Belted Kinematics

A 3D printer needs three axes of motion. Driving all three axes can be done in several different ways.

Bedslinger Cartesian

The simplest motion system, bedslinging moves the toolhead in X and Z, and the bed in Y.

This makes the two fast axes move completely independently. The X linear guide moves only slowly in Z, and the Y linear guides are completely stationary. This reduces friction when accelerating diagonally.

All belt runs are as short as possible for each axis with a minimum of idlers for low friction.

All motors are either stationary or slow-moving.

The motion itself is simple but the print itself moves and puts higher loads on the Y linear guide system. Additionally, the bed should be built as lightly as possible without losing rigidity.

One side benefit of bedslinging is that an air curtain mounted along the X rail can cool the entire print area without adding XY moving mass.

Box Cartesian (Serial X-Y)

Box Cartesian kinematics moves the X rail, together with the X motor(s), in the Y direction.

This allows the print to move slowly or not at all (depending on Z kinematics).

All belt runs are as short as possible for each axis, with a minimum of idlers for low friction, but there must be two Y axis belts.

The X motors move quickly in Y, making wiring an important consideration as well as their effect on the center of mass.

The X rail gets loaded during Y acceleration, increasing friction.

Cross Gantry

Cross gantry is a parallel cartesian kinematic that drives the toolhead using crossed linear guides that span the build area. The ends of the crossed guides are driven by simple short X and Y belt paths, and each end is supported by further linear guides.

This allows the print to move slowly or not at all (depending on Z kinematics).

All belt runs are as short as possible for each axis, with a minimum of idlers for low friction, but both X and Y need two belts each.

All motors are stationary or slow-moving.

This sounds ideal but there are several tradeoffs.

Cross gantry requires more hardware (at least 6 linear guides).

If only two guides are used to cross the build volume, at least one is misaligned with the center of mass of the toolhead, causing moment loads on the guides at the toolhead.

The two guides passing through the toolhead make toolhead design difficult regarding part cooling ducts and fan placement.

Finally, the multitude of linear guides make this prone to overconstraint, which leads to high friction with poor construction or in the case of thermal expansion mismatch.

CoreXY

CoreXY has two stationary motors with two P shaped belt paths combined to move both the toolhead in X and the X rail in Y. One motor changes X+Y and the other changes X-Y.

This allows the print to move slowly or not at all (depending on Z kinematics).

Belt runs are long in CoreXY, and differing tension between the two belts tries to rack the X axis out of square.

CoreXY has a lot of idlers on the belt path, causing higher friction particularly with higher belt tensions.

All motors are stationary or slow-moving.

HBot

HBot has two (or four) stationary motors with one H-shaped belt path that moves both the toolhead in X and the X rail in Y. One motor changes X+Y and the other changes X-Y.

This allows the print to move slowly or not at all (depending on Z kinematics).

The belt run is long in HBot, and any X acceleration causes belt tension that tries to rack the X axis out of square.

HBot has a lot of idlers on the belt path, causing higher friction particularly with higher belt tensions.

All motors are stationary or slow-moving.

MarkForged

MarkForged kinematic has dedicated short Y drive belts moving the X axis, and a T-shaped X belt path moving along one side and the X axis. Moving the Y axis motor(s) alone will move the toolhead diagonally, but moving the X motor will move the toolhead only in X.

This allows the print to move slowly or not at all (depending on Z kinematics).

The Y belts, which carry a heavier load, are short belt paths. The X belt is longer but the toolhead is comparatively light.

The X axis has a lot of idlers on the belt path, causing higher friction particularly with higher belt tensions.

All motors are stationary or slow-moving.

Delta

Delta printers have three columns, each with a straight belt run along a linear guide. Each carriage carries a spherical-jointed parallelogram linkage to a triangular plate that carries the toolhead, providing parallel 3-degree-of-freedom control of the toolhead.

The print is stationary.

All belts have short belt paths and minimal idlers.

All motors are stationary.

The motion system rigidity is limited by the preload of the spherical joints and the arm stiffness.

Delta kinematics require calibration that compensates for manufacturing variance (tower spacing and arm length) to achieve dimensional accuracy.

Revision #5
Created 7 October 2025 16:31:31 by CarVac
Updated 7 October 2025 17:36:44 by CarVac