Rack & Pinion

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(by EDUMOTIVA team)

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In this presentation

1. Rack & Pinion every day Applications
2. Basic Interlock concept in 3D printing
3. What is a rack & pinion structure
4. How to design a rack & pinion 3D design

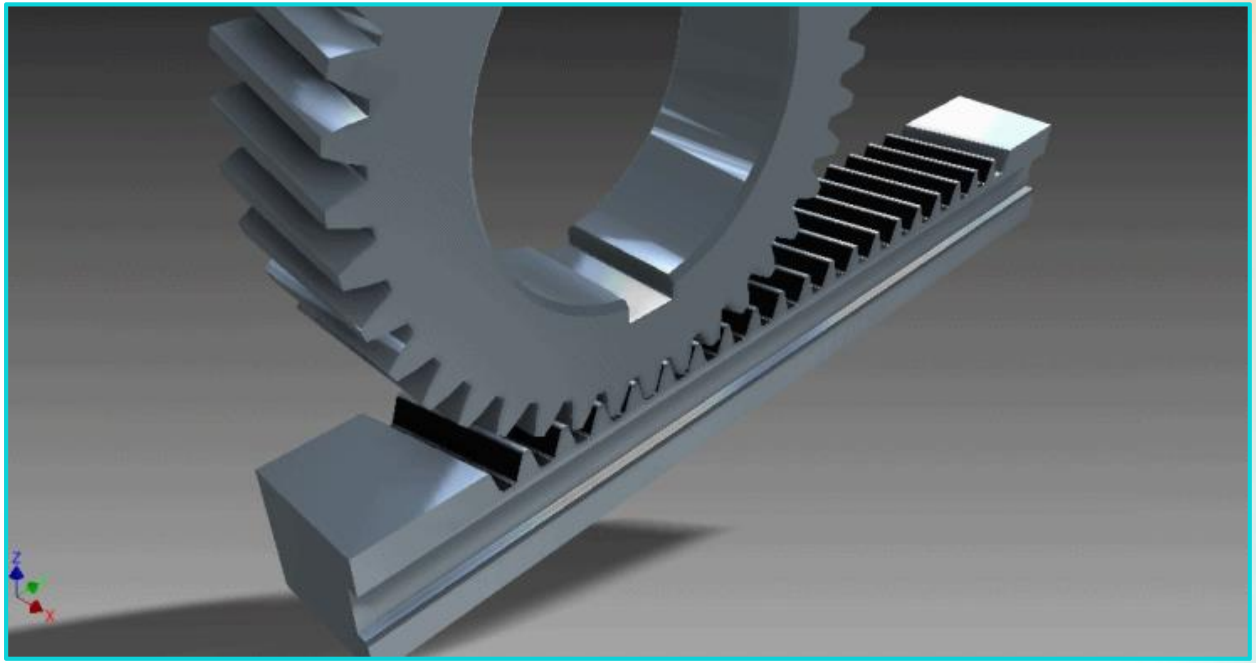
Rack & Pinion Every Day Applications

Basic Function

A rack and pinion is a type of linear actuator that comprises a pair of gears which convert rotational motion into linear motion.

A **circular gear** called "the pinion" engages teeth on a **linear** "gear" bar called "the rack“.

Rotational motion applied to the pinion causes the rack to move relative to the pinion, thereby translating the rotational motion of the pinion into linear motion.

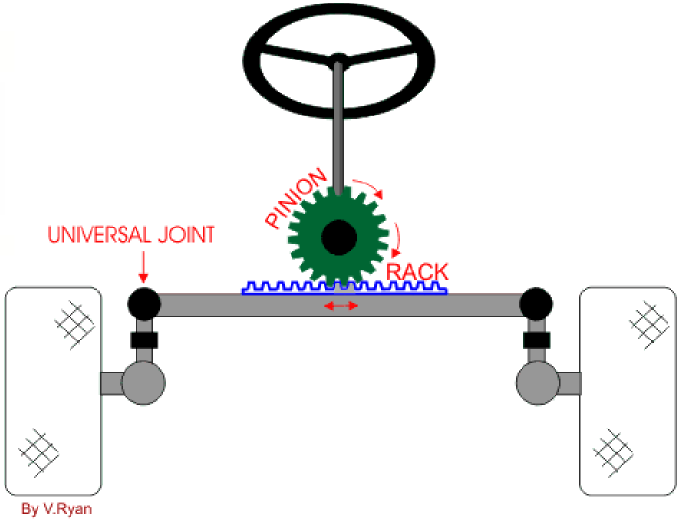


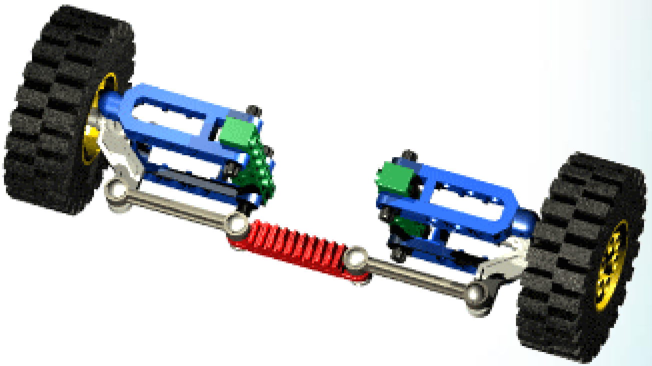
Rack-and-pinion steering

One of the most common application is the Rack-and-pinion steering.

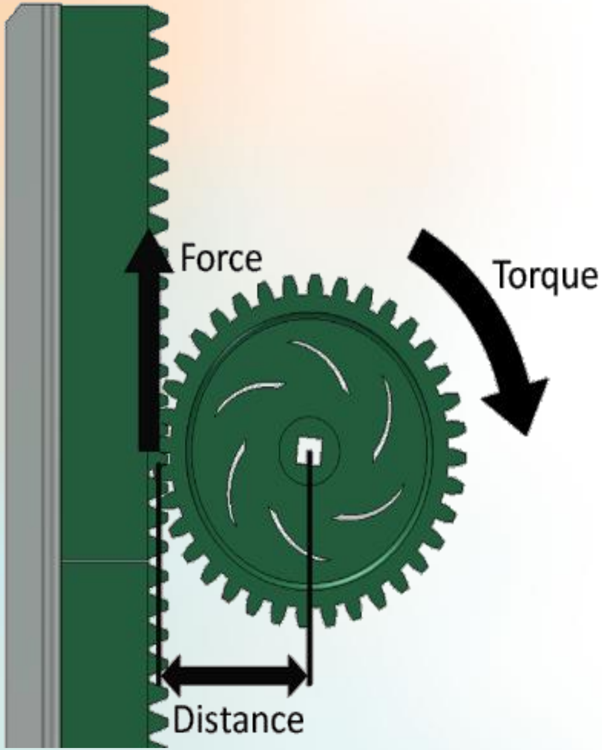
It is the most common type of steering on cars, small trucks and SUVs.

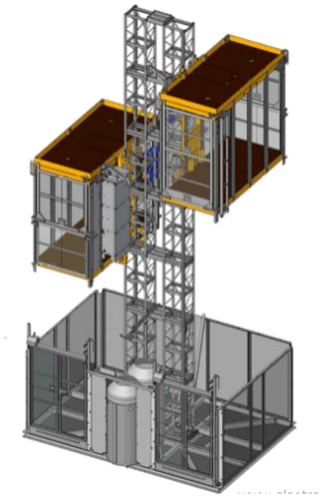
When you turn the steering wheel, the gear spins, moving the rack. The tie rod at each end of the rack connects to the steering arm on the spindle

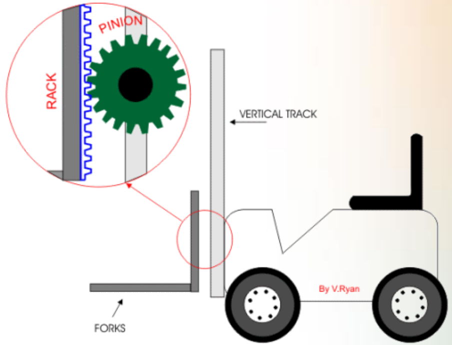


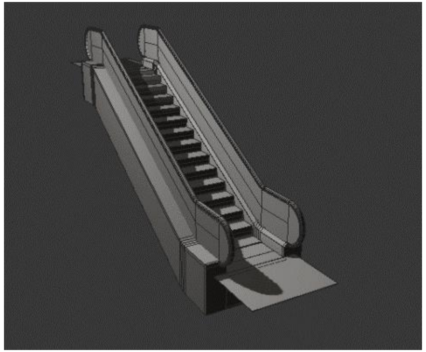


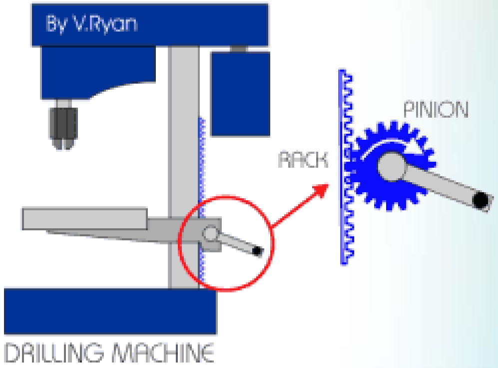
Lifting Mechanisms



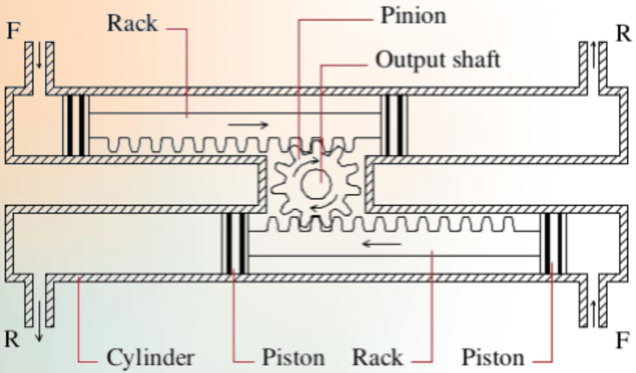


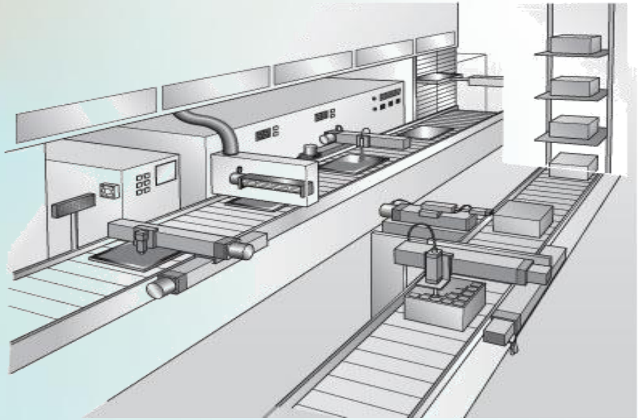


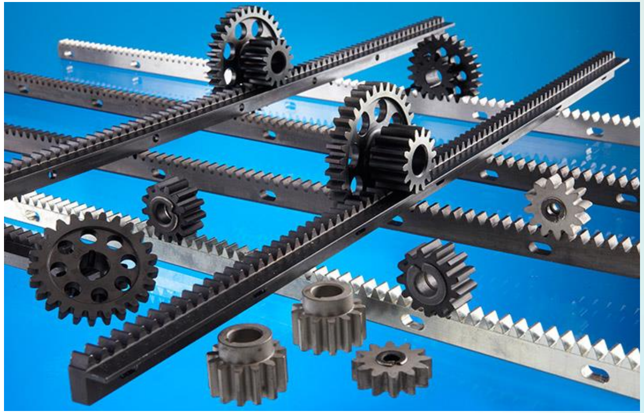




Rack – and – Pinion in Industry

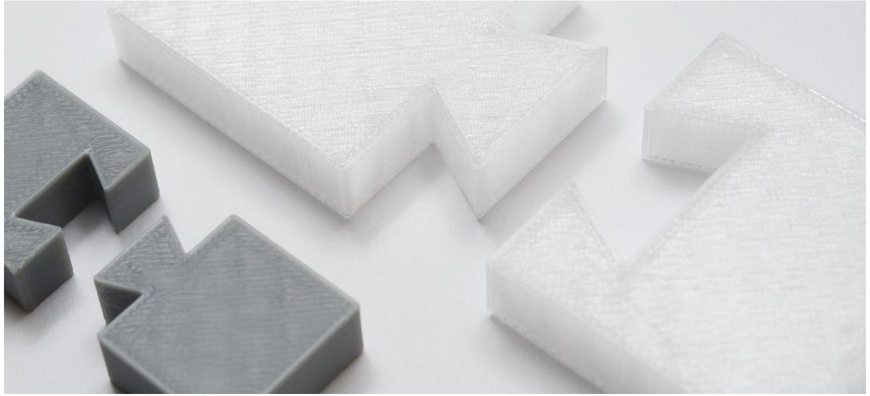


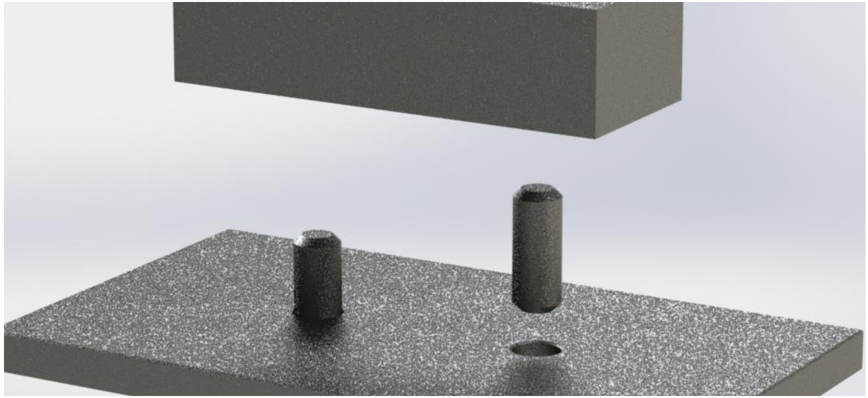


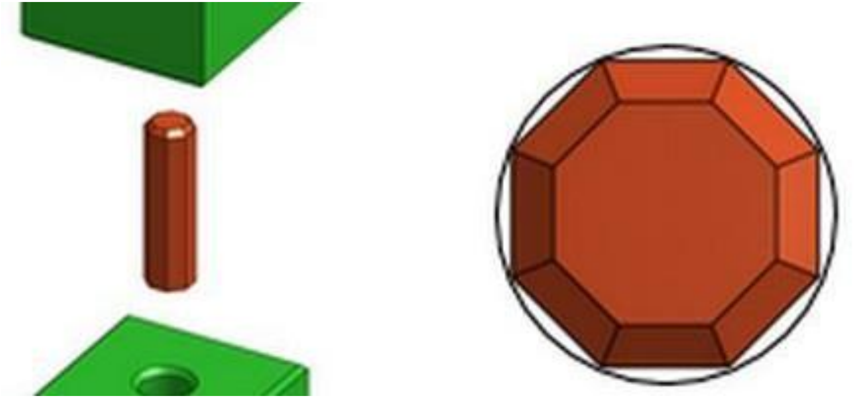


Interlock designs

Press fit parts



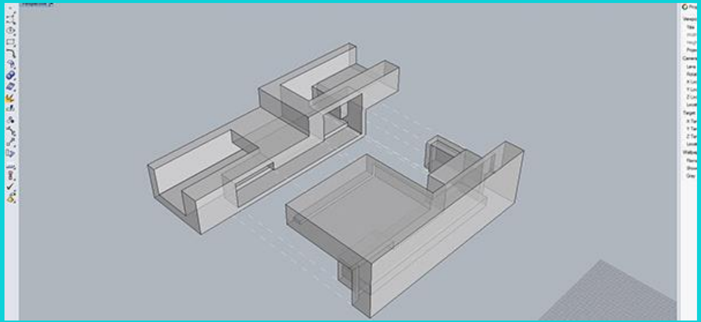


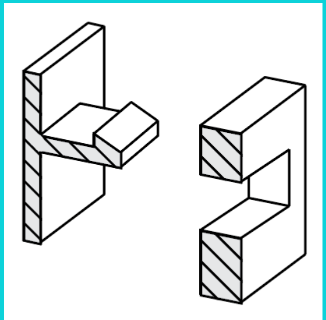


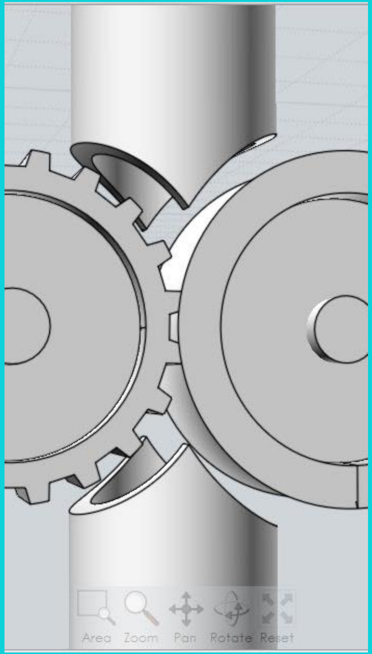
Interference fit

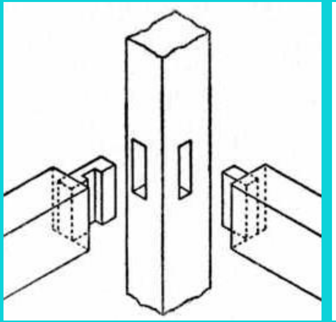
Also known as a press fit or friction fit is a fastening between two parts which is achieved by friction after the parts are pushed together, rather than by any other means of fastening.

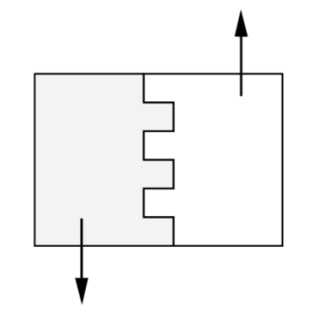
Consider designing different shapes like an octagon pin for a round hole

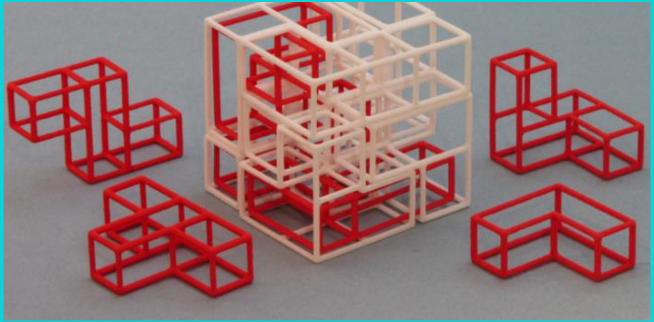










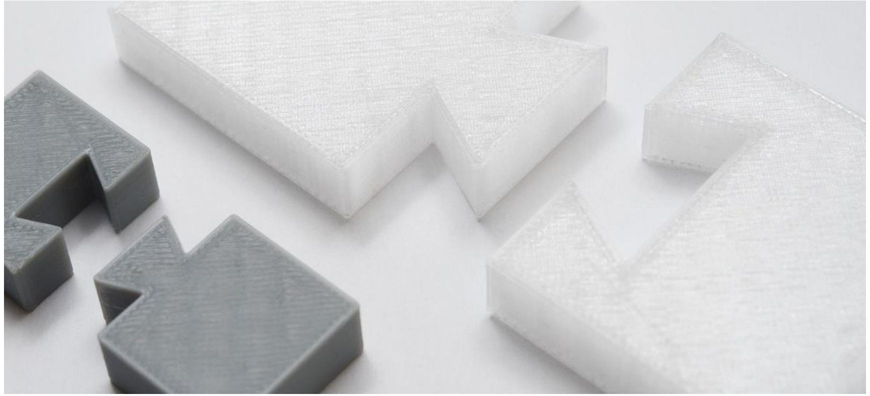


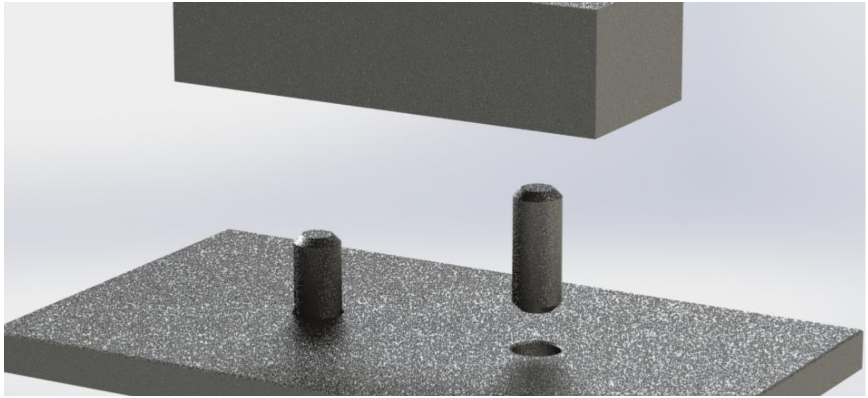
3D printing Printers’ size limitations

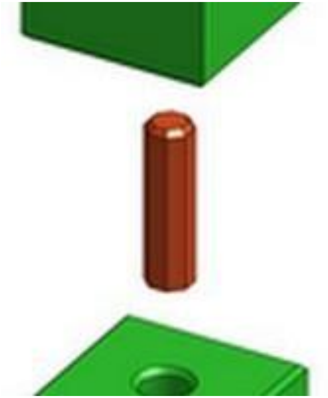
We cannot fabricate a single object that is larger than the working volume of a 3D printer

<u>Solution</u>:
we partition the given object into 3D parts of manageable sizes for printing, and then assemble the object from the printed 3D parts. Rather than using connectors, glue, or skew, we propose to connect the printed 3D parts by 3D interlocking such that the assembled object can be not only repeatedly disassembled and reassembled, but also strongly connected by the parts' own geometry.

Press fit parts





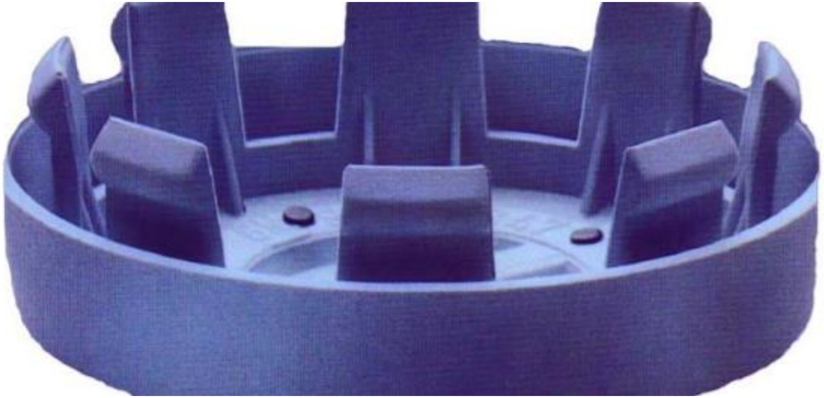


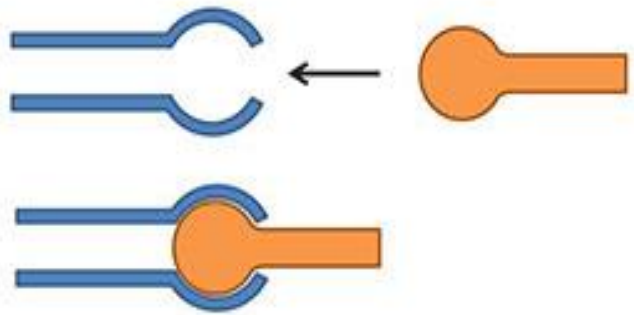
Interference fit

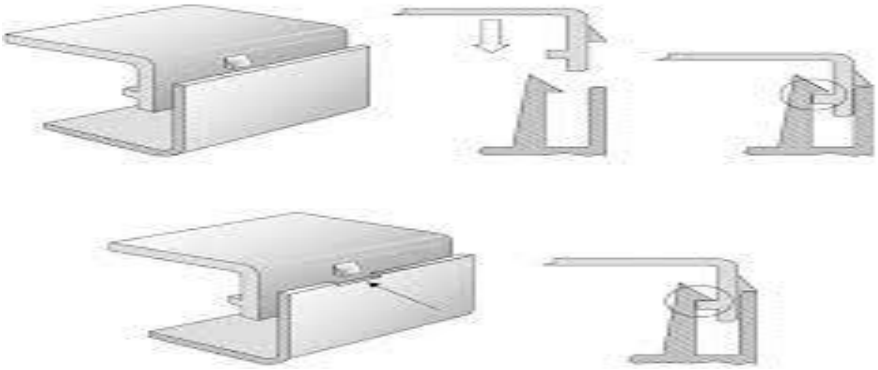
Also known as a press fit or friction fit is a fastening between two parts which is achieved by friction after the parts are pushed together, rather than by any other means of fastening.

Consider designing different shapes like an octagon pin for a round hole

Snap fit parts



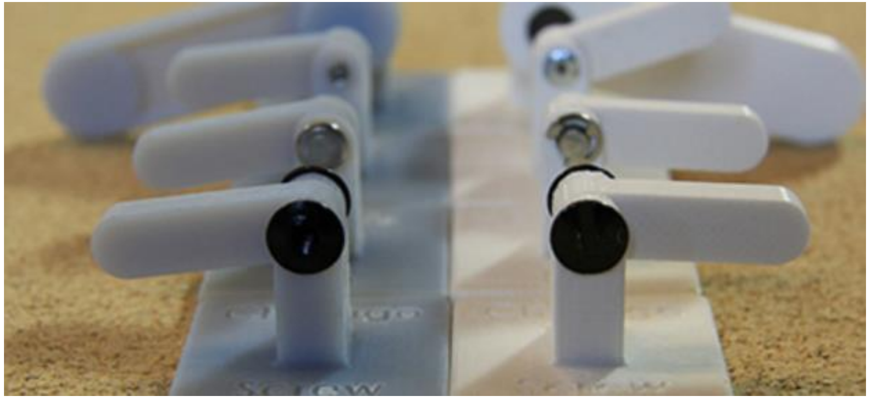


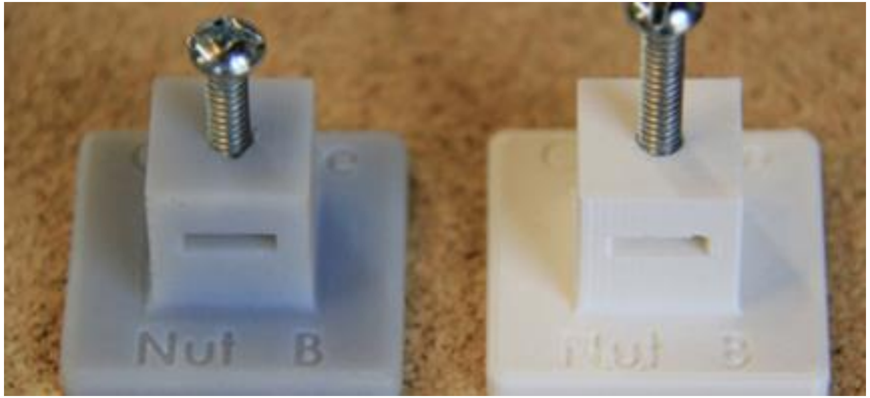


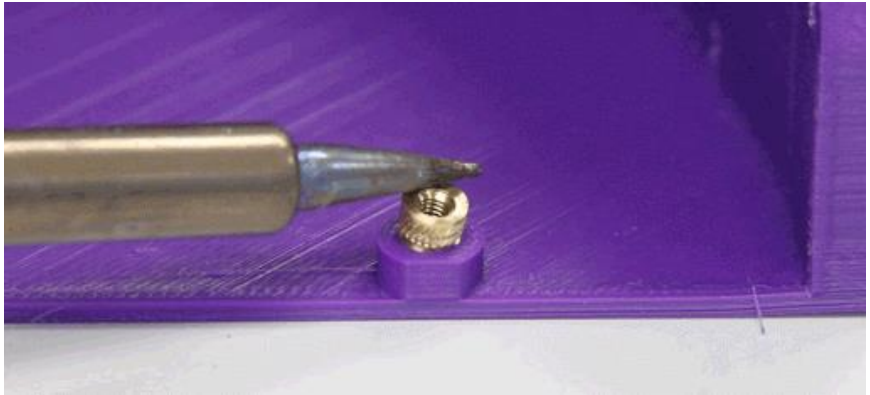
A design feature similar to a hook is inserted in another part, where there’s a special hole or space made for it. This is made possible thanks to the fact that this hook is quite **flexible** and moves while being inserted, and then gets back to its normal position when in the right spot, which blocks it.

Problems: The grip isn't very strong, the cantilevers deform over time.

Using Fasteners







3D printed parts can be used with a wide variety of traditional fasteners when additional strength or versatility is required. This is a great technique for a quick and “dirty” prototype. Using self tapping screws is quick, cheap and requires minimal design efforts.

Designing snapping and fitted joints

Basic design guidelines

Fit Tolerances

Use a 0.2mm offset for tight fit (press fit parts, connecters) and use a 0.4mm offset for lose fit (hinges, box lids).

Building up snaps in the Z-layer has the least amount of strength

Try to avoid printing your snaps in the Z direction (built up from the print bed vertically), they are much weaker than parts printed in the x/y direction.

Test early and often

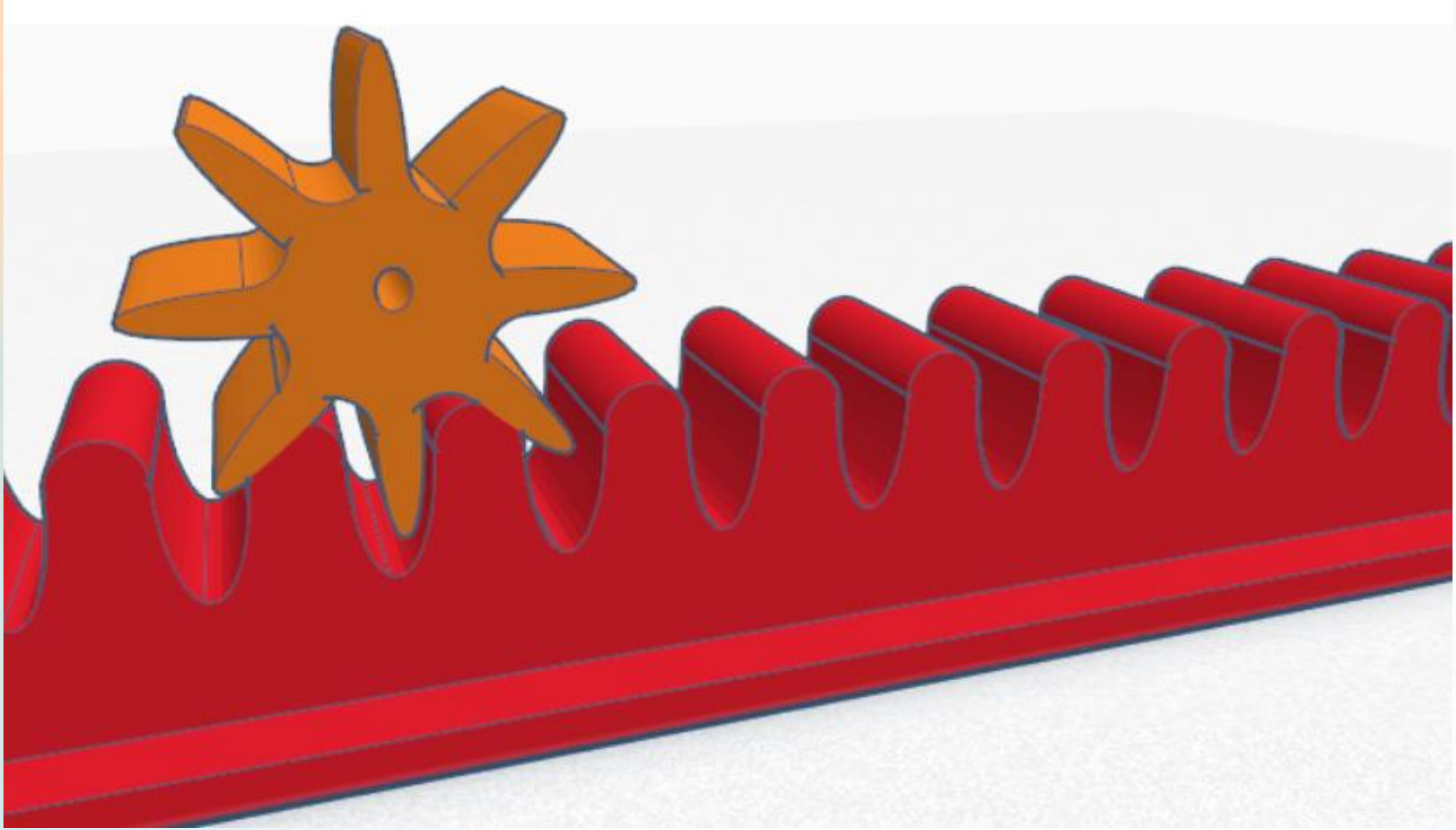
It’s good to test your connections to find the right tolerance. To avoid wasting time and material, print only the parts you are trying to test instead of the entire model.

Be careful with scaling

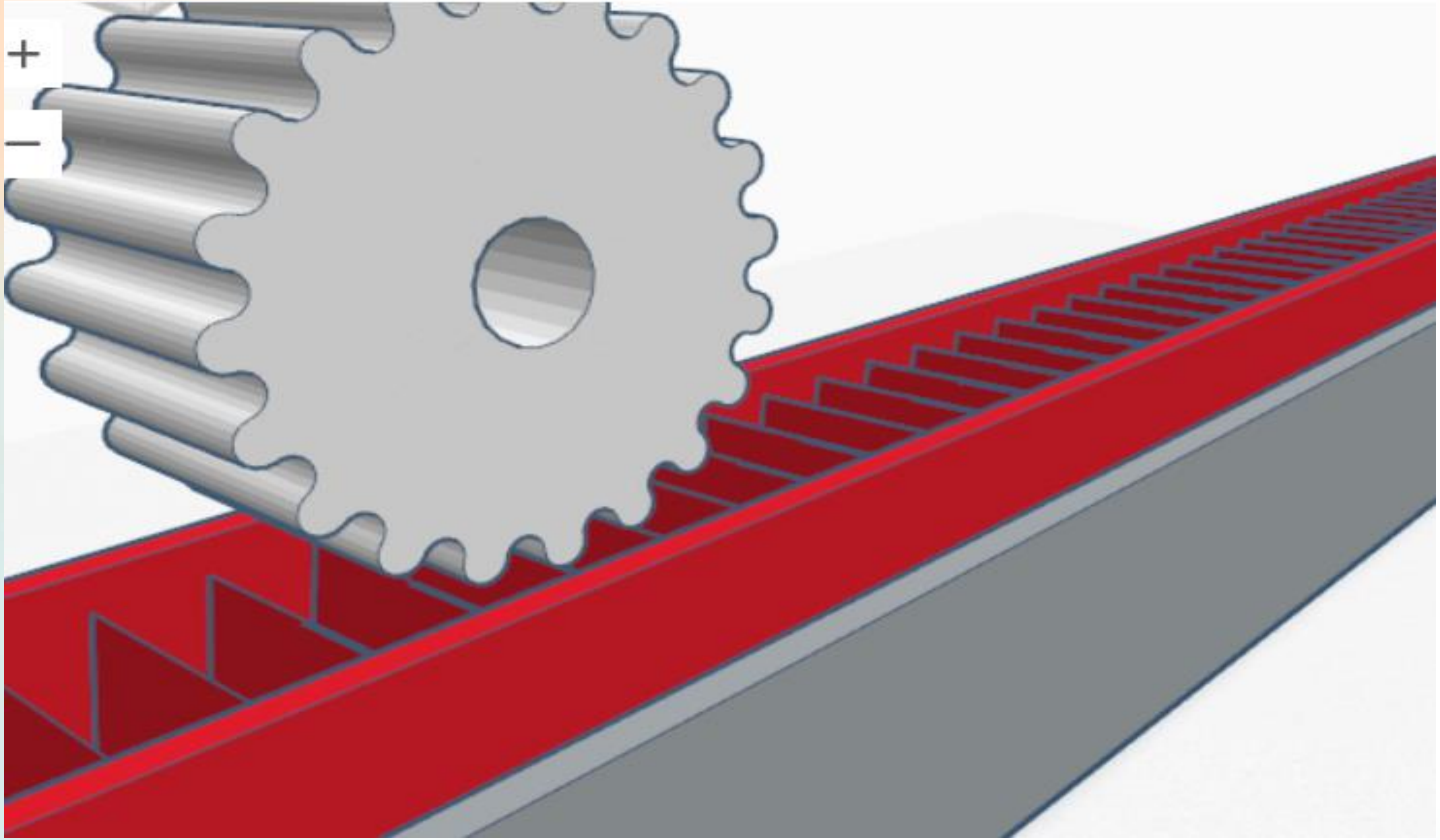
It is always best to model your parts at the right scale. But when you do need to scale a model with connecting parts, it will require you to readjust your tolerances.

Rack and Pinion

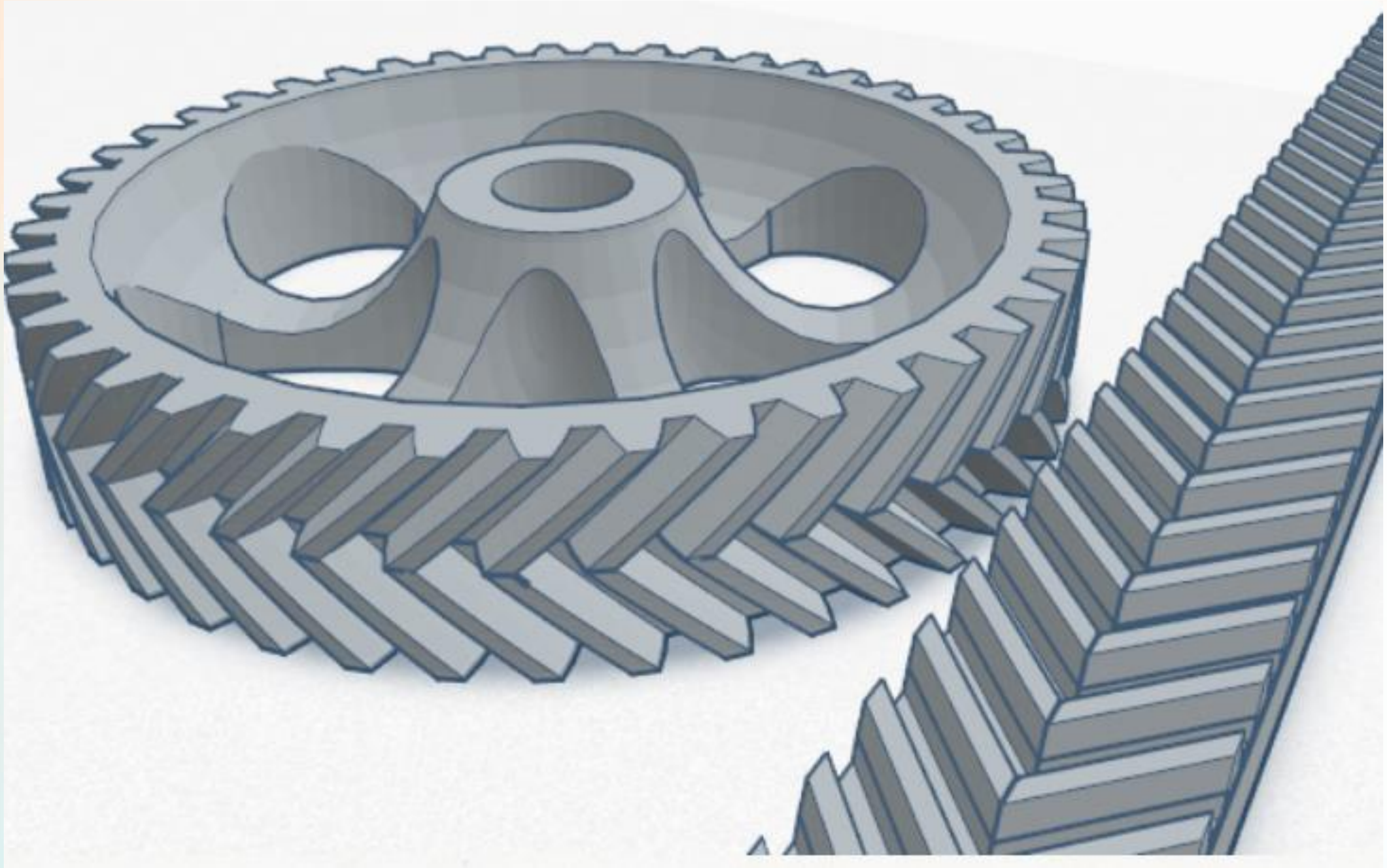
3D design Rack & Pinion -1-



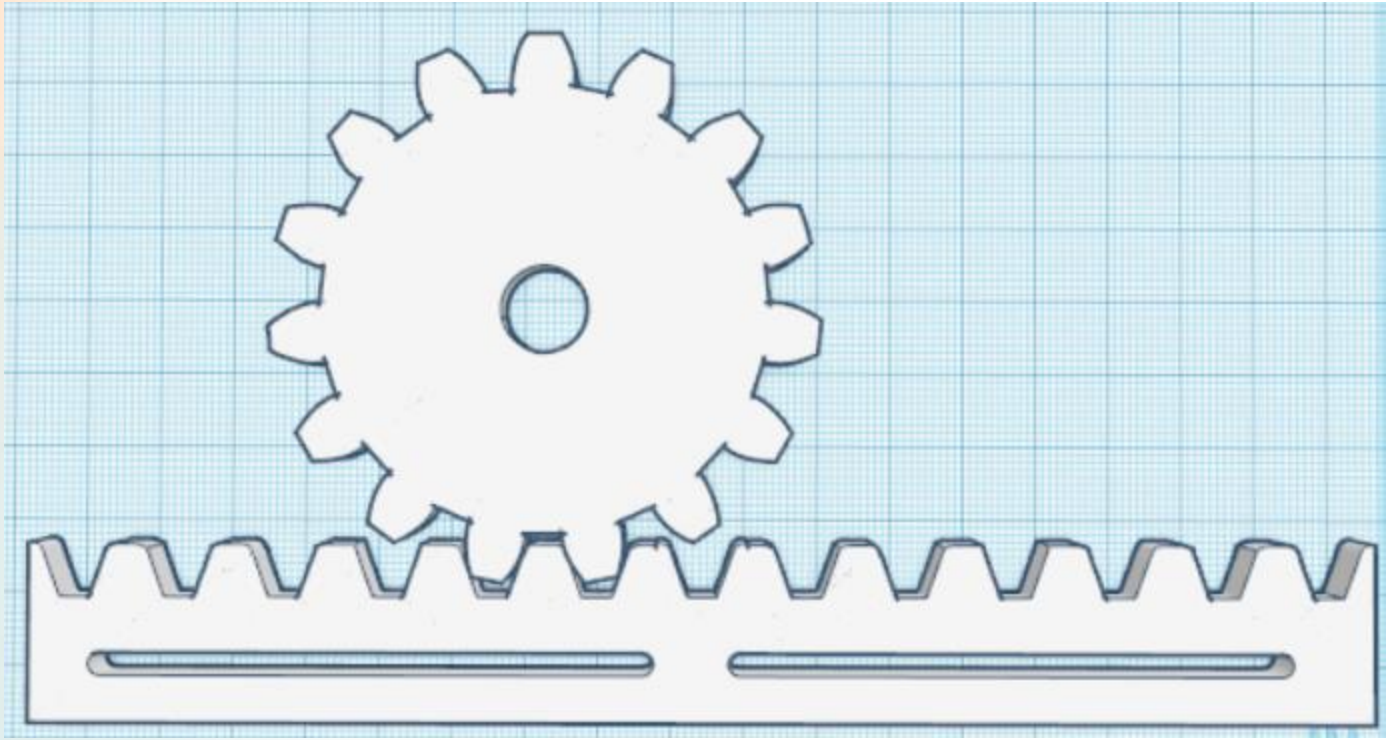
3D design Rack & Pinion -2-



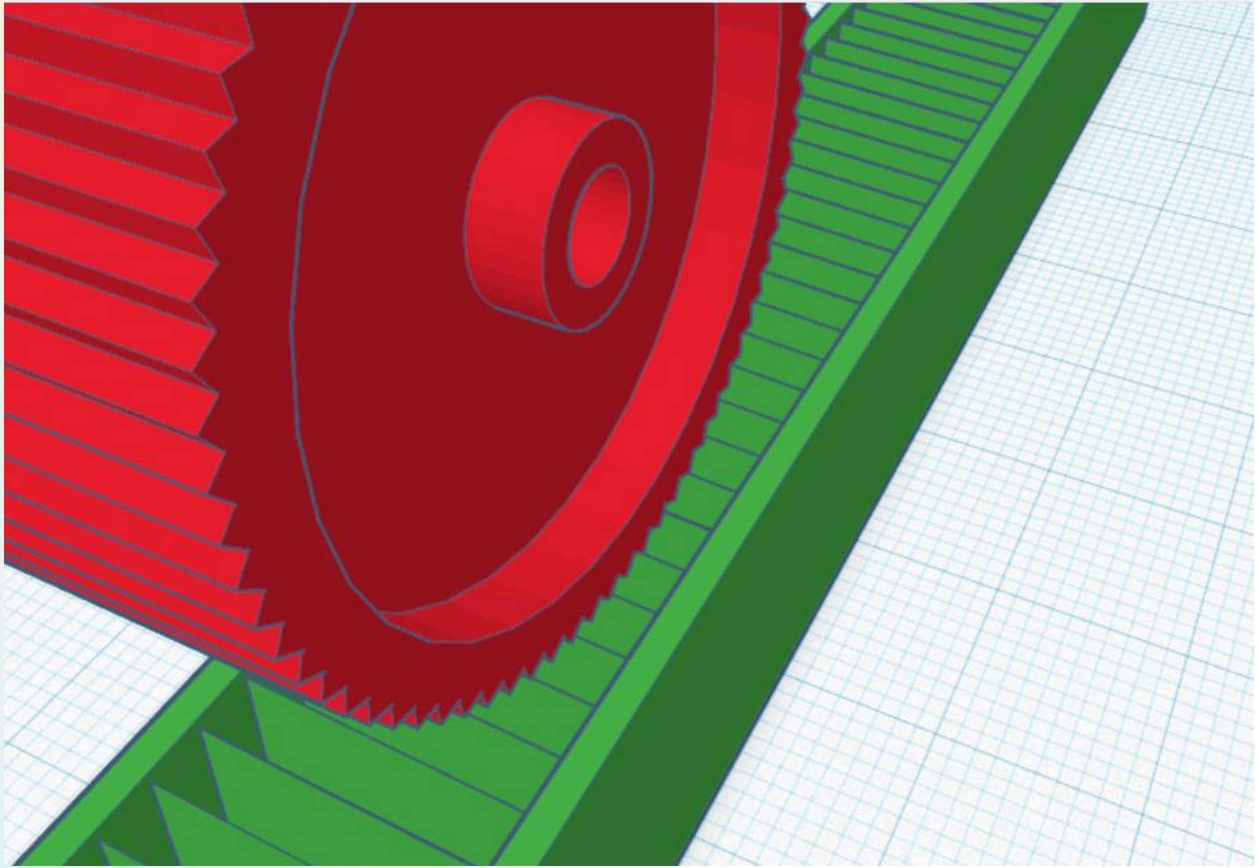
3D design Rack & Pinion -3-



3D design Rack & Pinion -4-

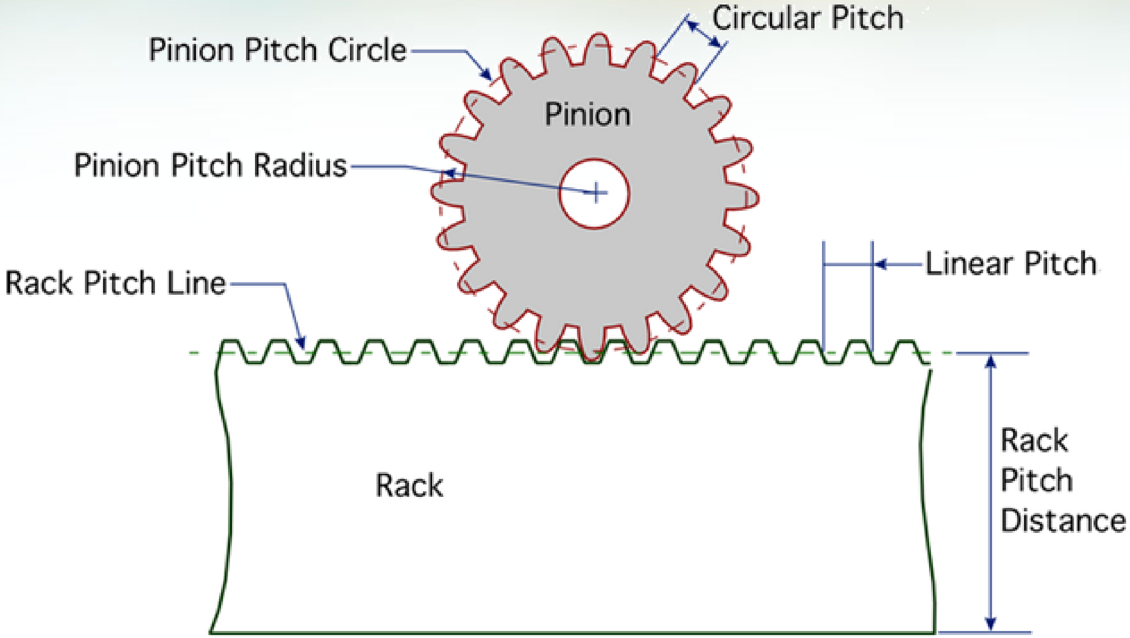


3D design Rack & Pinion -5-



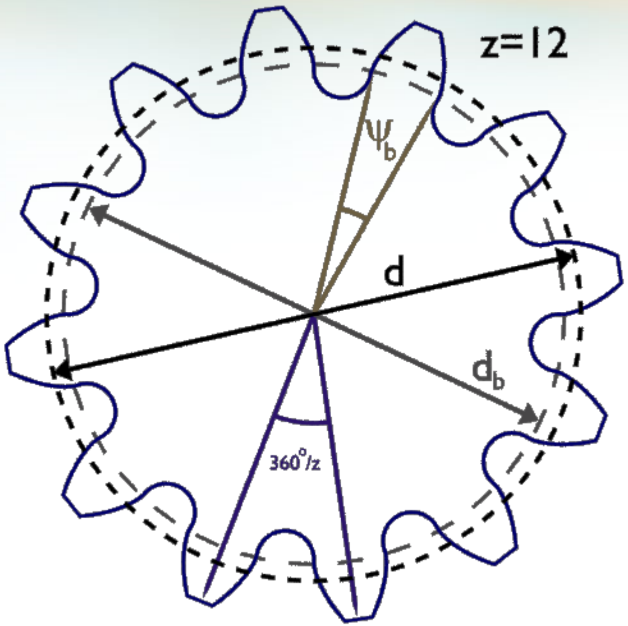
Design a Rack & Pinion

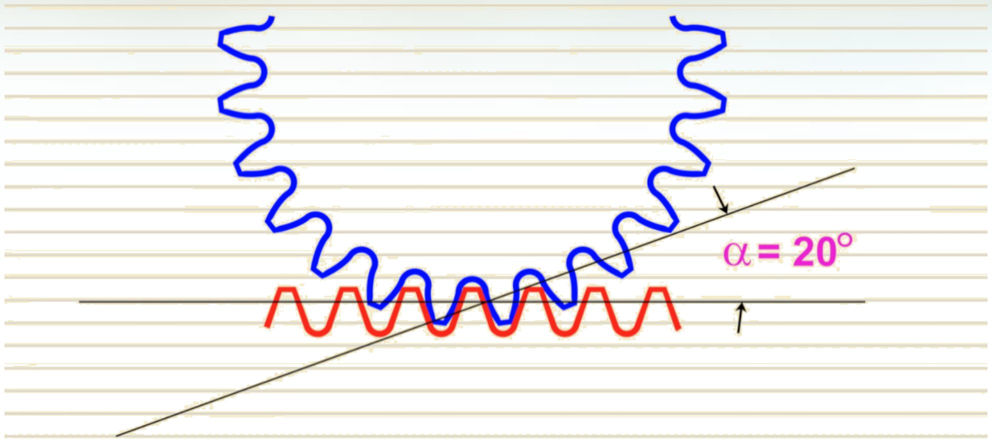
Basic parts of the design I



Number of teeth on the pinion (Z)	Pinion Pitch Circle (module)	Physical diameter of the gear (d)	Linear Pitch (p)
Keep this number under 18.	**m** = defines how big or small the gear is	$d = m \cdot z$	Linear distance between the teeth of the rack. $p = \pi \cdot m$

Basic parts of the design II





Pressure Angle (a)

Normally ***a* = *20º***

Number of teeth on the pinion (Z)

Keep this number under 18.

Pinion Pitch Circle (module)

m = defines how big or small the gear is

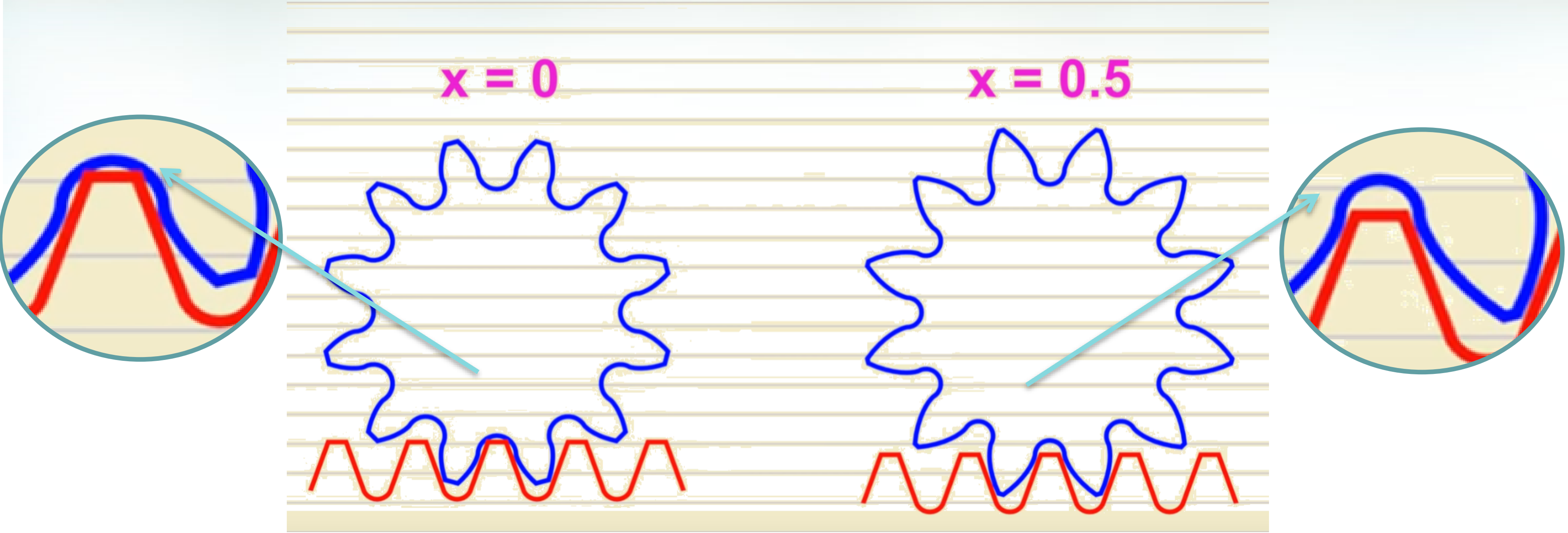
Physical diameter of the gear (d)

$d = m \cdot z$

Linear Pitch (p)

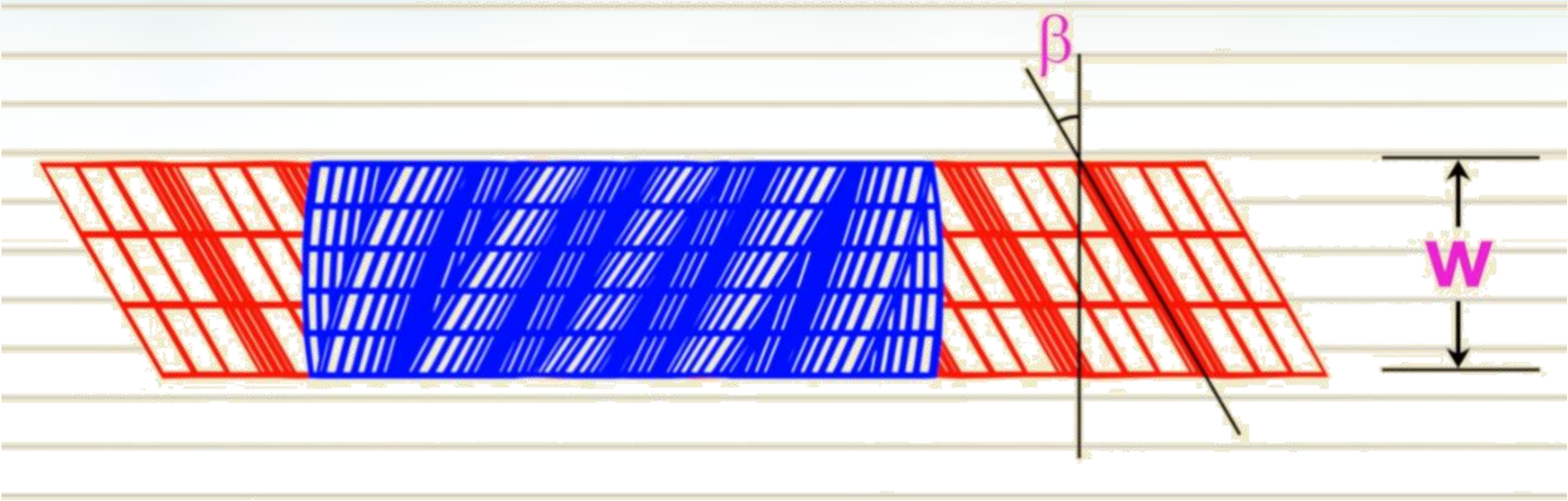
Linear distance between the teeth of the rack. $p = \pi \cdot m$

Basic parts of the design III



Profile Shift (x)
Defines the mounting distance between the pinion and the rack. Eliminates the overlap.

Basic parts of the design IV



Helix Angle (β) and Width (W)
Parameters only needed if the pinion and rack are helical.

For easy calculations: http://www.otvinta.com/rack.html

Accuracy

Three additional components need to be considered for accuracy.

01 **Tooth Quality**

Tooth Quality is the accuracy of the manufactured tooth flanks. Tooth accuracy affects backlash, the positioning accuracy, as well as the noise level of the rack and pinion.

02 **Backlash**

Backlash is the amount of clearance between the rack and pinion tooth flanks

03 **Pitch Deviation**

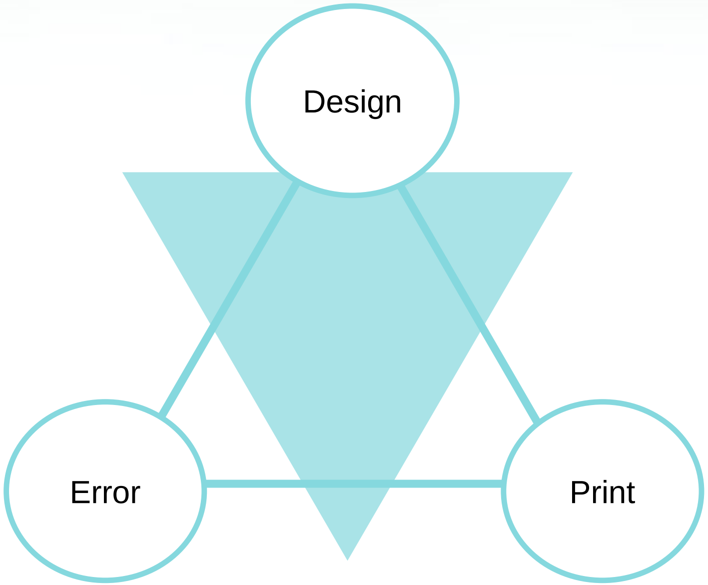
Pitch Deviation is the difference between the theoretical rack length and its actual length.

04 **Not Considered**

Pay Attention: This measurements are applicable for a simple design since no forces and load where considered during the calculations.

This is a trial – an – error Project

Be patient



Thank you

For your attention

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