics-primitives.tex` for a complete gallery.



Supports and a rod

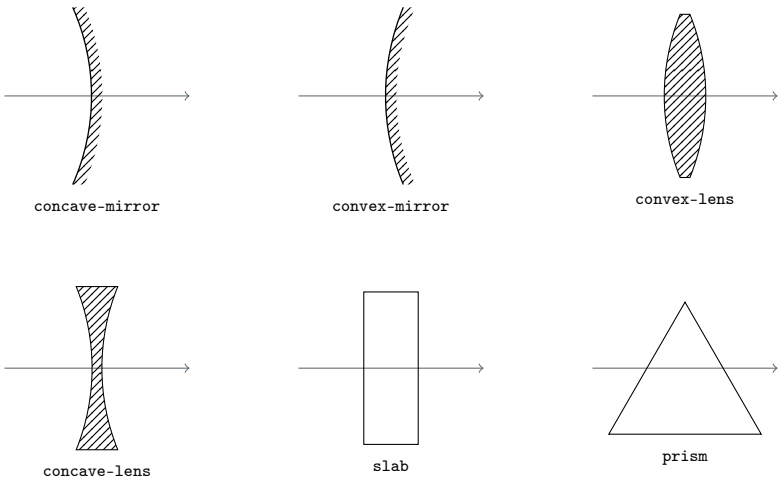


Disk, velocity and torque



5 Optical components

The tikzphysics.optics library provides six node styles. They remain ordinary TikZ nodes, so rotation, scaling, styling, naming, and anchor-based composition work in the usual way.



Short style	Collision-safe style	Geometry
concave-mirror	physicsconcavemirror	Concave reflecting surface
convex-mirror	physicsconvexmirror	Convex reflecting surface
convex-lens	physicsconvexlens	Symmetric biconvex element
concave-lens	physicsconcavelens	Symmetric biconcave element
slab	physicsslab	Parallel rectangular faces
prism	physicsprism	Isosceles triangular cross-section

5.1 Concave and convex mirrors

concave-mirror and convex-mirror are reflected variants of one spherical-mirror cross-section. The hatched side represents the backing; the solid arc is the reflecting surface.

Key	Meaning and default
mirror radius	Radius of the reflecting surface; default 5cm.
mirror thickness	On-axis backing thickness; default 0.25cm.
mirror aperture angle	Reflecting-surface half-angle; default 30 degrees.

The aperture angle must be strictly between 0 and 90 degrees. Named anchors include surface-mid, surface-top, surface-bottom, back-mid, back-top, back-bottom, vertex, top, and bottom. The families surface-0..100 and back-0..100 run from bottom to top.

Collision-safe aliases add the physics prefix:

- physics mirror radius;
- physics mirror thickness;
- physics mirror aperture angle.

```
\documentclass[tikz, border=6mm]{standalone}
\usepackage{tikzphysics}
\begin{document}
\begin{tikzpicture}
  \node[concave-mirror, mirror radius=5cm,
        mirror aperture angle=28] (M1) at (0,0) {};
  \node[convex-mirror, mirror radius=5cm,
        mirror aperture angle=28] (M2) at (5,0) {};
  \draw[->] (-2,0.7) -- (M1.surface-70);
  \draw[->] (3,0.7) -- (M2.surface-70);
\end{tikzpicture}
\end{document}
```

5.2 Convex and concave lenses

`convex-lens` draws a symmetric biconvex element, while `concave-lens` draws a symmetric biconcave element.

Key	Meaning and default
`convex lens radius`	Radius of both optical surfaces; default `5cm`.
`convex lens thickness`	Material thickness at the top and bottom caps; default `0.2cm`.
`convex lens aperture angle`	Half-angle of both surfaces; default 25 degrees.
`concave lens radius`	Radius of both optical surfaces; default `5cm`.
`concave lens thickness`	Material thickness on the optical axis; default `0.2cm`.
`concave lens aperture angle`	Half-angle of both surfaces; default 25 degrees.

The aperture angle must be strictly between 0 and 90 degrees. Named anchors include `front-mid`, `back-mid`, `front-top`, `front-bottom`, `back-top`, `back-bottom`, `top`, and `bottom`. The arc families `front-0..100` and `back-0..100` run from bottom to top. Collision-safe keys add the `physics` prefix, for example `physics convex lens radius` and `physics concave lens radius`.

5.3 Slab

`slab` uses native `minimum width` and `minimum height`; the unit-aware conveniences `slab width` and `slab height` set the same requirements. Defaults are `1.2cm` by `3cm`. The shape is an unfilled outline, so ray paths remain visible through it.

Named anchors are `front`, `back`, `front-top`, `front-bottom`, `back-top`, `back-bottom`, `top`, and `bottom`. Numeric families `front-0..100` and `back-0..100` run bottom to top; `top-0..100` and `bottom-0..100` cover the caps.

5.4 Prism

`prism` is an isosceles triangle. Use native `minimum width` and `minimum height`, or the unit-aware `prism width` and `prism height`. Defaults are `3cm` by `2.6cm`. If `prism apex angle` is supplied, it is authoritative and the height is derived from the width; the angle must be strictly between 0 and 180 degrees. The prism is also an unfilled outline.

Named anchors are `apex`, `base-left`, `base-right`, `base-mid`, `left-mid`, `right-mid`, `entry-mid`, `exit-mid`, and `centroid`. Numeric families are `base-0..100`, `left-0..100`, and `right-0..100`.

5.5 Short numeric anchors

Each optical shape also exposes its primary ray-entry surface directly as `.0` through `.100`. Thus `(L.50)` is the midpoint and `(L.80)` is a point near the top of the primary surface.

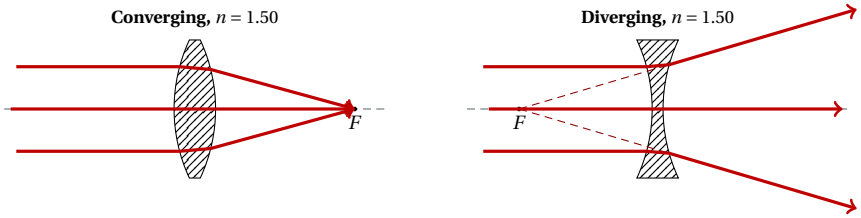
Shape	Meaning of `(name.T)` for $T = 0 \ldots 100$
`concave-mirror` / `convex-mirror`	Same as `surface-T`
`convex-lens` / `concave-lens`	Same as `front-T`
`slab`	Same as `front-T`
`prism`	Same as `left-T`

Explicit family names can mark corresponding points, for example `(L.80) - (L.back-80)`; that segment is not generally a physical ray.

5.6 Complete copy-paste ray diagram

For the fixed ratio $n_{\text{lens}}/n_{\text{air}} = 1.50$, the following Snell-law construction bends each non-axial ray at both interfaces. The axial ray stays straight because it meets both vertices normally.

```
\documentclass[tikz, border=6mm]{standalone}
\usepackage{tikzphysics}

\begin{document}
\begin{tikzpicture}[ray/.style={red!75!black, very thick, ->}]
  \node[convex-lens, convex lens radius=3cm,
        convex lens thickness=0.2cm,
        convex lens aperture angle=25] (L) at (0,0) {};
  \coordinate (Xlow) at ($(L.center)+(0.29194,-0.72588)$);
  \coordinate (Xhigh) at ($(L.center)+(0.29194,0.72588)$);
  \coordinate (F) at (2.93841,0);
  \draw[densely dashed, gray] (-3.5,0) -- (3.5,0);
  \fill (F) circle (1.2pt) node[below] {$F$};
  \draw[ray] ($(L.20)+(-3,0)$) -- (L.20) -- (Xlow) -- (F);
  \draw[ray] ($(L.50)+(-3,0)$) -- (L.50) -- (L.back-50) -- (F);
  \draw[ray] ($(L.80)+(-3,0)$) -- (L.80) -- (Xhigh) -- (F);
\end{tikzpicture}
\end{document}
```



Note. The package supplies geometry and anchors, not automatic ray tracing. These coordinates are valid only for the stated lens and index; recalculate them after changing either. The complete four-panel source is `examples/optics-complete-ray-diagrams.tex`.

6 Shared tools

6.1 Percentage anchors: a beginner's guide

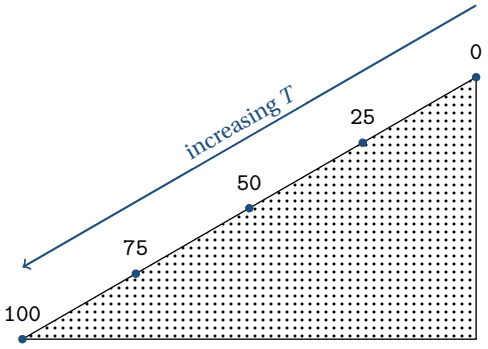
A percentage anchor names a point partway along one particular edge, arc, or contact surface. It removes the need to calculate coordinates manually. The general spelling is

`(node-name.family-number)`

For example, `(W.slope-25)` means: use node `W`, choose its `slope` edge, then travel 25 percent from that family's documented start towards its end. The number is an integer from 0 to 100; write 25, not 25%. The three landmarks worth memorising are:

`family-0`	start of the family
`family-50`	halfway along the family
`family-100`	end of the family

The family direction matters. On a wedge, `slope-0` is the top vertex and `slope-100` is the lower foot, so `slope-25` lies near the top rather than near the foot.



Using a percentage anchor

The node must first have a name. Then use the anchor anywhere TikZ accepts a coordinate:

```
\begin{tikzpicture}
  \node[wedge, wedge width=6cm, wedge angle=30] (W) at (0,0) {};

  % Put the block midpoint on the middle of the slope.
  % anchor=south makes the block's bottom touch that point.
  \node[block, minimum width=1cm, minimum height=0.7cm,
        rotate=30, anchor=south]
    (B) at (W.slope-50) {$m$};

  % Mark a point 25 percent of the way from the top to the foot.
  \fill[red] (W.slope-25) circle (1.5pt);

  % Draw between two percentage anchors.
  \draw[blue, very thick] (W.base-20) -- (W.slope-80);
\end{tikzpicture}
```

Changing the wedge width or angle moves all three points automatically. The number describes progress along the selected family, not an x coordinate, y coordinate, distance in centimetres, or angle around the node.

Which way does the percentage increase?

Use 0 as the start and 100 as the arrowhead in the table below. Explicit family names are recommended in teaching material because they state both the surface and its direction.

Family	Direction from 0 to 100
`floor-top-T`	right floor corner to left floor corner
`floor-bottom-T`	left floor corner to right floor corner
`wall-outer-T`, `wall-inner-T`	platform corner towards the far wall end
`base-T on a wedge`	`bl` to `br`
`right-T on a wedge`	`br` to `top`
`slope-T on a wedge`	`top` to `bl`
`surface-T on a ramp`	`surface-start` to `surface-end`, following the complete contact path
`curve-T on a curved ramp`	start to end of the circular portion only
`surface-T`, `front-T`, `back-T in optics`	bottom to top
`base-T on a prism`	`base-left` to `base-right`
`left-T on a prism`	`apex` to `base-left`
`right-T on a prism`	`base-right` to `apex`

For a multi-part ramp, the percentage follows distance along the complete contact path. Consequently `surface-50` is halfway by path length; it need not be the floor-to-incline joint or the visual centre of the node. On a circular family the percentage follows the arc.

Short form `(name.T)`

Ramps and optical shapes also provide a short form such as `(R.50)` or `(L.80)`. It selects one documented primary surface:

Shape	Meaning of `(name.T)`
`straight or curved ramp`	`surface-T`
`concave or convex mirror`	`surface-T`
`convex or concave lens`	`front-T`
`slab`	`front-T`
`prism`	`left-T`

Thus `(L.80)` and `(L.front-80)` are the same point. Platforms and wedges intentionally require the explicit family name, such as `(P.floor-top-50)` or `(W.slope-50)`. This also avoids confusion with ordinary TikZ numeric border anchors, where a number can mean an angle around a node rather than a percentage.

The complete annotated source is `examples/percentage-anchors-beginner.tex`; the more exhaustive edge gallery is `examples/surface-numeric-anchors.tex`.

6.2 Combining x and y coordinates

TikZ's native projection operators solve a common mechanics-diagram problem: take the horizontal position from one anchor and the vertical position from another. They avoid measured offsets and continue working when either object moves or changes size.

`(A |- B)`	x-coordinate from A, y-coordinate from B
`(A -| B)`	x-coordinate from B, y-coordinate from A

Suppose block `B` must connect horizontally to the vertical wall of ramp `R`. Use the wall anchor only as the x source and `B.west` as the y source:

```
\node[ramp, minimum width=8.6cm, ramp run=2.6cm,
      ramp rise=1.5cm] (R) at (0,0) {};
\node[block, minimum width=1cm, minimum height=0.75cm,
      anchor=south] (B) at (R.floor-mid) {$m$};

\coordinate (A) at (R.wall-mid |- B.west);
\draw[spring] (A) -- (B.west);
```

Both endpoints now have exactly the same y-coordinate, so the spring or line is horizontal by construction. The same recipe works with an upward platform wall:

```
\node[platform-left-up, minimum width=6cm] (P) at (0,0) {};
\node[block, anchor=south] (B) at (P.floor-top-25) {$m$};
\coordinate (A) at (P.wall-outer-mid |- B.west);
\draw[spring] (A) -- (B.west);
```

For a right upward wall, use `B.east` and a right-wall anchor instead. This projection is exact for vertical walls. For an angled wall it keeps the chosen anchor's x-coordinate; finding the geometric intersection with an arbitrary sloping wall instead requires TikZ's `intersections` library.

See `examples/coordinate-projection.tex` for both complete diagrams.

6.3 Explore keys and anchors inside TikZ

Add `show anchors` or `show keys` to a named object. Both keys accept `true`/`false`; a bare key means true. The original `physics debug/anchors`, `physics debug/keys`, and `physics debug/all` forms remain supported.

```
\begin{tikzpicture}
  \node[wedge,show anchors,show keys] (W) {};
\end{tikzpicture}
```

`show keys` is a complete feature reference, labelled as *defaults*, not a dump of live node values. It lists geometry keys, size aliases, all named anchors, percentage families, and common TikZ styling options. Arbitrary user-defined TikZ keys cannot be enumerated by the package. The full PGF/TikZ manual remains the reference for generic keys.

Use `\physicshelp{index}` to list every feature. Display a reference without constructing a shape:

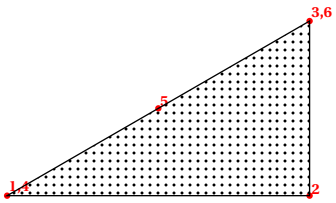
```
\begin{tikzpicture}
  \physicshelp{spring}
\end{tikzpicture}
```

`\physicshelp[<node options>]{<feature>}` accepts every public feature name, including paths and pics. You can place a card with `xshift`, `yshift`, `anchor`, or normal `at` node options. Use `\tikzphysicshelp` for the collision-safe command name. The reference cards also work when loading only one feature module. A card can describe another module's feature, but you must load that module before drawing it.

Choose points without covering the diagram

```
\node[wedge,show anchors,
  physics debug/anchor list={bl,br,top},
  physics debug/anchor families={surface},
  physics debug/anchor samples={0,25,50,75,100}] (W) {};
```

`anchor list=auto` is the default and enumerates all named anchors. An explicit comma-separated list replaces that selection. Families add the chosen samples; for example `surface` plus `50` adds `surface-50`. You may leave the named list empty to inspect only families. To inspect all points of one family, use `anchor samples={0,1,...,100}`. You can select every family with `anchor families=all`; most diagrams are clearer with a few samples. The reference always lists the full family ranges. Family names and samples must exist on that object; unknown anchors receive the normal PGF error. Coincident points share one label with multiple reference numbers.



1.	bl	2.	br
3.	top	4.	surface-0
5.	surface-50	6.	surface-100

Scope settings and move panels

```
\begin{tikzpicture}[show anchors]
  \node[block] (A) {};
  \node[block,show anchors=false] (B) at (4,0) {};
\end{tikzpicture}
```

Options are captured for each named object, so local false overrides, fonts, and colours remain associated with that object. Debug drawings do not recursively acquire debug overlays. Use explicit unique node names.

Key under physics debug/	Default and effect
anchors, keys, all	false; bare form enables the overlay.
anchor list	auto; all named anchors, or a comma-separated selection.
anchor families	Empty; selected percentage families, or all.
anchor samples	0,25,50,75,100.
anchor dot color, anchor dot radius	red, 1.2pt.
anchor label color, anchor label font	red!80!black, tiny typewriter.
key label color, key label font	gray, tiny typewriter.
anchor legend xshift, anchor legend yshift	0pt, -2cm from the object's centre.
key panel xshift, key panel yshift	0pt, 2cm from the object's centre.

Panels deliberately enlarge the picture's bounding box. For a complex system, inspect one object at a time or move its reference card beside the system. Disable overlays for the final diagram. The examples debug-explorer.tex and debug-scoped.tex are complete documents.

6.4 Troubleshooting and geometry limits

My default size did not apply. Put the style first and the size after it, or set every block. Built-in style values follow ordinary option order.
The block is on a vertical wedge edge. Use surface-T for physical contact. The older slope-T name follows a fixed CCW edge and is not the incline in every wedge mode.
My block is not rotated with its surface. Use the tangent-before/after path with sloped. Local scalar geometry values do not include an independent node transformation.
An automatic line ends outside the shape. Irregular shapes still inherit rectangular automatic border behaviour. Use explicit contact anchors; true outline intersections for all irregular bodies are future work.
Scaling makes a normal or rope wrong. Nonuniform scaling changes circles to ellipses and does not preserve perpendicularity. Keep physical constructions rigid or uniformly scaled. Use transform shape when scaling the entire node geometry with a scope.
Long text does not fit an irregular shape. Package geometry dimensions define its body; do not assume native text-driven minimum-size growth. Place labels in separate nodes. Blocks and circular primitives use standard TikZ shapes and can grow to fit text.
What does a bare number mean? Convenience lengths use centimetres; native sizing keys should receive explicit units. Angles are degrees.
Is a numeric anchor an angle? On a pulley or disk, yes. On ramps and optical shapes, integer .0 through .100 are retained percentage shortcuts. Explicit family names avoid ambiguity.
Does the package solve the physics? No. Forces, constraints, motion, optical exit points, and physically compatible placements are supplied by you.

7 Installation and development

The installed drawing package requires only LaTeX2e and PGF/TikZ; using it in a document does not require shell escape or an external executable. The source manual uses Fourier and minted, so building tikzphysics.pdf also requires those packages and shell escape for syntax highlighting.

For manual installation, place tikzphysics.sty and every tikzlibrarytikzphysics*.code.tex file in a directory searched by TeX. For a one-file Overleaf upload, run the bundle command shown below and upload only output/overleaf/tikzphysics.sty. The generated file contains all runtime modules and the in-picture feature catalog.

The source distribution uses l3build:

```
l3build check   # run coordinate and anchor regression tests
l3build doc     # build tikzphysics.pdf (shell escape is configured)
l3build ctan    # create the CTAN and TDS archives
python3 scripts/build_overleaf_bundle.py  # one-file Overleaf package
```

Standalone examples are stored in `examples/`. The command-line helper `tikzphysics-help` prints a compact key and anchor reference.

8 Complete feature reference

Each entry lists built-in defaults, anchors, and available percentage families. Use explicit family names in new diagrams. The same declarations generate `docs/reference.md` and the in-picture `\physicshelp` cards. Common TikZ keys are additional to the geometry keys shown here; see the earlier sections for sizing and transformation behaviour.

8.1 platform-left (node)

Key	Default
`minimum width`	5cm
`minimum height`	2cm
`strip width`	0.25cm
`wall angle`	-90 degrees
`wall inset`	0cm
`wall drop`	0cm
`pulley edge`	off; preset uses 0.5cm inset and drop

Size aliases: platform width = minimum width; platform depth = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, corner, pulley-center, wall-root, transition-mid, floor-tl, floor-tr, floor-br, floor-bl, floor-top-mid, floor-bottom-mid, floor-left-mid, floor-right-mid, floor-center, wall-A, wall-B, wall-C, wall-D, wall-outer-mid, wall-inner-mid, wall-near-mid, wall-far-mid, wall-center, text

Families: floor-bottom-0..100, floor-right-0..100, floor-top-0..100, floor-left-0..100, transition-0..100, wall-outer-0..100, wall-inner-0..100, wall-near-0..100, wall-far-0..100

pulley edge sets a 0.5cm wall inset and drop. pulley-center is the projecting floor tip; wall-root begins the wall; transition runs from tip to root.

8.2 platform-right (node)

Key	Default
`minimum width`	5cm
`minimum height`	2cm
`strip width`	0.25cm
`wall angle`	-90 degrees
`wall inset`	0cm
`wall drop`	0cm
`pulley edge`	off; preset uses 0.5cm inset and drop

Size aliases: platform width = minimum width; platform depth = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, corner, pulley-center, wall-root, transition-mid, floor-tl, floor-tr, floor-br, floor-bl, floor-top-mid, floor-bottom-mid,

floor-left-mid, floor-right-mid, floor-center, wall-A, wall-B, wall-C, wall-D, wall-outer-mid, wall-inner-mid, wall-near-mid, wall-far-mid, wall-center, text

Families: floor-bottom-0..100, floor-right-0..100, floor-top-0..100, floor-left-0..100, transition-0..100, wall-outer-0..100, wall-inner-0..100, wall-near-0..100, wall-far-0..100

pulley edge sets a 0.5cm wall inset and drop. pulley-center is the projecting floor tip; wall-root begins the wall; transition runs from tip to root.

8.3 platform (node)

Key	Default
`minimum width`	5cm
`minimum height`	2cm
`strip width`	0.25cm
`wall angle`	-90 degrees
`left wall angle`	-90 degrees
`right wall angle`	-90 degrees
`wall inset`	0cm
`left wall inset`	0cm
`right wall inset`	0cm
`wall drop`	0cm
`left wall drop`	0cm
`right wall drop`	0cm
`pulley edge`	off; shared preset uses 0.5cm inset and drop
`left pulley edge`	off; left-side preset uses 0.5cm inset and drop
`right pulley edge`	off; right-side preset uses 0.5cm inset and drop
`pulley edges`	off; both-side alias of pulley edge

Size aliases: platform width = minimum width; platform depth = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, left-corner, right-corner, left-pulley-center, right-pulley-center, left-wall-root, right-wall-root, left-transition-mid, right-transition-mid, floor-tl, floor-tr, floor-br, floor-bl, floor-top-mid, floor-bottom-mid, floor-center, left-wall-A, left-wall-B, left-wall-C, left-wall-D, left-wall-outer-mid, left-wall-inner-mid, left-wall-far-mid, left-wall-near-mid, right-wall-A, right-wall-B, right-wall-C, right-wall-D, right-wall-outer-mid, right-wall-inner-mid, right-wall-far-mid, right-wall-near-mid, text

Families: floor-bottom-0..100, floor-right-0..100, floor-top-0..100, floor-left-0..100, left-transition-0..100, right-transition-0..100, left-wall-outer-0..100, left-wall-inner-0..100, left-wall-near-0..100, left-wall-far-0..100, right-wall-outer-0..100, right-wall-inner-0..100, right-wall-near-0..100, right-wall-far-0..100

pulley edges sets both sides; left pulley edge and right pulley edge select one side. Use the corresponding left/right pulley-center, wall-root, and transition anchors.

8.4 wedge (node)

Key	Default
`minimum width`	4cm
`wedge height`	derived
`wedge angle`	30 degrees
`wedge right angle at`	br
`surface guide length`	0.5cm

Size aliases: wedge width = minimum width.

Anchors: surface-start, surface-end, center, north, south, east, west, north east, north west, south east, south west, bl, br, top, base-mid, right-mid, slope-mid, slope-right-mid, centroid, mid, text

Families: base-0..100, right-0..100, slope-0..100, surface-0..100, tangent-before-0..100, tangent-after-0..100, normal-0..100, right-surface-0..100, right-tangent-before-0..100, right-tangent-after-0..100, right-normal-0..100

surface runs left to right on the usable incline; top mode uses the left face. right-surface selects the right face in top mode. Legacy slope/right/base families keep their CCW directions. Directions and normals are local to the node.

8.5 ground (node)

Key	Default
`minimum width`	6cm
`minimum height`	0.3cm

Size aliases: ground width = minimum width; ground depth = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, top-left, top-right, top-mid, bottom-left, bottom-right, bottom-mid, left-mid, right-mid, surface, text

Families: bottom-0..100, right-0..100, top-0..100, left-0..100

8.6 ceiling (node)

Key	Default
`minimum width`	2cm
`minimum height`	0.3cm

Size aliases: ceiling width = minimum width; ceiling depth = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, top-left, top-right, top-mid, bottom-left, bottom-right, bottom-mid, left-mid, right-mid, surface, text

Families: bottom-0..100, right-0..100, top-0..100, left-0..100

8.7 wall-left (node)

Key	Default
`minimum width`	0.3cm
`minimum height`	3cm

Size aliases: wall thickness = minimum width; wall height = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, top-left, top-right, top-mid, bottom-left, bottom-right, bottom-mid, left-mid, right-mid, surface, text

Families: bottom-0..100, right-0..100, top-0..100, left-0..100

8.8 wall-right (node)

Key	Default
`minimum width`	0.3cm
`minimum height`	3cm

Size aliases: wall thickness = minimum width; wall height = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, top-left, top-right, top-mid, bottom-left, bottom-right, bottom-mid, left-mid, right-mid, surface, text

Families: bottom-0..100, right-0..100, top-0..100, left-0..100

8.9 ramp (node)

Key	Default
`minimum width`	8.6cm
`ramp run`	2.6cm
`ramp rise`	derived
`ramp angle`	30
`ramp depth`	0.25cm
`ramp wall height`	1.5cm
`ramp wall width`	0.25cm
`ramp direction`	right
`ramp guide length`	0.5cm

Anchors: center, surface-start, surface-mid, surface-end, floor-start, floor-mid, floor-end, ramp-foot, ramp-mid, ramp-top, wall-top, wall-mid, wall-bottom, base-start, base-end, angle-baseline, angle-label, angle-first, angle-second, text

Families: surface-0..100, tangent-before-0..100, tangent-after-0..100, normal-0..100; legacy .0..100 shorthand also available

surface follows the whole contact path by distance. At the sharp joint the tangent uses the incline side.

8.10 curved-ramp (node)

Key	Default
`curved ramp floor length`	2.5cm
`curved ramp radius`	4cm
`curved ramp angle`	90
`curved ramp back extension`	1cm
`ramp depth`	0.25cm
`ramp direction`	right
`ramp guide length`	0.5cm

Anchors: center, surface-start, surface-mid, surface-end, curve-center, curve-start, curve-mid, curve-end, floor-start, floor-mid, floor-end, base-start, base-end, back-top, back-bottom, text

Families: surface-0..100, curve-0..100, tangent-before-0..100, tangent-after-0..100, normal-0..100, curve-tangent-before-0..100, curve-tangent-after-0..100, curve-normal-0..100; legacy .0..100 shorthand also available

surface follows floor plus arc by distance; curve follows the arc only.

8.11 block (node)

Key	Default
`minimum width`	1cm
`minimum height`	1cm

Size aliases: block width = minimum width; block height = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, base, base east, base west, mid, mid east, mid west, text

Families: Numeric anchors are angles in degrees, as in ordinary TikZ.

8.12 pulley (node)

Key	Default
`minimum size`	1cm
`pulley axle radius`	1.5pt
`pulley axle color`	black

Size aliases: pulley diameter = minimum size.

Anchors: center, north, south, east, west, north east, north west, south east, south west, base, base east, base west, mid, mid east, mid west, text

Families: Numeric anchors are angles in degrees, as in ordinary TikZ.

Use a circular pulley with external rope endpoints. Set pulley axle radius=none to hide the axle.

8.13 particle (node)

Key	Default
`minimum size`	3mm

Anchors: center, north, south, east, west, north east, north west, south east, south west, base, base east, base west, mid, mid east, mid west, text

Families: Numeric anchors are angles in degrees, as in ordinary TikZ.

8.14 disk (node)

Key	Default
`minimum size`	15mm

Anchors: center, north, south, east, west, north east, north west, south east, south west, base, base east, base west, mid, mid east, mid west, text

Families: Numeric anchors are angles in degrees, as in ordinary TikZ.

8.15 ring (node)

Key	Default
`minimum size`	15mm

Anchors: center, north, south, east, west, north east, north west, south east, south west, base, base east, base west, mid, mid east, mid west, text

Families: Numeric anchors are angles in degrees, as in ordinary TikZ.

8.16 spring (path)

Key	Default
`pre length`	5pt
`post length`	5pt
`amplitude`	4.5pt
`segment length`	4.5pt
`aspect`	0.5

Anchors: No private anchors; use path endpoints and nodes along the path.

Use draw[spring] (A)–(B). No private anchors. Lead lengths may be zero; amplitude and segment length must be positive.

8.17 rope (path)

Key	Default
`line width`	0.5pt
`over pulley`	required node name
`string route`	surface-right
`string start solution`	2
`string end solution`	1
`string wrap`	clockwise

Anchors: No private anchors; use path endpoints and nodes along the path.

Use draw[rope] (A) to[over pulley=P] (B). Endpoints must lie outside a circular pulley. Labels on to sit on the final straight segment. shortest changes wrap only, not the tangent pair.

8.18 force (path)

Key	Default
`line width`	0.7pt

Anchors: No private anchors; use path endpoints and nodes along the path.

8.19 velocity (path)

Key	Default
`line width`	0.6pt

Anchors: No private anchors; use path endpoints and nodes along the path.

8.20 acceleration (path)

Key	Default
`line width`	0.6pt

Anchors: No private anchors; use path endpoints and nodes along the path.

8.21 torque (path)

Key	Default
`line width`	0.7pt

Anchors: No private anchors; use path endpoints and nodes along the path.

8.22 rod (path)

Key	Default
`line width`	2pt

Anchors: No private anchors; use path endpoints and nodes along the path.

8.23 pin-support (pic)

Key	Default
`support size`	6mm

Anchors: pivot, base, left, right

Use pic (S) pin-support; anchors are coordinates (S-pivot), (S-base), (S-left), (S-right).

8.24 roller-support (pic)

Key	Default
`support size`	6mm

Anchors: pivot, base, left, right

Use pic (S) roller-support; anchors are coordinates (S-pivot), (S-base), (S-left), (S-right).

8.25 pendulum (pic)

Key	Default
`pendulum length`	2cm
`pendulum angle`	30 degrees

Anchors: pivot, bob (node)

Use pic (P) pendulum. Angle is measured from downward vertical; positive swings right. Length is pivot to bob centre. Use (P-pivot) and (P-bob.center).

8.26 concave-mirror (node)

Key	Default
`mirror radius`	5cm
`mirror thickness`	0.25cm
`mirror aperture angle`	30 degrees

Anchors: center, north, south, east, west, north east, north west, south east, south west, vertex, arc-mid, surface-mid, front-mid, back-mid, front-top, front-bottom, surface-top, surface-bottom, back-top, back-bottom, top, bottom, text

Families: surface-0..100, front-0..100, back-0..100; legacy .0..100 shorthand also available

8.27 convex-mirror (node)

Key	Default
`mirror radius`	5cm
`mirror thickness`	0.25cm
`mirror aperture angle`	30 degrees

Anchors: center, north, south, east, west, north east, north west, south east, south west, vertex, arc-mid, surface-mid, front-mid, back-mid, front-top, front-bottom, surface-top, surface-bottom, back-top, back-bottom, top, bottom, text

Families: surface-0..100, front-0..100, back-0..100; legacy .0..100 shorthand also available

8.28 convex-lens (node)

Key	Default
`convex lens radius`	5cm
`convex lens thickness`	0.2cm
`convex lens aperture angle`	25 degrees

Anchors: center, north, south, east, west, north east, north west, south east, south west, front-mid, back-mid, front-top, front-bottom, back-top, back-bottom, top, bottom, text

Families: front-0..100, back-0..100; legacy .0..100 shorthand also available

8.29 concave-lens (node)

Key	Default
`concave lens radius`	5cm
`concave lens thickness`	0.2cm
`concave lens aperture angle`	25 degrees

Anchors: center, north, south, east, west, north east, north west, south east, south west, front-mid, back-mid, front-top, front-bottom, back-top, back-bottom, top, bottom, text

Families: front-0..100, back-0..100; legacy .0..100 shorthand also available

8.30 slab (node)

Key	Default
`minimum width`	1.2cm
`minimum height`	3cm

Size aliases: slab width = minimum width; slab height = minimum height.

Anchors: center, north, south, east, west, north east, north west, south east, south west, front, back, front-top, front-bottom, back-top, back-bottom, top, bottom, text

Families: front-0..100, back-0..100, top-0..100, bottom-0..100; legacy .0..100 shorthand also available

8.31 prism (node)

Key	Default
`minimum width`	3cm
`minimum height`	2.6cm
`prism apex angle`	derived

Size aliases: prism width = minimum width; prism height = minimum height.

Anchors: center, centroid, north, south, east, west, north east, north west, south east, south west, apex, base-left, base-right, base-mid, left-mid, right-mid, entry-mid, exit-mid, text

Families: base-0..100, right-0..100, left-0..100; legacy .0..100 shorthand also available

9 License