



Educational Gear Examples 1

0 osamutake

[VIEW IN BROWSER](#)

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Summary

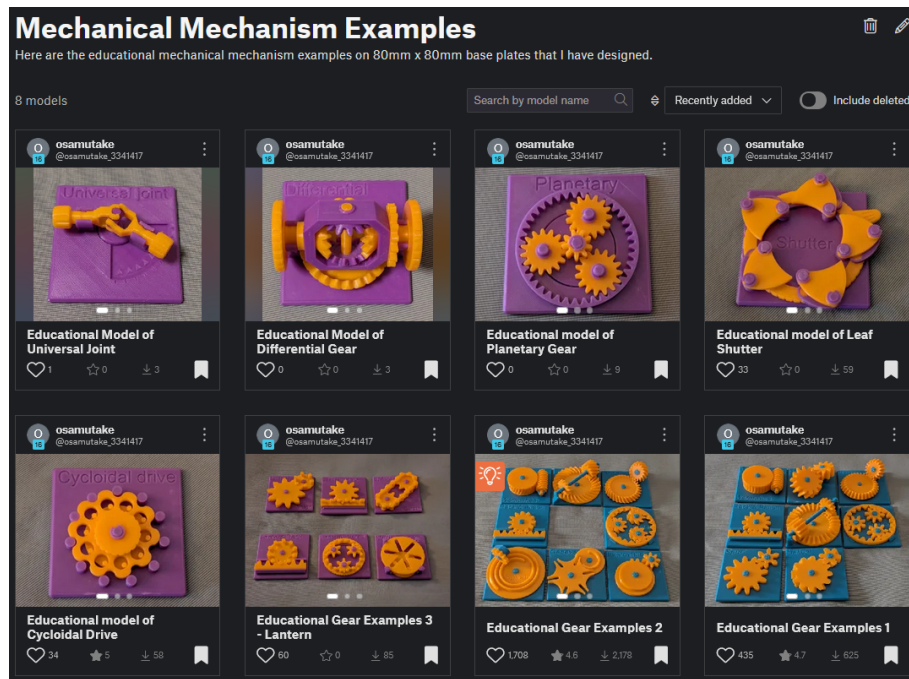
Spur, Helical, Rack & Pinion, Internal, Screw, Bevel, Worm and Crown gears.

[Learning](#) > [Engineering](#)

Tags: [gear](#) [education](#) [rackandpinion](#) [wormgear](#) [spurgear](#)
[bevelgear](#) [worm](#) [helicalgear](#) [internalgear](#) [screwgear](#)
[crown gear](#)

My Educational Mechanical Examples Series

This model is one of my educational mechanical mechanism examples series on 80mm x 80mm base plates. You can find all models of the series in this collection => [\[Mechanical Mechanism Examples\]](#)

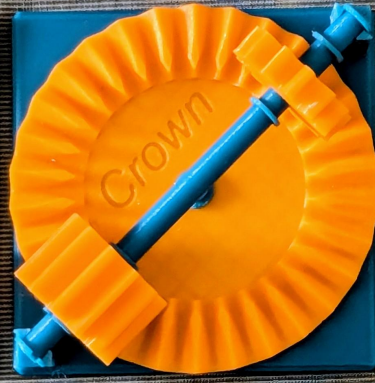


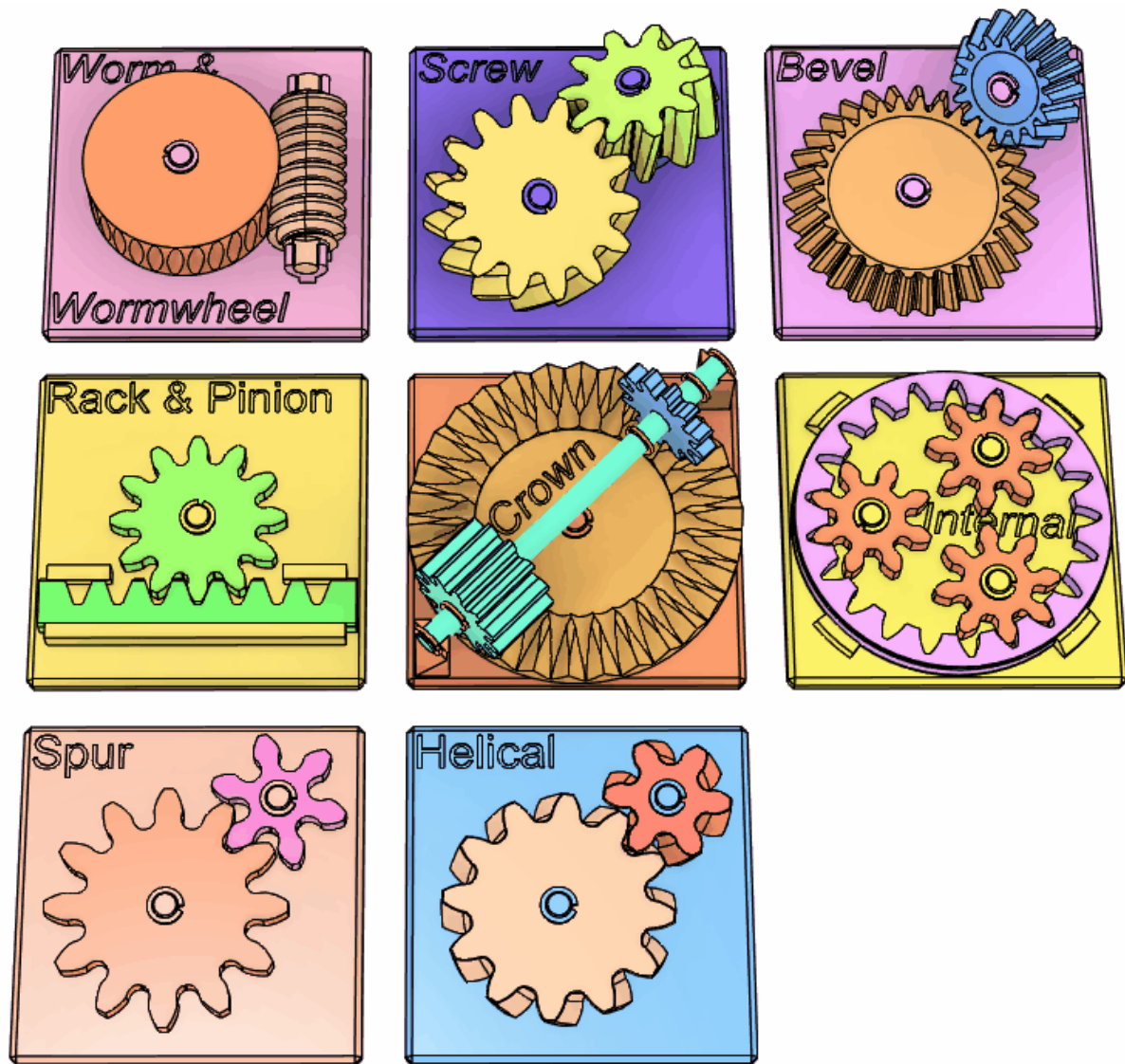
This set

This present set includes:

- Spur gear
- Helical gear
- Rack & Pinion
- Internal gear
- Screw gear
- Bevel gear
- Worm and Worm wheel
- Crown gear

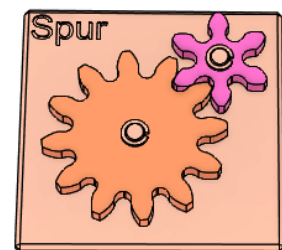






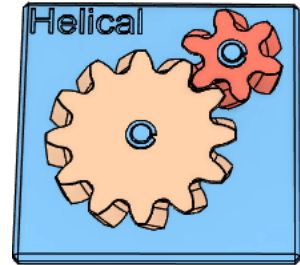
Introduction VideoBrief Descriptions

Spur gear is the simplest and most common type of gear, which is used to transmit rotation and power between two parallel shafts. It has a cylindrical shape, and its tooth trace is straight and parallel to the axis. When one gear turns, it makes the other gear turn in the opposite direction. The number of teeth determines the speed ratio between the two gears. If one gear has more teeth, it will turn more slowly but with greater torque. This model shows the most common type of spur gear, which is called as “involute gear.” Its tooth profile is made up of an involute curve on the outer side and an epitrochoid curve near the root. These shapes are naturally produced when the gear is cut by a rack-shaped cutting tools. So, involute spur gears are easy to manufacture and inexpensive. Only the involute portion of each tooth is used to transmit motion between gears. The epitrochoid portion does not contact with the other gear. When the number of teeth is

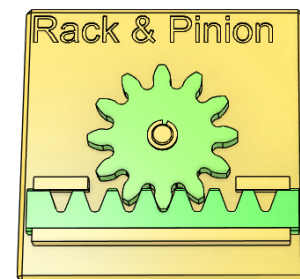


small, the tooth shape is cut deeply near the root as seen in the smaller gear in this model. This is called an undercut, and it helps prevent the teeth from colliding with the other gear but it also makes the teeth thinner and weaker. Spur gears are simple, efficient, and widely used in machines, such as clocks, vehicles, and industrial equipment.

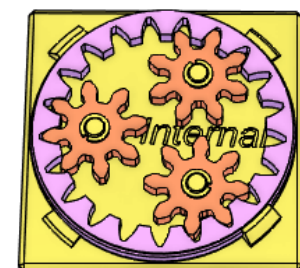
Helical gear can be thought of as a "twisted spur gear". Two meshing helical gears have the same helical angle, but in opposite directions (one right-hand, the other left-hand). More precisely, a standard helical gear is defined so that its "tooth-normal" tooth width and angle are the same as those of a standard spur gears. As a result, its "axis-normal" view of a helical gear shows thicker teeth than a spur gear with the same size. Because the teeth engage gradually along the helix, contact and separation occur progressively along the axis. This provides smoother meshing and quieter operation than spur gears. On the other hand, the angled contact also generates an axial thrust force, which must be absorbed or supported by bearings or other suitable supporting structures. Because of their quiet and smooth operation, helical gears are often used in automobiles and industrial machines.



Rack can be regarded as a spur gear with an infinite radius. Its tooth profile is exact trapezoidal, which consists of linear lines except for the root part that does not contact with the other gear. A rack can mesh with a standard spur gear, which is called the "**pinion**." In fact, standard spur gears are often manufactured by cutting a cylindrical material with a rack-shaped cutting tool, whose tip is slightly elongated to make the root clearance. The rack and pinion mechanism is used to convert rotational motion into linear motion, as seen in steering systems and machine tools.

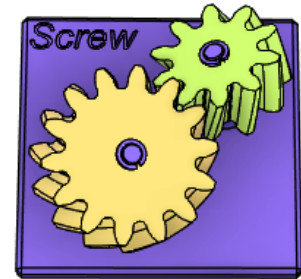


Internal gear looks so different from a standard "external" gear. Its teeth are teething from the outer circumference toward the center. However, if you look at the shape of the hollow part, you can see that an internal gear can be regarded as a disk-shaped piece with a "gear-shaped hole." This is exactly correct — the shape of the hole is identical to that of an external gear shape with same number of teeth. An internal gear meshes with an external gear that is placed inside it. This type of gear pair is often used in **planetary gear systems**, which works as compact speed reducers.

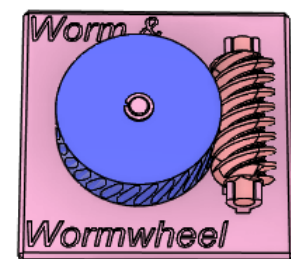


Screw gear consists of two helical gears whose axes are in a skew position. It equips with two thick gears in this model but, in theory, the meshing teeth contact at only a single point. So, screw gears are not suitable for heavy-load applications. The helix angles of the two meshing gears in a screw gear may be different in value but they must have the same hand – both right-hand or both left-hand.

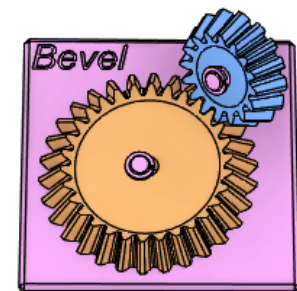
Screw gears are used when the shafts are neither parallel nor intersecting, and when quiet, light transmission is required — for example, in measuring instruments or small machinery.



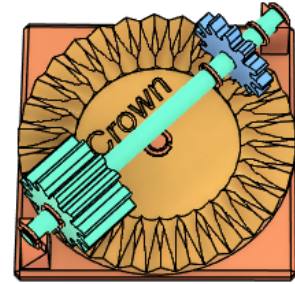
Worm can be regarded as a rack that is helically wrapped around a cylinder. This model shows single-thread worm, which has only one continuous tooth around the cylinder. A **worm wheel** may sometimes look similar to a helical gear. However, as shown in this model, it is actually formed by cutting a disk-shaped material with a worm-shaped cutting tool. As a result, the tooth shape of a worm wheel is different from that of a standard helical gear. Worm and worm wheel pair provides a very large gear ratio. Because of this, the transmission of motion is often one-way — the worm can drive the worm wheel but the worm wheel can not drive the worm. This self-locking property makes worm gears useful in hoisting machines, conveyors, and steering mechanisms, where backward motion must be prevented.



Bevel gear has cone-shaped reference surfaces whose apexes coincide with each other. Their tooth profile looks similar to that of a standard spur gear. However, strictly speaking, the tooth of a bevel gear are not formed by planar involute curves unlike spur gears, but by "spherical" involute curves. As shown in this model, when properly designed, two axes of two meshing bevel gears can intersect at any angle, although a right angle is the most common. Bevel gears are used to transmit motion between intersecting shafts, most commonly at a 90-degree angle, as in **automotive differentials** and machine tools.



Crown gears, also called face gears, can mesh with standard spur gears. Since the circumferential velocity changes with the radius, the tooth profile of a crown gear also varies along the radius. As shown in this model, the top surface of each tooth appears diamond-shaped. Only the outer portion — from the side vertices of the diamond — can mesh with the pinion. The inner portion does not contact the pinion.



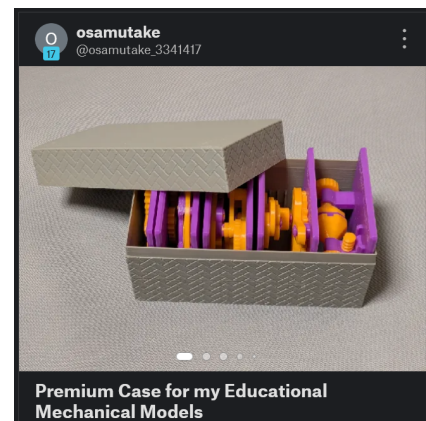
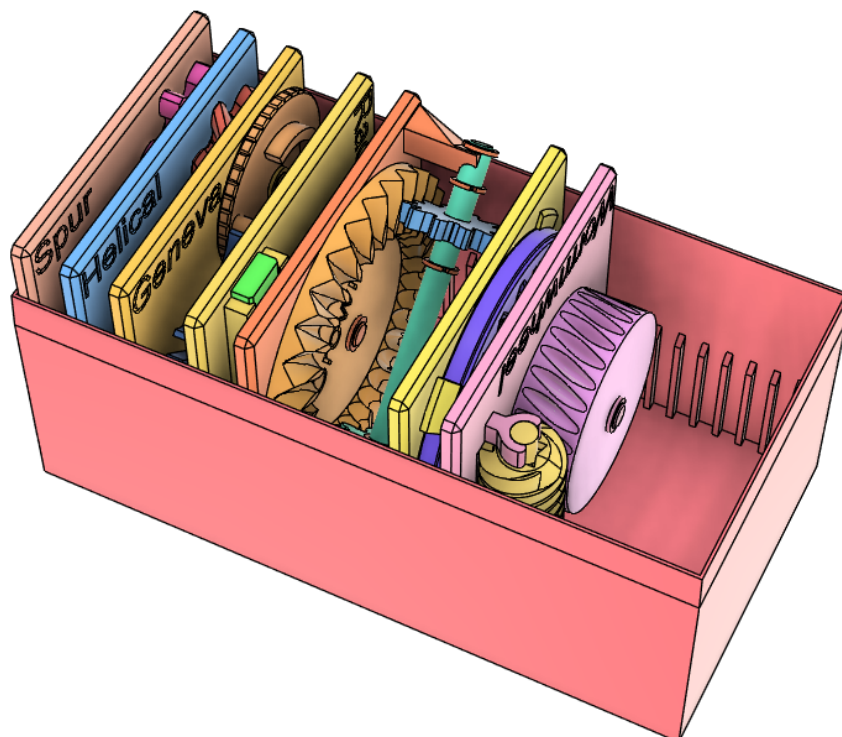
Crown gears are used to transmit motion between two shafts intersecting at a right angle, for example in instrument mechanisms and light-duty drives. Compared to the bevel gears, it does not require precise alignment of pinion gear along the axis. In this model, the thinner pinion can move freely along the shaft, and you can observe that it meshes perfectly regardless of its position.

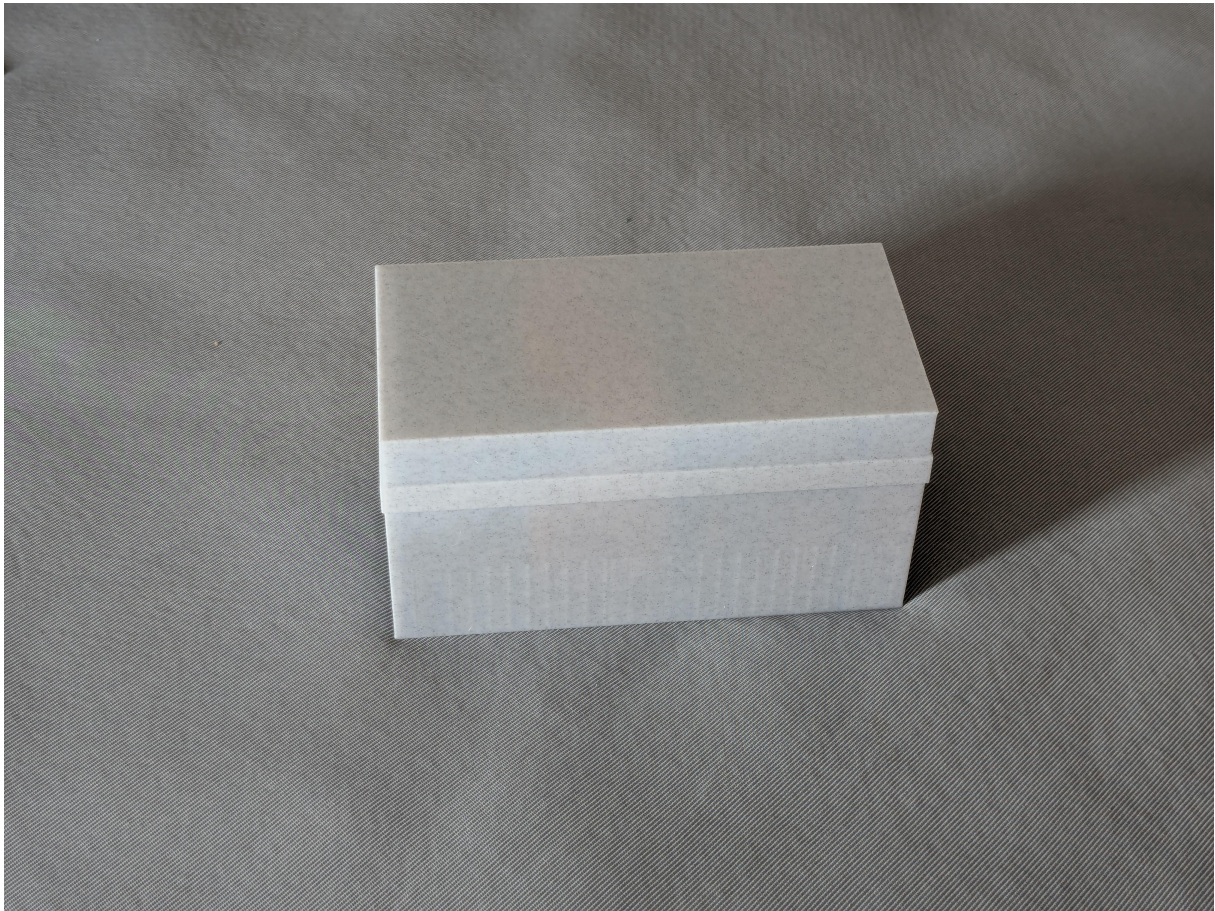
Light-Weight Standard Case

A **standard case for personal usage** is included in this model.

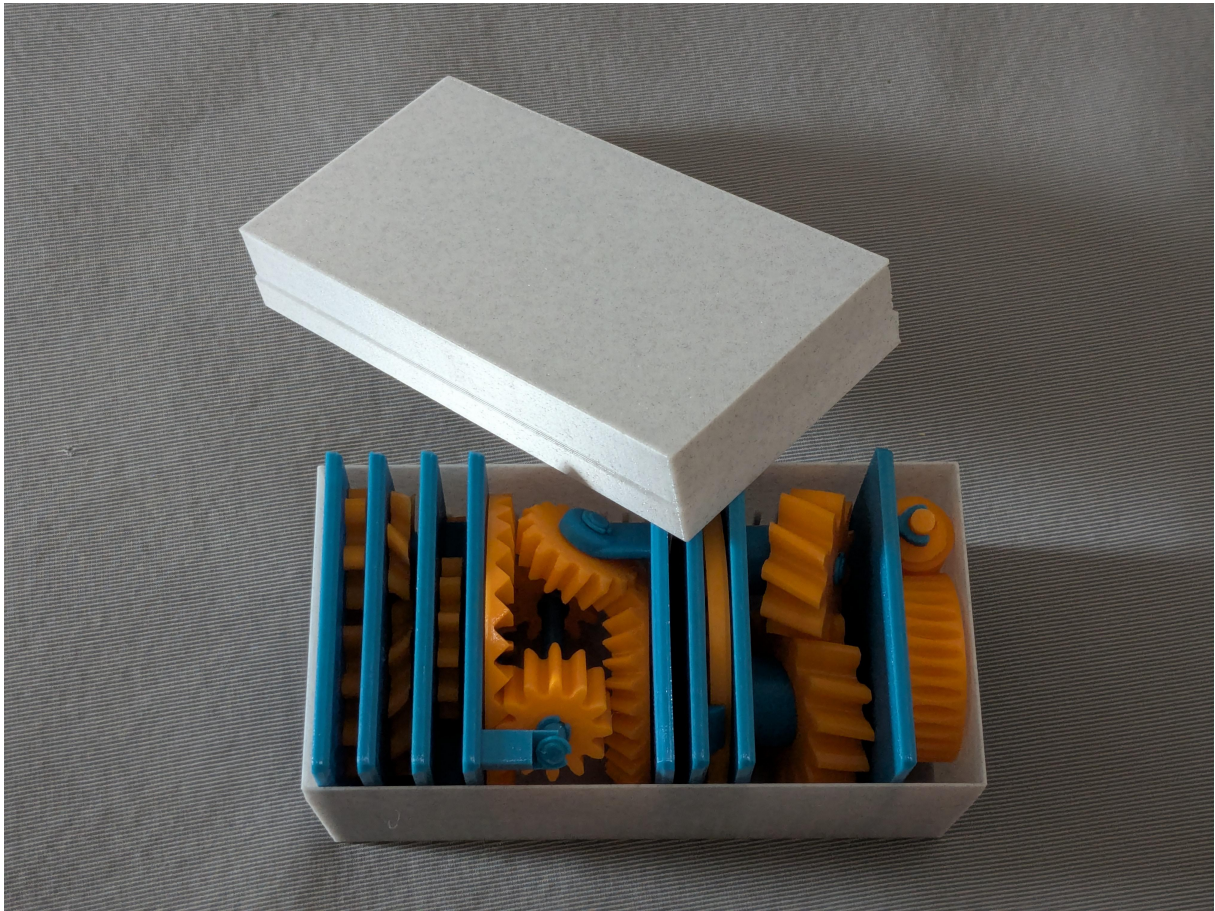
A **premium version** is available as an independent model.

=> [\[Premium Case for my Education Models\]](#)





All the eight gear examples included in this model can fit in a single case. Note that the crown gear and the bevel gear are facing to each other to save the space.

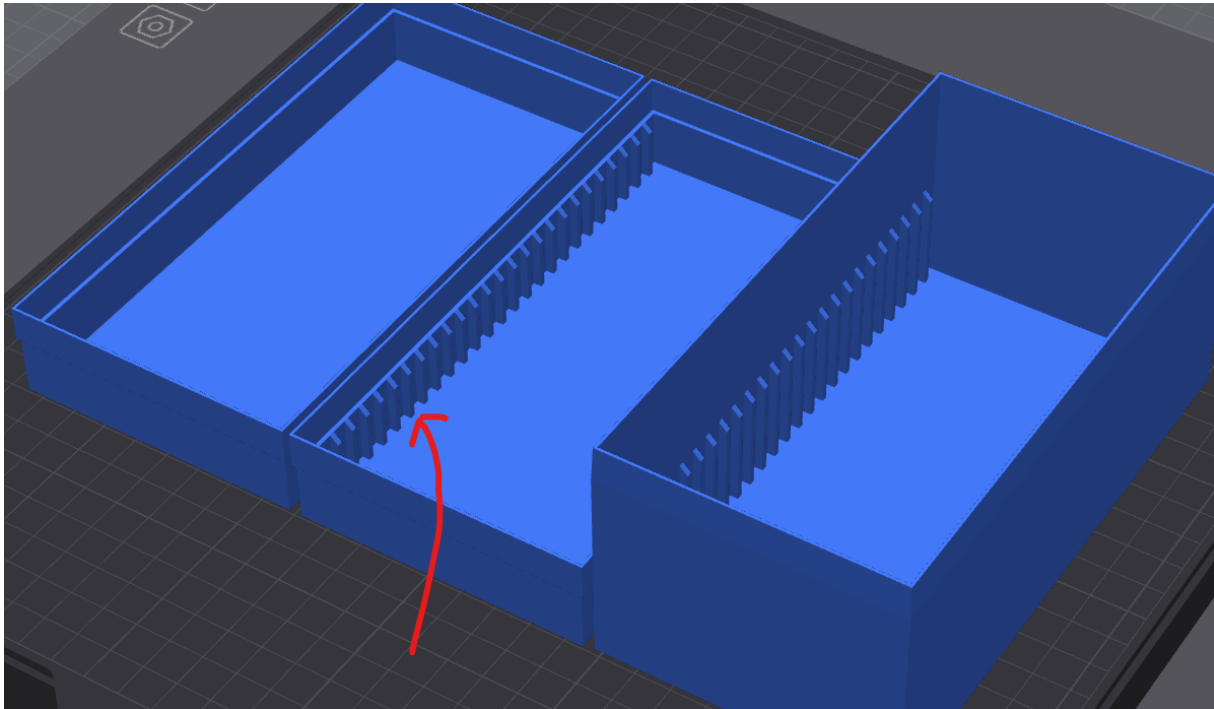
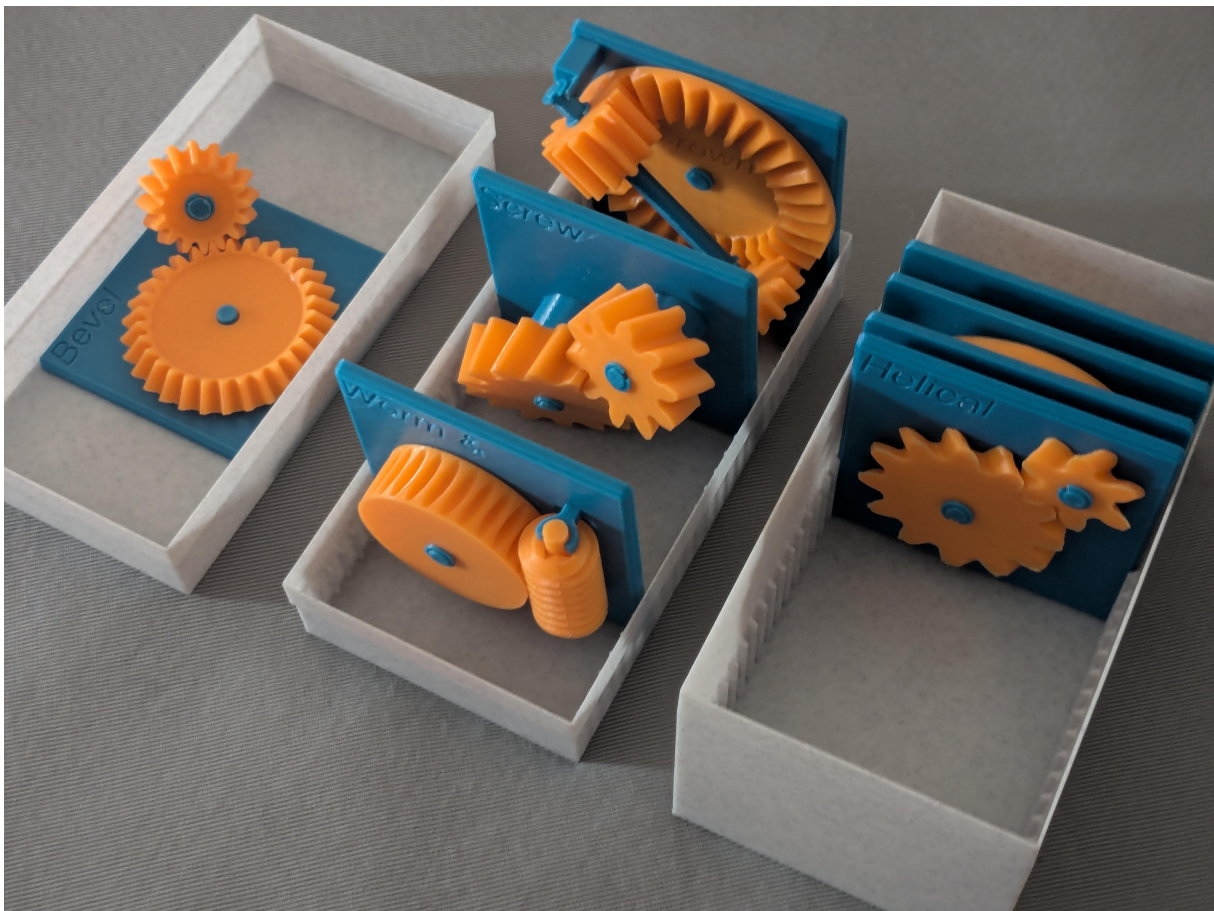


Lid with slots/ridges

I provide two kinds of the lid for the case.

One is a simple empty lid. It is easy to put on the case.

I lately added the other one, which is with slots or ridges to stably support the base plates of the models in the case. It is also useful as a temporal display stand for the printed models.

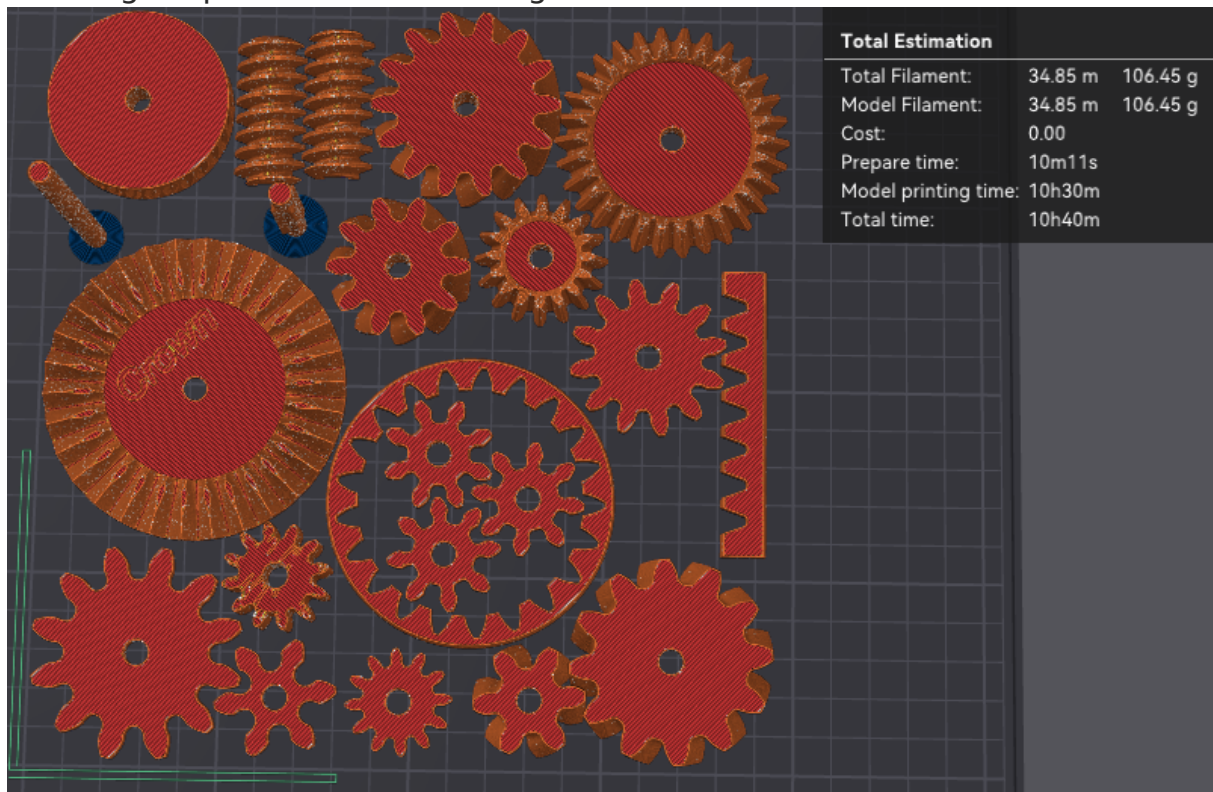


Printing

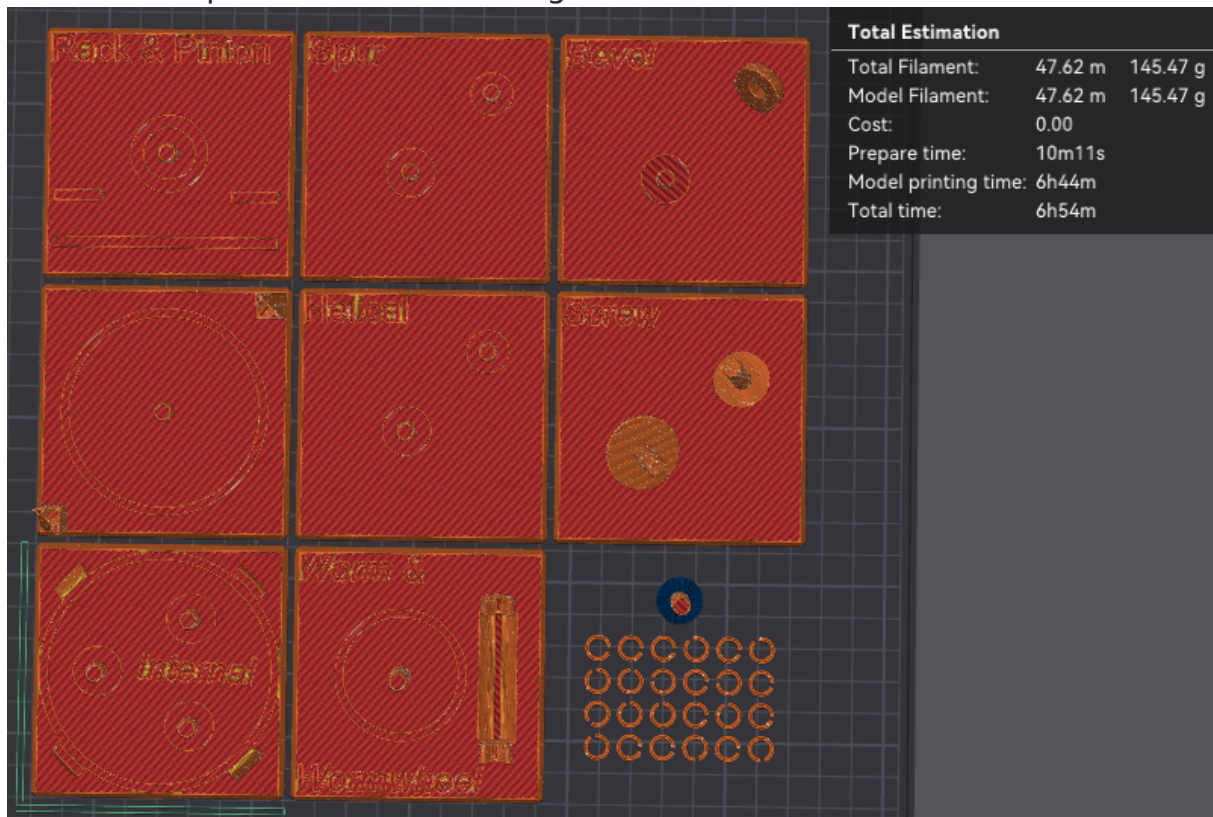
- Use the models named **???-printable.stl** for printing.
The models named **???-assembled.stl** are provided just to show how they should be assembled.
- Use well-dried PETG to have better dimensional accuracy.

- Use 0.1 mm or 0.08 mm layer height to have smoother surfaces.
- Use slow printing speed for overhangs.
- Select “Random” seam position to have smoother rotation.
- Printing orientations:
 - The long shafts of the worm and the pinion for the crown gear should be printed in a standing position. Add brims to them for safer printing.
 - Place the worm so as the flat cross section along the axis facing down.
 - The short shaft for bevel gear should be printed in a standing position, too.

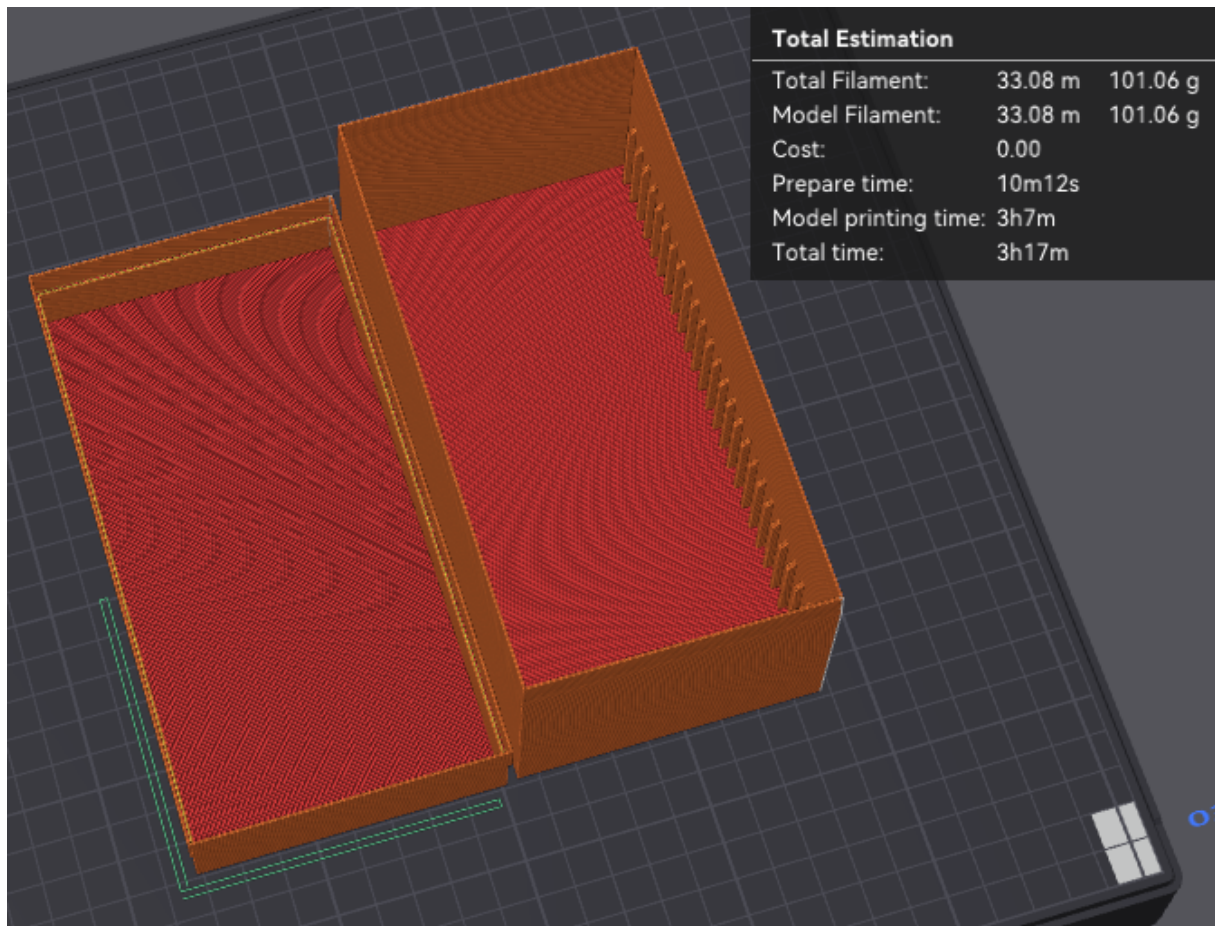
All the gear parts could be arranged in 198mm x 198mm.



All the base plates could be arranged in 244mm x 244mm.



- For the case, we do not need accuracy.
 - 0.2 mm or even 0.28 mm layer height will work for the case.
 - PLA can be used for the case.
 - If you increase the line width to 0.8 mm, you can reduce the printing time a lot.



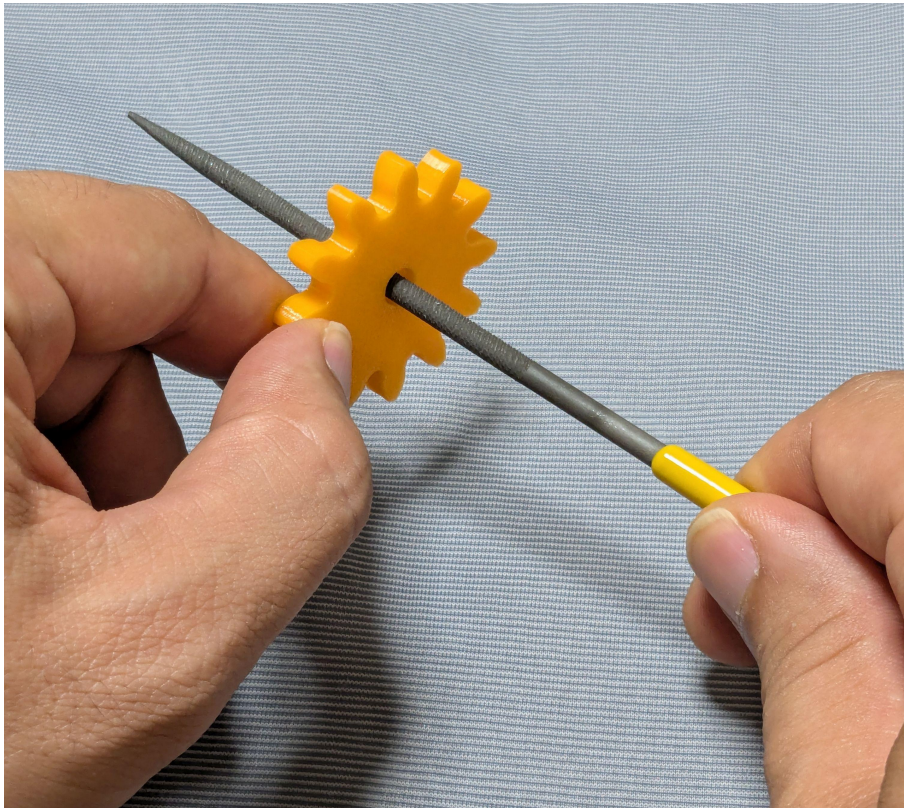
Filing and Sanding

Sometimes, the gears suffer from the elephant foot effect and/or stringing effect, resulting in a too tight fit to the shafts (they are designed with a 0.15 mm radial clearance).

If you see rough surface on the shafts due to stringing, sand off the roughness with small piece of sand paper.

You may also want to slightly file off the longitudinal edges of the rack.

If you feel the gears do not rotate smoothly due to an elephant effect, widen the hole slightly by using a thin round bar file.



Without those issues, the gears should rotate very smoothly with minimal friction.

Assembly

No glue is needed except for the worm.

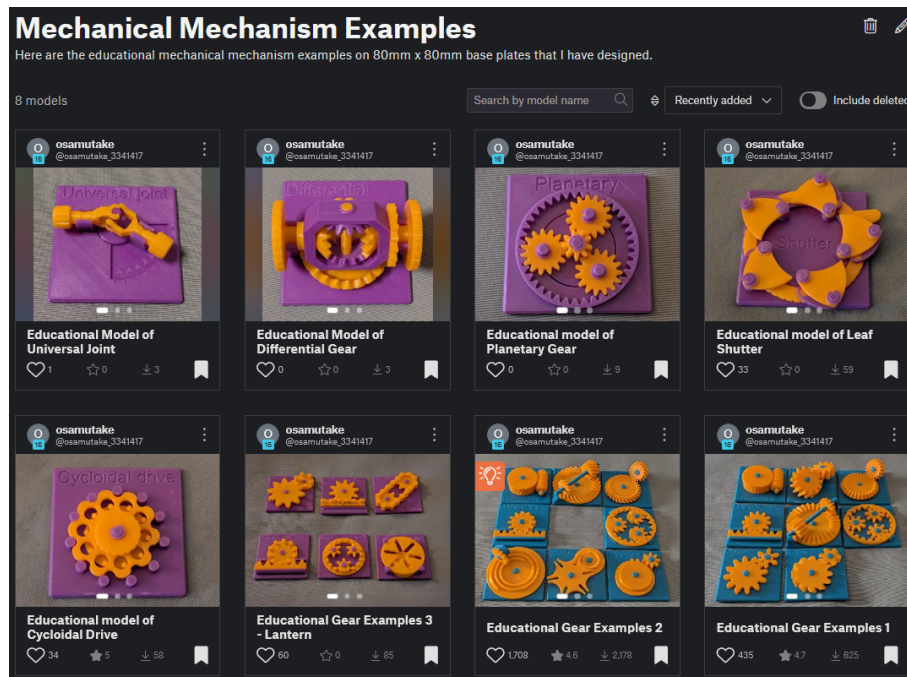
- Worm: If you feel the shaft of the worm is too loose, glue them by using some super glue.
- Rack & pinion: Slide in the rack first, before putting the pinion.
- Internal: Insert the internal gear first, before the other small gears.
- Bevel: Insert the shaft for the smaller gear at last.
- Crown: The thinner pinion can move along the axis. Be surprised to see that the pinion perfectly fits to the crown gear regardless of the position along the axis.

Other educational models

You may be also interested in the mechanical mechanism examples I have published.

Find them in this collection:

https://www.printables.com/@osamutake_3341417/collections/2728214



Happy printing!

Acknowledgement

I got into gears thanks to **K.\$uzuki**'s amazing [articles](#) and [YouTube videos](#). Many of the mechanisms shown in this series came from the introductions on [his website](#). He also makes [excellent gear models](#) himself. This series wouldn't have existed without his inspiration.

I learned a lot about technical detail of designing gear tooth profiles from [Haguruma-No-Hanashi website](#). I'm truly grateful for that.

Updates

- 2025-10-18
 - Added the lid with slots/ridges.
- 2025-10-07
 - Added the printable SLT files for easier printing.
 - Renamed the assembled STL files for clarity.

Model files



spur-v39-assembled.stl

☐ Not for printing. Use it to see how the parts should be assembled.



spur-v39-printable.stl

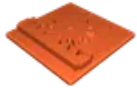


helical-v39-assembled.stl

☐ Not for printing. Use it to see how the parts should be assembled.



helical-v39-printable.stl



rackpinion-v39-assembled.stl

☐ Not for printing. Use it to see how the parts should be assembled.



rackpinion-v39-printable.stl

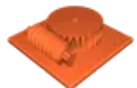


internal-v39-assembled.stl

☐ Not for printing. Use it to see how the parts should be assembled.



internal-v39-printable.stl



worm-v39-assembled.stl

☐ Not for printing. Use it to see how the parts should be assembled.



worm-v39-printable.stl



crown-v39-assembled.stl

☐ Not for printing. Use it to see how the parts should be assembled.



crown-v39-printable.stl



screw-v39-assembled.stl

☐ Not for printing. Use it to see how the parts should be assembled.



screw-v39-printable.stl



bevel-v39-assembled.stl

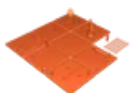
☐ Not for printing. Use it to see how the parts should be assembled.



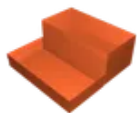
bevel-v39-printable.stl



gearexamples1-v39-gear.stl

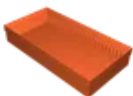


gearexamples1-v39-base.stl



gearexamples1-v39-case.stl

☐ A premium case is also available. See the text.



gearexamples1-v73-lid-with-slots.stl

☐ It holds baseplats more stably in the case and also useful as a temporal stand.

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