Nguyen Duc Thang

3200 ANIMATED MECHANICAL MECHANISMS

With

Images,
Brief explanations
and YouTube links.

Part 1

Transmission of continuous rotation

31 March 2020

This document is divided into 4 parts.
Part 1: Transmission of continuous rotation
Part 2: Other kinds of motion transmission
Part 3: Mechanisms of specific purposes
Part 4: Mechanisms for various industries

Autodesk Inventor is used to create all videos in this document.
They are available on Youtube channel “thang010146”.

To bring as many as possible existing mechanical mechanisms into this document is author’s desire. However it is obstructed by author’s ability and Inventor’s capacity. Therefore from this document may be absent such mechanisms that are of complicated structure or include flexible and fluid links.

This document is periodically renewed because the video building is continuous as long as possible. The renewed time is shown on the first page.

This document may be helpful for people who
- have to deal with mechanical mechanisms everyday
- see mechanical mechanisms as a hobby

Any criticism or suggestion is highly appreciated with the author’s hope to make this document more useful.

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- Designer of small mechanical engineering enterprises in Hanoi.
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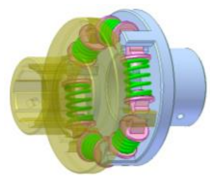
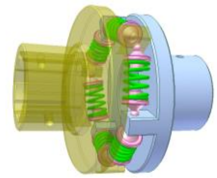
1. Continuous rotation transmission

1.1. Permanent couplings

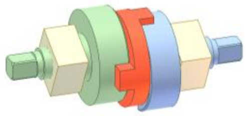
Chain drive 1C
http://youtu.be/FKuhi8hk96s
Chain coupling



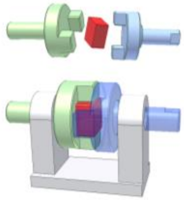
Coil spring coupling 1
http://youtu.be/CJ53SLiqGKQ
Due to revolution joints of the spring supports (in pink) this coupling can compensate a large offset of the shaft axes.
For this simulation:
Coupling outer dia. = 20 mm
Offset = 1 mm
Velocity variation is considerable.



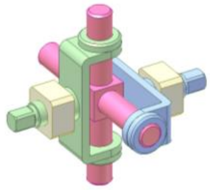
Coil spring coupling 2
http://youtu.be/xayBA5MaE2E
Due to spherical joints of the spring supports (in pink) this coupling can compensate a large offset of the shaft axes and a large angular misalignment between them.
For this simulation:
Coupling outer dia. = 20 mm
Offset = 1 mm
Angular misalignment = 4 deg.
Velocity variation is considerable.



Oldham coupling 1
http://www.youtube.com/watch?v=VPVxy9uW45E

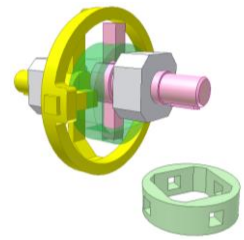


Oldham coupling 2
http://www.youtube.com/watch?v=M2IlDz_27GY
An embodiment of Oldham coupling
Axial dimenssion is reduced in comparison with “Oldham coupling 1”.

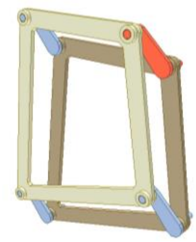


Oldham coupling 3
http://www.youtube.com/watch?v=OqpvbqdHgHc
An embodiment of Oldham coupling.
Axial dimenssion is reduced. Cylindrical joints are used instead of prismatic ones. It looks like Cardano coupling but it is totally diferent.

Oldham coupling 4
https://youtu.be/0vns5AZfPNk
An embodiment of Oldham coupling.
Axial dimenssion is reduced.

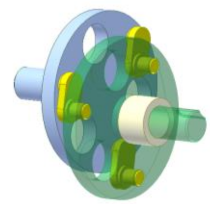


Parallel link coupling
http://www.youtube.com/watch?v=pkcdVQZubiM

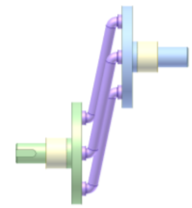


The absence of backlash makes this parallel coupling a precision, low-cost replacement for gear or chain drives that can also rotate parallel shafts. Any number of shafts greater than two can be driven from any one of the shafts, provided two conditions are fulfilled:
1. All cranks must have the same length.
2. The two polygons formed by shafts centers on the moving and grounded frames must be identical.
The main disadvantage of this mechanism is its dynamic unbalance. The moving frame should be made as light as possible. The mechanism can not be used for high speed.

Application of parallelogram mechanism 1
http://www.youtube.com/watch?v=7ihoj7SRZLg
Transmission of rotation movement between parallel shafts.

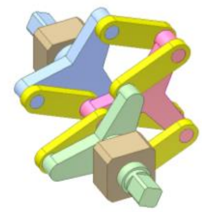


Application of parallelogram mechanism 2
http://www.youtube.com/watch?v=ZsThxf0OEuU
Transmission of rotation movement between parallel shafts



Application of parallelogram mechanism 3
http://www.youtube.com/watch?v=Bh0uDdx7z6M
Transmission of rotation movement between parallel shafts
The red disk rotates without fixed bearing.

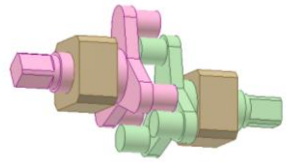
Schmidt coupling
https://youtu.be/ARs3y3i0enE
Transmission of rotation movement between parallel shafts.
The pink link rotates without fixed bearing.
Both shafts can move during transmission.



Pin coupling 1

http://www.youtube.com/watch?v=vjOqNd3c4rY

The pins are arranged on circles of equal radius on the two shafts

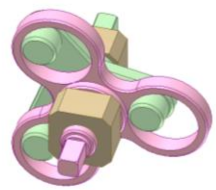


A = R1 + R2
A: Axis distance of the two shafts (eccentricity)
R1: Rose pin's radius
R2: Green pin's radius
Thus the coupling meets conditions of a parallelogram mechanism.
It is a constant velocity coupling.
Numbers of pins on the two shafts must be equal.

Pin coupling 2

http://www.youtube.com/watch?v=tYDqAES59C8

The pins and the holes are arranged on circles of equal radius on the two shafts

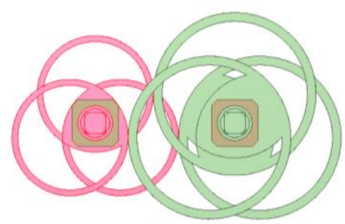


A = R2 - R1
A: Axis distance of the two shafts (eccentricity)
R2: Rose hole's radius
R1: Green pin's radius
Thus the coupling meets conditions of a parallelogram mechanism.
It is a constant velocity coupling.
This type of mechanism can be installed in epicyclic reduction gear boxes. See:
http://www.youtube.com/watch?v=MGVSRrI0ir4

Pin coupling 3

http://www.youtube.com/watch?v=xzwCuLT89EI

An embodiment of Pin Coupling 1
http://www.youtube.com/watch?v=vjOqNd3c4rY

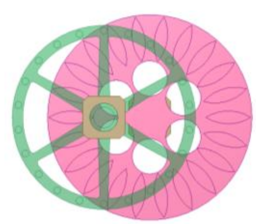


when R1 is different from R2 and pin's radius is larger than shaft's radius. Transmission ratio is 1.
The mechanism now looks like a gear drive but the two shafts rotate the same direction.
It has a high sensitivity to error in distance between the shaft axes.

Pin coupling 4

http://www.youtube.com/watch?v=1fe2QSs1HWY

An embodiment of Pin Coupling 1
http://www.youtube.com/watch?v=vjOqNd3c4rY



when R1 is different from R2, number of pins on each disks is 22. Pins on the pink disk is of lens shape because their radius is too large.
Transmission ratio is 1.

Pin coupling 5

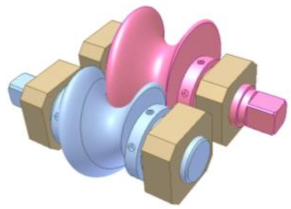
http://www.youtube.com/watch?v=QfiJSTRDASs

An embodiment of Pin Coupling 3

http://www.youtube.com/watch?v=xzwCuLT89EI

when:

- R1 is different from R2
- pins radius are larger than shafts radius
- number of pins is infinite so screw surfaces are created.



The working surface of the blue shaft is created when a circle of radius 10 (in the plane perpendicular to the shaft axis, its center is 5 from the shaft axis) moves along a helix of pitch 20. The working surface of the pink shaft is created similarly by a circle of radius 15 (in the plane perpendicular to the shaft axis, its center is 5 from the shaft axis) moving along a helix of pitch 20. Distance between the shafts is 25.

Transmission ratio is 1. The mechanism now looks like a gear drive but the two shafts rotate the same direction.

Pin coupling 7

http://www.youtube.com/watch?v=dTW8nhMjw-0

An embodiment of Pin Coupling1.

http://www.youtube.com/watch?v=vjOqNd3c4rY

when number of pins is infinite so screw surfaces are created.

The working surface of each shaft is created when a circle of radius 5 (in the plane perpendicular to the shaft axis, its center is 20 from the shaft axis) moves along a helix of pitch 40. Distance between the shafts is 10.

Transmission ratio is 1. The two shafts rotate the same direction.

The mechanism is pourely imaginary product, perhaps no practise application.

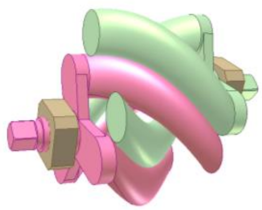
Pin coupling 8

http://www.youtube.com/watch?v=lC2GSi7deX4

An embodiment of Pin Coupling7

http://www.youtube.com/watch?v=dTW8nhMjw-0

when the number of working surfaces is 3.

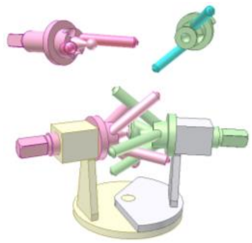


Transmission ratio is 1. The two shafts rotate the same direction.

The mechanism is pourely imaginary product, perhaps no practise application.

Pin universal joint

http://youtu.be/N_rHZwytmOk



It is a constant velocity joint.

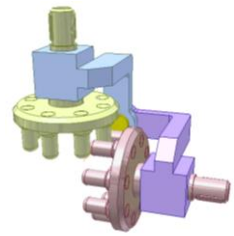
There is a spherical joint between pink shaft and green one.

For each shaft the opposite contact straight lines must be symmetric about the rotary axis and have a common intersection point with it.

Angle between the two shafts reaches up to 30 deg. in this video.

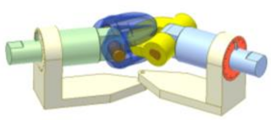
The mechanism can not be used for reversing rotation because of large backlash.

Finger coupling
https://youtu.be/QIYigaQ_Xzc



The coupling finds application in agricultural machines.
Relative angular position between two shafts can be adjusted to make the machines compact when not working (the coupling is folded up and the shafts are not aligned). The fingers are kept always in contact to maintain proper alignment, when the coupling is folded down.
Note: rotary axes of the shafts and rotary axis of the movable bearing are not concurrent.
The transmission is possible even when the shafts are not aligned.

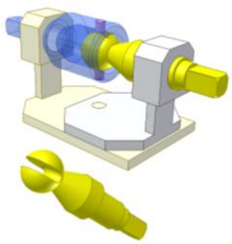
Universal joint 1
http://www.youtube.com/watch?v=rAM7YRCQWEc



Axles of the two shafts may be
1. Parallel and coincident
2. Parallel and distinct (with eccentricity)
3. Intersecting
4. Skew

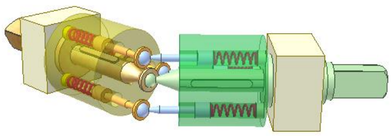
It is a constant velocity joint for cases 1, 2 and 3.
For details see:
http://meslab.org/mes/threads/20223-Khop-truc-ngam

Universal joint 2
http://youtu.be/NKaMj1oeP-Y



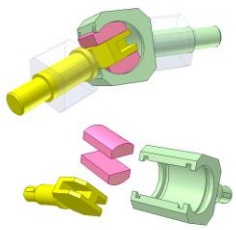
This low torque joint allows axial shaft movement.
The angle between shafts must be small.
Output velocity is not constant.

Universal joint 3
http://youtu.be/a_PbP0o-GOE



This pump type coupling has the reciprocating action of sliding rods in cylinders.
Centers of spherical joints are always in the plane that bisects the angle α between the two shafts even when α changes so it is a constant velocity joint.

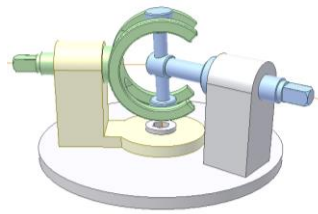
Universal joint 4
http://youtu.be/uDBj6MjhtLo

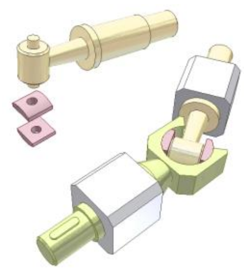


Joint for rotation transmission between two intersecting shafts.
Axes of three revolution joints must be concurrent.
Pink part has revolution joint with green shaft and planar joint with yellow shaft.
It is not a constant velocity joint.

Universal joint 5
https://youtu.be/QqLOhCZ1z_g
Joint for rotation transmission between two intersecting shafts (in grey and orange). The output shaft bearing can turn around the center of spherical joint between the two shafts.
It is a constant velocity joint because centers of spherical joints are always in the plane that bisects the angle α between the two shafts when α changes.

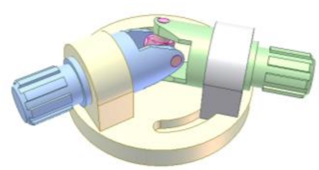
Universal joint 6
https://youtu.be/DTbrTTjtHHw
This video was made based on the design numbered as 879 in volume 2, Mechanisms in modern technic, I. Artobolevski.
It’s a spherical mechanism.
Axes of all revolution joints are concurrent.
Joint between input blue shaft and output green shaft is cylinder on plane one.
It works like a Cardano joint. Output velocity is not constant.



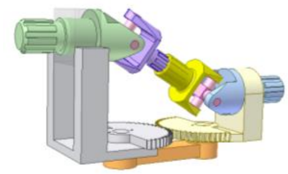


Cardan universal joint 1
https://youtu.be/4z8YScREiIA
A structure embodiment of ordinary Cardan joints.

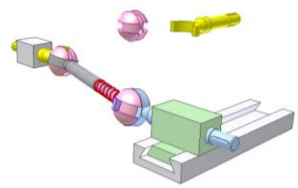
Study of Cardan universal joint 1
http://youtu.be/ZQt6cAmsgXQ
Universal joints allow to adjust A angle between input and output shafts even during rotary transmission. This case shows +/- 45 deg regulation. It is clear that single Cardan joint is not of constant velocity when A differs from 0 deg.



Study of double cardan universal joint 1a
http://youtu.be/gBoJT_Pl-RA
Double Cardan drives allow to adjust relative linear positions between the input and output shafts even during rotary transmission. The output velocity is always equal to the input one (constant velocity joint) because their shafts are kept parallel each other.
The pin axles on the intermediate half shafts (in yellow and in violet) must be parallel each other.

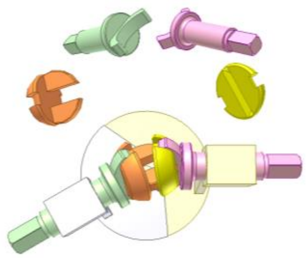


Double Cardan universal joint
https://youtu.be/aQrnXWo4DxE
Advantage: easy assembly but for light duty only.
Red spring maintains revolution joints between pink spheres and the shafts when center distance of the spheres changes.
Animation defect: red spring does not rotate together with the shafts.



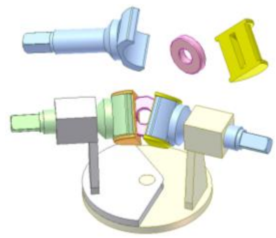
Tracta joint 1
http://youtu.be/IFQgH73W2Ao
It is a constant velocity joint.
There are a revolution joints between:
- orange male swivel and yellow female swivel.
- orange male swivel and green shaft
- yellow female swivel and pink shaft

Axes of cylindrical surfaces on each swivel are skew to each other at an angle of 90 deg.
The video shows the transmission when angle between two shafts is 0 deg. and then 30 deg.

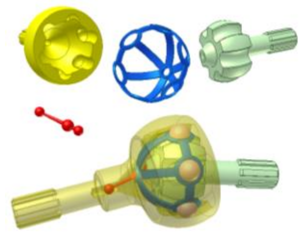


Tracta joint 2
http://youtu.be/qg8MpZYZjFE
It is a constant velocity joint, an embodiment of mechanism shown in “Tracta joint 1”.
Yellow swivel and orange one are identical.
There are a revolution joints between:
- orange swivel and pink disk.
- yellow swivel and pink disk.
- orange swivel and green shaft
- yellow swivel and blue shaft

Axes of cylindrical surfaces on each swivel are skew to each other at an angle of 90 deg.
The video shows the transmission when angle between two shafts is 0 deg. and then 25 deg.

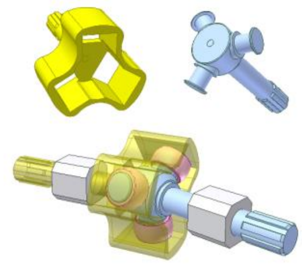


Rzeppa joint 1
http://youtu.be/6thw8xPt6ro
Red bar and yellow shaft create a joint of class II (allowing four degrees of freedom).
Red bar and green shaft create a joint of class II.
Red bar and blue retainer create a spherical joint.
With this arrangement, the plane containing ball centers almost always remains in a plane that bisects the angle α between the two shafts when α changes. See: “Slider crank and coulisse mechanism 1”
http://youtu.be/SdwIGoJ-3ag
The video shows the transmission when α is 0 deg. and then 30 deg.
The output shaft rotates nearly regularly with max error of 1.5% at α = 30 deg.



Tripod joint 1

http://youtu.be/U5TV5NC5YOg



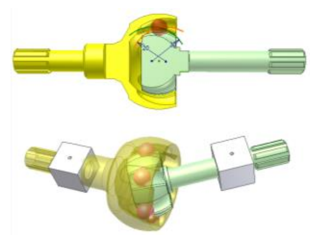
Pink spherical rollers slide in grooves of yellow shaft. Changes in the drive angle causes the rollers to move backwards and forwards along the grooved track as the joint rotates through one revolution. A small clearance is given between the roller and track to permit this movement.

The video shows the transmission when α (angle between two shafts) is 0 deg. and then 15 deg.

The simulation shows that the output shaft rotates nearly regularly with max error of 3.4% at α = 15 deg.

Birfield joint 1

http://youtu.be/OSTdCr-BcPc

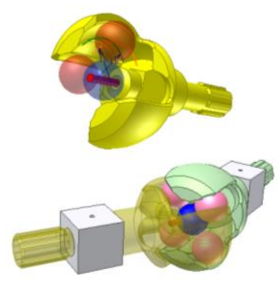


There is an offset between center of circular grooves on each shaft and the clutch center (see upper picture). Balls are positioned by the contact with the grooves.

With this arrangement, the plane containing ball centers always remains in a plane that bisects the angle α between the two shafts when α changes to meet condition of constant velocity.

Weiss joint 1

http://youtu.be/euihZOu3Cb0



There is an offset between center of circular grooves on each shaft and the clutch center (see upper picture). Each pink ball is positioned by the contact with grooves on both shafts and blue central ball. The latter can rotate around red pin.

With this arrangement, the plane containing ball centers always remains in a plane that bisects the angle α between the two shafts when α changes to meet condition of constant velocity.

Spherical 4R mechanism 1b

http://youtu.be/BPMh7hd-ZNU

Spherical: Joint center lines intersect at a common point.

Angle between center lines of revolute joints:

for the orange input link is γ = 20 deg.

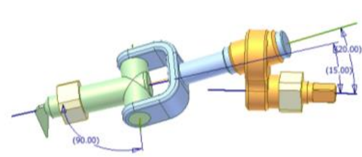
for the green output link is β = 90 deg.

for the blue link is α = 90 deg.

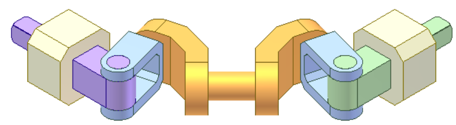
for the base link is δ = 15 deg.

The output link revolves irregularly.

Its 1 rev. corresponds 1 rev. of the orange input link.

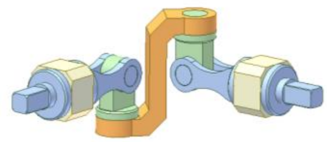


Angular Transmission 4R Mechanism 2
http://www.youtube.com/watch?v=JgLKdfQHUSg



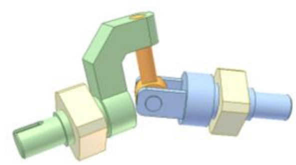
Two spherical 4R mechanisms are connected back to back.
4R: 4 revolute joints.
In each mechanism the center lines of 4 revolute joints intersect at a common point.
The angle between center lines of revolute joints for the orange link is not 90 deg. (rather than Cardan joints).
Angle between the input and output is A = 90 deg.
Angle between cylinder of the orange link and the input shaft is B = A/2 = 45 deg.
This condition makes the mechanism a constant-velocity joint.
The orange link rotates without fixed bearing.

Angular Transmission 4R Mechanism 1
http://youtu.be/LI996IZQUoU



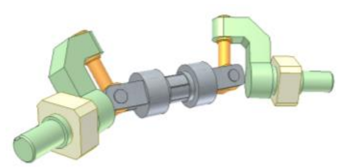
This is the double Cardan.
Angle between the input and output is A = 90 deg.
The orange S-link has a virtual axle.
Angle between the virtual axle of the orange S-link and the input shaft is B = A/2 = 45 deg.
This condition makes the mechanism a constant-velocity joint.
The orange link rotates without fixed bearing.

Spherical 4R mechanism 2a
http://youtu.be/o9RZ3goLvWA



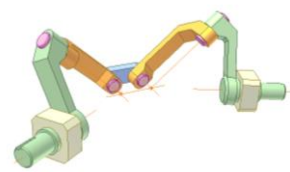
Axles of revolution joints must be concurrent.
Input: Green shaft, constant speed.
Output: Blue shaft, variable speed.

Spherical 4R mechanism 2b
http://youtu.be/4XJBJdCt8eY



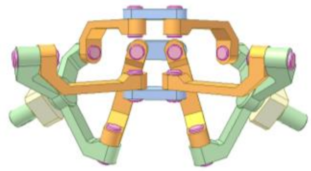
Combination of two "Spherical 4R mechanism 2a".
It is a constant velocity joint.

Spherical 4R mechanism 2c
http://youtu.be/pjVjGtRy6T4

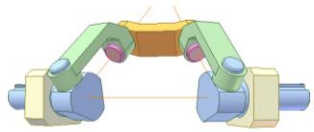


Modification of "Spherical 4R mechanism 2a" and "Spherical 4R mechanism 2b".
It is a constant velocity joint.

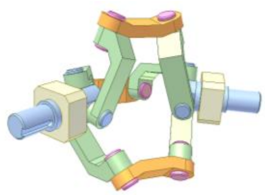
Spherical 4R mechanism 2d
http://youtu.be/mFoiSRWdW5E
Persian joint.
It is a modification of "Spherical 4R mechanism 2c" by adding more connecting rods for balancing.
It is a constant velocity joint.



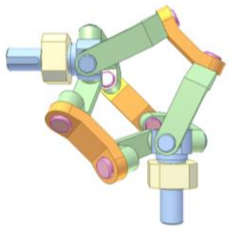
Spherical 4R mechanism 2e
http://youtu.be/SqQ9FLh9ktM
Modification of "Spherical 4R mechanism 2a" and "Spherical 4R mechanism 2b".
It is a constant velocity joint.



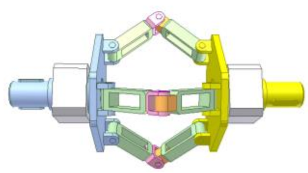
Spherical 4R mechanism 2f
http://youtu.be/vH8r3lC-Fm4
Persian joint.
It is a modification of "Spherical 4R mechanism 2e" by adding more connecting rods for balancing.
Acute angle between input and output shafts is 60 deg.
It is a constant velocity joint.



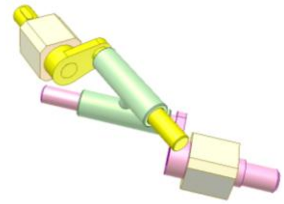
Spherical 4R mechanism 2g
http://youtu.be/M0whLy5hPzg
Persian joint.
It is a modification of "Spherical 4R mechanism 2e" by adding more connecting rods for balancing.
Angle between input and output shafts is 90 deg.
It is a constant velocity joint.



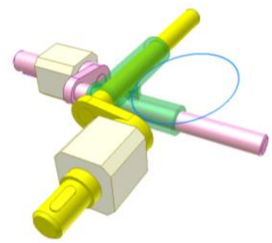
Rotation transmission of Canfield joints
https://youtu.be/inTHD56p20s
The simulation shows Canfield joint is not universal one.
Transmission between two coaxial shafts with axial displacement is possible as shown in this video.
The transmission is impossible for other relative positions of two shafts (offset, intersection, skew).



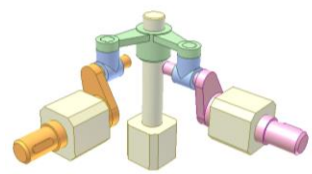
Shaft coupling for shafts out of line 1
https://www.youtube.com/watch?v=BurU2KrBbo8
The green solid block is bored at the same angle (α = 45 deg.) of the shafts and centres of the bores at a distance apart equal to the difference in the plane of shaft alignment.
It is constant velocity coupling.



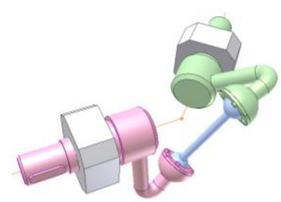
Shaft coupling for shafts out of line 2
https://www.youtube.com/watch?v=JqJCBplyAZY
The green solid block is bored at the same angle (α = 90 deg.) of the shafts and centers of the bores at a distance apart equal to the difference in the plane of shaft alignment.
It is constant velocity coupling.
The blue ellipse is locus of center point of the green block. It is in bisectional plane of two vertical planes containing shaft axes.
In term of movable joints the mechanism is similar to a planar Oldham coupling.
If α = 0 deg. the mechanism turns into a planar parallelogram (rhombus) one.



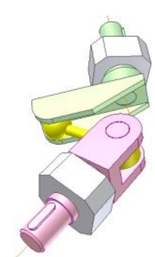
Right angle shaft transmission 1
https://www.youtube.com/watch?v=lEp0svfr5-Q
A green bell crank sliding on a fixed cross bar is pivoted at its ends to blue sleeves that slide on pins of two perpendicular shafts.
It is constant velocity coupling.
In comparison with bevel gear drive of transmission ratio 1/1 the direction of the output in this mechanism is reversed.



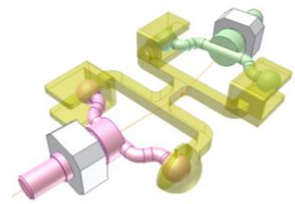
Universal joint of 4 links 1
https://youtu.be/XzOKRWZaOqE
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
It is not a constant velocity joint.
The video shows case when the input pink shaft axis intersects with the output green one at angle of 45 deg.



Universal joint of 4 links 2
https://youtu.be/980YniUbh3s
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
It is not a constant velocity joint.
The video shows case when the input pink shaft axis intersects with the output green one at angle of 45 deg.



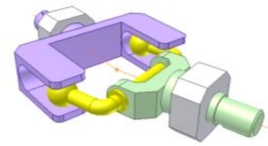
Universal joint of 4 links 3
https://youtu.be/RB6WbOpPPHE



It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
Unusual thing: two links are connected together via two joints (not one joint):
- Yellow part is connected to the input pink shaft via a spherical joint and a point-on-plane joint.
- Yellow part is connected to the output green shaft via a point-on-line joint and a point-on-plane joint.

The simulation shows that it is a constant velocity joint except the case when the input and outpot shafts are skew.
The video shows case when the shafts intersect with one another at angle of 15 deg.

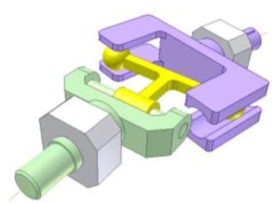
Universal joint of 4 links 4
https://youtu.be/_OxPtP0zpaY



It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
- Yellow bar is connected to the green shaft by a revolution joint.
- Yellow bar is connected to the violet shaft by point-on-plane joints

It is not a constant velocity joint, when the input green shaft axis intersects with the output violet one. The video shows case of 15 deg. intersecting angle.
It is a constant velocity joint, when the input and output shafts are parallel.

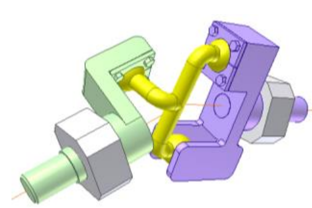
Universal joint of 4 links 5
https://youtu.be/2MKAO2dnpNQ



It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
- Yellow bar is connected to the green shaft by a cylindrical joint.
- Yellow bar is connected to the violet shaft by a point-on-plane joint and a point-on-line joint.

It is not a constant velocity joint, when the input green shaft axis intersects with the output violet one.
The video shows case of 15 deg. intersecting angle.
It is a constant velocity joint, when the input and output shafts are parallel.

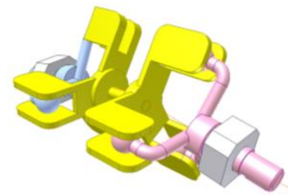
Universal joint of 4 links 6
https://youtu.be/6KcwpvtiGeo



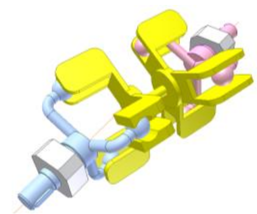
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
- Yellow bar is connected to the green shaft by a spherical joint.
- Yellow bar is connected to the violet shaft by a point-on-plane joint and a spherical joint.

It is not a constant velocity joint.
The video shows case when the input green shaft axis intersects with the output violet one at angle of 30 deg.

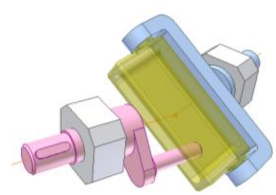
Universal joint of 4 links 7a
https://youtu.be/uut_Zo7GVHs
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
- Yellow part is connected to the input pink shaft via 3 point-on-plane joints.
- Yellow part is connected to the output blue shaft via a point-on-line joint and 2 point-on-plane joints.
The simulation shows that it is a constant velocity joint.
The video shows case when the shafts intersect with one another at angle of 20 deg.



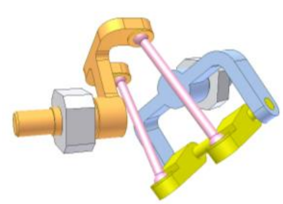
Universal joint of 4 links 7b
https://youtu.be/U_WSFQ6rtr8
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
- Yellow part is connected to the input pink shaft via 3 point-on-plane joints.
- Yellow part is connected to the output blue shaft via a point-on-line joint and 2 point-on-plane joints.
The simulation shows that it is a constant velocity joint.
The video shows case when the shafts are parallel.



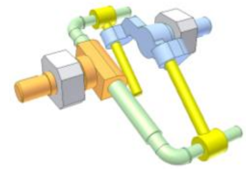
Universal joint of 4 links 8
https://youtu.be/lhqOR0uKlxM
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
Yellow bar is connected to the blue shaft by a revolution joint and to the pink shaft by a line-on-plane joint.
It is not a constant velocity joint.
The video shows case when the input blue shaft axis intersects with the output pink one at angle of 20 deg.



Universal joint of 6 links 1
https://youtu.be/0RSz1hXyQqo
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
The video shows case when input orange shaft and output blue shaft are skew.
In general it is not a constant velocity joint except the case when the shafts are in line.

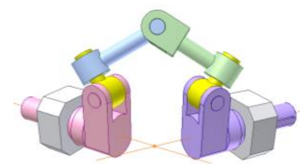


Universal joint of 6 links 2
https://youtu.be/Q7xCjbTkD6Y
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
In general it is not a constant velocity joint except the case when input orange shaft and output blue shaft are parallel as shown in this video.



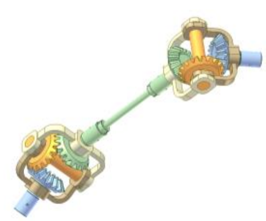
Universal joint of 7 links 1
https://youtu.be/s3un5KcgcEA
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
In general it is not a constant velocity joint except the case when the shaft axes intersect with one another as shown in this video.
Here the intersecting angle is 45 deg.

Universal joint of 7 links 2
https://youtu.be/pBOK2VECJ3Q
It is used for rotation transmission between the shafts, relative position of which in space is arbitrary.
In general it is not a constant velocity joint except the case when the shaft axes intersect with one another as shown in this video.
Here the intersecting angle is 60 deg.



Bevel Gear Coupling 1
http://www.youtube.com/watch?v=OlQWXFE-yo4
Rotation directions of the drive and driven shafts are opposite.
Angle between them can be ±75 degrees.

Bevel Gear Coupling 2
http://www.youtube.com/watch?v=stswj7cXV0w
Combination of two bevel gear couplings.
Relative position of two shafts can be arbitrary, even skew.



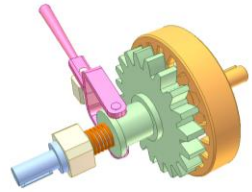
1.2. Clutches

1.2.1. Operator controlled clutches

1.2.1.1 Non-reverse clutches

Toothed clutch

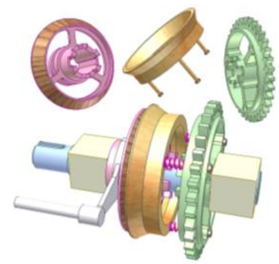
http://www.youtube.com/watch?v=KKOPif_yF8M



The orange shaft is driving. The clutch is connected by the spring force (manual force is possible).
Positioning device for the pink lever at the clutch's disconnected position is not shown.

Synchronic toothed clutch 1

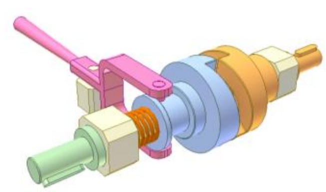
http://youtu.be/On1vXQ_ATu4



Input is blue shaft with which pink male cone disk has sliding joint. Output is green gear (having face teeth) with which orange female cone disk has sliding joint due to three bolts.
To connect the clutch move the pink disk to the right (via the grey shifter). At first it makes the orange disk and the green gear rotate to some extend due to friction at cone surfaces to ease teeth engagment proccess after.

Jaw clutch

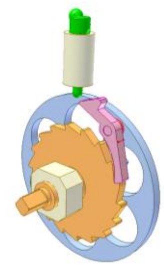
http://youtu.be/A6Az-YjwgeA



The orange shaft is driving. The clutch is connected by the spring force (manual force is possible).
Positioning device for the pink lever at the clutch's disconnected position is not shown.

Ratchet clutch

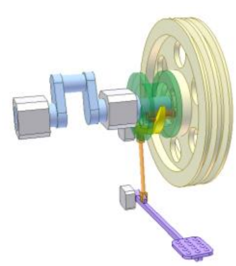
http://youtu.be/4tz_Q8LhK90



The pink pawl connects the orange driving shaft to the blue driven one.
To rotate the green pin of helix slot for controlling the clutch.

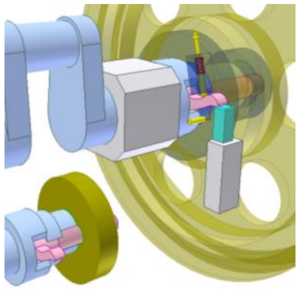
Pin clutch

http://youtu.be/wcYKttiovDA

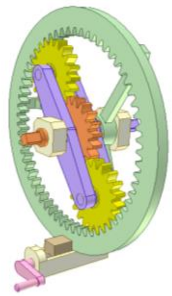


Clutch for small-size eccentric presses.
The big pulley rotates continuously. For connecting the clutch push down the violet pedal to allow the pin come into contact with curve slots on the pulley under the pink spring's force.
The spring for return the pedal after pushing is not shown.
Keep pushing down the pedal to make the crankshaft rotate continuously.

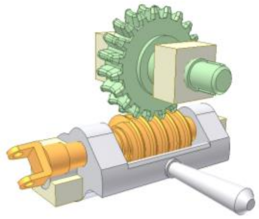
Rotary key clutch
http://youtu.be/f6q34XHP5Aw
Clutch for medium-size eccentric presses.
The big pulley rotates continuously. For connecting the clutch, step on a pedal (not shown) to pull down the green slider. Then the pink rotary key can rotate (under the red spring's force) when it meets the slot in the big pulley hole, thus makes the crankshaft rotate.
The green slider goes up to disconnect the clutch.
Keep down the pedal to make the crankshaft rotate continuously.
The small picture shows how the rotary key rotates in round hole between the crankshaft and the big pulley when they are immobile.



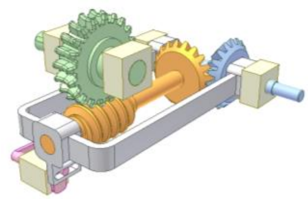
Planetary clutch
http://youtu.be/15vsNsWEdBM
The orange gear is input. The violet carrier is output.
Using the pink screw to hold or release the internal gear, hence to let the output carrier rotate or pause.
When the internal gear is released, the system has two degrees of freedom. However the load at the output carrier keeps it immobile to eliminate one.



Worm gear clutch 1
http://youtu.be/MXFlmvrsrrE
There is an eccentricity between the rotary axis of orange worm and the one of the grey bracket.
Teeth on the worm and on the wheel must be rounded to ease the engagement process.
Positioning device for the bracket is not shown.
The clutch connection should be done when the driving shaft stops
Double Cardan joint (not shown) is used for transmitting motion to the worm.



Worm gear clutch 2
http://youtu.be/s85DSggAZmI
Turn pink lever (having an eccentrical pin) to raise or lower left end of the orange shaft thus to connect or disconnect the clutch.
Teeth on the worm and on the wheel must be rounded to ease the engagement process.
Positioning device for the lever is not shown. The clutch connection should be done when the driving shaft stops
Instead of bevel gear drive, double Cardan joint can be used for transmitting motion to the worm.
This idea is taken from US patent 20110247440 A1.

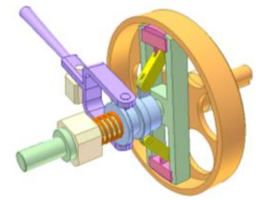


Friction clutch 1

http://youtu.be/_FKePQ8PvY0

The orange shaft is driving. The clutch is connected by the spring force (manual force is possible).

Positioning device for the violet lever at the clutch's disconnected position is not shown.

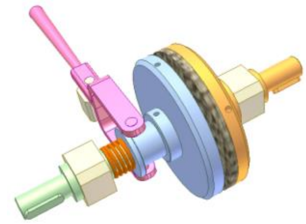


Friction clutch 2

http://youtu.be/NOwp_BQpNqw

The orange shaft is driving. The clutch is connected by the spring force (manual force is possible).

Positioning device for the pink lever at the clutch's disconnected position is not shown.



Friction clutch 3

http://youtu.be/_mMIk3RcPA0

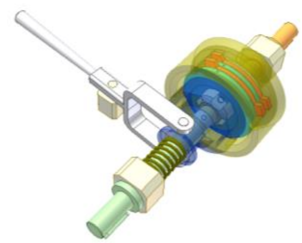
Multiple-disk clutch.

The orange shaft and the yellow cylinder are driving. The two orange outer disks are slidingly splined in the yellow cylinder.

The green shaft is driven. The blue part and the two green inner disks are slidingly splined on the green shaft.

The clutch is connected by the spring force which presses inner disks and outer disks together through the blue part (manual force is possible).

Positioning device for the white lever at the clutch's disconnected position is not shown.

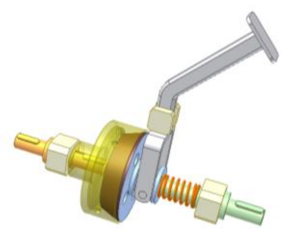


Friction clutch 4

http://youtu.be/QqaWJ7PDSg8

Cone clutch.

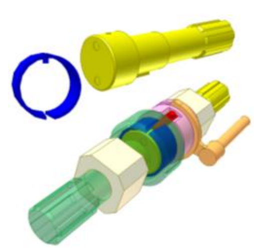
The orange shaft is driving. The clutch is connected by the spring force. To step on the white pedal to disconnect the transmission.



Friction clutch 5

http://youtu.be/JlQ0v77oGtE

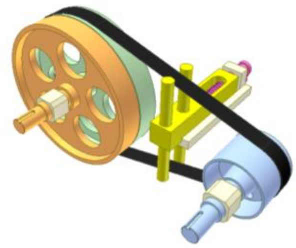
Blue elastic bush is fixed on the yellow driven shaft by a pin. Pink bush carrying red wedge has sliding key joint with the yellow shaft. When the pink bush moves to the left, the red wedge expands the elastic bush. The latter goes into contact with the inner cylindrical surface of the green driving shaft thus connects the clutch by friction.



Belt clutch 1

http://youtu.be/fM-OMJnaLks

The blue pulley is driving The orange one is driven.. The green one is idle. To rotate the pink crank to move the yellow slider for clutch controlling.



Belt clutch 2

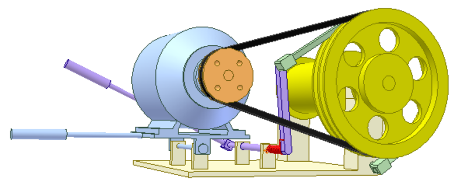
http://youtu.be/83NuMbT_M7Y

The orange pulley is driving. The yellow one is driven.

Using the blue lever to move the orange pulley closer to the yellow pulley to stop the transmission.

The violet lever is for braking the driven pulley when it stops or rotates back under the lowered object's weight.

The red spring is for returning the violet lever.



1.2.1.2 Reverse clutches

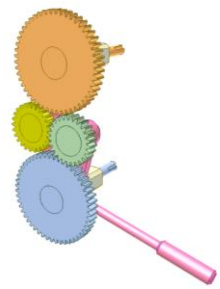
4-Roller clutch

http://youtu.be/15vsNsWEdBM

The blue roller is driving The orange one is driven.
The two small rollers are idle.
Using the pink arm to stop or reverse the orange roller's rotation.
The mechanism's weakness is needed measures to create pressure at the contact places of the blue, green and yellow rollers (not shown).

4-Gear clutch

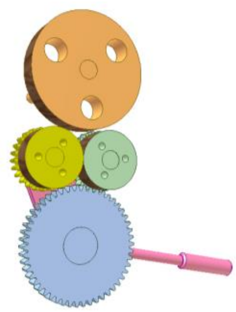
http://youtu.be/9pCcmDICEOQ



The blue gear is driving. The orange one is driven.
The two small gears are idle.
Using the pink arm to stop or reverse the orange gear's rotation.
Measure for fixing the pink arm at its three working positions is not shown.
The mechanism's weakness is the possible collision of the orange gear and the two small gears.

Gear and Roller clutch

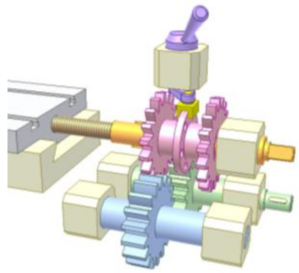
http://youtu.be/GcGHLRV7cnE



The blue gear is driving. The orange roller is driven.
The two gear and roller combinations are idle.
Using the pink arm to stop or reverse the orange gear's rotation.
The mechanism does not have the weaknesses shown in 4-roller clutch or in 4-gear clutch:
http://youtu.be/15vsNsWEdBM
http://youtu.be/9pCcmDICEOQ

Reverse mechanism 1

http://youtu.be/Hc22Jqs8FhY



Violet lever has 3 positions: forward, neutral and backward.
Ball spring device for the lever positioning is not shown.
Green and blue gears are in permanent mesh. When left pink gear is in mesh with the blue gear, grey slider goes forward. When right pink gear is in mesh with the green gear, grey slider goes backward.
The lever neutral position is for stopping the grey slider or setting its position (by hand turning orange screw).
The mechanism is suitable for low speed.
In case of high speed stop the input before reversing.

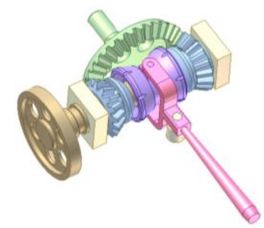
Bevel gear clutch for changing rotation direction 1

http://www.youtube.com/watch?v=lLm1Vqc7xVE

Input: orange shaft.

Output: green shaft

Violet clutch has prismatic joint with the orange shaft.



Bevel gear clutch for changing rotation direction 2

https://youtu.be/stxb291w9L0

This is used for case when input and output axes are coaxial.

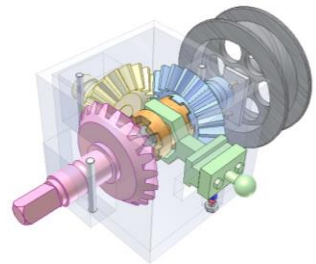
Input: pink bevel gear.

Output: gray pulley shaft

Three positions of green shifter (or of orange clutch) correspond three motion modes of the output: Turn right - Stop - Turn left.

The mechanism is suitable for low speed.

In case of high speed stop the input before moving the shifter.



Spur gear clutch for changing rotation direction 2

https://youtu.be/kBrmFi2FNRU

This is used for case when input and output axes are coaxial.

Input: orange shaft.

Output: blue crank-shaft.

Orange gear is in mesh with a yellow gear.

Green gear is in mesh with the other yellow gear.

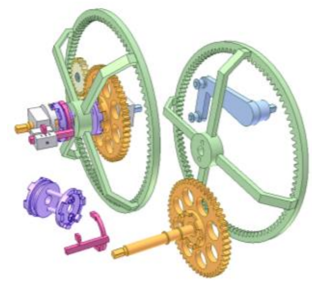
Zg = 2Zo

Zg: tooth number of the green gear.

Zo: tooth number of the orange gear.

Tooth number of the yellow gears are arbitrary.

Three positions of pink shifter (or of violet clutch) correspond three motion modes of the output: Turn right - Stop - Turn left. Device for positioning the shifter is not shown.



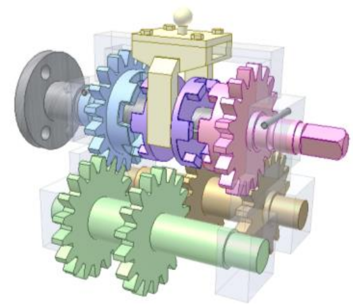
The video shows alternately:

1. Shifting process
2. Mode Stop, when the violet clutch is not in meshing. The output is immobile under the payload. If no payload it may rotate reluctantly.
3. Mode Turn right, when the violet clutch is in mesh with the orange shaft. The input and output rotate together.
4. Mode Turn left, when the violet clutch is in mesh with stationary semi-clutch. The input and output rotate in opposite directions with the same speed.

The mechanism is suitable for low speed. In case of high speed stop the input before moving the shifter.

Spur gear clutch for changing rotation direction 1

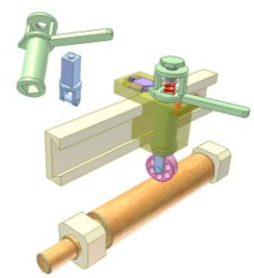
https://youtu.be/W3YtRWHa-wU



This is used for case when input and output axes are coaxial.
Input: pink shaft.
Output: gray shaft
Green gears are in mesh with brown and blue gears.
Brown gears are in mesh with green and pink gears.
Three positions of yellow shifter (or of violet clutch) correspond three motion modes of the output: Turn right - Stop - Turn left.
Device for positioning the shifter is not shown.
The mechanism is suitable for low speed.
In case of high speed stop the input before moving the shifter.

Spatial friction drive for translating motion 1a

http://youtu.be/i2J5au2czKo

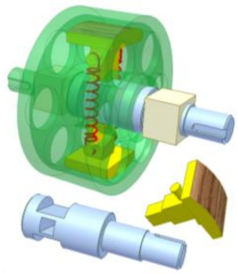


Input: orange shaft rotating regularly.
Output: yellow slider moving linearly.
Turn the green swivel to change motion direction of the slider.
The slider velocity V depends on the skew angle λ between axes of the input shaft and the roller.
$V = \omega . R . \tan(\lambda)$
ω: angular velocity of the input shaft
R: contact radius of the input shaft
Pink roller is forced toward the input shaft by red spring.
Small violet slider is for positioning the green swivel.
The mechanism is for light duty works.
Kinematic relation between the input and output is not kept strictly due to contact slipping.

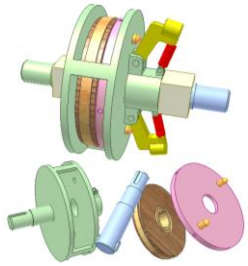
1.2.2. Self-controlled clutches

1.2.2.1 Non-reverse clutches

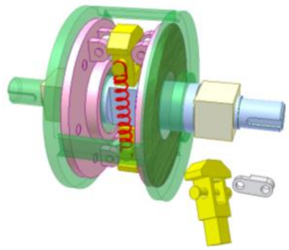
Centrifugal clutch 1
http://youtu.be/QpwWZIoh-cw
Input: blue shaft.
Output: green shaft.
Yellow sliders have prismatic joints with the input shaft.
When velocity of the input shaft increases to prescribed value, the yellow sliders move outward by centrifugal force, press on the inner surface of the output shaft and thus connect the clutch by friction.



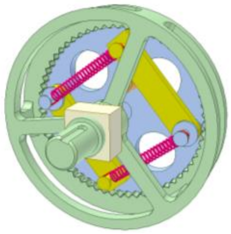
Centrifugal clutch 2
http://youtu.be/EwjFznLJJ4I
Input: green shaft.
Output: blue shaft.
The brown friction disk has prismatic joint with the blue output shaft.
When velocity of the input shaft increases to prescribed value, because of centrifugal force the yellow arms push orange pins of the pink disk towards the brown friction disk and thus connect the clutch by friction.



Centrifugal clutch 3
http://youtu.be/Uw4S9xpZd7Y
Input: blue shaft.
Output: green shaft.
Yellow sliders have prismatic joints with the input shaft.
When velocity of the input shaft increases to prescribed value, the yellow sliders move outward by centrifugal force. Pink friction disks press on the output shaft disks with large force (due to toggle action of the grey bars) and thus connect the clutch by friction.



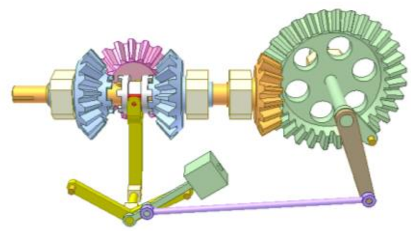
Centrifugal clutch 4
http://youtu.be/2oOX0L445Gw
Input: blue disk.
Output: green disk.
Yellow levers have revolution joints with orange pins of the input disk.
When velocity of the input disk increases to prescribed value, because of centrifugal force the yellow levers engage with teeth of the output disk and thus connect the clutch.



1.2.2.2 Reverse clutches

Bevel gear clutch for changing rotation direction 2

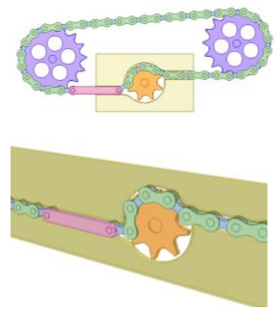
http://youtu.be/4cgamhTkBYQ



The pink gear is driving. The orange output shaft of a bevel gear oscillates. The two blue gears rotate freely on the orange shaft. The white clutch part is slidingly splined on the orange shaft.
The clutch connecting force is due to the weight on the green lever. The bevel drive on the right is for controlling the clutch. The oscillation forward and backward angles depend on transmission ratio of the said drive.
Instead of the weight action, the spring toggle mechanism can be used.

Chain drive 1E

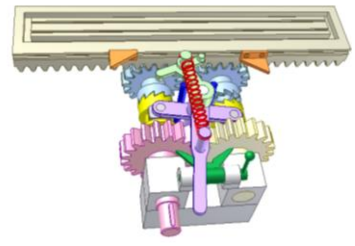
http://youtu.be/Dkfwev3-Xug



A chain drive that can itself reverse motion direction of the chain.
On the sketch: the orange sprocket is driving, the two large chain wheels are driven.
The animation shows the driving sprocket and chain behavior at reverse time: from the left-to-right motion of the chain to the right-to-left motion. For the reverse from the right-to-left motion of the chain to the left-to-right motion, the process is similar, the chain moves from the lower side of the orange sprocket to the the upper side.
The yellow leading plate and the pink link are key parts.
Time between two consecutive reverses depends on the chain length.

Gear-rack drive for auto reversing linear motion

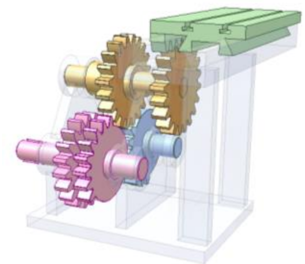
https://youtu.be/Fele3u6_TJs



Input: pink gear rotating one way.
Output: brown table to which a rack is fixed linearly reciprocating.
Positions of orange stoppers that are fixed to the table decide length stroke of the table.
Snap mechanism (green and violet T-shaped levers, red spring, blue stoppers) ensures that yellow semi clutches do not stop at their neutral positions.
Green V-shaped handle is for pausing the table without stopping the input (see last scene of the video).
This mechanism can be used for planing machines like in following video:
https://www.youtube.com/watch?v=qGAuX0e9pTc

Auto-reverser of spur gears

https://youtu.be/nPXQ_vTttrs

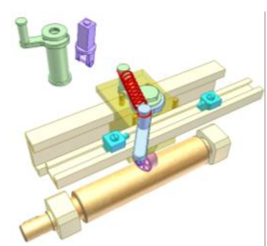


Input: pink shaft to which two gears (P1, P2) are fixed. P2 is teeth-uncompleted gear.
Two blue gears (B1, B2) are fixed to blue intermediate shaft. B2 is teeth-uncompleted gear.
P1 is in mesh with B1.
Output: orange shaft to which two gears (O1, O2) are fixed. O2 is in mesh with green rack.
O1 is in mesh with teeth-uncompleted gears P2 and B2.
Tooth number of P1, B1, O1 and O2: 20.
Tooth numbers of P2, B2:
- teeth-completed: 20
- teeth-uncompleted: 8

Change tooth number of O2 to get various stroke lengths of the green table.
Attention: relative position between P2 and B2 is very important for their proper meshing with O1 so measure to adjust relative position between P2 and P1 (or B2 and B1) is needed (not shown). Placing stopper (not shown) at the end positions of the green table is a measure to help the proper meshing.
This reverser should be used for low speed only because of gear sudden meshing.
Green table reciprocates at constant speed.

Spatial friction drive for translating motion 1b

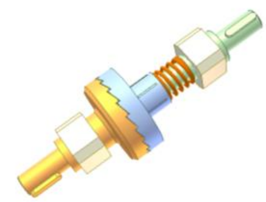
http://youtu.be/XZy856ocYgk



Input: orange shaft rotating regularly.
Output: yellow slider linearly reciprocating.
The slider velocity depends on the skew angle between axes of the input shaft and the roller.
Pink roller is forced toward the input shaft by a spring (not shown).
The automatic changing motion direction is performed by a spring toggle mechanism that consists of blue and green levers, red spring and two cyan adjustable stoppers. Refer to:
http://youtu.be/KaRBadgcUlU

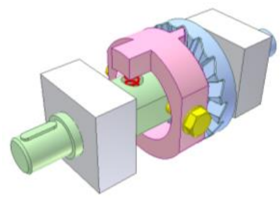
1.2.3. Oneway overrunning clutches

One way clutch 3 (jaw)
http://youtu.be/dMNlTVka8vc
The orange input shaft rotates two directions but the transmission is possible for one direction only.
There is collision when the output green shaft stops, so the mechanism should be used only for low speed.

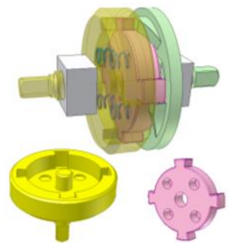


One way clutch 4 (slider)
http://youtu.be/nSP6F7qn1LM
The pink input disk rotates two ways but the transmission to the yellow disk is possible only for one.
The mechanism should be used for low speed because of collision.

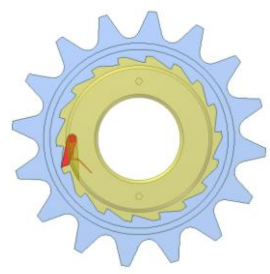
One way clutch 8
https://youtu.be/qpAB_RZ-v2Y
Green input shaft rotates two ways but the transmission to blue shaft of face tooth disk is possible only for one.
Pink ring of one tooth has revolution joint with the green shaft.
Red spring forces the pink tooth toward the blue disk.
The mechanism should be used for low speed because of collision.



One way clutch 8
https://youtu.be/Lmvd0IwApkk
The green input disk rotates two ways but the transmission to the yellow disk is possible only for one.
Blue springs always force the pink disk towards the green disk.
The mechanism should be used for low speed because of collision.

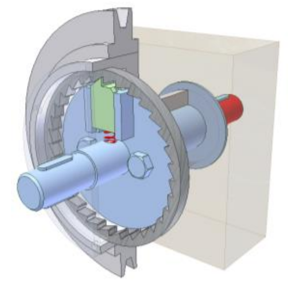


Ratchet mechanism 5
http://youtu.be/bAL_nWjuhOI
Bicycle free-wheel.
The blue sprocket receives motion from the pedaling bicyclist. The yellow hub rotates only when the sprocket rotates clockwise.
Clockwise rotation of the yellow hub has no inflection to the blue sprocket.
The red pawl is always pressed toward the sprocket's teeth by a spring. In reality two pawls are used.



Ratchet one way overrunning clutch

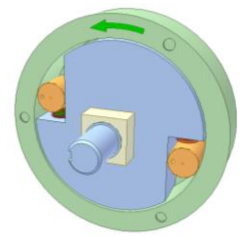
https://youtu.be/gOuLq2haqLY



Grey pulley, grey hollow step shaft, grey tooth ring and glass cover are fixed together.
The rotary transmission from the pulley to the blue shaft is possible only in counterclockwise direction.
The rotary transmission from the blue shaft to the pulley is possible only in clockwise direction.
When both the pulley and the blue shaft rotate at the same time in counterclockwise direction, the clutch can work only in case the blue shaft rotates faster than the pulley.
When both the pulley and the blue shaft rotate at the same time in clockwise direction, the clutch can work only in case the pulley rotates faster than the blue shaft.
When both the pulley and the blue shaft rotate at the same time in opposite directions the clutch can’t work only in case the pulley rotates clockwise.

Roller overrunning clutch 1

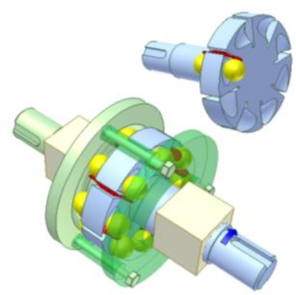
http://youtu.be/H4SiM5Dcblg



Green outter disk and blue inner disk rotate around a fixed axis.
The arrows show which link is the driving at different times.
When the outter disk is driving, its two way rotation can be transmitted to the inner disk only in clockwise direction.
When the inner disk is driving, its two way rotation can be transmitted to the outter disk only in anticlockwise direction.

Ball overrunning clutch 1

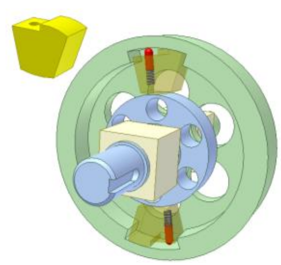
http://youtu.be/qRmwoGlQ7V8



Blue and green shafts rotate around a fixed axis.
The red flat springs always force the yellow balls into wedgeshaped gaps between the shafts.
The arrows show which link is the driving at different times.
When the blue shaft is driving, its two way rotation can be transmitted to the green shaft only in anticlockwise direction.
When the green shaft is driving, its two way rotation can be transmitted to the blue shaft only in clockwise direction.

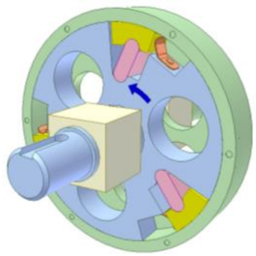
Sprag overrunning clutch 1

http://youtu.be/0gwzmLh03Bw

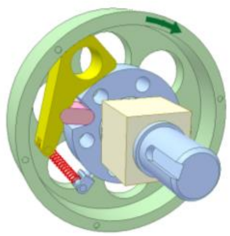


Blue and green shafts rotate around a fixed axis.
Blue springs and red pins maintain contact between yellow sprags and the two shafts.
The arrows show which link is the driving at different times.
When the blue shaft is driving, its two way rotation can be transmitted to the green shaft only in clockwise direction.
When the green shaft is driving, its two way rotation can be transmitted to the blue shaft only in anticlockwise direction.

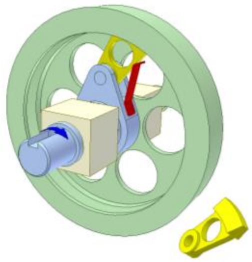
Sprag overrunning clutch 2
http://youtu.be/6R8t0pnh7sk
Blue and green shafts rotate around a fixed axis.
Copper springs maintain contact between yellow sprags, pink pins and the two shafts.
The arrows show which link is the driving at different times.
When the blue shaft is driving, its two way rotation can be transmitted to the green shaft only in clockwise direction.
When the green shaft is driving, its two way rotation can be transmitted to the blue shaft only in anticlockwise direction.



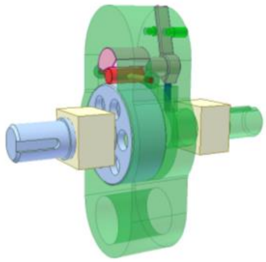
Sprag overrunning clutch 3
http://youtu.be/_pTC2iCmRkY
Blue and green shafts rotate around a fixed axis.
Red spring maintains contact between yellow sprag, pink pin and the two shafts.
The arrows show which link is the driving at different times.
When the blue shaft is driving, its two way rotation can be transmitted to the green shaft only in clockwise direction.
When the green shaft is driving, its two way rotation can be transmitted to the blue shaft only in anticlockwise direction.



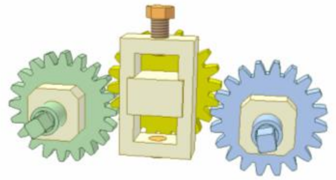
Sprag overrunning clutch 4
http://youtu.be/NagjHuASAoc
Blue and green shafts rotate around a fixed axis.
Red spring maintains contact between yellow sprag and V-shaped groove of the green shaft.
The arrows show which link is the driving at different times.
When the blue shaft is driving, its two way rotation can be transmitted to the green shaft only in clockwise direction.
When the green shaft is driving, its two way rotation can be transmitted to the blue shaft only in antclockwise direction.
If the green shaft is kept immobile, the blue shaft can rotate only anticlockwise. It is braked automatically when rotating clockwise (mechanism for preventing reverse rotation).



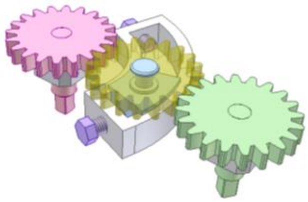
Roller overrunning clutch 3
http://youtu.be/Hvr8LC-Ph7w
Input: blue shaft rotating two directions.
Output: green shaft rotates with the input shaft only in the direction set by the pink lever.
The orange pins always force the red roller into wedgeshaped gaps between the input and output shafts.
The spring of the blue pin must be strong enough for positioning the pink lever.



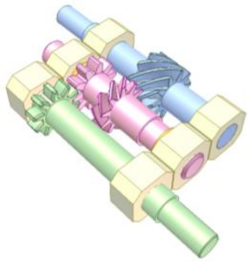
One way clutch 1 (gear)
http://youtu.be/X_fbDb4F5ZU
The blue gear is input.
A disengaging idler rises in a slot because of gear forces when the drive direction is reversed.
The mechanism should be used only for low speed because of gear collision.



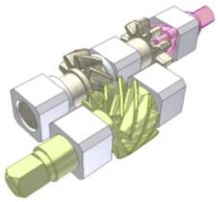
One way clutch 1b (gear)
https://youtu.be/iO0Ker81UmQ
This is an improvement of the clutch shown at
http://youtu.be/X_fbDb4F5ZU
for reducing gear collision.
Input: pink gear.
Output: green gear.
When the input rotates anti-clockwise, gear forces move the yellow idle gear out of its engagement with the output gear.
When the input rotates clockwise, gear forces move the yellow idle gear into contact with the output gear thus perform motion transmission.
The tooth top land must be rounded to prevent possible gear jam.
The mechanism should be used only for low speed because of collision.



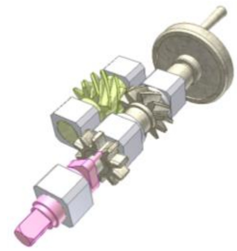
One way clutch 7 (helical gear)
http://youtu.be/iL8gOluzKUk
The blue input shaft rotates two directions but the transmission is possible only for one. The pink shaft moves longitudinally when the input shaft reverses because of axial component of gear force in the helical gear drive.
The mechanism should be used only for low speed because of gear collision.



One way clutch 9a
https://youtu.be/wow6nKqko14
The rotation is transmitted from input shaft (in green) to output shaft (in pink) only when the input rotates clockwise.
Advantage: no noise when the input rotates counter-clockwise although it is not friction clutch.
Disadvantage: the input and output are not coaxial.

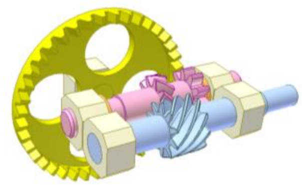


One way clutch 9b
https://youtu.be/2c_3-6aMaXk



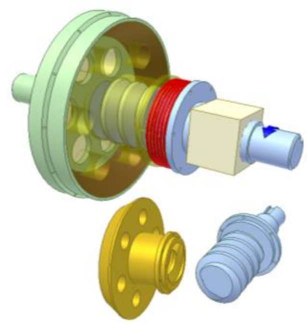
The rotation is transmitted from input shaft (in brown) to output shaft (in pink) only when the input rotates clockwise.
Advantage: no noise when the input rotates counter-clockwise although it is not friction clutch.
Disadvantage: the input moves axially when changing of rotation direction.

Face gear 14
http://youtu.be/CiaumcAX9ik



One way clutch.
The blue input shaft rotates two directions but the transmission is possible only for one. The pink shaft moves longitudinally when the input reverses because of axial component of gear force in the blue gear drive. The orange rings represent thrust bearings. The mechanism should be used only for low speed case because of gear collision.

Screw overrunning clutch 1
http://youtu.be/M4d_8VpNe9k



Blue and green shafts rotate around a fixed axis.
Yellow nut of male cone has a helical joint (right hand thread) with the blue shaft.
Red torsion spring tends to turn the yellow nut clockwise thus maintains contact for cone surfaces of the yellow nut and the green shaft.
The arrows show which link is the driving at different times.
When the blue shaft is driving and rotates anticlockwise, the green shaft tends to keep the nut immobile. The latter tends to move towards the green shaft, contact force at cone surfaces increases, the green shaft rotates together with the blue shaft.
When the blue shaft is driving and rotates clockwise, the green shaft tends to keep the nut immobile. The latter tends to move apart from the green shaft, contact force at cone surface decreases, the green shaft stays immobile.
In brief:
- When the blue shaft is driving, its two way rotation can be transmitted to the green shaft only in anticlockwise direction.
- When the green shaft is driving, its two way rotation can be transmitted to the blue shaft only in clockwise direction.
- If the green shaft is kept immobile, the blue shaft can rotate only anticlockwise. It is braked automatically when rotating clockwise(mechanism for preventing reverse rotation).
This mechanism is created purely on computer and needs to be verified in practice.

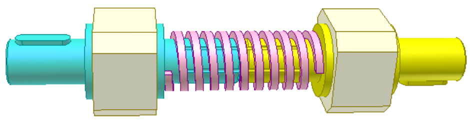
Screw gear overrunning clutch

http://youtu.be/2IlHyu6msTk

Green ring and blue gear rotate around a fixed axis.
The ring carries two yellow gear shafts with brown cones.
The arrows show which link is the driving at different times.
1. If the green ring is driving:
- When the ring rotates anticlockwise, gearing forces (axial components) push the yellow gear shafts towards the femal cones of the ring, the yellow gear shafts can not rotate and make the blue gear rotate.
- When the ring rotates clockwise, gearing forces push the yellow gear shafts away from the femal cones of the ring, the yellow gear shafts rotate idly and the blue gear is kept immobile by load applied on it.
2. If the blue gear is driving:
- When the blue gear rotates anticlockwise, gearing forces push the yellow gear shafts away from the femal cones of the ring, the yellow gear shafts rotate idly and the ring is kept immobile by load applied on it.
- When the blue gear rotates clockwise, gearing forces push the yellow gear shafts towards the femal cones of the ring, the yellow gear shafts can not rotate and make the ring rotate.
For an embodiment of this mechanism the three helical gears are replaced by a non self locking worm drive (one worm gear and two worms).

One way clutch 5 (spring)

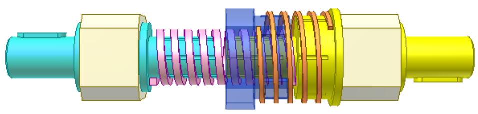
http://youtu.be/Cshn6B2l2WQ



The cyan input shaft rotates two directions but the transmission is possible only for one. The rotation direction that tends to wind the spring is transmitted to the yellow output shaft due to friction force between the spring and the shafts. For the inverse direction the yellow output shaft may rotate if there is no braking force or load applied to it.
The helix spring needs not be fastened at either end; a slight interference fit is acceptable.
The spring helix direction decides the transmission direction.

One way clutch 6 (spring)

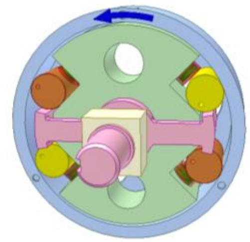
http://youtu.be/DESoTn5ui1c



The cyan input shaft rotates two directions but the transmission is possible only for one by the pink spring.
The rotation direction that tends to wind the pink spring is transmitted to the yellow output shaft due to friction force between the pink spring and the shafts.
The blue bush is stationary. The orange spring is for keeping the yellow output shaft immobile when it stops.
The helix springs need not be fastened at either end; a slight interference fit is acceptable.
The spring helix direction is the key factor for this mechanism.

1.2.3. Two way overrunning clutches

Two way overrunning clutch 1
http://youtu.be/-Y_SQGMRx8k
Blue outter disk and pink fork rotate around a fixed axis.
Green inner disk rotates idly on the pink fork.
The arrows show which link is the driving at different times.



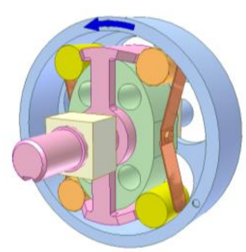
1. When the blue outter disk is driving, its rotation of both directions is transmitted to the green inner disk by wedging of the rollers between the blue outter disk and the green inner disk (orange rollers for anticlockwise direction, yellow rollers for clockwise direction).
The rotation of the green inner disk is transmitted to the pink fork by flexible contact via springs, red bushes and rollers (yellow rollers for clockwise direction, orange rollers for anticlockwise direction).

2. When the fork is driving, its rotation of both directions is transmitted to the green inner disk by flexible contact via rollers, red bushes and springs (orange rollers for clockwise direction, yellow rollers for anticlockwise direction)
The rotation can not transmitted to the blue outter disk because the wedging does not happen.

3. When the green inner disk is driving, its rotation of both directions is transmitted to the blue outter disk by wedging of the rollers between the blue outter disk and the green inner disk (orange rollers for clockwise direction, yellow rollers for anticlockwise direction).
The rotation of the green inner disk is transmitted to the pink fork by flexible contact via springs, red bushes and rollers (yellow rollers for clockwise direction, orange rollers for anticlockwise direction).

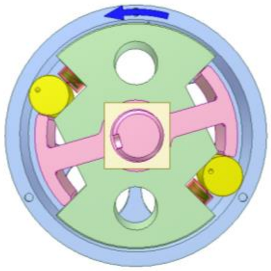
In brief, the rotation of two directions can be transmitted from the outter disk to the fork. The inverse is impossible. The fork and the inner disk always rotate together.
If the outter disk is kept immobile, the rotation can be transmitted only from the fork to the inner disk. The inverse is impossible, causing jam of the mechanism. So the inner disk can not act as a driving link.

Two way overrunning clutch 2
http://youtu.be/VgciAZMn7Zc
Blue outter disk and pink fork rotate around a fixed axis.
Green inner disk of oval shape rotates idly on the pink fork.
Brown flat springs force rollers into wedgeshaped gaps between the outter and inner disks.
The arrows show which link is the driving at different times.



The rotation of two directions can be transmitted from the outter disk to the fork. The inverse is impossible. The fork and the inner disk always rotate together.
This is an embodiment of the mechanism shown in “Two way overrunning clutch 1”
http://youtu.be/-Y_SQGMRx8k

Roller overrunning clutch 2
http://youtu.be/LLJJsPTaKic
Blue outter disk and pink fork rotate around a fixed axis.
Green inner disk rotates idly on the pink fork.
The arrows show which link is the driving at different times.

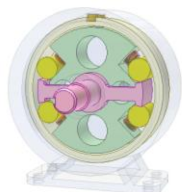


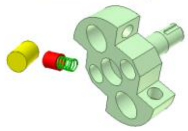
1. When the blue outter disk is driving, its anticlockwise rotation is transmitted to the green inner disk by wedging of the yellow rollers between the blue outter disk and the green inner disk.
Clockwise rotation of the blue outter disk can not be transmitted to the pink fork.

2. When the fork is driving, its rotation of both directions is transmitted to the green inner disk by flexible contact via yellow rollers, red bushes and springs (for clockwise direction) or by direct contact between the fork and the green inner disk (for anticlockwise direction).
The rotation can not transmitted to the blue outter disk because the wedging does not happen.

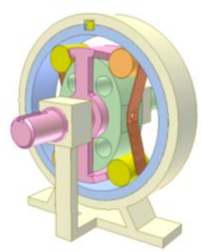
3. When the green inner disk is driving, its clockwise rotation is transmitted to the blue outter disk by wedging of the yellow rollers between the blue outter disk and the green inner disk. Anticlockwise rotation of the green inner disk can not be transmitted to the blue outter disk.
The rotation of the green inner disk is transmitted to the pink fork by flexible contact via springs, red bushes and yellow rollers (for anticlockwise direction) or by direct contact between the green inner disk and the fork (for clockwise direction)

Two-way anti-reverse transmission 1a
http://youtu.be/wZjoNIkYQqM
Pink input shaft transmits rotation to output green shaft in both directions.
Reverse transmission is impossible because yellow rollers wedge between the fixed outter rim and the green shaft. The mechanism has self-locking feature like worm drive but transmission ratio is 1/1.
It can be used for motion control system where servo motor needs a rest (interrupting electric supply) when motion control is not required.
For more see: “Two way overrunning clutch 1”
http://youtu.be/-Y_SQGMRx8k





Two-way anti-reverse transmission 1b
http://youtu.be/5DBfEdX5Ow8
This is an embodiment of the mechanism shown in “Two-way anti-reverse transmission 1a”
http://youtu.be/wZjoNIkYQqM
Pink input shaft transmits rotation to output green shaft in both directions.
Reverse transmission is impossible because rollers wedge between the fixed outter rim and the green shaft.



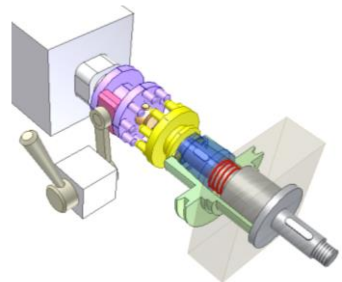
The mechanism has self-locking feature like worm drive but transmission ratio is 1/1.
It can be used for motion control system where servo motor needs a rest (interrupting electric supply) when motion control is not required.
For more see: “Two way overrunning clutch 2”
https://www.youtube.com/watch?v=VgciAZMn7Zc

Two way overrunning clutch 3

https://youtu.be/ScFAMheJRjc

It is developed from the mechanism shown at:

https://youtu.be/EVtOSFeq1qE



Input 1: green part rotating continuously in either directions.

Input 2: orange shaft of white motor. Violet clutch (having prismatic joint with the orange shaft) is controlled by brown shifting lever for transmitting rotation from the orange shaft to the yellow part.

Output: grey shaft.

Yellow part having two round protrusions at its face.

Blue cone has prismatic joint with the output shaft. It is forced toward the internal cone of the green part and the yellow part by red spring. The blue cone has V-shaped grooves at its face.

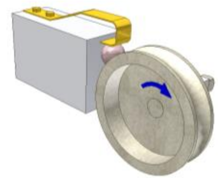
When the violet clutch is disengaged, the output shaft rotates together with the input 1 (green pulley) thanks to friction at the contact place between internal cone of the green part and the blue cone under red spring force.

When the violet clutch is engaged, the output shaft rotates together with the input 2 (blue shaft). At that time there is no contact between internal cone of the green part and the blue cone because the yellow part pushes the blue cone from the contact (the displacement is small due to the output shaft shoulder) and turns the output shaft (due to the interaction of the round protrusions of the yellow part and the V-shaped grooves of the blue cone). The video shows that the output can rotate faster than the input 1 or rotate in opposite direction to the input.

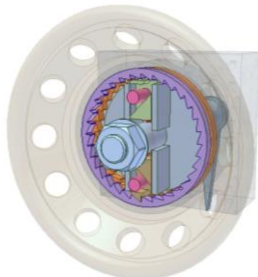
This mechanism is used for altering speed of a shaft continuously rotated thanks to motor A of constant velocity by using motor B without pausing motor A.

1.2.3. Oneway Lock

Anti-reverse clutch
https://youtu.be/0w4gF1ceZ9Q
The clutch prevents the brown shaft from counter-clockwise rotation thanks to wedge action of the pink ball.
Torques applied to the shaft are represented by blue and red arrows.



Ratchet irreversible lock
https://youtu.be/FqqHz4BYAQo
Input: glass handle to which two pink pins are fixed.
Output: blue shaft.
Violet and orange tooth rings are stationary.
Green and brown pawls slide in radial guide ways of the blue shaft.
Red spring forces the pawls toward the tooth rings.
The green pawl is in mesh with the orange tooth ring.
The brown pawl is in mesh with the violet tooth ring.
One pink pin moves in the green pawl groove.
The other pin moves in the brown pawl groove.



When the handle turns counterclockwise, one orange pin pulls the green pawl out of the mesh with orange tooth ring and makes the blue shaft turn counterclockwise by contact with the guide way wall. At that time the brown pawl slides on teeth of the violet tooth ring.

When the handle turns clockwise, the other orange pin pulls the brown pawl out of the mesh with violet tooth ring and makes the blue shaft turn clockwise by contact with the guide way wall. At that time the green pawl slides on teeth of the orange tooth ring.

When an unintended torque of any direction (counterclockwise or clockwise) is applied to the blue shaft, the shaft can not rotate because the pawls are in mesh with the tooth rings.
In brief, the rotation can be transmitted from the handle to the blue shaft.
The transmission in reverse direction (from the blue shaft to the handle) is impossible.
In other words, it is possible to adjust angular position of the blue shaft by turning the handle. The adjusted position is kept unchanged regardless of any torque applied to the blue shaft. A worm drive has the similar function but its transmission ratio is very large, not 1 like this lock.

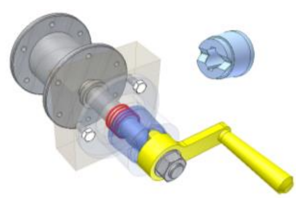
Pin irreversible lock

https://youtu.be/zDsIE2ejCb8

Input: yellow handle.
Output: blue shaft.
Two orange pins are fixed to the handle.
Two green studs are fixed to a hub fixed to the shaft.
The studs are inserted into holes on the handle. The hole diameters are a bit larger than the ones of the studs.
Violet pins are placed in the wedge-shaped space between the blue hub and the outer stationary disk (in glass). Red spring maintains permanent contact of the violet pins with them.
When the handle turns clockwise (yellow arrow), the left orange pin pushes the left violet pin, prevents its wedge action and the handle makes the blue shaft turn clockwise thanks to the green studs.
When the handle turns counter-clockwise (green arrow), the right orange pin pushes the right violet pin, prevents its wedge action and the handle makes the blue shaft turn counter-clockwise thanks to the green studs.
When an unintended clockwise torque (red arrow) is applied to the blue shaft, the shaft can not rotate because of the wedge action of the left violet pin.
When an unintended counter-clockwise torque (pink arrow) is applied to the blue shaft, the shaft can not rotate because of the wedge action of the right violet pin.
In brief, the rotation can be transmitted from the yellow handle to the blue shaft.
The transmission in reverse direction (from the blue shaft to the handle) is impossible.
In other words, it is possible to adjust angular position of the blue shaft by turning the yellow handle. The adjusted position is kept unchanged regardless of any torque applied to the blue shaft.
The video shows case of manually operated valve in pipe.
For more refer to:
https://www.interempresas.net/FeriaVirtual/Catalogos_y_documentos/784
This mechanism and the one shown at
https://youtu.be/FqqHz4BYAQo
have the similar working principles.

Cone irreversible lock

https://youtu.be/EVtOSFeq1qE



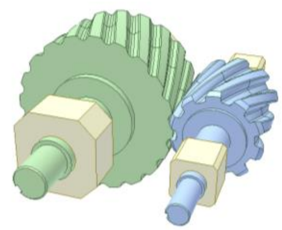
Input: yellow handle having two round protrusions at its face.
Output: grey shaft.
Blue outer cone has prismatic joint with the shaft. It is forced toward the stationary internal cone (in glass) and the handle by red spring. The blue cone has V-shaped grooves at its face.
When a torque is applied to the handle (orange arrows), the latter first pushes the blue cone from the contact with the internal cone (the displacement is small due to the shaft shoulder) then turns the grey shaft (due to the interaction of the round protrusions of the handle and the V-shaped grooves of the blue cone).
When a torque is applied to the grey shaft (pink arrows), it can’t make the shaft rotate because of the friction between the two cones.
The yellow round protrusions can be converted into V-shaped ones.
Number of the V-shaped grooves and protrusions can be more than two.

1.3. Gears

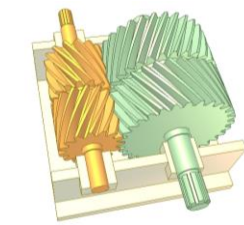
1.3.1. Spur gears

1.3.1.1. Simple drives

Novikov gearing
http://youtu.be/oHQ4ZaiRbgc
Features:
- Convexo-concave round spiral engagement.
- Point contact
It gives higher load capacity and efficiency than involute gearing.

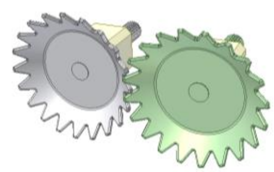


Herringborne gear
http://youtu.be/K_i4kU_L8Lw
By commbination of two helical gear of opposite hands it has advantage of helical gear: smooth and quiet engagement and avoids its disavantage: axial thrust.
Double helical gear



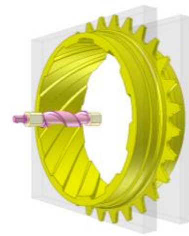
Sheet metal gears 1
http://youtu.be/c1nnWtySorQ
For light loads.
Low cost.
Adaptability to mass production.

Sheet metal gears 4
http://youtu.be/NCAawnVw8tM
For light loads. Low cost.
Adaptability to mass production.
Two blanked gears, conically form after blanking become bevel gears meshing on parallel axes.

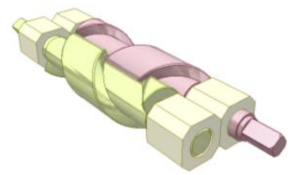


Spur gear drive 1a
http://youtu.be/zrUbFHnom1g
Input: blue gear of one tooth.
Gear face width must be larger than tooth axial pitch.
Output: yellow gear of 10 teeth.
Transmission ratio: 1/10.

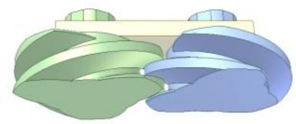
Spur gear drive 1b
http://youtu.be/DLJQTXQaBSE
Input: pink gear of one tooth.
Gear face width must be larger than tooth axial pitch.
Output: yellow gear of 10 teeth.
Transmission ratio: 1/10.



Spur gear drive 1c
http://youtu.be/L6Z5GY3DoI8
Each gear (screw) has only one tooth. Gear face width must be larger than tooth axial pitch.



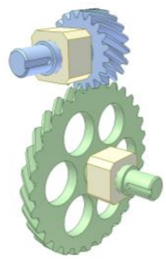
Standard transmission between 3 teeth gears (or screws)
http://www.youtube.com/watch?v=VlWn4GO5SUE
Two gears have opposite helix direction and rotate in opposite direction



Screw gear drive 1a
http://youtu.be/6F5GqB89Lkc
Normal module mn = 2 mm
Pinion:
- Helix angle B1 = 30 deg., right hand
- Face module ms1 = 2.31
- Tooth number Z1 = 20
- Pitch circle dia. D1 = 46.2 mm

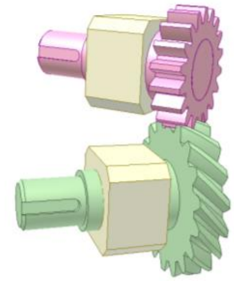
Wheel:
- Helix angle B2 = 60 deg., right hand
- Face module ms2 = 4.0
- Tooth number Z2 = 30
- Pitch circle dia. D2 = 120 mm

Angle between gear axles E = B1 + B2 = 90 deg.
Velocity ratio: i = Z2/Z1 = 1.5 (not D2/D1 = 2.6)



Screw gear drive 1b

http://youtu.be/_gE1v6ahjk4



This drive consists of a small gear (in pink) and a big one (in green) but its velocity ratio is 1. Screw gear causes this paradox.

Normal module mn = 2 mm

Pink gear:

- Helix angle B1 = 0 deg.,
- Face module ms2 = mn = 2 mm
- Tooth number Z1 = 18
- Pitch circle dia. D1 = 36.0 mm

Green gear:

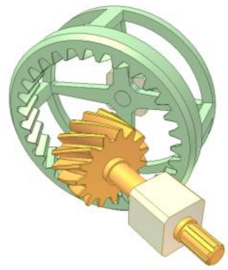
- Helix angle B2 = 45 deg., right hand
- Face module ms2 = 2.83
- Tooth number Z2 = 18
- Pitch circle dia. D2 = 50.91 mm

Angle between gear axles E = B1 + B2 = 45 deg.

Velocity ratio: i = Z2/Z1 = 1 (not D2/D1 = 1.41)

Screw gear drive 2

http://youtu.be/MJRtf_RMUa8



Normal module mn = 2 mm

+ Pinion:

- Helix angle B1 = 30 deg., left hand
- Tooth number Z1 = 15
- Pitch circle dia. D1 = 34.64 mm

+ Wheel:

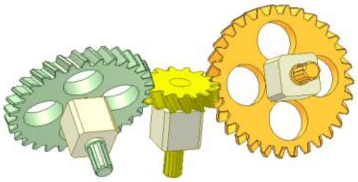
- Helix angle B2 = 30 deg., right hand
- Tooth number Z2 = 30
- Pitch circle dia. D2 = 69.28 mm

Angle between gear axles E = B1 + B2 = 60 deg.

Velocity ratio: i = Z2/Z1 = D2/D1 = 2

Screw gear drive 3

http://youtu.be/7bxZzhRREA8



Normal module mn = 2 mm

+ Pinion:

- Helix angle B1 = 30 deg., left hand
- Tooth number Z1 = 15
- Pitch circle dia. D1 = 34.64 mm

+ Wheels:

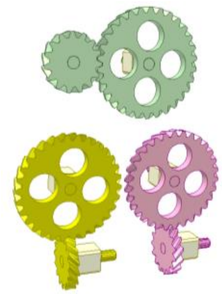
- Helix angle B2 = 30 deg., left hand
- Tooth number Z2 = 30
- Pitch circle dia. D2 = 69.28 mm

Velocity ratio: i = Z2/Z1 = D2/D1 = 2

Angle between gear axles E = B1 + B2 = 60 deg.

The wheels axles are not parallel even if the wheels engage with the pinion at its opposite sides.

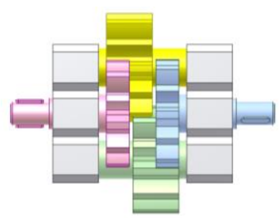
Screw gear drive 4
http://youtu.be/WZRst3BMCag
This video aims to show:
1. For screw gear drive with parallel shafts, i.e. spur gear drive of helical teeth (in green): helix angles of the two gears must be equal and of opposite hands.
2. For screw gear drive with skew perpendicular shafts (in yellow and in pink): helix angles of the two gears B1, B2 must be of same hand, B1 + B2 = 90 deg. The yellow drive is of right hand. The pink drive is of left hand. If input gears (small ones) rotate in the same direction, the output gears (large ones) rotate in opposite directions.



Screw gear drive 5
http://youtu.be/IYIVnTsG4E8
Orange pinion:
- Helix angle B1 = 45 deg., right hand
Green pinion:
- Helix angle B1 = 45 deg., left hand
Wheels:
- Helix angle B1 = 45 deg., right hand
Angle between pinion and wheel axles for the green drive E = B1 - B2 = 0 deg.
Angle between pinion and wheel axles for the orange drive E = B1 + B2 = 90 deg.
Pay attention to the rotation directions of the wheels in each drive. They are opposite for the orange drive and of the same direction for the green drive.

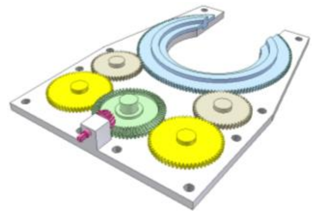
Transmission for rotors placed along a circle 2
https://youtu.be/nagGc8nxT3k
Input: pink pinion that engages with large yellow ring gear.
The yellow ring gear has pins on its face that engage with blue gears of internal helical teeth.

Coaxial rotation reverser of 4 spur pinions
http://youtu.be/MB7zUQCQRxI
Input: pink pinion.
Output: blue pinion.
They are of equal tooth number.
Green and yellow pinions rotate idly.
Green pinion engages with yellow and blue pinions.
Yellow pinion engages with green and pink pinions.
Tooth numbers of green and yellow pinions can be arbitrary.
The input and output rotate in opposite directions.
Their speeds are equal.
This mechanism is used instead of 3 bevel gear drive to avoid using perpendicular shafts.



Transmission for C-shaped gear

https://youtu.be/nQOieGYgXQo

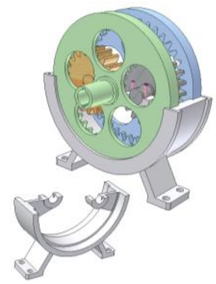


Input: pink bevel gear.
Output: blue C-shaped gear.
The gear arrangement must ensure that the blue is always in mesh with at least one among the two brown gears.
This transmission is used when the approach for centering in axial direction is impossible. Examples:
- Orbital welding heads
https://www.youtube.com/watch?v=vY51f06-YcU
- Motorized open end wrenches
https://www.youtube.com/watch?v=xF7uax2Ti1g
- Wrapping machine for torus-shaped products:
https://www.youtube.com/watch?v=UknoNWF7xd0

It is possible to use only three spur gears, the green spur gear is in mesh directly with two brown gears.

Gear reverser

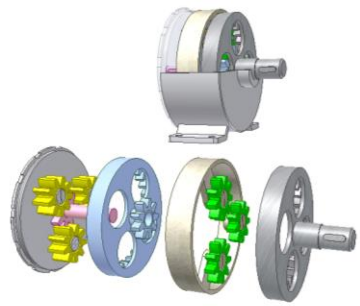
https://youtu.be/qwDAVmx2Grg



Input: green internal gear.
Output: blue internal gear or vice versa.
The internal gears have the same gear number: Ni
Orange and grey external gears have the same gear number: Ne
No compulsory relation between Ni and Ne. Here Ni = 2.Ne
The green gear is in mesh with the orange gear.
The blue gear is in mesh with the grey gear.
The orange gear is in mesh with the grey gear.
The coaxial input and output rotate in opposite directions with the same velocity.

Coaxial gearbox 1

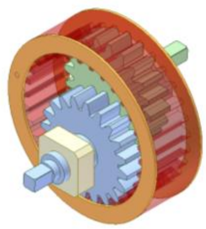
https://youtu.be/Dp2LQJZXVw4

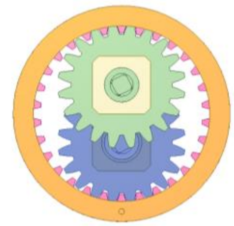


It is not a planetary drive.
Grey internal gear is in mesh with 3 green gears.
Blue small gear is in mesh with 3 green gears.
Blue internal gear is in mesh with 3 yellow gears.
Pink gear is in mesh with 3 yellow gears.
Tooth number of the blue small gear and the pink gear is Z1.
Tooth number of the grey and blue internal gears is Z2.
Pay attention to conditions of assembly when choosing Z1, Z2 because here there are 3 gears in mesh with one gear (external and internal)
Np is velocity of the pink shaft.
Ng is velocity of the grey shaft.
Transmission ratio Np/Ng = (Z2/Z1).(Z2/Z1)
Here Z2/Z1 = 3 so Np/Ng = 9
Add blue gears and green gears to get larger transmission ratios (27, 81, …).

3-gear coupling 1

https://www.youtube.com/watch?v=uCzyQT930JY





There is no bearing for the internal gear.
Z1 = Z2 = 20
Z3 = 30
Z1, Z2 are tooth numbers of the external gears.
Z3 is tooth number of the internal gear.
The external gears have the same velocity and rotation direction.
Velocity can be altered if Z1 differs from Z2

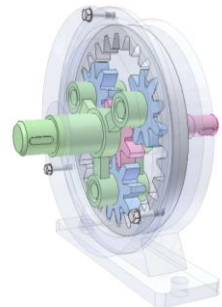
3-gear coupling 2

https://www.youtube.com/watch?v=nBCts0-4KIs

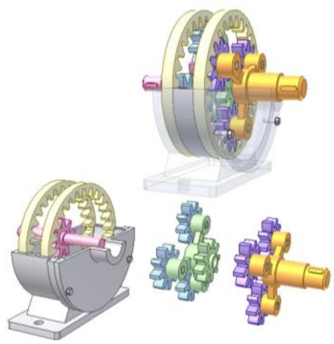
There is no bearing for the internal gear.
Z1 = 20, Z2 = 40
Z3 = 50
Z1, Z2 are tooth numbers of the external gears.
Z3 is tooth number of the internal gear.
The external gears have the same rotation direction.
Transmission ratio is 2.

1.3.1.2. Epicyclic drives

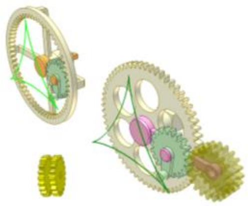
Planetary reduction gear
https://youtu.be/pnE3Z5Zn-Zc
Input: pink shaft.
Output: green shaft (carrier)
Tooth numbers of pink and blue gears: N1
Tooth number of stationary internal gear: N2
N2 = 3.N1
Transmission ratio: 4



Coaxial gearbox 2
https://youtu.be/aaGhPGV6xqM
It is a planetary drive.
Right internal gear is in mesh with 3 violet gears.
Green gear is in mesh with 3 violet gears.
Left internal gear is in mesh with 3 blue gears.
Pink gear is in mesh with 3 blue gears.
Tooth number of the green gear and the pink one is Z1.
Tooth number of the satellite gears (violet and blue) is Z2.
Pay attention to conditions of assembly when choosing Z1, Z2 because here there are 3 gears in mesh with one gear (external and internal)
Np is velocity of the pink shaft.
No is velocity of the orange shaft.
Transmission ratio Np/No = (2*((Z1+Z2)/Z1))* (2*((Z1+Z2)/Z1))
Here Z2 = Z1 so Np/No = 4*4 = 16
Add green carriers and internal gears to get larger transmission ratios (64, 256, …).

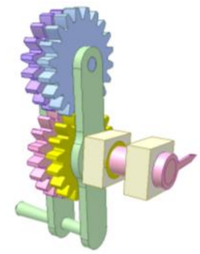


Internal and external gears
http://youtu.be/a4I0ZBnQ_20
The left planetary drive can be replaced by the right one when the manufacturing of internal gears is a problem. They give the same result (the green curves). Just lengthen the carrier and add an yellow double gear.
In this video tooth number of the fixed gears is triple of the one of the movables gears so the green curves are deltoids.



Crank for small angle rotation

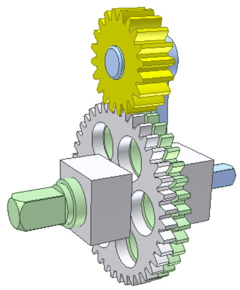
http://youtu.be/WAIg5tR1fzM



Input: green crank of Ng velocity.
Output: pink shaft of Np velocity.
Yellow gear is kept immobile.
Blue and violet gears are fixed each to other.
Tooth numbers of the pink, yellow, blue and violet gears:
Zp = 20, Zy = 19, Zb = 20 and Zv = 19.
Ng/Np = (Zp.Zb) / (Zp.Zb – Zv.Zy) = 10.26
The ouput rotates around 10 times slower than the input in the same direction.

Ferguson's paradox of gear drive 1

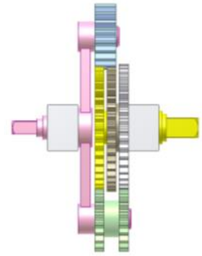
https://youtu.be/Paw4aKYjtb0



Input: blue carrier.
Output: green gear.
Zf: tooth number of stationary grey gear. Here Zf = 40.
Zg: tooth number of the green gear. Here Zg = 39.
Transmission ratio i = (Zf – Zg)/Zg. Here i = 1/39
The center distances between yellow gear and other large gears are the same despite the slightly different pitch diameters of each large gear. The "paradox" results from that.
The grey and yellow gears are standard ones.
The green gear are of corrected tooth profile. When cutting it, the tool moves from the gear center a little in comparision with standard gears.
The mechanism helps reduce velocity effectively.
Disadvantage: impossible to arrange more planet gear for force balancing the carrier.

Ferguson's paradox of gear drive 2

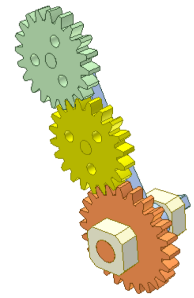
https://youtu.be/ZAOgYsmuK98



Input: pink carrier.
Output: yellow gear.
It is developed from "Ferguson's paradox of gear drive 1"
https://youtu.be/Paw4aKYjtb0
to balance forces applied to the input and output by using two planetary gears (in blue and green).
Zf: tooth number of stationary grey and brown gears. Here Zf = 41.
Zy: tooth number of yellow gear. Here Zy = 40.
Transmission ratio i = (Zf – Zy)/Zy. Here i = 1/40
The yellow gear is a standard one.
The grey and brown gears are of corrected tooth profile.
It is possible to use more planetary gears by the same way.

3-gear planetary mechanism E

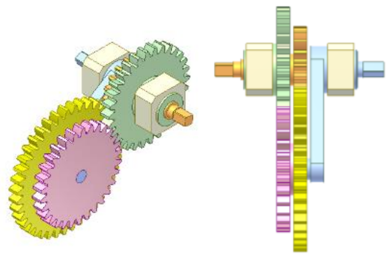
http://youtu.be/upo4rQWg_EI



i3 = n3/nc = (Z3 – Z1)/Z3
i2 = n2/nc = (Z1 + Z2)/Z2
nc: velocity of the blue crank.
n3: velocity of the green gear, its tooth number: Z3 = 20
n2: velocity of the yellow gear, its tooth number: Z2 = 20
Z1 = 24, tooth number of the fixed orange gear.
The crank, the yellow gear always rotate the same direction.
The rotation direction of the green gear depends on (Z3-Z1).

4-gear planetary mechanism A

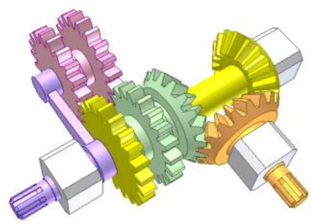
http://youtu.be/5dSVJxebzLY



Mechanism for reversing rotation direction.
i = n1/nc = 1 - ((Z2.Z4)/(Z1.Z3))
nc: velocity of the blue crank.
n1: velocity of the orange gear, its tooth number: Z1 = 20.
Z2 = 40 (yellow gear); Z3 = 30 (pink gear); Z4 = 30 (fixed green gear)
Z1 + Z2 = Z3 + Z4
i = - 1
The blue crank and the orange gear have equal velocity but rotate in opposite directions.

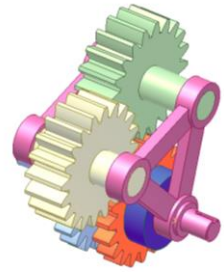
Planetary Reduction Gear 8

http://youtu.be/l-2-v3Bkfp8



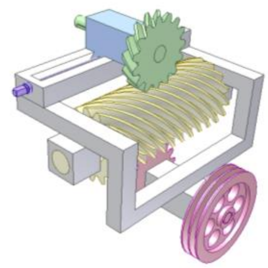
Input: violet carrier of velocity Nv
Output: orange bevel gear of velocity No
Three bevel gears have the same tooth number.
Yellow gear block has yellow spur gear of Zy teeth.
Green gear block has green spur gear of Zg teeth.
Pink gear block has pink gears of Zp1 teeth (gear on the left) and Zp2 teeth.
Zy + Zp1 = Zg + Zp2
No = Nv(1-A)/(1+A)
Where A = (Zp1.Zg)/(Zy.Zp2)
For this case Zy = Zp2 = 21; Zg = Zp1 = 20
No = Nv/20.51
If Zy = Zp2 = 101; Zg = Zp1 = 100
No = Nv/100.5
The three bevel gears aim that the yellow and green gear blocks rotate in opposite directions with the same velocity. Four spur gear drive can do that function. See:
https://www.youtube.com/watch?v=MB7zUQCQRxI

Reductor with gears of equal number of teeth 4



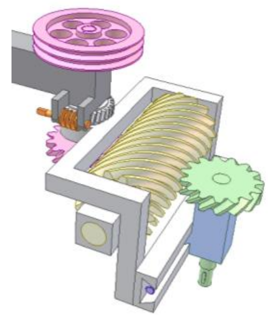
http://www.youtube.com/watch?v=dNsMZF7boCM
A result once generally supposed impossible.
The red gear is fixed.
The yellow gear engages with the red and the green gears.
The green gear engages with the yellow and the blue gears.
The blue shaft rotates two times faster than the pink crank.

Transmission to moving shaft 1



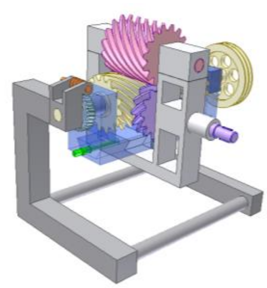
https://youtu.be/ypGXtQtCwPE
Input: pink shaft.
Output: green shaft.
Helical gear drives enable the output bearing (in blue) to move along a stationary runway while maintaining the transmission.
All 45 deg. right hand helical gears are of the same tooth number of 15.
Rotary directions of the input and output are opposite.

Transmission to moving shaft 2



https://youtu.be/XUAOQon1Y90
Input: pink shaft.
Output: green shaft.
Helical gear drives enable the output bearing (in blue) to be displaced while maintaining the transmission.
All 45 deg. right hand helical gears are of the same tooth number of 15.
Rotary directions of the input and output are opposite.
Position of the output shaft along the runway can be adjusted thanks to violet screw.
Position of the output shaft around the input axis can be adjusted thanks to orange worm and white worm wheel.
The adjusting motions can be performed without stopping the input motion as shown in the video last scene.

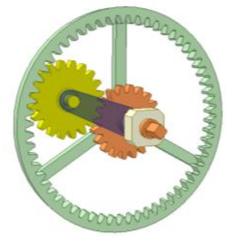
Transmission to moving shaft 3



https://youtu.be/fVpCdbFhR0g
Input: yellow shaft.
Output: violet shaft.
Helical gear drives enable the output bearing (in blue) to be displaced while maintaining the transmission.
All 45 deg. helical gears are of the same tooth number.
Pink and yellow gears are of right hand helical teeth, violet gear is of left hand helical teeth or vice versa.
Use green screw to adjust position of the output shaft along the runway.
Use orange worm drive to adjust position of the output shaft around the input axis.
* See a cable mehanism of the same function:
https://youtu.be/eWL-9nD16Gk

3-gear planetary mechanism A1

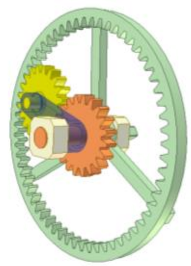
http://youtu.be/ZwdF96B55lY



i = nc/n1 = Z1/(Z1+Z3)
nc: velocity of the blue crank.
n1: velocity of the orange gear, its tooth number: Z1 = 20
Z2 = 20, tooth number of the yellow gear.
Z3 = 60, tooth number of the fixed green internal gear.
Z1 + 2Z2 = Z3
i = 1/4
The crank, the orange gear always rotate the same direction independently of the tooth numbers..

3-gear planetary mechanism A2

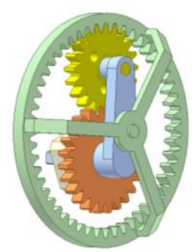
http://youtu.be/MfYuWLOqSwQ



i = nc/n3 = Z3/(Z1+Z3)
nc: velocity of the blue crank.
n3: velocity of the green internal gear, its tooth number: Z3 = 60.
Z1 = 20, tooth number of the fixed orange gear.
Z2 = 20, tooth number of the yellow gear.
Z1 + 2Z2 = Z3
i = 3/4
The crank, the green and yellow gear always rotate the same direction independently of the tooth numbers..

3-gear planetary mechanism B

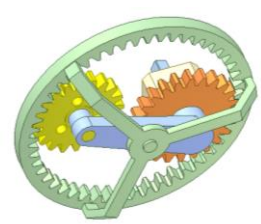
http://youtu.be/FMnWeK9-obg



i3 = n3/nc = (Z1 + Z3)/Z3
i2 = n2/nc = (Z1 + Z2)/Z2
nc: velocity of the blue crank.
n3: velocity of the green gear, its tooth number: Z3 = 50
n2: velocity of the yellow gear, its tooth number: Z2 = 20
Z1 = 24, tooth number of the fixed orange gear.
The crank, the yellow and green gears always rotate the same direction independently of the tooth numbers..

3-gear planetary mechanism C

http://youtu.be/-y1_foDmOtY



i3 = n3/nc = (Z3 – Z1)/Z3
i2 = n2/nc = (Z2 - Z1)/Z2
nc: velocity of the blue crank.
n2: velocity of the green gear, its tooth number: Z2 = 50
n3: velocity of the yellow gear, its tooth number: Z3 = 20
Z1 = 24, tooth number of the fixed orange gear.

3-gear planetary mechanism D

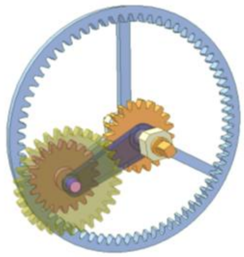
http://youtu.be/JhCTd-LeZHU

i3 = n3/nc = (Z1 + Z3)/Z3
i2 = n2/nc = (Z2 - Z1)/Z2
nc: velocity of the blue crank.
n3: velocity of the yellow gear, its tooth number: Z3 = 20
n2: velocity of the orange gear, its tooth number: Z2 = 20
Z1 = 70, tooth number of the fixed green gear.

4-gear planetary mechanism B

http://youtu.be/DcegsYhZEug

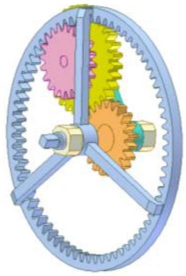
i = nc/n1 = 1/(1+ ((Z2.Z4)/(Z1.Z3)))
nc: velocity of the blue crank.
n1: velocity of the orange gear, its tooth number: Z1 = 20.
Z2 = 30 (yellow gear); Z3 = 20 (pink gear); Z4 = 30 (fixed blue gear)
Z1 + Z2 = Z4 – Z3
i = 4/25
The crank, the orange gear always rotate in the same direction independently of the tooth numbers..



4-gear planetary mechanism C

http://youtu.be/hW7VrI7WskU

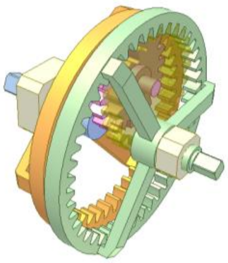
i = nc/n4 = 1/(1+ ((Z1.Z3)/(Z2.Z4)))
nc: velocity of the green crank.
n4: velocity of the blue internal gear, its tooth number: Z4 = 70.
Z2 = 30 (yellow gear); Z3 = 20 (pink gear); Z1 = 20 (fixed orange gear)
Z1 + Z2 = Z4 – Z3
i = 21/25
The crank, the blue internal gear always rotate in the same direction independently of the tooth numbers..



4-gear planetary mechanism D

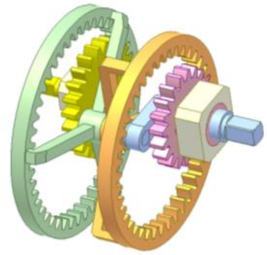
http://youtu.be/-JBWH6UvZtM

i = n1/nc = 1 – ((Z2.Z4)/(Z1.Z3))
n1: velocity of the green internal gear, its tooth number Z1 = 44
nc: velocity of the blue crank.
Z2 = 24 (yellow gear); Z3 = 20 (pink gear); Z4 = 40 (fixed orange internal gear). The yellow gear and the pink one are fixed together.
Z1 - Z2 = Z4 – Z3
i = -1/11
The crank, the green gear rotate in opposite directions for this case.



4-gear planetary mechanism E

http://youtu.be/c09J2mDX1yI



i = n1/nc = 1 – ((Z2.Z4)/(Z1.Z3))

n1: velocity of the yellow gear, its tooth number Z1 = 44

nc: velocity of the blue crank.

Z2 = 44 (green internal gear); Z3 = 40 (orange internal gear); Z4 = 20 (fixed pink gear). The green gear and the orange one are fixed together.

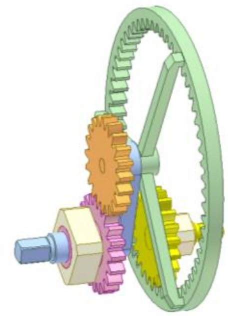
Z2 – Z1 = Z3 – Z4

i = 1/12

The crank, the yellow gear rotate the same direction for this case.

4-gear planetary mechanism F

http://youtu.be/798M628MUlM



i = n4/nc = 1 + ((Z1.Z3)/(Z2.Z4))

n4: velocity of the yellow gear, its tooth number Z4 = 20

nc: velocity of the blue crank.

Z2 = 20 (orange gear); Z3 = 60 (green internal gear); Z1 = 20 (fixed pink gear). The green gear and the orange one are fixed together.

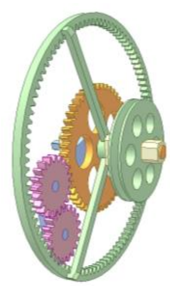
Z1 + Z2 = Z3 – Z4

i = 4

The crank, the yellow gear always rotate the same direction independently of the tooth numbers.

4-gear planetary mechanism G1

http://youtu.be/22hIFLhfDio



i = n4/nc = 1 – Z1/Z4

nc: velocity of the blue crank.

n4: velocity of the green gear, its tooth number: Z4 = 100.

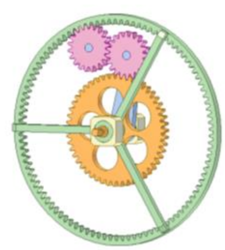
Z2 = Z3 = 20 (pink gears); Z1 = 50 (fixed orange gear)

i = 1/2

The blue crank and the green gear always rotate in the same direction independently of the tooth numbers..

4-gear planetary mechanism G2

http://youtu.be/ZZN3JBacmlM



Mechanism for reversing rotation direction

i = n1/nc = 1 – Z4/Z1

nc: velocity of the blue crank.

n1: velocity of the orange gear, its tooth number: Z1 = 50.

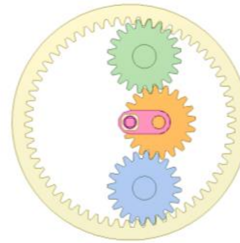
Z2 = Z3 = 20 (pink gears); Z4 = 100 (fixed green gear)

i = - 1

The blue crank and the orange gear have equal velocity but rotate in opposite directions.

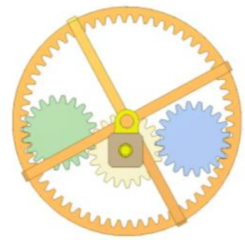
4-gear planetary drive 1
http://www.youtube.com/watch?v=OXy-ayPXFJM
Tooth number of:
- fixed ring gear: 60
- other gears: 20

N1 = 4 Nc
N1: velocity of the orange gear
Nc: velocity of the crank



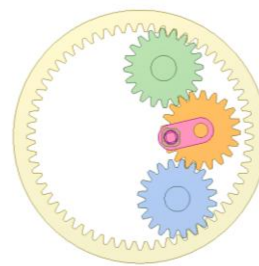
4-gear planetary drive 2
http://www.youtube.com/watch?v=BrCUnruM1j8
Tooth number of:
- ring gear: 60
- other gears: 20

N2 = (4/3) Nc
N2: velocity of the ring gear
Nc: velocity of the crank



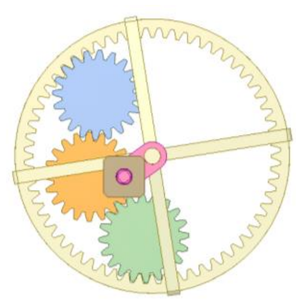
4-gear offset planetary drive 1
http://www.youtube.com/watch?v=jZ3BTzQ3ULw
Tooth number of:
- planet gears: 20
- fixed ring gear: 60

Gear module: 2 mm
Length of the crank = eccentric of the fixed bearing house with the ring gear, 17 mm.
N1 = 2Nc
N1: velocity of the orange gear
Nc: velocity of the crank
A successively increasing/decreasing space (suction/compression) is formed on either side of the ring gear and planet ones so the mechanism can be used for pumps.

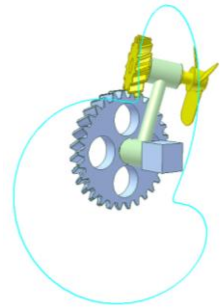


4-gear offset planetary drive 2
http://www.youtube.com/watch?v=UEtjQV10SVw
Tooth number of:
- ring gear: 60
- other gears: 20

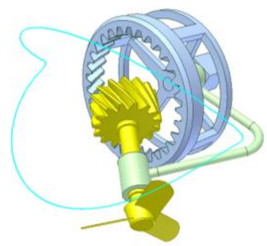
Gear module: 2 mm
Length of the crank = eccentric of the fixed bearing house with the orange gear, 17 mm.
N2 = (2/3)Nc
N2: velocity of the ring gear
Nc: velocity of the crank
A successively increasing/decreasing space (suction/compression) is formed on either side of the ring gear and planet ones so the mechanism can be used for pumps.



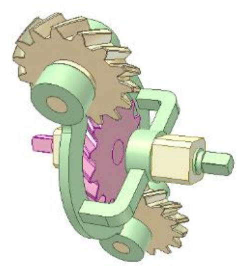
Screw gear drive 6
http://youtu.be/CC3L22A7M-E
Satellite external screw drive
Normal module mn = 2 mm
+ Pinion:
- Helix angle B1 = 30 deg., left hand
- Tooth number Z1 = 15
+ Wheel:
- Helix angle B2 = 30 deg., left hand
- Tooth number Z2 = 30
Angle between gear axles E = B1 + B2 = 60 deg.
The blue curve is locus of a point on the satellite pinion (a space epicycloid?)



Screw gear drive 7
http://youtu.be/hYjZuVhpEbQ
Satellite internal screw drive
Normal module mn = 2 mm
+ Pinion:
- Helix angle B1 = 30 deg., left hand
- Tooth number Z1 = 15
+ Wheel:
- Helix angle B2 = 30 deg., right hand
- Tooth number Z2 = 30
Angle between gear axles E = B1 + B2 = 60 deg.
The blue curve is locus of a point on the satellite pinion (a space hypocycloid?)



Screw gear drive 8
http://youtu.be/5AizQPWoGxI
Green ring and pink gear rotate around a fixed axis.
The ring carries two gears rotating idly on it.
The planetary mechanism has two degrees of freedom.
Input are the green ring and the pink gear.
The video shows case when the ring rotates regularly, at first the pink gear is kept immobile and then rotates.

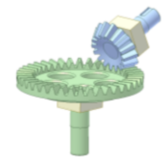


1.3.2. Bevel gears

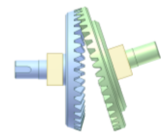
Bevel Gears 1
http://www.youtube.com/watch?v=kbBswXcIiKo
Angle between shafts α < 90 degrees

Bevel Gears 2
http://www.youtube.com/watch?v=Payj9xoQNjw
Angle between shafts α = 90 degrees

Bevel Gears 3
http://www.youtube.com/watch?v=fSfmEXJxebc
Angle between shafts α > 90 degrees.
Bevel gear with angle of wheel pitch cone of 180 degrees.

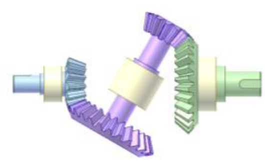


Bevel Gears 4
http://www.youtube.com/watch?v=omFu1uOtTEk
Angle between shafts α nearly equal 180 degrees.
Bevel gear with angle of wheel pitch cone of 180 degrees.



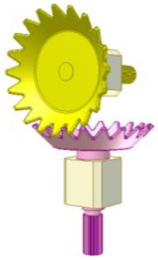
Bevel Gears 5
http://www.youtube.com/watch?v=S0fAeqzIA3k
Bevel gear with internal toothing.

Bevel Gears 6
http://www.youtube.com/watch?v=p_ZqoHcTQOU
Double reduction coaxial bevel gear.

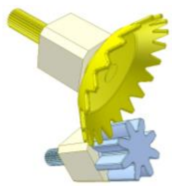


Bevel Gears 7
http://www.youtube.com/watch?v=EIHiPaJiIGk
Double reduction coaxial bevel gear.

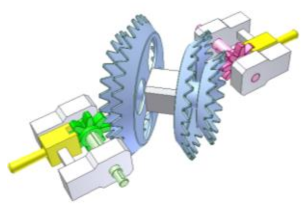
Sheet metal gears 3
http://youtu.be/BSvZs3uNNn0
For light loads.
Low cost.
Adaptability to mass production.
Two blanked gears, conically form after blanking become bevel gears.



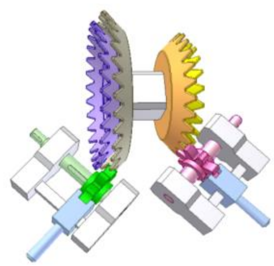
Sheet metal gears 5
http://youtu.be/h6SRmSO2Mzo
For light loads.
Low cost.
Adaptability to mass production.
Yellow bevel gear is conically formed after tooth blanking.
Blue pinion is made by extruding or machining.



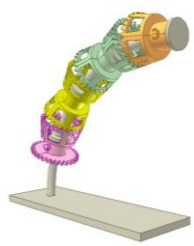
Gear box of sheet metal bevel gears 1
https://youtu.be/zHQHG_DNw2w
Input: pink shaft.
Output: green shaft.
Move yellow sliders to get four speeds of the output.
Input and output shafts are parallel.
It is used for bicycle transmission:
https://www.youtube.com/watch?v=lfRTzrHKNUo



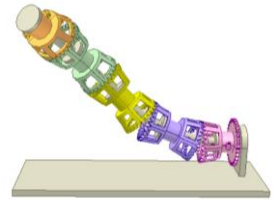
Gear box of sheet metal bevel gears 2
https://youtu.be/RPGr5xPHtkM
Input: pink shaft.
Output: green shaft.
Move blue sliders to get four speeds of the output.
Input and output shafts are perpendicular to each other.



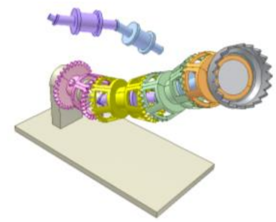
Transmission for rotors placed along a circle 3
https://youtu.be/3joyFSW5-2k
Input: pink gear-rotor.
The transmission is performed via bevel gear drives.
They are constant velocity joints.



Transmission for rotors placed along a spatial curve 2
https://youtu.be/Oki37UBtg5w
Input: pink gear-rotor.
The transmission is performed via bevel gear drives.
They are constant velocity joints.
The curve consists of two 45 deg. circular curves connected together.

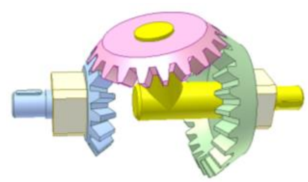


Transmission for rotors placed along a variable spatial curve
https://youtu.be/cZVzXlX6KA8
The curve consists of 4 sections, one stationary, the others movable.
They are connected together by revolution joints. So the curve has 3 DoF. Drives to vary the curve shape are not shown.
Motion from input pink gear-rotor is transmitted to orange gear-rotor (that may carry a tool) via bevel gear drives.
They are constant velocity joints.



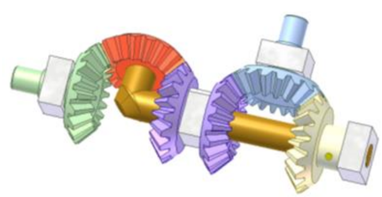
Reductor with gears of equal number of teeth 2
http://www.youtube.com/watch?v=aP1hr_9hQLA
A result once generally supposed impossible.
The blue gear rotates two times faster than the brass shaft.

Satellite Bevel Gear 8
https://www.youtube.com/watch?v=K7j8Pi4ATd0
Green gear is fixed.
Pink gear is idly mounted on yellow crank.
Pink gear axis is not perpendicular to rotary axis of the yellow crank.



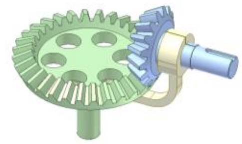
Vy = Vb.Zb/(Zb+Zg)
Vp = Vy(Zg/Zp)
Vb, Vy: velocities of blue gear and yellow crank.
Vp: velocity of pink gear around yellow crank.
Zg, Zb, Zp: tooth numbers of green, blue and pink gears respectively.
It is not easy to choose tooth numbers to meet assembly condition for this drive, especially in case of several satellite pink gears arranged symmetrically around the yellow crank.

Reductor with gears of equal number of teeth 5
http://www.youtube.com/watch?v=DT7N5GfLOUE
A result once generally supposed impossible.
The violet gears turn loosely on the brass shaft.
The yellow gear is fixed on the brass shaft.
The green gear rotates three times faster than the blue one.

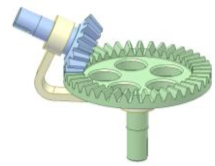


Satellite Bevel Gear 1
http://www.youtube.com/watch?v=EXuUtS-jvQs

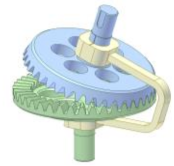
Satellite Bevel Gear 2
http://www.youtube.com/watch?v=YrSbMaC4Fx4



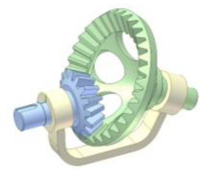
Satellite Bevel Gear 3
http://www.youtube.com/watch?v=rLDyDe9eaXs



Satellite Bevel Gear 4
http://www.youtube.com/watch?v=JJfQAcXirhI



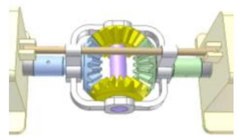
Satellite Bevel Gear 5
http://www.youtube.com/watch?v=nsk5zRCciww



Satellite Bevel Gear 6
http://www.youtube.com/watch?v=P1FX2Q5E1lk

Satellite Bevel Gear 7
http://www.youtube.com/watch?v=hV2LwzHDh2Q

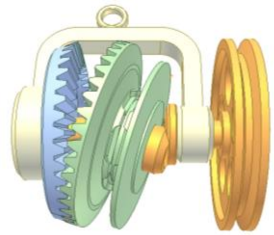
Bevel gear drive for reversing rotation 1
https://youtu.be/x8dRHC4XlbI



Reverse coupling.
Left and right coaxial shafts (in grey) rotate in opposite directions at the same velocity.
Brown bar is used for keeping white frame of the bevel gear drive immobile.

Satellite Bevel Gear

http://www.youtube.com/watch?v=eT_rtLEcjIs



Chain hoist with two bevel gears.

n2 = n1 (Z2-Z1)/Z2

n1: velocity of orange shaft

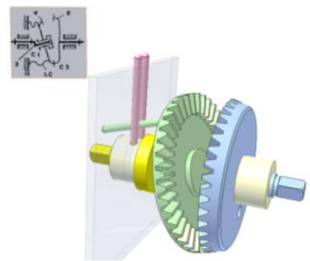
n2: velocity of green gear.

Z1: tooth number of blue gear

Z2: tooth number of green gear

Transmission through closed wall with bevel gear drive

https://www.youtube.com/watch?v=skt4KGzScbY



Green bevel gear: tooth number: 40, pitch angle: 90 deg.

Blue bevel gear: tooth number: 38, pitch angle: 71.80 deg.

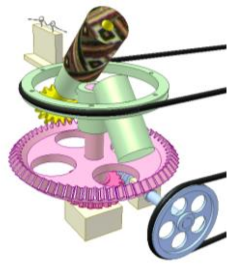
Input: yellow shaft having an oblique (18.20 deg.) pivot and rotating regularly.

Output: blue gear rotating irregularly (even turning back).

Purpose of 3 pins (in pink and green) is to show that the green gear can be kept not to rotate together with the yellow shaft. So it is possible to put a flexible tube connecting the green gear and the glass wall thus to perform the transmission through closed wall on which the left bearing is fixed (see the sketch).

Planetary drive 2

http://youtu.be/PuQ1K77piRM

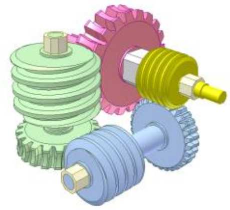


Mechanism for winding yarn ball.

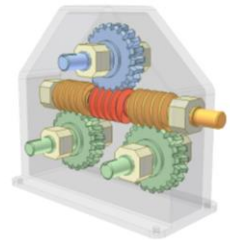
Pink gear, yellow satellite gear and green carrier create a differential planetary drive. The green carier is driving. The yellow satellite gear and yarn ball rotate around the vertical axis and around their own axis. Moreover the pink gear gets rotation from a worm drive and blue pulley. This motion helps increase or reduce the ball rotation around its own axis.

1.3.3. Worm gears

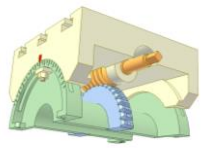
Worm Drive 1: Gear box
http://youtu.be/FZ1HQB4DEuQ
Serial connection of three worm drives. Input: the yellow worm; output: the pink worm wheel. They are coaxial.
Transmission ratio of each drive: i1, i2, i3.
Total ratio i = i1.i2.i3 = 30.20.20 = 12,000



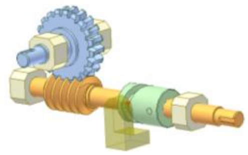
Worm Drive 2: Gear box
http://youtu.be/iQZegMhoYeU
One screw actuates 3 gears simultaneously. The axes of gears are at right angles to that of the screw. This mechanism can replace more expensive gear setups there speed reduction and multiple output from a single input is required.



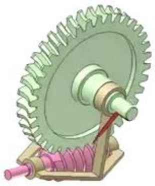
Worm Drive 4: Rotating and rolling worm
http://youtu.be/HVUwMqEiHBw
Swivel Table for Machine Tools
The worm rotates around its axle and rolls on the worm wheel simultaneously.



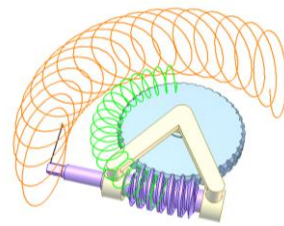
Worm Drive 5: Rotating and translating worm
http://youtu.be/kTCqSWVO32A
Beside rotation the input worm also moves longitudinally owing a cylinder cam. The worm wheel revolves with back rotation.



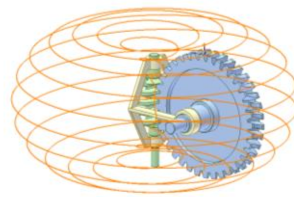
Worm Drive 6: Wheel rotating around worm
http://www.youtube.com/watch?v=4gS5QgwIkok
The wheel rotates around the worm.
The red hand proves that the wheel rotates around its axle.
Completing 1 revolution around the worm axle, the wheel makes Z1/Z2 revolution around its axle.
Z1: number of threads of the worm.
Z2: tooth number of the wheel.



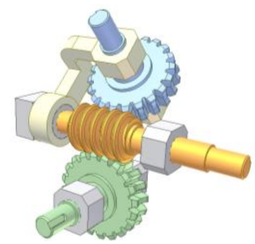
Worm Drive 7: Rotating and rolling worm loci
http://youtu.be/aOFozC13Wvg
The worm rotates around its axle and rolls on the wheel simultaneously. A worm's point (in the plane that is perpendicular to worm's axle and contains the wheel axle) traces a torus helix (green). A point that is not in the said plane traces skew torus helix (orange)



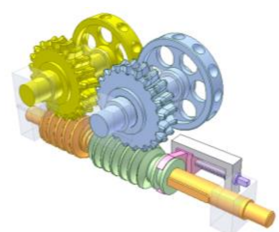
Worm Drive 8: Wheel rotating around worm locus
http://youtu.be/RcsllgLLm70
The wheel rotates around its axle and around the worm simultaneously.
The orange line is locus of a wheel's point situated in the plane that is perpendicular to the wheel's axle and contains the worm axle. The point's distance to the wheel's axle is equal to the axle distance between the worm and the wheel.



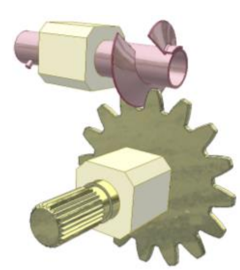
Worm drive 14
https://youtu.be/-Qi1TtnTQT4
Two possible motions of orange worm: rotation and translation make green wheels rotate in opposite directions.
Note: in case of three spur gears aranged in a line (orange middle gear engaging with blue and green gears), the blue and green gears rotate in the same direction.
Relative angular position between the wheels can be adjusted even during the transmission.



Transmission between two parallel shafts with adjustable relative angle 3
http://youtu.be/DTlt-7YyOJU
Input: orange shaft.
Yellow and blue shafts receive rotary motion from orange input shaft through two worm drives.
The green worm has prismatic joint (sliding key) with the orange shaft.
Turn violet screw for moving pink slider and green worm to adjust relative positioning angle between yellow and blue rollers.
The adjustment can be performed even during transmission.
The self-locking of the violet screw preserves the adjusted angle from accidental motion of the green worm.

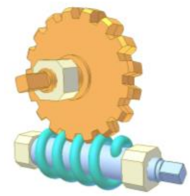


Sheet metal gears 8
http://youtu.be/zqYFVNY1CYA
For light loads.
Low cost.
Adaptability to mass production.
The worm is a sheet metal disk that was split and helically formed.
The worm can work only in one direction.

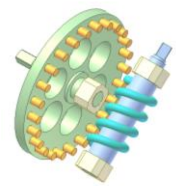


Worm Drive 9: Roller-Wheel
http://youtu.be/DNCOcXpccCk
The wheel is equipped with rollers to reduce friction loss.

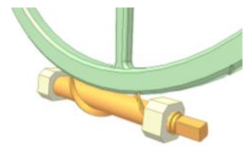
Worm Drive 10: Spring-Worm
http://youtu.be/s71Vo2jSBuA
Spring gives worm and helps absorb heavy shocks.



Worm Drive 11: Spring-Worm, Pinned Wheel
http://youtu.be/928LPTiLgnc
Spring and pins give alternate ways for producing the worm and worm-wheel.

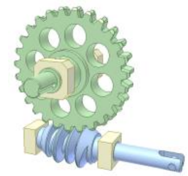


Worm Drive 12: Multiplying gear
http://youtu.be/YdfAwjfSYsA
Input: the green wheel.
The orange output worm has thread of large pitch.

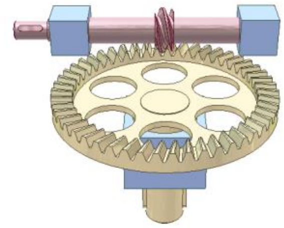


Worm Drive 13: Slotted Wheel
http://youtu.be/1V4x20xwbvo
Slots on a thin rim gives an alternate way for producing the wheel.
This concept is used for rubber pipe clamping, see:
http://kalyx.com/images/full/images_J/J_380030.jpg

Globoidal gear
http://youtu.be/wM4xuxoqiDI

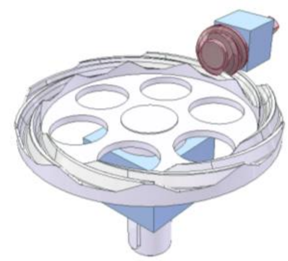


Worm and face gear drive 1



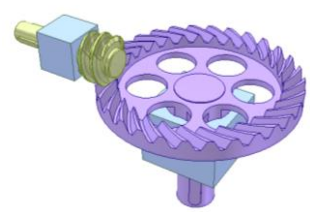
https://youtu.be/g3sFRdKdEkQ
Worm: 2 starts.
Wheel: 50 teeth. It is not a bevel gear.
Transmission ratio: 25.
Rotary axes of the worm and the wheel are skew at an angle of 90 deg. It works like a conventional worm – worm wheel drive but its load capacity can be increased with longer thread portion of the worm.
Here tooth profile of the wheel was created in an approximate way, so the motion is not smooth.

Worm and face gear drive 2

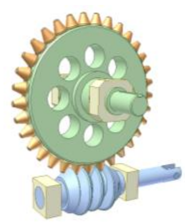


https://youtu.be/qGQtYx0pJVI
Worm: 2 starts.
Wheel: 10 teeth.
Transmission ratio: 5.
Rotary axes of the worm and the wheel are intersecting at an angle of 90 deg. It works like a bevel gear drive but its load capacity is much higher.
Here tooth profile of the wheel was created in an approximate way, so the motion is not smooth.

Worm and face gear drive 3

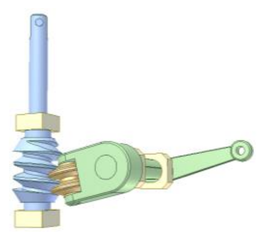


https://youtu.be/dk7TcDXzWGU
Worm: 2 starts.
Wheel: 30 teeth.
Transmission ratio: 15.
Rotary axes of the worm and the wheel are skew at an angle of 90 deg. It works like a spiral bevel gear drive but its transmission ratio is easy to get higher.
Here tooth profile of the wheel was created in an approximate way, so the motion is not smooth.



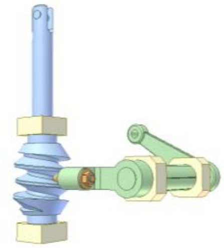
Globoid worm and pin gear
http://youtu.be/k5UuUUFP6b8

Globoid worm and roller drive

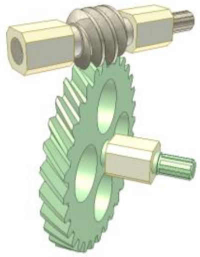


http://youtu.be/xxsgE8acedw
It is used in car steering system. The worm is connected to a steering wheel. The roller reduces friction at contact place. A globoid worm gives better performance than ordinary one.

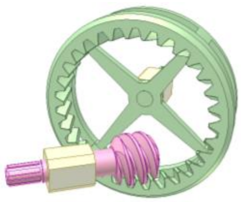
Globoid worm and pin drive
http://youtu.be/NI4fmw2YRRk
It is used in car steering system. The worm is connected to a steering wheel. The rotary pin reduces friction at contact place. A globoid worm gives better performance than ordinary one.



Worm and external gear
http://youtu.be/vgDblGX8xFg
Normal module mn = 2 mm
Input worm:
- Number of starts Z = 2
- Lead Angle LA = 10.81 deg.
- Direction of thread: right hand
- Pitch circle dia. D = 20 mm
Gear:
- Helix angle B2 = 45 deg., right hand
- Tooth number Z2 = 30
- Pitch circle dia. D2 = 84.85 mm
Angle between worm and gear axes is L = 55.81 deg.
Velocity ratio: i = Z2/Z1 = 15

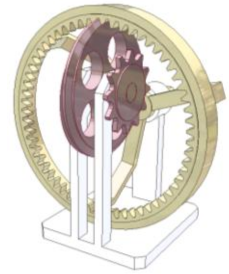


Worm and internal gear
http://youtu.be/jQFkUKiEwWU
Normal module mn = 2 mm
Input worm:
- Number of starts Z = 2
- Lead Angle LA = 10.81 deg.
- Direction of thread: right hand
- Pitch circle dia. D = 20 mm
Gear:
- Helix angle B2 = 30 deg., right hand
- Tooth number Z2 = 30
- Pitch circle dia. D2 = 69.28 mm
Angle between worm and gear axes is L = 40.81 deg.
Velocity ratio: i = Z2/Z1 = 15

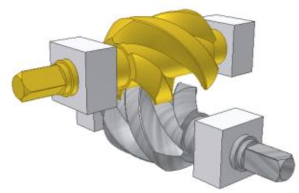


Internal worm 1
http://youtu.be/BDB-QOFkC8M
Internal worm is the grey ring. In fact it is a nut (1 start) engaging with green gear (40 teeth). Tooth shape of the green gear is not the one of ordinary spur gears.
Input is pink pinion (10 teeth) engaging with yellow large internal gear (60 teeth).
The grey ring and the internal gear are fixed together.
Output motion is taken from the green chain sprocket.
Total transmission ratio: (60/10).(40/1) = 240.

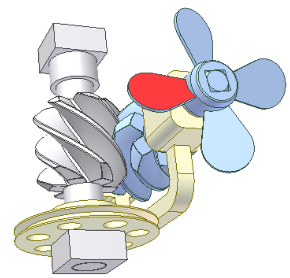
Internal worm wheel 1
http://youtu.be/mkDoJLZrXZA
Internal worm wheel is the yellow ring.
In fact it is a helical gear (60 teeth) engaging with pink worm (1 start).
Power is transmitted to chain sprocket fixed to the worm.
Transmission ratio: 60.



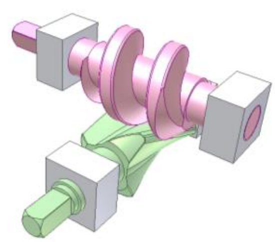
Two-worm drive 1
https://youtu.be/kGr6zlNDrwc
Transmission between two 90 deg. skew identical worms.
Lead angle of the worm thread is 45 deg.
Start number of the worms: 3
Transmission ratio: 1



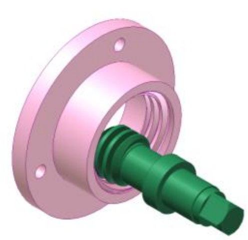
Two-worm drive 2
https://youtu.be/S5WQKetOCuQ
The white worm is stationary.
Yellow bracket rotates around the white worm axis (speed S1).
It makes the blue worm rotate around its own axis (speed S2).
S1 = S2
Threads of the two worms are identical.
Lead angle of the worm thread is 45 deg.
Start number of the worms: 6



Worm gear drive 2
https://youtu.be/1b--9WQwX4c
Axes of green gear and pink worm are skew at 90 deg. angle.
Start number of the worm: 1.
Tooth number of the gear: 3.
Input: the worm.
Transmission ratio: 3
It is a self-locking drive of small transmission ratio. The gear can not be the input.
The output rotation is not smooth because the gear tooth profile has not been designed well.

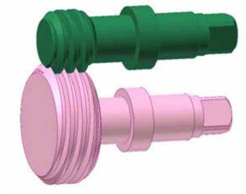


Rotary transmission between screw and nut
http://www.youtube.com/watch?v=KterrnNi-oA
$n1/n2 = Z2/Z1 = D2/D1 = P2/P1 = 2$
n1, n2: velosity of screw, nut
Z2, Z1: number of threads of nut, screw
D2, D1: average diameter of nut, screw
P2, P1: pitch of threads of nut, screw
Screw and nut have same helix direction (right-handed) and rotate in the same direction.



Rotary transmission between screws

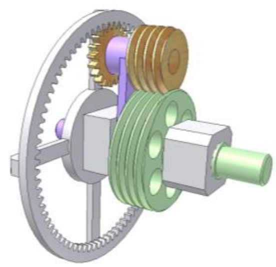
http://www.youtube.com/watch?v=R-Dy2eZ8Y64



n1/n2 = Z2/Z1 = D2/D1 = P2/P1 = 2
n1, n2: velosity of screws 1, 2
Z1, Z2: number of threads of screws 1, 2
D1, D2: average diameter of screws 1, 2
P1, P2: pitch of threads of screws 1, 2
Screws have opposite helix direction and rotate in opposite direction.

Worm–worm drive 2

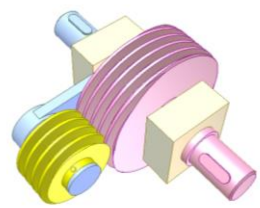
http://youtu.be/rgxeKBfs80M



Violet crank carrying orange block of small gear (pitch radius R2) and small worm (1 start, lead: t1, pitch radius: R3).
Green large worm: 2 starts, lead: t2 = 2.t1, pitch radius: R4 = 2.R3.
Grey internal gear (pitch radius R1 = 4.R2) is stationary.
V4 = Vc(1+A)
V4: velocity of the green worm
Vc: velocity of the violet crank
A = (R3/R4).(R1/R2); in this video A = 2 so V4 = 3Vc
The violet crank and the green worm rotate in the same direction.

Study of worm-worm drive 1

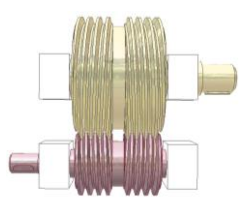
http://youtu.be/JvzI2_4UKBU



Input: blue crank to which is fixed a yellow small worm (1 start, lead: t1, pitch diameter: D1).
Output: large worm (2 starts, lead: t2 = 2.t1, pitch diameter: D2 = 2.D1)
The output and the input rotate with the same velocity and direction.
The small worm can be replaced with a cylinder of circular grooves or with a rack.
If the yellow worm has revolution joint with the crank and there is sufficient friction between the worms, the output and the input rotate with the same velocity and direction too (the yellow worm doesn't rotate on its pivot).
If not, the output rotates slower than the input.
Worm diameters do not play essential role in terms of kinematics.

Worm-worm drive 1

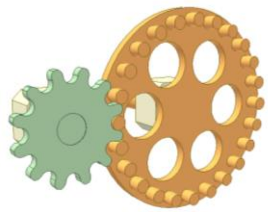
http://youtu.be/KP-5OLpI9cg



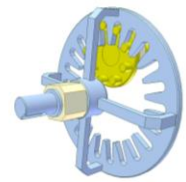
V-gearing, in which the teeth are at a very small angle with the plane of rotation, makes a perfectly silent of transmission of power.
Transmission ratio: 2
Small worm: 1 start, lead: t1, pitch diameter: D1
Large worm: 2 starts, lead: t2 = 2.t1, pitch diameter: D2 = 2.D1
It can be considered as a case of herringborne gear:
http://youtu.be/K_i4kU_L8Lw
When helix angle is near 90 deg.

1.3.4. Pin gears

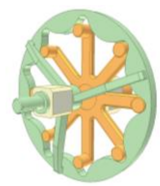
Pin gear drive 1A
http://youtu.be/5Wj3y08y4nQ
Transmission ratio i = 12/24
The pin wheel: orange. The tooth wheel: green.
The tooth profile is the envelope of a family of the pin circles, centers of which are on an epicycloid (external gearing) or a hypocycloid (internal gearing) traced by pin circle center when the pin wheel rolls without slipping on the tooth wheel.



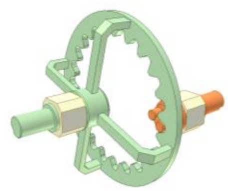
Pin gear drive 1B
http://youtu.be/F6hr0np0zsY
Transmission ratio i = 9/22



Pin gear drive 1C
http://youtu.be/yQLhCzcUexM
Transmission ratio i = 8/9

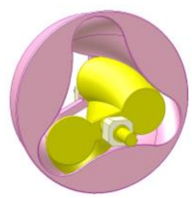


Pin gear drive 1D
http://youtu.be/JA9lKOEsCV4
Transmission ratio i = 2/22



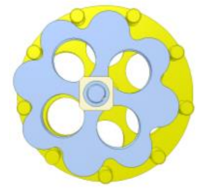
Pin gear drive 1E1
http://youtu.be/nOLV6L-3fsU
Transmission ratio i = 2/3

Pin gear drive 1E2
http://youtu.be/X9pqNhfv5fo
Transmission ratio i = 2/3
An embodiment of “Pin gear drive 1E1” with helical pins and teeth.

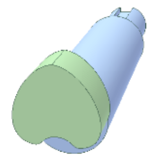
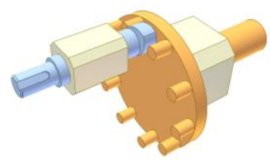


Pin gear drive 1F
http://youtu.be/nW1XrnThuRs
Transmission ratio i = 3/4

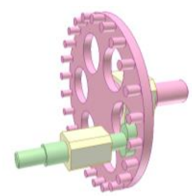
Pin gear drive 1G
http://youtu.be/hDWFOLADxsU
Transmission ratio i = 9/8



Pin gear drive 1H1
http://youtu.be/XXeFMr5kFl0
Transmission ratio i = 1/10

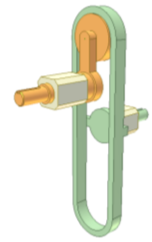



Pin gear drive 1H2
http://youtu.be/Gge11gvnM08
Transmission ratio i = 2/24

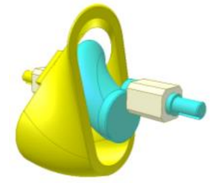



Pin gear drive 1H3
http://youtu.be/EocIZWIEAsY
Transmission ratio i = 3/24

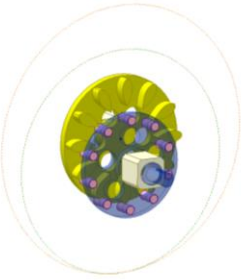
Pin gear drive 1I1
http://youtu.be/L5oN9EiksOA
Transmission ratio i = 1/2
The gear profile is a straight line.
The mechanism has an unstable position, when the pin centerline and the green gear centerline are coaxial. It is avoided by using helical pin and gear. See: ”Pin gear drive 1I2”



Pin gear drive 1I2
http://youtu.be/nGMOC7STi5E
Transmission ratio i = 1/2
An improvement of the mechanism shown in “Pin gear drive 1IA”.

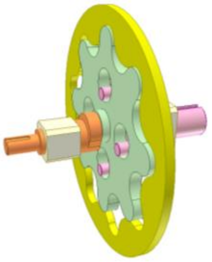


Pin gear drive 1M
http://youtu.be/yW8RGxV8xTU
Transmission ratio i = 10/12
The pin centers are not on the rolling circle of the pin wheel.
The two dashed circles are the rolling circles of the mechanism.
The tooth profile is the envelope of a family of the pin circles, centers of which are on an shortened hypocycloid traced by pin circle center when the pin wheel rolls without slipping on the tooth wheel.

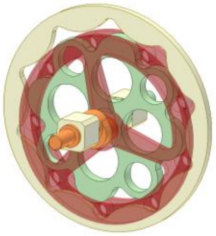


Pin gear drive 2
http://youtu.be/649flFhwUHE
An advantage of a pin wheel (the yellow one): it can work at the same time as a gear with external and internal teeth.

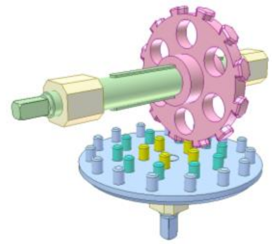
Pin gear drive 3A
http://youtu.be/h1l82ose0w4
Cycloidal speed reducer.
The orange input crank carries the green wheel. In fact it is a pin wheel (Z1 = 8 pins) that engages with stationary yellow tooth wheel (Z2 = 9 teeth). The pink output shaft has a disk of pins that engage with the holes of the green pin wheel. The radius difference of the pink pins and the holes is equal to the eccentricity of the orange crank.
i = n1/n3 = Z1/(Z2-Z1) = 8
n1: input crank velocity
n3: output velocity
If (Z2-Z1) small and Z1 large, i can be very large.
The input and the output rotate in opposite directions.



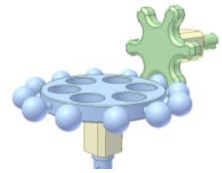
Pin gear drive 3B
http://youtu.be/mEx2qzJH37c
An advantage of a pin gear: it can work at the same time as a gear with external and internal teeth.
The orange input crank carries the red pin gear (Z2 = 9 pins) that engages with output green gear (Z1 = 8 teeth) and yellow stationary gear (Z3 = 10 teeth).
i = nc/n1 = Z1/(Z3-Z1) = 4
nc: input crank velocity
n1: output gear velocity
If (Z1-Z3) small and Z1 large, i can be very large.
The input and the output rotate in opposite directions.
The pins can be equipped with roller bearings to get a no-sliding speed reducer.



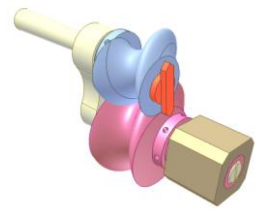
Pin gear drive 5
http://youtu.be/0n8wOO795Eg
Input: green shaft on which pink gear wheel can slide.
Output: blue disk with pins arranged in three concentric circles.
Adjust the pink gear position on the green shaft to get 3 forward and 3 reverse speeds.
The video shows cases of 2 forward and 1 reverse speeds.
A considerable backlash is present in the drive.



Space pin gear drive 1
http://youtu.be/VhyoKuoOv-8

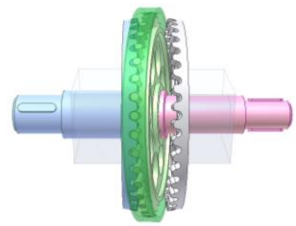


Pin coupling 6
http://www.youtube.com/watch?v=zfXDfoOAnrY
A planetary mechanism from Pin Coupling 5.
http://www.youtube.com/watch?v=QfiJSTRDASs
The direction of the red bar attached to the blue shaft is unchanged during the motion.



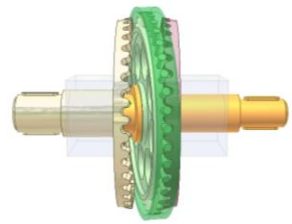
Multishaft driller
http://youtu.be/gLEKqk-8CEY
Special screw mechanisms are applied.
The output shafts rotate the same direction and with the same velocity in comparison with the input shaft although their axle distances to the input shaft are different.
For more see:
http://www.youtube.com/watch?v=QfiJSTRDASs

Wobbling pin gear mechanism 1
https://youtu.be/4EOUETtRSmA
Input: pink shaft having an inclined portion.
Output: blue gear of tooth number Zb.
Green pin gear (pin number Zgn) has revolute joint with the inclined portion of the pink shaft. It performs wobbling motion.
Zgn is larger than Zb.
Grey gear (tooth number Zgy) is stationary. It keeps the green gear from rotating because Zgy = Zgn.
Output velocity is regular.
Rotary directions of the input and output are opposite.
Transmission ratio i = (Zgn – Zb) / Zb
Here: Zb = 38 ; Zgn = Zgy = 40 ; i = 1/19.
This mechanism is called “Nutation drive” in “Mechanisms And Mechanical Devices Sourcebook”, Sclater & Chironis, 2001, page 244.



Wobbling pin gear mechanism 2

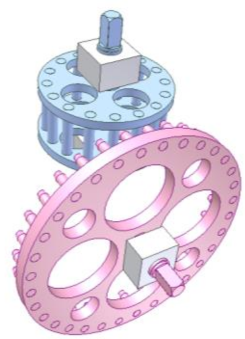
https://youtu.be/Nhy4hXdYCfw



Input: orange shaft having an inclined portion.
Output: yellow gear of tooth number Zy.
Pink gear (tooth number Zp) is stationary.
Green pin gear (pin number Zg = Zy) has revolute joint with the inclined portion of the orange shaft. It performs wobbling motion.
Its rotation is transmitted to the output gear.
Zg is larger than Zp.
Output velocity is regular.
Rotary directions of the input and output are the same.
Transmission ratio i = (Zg – Zp) / Zy
Here:
Zp = 38 ; Zg = Zy = 40 ; i = 1/20.
This mechanism is called “Nutation drive” in “Mechanisms And Mechanical Devices Sourcebook”, Sclater & Chironis, 2001, page 244.

Cage gear 1

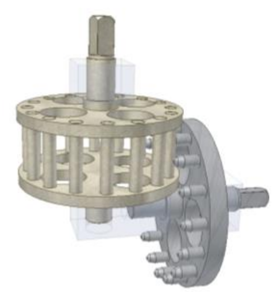
https://youtu.be/IOqToBvgHNc



Cage gear (in blue) is also called lantern gear or lantern pinion.
It is in mesh with pink crown pin gear.
Cage gears are more efficient than solid pinions, dirt can fall through the rods rather than becoming trapped and increasing wear. They can be constructed with very simple tools as the teeth are not formed by cutting or milling, but rather by drilling holes and inserting rods.
Cage gears were used in Leonardo da Vinci's inventions, in turret clocks.
Transmission ratio of the drive in this video: 2

Cage gear 2

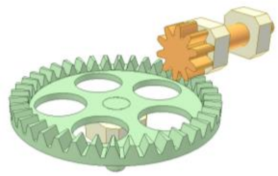
https://youtu.be/JuvNL2nIeTg



Cage gear (in brown) is also called lantern gear or lantern pinion.
It is in mesh with crown pin gear (in grey).
Cage gears are more efficient than solid pinions, dirt can fall through the rods rather than becoming trapped and increasing wear. They can be constructed with very simple tools as the teeth are not formed by cutting or milling, but rather by drilling holes and inserting rods.
Cage gears were used in Leonardo da Vinci's inventions, in turret clocks.
Transmission ratio of the drive in this video: 1

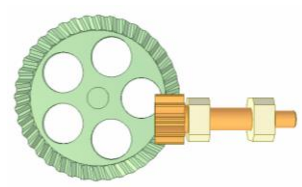
1.3.5. Face gears

Face gear 1
http://youtu.be/4QDNN8zon6k
Standard face gear.

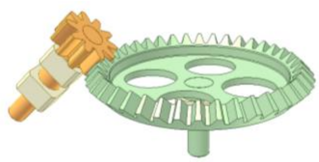


Face gear 2
http://youtu.be/MIPrAhNj7ag
Face gear with spur gear of helical teeth.

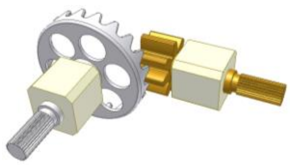
Face gear 3
http://youtu.be/b9zeHMyvUbY
Face gear with skew axles.



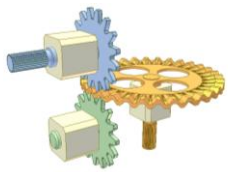
Face gear 16
http://youtu.be/ayOxgYGHCL0
Face gear according its expanding definition: angle between axes may differ from 90 deg..



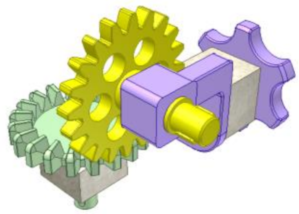
Sheet metal gears 6
http://youtu.be/2AMF48m9AX8
For light loads.
Low cost.
Adaptability to mass production.
The blanked, cup-shaped wheel meshes with a solid pinion on 90 deg. intersecting axes.



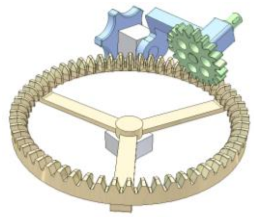
Sheet metal gears 7
http://youtu.be/Rb37-daSLQ4
For light loads.
Low cost.
Adaptability to mass production.
The horizontal wheel with waves on its out rim replacing teeth,
meshes with either one or two sheet-metal pinions. They have specially formed teeth and mounted on intersecting axes.



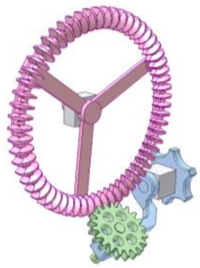
External gear drive of adjustable shaft angle
https://youtu.be/jLKOUYczfgQ
Yellow gear is of regular spur one.
Teeth of green gear is combination of spur and face ones.
They are cut on a gear shaping machine that can vary angle between workpiece and cutter axes during cutting



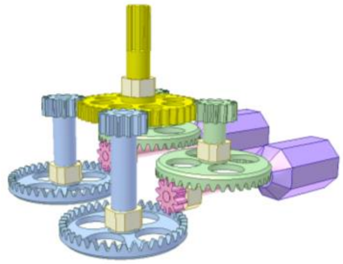
Internal gear drive of adjustable shaft angle
https://youtu.be/Vn1MC2GEv7Q
Green gear is of regular spur one.
Teeth of internal gear is combination of spur and face ones.
They are cut on a gear shaping machine that can vary angle between workpiece and cutter axes during cutting.



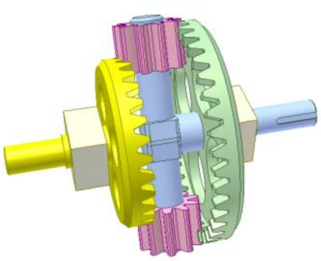
External-internal gear drive of adjustable shaft angle
https://youtu.be/TGKS2SR0I30
Green gear is of regular spur one.
Teeth of pink gear is combination of spur and face ones.
It is an attempt to increase adjustable range of the shaft angle to 180 deg.
There are considerable backlashes between teeth of the two gears.



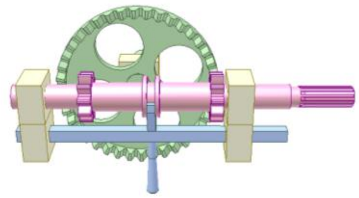
Face gear 7
http://youtu.be/QElC9kO-3BQ
Transmission for helicopter rotor (Lewis Research Center, Cleveland, Ohio, USA).
Two horizontal engines (violet) transmit torques to vertical yellow shaft that is connected to the rotor through a planetary gearbox (not shown). The system apportions torques equally along multiple, redundant drive paths thereby reducing the stresses on individual gear teeth. Face gears help forgive error in manufacturing and alignment, thermal and vibration changes for the meshing parts.



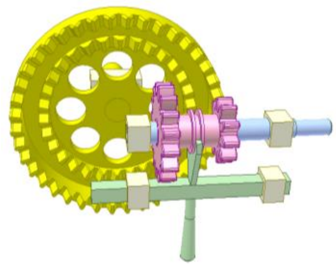
Face gear 8
http://youtu.be/dKYLYy8X4ts
Planetary mechanism with face gear.
The green gear (Z1 = 40 teeth) is fixed.
The yellow gear has 30 teeth (Z2).
n2/nc = (Z1+Z2)/Z2 = 7/3
nc: velocity of the blue crank
n2: velocity of the yellow gear
Unlike ordinary spur planetary mechanism there is no constraint between Z1, Z2 and tooth number of the pink gears.



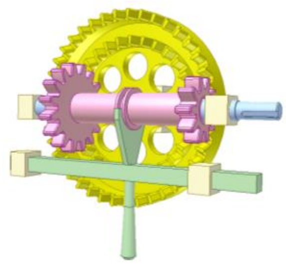
Face gear 10
http://youtu.be/-sA5_-3ZSa4
Reversing mechanism with face gear drive.
The pink shaft is input.
The blue slider is moved under manual action.



Face gear 11
http://youtu.be/vVRfKdGLjZ0
2-speed reducer.
The blue shaft is input.
The green slider is moved under manual action.

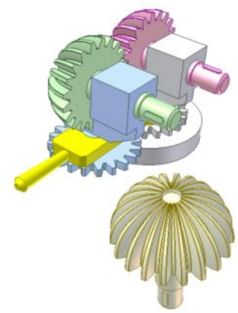


Face gear 12
http://youtu.be/W38bOovKApo
Reversing 2-speed reducer.
The blue shaft is input.
The yellow gears has two speeds of opposite directions.
The green slider is moved under manual action.



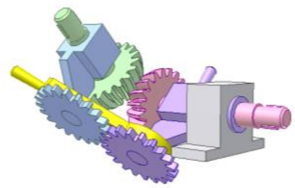
1.3.6. Spherical, torus gears

Semi-spherical gears 1
https://youtu.be/YNXCm4xp1ho
Input: pink gear.
Output: green gear.
This is a constant velocity joint
The tooth profile dimensions of the semi-spherical gears are varied from bottom to apex of the semi-spherical gear according to sine function.
The spur gear drive (its transmission ratio = -1) ensures the meshing takes place at equal circles of the semi-spherical gears. Centers of the semi-spherical gears lay on axes of spur gears.



Angle between the input and output shafts can be adjusted by turning the yellow carrier.
The video was made based on patent:
https://www.google.com/patents/US20140007722

Semi-spherical gears 2
https://youtu.be/eVpBUGLZ2W4
This mechanism is developed from the mechanism shown at:
https://youtu.be/YNXCm4xp1ho
Input: pink gear.
Output: green gear.
This is a constant velocity joint.



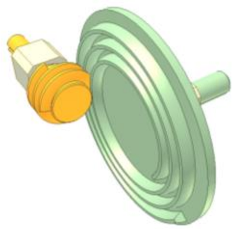
Spatial angle between the input and output shafts in any plane that contains the pink gear axis can be adjusted by turning the violet and yellow links.

Torus gears 1
https://youtu.be/j9lZRgyMufI
Input: pink gear.
Output: green gear.
This is a constant velocity joint
The torus gear was created on computer by bending a round rack of circular teeth.
The spur gear drive (its transmission ratio = -1) ensures the meshing takes place at equal circles of the torus gears.

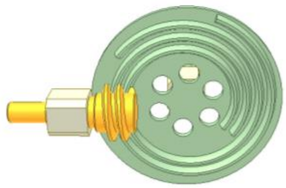
Angle between the input and output shafts can be adjusted by turning the blue bearing.
The video was inspired from:
https://www.youtube.com/watch?v=Sg5znXqimyU

1.3.7. Archimedean spiral gears

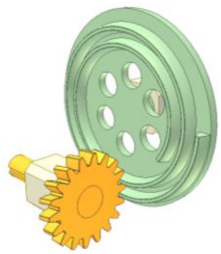
Archimedean spiral gear and Worm 1
http://youtu.be/kojrypcELnE
Input: the spiral gear of 1 start.
Output: the worm of 1 start.
Transmission ratio: 1
The number of stars can be more



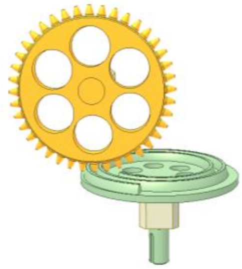
Archimedean spiral gear and Worm 2
http://youtu.be/49WcDE64mRk
Input: the spiral gear of 2 starts (Z1)
Output: the worm of 1 start (Z2)
1 rev. of the input corresponds 2 rev. of the output (Z1/Z2).



Archimedean spiral gear and Spur gear
http://youtu.be/YaV-VAxkEAQ
Input: the spiral gear of 1 star (Z1).
Output: the spur gear of 18 teeth (Z2).
Axle of the spiral gear must be laid in the front face of the spur gear.
The helical angle of the spur gear teeth must be in accordance with spiral direction of the spiral gear.
1 rev. of the input corresponds 1/18 rev. of the output (Z1/Z2).
The number of stars can be more.



Archimedean spiral gear and Pin gear 1
http://youtu.be/LSx4anFA6nQ
Input: the spiral gear of 1 start (Z1).
Output: the pin gear of 40 pins (Z2).
1 rev. of the input corresponds 1/40 rev. of the output (Z1/Z2).
The number of starts can be more.



Archimedean spiral gear and Pin gear 2
http://youtu.be/FJfH1rz5EA4
Input: the spiral gear of 1 start (Z1).
Output: the pin gear of 30 pins (Z2).
1 rev. of the input corresponds 1/30 rev. of the output (Z1/Z2).
The axles of two gears are not parallel.
The number of starts can be more.

Archimedean drive 1a
http://youtu.be/D6XjnCc6gKQ

The green and orange cams of Archimedean profile are identical.
The green one is input.
Two cams rotate in opposite directions with the same speed, like in a drive of two equal gears.
If the cams have different pitches of Archimedean profile (p1 and p2) then transmission ratio = p1/p2.
Pitch of the Archimedean profile must be big enough to prevent possible jam.
A spiral spring can be used instead of the weight.

Archimedean drive 1b
http://youtu.be/y-8fU6q5iV8

The green and orange cams of Archimedean profile are identical.
The green one is input.
Two cams rotate in the same direction with the same speed, like in a belt drive of two equal pulleys.
If the cams have different pitches of Archimedean profile (p1 and p2) then transmission ratio = p1/p2.
Pitch of the Archimedean profile must be big enough to prevent possible jam.
A spiral spring can be used instead of the weight.

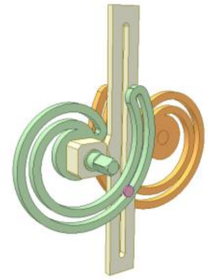
Archimedean drive 1c
http://youtu.be/naBSF38qeSY

The green and orange cams have different Archimedean profiles (pitches p1 and p2, p1 = 2.p2). The green one is input.
Two cams rotate in opposite directions with different speeds, like in a drive of two gears of different tooth numbers.
Transmission ratio = 1/2.
Pitch of the Archimedean profile must be big enough to prevent possible jam.
A spiral spring can be used instead of the weight.

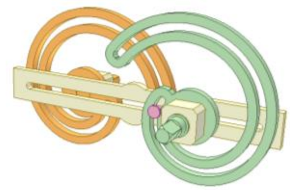
Archimedean drive 1d
http://youtu.be/JAKbVNx4IpI

The green and orange cams have different Archimedean profiles (pitches p1 and p2, p1 = p2/2). The green one is input.
Two cams rotate in the same direction with different speeds, like in a belt drive of two different pulleys.
Transmission ratio = 2.
Pitch of the Archimedean profile must be big enough to prevent possible jam.
A spiral spring can be used instead of the weight.

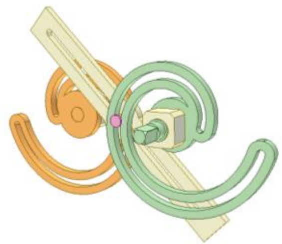
Archimedean drive 2a
http://youtu.be/dBYRbJxQSrw
The green and orange wheels of Archimedean grooves are identical.
The green one is input.
The pink pin slides in both grooves and in a straight slot of a fixed bar.
If the bar is perpendicular to the line connecting axes of the two wheels at its middle point, two wheels rotate in opposite directions with the same speed, like in a drive of two equal gears.
In case not at the middle point, the orange output wheel has irregular rotation.



Archimedean drive 2b
http://youtu.be/Jmls2qUs05w
The green and orange wheels of Archimedean grooves are identical. The green one is input.
The pink pin slides in both grooves and in a straight slot of a immobile bar. The slot is on the line connecting axes of the two wheels.
Two wheels rotate in the same direction with the same speed, like in a belt drive of two equal pulleys.

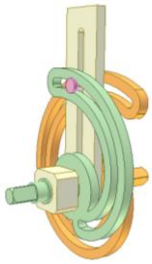


Archimedean drive 2c
http://youtu.be/-RIrEvSzv6Y
The green and orange wheels of Archimedean grooves are identical. Input is the green wheel.
The pink pin slides in both grooves and in a straight slot of an immobile bar.
If the bar is not perpendicular to the line connecting axes of the two wheels, the orange wheel has irregular rotation.
The output will be diversified with various positions of the bar, various pitches of Archimedean grooves of the input and output wheels.



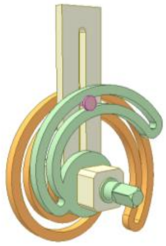
Archimedean drive 3a
http://youtu.be/r0AO8t-z3SI
The green and orange coaxial wheels of Archimedean grooves are identical.
The pink pin slides in both grooves and in a straight slot of a fixed bar.
The two wheels rotate in opposite directions with the same speed.
Pitch of the Archimedean groove must be big enough to prevent possible jam.

Archimedean drive 3b
http://youtu.be/bHDflbb9euc
The green and orange wheels are coaxial.
The pitch of Archimedean groove on the green is double the one on the orange.
The pink pin slides in both grooves and in a straight slot of a fixed bar.
The two wheels rotate in opposite directions with transmission ratio of 1/2.



Archimedean drive 3c

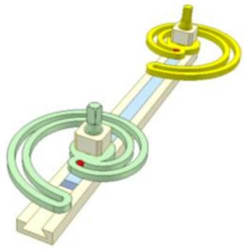
http://youtu.be/_pWGiUt36Ec



The green and orange wheels are coaxial.
The pitch of Archimedean groove on the green is double the one on the orange.
The pink pin slides in both grooves and in a straight slot of a fixed bar.
The two wheels rotate in the same directions with transmission ratio of 1/2.

Archimedean drive 4a

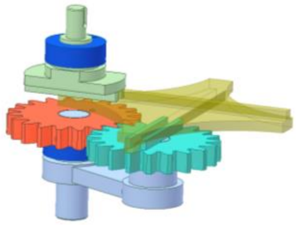
https://youtu.be/aNLLu7VUKVk



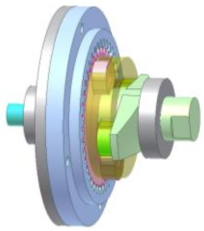
Input: green wheel.
Output: yellow wheel (or vice versa).
The wheels have Archimedean grooves of the same radial distance between successive turnings T and of opposite spiral directions.
Distance between two red pins of blue slider is equal to the one between two bearings of the wheels.
The two wheels rotate in opposite directions with the same speed (transmission ratio i = -1), like in a crossed belt drive but only for limited revolutions.
If T is not the same for the two wheels i differs from -1.

1.3.8. Gear drives combined with other mechanisms

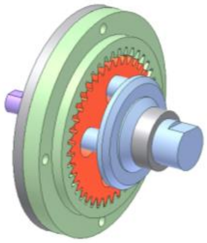
Reductor with gears of equal number of teeth 3
http://www.youtube.com/watch?v=H0aqcwNbMOA
A result once generally supposed impossible.
The green shaft rotates two times faster than the blue crank.
Rotation of the cyan gear is transmitted to the green shaft by Oldham mechanism



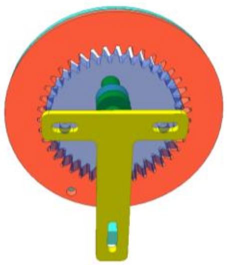
Planetary Reduction Gear 1 with Oldham coupling
http://www.youtube.com/watch?v=78gkc9mPT-w
Number of teeth of the fixed internal gear Z1 = 40
Number of teeth of the planetary gear Z2 = 38
Module m = 2 mm
The eccentricity caused by the blue shaft is 2 mm.
Transmission ratio i = - Z2 / (Z1 - Z2) = -19
Rotation of the pink gear is transmitted to the green shaft by Oldham coupling.



Planetary Reduction Gear 2
http://www.youtube.com/watch?v=MGVSRrI0ir4
Number of teeth of the fixed internal gear Z1 = 40
Number of teeth of two planetary gears (red and pink) Z2 = 38
Module m = 2 mm
The violet shaft has two 2 mm eccentric portions at 180o. The pink and red gears are on the portions.
Transmission ratio i = - Z2 / (Z1 - Z2) = -19
Rotation of the pink and red gears is transmitted to the blue shaft by four pins.

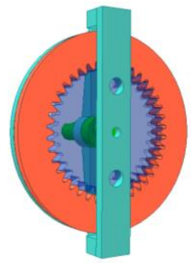


Planetary Reduction Gear 3
http://www.youtube.com/watch?v=XCpMWxyM9yc
Number of teeth of the red gear Z1 = 40
Number of teeth of the blue gear Z2 = 38
Module m = 2 mm
The eccentricity caused by the green shaft is 2 mm.
The blue gear Z2 has rotary translational motion due to the yellow plate that has linear translational motion.
Transmission ratio i = Z1 / (Z1 - Z2) = 20



Planetary Reduction Gear 4

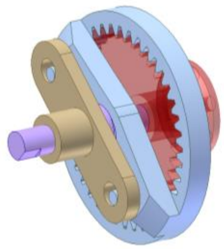
http://www.youtube.com/watch?v=RmUYrYai1S4



Number of teeth of the red gear Z1 = 40
Number of teeth of the blue gear Z2 = 38
Module m = 2 mm
The eccentricity e caused by the green shaft is 2 mm.
The blue gear Z2 has rotary translational motion due to the fixed green plate.
Radius of two holes on the green plate = e + radius of pins on the blue gear.
Transmission ratio i = Z1 / (Z1 - Z2) = 20

Planetary Reduction Gear 5

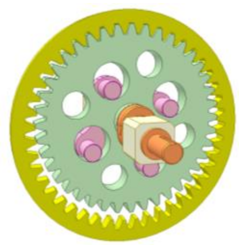
http://www.youtube.com/watch?v=czG3I4u8xMY



Number of teeth of the red gear Z1 = 38
Number of teeth of the blue gear Z2 = 40
Module m = 2 mm
The eccentricity e caused by the violet shaft is 2 mm.
The blue gear Z2 is on the eccentric portion of the violet shaft. It has rotary translational motion due to the fixed brown plate.
Radius of two holes on the brown plate = e + radius of pins on the blue gear.
Transmission ratio i = Z1 / (Z1 - Z2) = 20

Planetary Reduction Gear 6

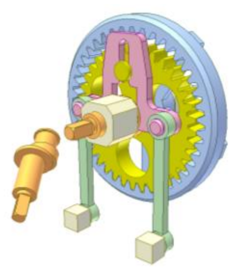
http://youtu.be/U7WEXjV0t0A



Planetary speed reducer.
The orange input crank carries the green gear (Z1 = 40 teeth) that engages with stationary yellow gear (Z2 = 44 teeth). The pink output shaft has a disk of pins that engage with the holes of the green gear. The radius difference of the pink pins and the holes is equal to the eccentricity of the orange crank.
i = n1/n3 = Z1/(Z2-Z1) = 10
n1: input crank velocity
n3: output velocity
If (Z2-Z1) small and Z1 large, i can be very large.
The input and the output rotate in opposite directions.

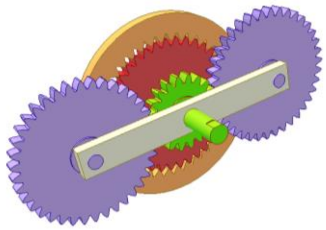
Planetary Reduction Gear 7

http://youtu.be/FBb9jIbf5xE

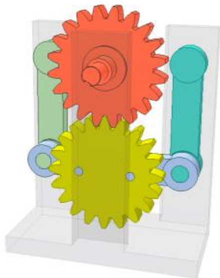


Teeth number of blue gear Z1 = 40
Teeth number of yellow gear Z2 = 36
Module m = 2 mm
The eccentricity of the orange input eccentric shaft (constant velocity V) is 4 mm.
Pink plate is the conrod of parallelogram mechanism of two green rockers. A pin of the yellow gear and a cylinder portion of the orange shaft slide in slots of the pink plate. The pink plate has translational motion. Its direction is kept unchanged during motion. The blue output gear Z1 rotates regularly with velocity V1
V1 = V.((Z1 - Z2)/Z1) = V/10

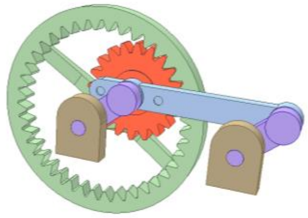
Parallelogram mechanism with gears 2
http://www.youtube.com/watch?v=2eFUqqiqOyk
The orange gear (internal teeth number Z5) is the connection rod.
Z4 is teeth number of the red gear.
Z2 is teeth number of the green gear.
Z1 is teeth number of the violet gears.
Velocity relation: $\omega 4 = \omega 2.(Z2/Z1).(Z5/Z4 - 1)$
$\omega 2$: velocity of Z2.
$\omega 4$: velocity of Z4.



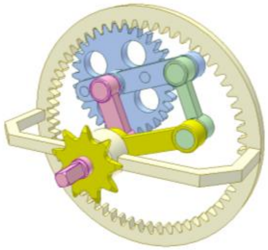
Reductor with gears of equal number of teeth 1
http://www.youtube.com/watch?v=wXX-kt7XPYE
A result once generally supposed impossible.
The cranks rotate two times slower than the red gear.



Parallelogram mechanism with gears 1
http://www.youtube.com/watch?v=JSaX43kX9CI
The red gear (teeth number Z2) is fixed with the blue connection rod.
The green gear has internal teeth number Z1.
Velocity relation: $\omega 1 = \omega c.(1-Z2/Z1)$
$\omega 1$: velocity of Z1
ωc: velocity of the violet crank.

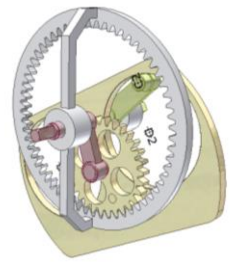


Parallelogram and internal gear mechanisms 1a
https://youtu.be/3wsrEWOIDP8
Pink, blue, green and yellow links create a parallelogram mechanism.
Length of the pink link is equal to center distance of the internal gear drive.
Z1: tooth number of blue gear (= 30).
Z2: tooth number of internal gear (= 60).
n1: pink input crank velocity
n3: yellow output crank velocity
Transmission ratio $i = n1/n3 = Z1/(Z2-Z1) = 30/(60-30) = 1$
Pink and yellow cranks (coaxial in the same side) rotate in opposite directions with the same velocity.



Parallelogram and internal gear mechanisms 1b

https://youtu.be/zjwgHU3WsvM



It is a structural embodiment of “Parallelogram and internal gear mechanisms 1a”

h – p = 2e

h: diameter of two holes on the plate.

p: diameter of two pins on output green crank.

Lines connecting the hole centers and the pin centers D1C1 and D2C2 (playing role of bars of the parallelogram mechanisms) must be parallel to pink input crank.

Z1: tooth number of external gear (= 30).

Z2: tooth number of internal gear (= 60).

n1: pink input crank velocity

n3: green output crank velocity

Transmission ratio i = n1/n3 = Z1/(Z2-Z1) = 30/(60-30) = 1

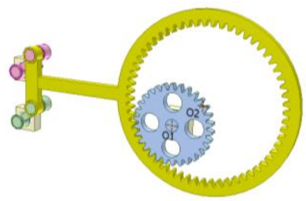
Pink and green cranks (coaxial in opposite sides) rotate in opposite directions with the same velocity.

This structure is good for large transmission ratio, when (Z2-Z1) is small. See:

http://youtu.be/U7WEXjV0t0A

Parallelogram and internal gear mechanisms 2

https://www.youtube.com/watch?v=ApkyagyaSdo



Pink, yellow and green links create a parallelogram mechanism. Length of the pink and green cranks are equal to center distance of the internal gear drive. Line connecting centers of the gears O1O2 (playing role of a crank of the parallelogram mechanism) must be parallel to pink and green cranks.

Z1: tooth number of blue gear (= 30).

Z2: tooth number of internal gear (= 60).

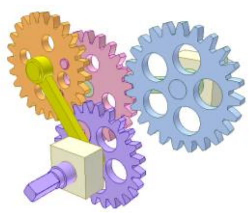
Pink, green and line connecting gear centers are always parallel.

Pink crank and blue gear rotate in opposite directions with the same velocity.

Yellow link and blue gear rotate around the same axis in opposite directions with the same velocity.

Gear and linkage mechanism 6a

http://www.youtube.com/watch?v=8Va05aWWTk0



Pink and orange gears are fixed together.

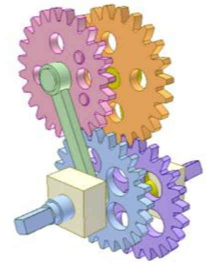
The pink gear and the blue one have revolution joints with green bar. The orange gear and the violet one have revolution joints with yellow bar. The gears have the same tooth number. The two bars and the orange and pink gear block create a 4-bar linkage. The orange and pink gears are fixed together in such a way that the axis of one gear goes through the pitch circle of the other gear.

Input is the orange gear rotating regularly.

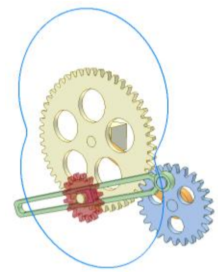
The bars oscillate. The violet and blue gears rotate irregularly and have dwells.

Their motion depends on the 4-bar linkage dimension.

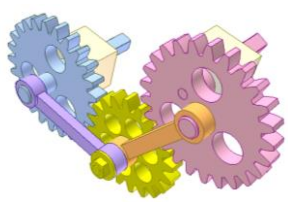
Gear and linkage mechanism 6b
http://youtu.be/f727Y_sfjJQ
Pink and orange gears are fixed together.
The pink gear and the blue one have revolution joints with green bar.
The orange gear and the violet one have revolution joints with yellow bar.
The gears have the same tooth number. The two bars and the orange and pink gear block create a 4-bar linkage.
Input is the violet gear rotating regularly.
The bars and the blue gear rotate irregularly.
Their motion depends on the 4-bar linkage dimension.



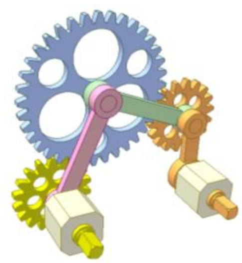
Gear and linkage mechanism 7
http://youtu.be/4lgI3KnQ8sQ
The blue and fixed popcorn gears and the orange carrier create a satellite drive. Tooth numbers of the gears are 25 and 50.
The green bar has revolution joint with the blue gear.
The red gear has revolution joint with the popcorn fixed gear and prismatic joint with the green bar.
While the orange carrier rotate regularly, the red gear rotates irregularly.
Beside geometric dimensions of the links, its motion also depends on the position between the pins of the blue gear and the popcorn gear when assembling.



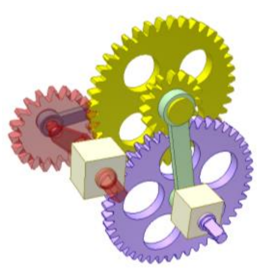
Gear and linkage mechanism 11a
http://youtu.be/gzMpuO2klGU
Tooth number of blue gear: 25
Tooth number of yellow gear: 20
Tooth number of pink gear: 25
The rotation axis of the pink gear is not its geometric one.
The input pink gear rotates regularly.
The blue gear rotates irregularly.



Gear and linkage mechanism 11b
http://youtu.be/j2QFbgwHwBU
Input: orange crank with gear fixed to it.
Output: yellow gear.
Blue gear idly rotates.
Depending on the gear diameters, the output gear can rotate, reach a short dwell, or even reverse itself briefly.



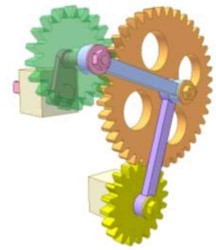
Gear and linkage mechanism 11c
http://youtu.be/WYrsowuLBn8
Tooth number of red gear: 20
Tooth number of violet gear: 45
Tooth numbers of yellow gears: 15 and 40.
The red gear and the red crank are fixed together and rotate regularly.
The violet gear has complicated rotation subject to the links dimensions.



Gear and linkage mechanism 12

http://youtu.be/g9nYKdroNhM

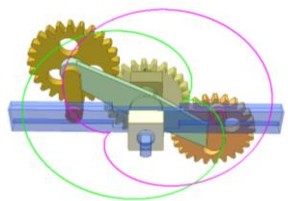
Tooth number of green gear: 20
Tooth number of orange gear: 40
Tooth number of yellow fixed gear: 20
Input is the pink crank shaft rotating regularly.
The green and orange gears rotate irregularly.



Gear and linkage mechanism 14

http://youtu.be/g0T0saXkA-E

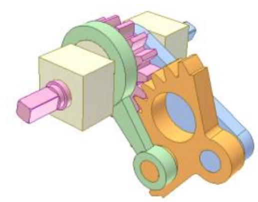
Three gears have a same tooth number.
The yellow glass gear is immobile.
Crank radii of two orange gears are equal to gear pitch ones.
Input : green carrier rotating regularly.
Output: blue shaft rotating irregularly with dwell.
The pink and green curves are loci of red rollers centers.



Gear and linkage mechanism 16

http://youtu.be/lMXCPIT4XRY

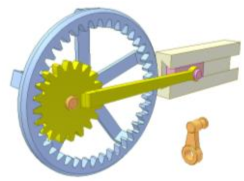
Blue crank, green bar and orange gear-conrod create a 4-bar linkage.
Rotation axes of the blue crank and the pink gear are coaxial.
Rotation axes of the green bar and the pink gear are not coaxial.
Input is the blue crank, rotating regularly.
The output pink gear rotates irregularly.



Planetary drive 3a

http://youtu.be/m_iEoDa2hZg

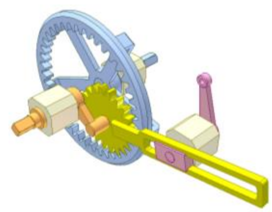
Blue input gear of tooth number Z1 rotates regularly.
Carrier of planetary drive is orange crank.
Yellow satellite gear of tooth number Z2 and yellow bar are fixed together. The orange crank rotates irregularly.
If Z1 = n.Z2, the pink slider reciprocates n times during 1 revolution of the blue gear. For this case n = 2.



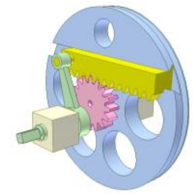
Planetary drive 3b

http://youtu.be/bep4vLlzR0g

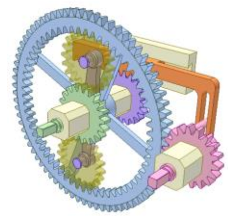
Input carrier of planetary drive is orange crank rotating regularly.
Yellow satellite gear of tooth number Z2 and yellow slotted bar are fixed together. Pink slider oscilates around fixed axis.
Blue internal gear of tooth number Z1 rotates irregularly.
If Z1 = n.Z2, the blue gear turns 1 revolution during n revolutions of the input crank. For this case n = 2.



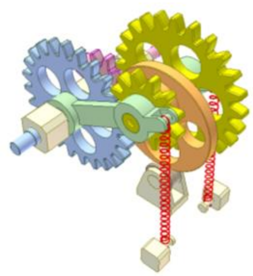
Gear, rack and linkage mechanism 2
http://youtu.be/i-wC0g5RZSo
Green crank, yellow rack-slider and blue disk create a coulisse mechanism.
Rotation axes of the blue disk and the pink gear are coaxial.
Rotation axes of the green crank and the blue disk are not coaxial.
The blue input disk rotates regularly.
The pink gear and the green crank rotates irregularly.



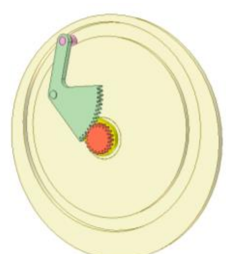
Gear, rack and linkage mechanism 3
http://youtu.be/-4ZrABfkOxM
Violet carrier, yellow satellite gears, blue and green gears create a differential planetary mechanism.
The blue gear is connected to the violet carrier via pink gear, orange rack and a sine mechanism.
The pink input gear rotates regularly.
The output green gear rotates irregularly.
Its motion is a sum of regular rotation and irregular rotation of sine function.



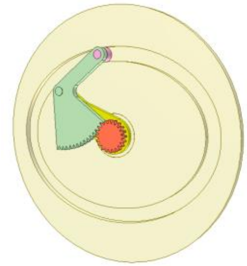
Cam and gear mechanism 12
http://youtu.be/_XsQhBFrGlM
Input: Pink gear shaft.
Block of two yellow gears and orange eccentric rotates idly on green cranks.
Blue output gear shaft, that is coaxial to the input, rotates irregularly.
This is a planetary drive in which the orange cam controls motion of the crank. The cam profile decides the output motion rule.
Tooth number of blue gear Zb = 24
Tooth number of pink gear Zp = 12
Tooth number of yellow gears: 12 and 18
Working cycle: 4 rev. of the input



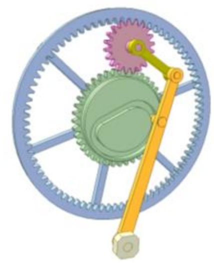
Cam-controlled planetary gear 1
http://youtu.be/JKJfXL6TYXU
Grooved cam is fixed.
The red sun gear rotates on a fixed bearing.
The yellow planet arm rotates on a bearing that is coaxial with the red sun gear.
The green gear sector (planet gear) has follower roller which rides in the cam groove.
If the yellow planet arm is input link rotating regularly, the red output gear can get variety in the kind of motion depending on the cam groove contour and ratio of tooth numbers.
The contour is a eccentric circle in this video. The output rotates with dwell. 1 full revolution of the input corresponds 1 full revolution of the output.



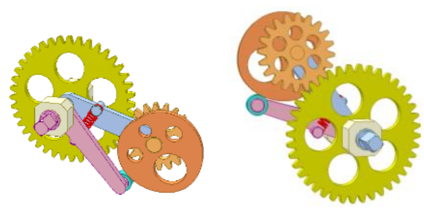
Cam-controlled planetary gear 2
http://youtu.be/B5XkX2ct0P8
Grooved cam is fixed.
The red sun gear rotates on a fixed bearing.
The yellow planet arm rotates on a bearing that is coaxial with the red sun gear.
The green gear sector (planet gear) has follower roller which rides in the cam groove.
If the yellow planet arm is input link rotating regularly, the red output gear can get variety in the kind of motion depending on the cam groove contour and ratio of tooth numbers.
The contour is a concentric ellipse in this video. 1 full revolution of the input corresponds 1 full revolution of the output. The output rotates back two times in a cycle.



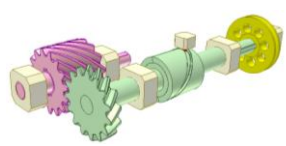
Cam and gear mechanism 11
http://youtu.be/5PT5H_tMa2E
Input is the green gear and cam that rotate regularly. The blue output internal gear rotates with inconstant velocity.



Mechanism of cam's planar motion 3
http://youtu.be/vIU9uzsOLbU
Input is the blue crank of constant velocity. The big yellow gear is immobile. The orange cam fixed to the small gear has planar motion. The red spring maintains permanent contact between roller and cam.
The output pink crank rotates irregularly.



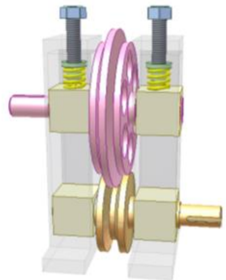
Barrel cam and helical gears 1
http://youtu.be/QzPfy8KnB6E
Input: green gear shaft of barrel cam. It rotates and linearly reciprocates simultaneously.
Output: pink shaft that rotates irregularly. The irregularity depends on helix angles of the helical gears and cam profile.



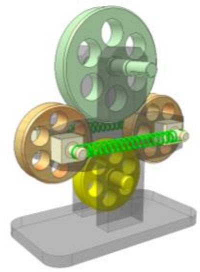
Barrel cam and helical gears 2
http://youtu.be/M7Wa-W6wqqY
Input: green gear shaft of barrel cam rotating regularly.
The blue intermediate shaft can slide only thanks to the green barrel cam. Block of two yellow gears can rotate on the blue shaft.
Output: pink shaft that rotates irregularly.
The irregularity depends on helix angles of the helical gears and cam profile.

1.4. Friction drives

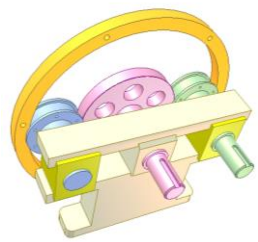
Friction roller drive 1
http://youtu.be/HkjnM-g-dQ0
Input: smaller roller.
The adjustable friction forces at contact places are created by the blue bolts.
The roller angle profile helps to increase the friction force.
The springs give relatively constant pressure regardless of manufacturing errors.



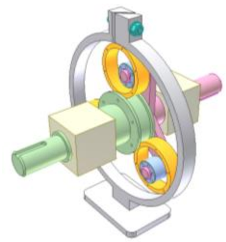
Friction roller drive 2
http://youtu.be/MZT4hg53IF8
Input: the yellow roller.
Output: the green roller.
The orange rollers idly rotate on their bearings which can slide horizontally.
The friction forces at contact places are created by the green springs.



Friction roller drive 3
http://youtu.be/FNK92viLoo0
Input: the green roller.
Output: the pink roller.
The blue roller rotates idly.
The yellow bearings can move horizontally.
Pressure at contact places is created by the orange flexible ring.
The radial forces applied to the bearings are reduced to the minimum.



Friction roller drive 4
http://youtu.be/R9gJJq2hfh0
Input: the green roller.
Output: the pink shaft of 3 cranks carrying 3 blue idle rollers.
The orange flexible rings contacts with the green input roller and the fixed outer ring. Initial deformation of the orange flexible rings creates contact pressure which can be regulated to some extent by the cyan bolt.

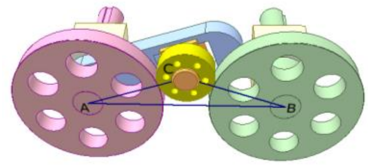


Friction roller drive 5
http://youtu.be/_JcSQM-URWA
Input: the pink roller.
Output: the green ring with belt groove.
The blue rollers idly rotate on their bearings which can slide horizontally.
The friction forces at contact places are created by the rim weight.

Friction roller drive 6

http://youtu.be/_jp1s8UZ0js

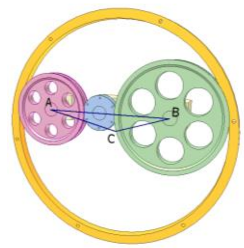
Input: the pink roller rotating clockwise.
Output: the green roller.
The blue crank can idly rotate on the pink shaft.
The yellow roller idly rotate on axle of the orange slider.
The friction forces at contact places are created automatically.
The transmission is possible if tg((a+b)/2) is less than m.
a is angle CAB, b is angle CBA
m is friction coefficient of roller materials (the smaller one)
Weights of the blue crank, the orange slider and the yellow roller create initial friction forces at the contact places.
No transmission if the pink roller rotates counterclockwise.



Friction roller drive 7

http://youtu.be/chSg5IbNkLM

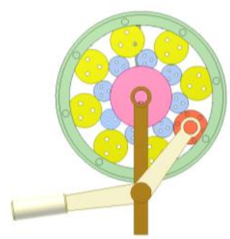
Input: the pink roller, rotates counterclockwise.
Output: the green roller.
The orange ring contacts with the two rollers under its weight.
The friction forces at contact places are regulated automatically.
The blue roller of low friction coefficient material is for supporting the input and output rollers only (not for torque transmission).
The transmission is possible if tg((a+b)/2) is less than m.
a is angle CAB, b is angle CBA
C is the ring center.
m is friction coefficient of roller materials in contact with the ring (the smaller one)
Transmission is impossible if the pink roller rotates clockwise.



Friction roller drive 8

http://www.youtube.com/watch?v=uFn8h94SySU

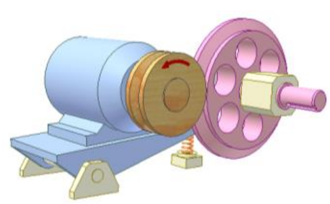
The arm and the red roller create normal forces on contact surfaces.
It can be used as a controllable clutch.
Trasmission ratio i = n1/n2 = R2/R1
R1: Radius of contact surface of the pink shaft.
R2: Radius of contact surface of the green shaft.



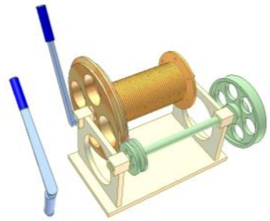
Friction roller drive 9

http://youtu.be/04jEqIn4SRI

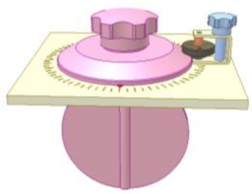
Input: the orange roller installed on a plate that can turn around a fixed shaft. Center of the small roller must be above the line connecting center of the big roller and rocking center of the plate. The weight of the orange roller assembly causes the pressure at contact place between the rollers. The red arrow shows the recommended rotary direction due to which the pressure can be automatically increased in accordance with increasing load.
The orange spring is used to reduce the pressure in case the weight of the orange roller assembly is too large.



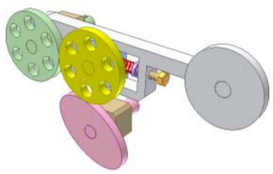
Friction roller drive 10
http://youtu.be/zaVAsLNgHIk
Friction windlass.
Input: the green shaft.
Output: the orange drum.
Pulling the lever of the blue eccentric shaft to bring the orange large roller into contact with the green small roller and create pressure at contact place.



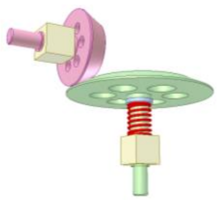
Friction roller drive 11
http://youtu.be/-59xRJqgIhs
The pink knob is for rough adjustment.
The blue one is for fine adjustment.
The small cone roller is made of rubber.



Friction roller drive 12
http://youtu.be/sN7oqKl8Zy8
The input pink ellipse roller rotates regularly.
The output green roller rotates irregularly.
Contact pressures are created by the grey weight and the orange screw.



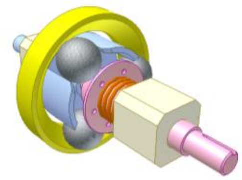
Friction cone roller drive 1
http://youtu.be/ZAWVAgUmAho
Input: the pink cone roller.
Output: the green cone roller.
The friction forces at contact places are created by the red spring.



Friction cone roller drive 2
http://youtu.be/E3EB3O7tiFw
This is a friction cone drive with V-groove rim.
The pressure at contact place is created by a spring.
The V-groove helps to increase the normal force at contact place.
The working surfaces are in orange color.

Friction ball drive 1

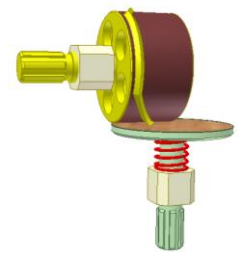
http://youtu.be/ohuHyiLLL0s



It is a planetary drive. The blue output shaft plays role of a planet carrier.
Input: the pink cone shaft (sun gear).
The yellow ring of internal cone surface (annulus) is fixed.
The friction forces at contact places are created by the orange spring.
This mechanism can be realized by using a ordinary ball bearing. Fix a shaft to its inner ring, replace its separator by a carrier.
Connect several mechanisms in series to get large transmission ratio.

Barrel cam friction drive

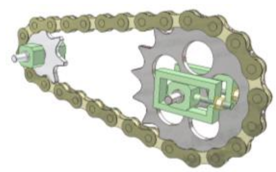
http://youtu.be/UblRctFXjh4



Input: yellow barrel cam rotating regularly.
Output: Green disk rotating irregularly.
Red spring creates friction force for motion transmission.

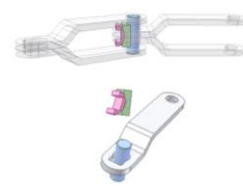
1.5. Chain drives

Chain drive 1A
http://youtu.be/A9Fl4Bka7FE
A typical chain drive having device for chain tensioning.

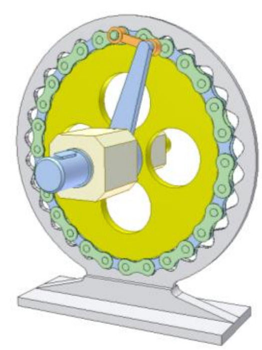


Chain drive 1B
http://youtu.be/k0-Gd4PYR_o
Chain drive arrangement to get two shafts (pink and orange) rotating in opposite directions. The two yellow sprockets are idle.

Chain revolution joint for material saving
https://youtu.be/icfG4-K2WWs
Green and pink parts are arranged only at places of load transmission.
Pink part and green parts are connected together by a spherical joint.
There are four degrees of freedom between two adjacent chain links (three rotations and one translation (along blue pin axis)). So there is no need of high parallelism between sprocket axes.



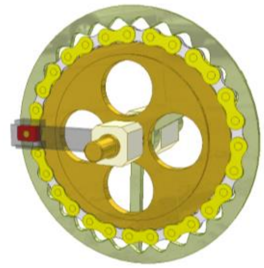
Chain harmonic drive 1
http://youtu.be/VsDJqDnqbw8
Yellow input wave generator of oval shape always contacts with all rollers of a closed chain. A link of the chain has an elongated pin to create a revolution joint with orange conrod. The latter has revolution joint with blue output crank. The input, the output and the gear are coaxial. The chain performs a complicated motion forming "waves".



Tooth number of grey fixed gear $Z_g = 30$
Link number of the chain $Z_c = 28$
Transmission ratio: $i = Z_c / (Z_g - Z_c)$
If $(Z_g - Z_c)$ small and Z_c large, i can be very large.
The input and output rotate in opposite directions.
For this case 14 revolutions of the generator correspond 1 rev. of the blue output crank. Velocity of the latter is not constant.
For comparison: if chain, conrod and crank of this mechanism are merged into a flexible part, it becomes a familiar harmonic drive of flexible gear.
Replacement of revolution joint (the orange conrod) with a prismatic one (a slider sliding in a runway on the output crank) is possible.

Chain harmonic drive 2

http://youtu.be/yEWUGvWydQc

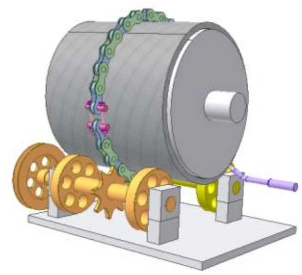


Orange input wave generator of oval shape always contacts with all rollers of a closed chain. A link of the chain has an elongated pin to create a revolution joint with red slider that moves in a slot of a fixed runway. The input and the output gear are coaxial. The chain performs a complicated motion forming "waves".

Tooth number of the gear Zg = 30
Link number of the chain Zc = 28
Transmission ratio: i = Zg / (Zg – Zc)
If (Zg – Zc) small and Zg large, i can be very large.
The input and output rotate in the same direction.
For this case 15 revolutions of the generator correspond 1 rev. of the output gear.
Velocity of the latter is not constant.
For comparison: if chain, slider and runway of this mechanism are merged into a flexible part, it becomes a familiar harmonic drive of flexible gear.

Transmission of rotation to non-circular object

https://youtu.be/ntcncuIqYng

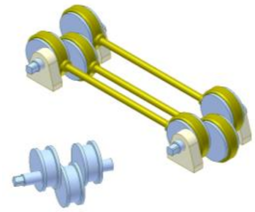


A chain fixed around a convex non-circular object enables the latter to rotate on two roller shafts.
Input: orange roller shaft of a chain sprocket.
This transmission is suitable only for low speed.
The video shows an application of this mechanism for welding a flange to a non-circular pipe.
This video was made based on the concept shown at Fig.2, page 262 of the book:
Sclater & Chironis, Mechanisms And Mechanical Devices Sourcebook, 2001.

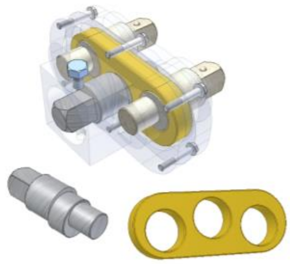
1.6. Bar drives

1.6.1. Planar drives

Parallelogram Mechanism
http://www.youtube.com/watch?v=prMefg7NCsc
Overcoming dead point by added cranks at various angles

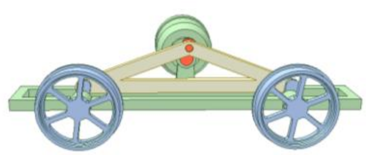


Transmission box for 2 output shafts
https://youtu.be/ISi36B0LEX0
Input: grey shaft.
Output: two remaining shafts.
The three shafts are identical. There is eccentric portion on each shaft.
Brass conrod (having revolution joints with the shafts at their eccentric portions) transmits rotation from the input to the outputs (parallelogram mechanism).

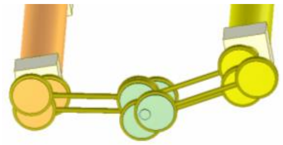


This box can be used for tightening two nuts at the same time from one torque gun. Blue screw is for fixing the box to the gun.
Using rolling bearings for the revolution joints is difficult to implement because of limited space.
No fear for dead positions of parallelogram mechanism because three revolution joints of the conrod are not set in line.

Application of parallelogram mechanism 5
http://www.youtube.com/watch?v=mP6WFS0_1jM
Transmission for electric locomotive.
There are 3 parallelogram mechanisms.
The one connecting the two wheels helps overcome dead positions that may happen to other parallelogram mechanisms.



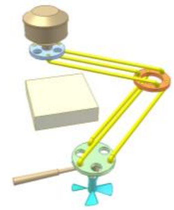
Application of parallelogram mechanism 9
http://www.youtube.com/watch?v=dg1C69jaoRw
Transmission of rotation movement between parallel shafts
The green shaft rotates without fixed bearing.



Application of parallelogram mechanism 4

http://www.youtube.com/watch?v=tjZ8qw3CTYA

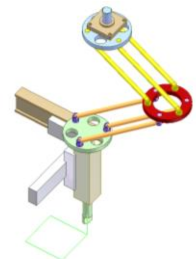
Transmission of rotation movement between parallel shafts.
The red disk rotates without fixed bearing.
The driven shaft bearing is movable.



Application of parallelogram mechanism 10

http://www.youtube.com/watch?v=hPFvm6eisuQ

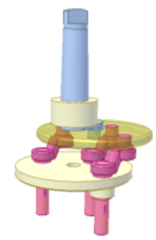
The tool head can move along Ox, Oy and Oz.



Parallel-link driller

http://www.youtube.com/watch?v=cHnnd78tUZ8

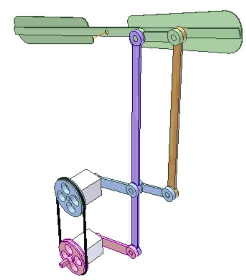
An application of parallelogram mechanism.
The yellow moving disk plays role of connecting rods.
Input crank and output cranks have the same length and the same speed.
Positions of the crank axes on the moving and fixed disks are the same.



Virtual rotation axis 1

https://youtu.be/-7H6iGYiEXg

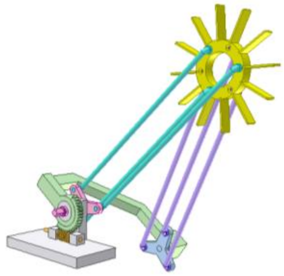
It is an application of parallelogram mechanism.
Pink and blue crank, violet conrod create a parallelogram mechanism.
Green propeller, blue crank, violet and yellow conrods create a parallelogram.
Input: pink crank.
Black belt helps the mechanism overcome its dead points.
The green propeller rotates around a virtual axis.
This video aims to illustrate the rotation around a virtual axis.
The mechanism is applied where the placing a real rotation axis is impossible. For example:
http://youtu.be/yLGqlwvKinY
The rotation around a virtual axis is found also in:
http://www.youtube.com/watch?v=Bh0uDdx7z6M
http://www.youtube.com/watch?v=hPFvm6eisuQ
https://youtu.be/ARs3y3i0enE



Virtual rotation axis 3

https://youtu.be/TPfMvtVc76w

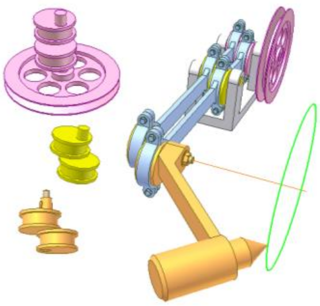
It is an application of a double parallelogram mechanism.
Input: pink crank.
Yellow propeller rotates around a virtual axis.
Its position can be changed thanks to worm drive (orange worm and green worm wheel) which moves the blue shaft bearing.
If the yellow propeller is driving, its rotation is transmitted to the pink shaft (output).



Virtual rotation axis 4

https://youtu.be/X3qVVffTEEY

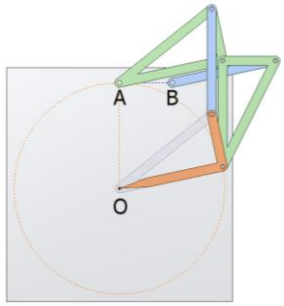
It is an application of parallelogram mechanisms.
Two acsymmetric eccentrics for each crank shaft and two conrods help parallelogram mechanisms overcome their dead positions.
Input: pink crank shaft.
The orange tool rotates around a virtual axis.
This video aims to illustrate the rotation around a virtual axis.
The mechanism is applied in case when placing a real rotation axis is impossible.



Virtual rotation axis 2a

https://youtu.be/Sx2lVREj6ts

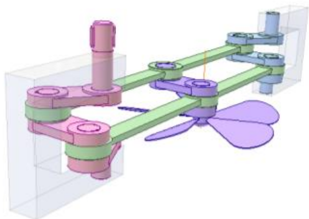
Length of two blue links is L.
Side lengths of right triangular links are L and L/2.
Input: the blue bar pivoted to the base.
The orange output link rotates around axis O although there isn't its revolution joint with the base.
This avoids placing hinges at distant or inaccessible spots.
The transparent triangular link doesn't belong to the mechanism.
Its presence aims to show that the orange link dimensions are similar to green triangular links.



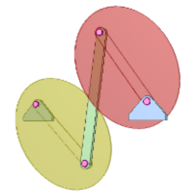
Virtual rotation axis 5

https://youtu.be/72WiyV3UoIc

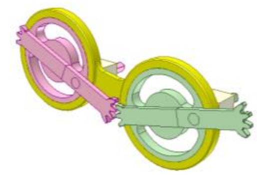
Pink, green, violet cranks and two green conrods create a double parallelogram mechanism.
Input: pink crank-shaft
For each crank-shaft (in pink, blue and violet) angle between the cranks is 60 deg.
Violet propeller fixed to the violet crank rotates around a virtual axis (no bearing for the axis).



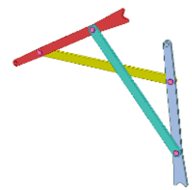
Inverse Parallelogram Mechanism 1
https://youtu.be/aPUcdGnf2uk
Inverse Parallelogram Mechanism = Ellipse Gear
Ellipse's major axis = b
Ellipse's minor axis = sqrt(b^b-a^a)
a: crank length; b: coupler link length
Ellipse's foci are centers of crank's rotary joints.



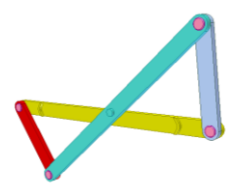
Inverse parallelogram mechanism 14
http://youtu.be/c9jSFZZX6uA
Input: pink crank rotating regularly.
Output: green crank rotating irregularly in opposite direction.
Added gears help the mechanism overcome unstable positions.



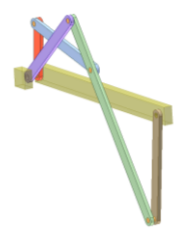
Inverse Parallelogram Mechanism 2
https://youtu.be/I4V3NqwZG0o
The concave curves and the pins on the red and blue cranks bar are for overcoming dead points.



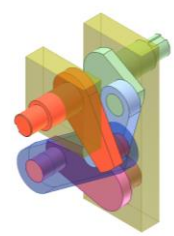
Inverse Parallelogram Mechanism 3
https://youtu.be/RkwA9F77IPQ
The concave curves on the yellow fixed bar and the pin on the cyan rod are for overcoming dead points.



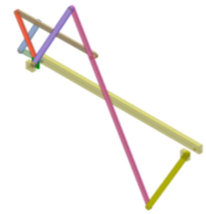
Inverse Parallelogram Mechanism 7
http://www.youtube.com/watch?v=cw0Wco_O600
Double Inverse Parallelogram
A second similar inverse parallelogram is connected to the first.
Similar ratio for this case is 2.
The red crank makes 2 revolutions while the violet one makes 1.



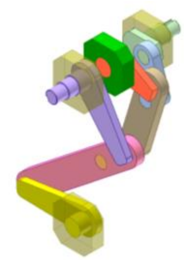
Inverse Parallelogram Mechanism 8
http://www.youtube.com/watch?v=ox03D0LQxck
Double Inverse Parallelogram
A second similar inverse parallelogram is connected to the first.
Similar ratio for this case is 2.
It is a constructive embodiment of Inverse Parallelogram Mechanism 7
The red crank makes 2 revolutions while the violet one makes 1.
The mechanism consists of only bars and revolution joints.



Inverse Parallelogram Mechanism 9
http://www.youtube.com/watch?v=zlcf7e8L0Ho
Triple Inverse Parallelogram
A third similar inverse parallelogram is connected to a double inverse parallelogram. Similar ratio for this case is 2.
The red crank makes 3 revolutions while the violet one makes 2 and the green makes 1.
Further similar connections allow getting transmission ratio of 4, 5, 6 …
There may be difficulty in arranging the crank bearing supports.

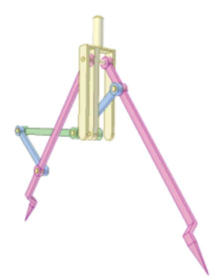


Inverse Parallelogram Mechanism 10
http://www.youtube.com/watch?v=YuqHVUsr2N0
Triple Inverse Parallelogram
A third similar inverse parallelogram is connected to a double inverse parallelogram.
Similar ratio for this case is 2.
The red crank makes 3 revolutions while the violet one makes 2 and the green makes 1.
Further similar connections allow getting transmission ratio of 4, 5, 6 …
The mechanism consists of only bars and revolution joints.
There may be difficulty in arranging the crank bearing supports.



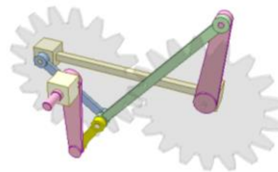
Inverse parallelogram mechanism 11
http://youtu.be/S8sIOrvrYJM
This modification of inverse parallelogram (4 V-shaped arm mechanism) was proposed in 1877 by A. B. Kempe, London.
The original consists of two orange bars and two violet ones.
Each bar is modified by adding a V-shaped arm and becomes an isosceles right triangle. Their right angle vertices create a variable rectangular (in red).

Inverse parallelogram mechanism 12
http://youtu.be/CsEWqFHsx9g
A compass of Double Inverse Parallelogram.
A second similar inverse parallelogram is connected to the first.
Similar ratio is 2.
The long bars of the first (big) are the left pink bar and the green bar.
The long bars of the second (small) are the right blue bar and the yellow ground bar.
The pink bars turn in opposite directions with the same velocity.
This mechanism can be used for the inverse transmission with limited rotation angle between two opposite coaxial shafts.



Inverse parallelogram mechanism 13

http://youtu.be/dqDHfOBE8EQ



Double Inverse Parallelogram.
A second similar inverse parallelogram is connected to the first.
Similar ratio is 2.
The long bars of the first (big) are the ground bar and the green bar.
The long bars of the second (small) are the blue bar and the left pink crank.
The pink cranks turn in opposite directions with the same velocity.
This mechanism acts as a spur gear drive (in glass, added for illustration), each gear is fixed to the pink crank. Measure for overcoming dead points is not shown.

Bar mechanism for reversing rotation 4

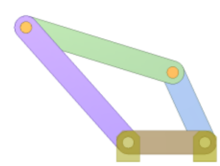
https://youtu.be/FmyKb0TjJAU

Input: pink crank rotating regularly.
Output: orange crank.
Joint between the orange crank and blue bar is pin-slot.
Length of glass bar: a
Length of blue bar: a + a
Length of cranks : 0.136a
Three stationary bearings create an isosceles right triangle. Length of its hypotenus: 2a
Blue curve is traced by center of the blue bar pin. It is nearly round. Orange curve is traced by center of the orange crank slot. Two curves are about coincident.
Pink and orange cranks rotate in opposite directions. Transmission ratio: 1/1. Orange crank rotates nearly regularly.
To make the mechanism compact the glass bar and glass bearing are replaced with red slider and grey stationary circular runway.
Advantages over ordinary antiparallelogram mechanisms:
- no dead points
- nearly constant output velocity.

See also:
http://youtu.be/dqDHfOBE8EQ

Kite mechanism 1

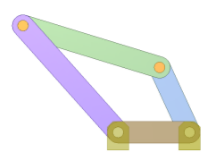
http://www.youtube.com/watch?v=5o-PS0ixoUQ



a = d; b = c; b > a
a, b, c and d are lengths of the blue, green, violet and tan link respectively.
It has two dead positions. The video shows how it works without measure to overcome dead positions.
At times it works as a mechanism of one link and one revolution joint.

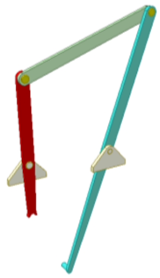
Kite mechanism 2

http://www.youtube.com/watch?v=ukYuFjQ_92Y

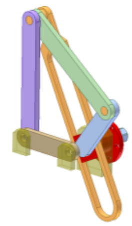


a = d; b = c; b > a
a, b, c and d are lengths of the blue, green, violet and tan link respectively.
The video shows how it works, suppose it can overcome dead positions.
When the violet link makes one revolution, the blue makes two.
If one rotates regularly, the other not.

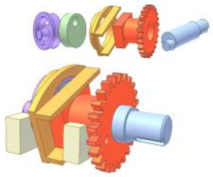
4 bar linkage mechanism a+b=c+d
http://www.youtube.com/watch?v=CJXSHnn0PiY
Kite mechanism.
Length of the red input crank a = 9
Length of the green rod b = 15
Length of the cyan crank c = 15
Distance between two fixed pins d = 9
When the red turns 2 rev., the cyan turns 1 rev.
The concave curve on the red crank and the pin on the cyan crank are for overcoming dead points.



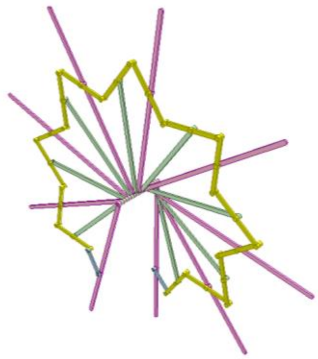
Kite mechanism 3
http://www.youtube.com/watch?v=R6kJK8_stjs
A development of kite mechanism by adding a coulisse mechanism.
When the red link makes one revolution, the blue makes two.
Both rotate regularly.
The measure to overcome dead positions is not shown.



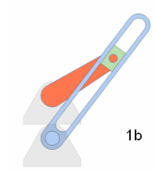
Kite mechanism 4
http://www.youtube.com/watch?v=BseymDwghxI
A development of kite mechanism by adding a coulisse mechanism.
When the red link makes one revolution, the blue makes two.
Both rotate regularly.
It is a constructive embodiment of Kite mechanism 3
The measure to overcome dead positions is not shown.
(Bar mechanism for speed reduction)



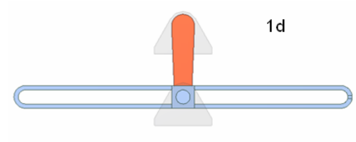
Kite mechanism 6
http://youtu.be/gY0oJDQ-uVU
It was proposed in 1877 by A. B. Kempe.
Length of blue bars: a
Length of yellow bars: a + a
Length of green bars: 4a
Distance between revolution joints of pink bars: 4a
Numbering:
0 for the fixed pink bar,
1 for the next pink bar, …
n for the last pink bar,
i = 1 to n
A1 is angle between bar 1 and bar 0
Ai is angle between bar i and bar 0
The mechanism maintains relation: Ai = i.A1
i.e.: A2 = 2.A1 ; An = n.A1
Theoretically it can be used for dividing an angle into n equal portions or for velocity multiplication of n times.



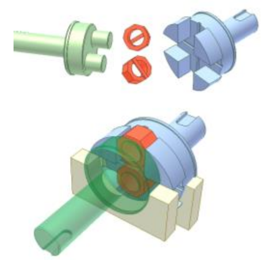
Coulisse mechanism 2
http://www.youtube.com/watch?v=E1wY_h4ZzhI
a > d: the coulisse revolves
a: crank length; d: axle distance



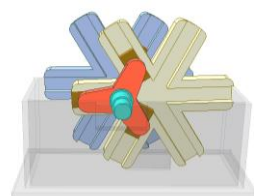
Coulisse mechanism 3
http://www.youtube.com/watch?v=p8bsOZu0BpE
a = d: the coulisse regularly revolves.
Its velocity is half of the crank one.
a: crank length; d: axle distance



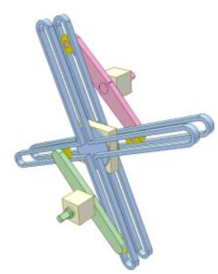
Coulisse Gearbox 2
http://www.youtube.com/watch?v=gKQ-ro9gRcg
An application of special coulisse mechanism when a = d.
a: crank length; d: axle distance. Transmission ratio: 1:2
Compact due to the additional slots.



Coulisse Gearbox 1
http://www.youtube.com/watch?v=bQYQS2rt80k
An application of special coulisse mechanisms when a = d.
a: crank length; d: axle distance.
See: http://www.youtube.com/watch?v=8YImZomIFWI
Transmission ratio: 1:4

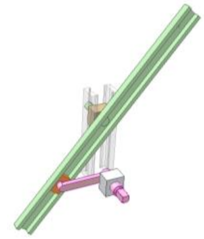


Coulisse mechanism 4
https://youtu.be/dab5_kQH2vk
Transmission of rotary motion between two cranks (pink and green).
The cranks have the same velocity V and rotate in the same direction.
Velocity of blue bar: V/2
Crank length: a
Stationary bearing distances: d + d
a = d
It is an application of mechanism shown at:
http://www.youtube.com/watch?v=p8bsOZu0BpE



Planar coulisse mechanism

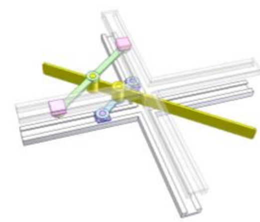
https://youtu.be/yCRlfDjny1o



Input: pink crank of radius R.
Output: green bar.
Output motion depends on distance A between two grey bearings.
The video shows the motion of the green bar when A is set at various values:
When A < R: the green bar rotates. Transmission ratio: 1 but output velocity is not constant.
When A = R: the green bar rotates. Transmission ratio: 2, output velocity is constant. There are unstable positions when rotary axes of the green bar and the orange slider are in line.
When A > R: the green bar oscillates.

Virtual rotation axis 2

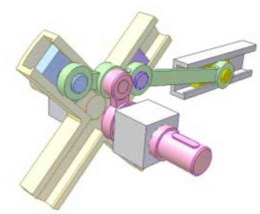
https://youtu.be/OXLYkhZH8Tc



Two ellipse mechanisms (blue bar, two violet sliders and green bar, two pink sliders) are connected by yellow bar at center points of the blue and green bars.
The yellow bar rotates around a virtual axis.
Driving motion is the rotation of blue or green bar.
This video aims to illustrate the rotation around a virtual axis.
The mechanism is applied where the placing a real rotation axis is impossible.

Ellipse mechanism 3b

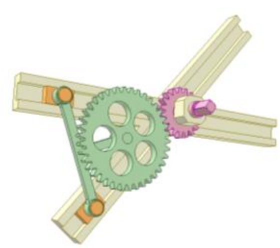
https://youtu.be/nR62MsDpLmw



Input: pink crank of radius a
Output: yellow shaft of two 90 deg. runways.
Length of green conrod: a + a + b
Two revolutions of the input pink crank corresponds with one revolution of the output yellow shaft (transmission ratio = 2).
The output velocity is not regular.

Ellipse mechanism 3a

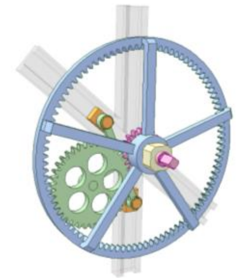
http://youtu.be/TaraJQHhGNA



Ellipse mechanism with non 90 deg. angle between sliding directions.
The T-conrod and the large gear are fixed together. Position of the green gear center and and the center distance of gear drive must be selected based on the description in
http://www.youtube.com/watch?v=8WCee-fP9rg
Tooth number of the small gear: 19
Tooth number of the large gear: 38
5 rev. of the small gear corresponds 1 rev. of the green gear.
The strange thing is that the gear drive acts as a planetary gear one but without a carrier.
In case the center distance is small, an internal gear drive can be used instead.

Ellipse mechanism 3b

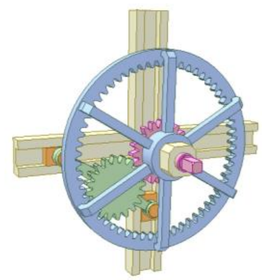
http://youtu.be/VK0hndCKo8o



Ellipse mechanism with non 90 deg. angle between sliding directions.
The T-conrod and the large gear are fixed together. Position of the green gear center and and the center distance of the external gear drive must be selected based on the description in
http://www.youtube.com/watch?v=8WCee-fP9rg
Tooth number of the small external gear: 19
Tooth number of the large external gear: 38
Tooth number of the internal gear: 95
1 rev. of the internal gear corresponds 25 rev. of the pink gear, in same direction.
The strange thing is that the gear drive acts as a planetary gear one but without a carrier gear.

Ellipse mechanism 3c

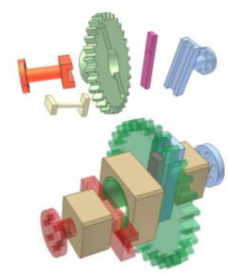
http://youtu.be/HPJgUTGt6Ig



Ellipse mechanism with 90 deg. angle between sliding directions.
The conrod and the green gear are fixed together. Center of the green gear is in the middle of the conrod and the center distance of the external gear drive is a half of the conrod length.
Tooth number of the pink gear Z1 = 20
Tooth number of the green gear Z2 = 20
Tooth number of the internal gear: Z3 = 60
n3/n1 = (Z1.Z2)/(Z3.Z3)
n3: velocity of the internal gear
n1: velocity of the pink gear
1 rev. of the internal gear corresponds 9 rev. of the pink gear in same direction.
The strange thing is that the gear drive acts as a planetary gear one but without a carrier.

Altering speed with Oldham mechanism 1

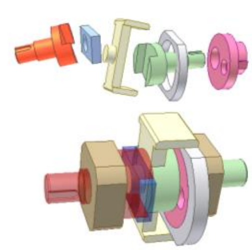
http://www.youtube.com/watch?v=daLBKiA5Ing



If the green gear is driving, the two output shafts speed is half of the green gear one.
The remark in “Oldham mechanism 2”
http://www.youtube.com/watch?v=TBYJwi4BTsM
is used for this case.

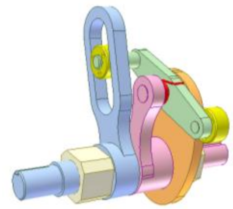
Altering speed with Oldham mechanism 2

http://www.youtube.com/watch?v=3JrO7tWzYXQ



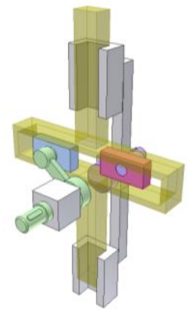
If the red shaft is driving, the green shaft speed is half of the red shalf one.
The remark in “Oldham mechanism 2”
http://www.youtube.com/watch?v=TBYJwi4BTsM
is used for this case.

Fixed cam mechanism 1
http://youtu.be/FVQjX8p3UZ4



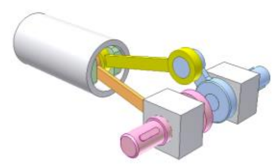
The orange cam is fixed. The pink input crank of constant velocity carries a green follower, one roller of which contacts with the cam. The other roller moves in a slot of the blue output shaft that has irregular speed. A red torsion spring forces the green follower towards the cam. This example shows that the disk cam does not always an input rotational link, it can be fixed.

Bar mechanism for reversing rotation 2
https://youtu.be/7wEIiMXYB-g



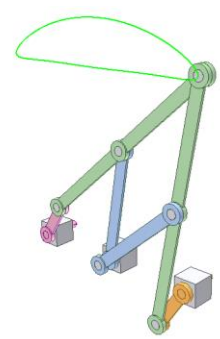
It is a combination of two sine mechanisms sharing a common yellow slider.
Input: green (or violet) crank.
Output: the other crank. It turns at the same input velocity but in opposite direction.
Input and output are coaxial.
Disadvantages:
- Inertia forces created by reciprocating parts.
- Dead positions when output crank is vertical.
The mechanism becomes a regular coupling (no reversing) when the cranks are set to be always parallel.

Bar mechanism for reversing rotation 3
https://youtu.be/wMOVNR9c5P4



It is a combination of two slider-crank mechanisms sharing a common green slider.
Input: pink crank.
Output: blue crank. It turns at the same input velocity but in opposite direction.
Input and output are coaxial.
Disadvantages:
- Inertia forces created by reciprocating parts.
- Dead positions (when output crank and its conrod are in line).
The mechanism becomes a regular coupling (no reversing) when the cranks are set to be always parallel.

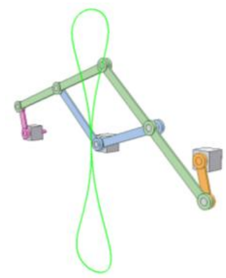
Pantograph transmission 1a
https://youtu.be/JEacmKIeijA



Input: pink crank rotating regularly.
Output: orange crank rotating regularly.
The cranks rotate in the same direction with the same velocity
Lengths of cranks : a
Lengths of blue bars : 2.5a
Lengths of green bars: 2.5a + 2.5a
Distances between stationary bearings: b + b
b can not be larger than 4a.
Green curve: locus of center of joint between two green bars.
Because here b = 2a, part of the locus is nearly straight.

Pantograph transmission 1b

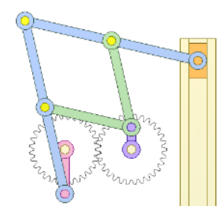
https://youtu.be/FNKHAa3xuA0



Input: pink crank rotating regularly.
Output: orange crank rotating regularly.
The cranks rotate in the same direction with the same velocity
Lengths of cranks : a
Lengths of blue bars : 2.5a
Lengths of green bars: 2.5a + 2.5a
Distances between stationary bearings: b + b.
Green curve: locus of center of joint between two green bars.
Because here b = 4a, unstable positions happen when all the bars are in line. One working cycle corresponds 2 revolutions of the input.

Pantograph for reversing rotation

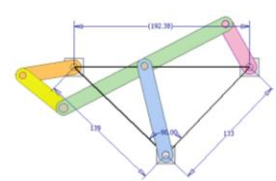
https://youtu.be/Bwnm_eniRbc



Green and blue bars create a pantograph.
Input: pink (or violet) crank.
Output: the other crank. It rotates at the same input velocity but in opposite direction.
Line connecting centers of fixed revolute joints of the cranks is perpendicular to sliding direction of orange slider.
When the cranks are parallel to sliding direction of the orange slider, the pantograph three joints with the cranks and the slider are in line.
For this pantograph: length of blue bars: a + a, length of green bars: a.
Length ratio of the pink and violet cranks: 2.
White gears do not belong to the mechanism. Their apperance aims to show transmission ratio of -1 between the cranks.
On the contrary, a mechanism with the gears and without the slider can be used for tracing an absolutely straight line. See:
https://youtu.be/ZbiExQK6Crg
The mechanism has unstable positions when the two cranks are in line.

Six bar linkage for reversing rotation

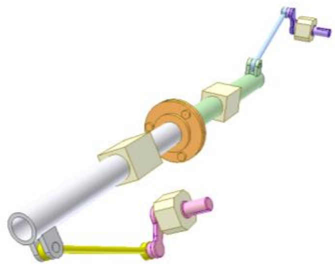
https://youtu.be/0TeNsu7HvjU



Pink bar length: 54
Blue bar length: 100
Green bar length: 100 + 100
Yellow bar length: 57
Orange bar length: 57
Input: pink bar rotating regularly
Output: orange bar rotating irregularly.
Transmission ratio: 1

Transmitting rotation by two slider-crank mechanisms

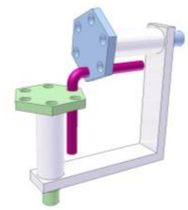
http://youtu.be/OxVwOoN3eRI



There are two identical slider-crank mechanisms. Their positions in relation with the slider centerline are identical too.
Input: the pink crank rotating regularly.
Output: the violet crank.
Rotation direction of the output crank depends on its start position.
- If the two cranks rotate in opposite directions, the output crank rotates regularly as per this video.
- If the two cranks rotate in the same direction, the output crank rotates irregularly.
This phenomeno has been seen for parallelogram and anti-paralellogram mechanisms.
Measure to overcome dead points for the output crank is necessary (not shown).
This mechanism shows that slider-slider mechanisms can transmit rotary motion between two skew shafts of large center distance, subject to slider length. However the slider large inertia is a problem.
The revolution joint (in orange) between two sliders is for easy setting relative position of two crank shafts.

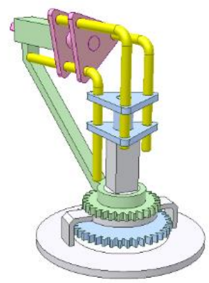
1.6.2. Spatial drives

Angular transmission (90 degrees)
http://www.youtube.com/watch?v=2TgoJXbncf0
The simplest way to transmit rotation between perpendicular shafts.
Driving and driven shafts rotate regularly.



Angular transmission (90 degrees)
http://www.youtube.com/watch?v=NdzSqc8pxVg
The simplest way to transmit rotation between perpendicular shafts.
Driving and driven shafts rotate regularly.

Epicyclic bar angular transmission
https://youtu.be/12CiLupFwSE
Input: green arm and blue shaft
Output: pink shaft.
The video shows alternately:
1. The green arm is kept immobile, the blue shaft rotates.
2. The green arm rotates, the blue shaft is kept immobile.
3. Both green arm and blue shaft rotate in different directions.

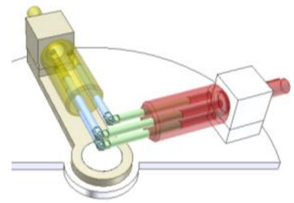


Angular transmission (45 degrees)
http://www.youtube.com/watch?v=QEMpifDSqF0
The simplest way to transmit rotation between intersecting shafts.
Driving and driven shafts rotate regularly.

Angular transmission (135 degrees)
http://www.youtube.com/watch?v=8W6lziEuNzQ
The simplest way to transmit rotation between intersecting shafts.
Driving and driven shafts rotate regularly.

Universal Hobson's joint

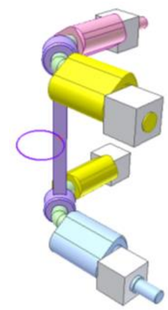
https://youtu.be/0cU5oB8V_08



Each angular bar of an ordinary Hobson's joint is divided into two parts that are connected together by a revolute joint.
Input: red shaft.
Output: yellow shaft
The angle between the two shafts can be varied during transmission. It is a constant velocity joint.
The mechanism has an unstable position when the input and output shafts are in line.

Transmission between skew shafts by Hobson's joints

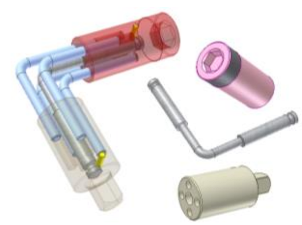
https://youtu.be/GlTuH0YEBWo



Input: pink crank.
Output: blue crank.
The input and output cranks are skew at 90 deg. angle.
Angular green bars have cylindrical joints with pink, blue and yellow cranks.
Violet conrod is translated along an ellipse.
The mechanism has unstable positions when the planes created by axes of two joints of each crank are vertical.

Gearless right-angle socket adapter

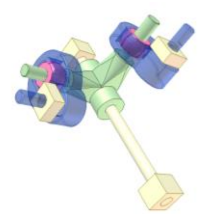
https://youtu.be/yKjTuCerWdQ



An application of the Hobson's joint.
It is used for working in tight quarter.
See a real adapter:
https://www.youtube.com/watch?v=_6in9Q8DDoY

Transmission between intersecting shafts 1

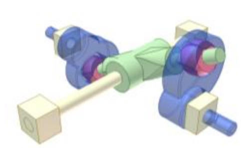
http://www.youtube.com/watch?v=hzWU8A6hhTE



Both shafts rotate regularly.
Intersecting angle α = 90 degrees.
For other α value the angular arm must be amended accordingly.

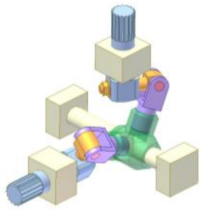
Transmission between coaxial shafts 1

http://www.youtube.com/watch?v=xjLXMhkRR8Q

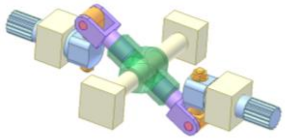


Rotary directions are opposite.
Both shafts rotate regularly.

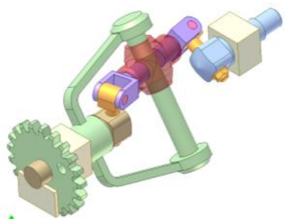
Transmission between intersecting shafts 2
http://www.youtube.com/watch?v=tp_-sN5VpA0
Both shafts rotate regularly.
Intersecting angle α = 90 degrees.
For other α value the angular arm must be amended accordingly.



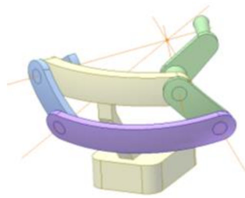
Transmission between coaxial shafts 2
http://www.youtube.com/watch?v=EWCK_IZLM_s
Rotary directions are opposite.
Both shafts rotate regularly.



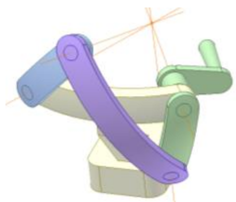
Bar mechanism for speed reduction
http://www.youtube.com/watch?v=XInp3zS6Qkg
When the blue shaft makes two revolutions, the green makes one.
Both rotate regularly.



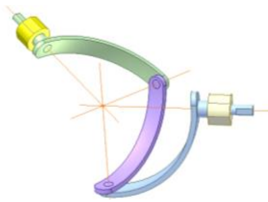
Spherical 4-bar linkage mechanism 2
http://www.youtube.com/watch?v=XQCVg_iXV7U
Axes of all revolution joints intersect at a common point.
Spherical parallelogram mechanism.
Measures to overcome dead points are needed.



Spherical 4-bar linkage mechanism 3
http://www.youtube.com/watch?v=q0erDDuPO7w
Axes of all revolution joints intersect at a common point.
Spherical anti parallelogram mechanism
Measures to overcome dead points are needed.

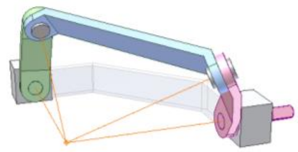


Spherical 4-bar linkage mechanism 7
http://www.youtube.com/watch?v=Y3QtVdXIKbc
Axes of all revolution joints intersect at a common point.
The simplest embodiment of a Cardan joint.



Spherical 4-bar linkage mechanism 2b

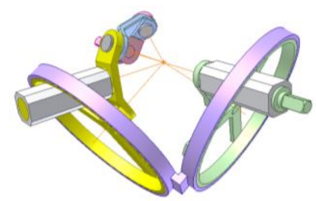
https://youtu.be/PUGe-pmwJ7g



Input: pink crank rotating regularly.
Output: green crank rotating irregularly. Max velocity differences are +73% and -42% of the input velocity.
All axes of the revolution joints are concurrent.
Angle between the two crank axes: 90 deg.
Angle between two revolution joint axes of blue bar: 90 deg.
Angle between two revolution joint axes of the pink crank is equal to the one of the green crank.

Reverse mechanism of spherical linkage

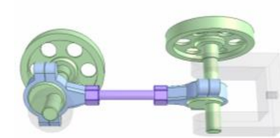
https://youtu.be/o0iy914iphE



Input: pink crank rotating regularly.
Yellow intermediate crank rotates irregularly.
Output: green crank rotating regularly.
The input and output shafts are coaxial and rotate in opposite directions at the same velocity.
All axes of the revolution joints are concurrent.
It is created by connection of two mechanisms shown at:
https://youtu.be/PUGe-pmwJ7g
In order to avoid collision of the violet conrod with the blue one, the violet conrod, yellow and green cranks have strange shapes.
It is a study to show that the mechanism has the same function of 3 bevel gear drive.

Spatial 4-bar linkage mechanism 1

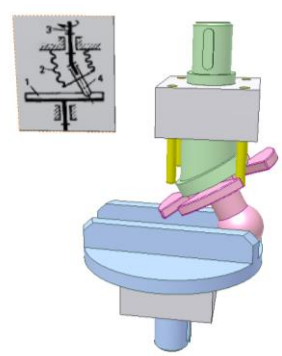
http://www.youtube.com/watch?v=hXsG7eLSQbQ



Spatial "Parallelogram" Mechanism:
Transmission between two skew shafts.
Connection rod length = distance of two shafts.
The two shafts have the same eccentricity.
Joints between the conrod and the cranks are spherical.
Angle between two shafts is arbitrary.

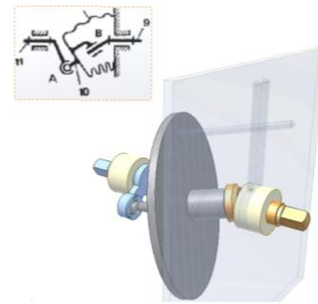
Coulisse mechanism 7

https://youtu.be/8rPSskNzKzM



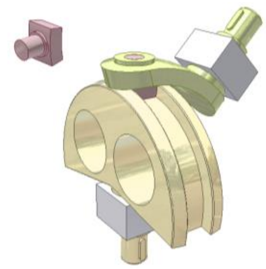
There is an offset A between green input shaft and blue output shaft.
The green shaft has an oblique pivot for pink part.
Distance between center of sphere of the pink part and rotary axis of the green shaft is B.
If B < A: the blue shaft rocks.
If B > A: the blue shaft rotates irregularly, Transmission ratio: 1.
The video shows case when B = A. The blue shaft rotates regularly. Transmission ratio: 1/2.
The B = A mechanism has unstable position when center of the pink sphere is on the axis of the blue shaft. Inertia of the output helps overcome this position.
Purpose of yellow pins and slots on the pink part is to show that the latter does not rotate together with the green shaft. So it is possible to put a flexible tube connecting upper bearing and disk of the pink part thus to perform motion transmission through closed wall on which the upper bearing is fixed (see the sketch).

Transmission through closed wall with bar mechanism



https://youtu.be/5ZjQulhfm0A
Input: orange shaft having an oblique (15 deg.) pivot and rotating regularly.
Output: blue shaft rotating regularly. Transmission ratio: 1.
Grey disk has revolute joint with the orange shaft and spherical joint with the blue shaft.
Purpose of 3 pins (in glass) is to show that the grey disk can be kept not to rotate together with the orange shaft. So it is possible to put a flexible tube connecting the grey disk and the glass wall thus to perform the transmission through closed wall on which the right bearing is fixed (see the sketch).

Spherical coulisse mechanism 1a

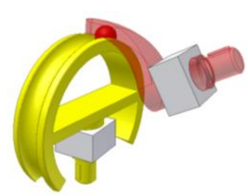


https://youtu.be/8OEczNJ7-U8
Input: green shaft.
Output: yellow shaft
It is a spherical mechanism.
Its center is intersecting point of the two shaft axes.
Axes ot the input and output shafts intersect at angle A = 45 deg.
Angle between axes of the input and the pink slider is B = 45 deg.
- If B = A (this video case) two revolutions of the input correspond one revolution of the output. Output velocity is not constant.
When pink slider axis is in plane containing axes of the two shafts, it is in line with axis of the yellow shaft.
- If B is smaller than A, the output rocks. See “Oblique Crank - Rocker mechanism 2”:
http://www.youtube.com/watch?v=pxQIrf1U7G8
- If B is larger than A, one revolution of the input corresponds one revolution of the output. Output velocity is not constant. See “Spherical coulisse mechanism 1b”
https://youtu.be/TtdoS8pRJZA

Spherical coulisse mechanism 1b

https://youtu.be/TtdoS8pRJZA
Input: white shaft.
Output: yellow shaft
It is a spherical mechanism.
Its center is intersecting point of the two shaft axes.
Axes ot the input and output shafts intersect at angle A = 45 deg.
Angle between axes of the input and the pink slider is B = 60 deg.
B is larger than A, one revolution of the input corresponds one revolution of the output. Output velocity is not constant.

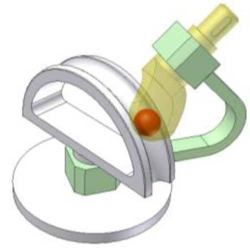
Spherical coulisse mechanism 1c



https://youtu.be/FwGJjVulBwE
It is a structural embodiment of “Spatial coulisse mechanism 1a”
A ball fixed to red shaft replaces the slider. A = B = 60 deg.
Input: red shaft.
Output: yellow shaft
Two revolutions of the input corresponds one revolution of the output.
Output velocity is not constant.

Spherical coulisse mechanism 1d

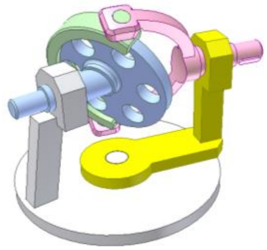
https://youtu.be/bBcJecvNcIM



This satellite mechanism is developed from “Spatial coulisse mechanism 1a”
A ball fixed to red shaft replaces the slider. A = B = 45 deg.
Input: green carrier rotating regularly around grey fixed part.
Output: yellow shaft.
One revolution of the input makes the output rotate two revolutions in relation with the input.

Spherical coulisse mechanism 2

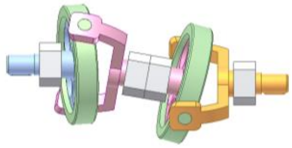
https://youtu.be/TJ3bXO0z94c



Input: blue shaft of oblique disk. Oblique angle: 30 deg.
Output: pink shaft.
Axes of three revolute joints intersect at one point.
The video shows the motion of the pink fork when the angle between the blue and the pink shafts is set at various values: 0 deg. ; 15 deg. ; 30 deg.; 60 deg.; 90deg.
At 0 deg.: the two shafts rotate at the same velocity.
At 15 deg.: transmission ratio: 1 but the output velocity is not constant.
At 30 deg.: transmission ratio: 2, the output velocity is rather regular.
At 60 and 90 deg.: the pink shaft oscillates.

Spherical coulisse mechanism 3

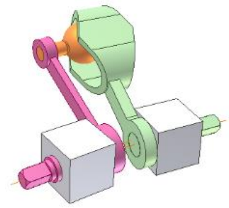
https://youtu.be/Ya2f_lpTE1g



It is a serial connection of two mechanisms shown at https://youtu.be/TJ3bXO0z94c
Oblique angle of the disks is 10 deg.
Input: blue shaft of oblique disk.
Output: orange shaft.
The input and output shafts are parallel.
Angle beween pink shaft and input shaft: 10 deg. Total transmission ratio: 4
Output velocity is rather regular. Velocity variation is around 3%.
The mechanism has not been verified in practice.

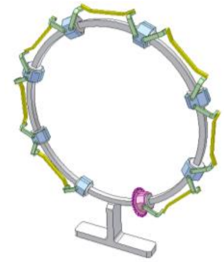
Spatial coulisse mechanism 1

https://youtu.be/cUW0K8Yp3n8

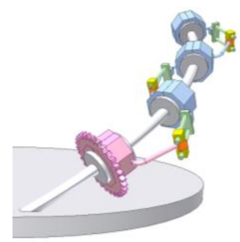


Input: pink crank.
Output: green crank.
Relative position between the cranks can be arbitrary, even skew.
Output velocity is not constant when the output one is constant.

Transmission for rotors placed along a circle 1
https://youtu.be/mYADAD7PzXA
Input: pink gear rotor.
The bar coupling of two adjancent rotors is constant velocity one.
It is an application of mechanism shown at:
http://youtu.be/SqQ9FLh9ktM
This mechanism can be used for the kinetic scupture (at minute 0.38):
https://www.youtube.com/watch?v=1CNU3DQclGs

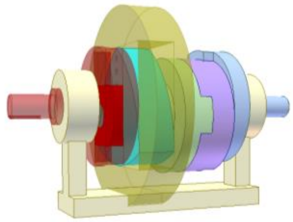


Transmission for rotors placed along a spatial curve 1
https://youtu.be/tn0Ai6-nN8w
Input: pink gear-rotor.
The blue output rotors are placed along a helical curve.
The transmission is performed via spatial 6-bar mechanisms.
They are not contant velocity joints for this case.
They are contant velocity joints if the curve is planar.

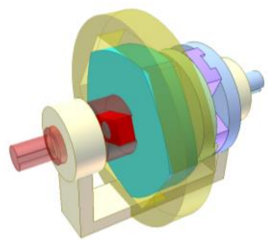


1.7. Cam drives

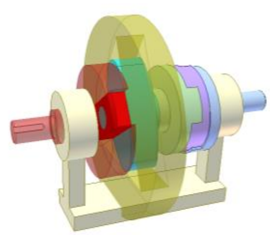
Altering speed with Reuleaux polygon 1a
http://www.youtube.com/watch?v=8CuVNvTmbiI
The mechanism is built based on the fact that while the n-sided Reuleax polygon makes 1 rev in an ambient polygon, its center traces a loop n times. See:
http://www.youtube.com/watch?v=BnvT45CjD-E
Transformation ratio is 3 (= n, number of Reuleax polygon sides)
Velocity of the output shaft is very inconstant.
Theoretically, by increasing number of sides of a Reuleax polygon (7, 9, 11 …) it is possible to get large transformation ratio and make the velocity less inconstant.



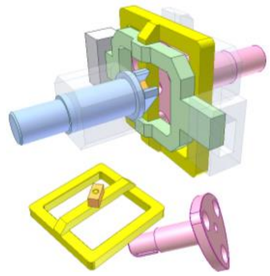
Altering speed with Reuleaux polygon 2
http://www.youtube.com/watch?v=aXOwSmVi94I
The mechanism is built based on the fact that while the n-sided Reuleax polygon makes 1 rev in an ambient polygon, its center traces a loop n times. See:
http://www.youtube.com/watch?v=oe8e-N3VusI
Transformation ratio is 5 (= n, number of Reuleax polygon sides)
Velocity of the output shaft is very inconstant.
Theoretically, by increasing number of sides of a Reuleax polygon (7, 9, 11 …) it is possible to get large transformation ratio and make the velocity less inconstant.



Altering speed with Reuleaux polygon 3
http://www.youtube.com/watch?v=gisagr0r5Ww
The mechanism is built based on the fact that while the n-sided Reuleax polygon makes 1 rev in an ambient polygon, its center traces a loop n times. See:
http://www.youtube.com/watch?v=gGNC3ltLJK4
It is a case of Reuleax polygon variation.
Transformation ratio is 2
Velocity of the output shaft is very inconstant.

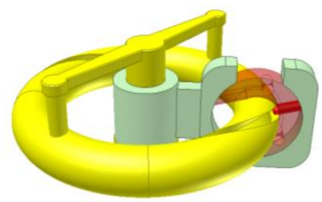


Altering speed with Reuleaux polygon 1b
http://youtu.be/NDcAWIbEfpM



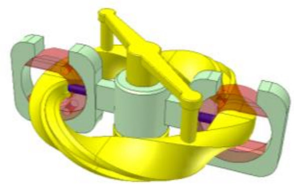
It is built based on the fact that while the n-sided Reuleax polygon makes 1 rev. in an ambient polygon, its center traces a loop n times. See:
http://www.youtube.com/watch?v=BnvT45CjD-E
Transformation ratio is 3 (= n, number of Reuleax polygon sides).
Two shafts are coaxial and rotate in different directions. Velocity of the output shaft is inconstant.
Theoretically, by increasing number of sides of a Reuleax polygon (7, 9, 11 …) it is possible to get large transformation ratio and make the output velocity less inconstant.
The mechanism has not been seen in practice and needs to be verified.

Torus transmission 1
http://youtu.be/blMbnSe44Ag



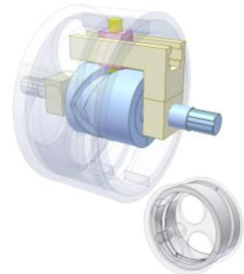
Helix torus joint.
Transmission of rotary motion between two 90 deg. skew shafts. Input is the yellow torus. Output is the red bush carrying a red pin that slide in a helix groove of the yellow torus. The helix groove has two rev. (n = 2) thus gives a transmission ratio of n = 2.

Torus transmission 2
http://youtu.be/bcrJcaKA4MA



Helix torus joint.
The green crank is input. The yellow torus cam is fixed. It has a helix groove of two rev.. The red bushes are output. They have blue pins sliding in cam groove.
1 rev. of the green crank corresponds 2 rev. of the red bushes.
This mechanism may be applied for park rotating equipments.

Barrel cam reverser 1
https://youtu.be/V6w7WIfCDk8



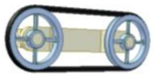
Yellow pin of the pink slider moves along helical grooves of inside cam shaft (in blue) and outside cam shaft (in glass).
The slider moves along a fixed runway.
Each helical groove consists of right-hand and left-hand portions.
At start position the yellow pin is set to be in opposite hand portions of two grooves. The shafts rotate in opposite directions.
The input is outside cam shaft.
Weakness of this mechanism: unstable positions when the pin is at the corners of each groove. The output inertia helps to overcome them. So at start position the yellow pin must not be at such unstable positions. Adding a device to avoid that is necessary.

Barrel cam coaxial reductor
https://youtu.be/m7hja8mC7Uo
Input: outer cam (in glass).
Output: inner cam (in blue).
They are coaxial.
The slider (in red glass) slides in a stationary runway.
Yellow pin is fixed to the slider and moves along helical grooves of the outer and inner cams. It is possible to use two yellow pins and sliders arranged symmetrically.

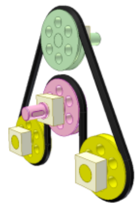
The inner cam consists of six V-shaped portions (N = 6).
The outer cam consists of only one V-shaped portion.
So the output rotates 6 times slower than the input.
Increase N for greater transmission ratio.
The ouput rotary direction may differ from the input one subject to relative position between the input and output shafts at their initial positions.
Weakness of this mechanism: unstable positions when the pin is at the corners of each groove. The output inertia helps to overcome them. So at start position the yellow pin must not be at such unstable positions. Adding a device to avoid that is necessary.

1.8. Belt drives

Belt drive 1
http://youtu.be/LVro9AMkPAU
Rotation transmission between two parallel shafts.
The reverse is possible for rope, flat belts, not for V-belt.



Belt drive 1b
http://youtu.be/mEDpH4xR8KE
Reverse rotation transmission between two parallel shafts (in pink and green). Its belt can be of round or hexagonal section.
Double sided timing belt is better option. Using chain instead of belt is possible.

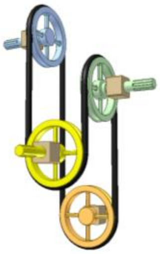


Belt drive 2
http://youtu.be/RpVSn_ZZCOI
Used with shafts at right angle rotating in one definite direction.
In order to prevent the belt from leaving the pulleys the latter should be sufficiently wide and fixed and secured finally only after a trial run.

Belt drive 3
http://youtu.be/m7ram9-X-2s
Used with shafts at right angle rotating in one definite direction.
In order to prevent the belt from leaving the pulleys the latter should be sufficiently wide and fixed and secured finally only after a trial run.

Belt drive 4a
http://youtu.be/tzg6DS9rNJc
Reversing rotation transmission between two coaxial shafts.
Rotation transmission between two skew shafts (skew angle is 90 deg.). Rotary directions of two coaxial shafts are opposite.
It uses rope belts only.

Belt drive 4b
http://youtu.be/LySVtyqfBBs
Rotation transmission between parallel shafts.
Rotation transmission between two skew shafts (skew angle is 90 deg.).
Rotary directions of two parallel shafts are opposite.
It uses rope belts only.

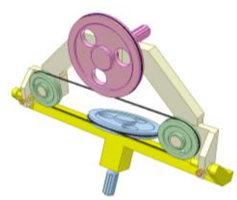


Belt drive 4c
http://youtu.be/ZXLJzeK2PSQ
Rotation transmission between two intersecting shafts.
Angle between the blue and yellow shafts may differ from 90 deg. It is similar to a bevel gear drive but rotay directions of the outputs are oposite.
It uses rope and flat belts, not V-belts.

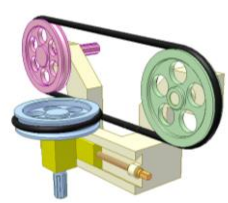
Belt drive 5a
http://youtu.be/dZllsgv0GyE
Rotation transmission between two intersecting or skew shafts with rope belt.
The belt wraps 1 rev. around the blue pulley.
Angle between the blue and pink shafts may differ from 90 deg.
Axle distance between the shafts can be adjusted in small range.

Belt drive 5b
http://youtu.be/YUOyXmsETi8
Rotation transmission between two skew shafts with rope belt.
By moving the yellow bar it is possible to adjust angle between the shafts (from 0 to 360 deg.) and their axle distance.
The belt wraps 1 rev. around the blue pulley.
Two belt branches connecting to the pink pulley can be crossed to increase arc of contact or to reverse output direction.
To some extent it is a constant velocity joint.

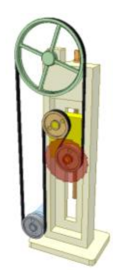
Belt drive 5c
http://youtu.be/eWL-9nD16Gk
Rotation transmission between two skew shafts with rope belt.
By moving the yellow bar it is possible to adjust angle between the shafts (from 0 to 360 deg.) and their axle distance.
The belt wraps 1 rev. around the blue pulley and the pink pulley.
To some extent it is a constant velocity joint.



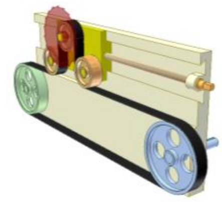
Belt drive 6
http://youtu.be/Idc3LDbRby8
Rotation transmission between two skew shafts with rope belt.
Angle between the blue and pink shafts is 90 deg. The belt wraps 1 rev. around the blue pulley.
The blue shaft can translate during rotation.



Belt drive 7
http://youtu.be/CTw53zSy4Wk
Rotation transmission between parallel shafts, one can move.
The key factor is: 3 belt branches connecting to the grey and blue pulleys must be parallel.
It uses rope and flat belts, not V-belts.

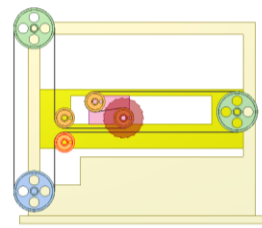


Belt drive 8



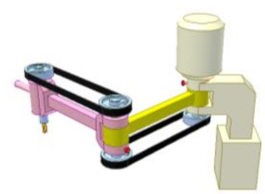
http://youtu.be/CnG6PuEGD-s
Rotation transmission between parallel shafts, one can move.
The key factor is: 4 belt branches connecting to the green and blue pulleys must be parallel.
It uses rope and flat belts, not V-belts.

Belt drive 9



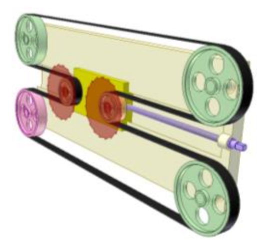
http://youtu.be/LZIZaLQipY0
Rotation transmission between parallel shafts, one can move in both vertical and horizotal directions.
Devices for moving vertical and horizotal sliders are not shown.
The key factor is: all belt branches must be vertical or horizontal (except the one connecting two small pulleys on the pink horizontal slider).
It uses rope and flat belts, not V-belts.

Belt drive 10



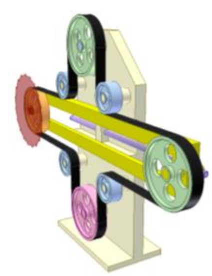
http://youtu.be/9XH9Htx9qTk
Rotation transmission between parallel shafts, one can move.
The tool can reach any point in an annulus, radii of which are (R1 + R2) and (R1 – R2).
R1, R2: lengths of yellow and pink bars respectively.
R1 is larger than R2.

Belt drive 11



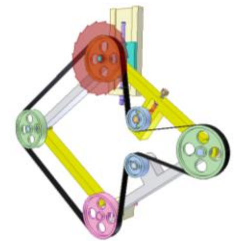
http://youtu.be/eBJ5gQ9LLZs
Rotation transmission between parallel shafts, one can move.
The key factor is: belt straight branches must be parallel.
It uses rope and flat belts, not V-belts.

Belt drive 12

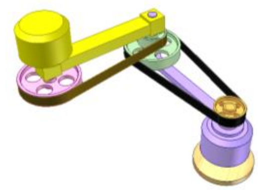


http://youtu.be/AlLsfkpbmYQ
Rotation transmission between parallel shafts, one can move.
The key factor is: all belt straight branches must be vertical or horizontal.
It uses rope and flat belts, not V-belts.

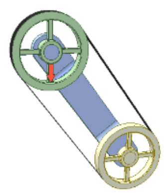
Belt drive 13
http://youtu.be/rOYx6JzlRSc
Rotation transmission between parallel shafts, one can move.
Input is the pink pulley.
Large pulleys are mounted at four vertices of a rhombus created by a four bar linkage. Small blue pulleys are for increasing arcs of contact.
It uses rope and flat belts, not V-belts.
In case no the runway, the mechanism can act as the mechanism of video “Belt drive 10”



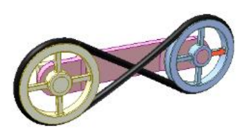
Belt drive 14
http://youtu.be/3MCsaYiCbP4
Rotation transmission between parallel shafts, one can move.
Input is the yellow motor (Vy velocity) and the violet motor (Vv velocity). The violet crank carrying a tool (for example a polishing wheel) rotates with velocity Vc.
Alter Vy for a desired Vc.
This case:
The diameter of large pulleys is double the one of small pulleys,
Vy = 60 rev./min. Vv = 252 rev./min.
Vc = 10 rev./min.



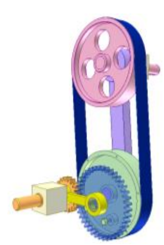
Belt planetary drive 2
http://youtu.be/8o6g-12cBEM
Two pulleys have the same diameter.
The green pulley orientation (red arrow) does not change during motion.



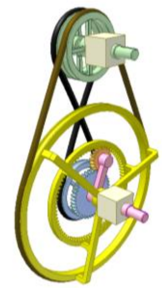
Belt planetary drive 1
http://youtu.be/7Pq5YkXKIRw
Two puleys have the same diameter.
The blue pulley rotates twice faster than the pink crank..
It uses rope and flat belts, not V-belts.



Belt and gear drive 1
http://youtu.be/UZ8XRrBLAxs
Input is the pink pulley shaft rotating regularly.
Output is the orange gear shaft rotating irregularly.
The violet and yellow cranks, the block of green pulley and blue gear with a certain eccentricity create a 4-bar linkage.

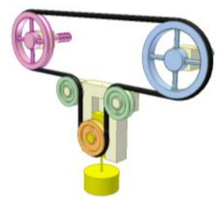


Belt and gear drive 2
http://youtu.be/5uwvUzCRLtM



Input is the green shaft of two green pulleys (Dg dia.) rotating regularly with Vg velocity.
Output is the pink crank of Vp velocity.
The blue block of a blue small pulley (Db dia.) and a gear of Zb teeth idly rotates on the pink crank.
The yellow block of a yellow large pulley (Dy dia.) and a gear of Zy teeth idly rotates on the pink crank.
The orange gear of Zo teeth idly rotates on a pin of the pink crank.
Vp = Vg (Dg/(Dy.Db)).((Db.Zy – Dy.Zb)/(Zy + Zb))
This case:
Dy = 3.Dg + 3.Db
Zo = 20; Zb = 40; Zy = 80
Vp = 9.Vg
Vp can be very small by choosing appropriate pulley diameters anf gear tooth numbers in order to decrease value of ((Db.Zy – Dy.Zb).

Belt tensioner 1
http://youtu.be/-2bxol03MO8



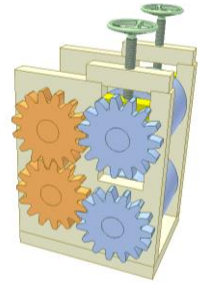
Input: the pink pulley.
The tensioner must not be placed on the tight side of the belt.
It uses rope and flat belts, not V-belts.

1.9. Transmission for parallel shafts of adjustable relative positions

Transmission between two parallel shafts with adjustable axle distance 1

http://youtu.be/odUVzfuy9Qc

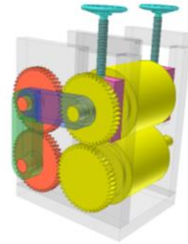
Added two orange idle gears extend adjustment range of axle distance in comparision with mechanism of two shafts having two gears directly meshing.



Transmission between two parallel shafts with adjustable axle distance 2

http://www.youtube.com/watch?v=37bJ8MsH4VA

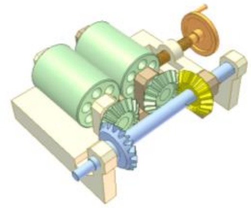
Transmission between two parallel shafts with axle distance regulation. Added two orange gears and two bars maintain proper gear engagement.



Transmission between two parallel shafts with adjustable axle distance 3

http://youtu.be/dMdbhUycRn0

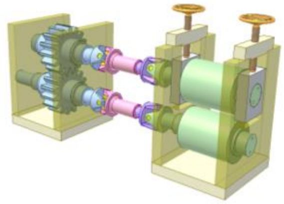
The yellow sliding gear allows to adjust axial distance between the rollers.



Transmission between two parallel shafts with adjustable axle distance 4

http://youtu.be/LLndwZXh50s

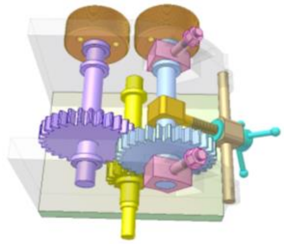
Cardan drives allow to adjust axial distance between the rollers.



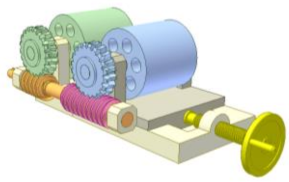
Transmission between two parallel shafts with adjustable axle distance 5

http://youtu.be/_Iay6sqmheU

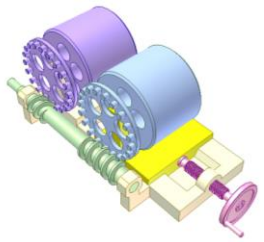
When turning the cyan nut, the blue gear rolls on the yellow driving gear for adjusting axle distance. Two orange rollers have the same rotation direction. The mechanism finds application in tangential thread rolling.



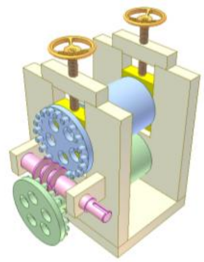
Worm Drive 3: Rolling worm wheel
http://youtu.be/vO0BYM-IZrg
The worm wheel rolls on the worm to adjust axle distance of two rolling cylinders.



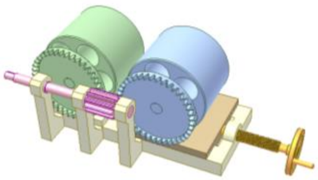
Transmission between two parallel shafts with adjustable axle distance 6
http://youtu.be/EGZBvA8ueuk
Pin gear and worm drives allow to adjust axial distance between the rollers.
The rollers rotate in opposite directions if worms are of opposite hand and vice versa.



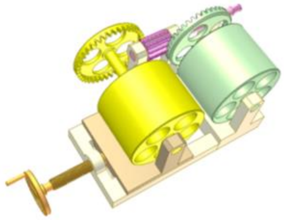
Transmission between two parallel shafts with adjustable axle distance 7
http://youtu.be/VOIqqDi7Ux0
Pin gear and worm drives allow to adjust axial distance between the rollers.
The rollers rotate in opposite directions.



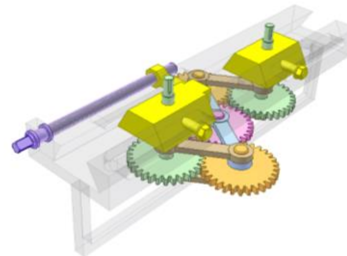
Face gear 4
http://youtu.be/hl6y-uoirio
Face gear drive allows to adjust axial distance between the rollers.
The rollers rotate in opposite directions. Their speeds can be different if tooth numbers of the two face gears are diferent.



Face gear 5
http://youtu.be/FoFoFWgVXuE
Face gear drive allows to adjust axial distance between the rollers.
The rollers rotate in the same direction. Their speeds can be different if tooth numbers of the two face gears are diferent.

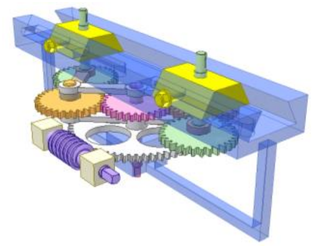


Gear and twin slider-crank mechanism 1
http://youtu.be/Tm6MwViCO04



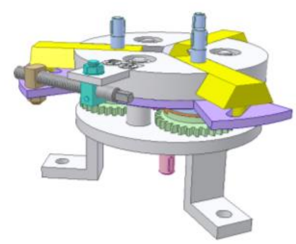
Blue, brown bars and yellow sliders create a twin slider-crank mechanism.
Input is pink gear.
Two green output shafts rotate in the same direction.
The two yellow sliders can be moved towards the mechanism center synchronously by violet screw for adjusting the center distance of the two output shafts.
Yellow nuts are for fixing the sliders after adjusting.

Gear and twin slider-crank mechanism 2
http://youtu.be/rQaUncfdGgc



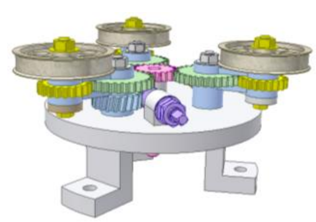
Grey, brown bars and yellow sliders create a twin slider-crank mechanism.
The grey bar and grey worm wheel are fixed together.
Input is pink gear.
Two green output shafts rotate in the same direction.
The two yellow sliders can be moved towards the mechanism center synchronously by violet worm for adjusting the center distance of the two output shafts.
Yellow nuts are for fixing the sliders after adjusting.

Three shafts rotating and radially moving
https://youtu.be/0u3iQJPqrj4



Input: pink gear shaft.
Output: three blue shafts placed symmetrically around the input axis. They receive rotation from the input gear via green gears and Oldham couplers of orange cross disks.
Turn grey screw to move the blue shafts radially. Violet cam and yellow followers help to do that. The output shafts rotate on the followers.
This mechanism can reach small radial displacements only. For larger ones see:
http://youtu.be/Tm6MwViCO04
http://youtu.be/rQaUncfdGgc

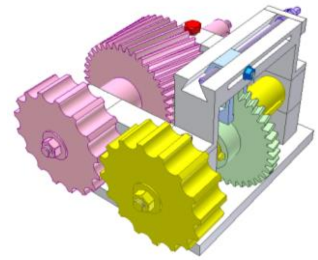
Three shafts rotating and radially moving 2
https://youtu.be/-s5M_kMWn4o



Input: pink gear shaft.
Output: three yellow shafts placed symmetrically around the input axis. They receive rotation from the input gear via green and yellow gears.
Turn violet worm thus to rotate the first blue crank (to which a worm wheel is fixed). Two other blue cranks (without the worm wheel) rotate synchronously with the first crank thanks to parallelogram mechanisms of brown conrods.
The yellow shafts move toward the center along circular curves.
The video last scene shows how this mechanism centers, clamps and transmits rotation for a ring.

Shaft synchronizer 2

https://youtu.be/eRlyXOL7jWU

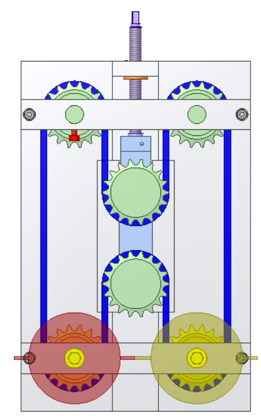


The pink input shaft and the yellow shaft rotate in opposite directions. Green helical gear has prismatic joint with the yellow shaft (sliding key). When the pink helical gear is immobile, an axial displacement of the green gear makes the yellow shaft rotate.
This mechanism enables to get the right positions between the slots on the pink and yellow rollers.
Adjustment process:
- Let a slot of the pink roller lie on the horizontal plane (containing two rotary axes of the two shafts) on side of the yellow shaft and fix the pink shaft by any method (here by the red screw).
- Turn violet screw to bring a slot of the yellow roller to inline position with the slot of the pink roller (said above).
- Unfix the pink shaft.

Three first scenes of the video are related to the adjustment process.
The last scene shows how the mechanism works after adjustment.
In other words, this mechanism enables to adjust the angular position between two shafts rotating in opposite directions when imagining that one shaft is immobile. This avoids the adjustment of the roller angular position in relation with its shaft.
The adjustment can be performed without stopping the mechanism, if needed.

Shaft synchronizer 3

https://youtu.be/wFn1w4qDT7E

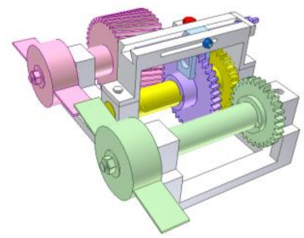


The orange input shaft and the yellow shaft rotate in the same direction. The blue slider carrying two idly sprockets is movable in the base runway thanks to violet screw and stationary orange nut. The blue string represents a chain or a timing belt. When the orange shaft is immobile, a displacement of the blue slider makes the yellow shaft rotate. This mechanism enables to get the right positions between the wings on the orange and yellow disks.
Adjustment process:
- Let a wing of the orange disk lie on the plane (containing two rotary axes of the orange and yellow shafts) on side of the yellow shaft and fix the orange shaft by any method (here by the red screw).
- Turn violet screw to bring a wing of the yellow disk to the inline position with the wing of the orange disk (said above).
- Unfix the orange shaft.

Three first scenes of the video are related to the adjustment process.
The last scenes show how the mechanism works after adjustment: the wings on the two disks are parallel.
In other words, this mechanism enables to adjust the angular position between two shafts rotating in the same opposite direction when imagining that one shaft is immobile. This avoids the adjustment of the disk angular position in relation to its shaft.
The adjustment can be performed without stopping the mechanism, if needed.
This video was made based on the mechanism shown on page 155 of Sclater & Chironis, Mechanisms And Mechanical Devices Sourcebook, 2001, 485 p.

Shaft synchronizer 2b

https://youtu.be/I3Z5XmHKiYM

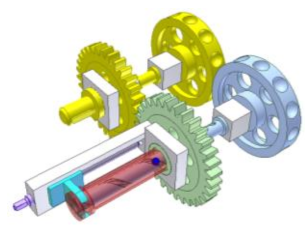


The pink input shaft and the green shaft rotate in the same direction. Violet helical gear has prismatic joint with the yellow shaft (sliding key). When the pink helical gear is immobile, an axial displacement of the violet gear makes the yellow and green shafts rotate. This mechanism enables to get the right positions between the wings on the pink and green disks.
Adjustment process:
- Let a wing of the pink disk lie on the plane (containing two rotary axes of the pink and green shafts) on side of the green shaft and fix the pink shaft by any method (here by the red screw).
- Turn violet screw to bring a wing of the green disk to the inline position with the wing of the pink disk (said above).
- Unfix the pink shaft.

Three first scenes of the video are related to the adjustment process.
The last scenes show how the mechanism works after adjustment: the wings on the two disks are parallel.
In other words, this mechanism enables to adjust the angular position between two shafts rotating in the same direction when imagining that one shaft is immobile. This avoids the adjustment of the disk angular position in relation to its shaft.
The adjustment can be performed without stopping the mechanism, if needed.

Transmission between two parallel shafts with adjustable relative angle 1

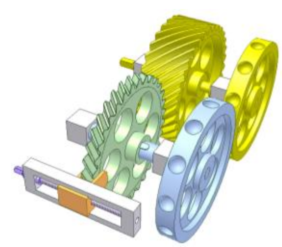
http://youtu.be/kVjeKDnll8U



Input: yellow shaft.
Blue pin is fixed to red bush to create helical joint with blue shaft.
Helix angle of the screw is 45 deg. to ease the motion. This joint can be of regular nut-screw type (multi-start thread).
The red bush has prismatic joint (sliding key) with green gear.
Turn violet screw for moving cyan slider to adjust relative positioning angle between yellow and blue rollers. In this animation the yellow shaft is supposedly kept immobile.
The adjustment can be performed even during transmission.
The self-locking of the violet screw preserves the adjusted angle from accidental motion of the red bush.

Transmission between two parallel shafts with adjustable relative angle 2

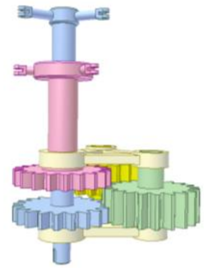
http://youtu.be/jmQnVhF7u-E



Input: yellow shaft.
Blue shaft receives rotary motion from the input through helical gear.
The blue shaft has prismatic joint (sliding key) with green gear.
Turn violet screw for moving orange slider to adjust relative positioning angle between yellow and blue rollers thanks to the helical teeth. In this animation the yellow shaft is supposedly kept immobile.
The adjustment can be performed even during transmission.
The self-locking of the violet screw preserves the adjusted angle from accidental motion of the green gear.
For larger angular adjustment use smaller gears and add intermediate gears to keep roller center distance unchanged.

1.10. Transmission for two coaxial shafts

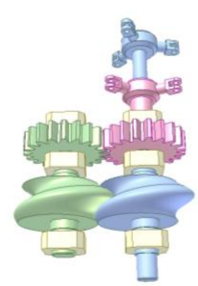
Drive for coaxial propellers 1
http://www.youtube.com/watch?v=4mWe9EnW9hE



Drive for coaxial propellers 2
https://youtu.be/DorRTKBuS6Y
Input: blue shaft
Blue and pink shafts rotate with the same velocity in opposite directions.

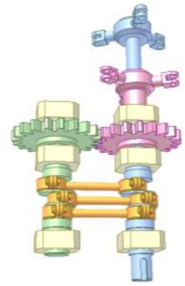
Drive for coaxial propellers 3
http://www.youtube.com/watch?v=QN500KQb0kw

Drive for coaxial propellers 5
http://www.youtube.com/watch?v=b-qCk11Nfic
An internal gear without bearing is used.



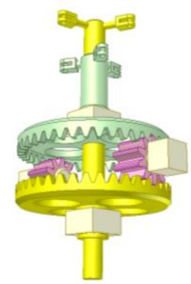
Drive for coaxial propellers 6
http://www.youtube.com/watch?v=eRH6-evj9VI
A special screw mechanism is applied.
For more see:
http://www.youtube.com/watch?v=QfiJSTRDASs
http://www.meslab.org/mes/threads/27853-bo-truyen-2-truc-vit-la

Drive for coaxial propellers 7
http://www.youtube.com/watch?v=_EBVoOqWhAg
Parallelogram mechanisms are used.



Drive for coaxial propellers 8
https://youtu.be/Ir9OifTCed0
Input: blue shaft
Yellow and pink shafts rotate with the same velocity in opposite directions.

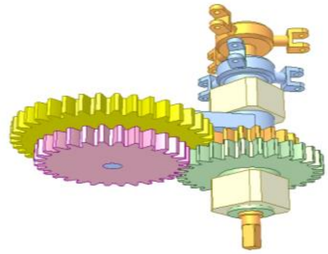
Face gear 6 - Drive for coaxial propellers 12
http://youtu.be/xda1WgL9fd0
Drive for coaxial propellers
The yellow shaft is input.
Face gears help forgive error in manufacturing and alignment, thermal and vibration changes for the meshing parts.



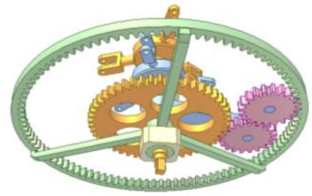
Drive for coaxial propellers 9
http://youtu.be/t5u-_HslCxg

Drive for coaxial propellers 14
http://youtu.be/X9zArLH-JJM
The blue belt can be of any type.
The black belt is of hexagonal section.
Double sided timing belt is better option. Using chain instead of belt is possible.

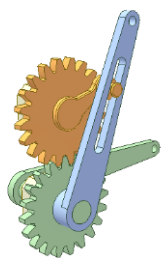
Drive for coaxial propellers 10
http://youtu.be/kRksNKMhkwc
The green gear of 30 teeth is fixed.
The pink gear of 30 teeth and the yellow gear of 40 teeth are fixed together and rotate on the blue crank.
The orange gear has 20 teeth.



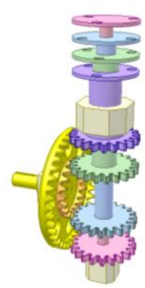
Drive for coaxial propellers 11
http://youtu.be/0ud5o1eIFM4
The green internal gear of 100 teeth is fixed.
The blue crank carries two pink gears of 20 teeth each.
The orange gear has 50 teeth.



Two coaxial cranks
http://youtu.be/E1c5ZbH2aUA
The orange gear and orange crank are fixed together.
Input is the green gear crank.
Output is the blue crank.
The two coaxial cranks synchronously oscillate in opposite directions with different angles and speeds.

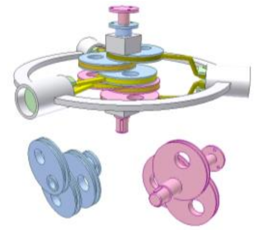


Drive for coaxial propellers 13a
http://youtu.be/6Ak9MHpE4C0
Four coaxial propellers.
Input: yellow and orange gears that are fixed together.
Blue and green gears rotate with the same speed (A) but in opposite directions.
Pink and violet gears rotate with a double of A speed in opposite directions.

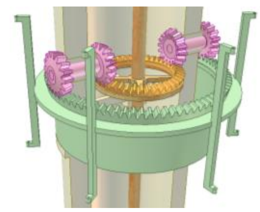


Drive for coaxial propellers 13b
http://youtu.be/XNBzl9GYwCc
Four coaxial propellers.
Input: yellow and orange gears that are fixed together.
Pink and violet gears rotate with the same speed (A) but in opposite directions.
Blue and green gears rotate with a double of A speed in opposite directions.

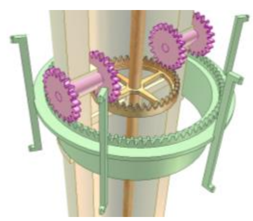
Drive for coaxial propellers 15
https://youtu.be/_BLHuS2AQRI
It is a modification of mechanism shown in
“Bar mechanism for reversing rotation 3”
https://youtu.be/wMOVNR9c5P4
Input: pink shaft.
Output: blue shaft. It turns at the same input velocity but in opposite direction.
Input and output are coaxial.
Thanks to the symmetric arrangemenr of slider crank mechanisms:
- Inertia forces created by reciprocating parts are reduced.
- No dead positions.



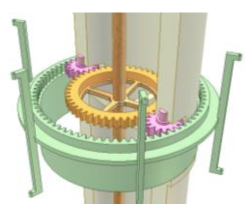
Transmission between two coaxial shafts separated by a tube 1
https://youtu.be/jxGgtJ8-1nw
Input: green bevel gear
Output: orange bevel gear that rotates faster that the input.
Apexes of all bevel gears are coincident.
The tube is cut off half for easy understanding.



Transmission between two coaxial shafts separated by a tube 2
https://youtu.be/a0yT56rSeX8
Input: green face gear
Output: orange face gear that rotates faster that the input.
Assembling face gear drives is easy in comparison with bevel gear drives.
The tube is cut off half for easy understanding.
It is possible to get input and output velocities equal by selecting appropriate tooth numbers of gears and pinions to meet equation (Z2/Z1)*(Z4/Z3) = 1
Z1, Z2 are tooth numbers of gear and pinion for the outer drive respectively.
Z4, Z3 are tooth numbers of gear and pinion for the inner drive respectively.

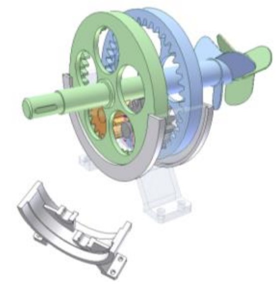


Transmission between two coaxial shafts separated by a tube 3
https://youtu.be/fQLOvws-8hk
Input: green gear
Output: orange gear that rotates faster that the input.
The tube is cut off half for easy understanding.



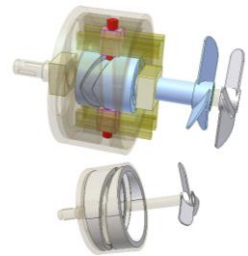
Drive for coaxial propellers 4

https://youtu.be/MkjD-U9yScs
Input: green internal gear.
Two internal gears have the same gear number.
Orange and grey external gears have the same gear number.
The green gear is in mesh with the orange gear.
The blue gear is in mesh with the grey gear.
The orange gear is in mesh with the grey gear.
Green and blue propellers rotate in opposite directions with the same velocity.



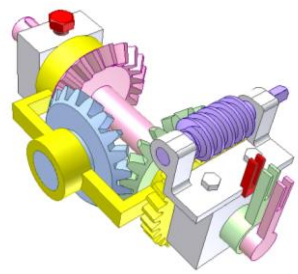
Drive for coaxial propellers 16

https://youtu.be/Nqvtu2Ouzdk
It is an application of “Barrel cam reverser “ shown at:
https://youtu.be/V6w7WIfCDk8
Input is the grey shaft.
Grey and blue propellers rotate in opposite directions with the same velocity.



Shaft synchronizer 1

https://youtu.be/6XHU78DXczc
The pink input shaft and the green shaft coaxially rotate in opposite directions.
This mechanism enables to get three slots (in red, green, pink) in line at the mechanism stop position.
Adjustment process:
- Bring pink slot in line with the red stationary slot and fix the pink shaft by any method (here by the red screw).
- Turn violet worm to bring the green slot to inline position with the other slots.
- Unfix the pink shaft.

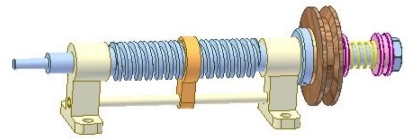


Two first scenes of the video are related to the adjustment process.
The last scene shows how the mechanism works after adjustment.
In other words, this mechanism enables to adjust the angular position between two coaxial shafts rotating in opposite directions when imagining that one shaft is immobile.
The adjustment can be performed without stopping the mechanism, if needed.
This video was made based on the mechanism shown on page 157 of Sclater & Chironis, Mechanisms And Mechanical Devices Sourcebook, 2001, 485 p.

1.11. Rotation limitation

Shaft rotation limiter 1

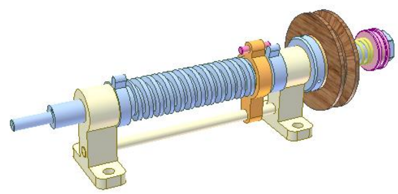
http://youtu.be/BBYfNYadt0w



The brown driving pulley transmits rotation to the blue shaft through a friction clutch. Number of turns the shaft can rotate:14.
A traveling nut (orange) moves along the threaded shaft until the frame prevents further rotation. This is a simple device, but the traveling nut can jam so tightly that a large torque is required to move the shaft from its stopped position. For a way to avoid it see Shaft rotation limiter 2:
http://youtu.be/bZXCfSEa-OU

Shaft rotation limiter 2

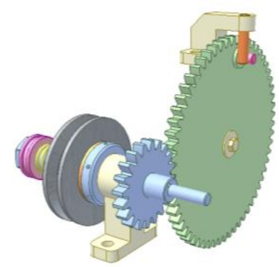
http://youtu.be/bZXCfSEa-OU



The brown driving pulley transmits rotation to the blue shaft through a friction clutch.
Number of turns the shaft can rotate: around 12.
The fault said in Shaft rotation limiter 1:
http://youtu.be/BBYfNYadt0w
is overcome at the expense of increased device length by providing a stop pin in the orange traveling nut.
The engagement between the pin and the rotating finger must be shorter than the thead pitch so the pin can clear the finger on the first reverse turn. Using rubber ring and oil-impregnanted metal grommet for the sliding joint of the traveling nut and the lower rod helps lessen the impact

Shaft rotation limiter 3

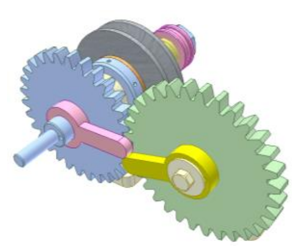
http://youtu.be/MVkAum9f_qI



The driving grey pulley transmits rotation to the blue shaft through a friction clutch. The shaft can rotates only around 3 turns because the immobile orange pin allows the green gear (60 teeth) to rotate less than 1 turn. The tooth number of the blue gear is 20. So for the large turn number, the large trasmission ratio of the gear drive is needed.

Shaft rotation limiter 4

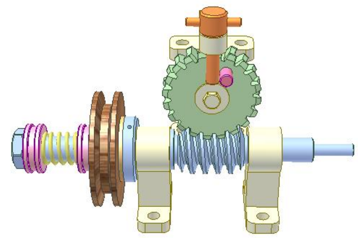
http://youtu.be/go3LyVKVZoA



The driving grey pulley transmits rotation to the blue shaft through a friction clutch.
Tooth number of the blue gear Z1 = 30.
Tooth number of the green gear Z2 = 32.
The shaft can rotates around 15 turns (= Z1/(Z2-Z1)) until the moving stoppers (pink and yellow) collide each other.
There is no need of large trasmission ratio of gear drive as said in video Shaft rotation limiter 3:
http://youtu.be/MVkAum9f_qI

Shaft rotation limiter 5

http://youtu.be/c1Xlah1sOEI



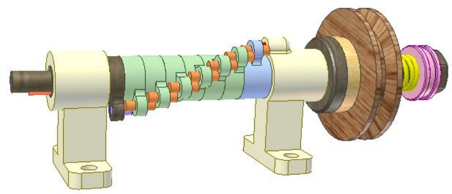
The brown driving pulley transmits rotation to the blue shaft through a friction clutch. A worm drive is used to get large trasmission ratio thus the working shaft can get large turn number (17 for this case).

The green worm wheel has 20 teeth and the number of the blue worm starts is 1.

To avoid reverse rotation for the new working cycle, at the end of the working process raise the orange stopper and rotate the green worm wheel to the starting position.

Shaft rotation limiter 6

http://youtu.be/3airCg2Xd-4



Pinned disks limit shaft turns to (N+1).α/360, where

N is the number of idle disks,

α is angle depending on pin diameter and distance between pin center and shaft center.

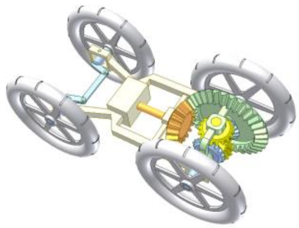
For this limiter: 7 idle disks allow shaft to rotate 7.1 turns.

There is a friction clutch between the driving pulley and the shaft.

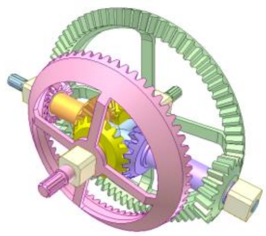
The mechanism can be used for winding springs. The red wire on the left shows how to clamp the wire end for winding springs

1.12. Car differentials

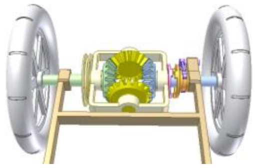
Car Differential with Bevel Gears 1
https://youtu.be/YjhzkV5Ya2k
There are two mechanisms:
1. Changing direction: 4-bar linkage with two equal cranks enables axles of four wheels to intersect at a common point, avoiding wheel lateral slipping.
2. Differential: it allows driving rear wheels to rotate at different speeds mainly when cornering.



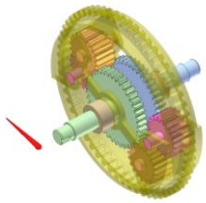
Car differential with bevel gears 2
http://youtu.be/yDcOhhbbc-U
Input is the blue cross shaft of n1 constant velocity. Output are the pink and green shafts of n2 and n3 velocities. The yellow, orange and violet gears have the same tooth number. The orange gear and the pink pinion are fixed together and idly rotate on the blue shaft. The violet gear and the green pinion are fixed together and idly rotate on the blue shaft.
The pink and green bevel gear drives have the same transmission ratio.
The video shows when the pink shaft slows down, the green one speeds up and vice versa to maintain the equation n1 = (n2 + n3)/2.
The satellite gears turn around their own axles only when n2 differs from n3.



Car differential with locker
http://youtu.be/xTYGVGU_g88
The popcorn case and pulley receive rotation from car engine.
The right wheel losses traction, slips. Due to the disavantage of a standard (open) drive, the moment delived to the left wheel reduces to null so it does not rotate.
To overcome this situation the driver closes the clutch (on the right) to deliver moment to both wheels and thus they rotate with the same velocity.

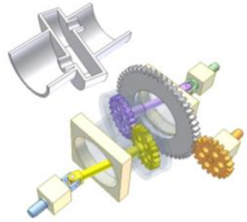


Car differential with spur gears 1
http://www.youtube.com/watch?v=tOSQK5ZZzhg
The red hand shows car moving direction.
When car turns left, the left disk slows down, the right one speeds up and vice versa.



Car differential with spur gears 2

https://youtu.be/R6nNknbQOZc



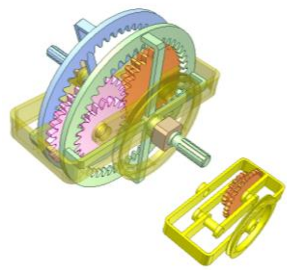
Yellow and violet gears have the same tooth number.
Rotary axes of grey case, blue and green shafts are in line.
The blue and green shaft carry car wheels.
This mechanism maintains equation n1 = (n2 + n3)/2.
n1: velocity of grey gear and case (fixed together).
n2 and n3: velocities of blue and green shafts respectively.
The mechanism has 2 degrees of freedom. Two input motions in this video are n1 and n2.
The video shows three stages of the blue shaft:

1. n2 = n1
2. n2 is larger than n1
3. n2 is smaller than n1

Yellow and violet gears roll on each other only when n2 differs from n1.
Assembly condition: when axes of blue, yellow, violet and green shafts are in a plane, axes of cross holes on the blue and green shafts must be parallel. If not, velocity of the green shaft will be irregular when n2 differs from n1.
The space around yellow and violet gears is filled with oil. Rooms of two sides of the contact teeth are connected via a spring valve. Thus friction torque is created when the two gears roll on each other to prevent the slipping once one wheel losses traction. Complete closing the valve will lock two wheel together.

Car differential with internal gears

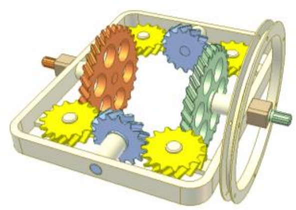
http://youtu.be/PbXnxGb96go



Input is the case with pulley of n1 constant velocity. Output are the blue and green identical internal gear shafts of n2 and n3 velocities.
The pink and orange gear blocks are identical.
The video shows when the blue shaft slows down, the green one speeds up and vice versa to maintain the equation n1 = (n2 + n3)/2.
The satellite gears turn around their own axles only when n2 or n3 differs from n1.

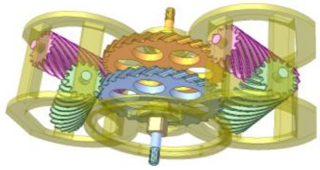
Car differential with helical gears 1

http://youtu.be/dux_RKg4-Xo



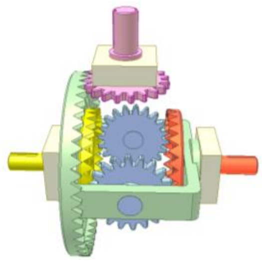
Input is the case with pulley of n1 constant velocity. Output are the orange and green identical gear shafts of n2 and n3 velocities. The yellow and blue satellite gears have the same tooth number.
The video shows when the orange shaft slows down, the green one speeds up and vice versa to maintain the equation n1 = (n2 + n3)/2.
The satellite gears turn around their own axles only when n2 or n3 differs from n1.

Car differential with helical gears 2
http://youtu.be/S4A0s3WXJCs



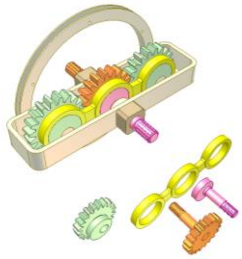
Input is the case with pulley of n1 constant velocity. Output are the orange and blue identical gear shafts of n2 and n3 velocities. The green and pink satellite gears have the same tooth number.
The video shows when the orange shaft slows down, the blue one speeds up and vice versa to maintain the equation n1 = (n2 + n3)/2.
The satellite gears turn around their own axles only when n2 or n3 differs from n1.

Face gear 9
http://youtu.be/7HM1O_-p4R4



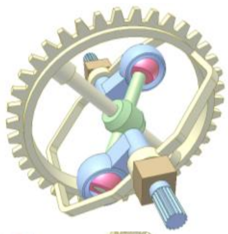
Car differential with face gears.
The green gear (receiving torque from engine) rotates with constant speed Ng. If the speed N1 of the red gear of Z1 teeth varies (even reverses), the speed N2 of the yellow gear of Z2 teeth (Z2 = Z1) varies accordingly to maintain the equation:
2.Ng = N1 + N2
Advantages over bevel gear differential:
- No need for the exact axial positioning of the pinions.
- Tolerable contact pattern changing.

Car differential with gear and parallelogram mechanism
http://youtu.be/-NyBR2mlPDQ



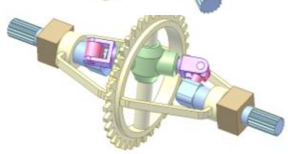
Input is the case with pulley of n1 constant velocity. Output are the pink and orange shafts of n2 and n3 velocities. The gears have the same tooth number.
The video shows when the pink shaft slows down, the orange one speeds up and vice versa to maintain the equation n1 = (n2 + n3)/2.
The parallelogram acts only when n2 or n3 differs from n1.

Car Differential with Bars 1
http://www.youtube.com/watch?v=BW_jGuIkOZw



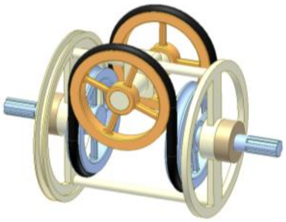
The red hand shows car moving direction.
When car turns left, the left crank slows down, the right one speeds up and vice versa.

Car Differential with Bars 2
http://www.youtube.com/watch?v=J-vX0XtTQOI



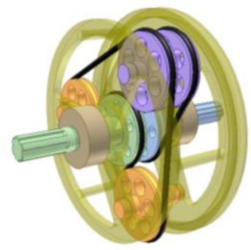
The red hand shows car moving direction.
When car turns left, the left crank slows down, the right one speeds up and vice versa.

Car Differential with Belt 1
http://www.youtube.com/watch?v=-dtBWDVshYY

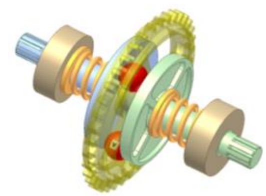


The red hand shows car moving direction.
When car turns left, the left blue wheel slows down, the right one speeds up and vice versa.

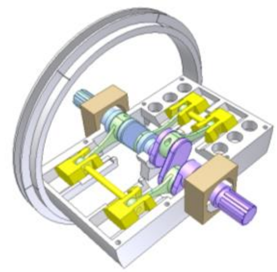
Car Differential with Belt 2 (or Chains)
http://www.youtube.com/watch?v=91QMBe-0i3g
It can become a car differential with chains by using chain transmissions in stead of the belt ones.
The red hand shows car moving direction.
When car turns left, the left blue wheel slows down, the right one speeds up and vice versa.



Car Differential with Balls
http://www.youtube.com/watch?v=IkpTGkMxgLc
The red hand shows car moving direction.
When car turns left, the left disk slows down, the right one speeds up and vice versa



Slider-crank differential
https://youtu.be/C44giyG6KbI
This video is based on the design numbered as 1458 in volume 2, Mechanisms in modern technic, I. Artobolevski.
Violet, blue crank-shafts and white box to which a white pulley is fixed can rotate on brown bearings. Yellow sliders on each side are fixed together.



Nw = (Nv + Nb)/2
Nw: velocity of the box.
Nb: velocity of blue shaft.
Nv: velocity of violet shaft.
The sliders move along their runways only in case when motions of the shafts aren't identical.
The video shows 3 cases in turn:

1. Nv = Nb; Nw = Nv = Nb
Two shafts rotate at the same velocity in the same direction.
The box rotates at the same velocity in the same direction of the two shafts.
Yellow sliders don't move in relation with the box runways.

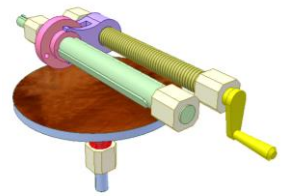
2. Nb = 0; Nw = Nv/2
Yellow sliders move in relation with the box runways.

3. Nv = -Nb; Nw = 0
Two shafts rotate at the same velocity but in opposite directions.
The box is immobile.
Yellow sliders move in relation with the box runways.

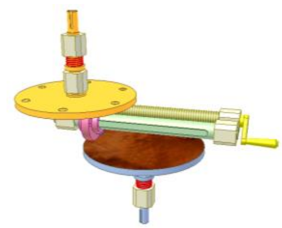
This differential can be used for a car where the box receives motion from the car engine and the blue and violet shafts are connected with the wheels.
Influence of the dead points in slider-crank mechanisms on this differential is not clear for me.

1.13. Variators (continuously variable transmission)

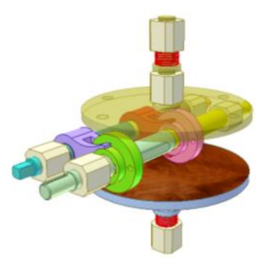
Friction disk variator 1
http://youtu.be/V1Y7ayNun-4
Input: the green shaft on which the roller can slide.
Turn the yellow screw for changing velocity or rotary direction of the blue output shaft carrying a friction disk.
Velocity of the output shaft depends on contact position of the roller with the disk.
The friction force at contact place is created by the red spring.
Input and output shafts are perpendicular to each other.



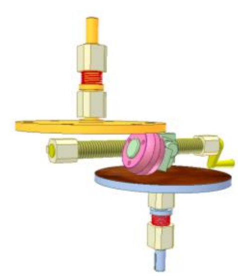
Friction disk variator 2
http://youtu.be/JlULYqF2hkA
Input: the orange shaft carrying a friction disk.
Turn the yellow screw to move the pink roller for changing velocity of the blue output shaft carrying a friction disk.
Velocity of the output shaft depends on contact position of the roller with the disks.
The two disks are forced toward the roller by red springs.
Input and output shafts are parallel.



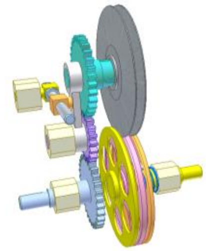
Friction disk variator 3
http://youtu.be/Zi-eMKKpOas
Input: the green shaft carrying a green friction roller.
Output: the yellow shaft carrying a pink friction roller.
Each roller can move along its shaft independently by turning its corresponding screw.
Velocity of the output shaft depends on contact positions of the rollers with the disks.
The friction forces at contact places are created by red springs.
Using two friction disks doubles transmitted torque.
Input and output shafts are coaxial.



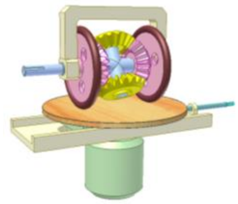
Friction disk variator 4
http://youtu.be/lorIO9hJ960
Input: the orange shaft carrying a friction disk.
Turn the yellow screw to move the pink double cone roller for changing velocity of the blue output shaft carrying a friction disk.
The two disks are forced toward the roller by red springs.
Input and output shafts are parallel.



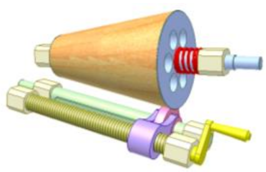
Friction disk variator 5
http://youtu.be/_D0GFcfO_VY
Input: the blue gear-shaft. Output: the yellow shaft.
The white crank, carrying cyan gear-shaft, can oscillate around a fixed axle. Two grey disks have sliding key joints with the cyan gear-shaft. The pink and orange disks have sliding key joints with the yellow shaft. The blue spring forces four mentioned disks towards the yellow disk.
Turn the blue screw to change contact place between the disks (near or far from the center of the grey disks), hence the output velocity.
Transmitted power can be increased by using more pink and grey disks.



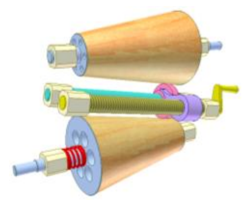
Friction disk variator 6
http://youtu.be/HJutD78Av4A
Input: the orange disc receiving rotation from the green motor.
Output: the blue shaft.
Turn the cyan screw to move the disc for desired output velocity n.
n = (n1 + n2)/2
n1, n2 are velocities of the pink rollers.
n can be 0 or minus (reversing).
Using the bevel gear differential enables accurate adjustment of output velocity.



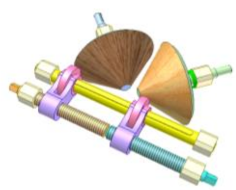
Friction cone variator 1
http://youtu.be/nCav0rm53uc
Input: the green shaft carrying a friction roller.
Output: the blue shaft carrying a friction cone.
The roller can move along its shaft by turning the yellow screw.
Velocity of the output shaft depends on contact position of the roller with the cone.
The friction force at contact places is created by the red springs.
Input and output shafts are intersecting.



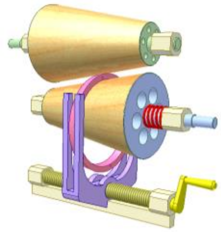
Friction cone variator 2
http://youtu.be/GFEXGw7uXr8
Input: the lower shaft carrying a friction cone.
Output: the upper shaft carrying a friction cone.
The pink roller can move along its shaft by turning the yellow screw.
Velocity of the output shaft depends on contact position of the roller with the cones.
The friction forces at contact places are created by the red springs.
Input and output shafts are parallel.



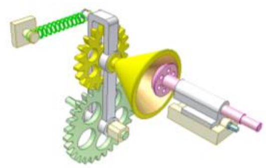
Friction cone variator 3
http://youtu.be/ZUGgT3NiYpI
Input: the green shaft carrying a friction cone.
Output: the blue shaft carrying a friction cone.
Each roller can move along the yellow shaft independently by turning its corresponding screw.
Velocity of the output shaft depends on contact positions of the rollers with the cones.
The friction forces at contact places are created by the green springs.
Input and output shafts are perpendicular to each other.



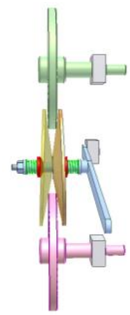
Friction cone variator 4
http://youtu.be/BlgAHk_MDBs
Input: the blue shaft carrying a friction cone.
Output: the green shaft carrying a friction cone.
The pink ring in contact with both cones can axially move by turning the yellow screw.
Velocity of the output shaft depends on contact positions of the ring with the cones.
The friction forces at contact places are created by the red springs.



Friction cone variator 5
http://youtu.be/u4lyOtNP9TE
Input: the pink shaft carrying a friction external cone.
Output: the green shaft carrying a spur gear. The yellow shaft with a gear and an internal cone can rotate on bearing of the white crank.
The white crank can rotate around fixed bearing houses. The green spring creates pressure at contact place between the cones.
Turn the blue screw for changing velocity of the output shaft.
Input and output shafts are parallel.



Friction cone variator 6
http://youtu.be/5yftEf5vpeg
Input: the green shaft carrying a disk.
Output: the pink shaft carrying a disk.
The blue pivoting lever has an axle which has cylindrical joints with two red bushes. Two yellow cone disks have spherical joints with the two red bushes. The two yellow disks can contact with the input and output disks.
Select angular position of the blue lever for desired output velocity.

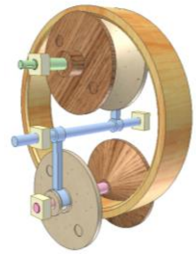


Friction cone variator 7
http://youtu.be/cFTMUfRsHUc
Input: the green shaft.
Output: the violet shaft.
Constant velocity joints connects the input shaft or the output shaft and the long hollow cones. Using this joint kind allows the input and output shaft to be parallel.
Move the orange flexible ring for desired output velocity. The moving mechanism is not shown.
The pink rollers are for supporting the cones additionally.

Friction cone variator 8
http://youtu.be/_v2aeJgbz9M
Input: the green shaft.
Output: the violet shaft on which an orange roller can slide.
A constant velocity joint connects the input shaft and the long hollow cone. Using this joint kind allows the input and output shaft to be parallel.
Move the orange roller for desired output velocity.
The pink roller is for supporting the cone additionally.
Devices for moving the roller and creating contact pressure are not shown.

Friction cone variator 9

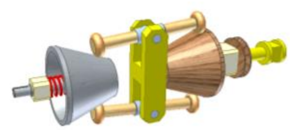
http://youtu.be/LYGU8rMNApQ



Input: the green shaft of one fixed cone and one sliding cone.
Output: the pink shaft of one fixed cone and one sliding cone.
Thre orange ring contacts with all cones.
The blue bar can move the sliding cones to change contact positions of the ring for desired output velocity.
The pressure at contact places is created by choosing right value of the ring inside diameter.
Two cones on each shaft can be assembled back to back (instead of face to face) with appropriate section of the ring in embodiments of this variator.

Friction cone variator 10

http://youtu.be/YP_QUjL9-J0



Input: the grey cone.
Output: the brown cone in which an yellow control bar can slide (not rotate). Two long rollers contact with both cones due to revolution joints between roller bearings and the control bar.
Move the control bar for desired output velocity.

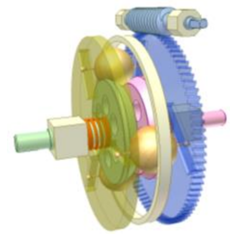
Friction ball variator 1

http://youtu.be/VhTWbcQPMY4

Input: the orange cylinder.
Output: the green disk that does not contact with the cylinder.
Velocity of the output shaft depends on contact position of the ball with the disk. Move the yellow slider for various velocities..
The friction force at contact places is created by the ball weight.

Friction ball variator 2

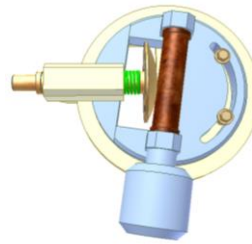
http://youtu.be/cXD2nyWu-aM



Input: the green cone.
Output: the pink cone.
Three orange balls contact with both cones.
Each ball has its shaft that slides in radial slots of the yellow fixed disc and in oblique slots of the blue disc.
Turn the blue disc through a worm wheel drive to change angular position of the ball axis, hence distances from contact points (with the input and output cone) to the ball axis, for desired output velocity.
The yellow fixed ring is for positioning the balls.
The pressure at contact places is created by red springs.

Friction sphere variator 1

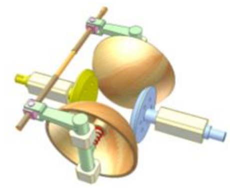
http://youtu.be/UKxzoa0AfhI



Input: the brown cylinder.
Output: the orange disk of spherical cap.
Velocity of the output depends on contact position.
Angular adjustment of the blue disk gives various velocities and rotary direction change of the output.
The friction force at contact places is created by the green spring.

Friction sphere variator 2

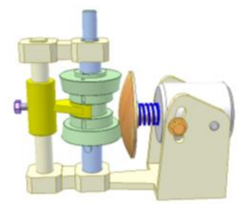
http://youtu.be/0s7YRBUoCR8



Input: the blue shaft with a cone disk.
Output: the yellow shaft with a cone disk.
The orange spherical caps idly rotate on their axles and are forced toward the cone disks by red springs.
The green shafts carrying the caps axles can rotate in fixed bearings.
The orange screw has two thread portions of opposite hands.
Turn the screw to change contact position between the disks and the spherical caps for various output velocities.
Using two caps instead of one reduces shaft bending forces.

Friction sphere variator 3

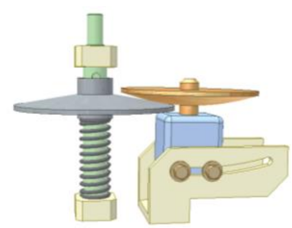
http://youtu.be/WMhGk7HMU4c



Input: the orange disk of spherical cap mounted on a motor shaft.
The green double cone has sliding key joint with the blue output shaft.
The disk can contact with the double cone under spring pressure.
Move the yellow slider with the double cone to one of their two positions for desired rotary direction.
Turn the white motor to get desired output velocity. The center of the orange spherical cap is laid on the axis of this rotary motion.

Friction sphere variator 4

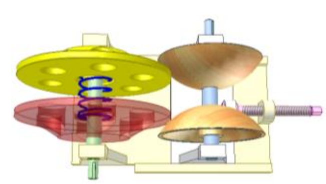
http://youtu.be/jgg0WMAW_XA



Input: the orange disk of spherical cap mounted on a motor shaft.
The grey disk has sliding key joint with the blue output shaft.
A spring creates contact pressure between the disks.
Turn the blue motor to get desired output velocity. The center of the orange spherical cap is laid on the axis of this rotary motion.

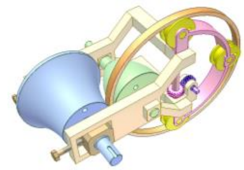
Friction sphere variator 5

http://youtu.be/l-TQdWADlZg



Input: the blue shaft having two orange disks of spherical cap.
The yellow and red disks have sliding key joints with the green output shaft.
A spring creates contact pressure between the disks.
Turn the pink screw for moving the input shaft to get desired output velocity.

Friction globoid variator 1
http://youtu.be/pc0RThp_lw0

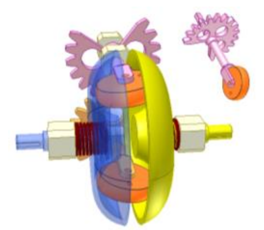


Input: the blue shaft.
Output: the green shaft.
The orange ring (a spherical segment) is supported by three rollers and contacts with the two shafts. The contact pressure is created by the brown screws.
Turn the pink frame (by the violet helical gear) to change contact position between the ring and the two shafts for various output velocities.

Friction globoid variator 2
http://youtu.be/RI7lQuxPOl4

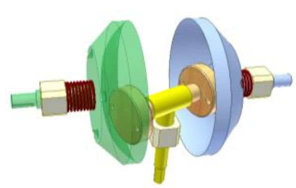
Input: the yellow shaft of a globoid cone.
Output: the blue shaft of a globoid cone.
The green roller that can rotate on an axle of the pink shaft, contacts with both cones.
The contact pressure is created by the red springs.
Turn the pink shaft to change contact position between the rollers and the two cones for various output velocities.

Friction globoid variator 3
http://youtu.be/VAfWV5Qnynw



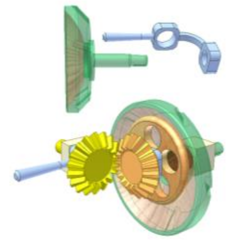
Input: the yellow shaft.
Output: the blue shaft.
Each shaft has a disk of torus groove.
Two orange rollers contacts with both disks.
Each roller rotates on its gear shaft. The gear shafts are connected together by a gear drive.
The contact pressure is created by the brown springs.
The input and output shafts rotate in opposite directions.
Turn the pink gear shaft to change contact position between the rollers and the two disks for various output velocities.

Friction globoid variator 4
http://youtu.be/hvF-SLZjABo

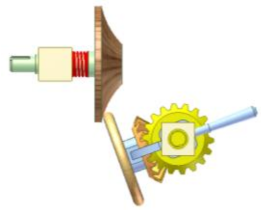


Input: the green disk.
Output: the blue disk.
The yellow bearing house of the orange roller can rotate around a fixed bearing.
The inside surface ot the disks is created by a round profile, center of which is on the axis of the yellow bearing house. This axis does not intersect the disk axes. There is a offset.
The roller contacts with the disks at its outside edges.
Contact pressure is created by two brown springs.
Turn the yellow shaft to change contact position for various output velocities.

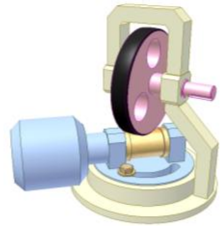
Friction globoid variator 5a
http://youtu.be/dX2L_EirVD4
Input: yellow gear.
Output: green shaft.
Bearing of orange gear and friction disk can rotate around axis of the yellow gear.
Center of inner round profile of the green shaft and center of bevel gear drive are identical.
Contact pressure is created by red spring.
Turn the blue crank to change contact radius on the green shaft for various output velocities.
This video was made based on the idea of a Youtube user, Mr. Adrián Martín. See: http://youtu.be/xkR_uuV-o-8



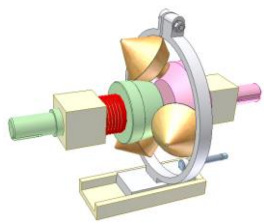
Friction globoid variator 5b
http://youtu.be/QfbN1DMNXuA
Input: yellow gear.
Output: green shaft.
Bearing of orange gear of friction disk can rotate around axis of the yellow gear.
Center of round profile of the green shaft and center of bevel gear drive are identical.
Contact pressure is created by red spring.
Turn the blue crank to change contact radius on the green shaft for various output velocities.
This video was made based on the idea of a Youtube user, Mr. Adrián Martín. See: http://youtu.be/xkR_uuV-o-8



Friction roller variator 1
http://youtu.be/xQZ9gaKpQm4
Input: the motor shaft carrying a roller.
Output: the pink wheel of rubber rim.
Select angular position of the motor for desired output velocity.
Weakness: high wear at contact places

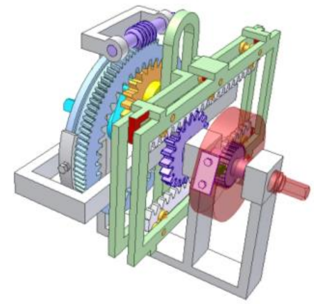


Satellite friction variator 1
http://youtu.be/K6xu0qqBCxs
Input: the green shaft of a friction cone playing role of a sun. Output: the pink shaft playing role of a carrier.
The orange double cone rollers play role of satellites. They contact with the green cone and with a grey non rotary ring.
Input and output shafts are coaxial.
Turn the blue screw to move the ring for changing output velocity.
Contact pressure is created by the grey screw and the red spring.



Variator without friction drive 1

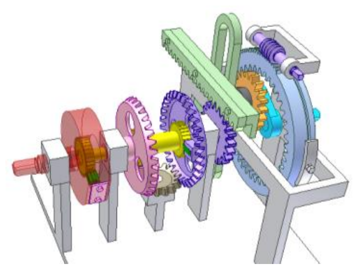
https://youtu.be/LzD9b2Z-OJs



Most variators (continuously variable transmissions) contain friction drives, weaknesses of which are low load, large pressure on bearings and heat generating. This video aims to show a concept of no friction drive.
Input: cyan crank.
Output: red shaft
Two devices are connected in series:
Device 1 for creating linear translating motion. It's stroke length is adjustable:
http://youtu.be/5cbfFIlPENI
Device 2 for converting linear translating motion received from Device 1 into continuous rotation. For easy understanding the following is used here:
https://youtu.be/k6RqU0F6QdA
But the better is:
http://youtu.be/MswriP9QKxE
The output shaft is connected to violet gear shaft via an overrunning clutch (ratchet mechanism).
Turn the violet worm to alter output speed.
The video shows the adjusting process from high to low and 0 speed of output rotation.
Disadvantages:
Reciprocating masses cause variable inertia forces and vibration.
Output rotation is irregular. It can be restrained by using spring couplings:
http://youtu.be/zjjv5NIT-54

Variator without friction drive 2

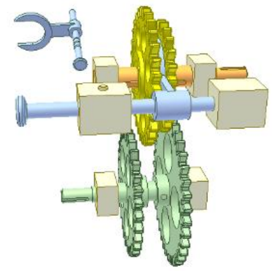
https://youtu.be/Hcg6OLIS9h0



Most variators (continuously variable transmissions) contain friction drives, weaknesses of which are low load, large pressure on bearings and heat generating. This video aims to show a concept of no friction drive.
Input: cyan crank.
Output: red shaft
Three devices are connected in series:
Device 1 for creating linear translating motion. It's stroke length is adjustable:
http://youtu.be/5cbfFIlPENI
Device 2 (green rack and violet spur gear) for converting linear translating motion received from Device 1 into reciprocating rotation.
Device 3 for converting reciprocating rotation received from Device 2 into continuous rotation:
https://youtu.be/JOu3ZFo2Vqw
The output shaft (in red) is connected to yellow ratchet shaft (output shaft of Device3) via an overrunning clutch (ratchet mechanism). It plays role of a flywheel to make the output rotation regular.
Turn the violet worm to alter output speed.
The video shows the adjusting process from high to low and 0 speed of output rotation.
Disadvantages:
Reciprocating masses cause variable inertia forces and vibration.

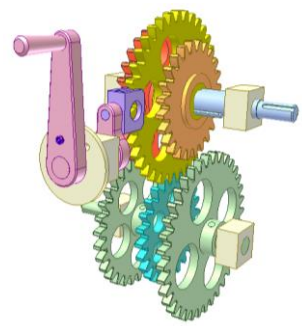
1.14. Mechanisms for gear shifting

Shifting gear mechanism 1a
http://youtu.be/ap7WwwVzIAE



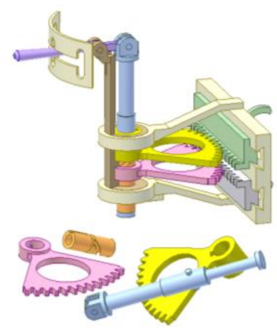
Input: the green shaft to which 2 gears are fixed. Output: the orange shaft on which a block of 2 gears can slide (key sliding joint).
Move the blue bar to get 3 positions of the gear block corresponding 3 speeds (one is zero) of the output. There is a positioning device (spring ball) for the bar.
To avoid gear collision the speed change must be carried out when the input shaft stops. The operation shown in this video is for the case of very slow speed.

Shifting gear mechanism 1b
http://youtu.be/IUsQ_dyTTWk



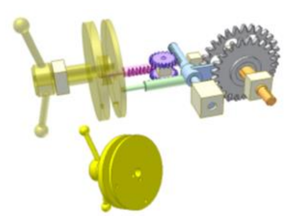
Input: the green shaft to which 3 gears (green and cyan) are fixed. Output: the blue shaft on which a block of 3 gears (red, yellow and orange) can slide (key sliding joint).
Turn the pink lever to get 3 positions of the gear block corresponding 3 speeds of the output. There is a positioning device (spring ball) in the pink crank.
To avoid gear collision the speed change must be carried out when the input shaft stops. The operation shown in this video is for the case of very slow speed.

Shifting gear mechanism 2a
http://youtu.be/dCyL54KQAZc



The violet lever can turn in vertical and horizotal planes to control two racks carrying shifting forks. Each rack has 3 working positions.
The control lever pushes or pulls the blue shaft and the orange bush to turn the pink gear sector. There is a helical joint between the orange bush and the pink gear sector. There is a sliding key joint between the orange bush and the popcorn housing.
The control lever turns the blue shaft and the yellow gear sector. There is a sliding key joint between them.
The brown part can only rotate (no translation) in the popcorn housing.

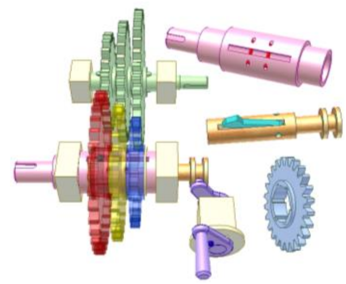
Shifting gear mechanism 2b
http://youtu.be/J49Ro2ly1vY



Pull yellow disk, turn it to a new position and push it back to shift grey gear block through rack-pinion drives. Position devices are not shown.
Key factor is various depths of holes on the disk.
The mechanism is used in Russian lathe 1616

Shifting gear mechanism 3

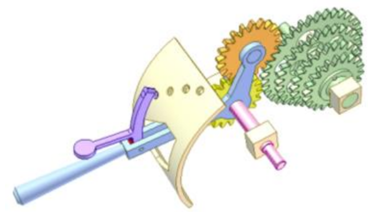
http://youtu.be/2kRQHNAR3M0



Input: green shaft carrying three gears.
Output: pink hollow shaft in which orange shaft slides. The pink and orange shafts rotate together owing cyan key, that has a revolution joint with the orange shaft.
Red, yellow and blue gears engage with the green gears and idly rotates (with different speeds) on the pink shaft.
Depending to axial position of the orange shaft which is controlled by violet crank, the cyan key enters into key slots of one of the red, yellow and blue gears and connects it with the pink output shaft. Red pins help retreave the cyan key from the gear key slots when the orange shaft moves longitudinally.
There is a flat spring (not shown) that forces the cyan key towards the gears.
The video shows 3 positions of the orange shaft that give 3 output speeds.

Shifting gear mechanism 4

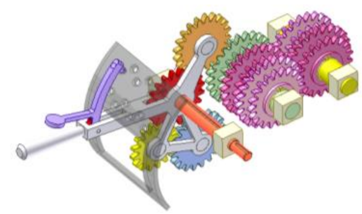
http://youtu.be/9d2kf2A88rs

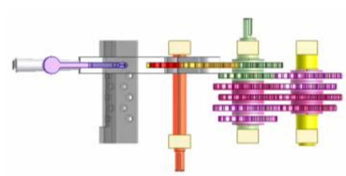


Input: green shaft with four gears fixed on it.
Output: pink shaft, that has a cylindrical joint with blue angle crank.
Yellow gear has sliding key joint with the pink shaft and engages with orange gear. The blue crank carrying the orange and yellow gears can move with them along the pink shaft.
To change speed:
1. Pull violet positioning trigger, turn back the blue crank and move them to other green gear.
2. Turn forwards the blue crank until the orange gear get in mesh with the green gear and release the trigger.
A red flat spring forces the trigger towards positioning holes.
The video shows the change from highest to lowest speed.

Shifting gear mechanism 5

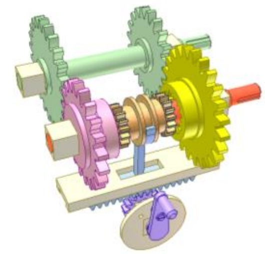
http://youtu.be/xs9YzKWG1zs





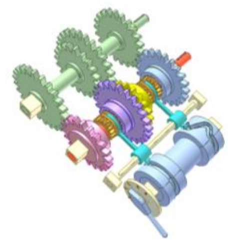
Input: green shaft with two green gears fixed on it.
Yellow shaft is fixed immobile. Blocks of two pink gears rotate idly on the green and yellow shafts. These blocks get rotation from the green shaft in a meandering manner.
Output: red shaft, with which grey crank has a cylindrical joint.
The grey crank carrying the red, orange, yellow and blue gears can move with them along the red shaft.
The red gear has sliding key joint with the red shaft and engages with orange and yellow gears. The yellow gear is in mesh with the blue gear.
To change speed:
1. Pull violet positioning trigger, turn back the grey crank and move them to other gear of the green shaft.
2. Turn forwards the grey crank until the orange gear (or the blue gear for reversing output direction) to get in mesh with the selected gear and release the trigger.
A red flat spring forces the trigger towards positioning holes.
The video shows the change from forward highest speed to reverse lowest one.

Shifting gear mechanism 6a
http://youtu.be/mecDD74_XXE



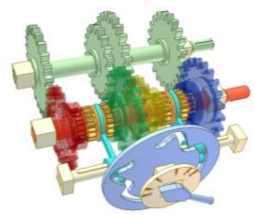
Input: green shaft with two green gears fixed on it.
Output: red shaft with yellow and pink gears rotating idly on it.
The gears are permanently in mesh. The orange toothed clutch has sliding key joint with the output shaft. The clutch's 3 positions are controlled by a rack-pinion drive.
To avoid clutch collision, the speed change must be carried out when the input shaft stops. The operation shown in this video is for the case of very slow speed.

Shifting gear mechanism 6b
http://youtu.be/p51_OnId75I



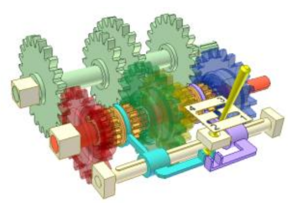
Input: green shaft with four gears fixed on it.
Output: red shaft with pink, violet, yellow and blue gears rotating idly on it.
The gears are permanently in mesh. The orange toothed clutches has sliding key joint with the output shaft. 3 positions of each clutch are controlled by blue barrel cam. The mechanism gives 4 speeds and neutral positions.
To avoid clutch collision, the speed change must be carried out when the input shaft stops. The operation shown in this video is for the case of very slow speed.

Shifting gear mechanism 6c
http://youtu.be/96yo_8AIHXs



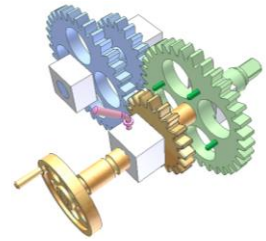
Input: green shaft with four gears fixed on it.
Output: red shaft with pink, violet, yellow and blue gears rotating idly on it.
The gears are permanently in mesh. The orange toothed clutches has sliding key joint with the output shaft. 3 positions of each clutch are controlled by blue disk cam. The mechanism gives 4 speeds and neutral positions.
To avoid clutch collision, the speed change should be carried out when the input shaft stops.

Shifting gear mechanism 6d
http://youtu.be/uZDfj0u1MXo



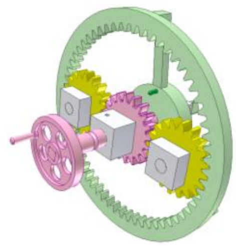
Input: green shaft with four gears fixed on it.
Output: red shaft with pink, violet, yellow and blue gears rotating idly on it.
The gears are permanently in mesh. The orange toothed clutches has sliding key joint with the output shaft. 3 positions of each clutch are controlled by yellow lever and cyan and violet forks. The mechanism gives 4 speeds and neutral positions.
To avoid clutch collision, the speed change should be carried out when the input shaft stops.

Gear box of two velocities 1
https://youtu.be/111T6JYHJRE



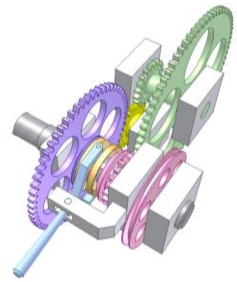
Input: orange gear shaft rotating at velocity Vi.
Output: green gear shaft that rotates in the same direction of the input.
When the orange gear is set to engage with the large blue gear, the output rotates at velocity V1:
V1 = Vi/((Z2*Z4)/(Z1*Z3))
Z1, Z2, Z3 and Z4 are tooth numbers of orange, large blue, small blue and green gears respectively.
In this video Z1 = 20; Z2 = 35; Z3 = 20; Z4 = 35 so V1 = Vi/3
When the orange gear is in mesh with green pins fixed to the green gear, the output rotates together with the input at velocity V2 = Vi.
The pink pin is used for fixing the orange shaft axially after adjustment.

Reversing clutch of two velocities 1
https://youtu.be/H2HSXkCCJ8A



Input: pink gear shaft rotating one way (clockwise) at Vi velocity.
Output: green gear shaft that can rotate two ways subject to axial position of the pink shaft.
When the pink gear is in mesh with yellows gears, the output rotates counterclockwise at velocity V1
V1 = Vi/(Zg/Zp)
Zg and Zp are tooth numbers of green and pink gears respectively.
In this video Zg = 60; Zp = 20; V1 = Vi/3
When the pink gear is in mesh with green pins fixed to the green gear, the output rotates together with the input at velocity V2 = Vi.
A pin, which can slide in the hole of the middle bearing to fix the pink shaft axially after adjustment, is not shown.

Reversing clutch of two velocities 2
https://youtu.be/TN_sIhQCvu8



Input: pink shaft of a gear and a pulley rotating one way (clockwise) at Vi velocity.
Output: grey shaft that can rotate two ways subject to axial position of the orange friction clutch.
When the clutch is in the left, the output rotates counterclockwise at velocity V1
V1 = Vi/((Z2*Z4)/(Z1*Z3))
Z1, Z2, Z3 and Z4 are tooth numbers of pink, large green, small green and violet gears respectively.
In this video Z1 = 20; Z2 = 80; Z3 = 20; Z4 = 60 so V1 = Vi/12
When the clutch is in the right, the output rotates clockwise at velocity V2 = Vi (together with the input).
The grey shaft has prismatic joint with the orange clutch.

Automatic gearing when reversing 1
https://youtu.be/jFaTBeQ8e78
Input: blue shaft.
Output: green shaft rotating in the same direction of the input.
The output velocity depends on the input rotary direction.
Axial force of the helical gear drive moves the grey shaft.
Its is an application of the mechanism shown in:
https://youtu.be/J9kGUj8Nmzw