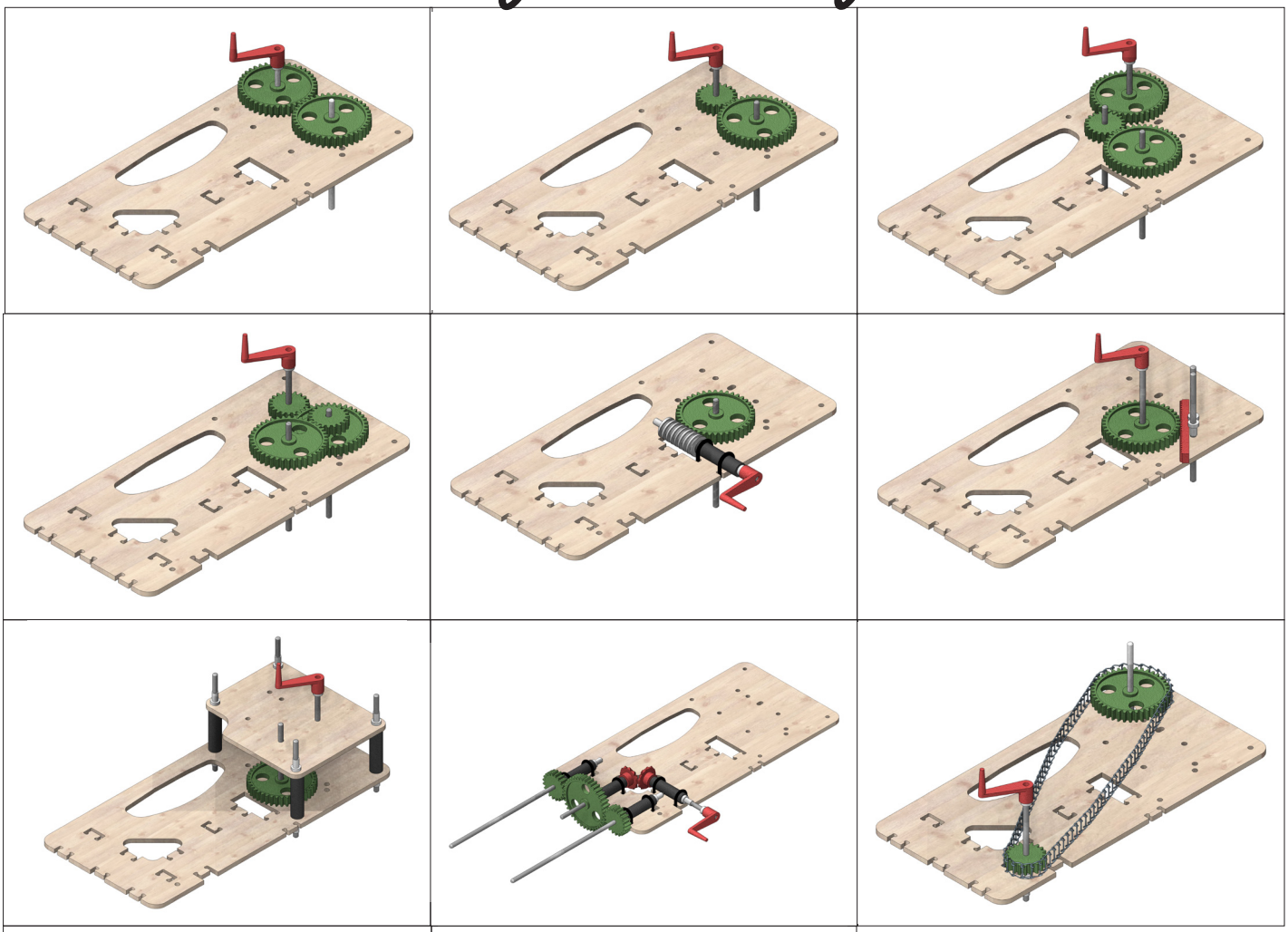
121.043

# Gear Technology - Learning Program Easy



**Tools Required:**

Hammer

***Please Note!***

The OPITEC range of projects is not intended as toys for young children. They are teaching aids for young people learning the skills of Craft, Design and Technology. These projects should only be undertaken and operated with the guidance of a fully qualified adult. The finished projects are not suitable to give to children under 3 years old. Some parts can be swallowed. Danger of suffocation!



OPITEC

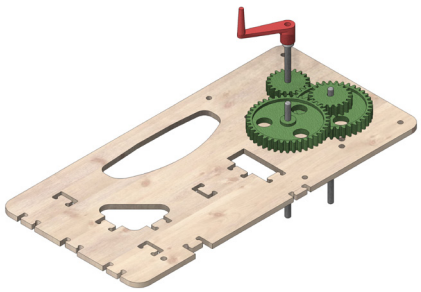
| Parts List | Number of Pieces | Size (mm): | Description | Part Number. |
|---|---|---|---|---|
| Wooden parts for gearbox (set) | 1 | | Base Plate | 1 |
| Metal Axle | 2 | ø3x150 | Axle | 2 |
| Metal Axle | 6 | ø3x70 | Axle | 3 |
| Gear (40 teeth) green | 2 | ø41 | Gearwheel | 4 |
| Gear (40 teeth) green | 2 | ø 21 | Gearwheel | 5 |
| Bevel Gear | 2 | | Bevel Gear | 6 |
| Worm Module | 1 | | Worm Module | 7 |
| Rack | 1 | | Rack | 8 |
| Crank Handle | 1 | | Crank | 9 |
| Steering Wheel | 2 | ø 35 | Steering Wheel | 10 |
| Beech Wood Rim | 2 | ø 25 | Rim/Wheel | 11 |
| Distance Rolls | 5 | ø8x30 | Spacer | 12 |
| Rubber Band | 6 | | Bracket | 13 |
| Metal Chain | 1 | 45 | Chain | 14 |
| Reducer | 15 | 4/3 | Reducer/Spacer | 15 |
| Rubber Band | 1 | ø 40 | Rubber Drive | 16 |

## Transmission technology

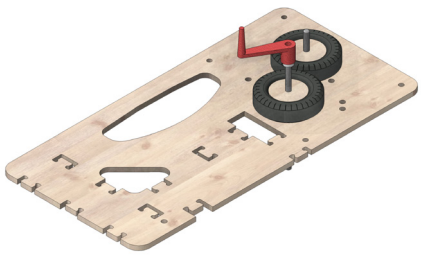
With gearboxes different properties in mechanics can be changed.
Mainly they are used to transmit torques, increase circumferential forces, increase or decrease rotational speeds and reverse the direction of rotation. But they also serve, depending on the design, to turn rotary motion into linear motion (rotation in translation) and vice versa. Or also to overcome distances between drive and output or to redirect the drive direction by a certain number of degrees.

## You can divide the gears of this tutorial into the categories

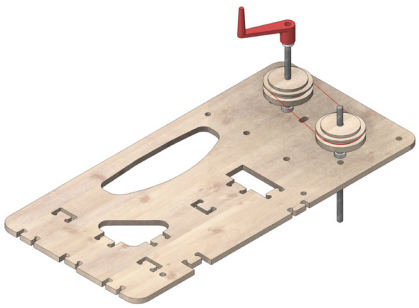
**1. Gear transmission**



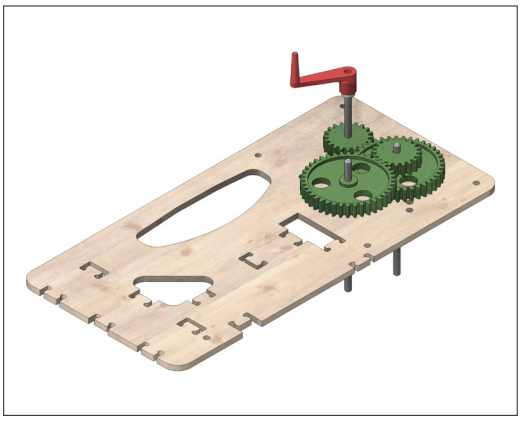
**2. Friction gear**



**3. Traction mechanism**



### How does a gear drive work?

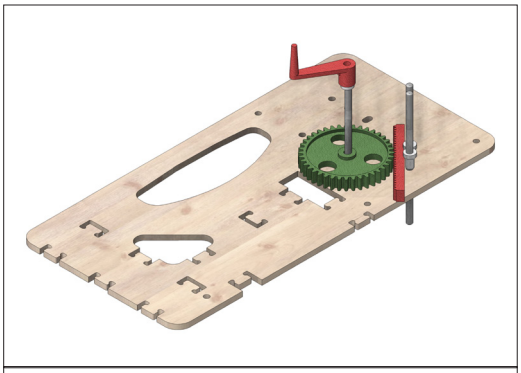


In a gear, the teeth are evenly distributed around the circumference. The bigger the diameter, the more teeth. The peripheral force is transmitted from the tooth of the driving gear to the tooth of the driven wheel.
A tooth of one wheel shifts a tooth of the other wheel around a tooth. The next tooth of the driving wheel then only moves again the subsequent tooth of the driven wheel. A distinction is made between helical gearboxes where the axes run in the same direction, bevel gearboxes where the axes intersect and worm gears where the axes intersect.
Incidentally, with the worm gear, the largest gear ratios can be achieved. But what is that actually a translation ratio?

### ratio

Take as an example a very ordinary spur gear as in experiment 1 and 2. The smaller wheel has fewer teeth, so only a few teeth have to be moved for one revolution. For example, if the small wheel has 20 teeth and the big wheel has 40 teeth, then it rotates
The small wheel turns twice around the big wheel once. This gearbox has a gear ratio of 2: 1.
If both wheels have the same number of teeth (ie the same diameter), then the gear ratio is 1: 1.
Note for teachers: Based on the gear ratios of the wheels, the "golden rule of mechanics" can also be explained well.
Whether lever lengths are compared with the levers or the diameters are compared with the wheels is irrelevant. In both cases, gear ratios arise.

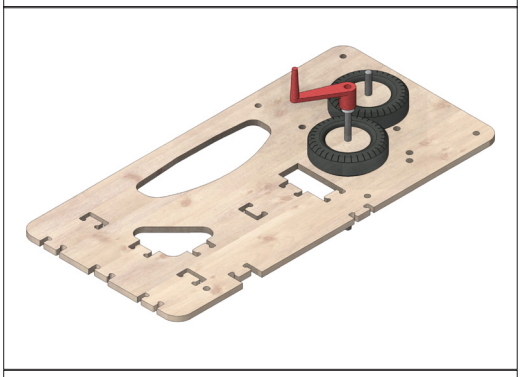
### Special forms of gear transmission



There are still several other types and subspecies in the gear transmissions. For example, gear with internal teeth, helical-worm gearboxes and the like.
In the context of this kit, we deal only with the special form of the rack and pinion.

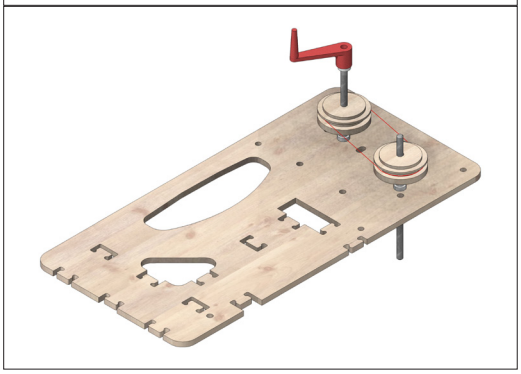
The special feature of this gear is that the rotational movement of the gear is converted into a straight-ahead reciprocating motion

### 2. Friction gear



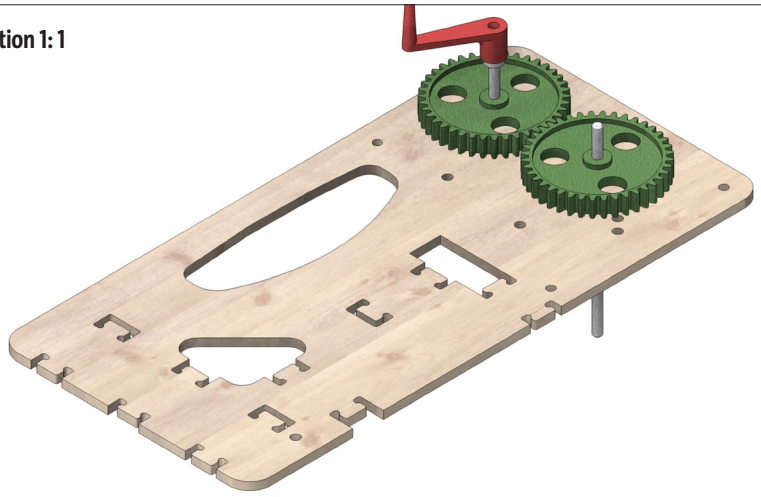
the rotational movement is transmitted by the frictional forces between two wheels, which are pressed together. One speaks of non-positive transmission. eg bicycle dynamo.

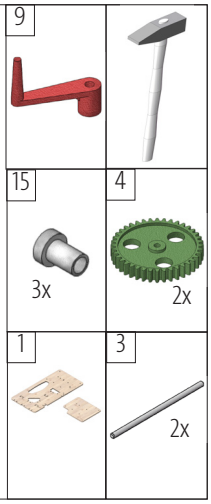
### 3. Traction mechanism



As a special feature, at the same time as the transmission of power, bridges distances between two waves that are further apart. In a simple way, it is also possible to reverse the direction of rotation (crossed belt drive).
The most well-known variants are the belt transmissions (flat wedge or round belts) and the chain or toothed belt transmissions.
The main differences between these:
The belts transmit by means of frictional forces and always have a certain amount of slippage. The chain and toothed belt transmissions transmit their forces through positive locking and can therefore also be used for exact positioning (timing belt on the car engine, drive for moving the machine table on CNC machines).

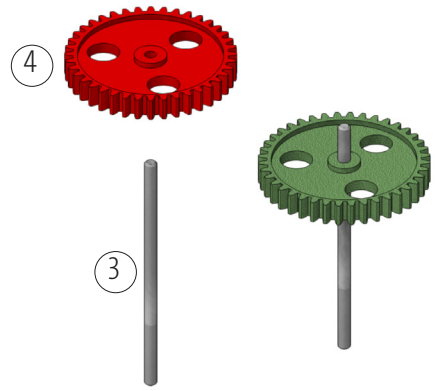
**1** **Translation 1: 1**



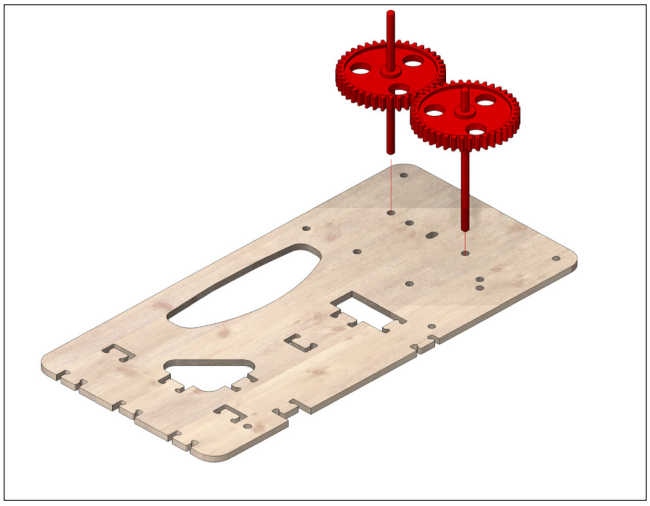



The gears have the same number of teeth and the same diameter Thus, both wheels rotate at the same speed, with the same speed and the same circumferential force. It only changes the direction of rotation.

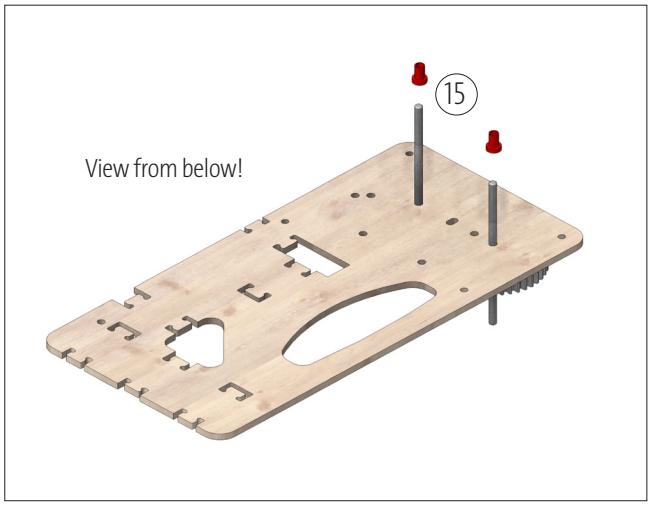
**Construction:**



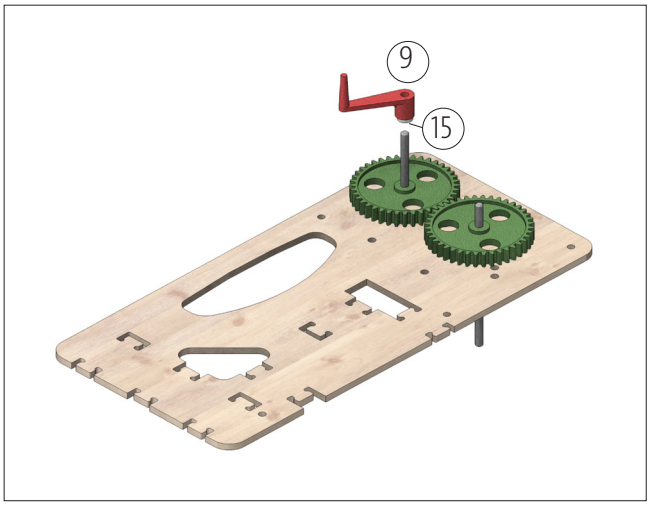

Attach a gearwheel (4) to an axle (3) in each case 10 or 20 mm in an indented manner. If necessary, use a hammer.



Insert the two axles with the gear wheels through the holes (see illustration) of the base plate (1).

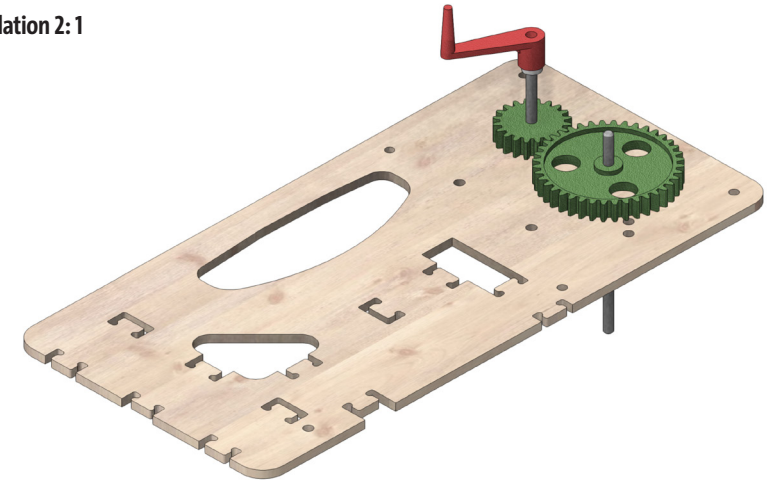


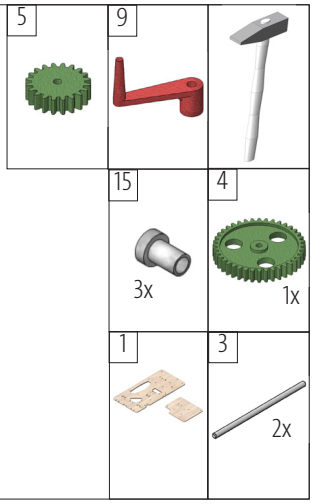

Slide on a reducer (15) from below and fix in place.




Insert a reducer (15) from below into the crank (9) and attach it to the axle (3) as shown. Finished!

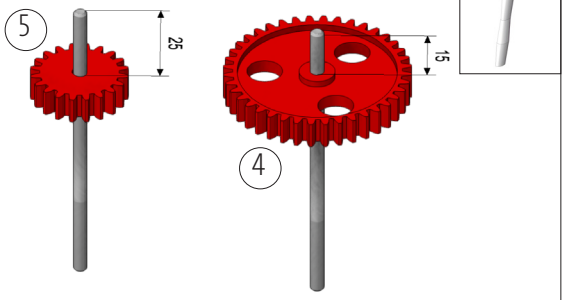
## 2 Translation 2: 1





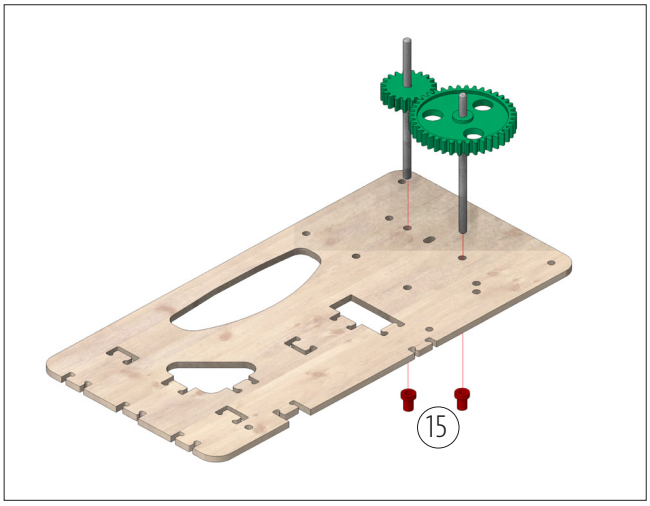

The gears have unequal numbers of teeth. The small wheel has 20 teeth, the big 40 teeth. So the big wheel has twice as many teeth and twice the diameter. Half speed, double peripheral force.

**Construction:**

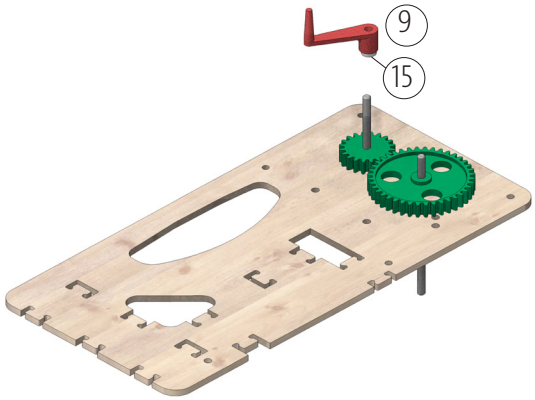



Insert a gearwheel (5) indented 25mm on an axle (3). Engage a sprocket (4) 15mm on an axle (3). If necessary, use a hammer to help.

1x

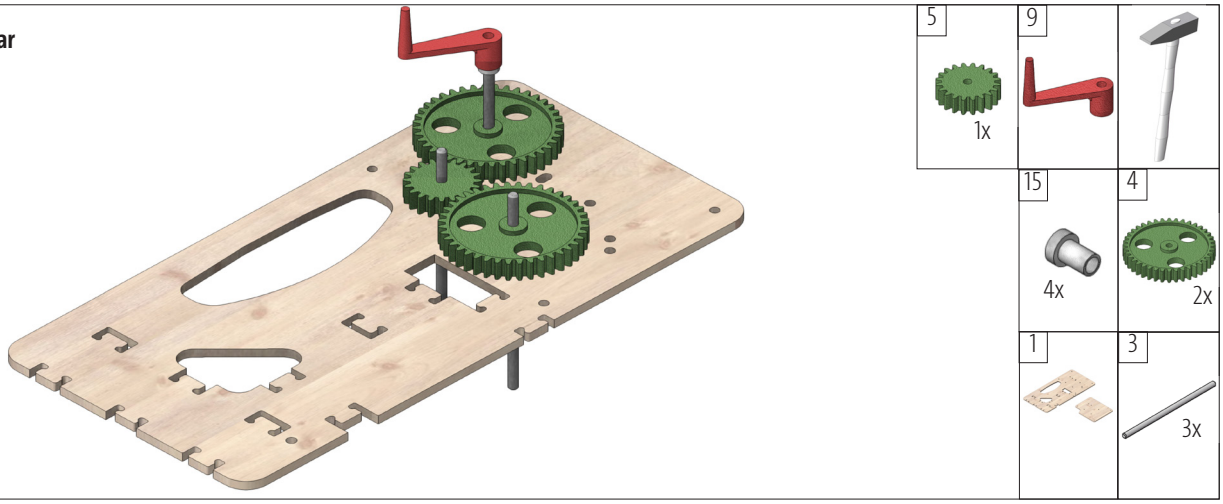



Insert the two axles with the gear wheels through the holes (see illustration) of the base plate (1) and fix them from below with one reducer each (15).



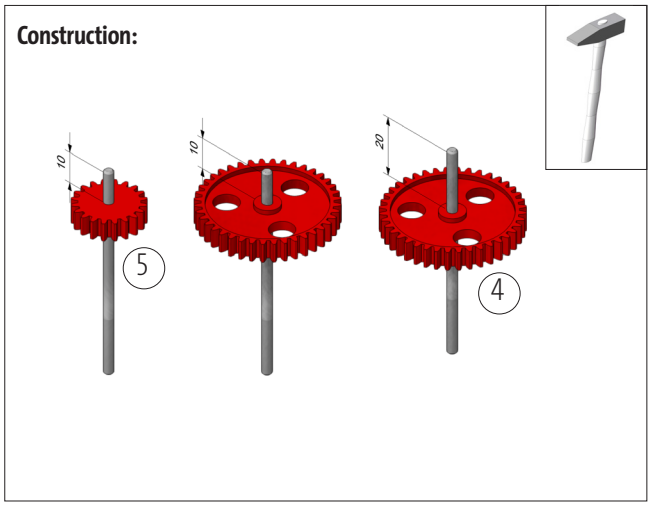

Insert a reducer (15) from below into the crank (9) and attach it to the axle (3) as shown. Finished!

## 3 Idle Gear

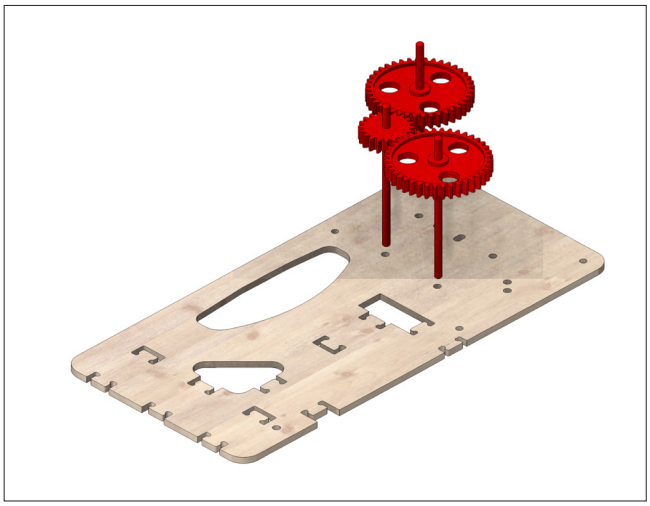



The idler does not change the ratio, no matter how big or small it is.
Each tooth of the first wheel, which pushes on one tooth of the idler wheel, causes the third wheel to be pushed by one tooth even by one tooth. So translation 1: 1. The purpose of a idle gear is the change of the sense of rotation and / or the bridging a short path between the shafts of gear 1 and gear 3rd.

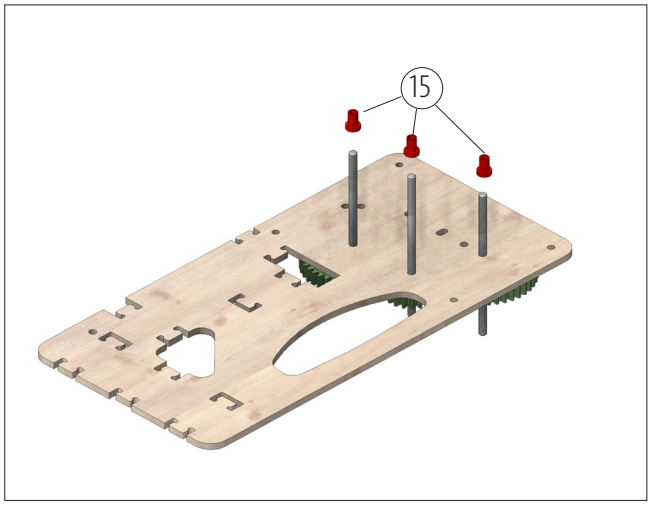
**Construction:**



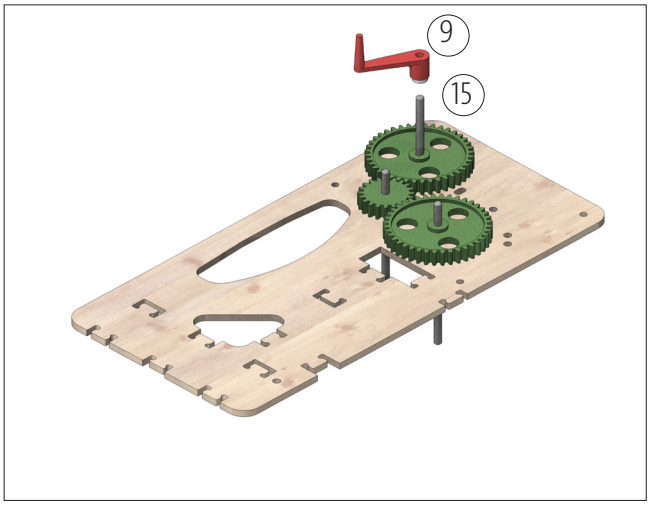

Insert a gearwheel (5) indented 25mm on an axle (3). Engage a sprocket (4) 15mm on an axle (3). If necessary, use a hammer to help.



Insert the two axles with the gear wheels through the holes (see illustration) of the base plate (1) and fix them from below with one reducer each (15).

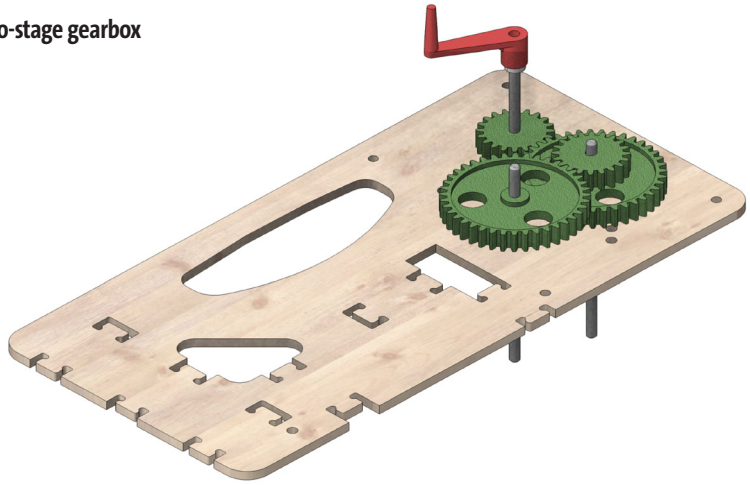


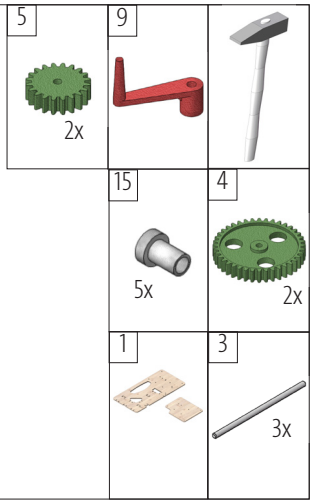

Slide on a reducer (15) from below and fix in place.




Insert a reducer (15) from below into the crank (9) and attach it to the axle (3) as shown. Finished!

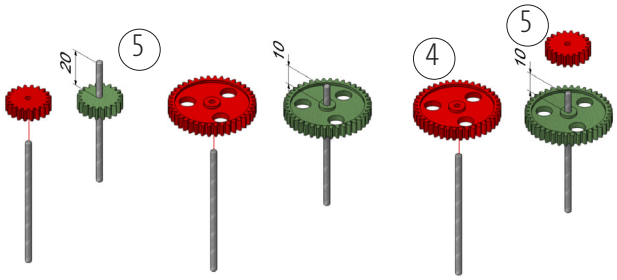
## 4 The two-stage gearbox



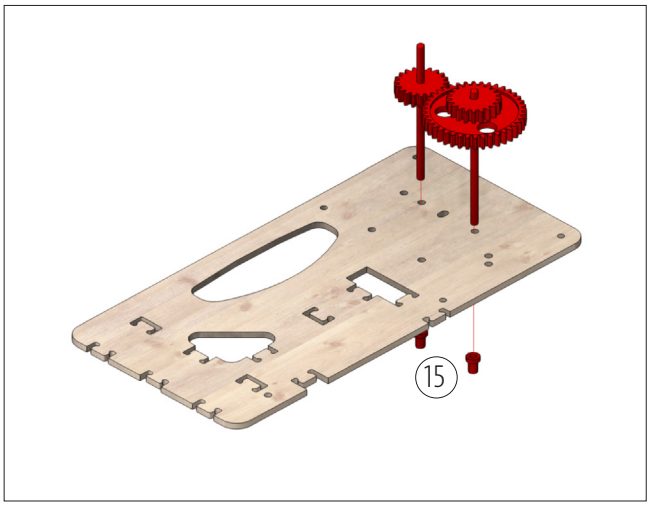



Translations can not be arbitrarily large between two wheels. Usually it will not be bigger than 1: 6. If one wants to use a larger translation one either a second stage (altogether 4 gears) or one reaches for the two-stage transmission.

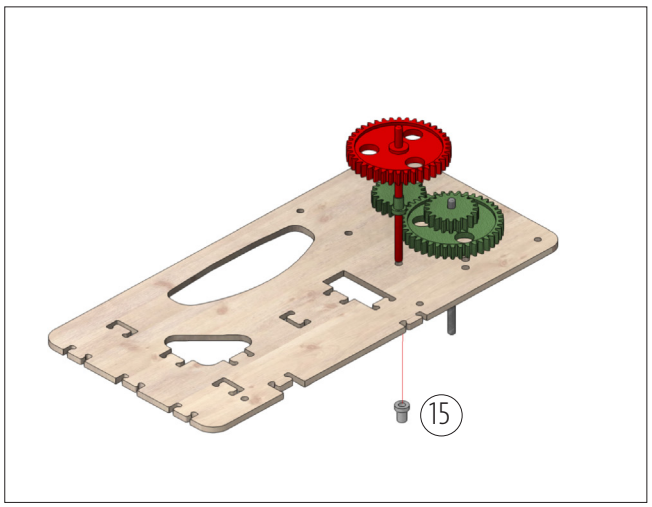
**Construction:**



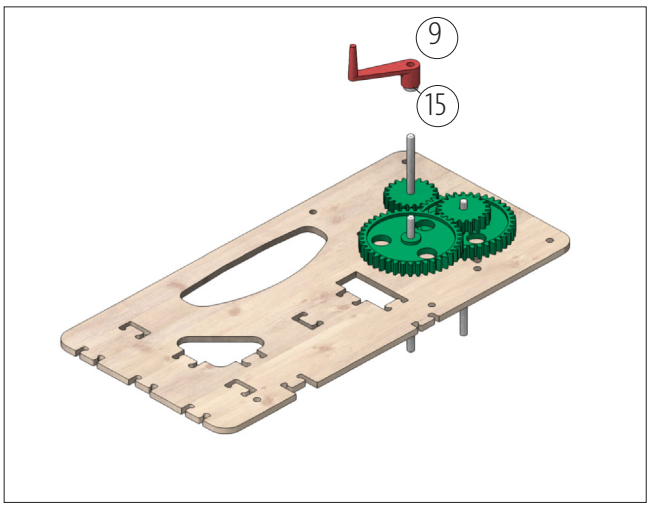

Insert a gearwheel (5) indented 25mm on an axle (3). Engage a sprocket (4) 15mm on an axle (3). If necessary, use a hammer to help.




Insert the two axles with gearwheel (5) and double gearwheel (4/5) into the baseplate as shown and fix them from below with one reducer each.

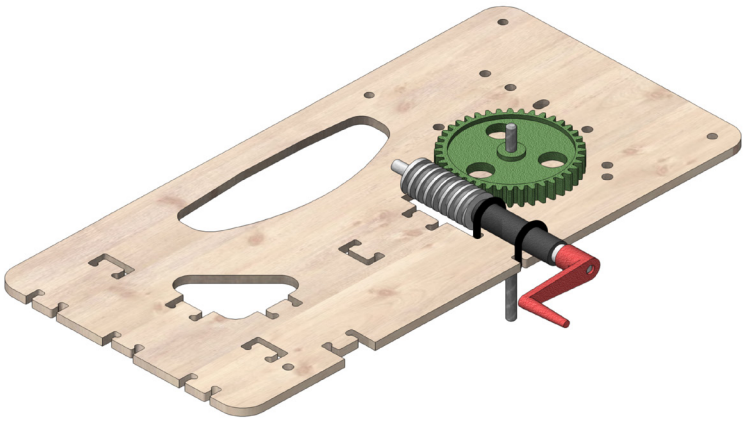


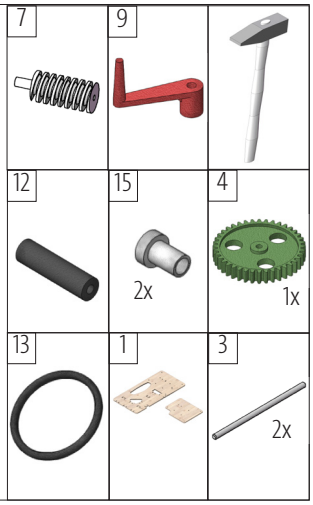

Insert the axle with the second large gear (4) as shown and fix from below with a reducer (15).




Insert a reducer (15) from below into the crank (9) and attach it to the axle (3) as shown. Finished!

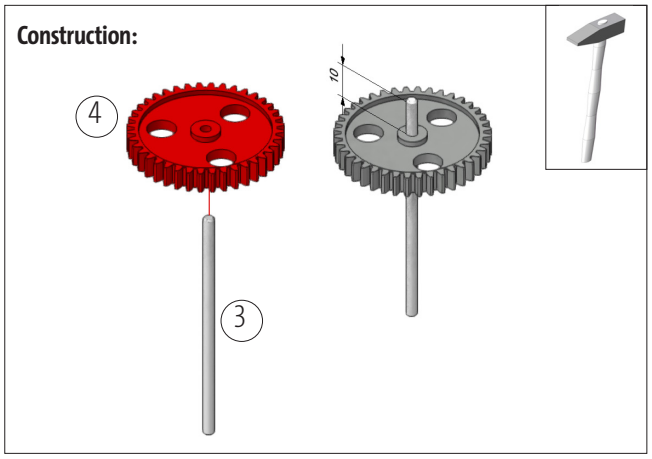
## 5 The worm gear



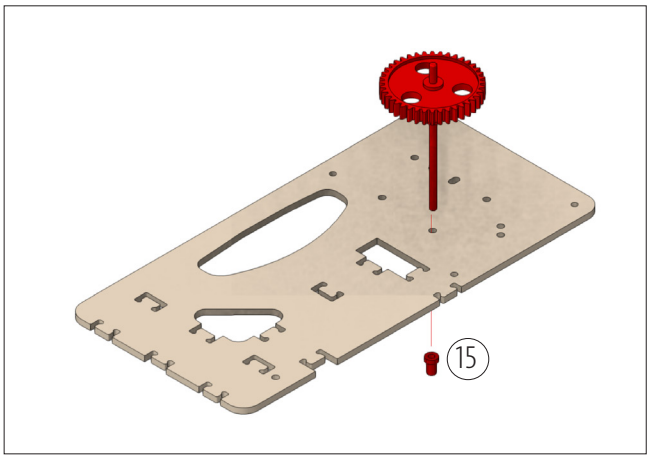



The worm gear has some special features.
One can realize with him very large translations (up to about 1: 100 and above) in one step. It is self-locking, ie you can drive it only from the snail side. The result is always the crossing of the driven axle with the driving axle. The screw can be 1, 2 or 3 common. With the single-flighted worm, the worm wheel is only rotated by one tooth during one revolution of the worm. Of course, two-legged snails have two teeth and three-legged snail have three teeth.
If one wants to calculate the gear ratio one computes with the screw as a wheel with one, two or three teeth.
Example: gear with single-start worm and worm wheel with 60 teeth. Gear ratio i = number of teeth of the driving wheel divided by the number of teeth of the driven wheel = 1/60.

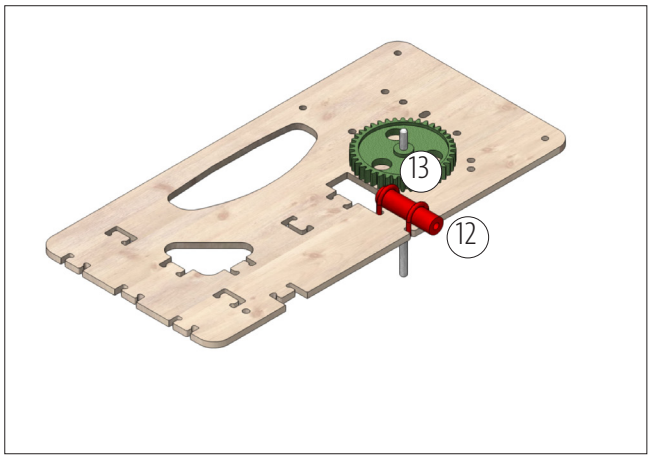
**Construction:**



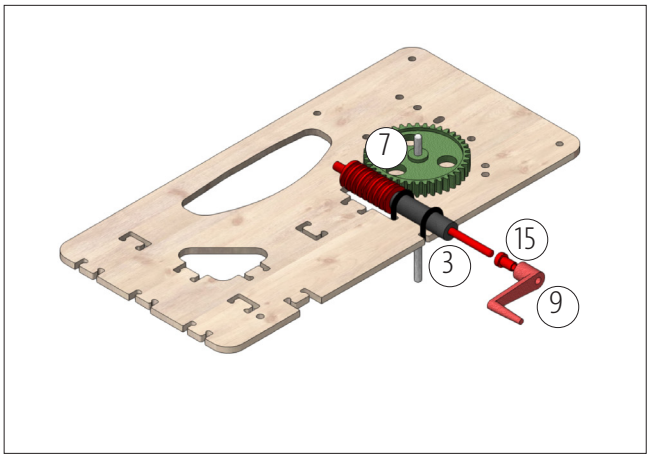

Insert a gearwheel (4) indented 10mm on an axle (3).




Insert the axle with the gear wheel in the base plate as shown and fix it from below with a reducer (15).




Fix the spacer roller (12) with an O-rubber ring (13) in the provided opening.




Slide the axle (3) through the spacer roller and attach the screw module (7) as shown. Insert a reducer (15) into the hand crank (9) and attach the crank to the free shaft end.



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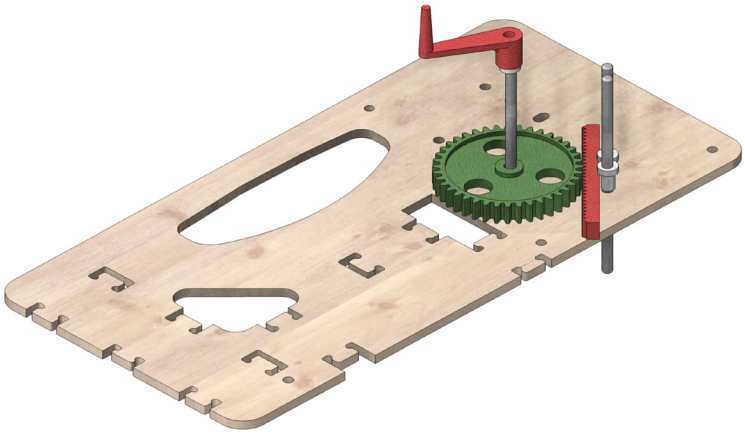
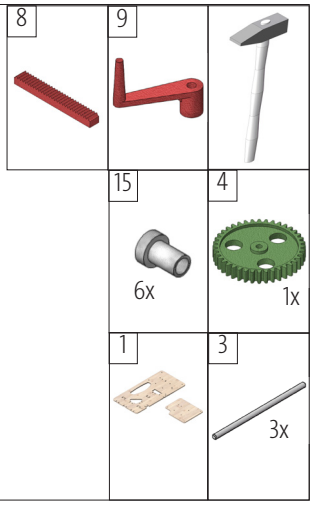
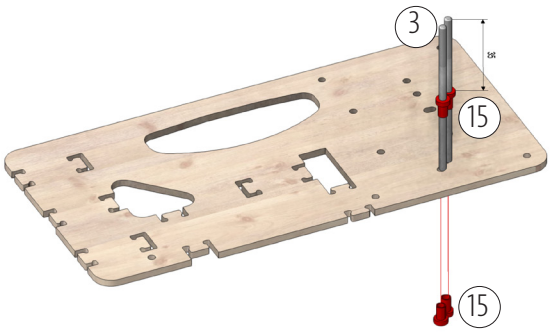
## 6 The rack and pinion gear



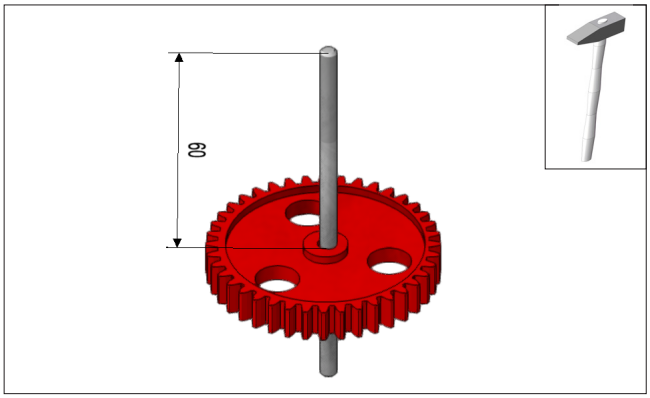



In the rack and pinion, the rack can be considered as a gear with an infinite diameter. The rack and pinion gearbox converts a rotary movement into a straight-line movement (or vice versa). Application example: Height adjustment of machine tables.

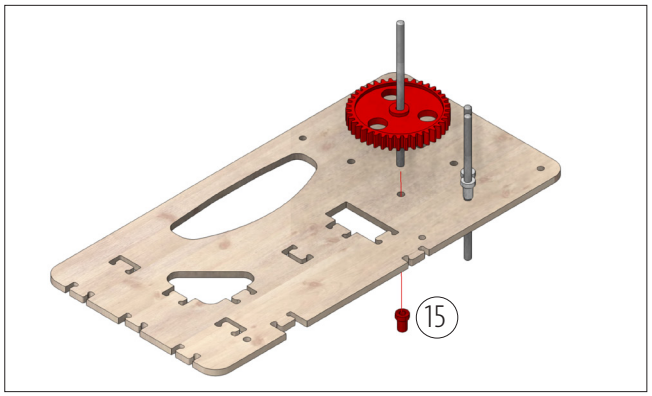
**Construction:**



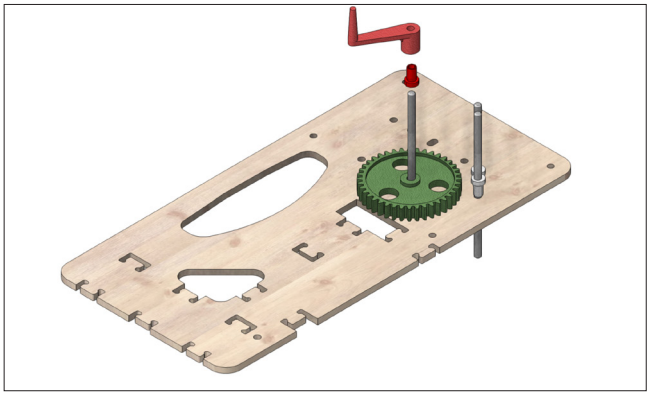

Place one reducer (15) at a distance of 35mm on each axle (3). Then insert the axles as shown and fix them from below with one reducer each (15).



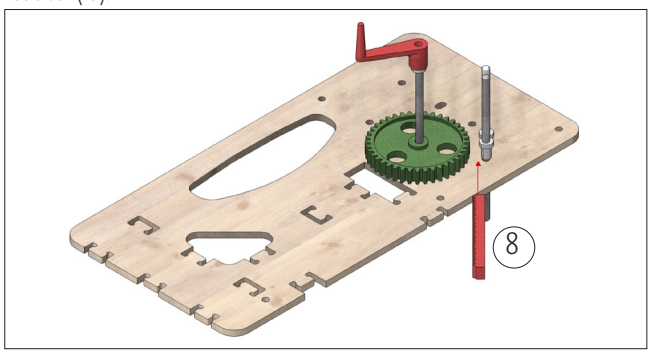

Attach the gearwheel (4) to an axle (3) with an engagement of 60mm. If necessary, hammer in with a hammer.




Insert the axle with the gear as shown and fix it from below using a reducer (15).



Insert a reducer (15) from below into the crank (9). Then attach to the axle as shown.




Insert the rack (8) between the gear and the guide (axles with reducers) as shown.



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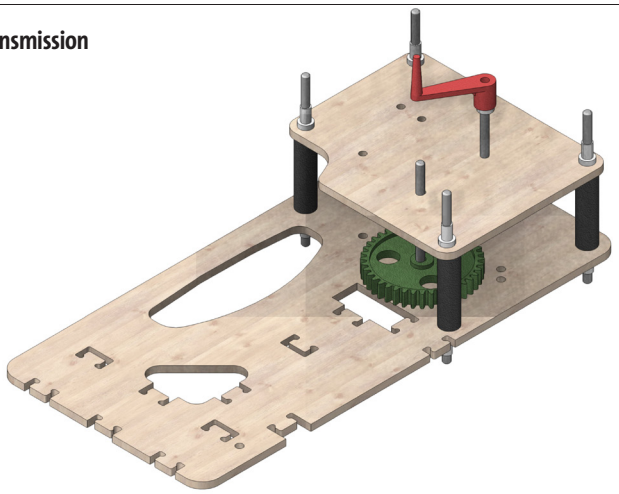
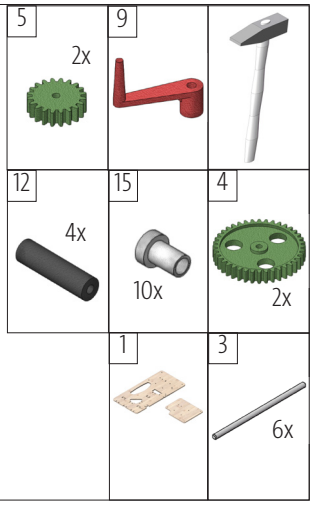
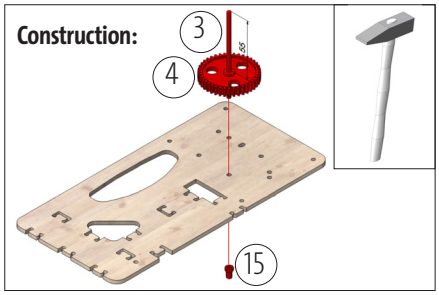
## 7 The manual transmission

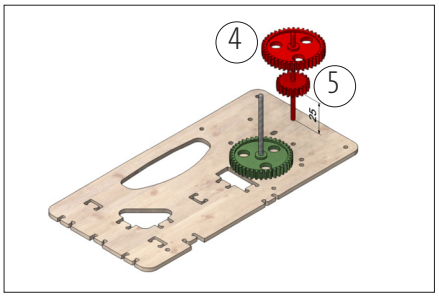




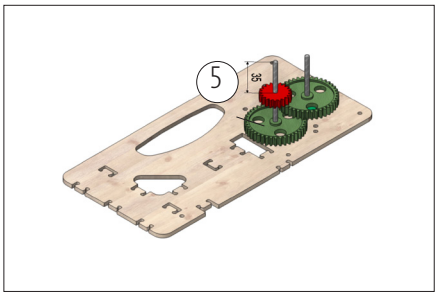

If you need several gear ratios in a gearbox, you can access the gearbox. To shift from one gear to the other, one to several wheels must be slidable along its shaft axis. The best known example is the manual transmission in cars.



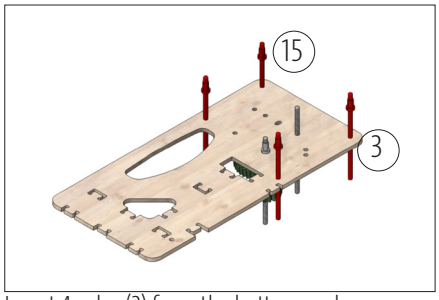

Engage a gearwheel (4) 55mm indented on the axle and fix it from below with a reducer (15).



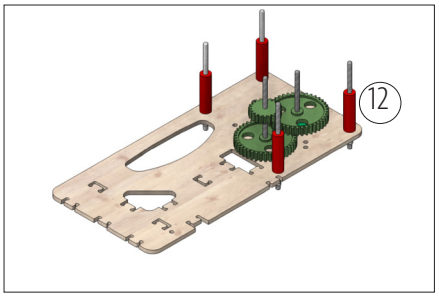

Attach a gearwheel (5) to the axle 25mm from the bottom as shown. Attach another gear (4) so that it rests on the small gear. Then insert as shown.



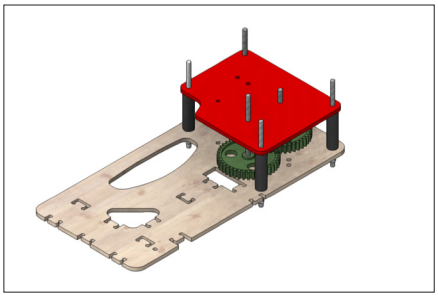

Attach a gear (5) 35mm indented to the axle as shown.



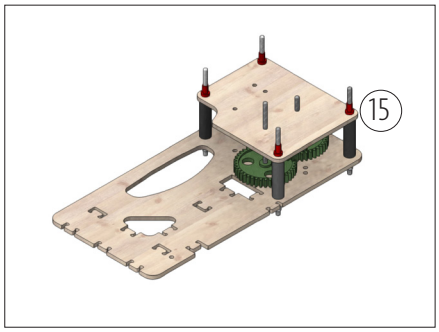

Insert 4 axles (3) from the bottom and secure with one reducer each (15).



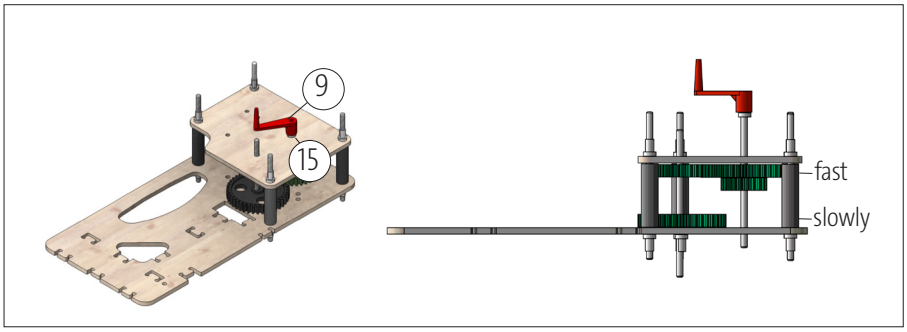

Turn it over again and attach a spacer roller (12) to the axles from above.



Attach the small base plate (1) as shown.

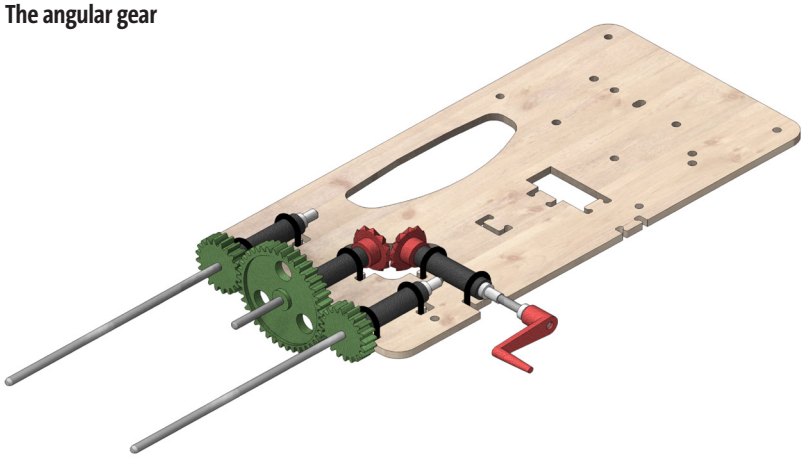


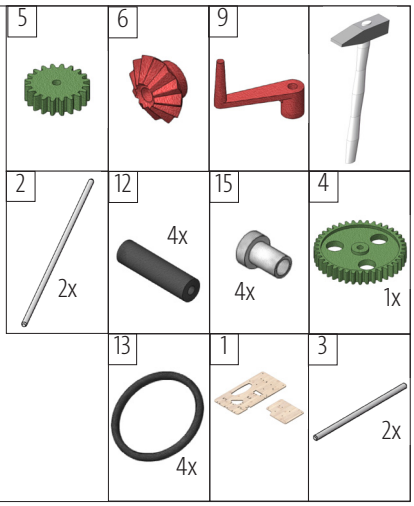

Fix from above with a reducer (15).



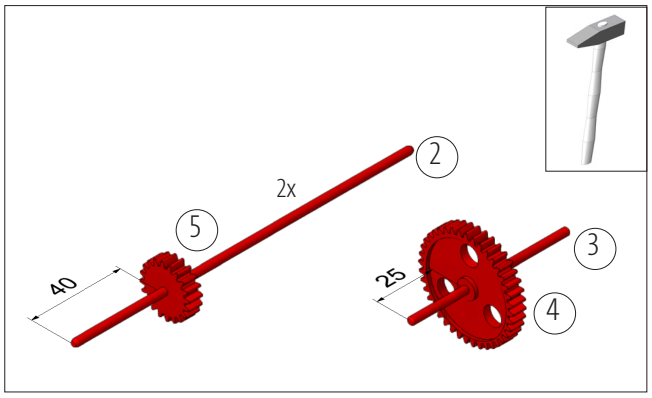

Insert a reducer (15) into the crank (9) and attach to the axle (3) as shown.

## 8 The angular gear

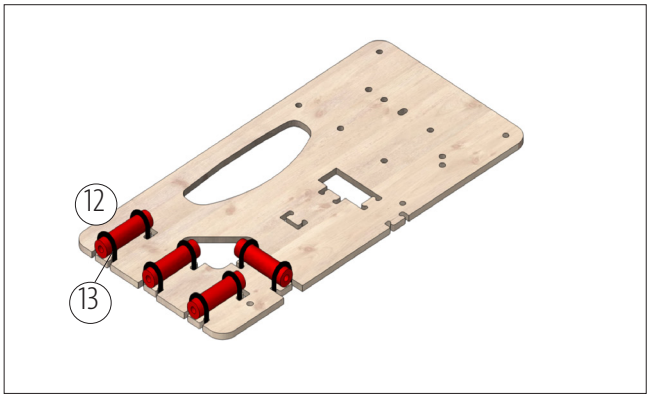




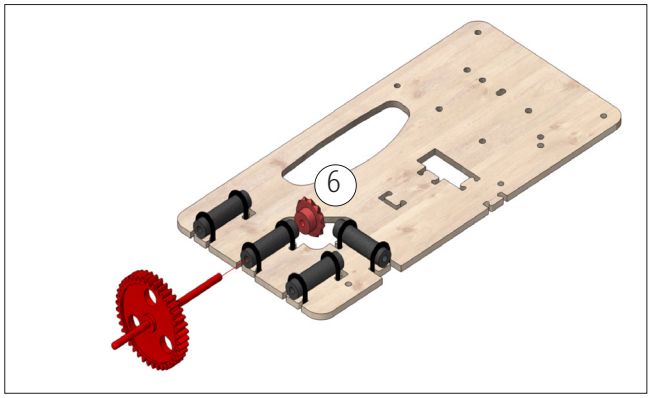

Like the worm gear, the bevel gear also changes the direction of the shafts by 90 degrees. In contrast to the worm gear but small translations are possible in the angular gear. Mostly used is 1: 1. Application example: Operating gear of skylights.



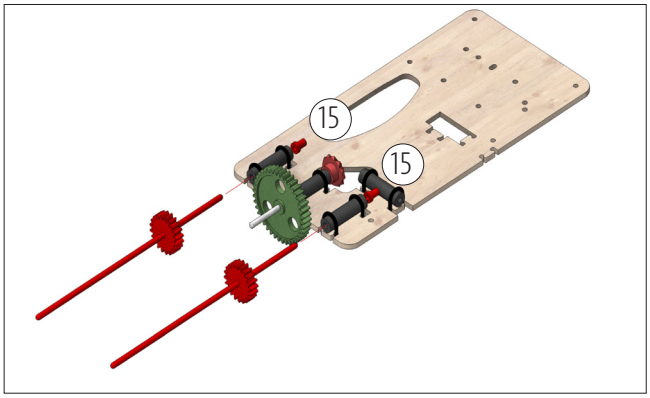

On each of the two axles (2), insert one toothed rod (5), 40 mm indented. Attach one gearwheel (4) about 25mm on an axle (3).



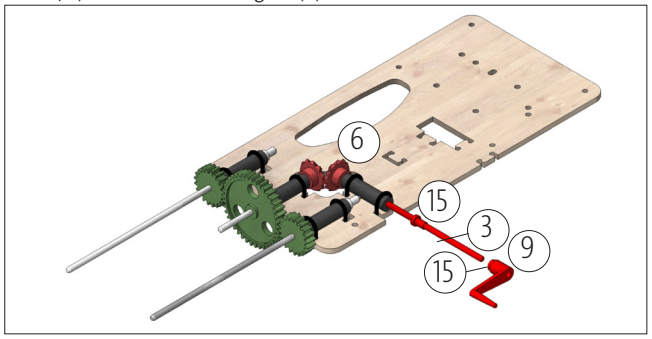

Attach 4 spacer wheels (12) with one O-rubber ring (13) at the intended locations (see illustration).




Insert the axle (3) with the gearwheel (4) through the middle spacer roller (12) and attach a bevel gear (6).




Insert the two axles (2) with the gearwheels (5) through the outer spacer rollers (12) as shown and fix them with one reducer (15) each.

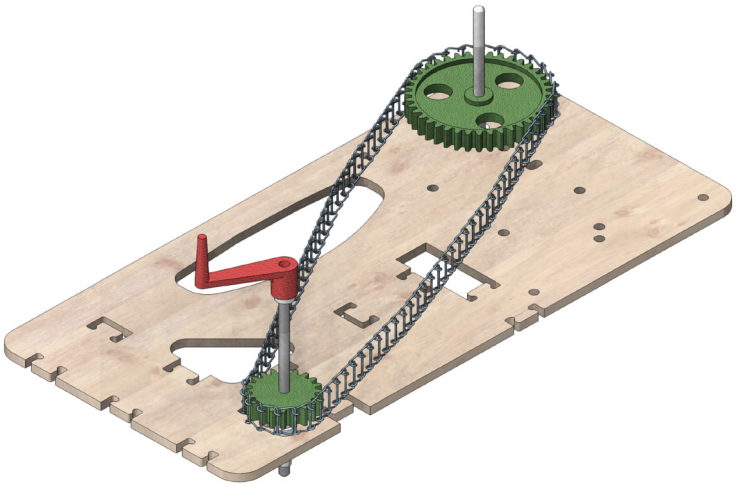


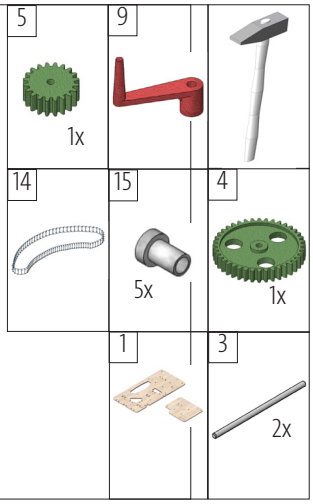

Slide one axle (3) through the side spacer wheel. Fit a bevel gear (6). Fix with a reducer (15). Insert a reducer (15) from below into the crank (9) and attach it to the axle as shown. Finished!



OPITEC

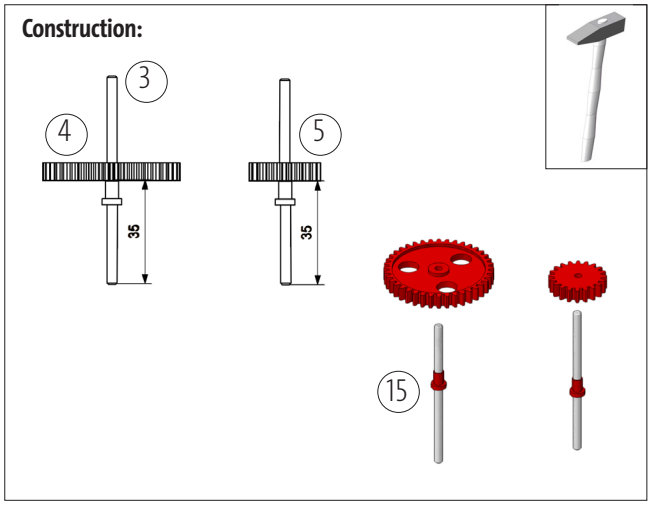
## 9 chain transmission



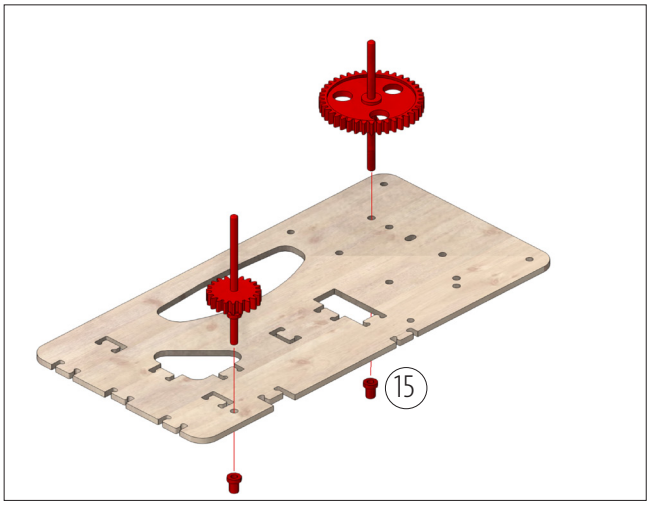



Since the chain drive transfers the forces positively, this drive is suitable for exact positioning and exact transmission ratios. This also applies to the toothed belt drive. Chain drives are among the traction drives and are used where there is a greater distance between the drive shaft and the output shaft. Example valve control in the car via timing chains or belts, as well as the bicycle chain.

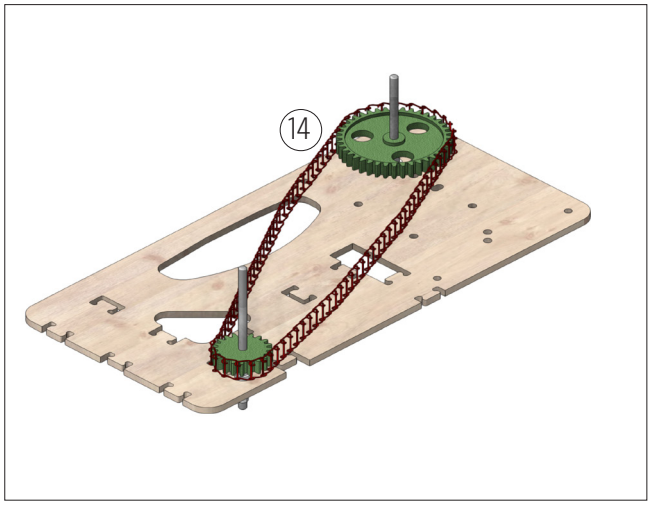
**Construction:**



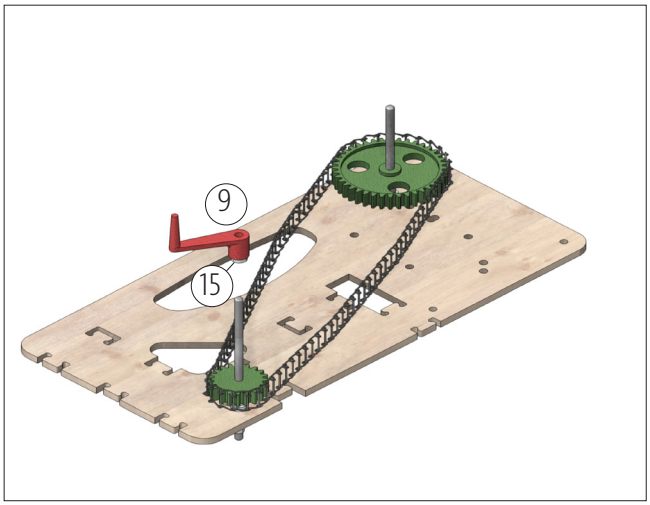

On an axle (3) a gear (4) and an axle (3) a gear (5) inserted 35mm indented. Attach 1 reducer (15) from below.




Insert the two axles (3) with the gearwheels (4/5) in the base plate as shown above and fix them with a reducer (15) from below.

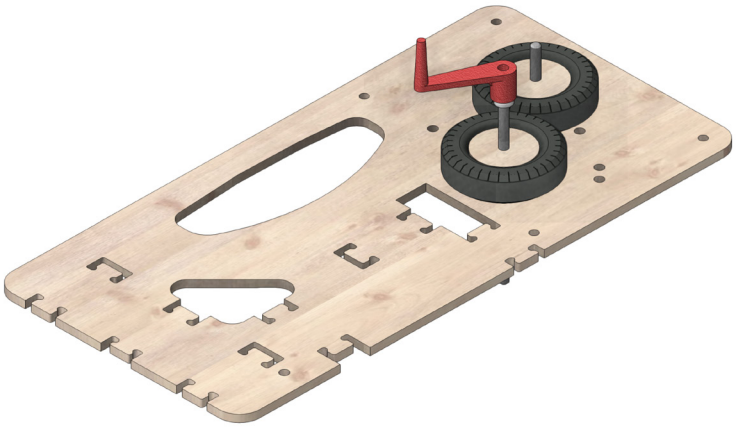


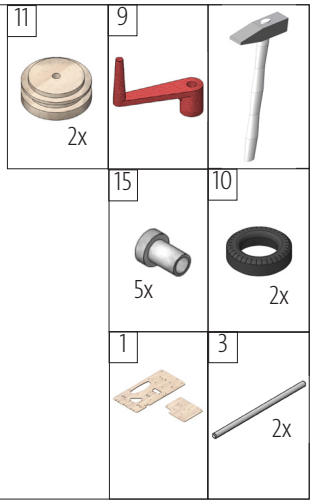

Attach the chain (14) as shown. Cut this to the appropriate length. (To shorten shorten chain links!)



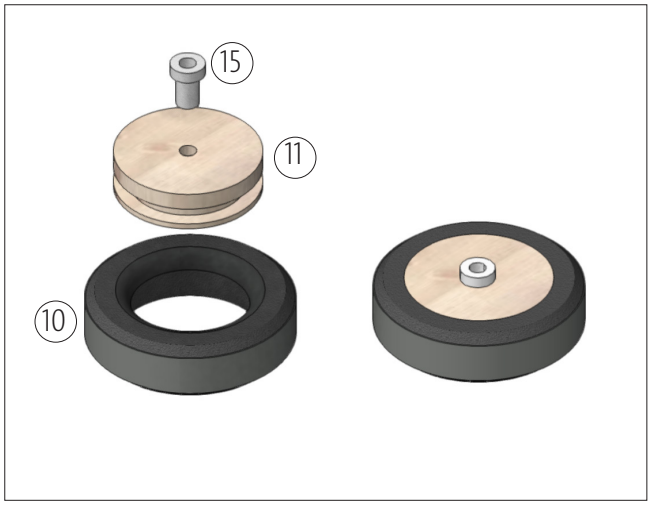

Insert a reducer (15) from below into the crank (9) and attach it to the axle (3) as shown. Finished!

## 10 friction gear



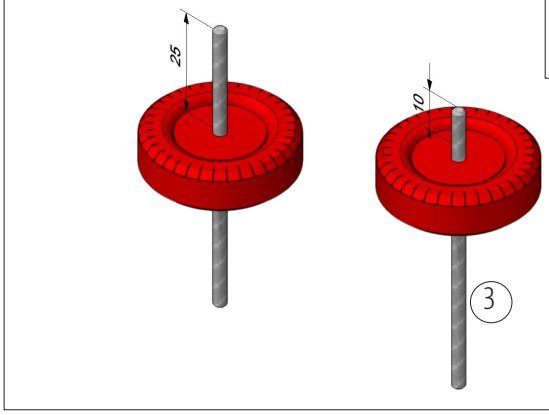



Friction gear units are used for rather modest drive tasks. The transmission of the circumferential forces is done by the friction that occurs between two pressed wheels or rollers. The disadvantages are slippage, relatively low transmittable torque, high wear and high friction losses. Advantages: It is cheap and easy to manufacture.

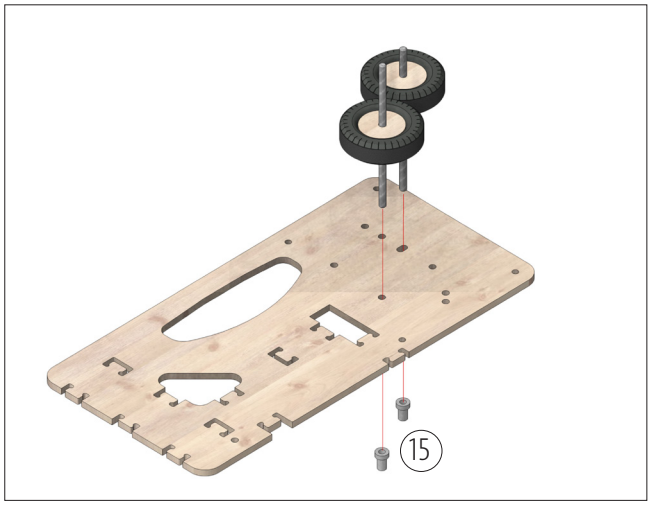



Insert one wooden rim (11) into one impeller (10). Insert a reducer (15) into each rim.

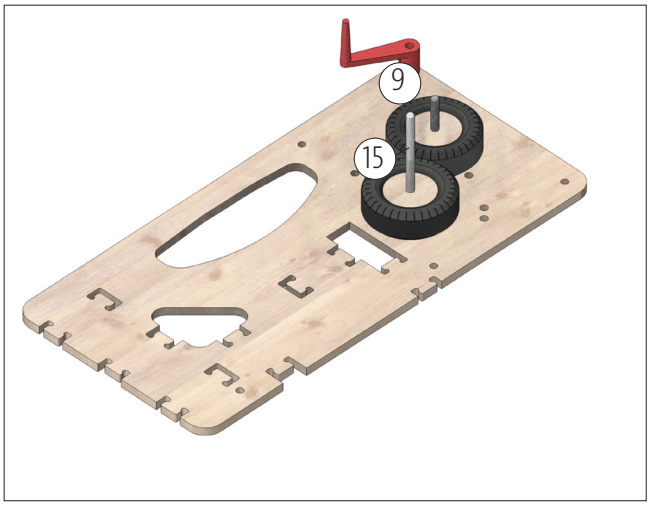
**Construction:**




Insert a wheel 25mm on an axle (3). Engage the other wheel 10mm on another axle (3).

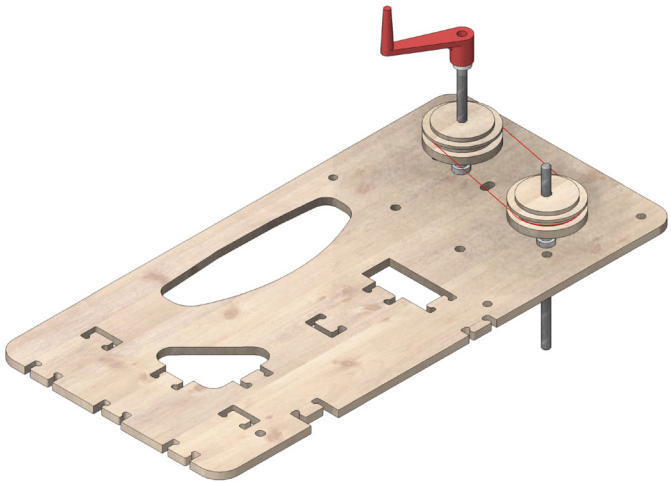


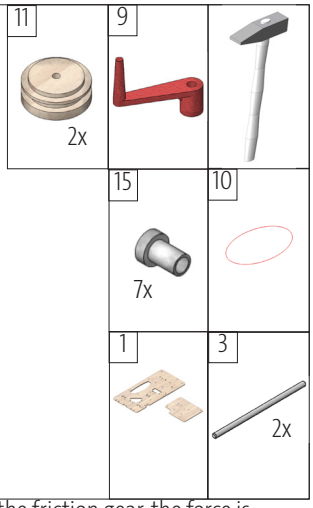

Insert the wheels on the axles into the base plate as shown and fix them with a reducer (15) from below.




Insert a reducer (15) from below into the crank (9) and attach it to the axle (3) as shown. Finished!

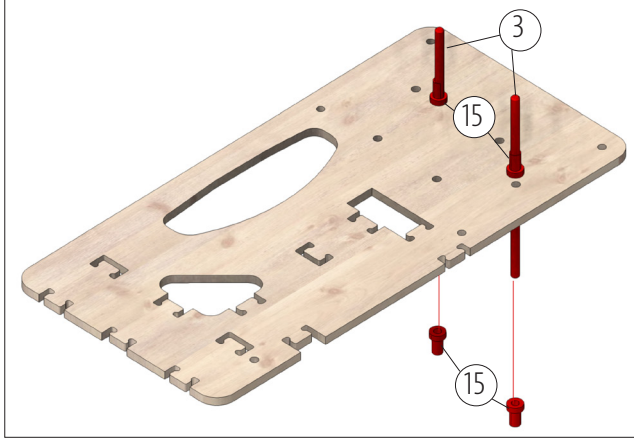
## 11 belt transmission



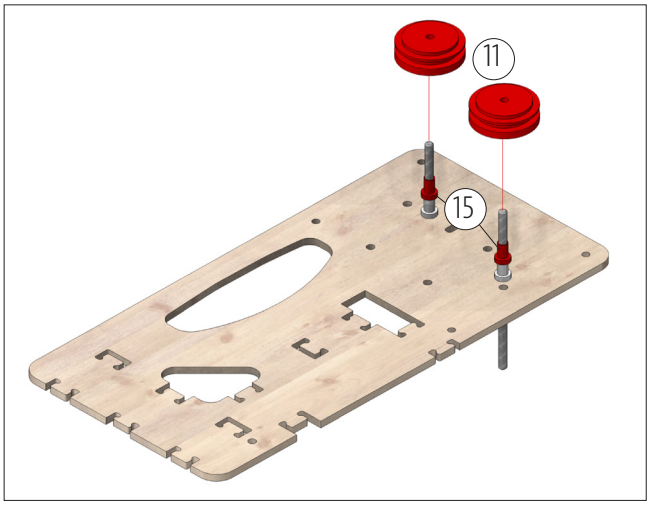



They are also part of the traction mechanisms. The best known examples are V-belts, flat belts, round belts. As with the friction gear, the force is transmitted by friction here. The biggest difference: the waves can be very far apart (in extreme cases several meters).
With V-belts very large torques can be transmitted because the spline of the belt is pulled into the keyway of the pulley. Advantage: inexpensive.

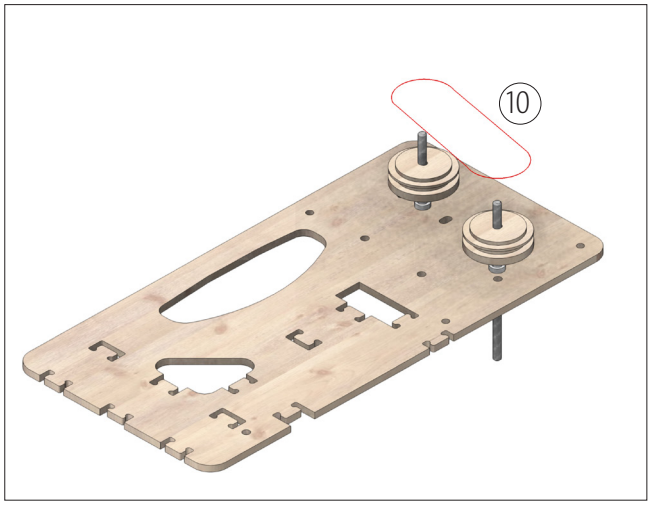
**Construction:**



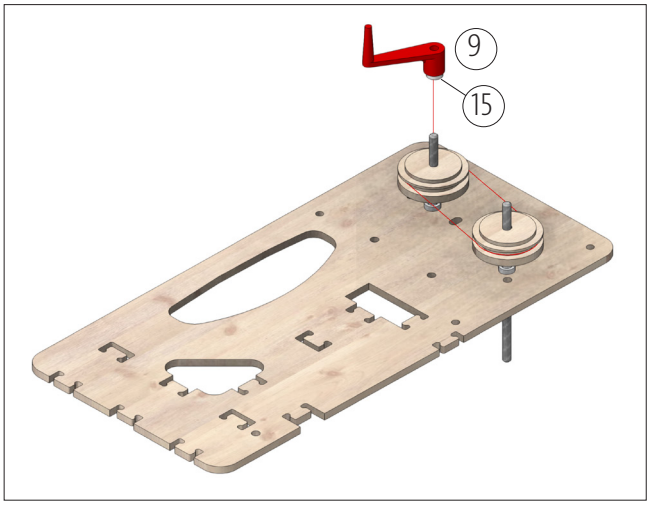

Insert two axles (3) through the base plate as shown, center them and fix them from above and below with a reducer (15).




Fit another reducer (15) on each axle and then attach a wooden rim (11).



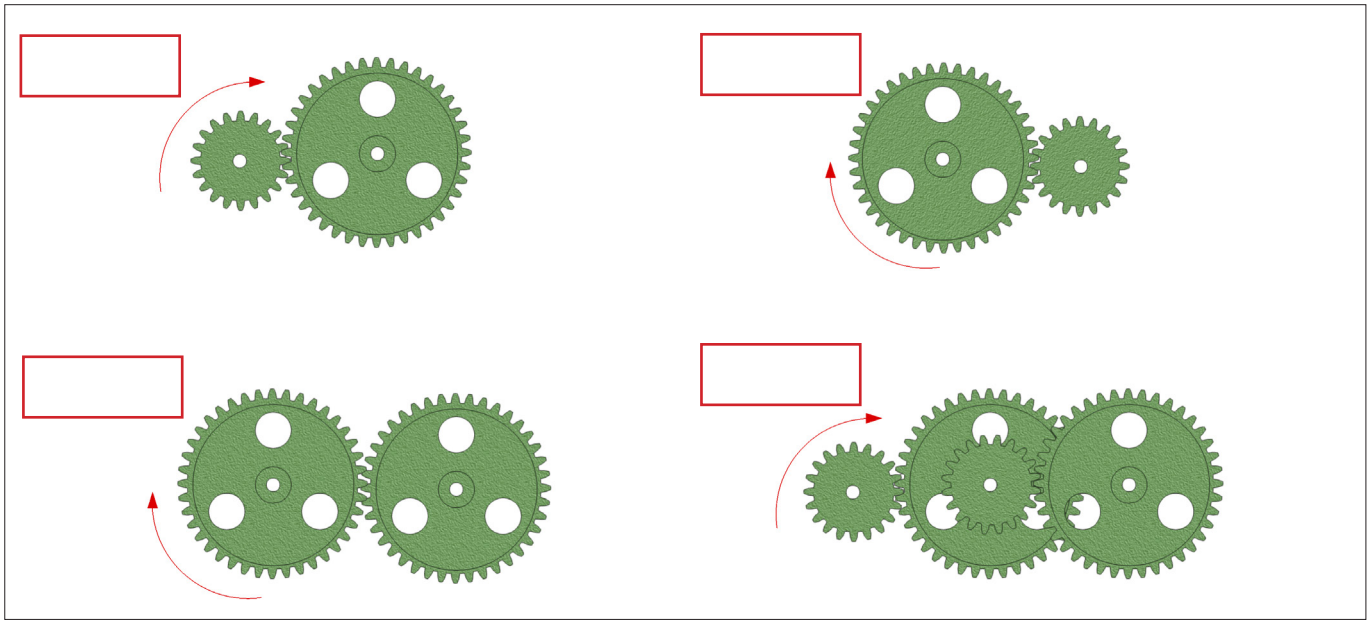

Fit the rubber ring (10) on the wooden rims (11).



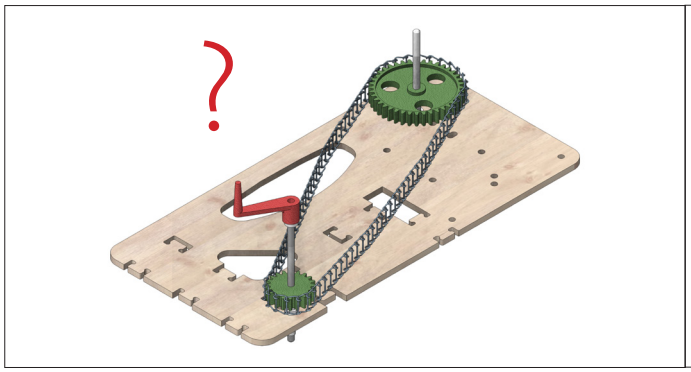

Insert a reducer (15) from below into the crank (9) and attach it to the axle (3) as shown. Finished!

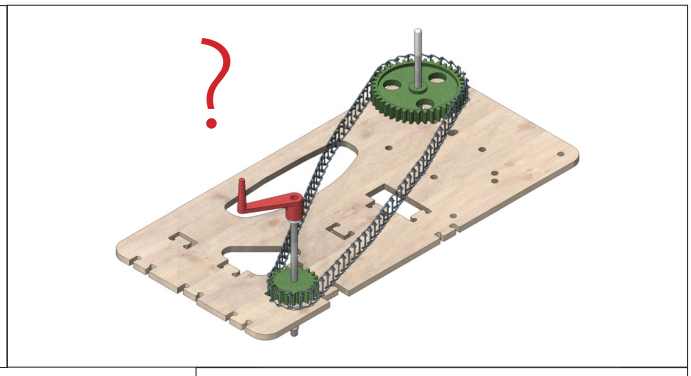
**Building Instructions 121.043**
**Gear Technology - Learning Program**
**TASKS:**

1. What kind of transmission are the following 4 examples?

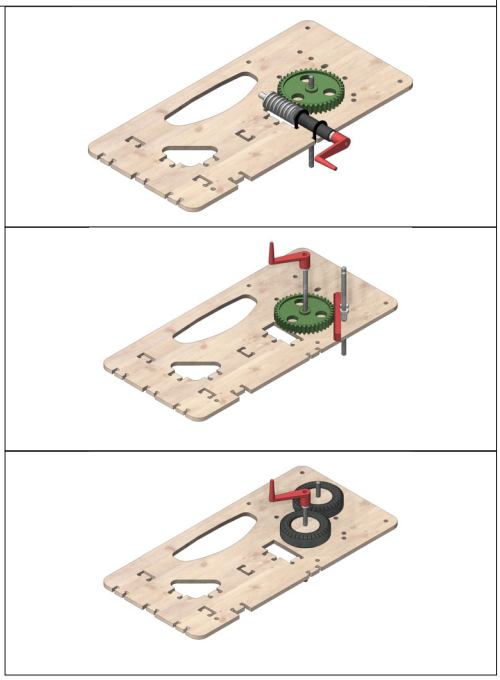


2. How can you ensure that the chain does not sag in a chain drive?
Name two options!




3. Why can the worm never be the output side of a worm gear?



4. With a rack and pinion gear is a rotating movement in one
Movement transformed.

5. A special form among the gears is the
because here the movement is not with gears or a chain / belt, but instead
transfer.



OPITEC

6. The blades of a windmill rotate four times a minute.
The attached grindstone but only twice.

Which formula do you use?
Calculate the gear ratio.

7. The drive gear of a spur gear has 99 teeth.
The abating gear has 33 teeth.

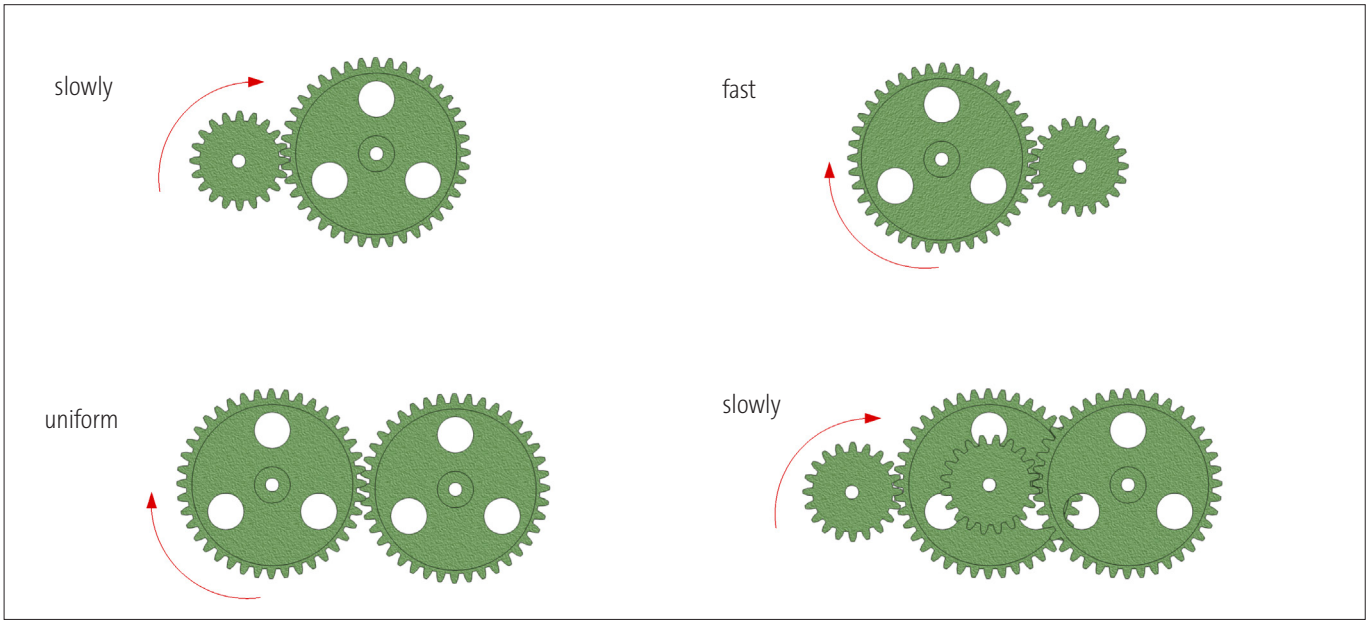
Which formula do you use?
Calculate the gear ratio.

8. Calculate the gear ratio of the friction gear
a turntable.
Diameter of the turntable 300mm
Diameter of the drive wheel 4mm
Which formula do you use?

9. For a drift with several gear ratios, the iG should be calculated!
Sufe 1 has a translation of i = 4: 1 - Level 2 has a translation of i = 8: 1 - Level 3 has a translation of i = 3: 1
Which formula is used to calculate $i_G$?

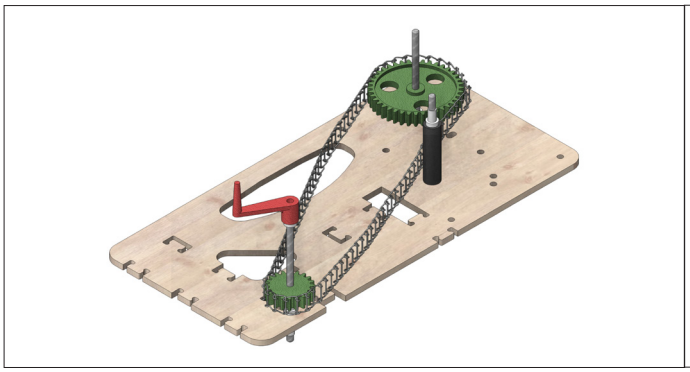
**Building Instructions 121.043**
**Gear Technology - Learning Program**
**SOLUTIONS:**

1. What kind of transmission are the following 4 examples?

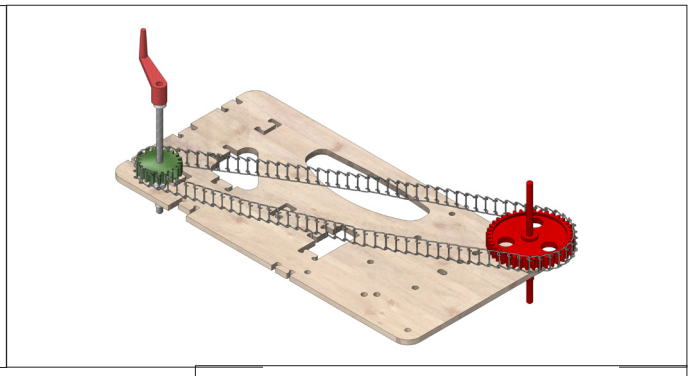



2. How can you ensure that the chain does not sag in a chain drive?
Name two options!

a) attach a tensioner pulley

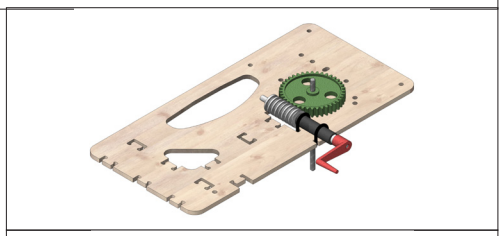


b) by moving a gear

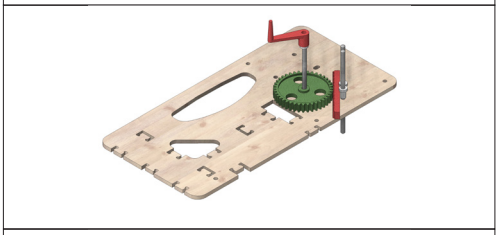


3. Why can the worm never be the output side of a worm gear?

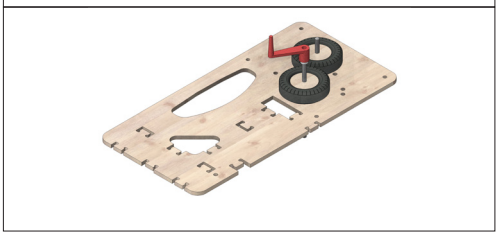
Because the worm knows how to inhibit a brake by itself, if not as a drive is being used.



4. With a rack and pinion gear, a rotating movement becomes a linear movement transformed.



5. A special form among the gearboxes is the Friction gear, because here is the movement not with gears or a chain / belt, but transmitted by friction.





OPITEC

6. The blades of a windmill rotate four times a minute.
The attached Mahlstein but only twice.

Which formula do you use?
Calculate the gear ratio.

$$i = \frac{n_2}{n_1} = \frac{4}{2} = 2:1$$

7. The drive gear of a spur gear has 99 teeth.
The abating gear has 33 teeth.

Which formula do you use?
Calculate the gear ratio.

$$i = \frac{z_2}{z_1} = \frac{33}{99} = 1:3$$

8. Calculate the gear ratio of the friction gear
a turntable.
Diameter of the turntable 300mm
Diameter of the drive wheel 4mm
Which formula do you use?

$$i = \frac{d_2}{d_1} = \frac{300}{4} = 75:1$$

9. For a drift with several gear ratios, the iG should be calculated!
Sufe 1 has a translation of i = 4: 1 - Level 2 has a translation of i = 8: 1 - Level 3 has a translation of i = 3: 1
Which formula is used to calculate $i_G$?

$$i_G = i_1 \text{ x } i_2 \text{ x } i_3 \text{ x } ..... = 4 \text{ x } 8 \text{ x } 3 = 96:1$$