

Nguyen Duc Thang

# **1700 ANIMATED MECHANICAL MECHANISMS**

**With  
Images,  
Brief explanations  
and Youtube links.**

## **Part 2 Other kinds of motion transmission**

Renewed on 31 December 2014

This document is divided into 3 parts.

Part 1: Transmission of continuous rotation

Part 2: Other kinds of motion transmission

Part 3: Mechanisms of specific purposes

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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## 2. Converting continuous rotation into interrupted rotation

### 2.1. Tooth-uncompleted gears

#### Transmission with teeth-uncompleted gears 1

<http://www.youtube.com/watch?v=AtoqZKDH-fY>

The blue driving gear is a teeth-uncompleted one.

Its number of remained teeth  $Z1c = 1$

Its number of teeth (teeth-completed)  $Z1 = 40$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 39$ .

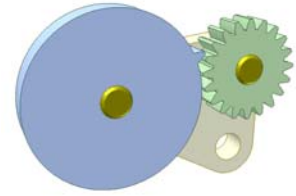
The number of the green driven gear (teeth-completed)  $Z2 = 20$

When the blue makes 1 revolution, the green makes  $3/20$  revolution.

#### Avoid wrong calculation:

When the blue makes 1 revolution, the green makes  $Z1c/Z2$  revolution.

For this case it means when the blue makes 1 revolution, the green makes  $1/20$  revolution (!).



#### Transmission with teeth-uncompleted gears 2

<http://youtu.be/YNsSa9hSw4A>

A funny mechanical problem:

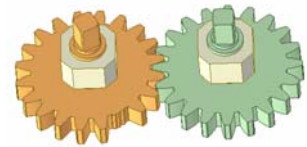
There is a drive of two gears of 20 teeth each.

What is the motion of the driven gear if 1 tooth of the driving gear is broken?

Wrong answer: 1 revolution of the driving gear corresponds  $19/20$  revolution of the driven gear.

Correct answer:

The driven gear rotates as if the tooth was not broken, because if the driving gear has only 1 tooth, it makes the driven gear move 2 teeth.



#### Transmission with teeth-uncompleted gears 3

<http://youtu.be/zSTqwzXCR9M>

Input: the orange gear.

Its number of remained teeth  $Z1c = 5$

Its number of teeth (teeth-completed)  $Z1 = 18$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 13$

Output: the green gear.

Its number of teeth (teeth-completed)  $Z2 = 18$ .

When the orange makes 1 revolution, the green makes  $1/3$  revolution.



#### Transmission with teeth-uncompleted gears 4

<http://youtu.be/LkweQilGCRs>

Input: the yellow gear.

Its number of remained teeth  $Z1c = 2$

Its number of teeth (teeth-completed)  $Z1 = 20$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 18$

Output: the green gear.

It has 14 tooth slots.

Its number of teeth (teeth-completed)  $Z2 = 21$ .

When the yellow makes 1 revolution, the green makes  $1/7$  revolution.



### Transmission with teeth-uncompleted gears 5

<http://youtu.be/ebMgECUuHdg>

Input: the yellow gear.

Its number of remained teeth  $Z1c = 1$

Its number of teeth (teeth-completed)  $Z1 = 20$

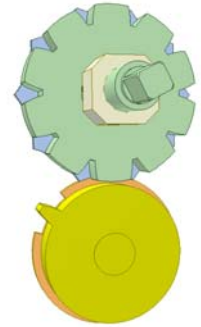
Its number of cut-off teeth  $Z1f = Z1 - Z1c = 19$

Output: the green gear.

It has 10 tooth slots.

Its number of teeth (teeth-completed)  $Z2 = 20$ .

When the yellow makes 1 revolution, the green makes 1/10 revolution.



### Transmission with teeth-uncompleted gears 8

<http://youtu.be/wPxQOsEiJ2E>

Input: the yellow gear.

Its number of remained teeth  $Z1c = 9$

Its number of teeth (teeth-completed)  $Z1 = 20$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 11$

Output: the green gear.

Its number of teeth (teeth-completed)  $Z2 = 20$ .

When the yellow makes 1 revolution, the green makes 1/2 revolution.



### Transmission with teeth-uncompleted gears 10

<http://youtu.be/scBbYOlmlUo>

Input: the yellow gear.

Its number of remained teeth  $Z1c = 18$

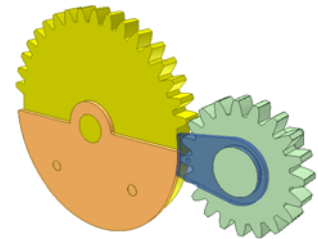
Its number of teeth (teeth-completed)  $Z1 = 40$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 22$

Output: the green gear.

Its number of teeth (teeth-completed)  $Z2 = 20$ .

When the yellow makes 1 revolution, the green makes 1 revolution and pause during 1/2 revolution of the yellow.



### Transmission with teeth-uncompleted gears 18a

<http://youtu.be/lj8J37zluhU>

Input: the blue gear.

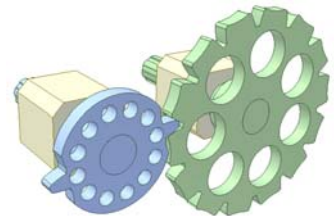
Its original number of teeth  $Z1 = 16$

Output: the green gear

Its original number of teeth  $Z2 = 28$

When the blue makes 1 revolution, the green turns two times and pauses two times.

The arcs on both gear keep the output gear immobile during its pause period.



### Transmission with teeth-uncompleted gears 19c

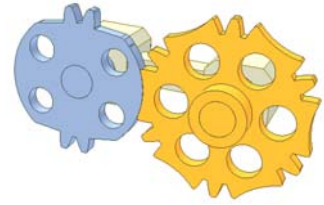
<http://youtu.be/NmiXFGb-dD8>

The blue gear is fixed. The orange gear is a satellite.

Input is the yellow crank.

In 1 revolution of the crank, the orange turns two times and pauses two times.

The arcs on both gear keep the orange gear immobile during its pause period.



### Transmission with teeth-uncompleted gears 17

<http://youtu.be/7ifFtlc5t8>

A measure to ensure proper engagement (jam avoiding).

Input: the pink gear.

Its number of remained teeth  $Z1c = 30$

Its original number of teeth  $Z1 = 40$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 10$

The blue gear sector has 4 teeth ( $Zs$ )

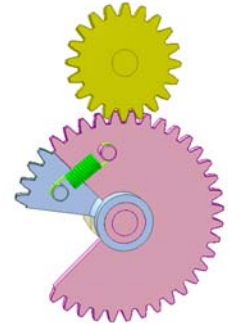
Output: the yellow gear of  $Z2 = 20$  teeth.

When the pink makes 1 revolution, the yellow makes  $(Z1c + Zs + A)/Z2 = (30 + 4 + 2)/20 = 36/20 = 1.8$  revolution and pause during  $(40 - 36)/40 = 1/10$  revolution of the pink.

Why  $A = 2$ ? If the pink gear has only 1 tooth and the blue gear sector is absent so when the pink makes 1 revolution, the yellow makes  $3/20$  revolution.

Measure to keep the output gear immobile during its pause is not shown.

Disadvantage: Pause time can not be long.



### Transmission with teeth-uncompleted gears 19b

<http://youtu.be/5nCJj2hxpUs>

Input: the blue gear.

Its original number of teeth  $Z1 = 20$

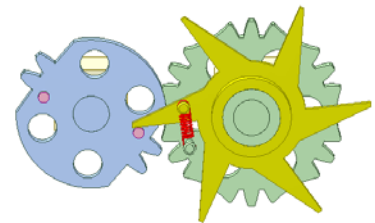
Output: the green gear

Its original number of teeth  $Z1 = 24$

When the blue makes 1 revolution, the green turns two times and pauses two times.

The arcs on both gear keep the output gear immobile during its pause period.

The yellow star, red spring and two pink pins are used for reducing shock. Before teeth engagement, the pink pin pushes the star. The latter pulls the output blue gear through the spring and gives the output a low initial speed.



### Transmission with teeth-uncompleted gears 20

<http://youtu.be/CQTx412p6nI>

Input: the green gear.

Its original number of teeth  $Z1 = 24$

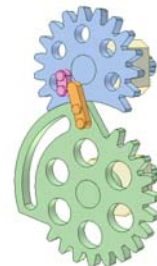
Output: the blue gear

Its original number of teeth  $Z2 = 19$

In one rev. of the input, the output turns 1 rev. and then pauses.

The arcs on both gear keep the output gear immobile during its pause period.

The pink and orange bars give the output an added rotation before the teeth engagement.



### Transmission with teeth-uncompleted gears 21

<http://youtu.be/RIVk2eYRw3Q>

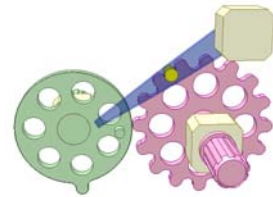
Input: the green gear of 1 tooth.

Its original number of teeth  $Z_1 = 16$

Output: the pink gear of  $Z_2 = 16$  teeth

In one rev. of the input, the output turns  $1/8$  rev. and then pauses.

The yellow pin of the blue arm keeps the output immobile during its pause period. The pin on the input controls the blue arm.



### Transmission with teeth-uncompleted gears 22

<http://youtu.be/PZ54x2hgU9A>

Input: yellow gear of tooth number  $Z_i = 18$ .

Output: green teeth-uncompleted gear.

Its tooth number (teeth-completed)  $Z_o = 20$

Its number of remained teeth  $Z_{oc} = 17$

Its number of cut-off teeth  $Z_{of} = Z_o - Z_{oc} = 3$ .

When the input turns 2 revolutions, the output turns 1 revolution and has long dwell (time of 1 input revolution).

The key concept:  $Z_i$  is less than  $Z_o$

Measure to kept the output immobile during its dwell is not shown.

The unusualness for this mechanism is that the input is a tooth completed gear. Not like in ordinary drive: the input is the teeth-uncompleted gear.



### Transmission with teeth-uncompleted gears 23

<http://youtu.be/anoaPGu2QMI>

Input: yellow shaft of constant velocity

Output: blue shaft having two velocities (transmission ratio  $i = 20/10$  and  $12/18$ ) in its every revolution.



### Transmission with teeth-uncompleted gears 6

[http://youtu.be/31vVO\\_i8WO8](http://youtu.be/31vVO_i8WO8)

Input: the orange gear.

Its number of remained teeth  $Z_{1c} = 1$

Its number of teeth (teeth-completed)  $Z_1 = 20$

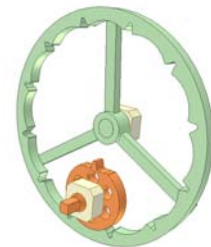
Its number of cut-off teeth  $Z_{1f} = Z_1 - Z_{1c} = 19$

Output: the green gear.

It has 12 tooth slots.

Its number of teeth (teeth-completed)  $Z_2 = 60$ .

When the orange makes 1 revolution, the green makes  $1/12$  revolution.



### Transmission with teeth-uncompleted gears 9

<http://youtu.be/p04ZgliBLVY>

Input: the orange gear.

Its number of remained teeth  $Z_{1c} = 1$

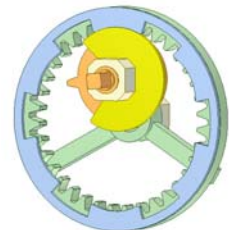
Its number of teeth (teeth-completed)  $Z_1 = 20$

Its number of cut-off teeth  $Z_{1f} = Z_1 - Z_{1c} = 19$

Output: the green gear.

Its number of teeth (teeth-completed)  $Z_2 = 36$ .

When the orange makes 1 revolution, the green makes  $1/6$  revolution.





### Transmission with teeth-uncompleted gears 7

<http://youtu.be/YzIYI4ssr9I>

Planetary drive with dwell.

R1: pitch diameter of the green gear having 20 teeth.

R2: pitch diameter of the yellow gear having 20 teeth.

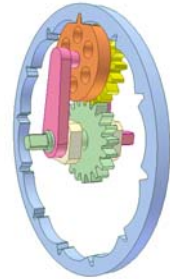
R3: pitch diameter of the orange gear having 1 tooth.

R4: pitch diameter of the blue internal gear having 12 tooth slots.

$R1 = R2 = R3$ ;  $R4 = 3R1$

The green gear is input.

The output pink crank carrying the yellow and orange gear block rotates with periodical pauses.



### Skew teeth-uncompleted gear drive 1a

<http://youtu.be/ePdEwNcnolo>

Input: yellow gear rotating continuously.

Output: blue gear rotating interruptedly.

For the yellow gear:

Its number of remained teeth  $Z1c = 12$  (180 deg.)

Its number of teeth (teeth-completed)  $Z1 = 24$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 12$  (180 deg.).

There is an orange rim located in the place, where the teeth are cut off.

The number of the blue gear (teeth-completed)  $Z2 = 24$ .

It has two red triangular slots.

The rim and slots are for keeping the blue gear immobile during its dwell.

When the yellow makes 1 revolution, the blue makes an angle  $A = 1/2$  revolution.

Alter  $Z1$ ,  $Z1c$  and  $Z2$  to get various values of  $A$ .



### Skew teeth-uncompleted gear drive 1b

<http://youtu.be/iBr34hiWXNE>

Input: lower gear rotating continuously.

Output: upper gear rotating interruptedly.

For the lower gear:

Its number of remained teeth  $Z1c = 3$  (45 deg.)

Its number of teeth (teeth-completed)  $Z1 = 24$

Its number of cut-off teeth  $Z1f = Z1 - Z1c = 21$  (315 deg.)

There is a pink rim located in the place, where the teeth are cut off.

The number of the upper gear (teeth-completed)  $Z2 = 24$ .

It has eight red triangular slots.

The rim and slots are for keeping the upper gear immobile during its dwell.

When the yellow makes 1 revolution, the blue makes an angle  $A = 1/8$  revolution.

Alter  $Z1$ ,  $Z1c$  and  $Z2$  to get various values of  $A$ .





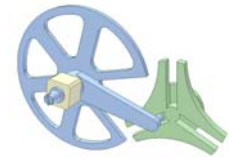
## 2.2. Geneva drives

### Geneva mechanism 1

<http://www.youtube.com/watch?v=vEU5cXwiykQ>

The ratio of motion period to dwell period is 1/5.

Angle of each rotation of the driven shaft is 120 degrees.



### Geneva mechanism 2

[http://www.youtube.com/watch?v=GbEJFDP8f\\_E](http://www.youtube.com/watch?v=GbEJFDP8f_E)

Angle between the three pins is 120 degrees.

During 1 revolution of the driving shaft the driven disk has 3 dwell times and 3 motion times alternately.

Angle of each rotation of the driven shaft is 120 degrees.



### Geneva mechanism 3

[http://www.youtube.com/watch?v=qFd-Kt\\_vTDs](http://www.youtube.com/watch?v=qFd-Kt_vTDs)

Angle between the two pins is 120 degrees.

During 1 revolution of the driving shaft the driven disk has 2 dwell times and 2 motion times alternately. Dwell periods of the two dwell times are different.

Angle of each rotation of the driven shaft is 120 degrees.



### Geneva mechanism 4

[http://www.youtube.com/watch?v=TErAWmR66\\_s](http://www.youtube.com/watch?v=TErAWmR66_s)

The ratio of motion period to dwell period is 1/3.

Angle of each rotation of the driven shaft is 90 degrees.



### Geneva mechanism 5

<http://www.youtube.com/watch?v=BM5fLiOxM3o>

Angle between the two pins is 180 degrees.

During 1 revolution of the driving shaft the driven disk has 2 dwell times and 2 motion times alternately.

Angle of each rotation of the driven shaft is 90 degrees.



### Geneva mechanism 6

<http://www.youtube.com/watch?v=NjlfexPXpds>

Angle between the two pins is 120 degrees, not a multiple of 90.

Angle of each rotation of the driven shaft is 90 degrees.



### Geneva mechanism 7

<http://www.youtube.com/watch?v=uhEvxBxFoXA>

The ratio of motion period to dwell period is 1/5.

Angle of each rotation of the driven shaft is 60 degrees.



### Geneva mechanism 8

<http://www.youtube.com/watch?v=3Ju7N-VM7Qw>

The disks rotate and pause one after another.

The ratio of motion period to dwell period is 1/5.

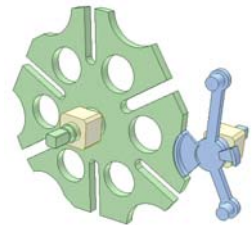
Angle of each rotation of the disks is 120 degrees.



### Geneva mechanism 9

<http://www.youtube.com/watch?v=RF5JN2dHMMA>

The disk interruptedly rotates 70 and 50 degrees.



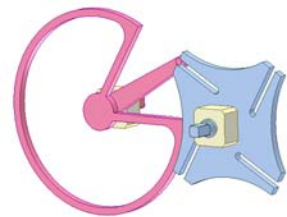
### Geneva mechanism 10

<http://www.youtube.com/watch?v=BuuVSIchqZU>

By applying skew slots the ratio of motion period to dwell period is 1/5, not 1/3 like in standard 4-slot Geneva mechanism:

[http://www.youtube.com/watch?v=TErAWmR66\\_s](http://www.youtube.com/watch?v=TErAWmR66_s)

Angle of each rotation of the driven shaft is 90 degrees.

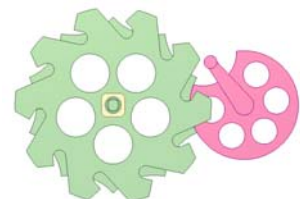


### Geneva mechanism 11

[http://www.youtube.com/watch?v=845\\_WfUmSI0](http://www.youtube.com/watch?v=845_WfUmSI0)

By applying skew slots the ratio of motion period to dwell period is 1/5, not 2/5 like in standard 10-slot Geneva mechanism.

Angle of each rotation of the driven shaft is 36 degrees.



### Geneva mechanism 12

<http://www.youtube.com/watch?v=pPhjq5IHVyY>

Twin Geneva mechanism. The green disk interruptedly rotates 60 degrees with different dwell periods.



### Geneva mechanism 13

<http://www.youtube.com/watch?v=PoJBGr5mR2c>

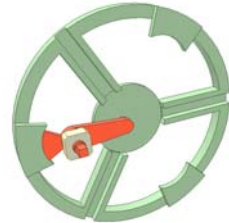
Twin Geneva mechanism. The green disk interruptedly rotates 120 degrees. The ratio of dwell period to motion period is 8/1.



### Internal Geneva mechanism 1

<http://www.youtube.com/watch?v=n8xLpbwsTcg>

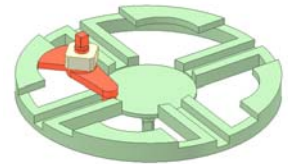
The ratio of dwell period to motion period is 1/2.  
Angle of each rotation of the driven shaft is 120 degrees.



### Internal Geneva mechanism 2

<http://www.youtube.com/watch?v=ReXprJUMqF4>

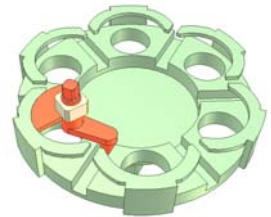
The ratio of dwell period to motion period is 1/3.  
Angle of each rotation of the driven shaft is 90 degrees.



### Internal Geneva mechanism 3

<http://www.youtube.com/watch?v=MQP7yNxx3ag>

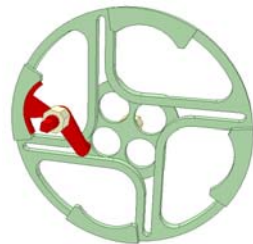
The ratio of dwell period to motion period is 1/5.  
Angle of each rotation of the driven shaft is 60 degrees.



### Internal Geneva mechanism 4

[http://www.youtube.com/watch?v=w1oT0Zx\\_xcU](http://www.youtube.com/watch?v=w1oT0Zx_xcU)

The ratio of dwell period to motion period is 1/3.  
Angle of each rotation of the driven shaft is 90 degrees.



### Trivision Billboard with Geneva mechanism

<http://www.youtube.com/watch?v=uCx9riKxTvY>

Meslab is the name of the Vietnamese forum of Materials, Mechanical, Automation and Industrial Engineering.

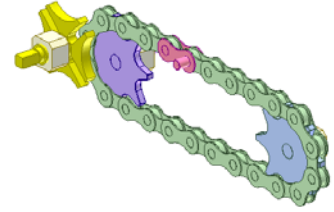


### Chain drive 3D

[http://youtu.be/1\\_yyZ93JJA1](http://youtu.be/1_yyZ93JJA1)

The violet sprocket is driving.

Dwell time of the output Geneva disk depends on the number of the chain links.



### Geneva mechanism 14

[http://youtu.be/\\_TmvoXFxyNw](http://youtu.be/_TmvoXFxyNw)

Input: blue crank

Output: green disk rotating with dwells.

Input and output are coaxial.

In one revolution of the blue crank the green disk rotates  $\frac{1}{4}$  rev.

Red curve is locus of the red roller center.

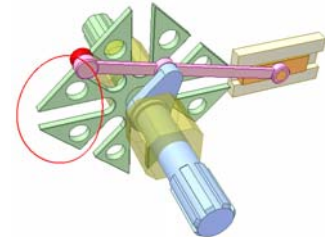
Orange slider kept the green disk immobile during its dwell.

Main dimensions of the mechanism are:

- crank radius of the blue crank
- side length of the green square disk
- length of the pink conrod.

They are determined based on a sketch (not shown) where:

- Angle of crank and horizontal line is 60 deg.
- Angle of square side of the green disk and horizontal line is 45 deg.
- Square side (contains roller center), crank radius line and the line that is drawn from the slider center and perpendicular to the sliding direction of the runway, are concurrent.



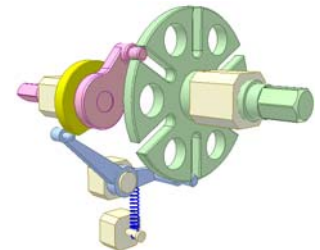
### Geneva mechanism 15

<http://youtu.be/TYRks3vmAl1>

Input: pink crank

Output: green disk rotating with dwells.

Yellow cam (fixed to the crank) and blue lever with its pins keep the green disk immobile during dwells.



### Geneva mechanism 16a

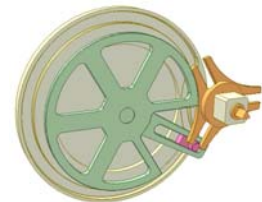
<http://youtu.be/rI9VJuzrNVg>

Input: green crank

Output: orange disk rotating with dwells.

Pink slider has pins that slide in grooves of the green crank and the orange disk.

Fixed popcorn disk cam and the pink slider help to reduce acceleration of the orange disk.



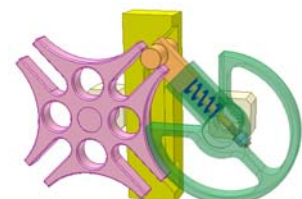
### Geneva mechanism 16b

<http://youtu.be/rhObov9nyVQ>

Input: green crank carrying orange slider

Output: pink disk rotating with dwells.

The slider has pins that slide in grooves of the pink disk and of fixed yellow guide plate. The latter and the orange slider help to reduce acceleration of the pink disk.



### Geneva mechanism 19

<http://youtu.be/LkYHh29c16A>

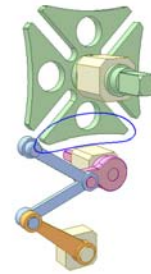
Input: pink crank

Output: green disk rotating with dwells.

A four bar linkage makes angular speed of the output more regular.

Blue curve is locus of pin center of the blue V-shaped bar.

Measure to keep the green disk immobile during its dwells is not shown.



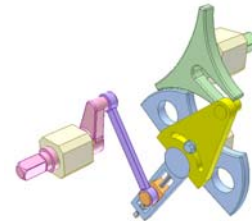
### Geneva mechanism 20

<http://youtu.be/CsEaqHMsXEA>

Input: pink crank

Output: green disk oscillating with dwells at both stroke ends.

Adjust positions of orange slider and yellow plate to get various motion rules of the output.



### Geneva mechanism 20

[http://youtu.be/vu6\\_WfDXUIQ](http://youtu.be/vu6_WfDXUIQ)

Input: blue crank with locking disk carrying green planet gear.

Output: orange disk rotating interruptedly.

Two gears have same tooth number. Blue crank radius is equal to gear pitch one.

The motion period of the output is decreased over ordinary Geneva mechanism.



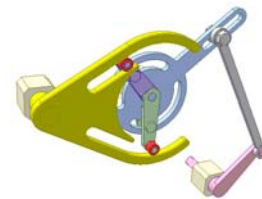
### Geneva mechanism 22

<http://youtu.be/QkzRb7b36lY>

Input: pink crank.

Output: yellow Geneva disk oscillating with dwell at its stroke middle.

Output motion rule can be adjusted by setting positions of violet or green roller bars and grey conrod on blue disk.



### Geneva mechanism 21

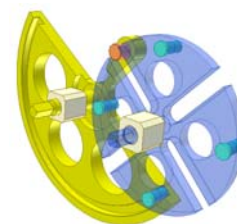
<http://youtu.be/HuJSoUqIKws>

Input: yellow disk of orange pin rotating continuously.

Output: blue disk rotating interruptedly.

1 rev. of the input makes the output rotate 90 deg.

Other than standard Geneva mechanism it uses four cyan pins on the blue disk and circular groove of the yellow disk to keep the blue disk immobile during its dwells.





### Geneva mechanism 17

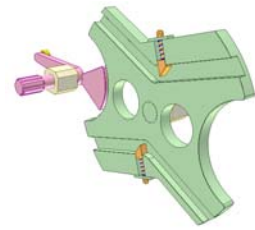
<http://youtu.be/J7-lAwdrEkw>

Input: pink crank

Output: green disk rotating with dwells.

In one revolution of the pink crank the green disk rotates 180 deg., a thing that ordinary Geneva mechanisms can not get.

Orange sliders prevent reverse rotation of the green disk when yellow roller of the pink crank reaches corners of the disk grooves.



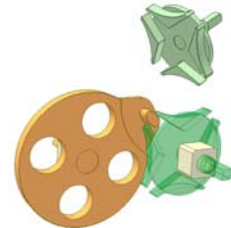
### Geneva mechanism 18

<http://youtu.be/uNVF-EZ6myA>

Input: orange crank carrying an ellipsed-shape pin.

Output: green disk rotating with dwells.

I have tried to find out what is the advantage of this Geneva mechanism but no success. Unexpected result: its output acceleration is even larger than in ordinary Geneva mechanism.



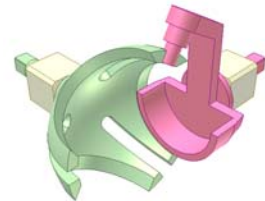
### Spatial Geneva mechanism 1

<http://www.youtube.com/watch?v=rqDfalBVhIU>

The ratio of dwell period to motion period is 1/1.

Angle of each rotation of the driven shaft is 120 degrees.

Angle between the pin axis and the crank axis is 60 degrees.



### Spatial Geneva mechanism 2

<http://www.youtube.com/watch?v=IUv4TaxKyuw>

The ratio of dwell period to motion period is 1/1.

Angle of each rotation of the driven shaft is 90 degrees.

Angle between the pin axis and the crank axis is 45 degrees.



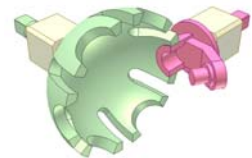
### Spatial Geneva mechanism 3

[http://www.youtube.com/watch?v=cKi\\_Hlp9rA8](http://www.youtube.com/watch?v=cKi_Hlp9rA8)

The ratio of dwell period to motion period is 1/1.

Angle of each rotation of the driven shaft is 60 degrees.

Angle between the pin axis and the crank axis is 30 degrees.



### Spatial Geneva mechanism 4

<http://www.youtube.com/watch?v=-M3BIExZAYs>

The ratio of dwell period to motion period is 1/1.

Angle of each rotation of the driven shaft is 20 degrees.

Angle between the pin axis and the crank axis is 10 degrees.



### Spatial Geneva mechanism 5a

<http://youtu.be/a-l3VCDKuvs>

Input: blue crank with locking ring.

Output: yellow cylinder with orange locking disk rotating interruptedly.

Ellipse section of the blue crank pin is for easy designing the mechanism. Round section is possible.



### Spatial Geneva mechanism 5b

<http://youtu.be/2vB68uod2Bc>

Input: blue crank with locking ring.

Output: yellow cylinder with orange locking disk.

Ellipse section of the blue crank pin is for easy designing the mechanism. Round section is possible.

The mechanism performs 180 deg. indexing that is impossible for ordinary Geneva mechanisms.



### Star wheel drive 4

<http://youtu.be/TaZKjLB-KVU>

An invention of Martin Zugel of Cleveland, Ohio, USA.

Input: green disk of two pink pins.

Output: yellow disk rotating interruptedly.

In one revolution of the input, the output turns 90 deg.

Motion time is around 20% cycle time (25% cycle time for a standard Geneva one).

Inertia load is less than in a standard Geneva drive.



### Star wheel drive 3

<http://youtu.be/qFECTmIUtMM>

An invention of Martin Zugel of Cleveland, Ohio, USA.

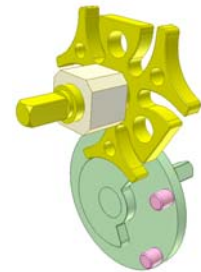
Input: green disk of two pink pins.

Output: yellow disk rotating interruptedly.

In one revolution of the input, the output turns 120 deg.

Motion time is around 40% cycle time (16.7% cycle time for a standard Geneva one).

Inertia load is less than in a standard Geneva drive.



### Star wheel drive 1

[http://youtu.be/9hG\\_dL40M6Y](http://youtu.be/9hG_dL40M6Y)

An invention of Martin Zugel of Cleveland, Ohio, USA.

Input: green disk of two pink pins.

Output: orange disk rotating interruptedly.

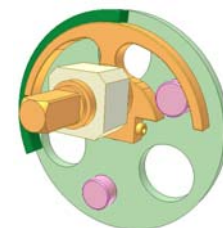
The input and output are not coaxial.

In one revolution of the input, the output turns 360 deg.

This operation is not possible with standard Geneva drives.

Motion time is around 40% cycle time.

Dark green rim keeps the output disk immobile during its dwell.





## 2.3. Ratchet drives

### Ratchet mechanism 1

<http://www.youtube.com/watch?v=eijyLC4ZzQk>

A device directly converts the continuous rotary motion of a drive shaft into the intermittent rotary motion of a driven shaft.



### Ratchet mechanism 2

<http://youtu.be/V4yxGR4d7I8>

This mechanism directly converts the continuous rotary motion of a drive shaft into the intermittent rotary motion of a driven shaft.

By flipping the blue pawl the motion direction of the driven shaft can be changed without changing the input motion direction.



### Sheet metal ratchet drive 1

<http://youtu.be/qT3S7sOhys8>

For light loads.

Low cost.

Adaptability to mass production.

Permanent contact between pawl and ratchet wheel is maintained by pawl's weight.



### Sheet metal ratchet drive 2

<http://youtu.be/miDCNBMLR3E>

For light loads.

Low cost.

Adaptability to mass production.

Permanent contact between pawl and ratchet wheel is maintained by pawl's weight.



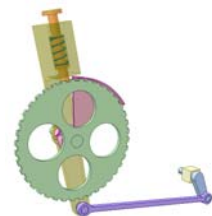
### Ratchet mechanism 3

<http://youtu.be/WeV89YavvO8>

To adjust position of the pink cover for getting various rotation angle of the green wheel.

To pull the orange pawl and rotate it 180 degrees to change rotation direction of the green wheel.

This mechanism is used in shapers.



### Ratchet mechanism 4

<http://youtu.be/vW6PuvfIUrM>

The ratchet wheel has internal teeth.



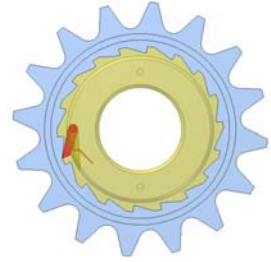
### Ratchet mechanism 5

[http://youtu.be/bAL\\_nWjuhOI](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 influence to the blue sprocket.

The red pawl is always pressed toward the sprocket's teeth by a spring. In reality two pawls are used.

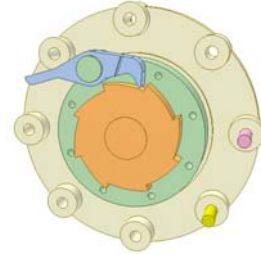


### Ratchet mechanism 8

<http://youtu.be/4wQkKdf9ReU>

The input green disk through the blue pawl makes the output ratchet wheel rotate interruptedly. The pink and yellow pins control pause time of the ratchet wheel. Each pin makes the ratchet wheel pause for 1/8 revolution of the input disk.

The blue pawl is always pressed toward the sprocket's teeth by a spring (not shown).



### Ratchet mechanism 9

<http://youtu.be/wqPI2ms2kk>

There are two pawls. The pink pushes the ratchet wheel.

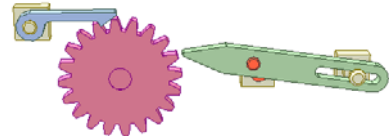
The green keeps the wheel immobile when the pink reverses.



### Ratchet mechanism 12

<http://youtu.be/tvByEbHmcfc>

There are two pawls. The green pushes the pink gear and is not always in contact with it (unlike ordinary ratchet mechanism). The blue keeps the wheel immobile when the green does not push the gear.



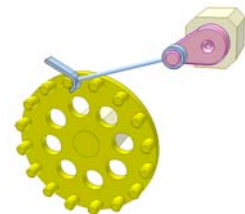
### Ratchet mechanism of pin gear 1

<http://youtu.be/ISQQZAvi7H0>

Input: pink crank rotating continuously.

Output: yellow pin gear.

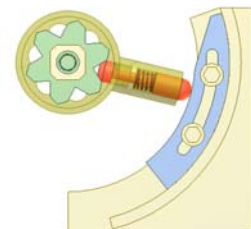
Gravity maintains contact between blue pawl and pin gear.



### Ratchet mechanism 13

<http://youtu.be/r-2Xe3moMPs>

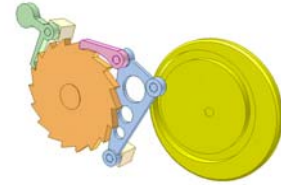
The input yellow disk through the orange pawl makes the output green ratchet wheel rotate interruptedly. The length of the blue cam regulates moving time of the wheel.



### Ratchet mechanism 15

<http://youtu.be/k7JzvFg88g>

There are two pawls. The pink pushes the ratchet wheel. The green keeps the wheel immobile when the pink reverses. The yellow slotted cam is the input.

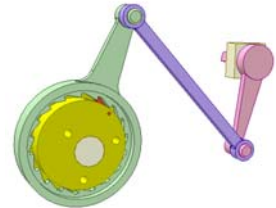


### Ratchet mechanism 16

<http://youtu.be/5l74rKEJLp0>

Input is pink crank of constant velocity.

Green rocker (ratchet wheel of internal teeth) turns an angle of around three teeth in each revolution of the crank. But the yellow disk rotates at different angles because of its eccentrical rotary axis.



### Ratchet mechanism 31

<http://youtu.be/sSVz1cMMYIY>

Input: green crank oscillating.

Output: ratchet wheel rotating interruptedly.

Blue spring maintains contact between yellow pawl and ratchet wheel.

Speciality: internal tooth wheel, external pawl.



### Ratchet mechanism 17

<http://youtu.be/GuM-WgaQnc8>

Input: green eccentric shaft.

Output: grey ratchet wheel.

Gravity maintains contact between pawl and ratchet wheel.



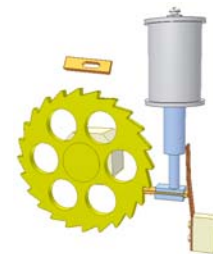
### Ratchet mechanism 27

<http://youtu.be/vWezNG0l8g>

Grey solenoid makes blue rod reciprocate.

The unusualness is: orange pawl has prismatic joint with the blue driving rod, not revolution one as ordinary pawls.

Flat spring maintains the contact between pawl and yellow wheel.



### Spatial ratchet mechanism 1

<http://youtu.be/Hev7Im-DhVA>

Input: eccentric shaft rotating continuously.

Output: face tooth ratchet wheel rotating interruptedly.

Gravity maintains contact between blue pawl and the wheel.



### Cable drive for 180 deg. rotation

<http://youtu.be/VzBulhvWsJY>

Pull and release brown tow to let yellow ratchet disk turn 180 deg. One end of the tow is fixed to blue disk. Orange leaf spring keeps the yellow ratchet disk immobile during its dwell. A circular slot on the blue disk and a pin on the case limit oscillating angle of the blue disk. A coil spring (not shown) makes the blue disk turn back when the tow is released.

Replacement of cable drive with rack-pinion one is possible.



### Spatial ratchet mechanism 2

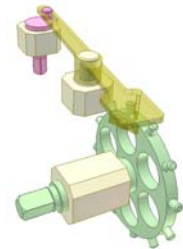
<http://youtu.be/TuJxhLaOJjo>

Input: pink crank rotating continuously.

Output: green ratchet wheel of tooth number Z.

Both go and back motions of yellow oscillating crank make the wheel rotate in the same direction.

In 1 rev. of the input, the output rotates  $2/Z$  rev. with two dwells.



### Spatial ratchet mechanism 3a

<http://youtu.be/OGGWPJUgAA8>

Input: orange oscillating crank.

Output: green twin ratchet wheel of tooth number Z.

Both go and back motions of the crank make the wheel rotate in the same direction.

In 1 rev. of the input, the output rotates  $1/Z$  rev. with two dwells.

Angle deflection between the two ratchet wheels is  $360/2Z$  deg.



### Spatial ratchet mechanism 3b

<http://youtu.be/HWZBdD80ZE4>

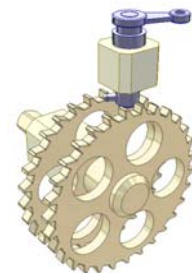
Input: blue oscillating crank.

Output: twin ratchet wheel of tooth number Z.

Both go and back motions of the crank make the wheel rotate in the same direction.

In 1 rev. of the input, the output rotates  $1/Z$  rev. with two dwells.

Angle deflection between the two ratchet wheels is  $360/2Z$  deg.



### Ratchet mechanism 18

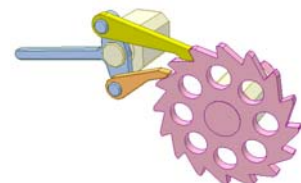
<http://youtu.be/urvRRQQMd9Y>

Input: blue crank.

Output: pink ratchet wheel.

Both go and back motions of the blue crank make the wheel rotate in the same direction. The pawls push the wheel.

Gravity maintains contact between pawls and ratchet wheel.



### Ratchet mechanism 19

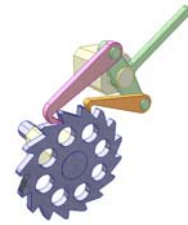
<http://youtu.be/RYrn5XjDTg4>

Input: green crank.

Output: ratchet wheel.

Both go and back motions of the green crank make the wheel rotate in the same direction. The pawls pull the wheel.

Gravity maintains contact between pawls and ratchet wheel.



### Ratchet mechanism 20

<http://youtu.be/tZfwSkw8uGM>

Input: green crank.

Output: blue ratchet wheel.

Both go and back motions of the crank make the wheel rotate in the same direction. Yellow pawl pushes and orange pawl pulls the wheel.

Violet springs maintain contact between pawls and ratchet wheel.



### Ratchet mechanism 21

<http://youtu.be/JZt-L8xFLyU>

Input: pink crank.

Output: yellow ratchet wheel that can rotate interruptedly in both direction.

Blue rocker oscillates thanks to four bar mechanism.

Red springs maintain contact between pawls and ratchet wheel.

Use grey sector to prevent contact between the wheel and one of the pawls for changing rotary direction of the output.



### Ratchet mechanism 22

<http://youtu.be/4wMIWhl2DhE>

Input: pink crank.

Output: green ratchet wheel.

Both go and back motions of blue slider make the wheel rotate in the same direction. Orange pawl pushes and yellow pawl pulls the wheel.

Spring maintains contact between pawls and ratchet wheel.



### Ratchet mechanism 23

<http://youtu.be/jfjCLOztQZM>

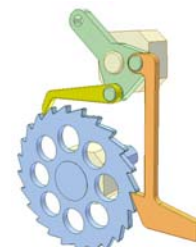
Input: green crank oscillating.

Output: blue ratchet wheel.

Both go and back motions of oscillating green crank make the wheel rotate in the same direction.

Yellow pawl pushes and orange pawl pulls the wheel.

Gravity maintains contact between pawls and wheel.



### Ratchet mechanism 24

<http://youtu.be/37kxWCIRLO4>

Input: green crank oscillating.

Output: ratchet wheel.

Both go and back motions of oscillating green crank make the wheel rotate in the same direction.

The pawls push the wheel.

Spring maintains contact between pawls and ratchet wheel.



### Ratchet mechanism of pin gear 2

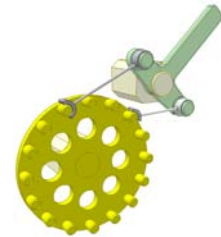
<http://youtu.be/PSMWGHKGU5k>

Input: green crank .

Output: yellow pin gear.

Both go and back motions of the green crank make the gear rotate in the same direction. The green bars push the gear.

Gravity maintains contact between pawls and pin gear



### Ratchet mechanism 25

<http://youtu.be/gzLSJ-6qvWA>

Input: green oscillating crank.

Output: yellow ratchet wheel.

Blue ratchet wheel is idly mounted on violet fixed shaft.

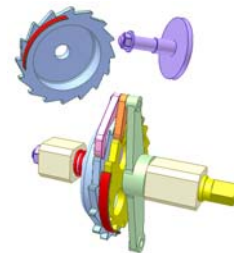
Red spring creates friction between the blue ratchet wheel and fixed violet shaft thus prevents the blue wheel from reverse rotation.

Pink pawl makes the blue ratchet wheel rotate.

Orange pawl makes the yellow ratchet wheel rotate.

Red sector of the blue ratchet wheel periodically prevents contact between the orange pawl and the yellow wheel thus the latter rotates interruptedly with different dwell times.

Gravity maintains contact between pawls and wheels.



### Ratchet mechanism 26

<http://youtu.be/UFU1NkXvCJo>

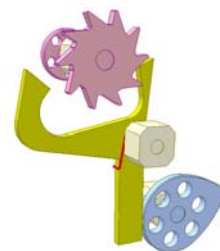
Input: blue cam.

Output: pink ratchet wheel rotating interruptedly with long dwells.

Both go and back motions of yellow oscillating pawl make the wheel rotate in the same direction (one tooth).

The pawl keeps the ratchet wheel immobile during its dwells.

Red spring maintains contact between the pawl and the cam.





### Ratchet mechanism 32

<http://youtu.be/uwqsltwBa7g>

Input: green crank oscillating.

Output: ratchet wheel of tooth number  $Z$  rotating interruptedly.

The gravity maintains contact between 2 coaxial pawls and ratchet wheel.

The ratchet wheel thickness must be twice the pawl ones.

Speciality: the mechanism acts as in case where there is one pawl and ratchet wheel tooth number is  $2Z$ . It helps increase tooth strength.

The pawls one by one push the wheel.



### Ratchet mechanism 33

<http://youtu.be/ZeAYihlABSw>

Input: green crank oscillating.

Output: ratchet wheel of tooth number  $Z$  rotating interruptedly.

The gravity maintains contact between 3 identical pawls and ratchet wheel.

Speciality: the mechanism acts as in case where there is one pawl and ratchet wheel tooth number is  $3Z$ . It helps increase tooth strength.

The pawls one by one push the wheel.



### Ratchet mechanism 35

<http://youtu.be/3e6axpv1SsY>

Input: grey crank oscillating.

Output: violet slider that linearly moves interruptedly.

Tooth number of green wheel  $Z_g = 12$ .

Tooth number of yellow wheel  $Z_y = 11$ .

Blue pawl contacts the green wheel.

Orange pawl contacts the yellow wheel.

The green wheel has helical joint with pink screw.

The yellow wheel has prismatic joint with pink screw.

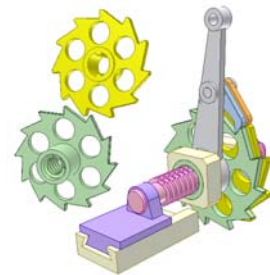
The gravity maintains contact between the wheels and the pawls.

The screw pitch is  $P$  mm.

12 double strokes of the input crank make the green wheel turn 1 revolution and the yellow wheel turn  $1 + 1/11$  revolutions. Thus the screw turns  $1/11$  rev. in relation with the green wheel (nut) and the slider moves  $P/11$  mm (small displacement).

The video also shows case when the orange pawl does not engage with the yellow wheel.

The latter is immobile so the screw can not rotate. 12 double strokes of the input crank make the green wheel turn 1 revolution and the slider moves  $P$  mm (large displacement) in the opposite direction (in the same direction if  $Z_g = 11$ ,  $Z_y = 12$ ).

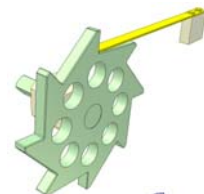


### Ratchet mechanism for anti-reverse 1

<http://youtu.be/rKYTr9NigQA>

Green ratchet wheel rotates only anticlockwise.

The reverse rotation is prevented by yellow flat spring.



### Ratchet mechanism for anti-reverse 2

<http://youtu.be/g4vFJtps-Q>

Yellow ratchet wheel rotates only anticlockwise.

The reverse rotation is prevented by blue slider.





### Ratchet mechanism for anti-reverse 3

<http://youtu.be/14i2UWR87ik>

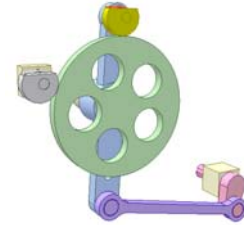
Yellow face tooth ratchet wheel rotates only clockwise.  
The reverse rotation is prevented by pink pawl.



### Friction ratchet mechanism 1

<http://youtu.be/JWLXmY0QzP8>

The yellow cam plays pawl's role. The friction force between the yellow cam and the green no-teeth wheel drives the latter.  
No noise and backlash in comparison with ordinary ratchet mechanisms



### Friction ratchet mechanism 2

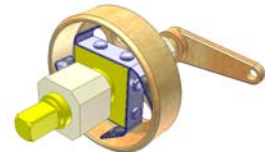
<http://youtu.be/aCN-HEBsdYM>

Input: orange oscillating drum.

Output: yellow shaft rotating interruptedly.

Four flat springs allow motion transmission only in anticlockwise direction.

The mechanism is for light duty works and where the kinematic relation between the input and output is not required strictly.



### Friction ratchet mechanism 3

<http://youtu.be/M-3eLefY3fw>

Input: blue oscillating lever.

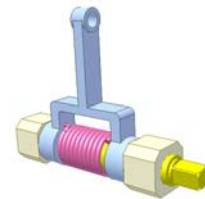
Output: yellow shaft rotating interruptedly.

One spring end is fixed to the blue lever. A slight grip between the spring and the yellow shaft is needed. Torsion spring allows motion transmission only in clockwise direction. The spring helix direction (right-handed in the video) decides the transmission direction.

The rotation direction that tends to wind up the spring is transmitted to the yellow output shaft due to friction force between the spring and the shaft.

For the inverse direction the yellow output shaft may rotate if there is no braking force or load applied to it.

The mechanism is for light duty works and where the kinematic relation between the input and output is not required strictly.



### Friction ratchet mechanism 4

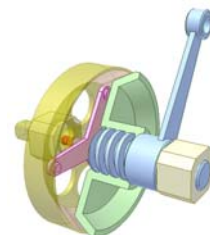
[http://youtu.be/sRkZ\\_EgUIRQ](http://youtu.be/sRkZ_EgUIRQ)

Input: blue oscillating lever with a threaded portion on its shaft.

Output: yellow inner cone disk rotating interruptedly.

The light friction of pink spring-loaded pins keeps the green outer cone disk (split for easy understanding) from rotating with the lever at moment when the lever changes its motion direction. Thus the green disk moves a little like a nut back and forth along the threaded portion of the lever. This motion creates or removes the contact between two disks (engagement or disengagement).

Thread direction (right-handed in the video) decides the transmission direction.



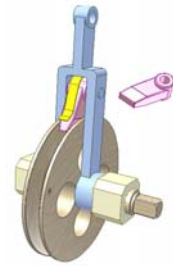
### Friction ratchet mechanism 5

<http://youtu.be/QCvbg2p0Uns>

Input: blue oscillating lever.

Output: brown V-shaped groove wheel rotating interruptedly.

Yellow flat spring maintains contact between pink pawl and the wheel.



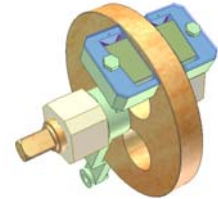
### Friction ratchet mechanism 6

<http://youtu.be/tlwmkvEeZLQ>

Input: green oscillating lever.

Output: orange wheel rotating interruptedly.

Red flat spring maintain contact between yellow wedges and the wheel.



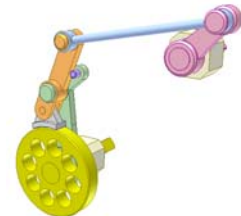
### Friction ratchet mechanism 7

<http://youtu.be/78l17ntJeqo>

Input: pink crank.

Output: yellow wheel rotating interruptedly.

Violet pin keeps grey shoe in position during non transmission time.



### Friction ratchet mechanism 8

<http://youtu.be/4C8WE6frs9E>

Input: blue oscillating lever.

Output: yellow wheel rotating interruptedly.

Gear force of the gear rack drive creates friction on the contact cylindrical surface between the rack and the wheel for transmission.

Orange plate prevents the rack from leave out during non transmission time.



### Friction ratchet mechanism 9

<http://youtu.be/l0CpzCxGWEM>

Input: yellow oscillating lever.

Output: blue shaft rotating interruptedly.

Pink pin can slide in the lever hole. Annular groove of the blue shaft contacts the pin flat bottom. Blue spring maintains this contact.

Transmission happens only when the input turns counterclockwise when the pin is wedged against the blue shaft.



### Quiet ratchet mechanism 1

<http://youtu.be/xxsCE1E7jLI>

Input: pink crank rotating continuously.

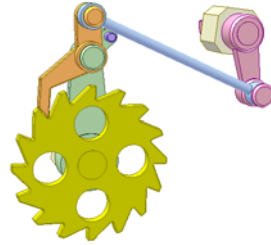
Output: yellow ratchet wheel rotating interruptedly.

Four-bar linkage (pink crank, blue conrod and block of orange pawl and green rocker) makes the green rocker oscillate.

A violet stopper is mounted on the green rocker.

Measure to create some breaking force for the green rocker is not shown.

The mechanism is quiet because when the rocker goes back, the pawl does not contact the wheel.



### Quiet ratchet mechanism 2

<http://youtu.be/OYhx7OXYKQA>

Input: pink crank rotating continuously.

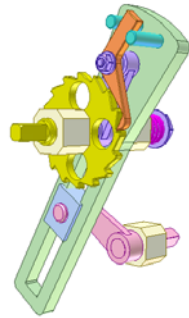
Output: yellow ratchet wheel rotating interruptedly.

Coulisse mechanism (pink crank, blue slider and green slotted rocker) makes the green rocker oscillate.

Violet crank has a pin for orange pawl. Pink spring creates some breaking force for the violet crank.

Two cyan pins on the green rocker contact the pawl.

The mechanism is quiet because when the rocker goes back, the pawl does not contact the wheel.



### Quiet ratchet mechanism 3

<http://youtu.be/9W9wgFsOVIA>

Input: pink crank rotating continuously.

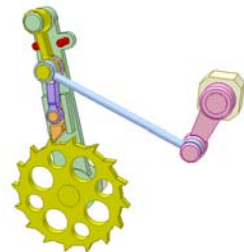
Output: yellow ratchet wheel rotating interruptedly.

Six-bar linkage (pink crank, blue conrod, yellow and violet levers, orange pawl and green rocker) makes the green rocker oscillate.

Two red stoppers are mounted on the green rocker.

Measure to create some breaking force for the green rocker is not shown.

The mechanism is quiet because when the rocker goes back, the pawl does not contact the wheel.



### Escapement 1

[http://youtu.be/fC8D\\_KzMGrk](http://youtu.be/fC8D_KzMGrk)

Pink gravity pendulum performs a harmonic angular oscillation.

Green ratchet wheel tends to rotate clockwise due to blue weight.

The pink anchor allows the wheel rotate only two teeth during one oscillation of the pendulum.

Tick-tock sound is caused when the anchor collides the wheel teeth.

The mechanism is used in pendulum clocks where the wheel motion is transmitted to hands through a gear train to show time.

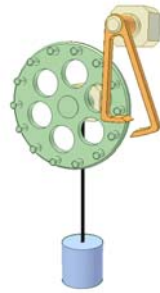
Besides the wheel transfers energy to the pendulum (timekeeper) to replace the energy lost to friction during its cycle and keep the timekeeper oscillating.



### Escapement 2

<http://youtu.be/S6ptnwOtpdQ>

Orange pendulum performs a harmonic angular oscillation.  
Green pin wheel tends to rotate clockwise due to blue weight.  
The pendulum allows the wheel rotate only two teeth during one oscillation of the pendulum.



### Escapement 3

[http://youtu.be/D49F90k7\\_vE](http://youtu.be/D49F90k7_vE)

Orange pendulum performs a harmonic angular oscillation.  
Green pin wheel tends to rotate clockwise due to blue weight.  
The pin number on each circle of the wheel is Z.  
The pendulum allows the wheel rotate an angle of  $360/Z$  deg. during one oscillation of the pendulum.



### Escapement 4

[http://youtu.be/C26G-M\\_cNjI](http://youtu.be/C26G-M_cNjI)

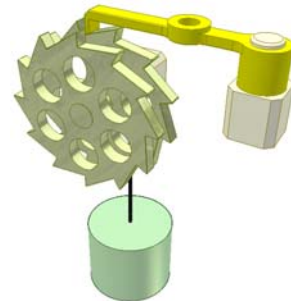
Green pendulum performs a harmonic angular oscillation.  
Blue wheel tends to rotate counterclockwise due to grey weight.  
Two identify pawls are mounted on both sides of the pendulum.  
The mechanism allows the wheel rotate two teeth during one oscillation of the pendulum.



### Escapement 5

<http://youtu.be/pN9COn0b4Dg>

Yellow pendulum performs angular oscillation.  
Twin ratchet wheel tends to rotate counterclockwise due to green weight.  
The mechanism allows the wheel rotate one teeth during one oscillation of the pendulum.



## 2.4. Pin drives

### Interrupted rotation 1

<http://www.youtube.com/watch?v=WK2dRTJvN3o>

1 revolution of the green shaft corresponds a half-revolution of the blue one.

The driving and driven shafts rotate in the same direction.

The shafts are parallel.



### Interrupted rotation 2

<http://www.youtube.com/watch?v=43FM0QRNS4Q>

1 revolution of the green shaft corresponds one-sixth-revolution of the blue one.

The driving and driven shafts do not rotate in the same direction.

The shafts are parallel.



### Interrupted rotation 3

<http://www.youtube.com/watch?v=LsysC380Cdw>

1 revolution of the blue shaft corresponds one-sixth-revolution of the green one.

The shafts are perpendicular to each other.



### Interrupted rotation 4

[http://www.youtube.com/watch?v=IX\\_TERmp4nc](http://www.youtube.com/watch?v=IX_TERmp4nc)

1 revolution of the blue shaft corresponds one-third-revolution of the green one.

The shafts are perpendicular to each other.



### Interrupted rotation 5

<http://www.youtube.com/watch?v=gG0dUrBT79k>

1 revolution of the blue shaft corresponds one-fourth-revolution of the green one.

The two shafts are skew at angle of 45 degrees.



### Interrupted rotation 6

<http://youtu.be/8tSOQDxLYvo>

1 revolution of the blue shaft corresponds one-fifteenth-revolution of the green one.

The two shafts are skew at angle of 90 degrees.



### Interrupted rotation 7

<http://www.youtube.com/watch?v=H5ZLztp5uw>

1 revolution of the blue shaft corresponds one-twelfth-revolution of the green one.

The two shafts are skew at angle of 90 degrees.

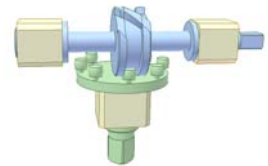


### Interrupted rotation 8

<http://www.youtube.com/watch?v=EX2Adzx53FE>

1 revolution of the blue shaft corresponds one-twelfth-revolution of the green one.

The two shafts are skew at angle of 90 degrees.



### Interrupted rotation 9

[http://www.youtube.com/watch?v=eT\\_bglEK\\_7s](http://www.youtube.com/watch?v=eT_bglEK_7s)

1 revolution of the blue shaft corresponds one-sixth-revolution of the green one.

The driving and driven shafts rotate in the same direction.

The shafts are parallel.



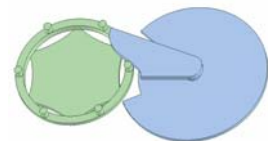
### Interrupted rotation 10

<http://www.youtube.com/watch?v=5RG3fCh4kqs>

1 revolution of the blue shaft corresponds one-sixth-revolution of the green one.

The driving and driven shafts do not rotate in the same direction.

The shafts are parallel.



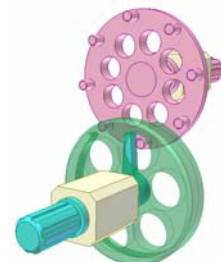
### Pin gear drive 1N

[http://youtu.be/B8dsC\\_QNyVg](http://youtu.be/B8dsC_QNyVg)

Input: the cyan shaft having an arm.

Output: the pink pin wheel.

In 1 revolution of the cyan shaft, the arm makes the output rotate 1/8 rev. The green rim keeps the output immobile during its pause period.





### Intermittent rotation mechanism

[http://youtu.be/JdJNG3\\_dIQ8](http://youtu.be/JdJNG3_dIQ8)

Input: blue disk of two cyan pins rotating continuously.

Output: orange shaft of two three wing disks rotating interruptedly.

1 rev. of the input makes the output rotate 120 deg.

Beside keeping the output shaft immobile during its dwells, the blue disk also participates in motion transmission.

The mechanism can work for two rotation directions of the input. In case of one direction one cyan pin is enough.



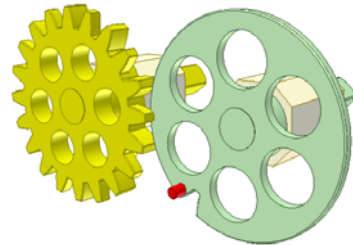
### Transmission with mutilated tooth gear

<http://youtu.be/ITEHVWzRPi>

Green driving disk of width  $w$  has a tooth groove and a red pin nearby.

Yellow driven gear of width  $2w$  has an even number of standard spur gear teeth. They alternately have full and half-width (mutilated) teeth.

During the dwell period, two full-width teeth are in contact with the circumference of the driving disk, thus locking the gear. The mutilated tooth between them is in front of the driver. At the end of the dwell period, the red pin contacts the mutilated tooth and turns the driven gear around one circular pitch. Then the full-width tooth engages the tooth groove and the driven gear moves around one more pitch. The dwell period starts again and the cycle is repeated. Totally in one revolution of the driver, the driven gear turns two circular pitches.



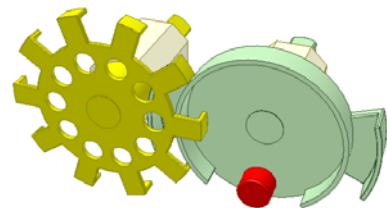
### Interrupted rotation 11

<http://youtu.be/bJFFoWd2Pr8>

Input: green disk of a red pin.

Output: yellow gear interruptedly rotating.

Inner cylinder on the green disk is for locking the output gear during dwell period. However shortly before and after the engagement of two teeth with red pin at the end of the dwell period, the inner cylinder is unable to cause positive locking of the driven gear. Consequently, a concentric auxiliary outer cylinder is added. Only two segments are necessary to obtain positive locking. Their length is determined by the circular pitch of the driven gear.





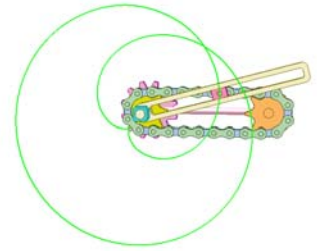
## 2.5. Bars and Cams

### Chain drive 5B

<http://youtu.be/spJVvyv9Oo0>

The orange sprocket is immobile.

The pink gear and crank is driving. The coulissee rotates interruptedly with long dwells. Its motion depends on the ratio of tooth numbers of the two sprockets (8/8) and the chain link number (24). The green curve is locus of the center of the small slider.

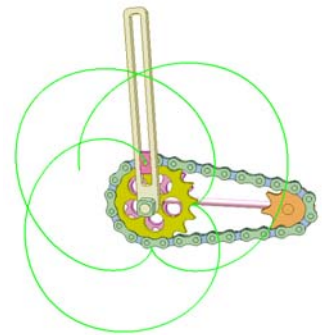


### Chain drive 5C

<http://youtu.be/ZRo3mszuHHw>

The yellow sprocket is immobile.

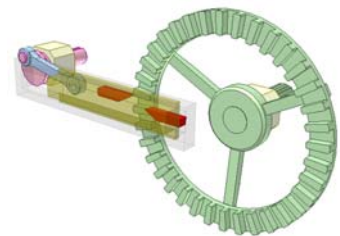
The pink gear and crank is driving. The coulissee rotates interruptedly with long dwells. Its motion depends on the ratio of tooth numbers of the two sprockets (8/16) and the chain link number (28). The green curve is locus of the center of the small slider.



### Translating cam and crank-slider mechanism 1

<http://youtu.be/OTNmbroZkqc>

Converting continuous rotary motion into intermittent rotary one.



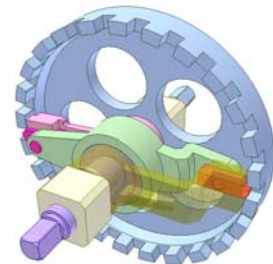
### Translating cam and crank-slider mechanism 2

<http://youtu.be/QO2UoKZagIQ>

Converting continuous rotary motion into intermittent rotary one. Input is the violet shaft.

The green double conrod oscillates on eccentric portion of the violet shaft. The magenta slider moves in slot of the pink oscillating runway. The red slider moves in slot of the yellow fixed runway and keeps the blue output disk immobile during its dwells.

The blue output disk of Z slots rotates  $1/Z$  rev. during 1 rev. of the input shaft.



#### Cam and gear mechanism 4

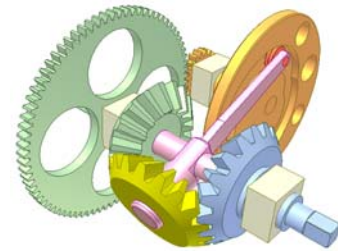
<http://youtu.be/jvAg5HHLPS4>

This is a combination of cam and bevel gear differential mechanisms. The bevel gears have the same tooth number. Input is the orange spur gear shaft to which a cam is fixed. The cam's profile is a symmetric double Archimedes curve. The green spur gear shaft and the green bevel gear are fixed together.

Transmission ratio of the spur gear drive is 4.

The yellow bevel gear idly rotates on the pink arm carrying the red roller.

The blue output bevel gear has four dwells in one revolution of the green and blue bevel gears.



#### Worm Drive 5b: Rotating and translating worm

<http://youtu.be/fl2cBpDs1tE>

A worm drive, compensated by a cam on a work shaft, produces intermittent motion of the gear.

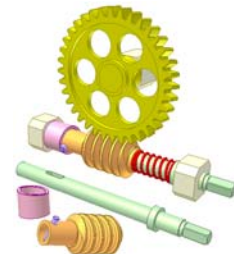
Input: green shaft.

Orange one start worm has prismatic joint with the green shaft.

Pink cam is stationary. The cam profile consists of two helix curves of opposite directions. Pitch of the curves is equal to the worm pitch.

Red spring maintains contact between the cam and violet pin.

In one revolution of the input, the gear stays immobile and then turns one tooth.



#### Mechanism for converting interrupted rotation to continuous rotation 1

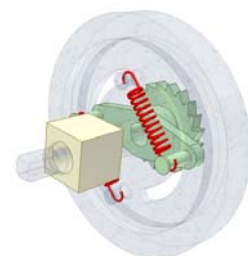
<http://youtu.be/zijv5NIT-54>

Input: green ratchet wheel of two spring pins rotating interruptedly.

Output: flywheel of two spring pins.

Flywheel inertia and spring connection between the input and output make the output rotate continuously.

Output motion irregularity depends on flywheel inertia and spring parameters.



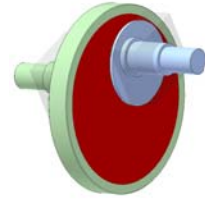
### 3. Converting continuous rotation into rotary oscillation

#### 3.1. Bars

##### 4-bar linkage mechanism

<http://www.youtube.com/watch?v=4dHKbPAQEY>

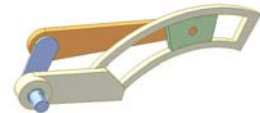
Length of red connection rod is smaller than radius of its revolution joint with the green rocker.



##### 4-bar linkage mechanism

<http://www.youtube.com/watch?v=mTxpSpPOUmU>

Length of green rocker and radius of its revolution joint with the fixed link are equal.



##### Fan swinging device

<http://www.youtube.com/watch?v=lusvDse493g>

A 4-bar linkage is used for fan swinging. The input link is the yellow connecting rod. The pink bar and the rotor house place the role of rockers.

For easy observation the transmission ratio is chosen less than in reality.



##### Four bar linkage 7

<http://youtu.be/qwB-WuX2Z18>

Four bars: blue, yellow, green and pink.

Input: the yellow bar rotating continuously.

Orange lever with positioning spring pin is for controlling the linkage.

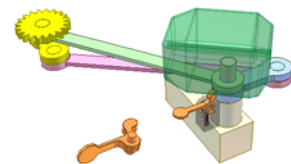
When the orange lever enters in the slot of the blue bar, the latter is kept immobile and the green bar oscillates.

When the orange lever is not in the slot of the blue bar, the blue bar oscillates and the green bar does not move because of its huge mass.

The mechanism used to be applied for fan swinging control.

For example it can be used in this case:

<https://www.youtube.com/watch?v=lusvDse493g>



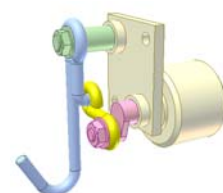
##### Auto rocker for hammock

[http://youtu.be/gaD\\_JI0YQHQ](http://youtu.be/gaD_JI0YQHQ)

Input: pink crank.

Output: blue rocker that has a hook serving as anchor point for hammocks or cradles.

Disadvantage: noise from revolute joints

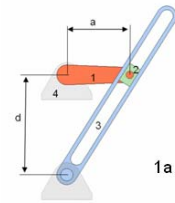


### Coulisse mechanism 1

<http://www.youtube.com/watch?v=dqt1jkwLgs0>

$a < d$ : the coulisse rocks

a: crank length; d: axle distance



### Coulisse mechanism 6

<http://www.youtube.com/watch?v=RvyKFLZi2SM>

Combination of two coulisse mechanisms.

The green rocker has working stroke slower than return one.



### Coulisse mechanism with closed curve slot 1

<http://youtu.be/qaion6T6nVg>

Two identical mechanisms on the left give two different output motions due to different relative positions of the input and output at starting. Center distance of two grey fixed bearings and the eccentricities of circular slot of green and blue rockers are equal.

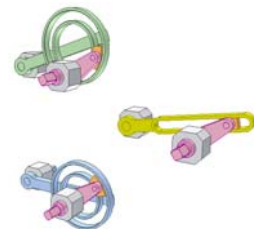
Input: pink cranks rotating regularly.

Upper mechanism: green rocker oscillates with large angle.

Lower mechanism: blue rocker is immobile.

The mechanism on the right is an ordinary coulisse one for comparison purpose.

Its yellow rocker oscillates with small angle.



### Coulisse mechanism with closed curve slot 2

<http://youtu.be/NwedertJEJl>

Two identical mechanisms give two different output motions due to different relative positions of the input and output at starting.

Input: cranks (green and pink) rotating regularly.

Upper mechanism: blue rocker oscillates with large angle.

Lower mechanism: yellow rocker oscillates with small angle and rather constant speed.

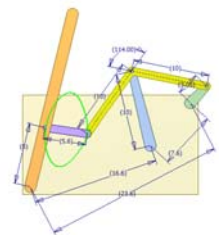
When the cranks and the rockers are in line, unstable positions happen. They can be overcome thanks to the rockers inertia.



### Dwell Rocker Linkage 1

<http://youtu.be/rhyoWC6abSI>

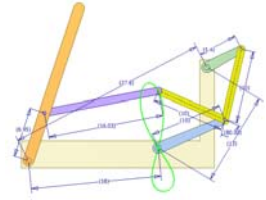
The green crank is the input. Choosing appropriate length of the violet rod in relation with the green locus enables the orange output rocker to have a long pause (half revolution of the green crank) at its rightest position.



### Dwell Rocker Linkage 2

<http://youtu.be/fECIXdX1G8M>

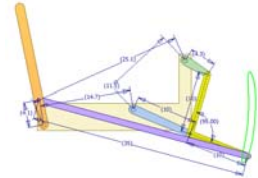
The green crank is the input. Choosing appropriate length of the violet rod in relation with the green locus enables the orange output rocker to have a pause in the middle of its stroke.



### Dwell Rocker Linkage 3

<http://youtu.be/ueyak6YAadE>

The green crank is the input. Choosing appropriate length of the violet rod in relation with the green locus enables the orange output rocker to have a pause at the ends of its stroke.



### Six bar linkage of long output dwell

<http://youtu.be/G9jeOxIRbY0>

Input: orange crank.

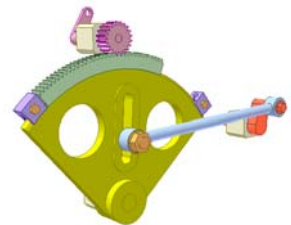
Output: yellow rocker oscillating with long dwell at its extreme right position. This occurs because point C describes a green curve part that is approximately a circular arc with its center at P. The output is almost stationary during that circular arc.



### Dwell rocker mechanism 1

<http://youtu.be/8h9mjKA5SiQ>

The red crank is driving. The pink output gear shaft oscillates with dwell at its stroke ends. The oscillation angle and dwell time of the output depend on positions of the violet adjustable stoppers and position of the orange pin in the yellow sector slot.

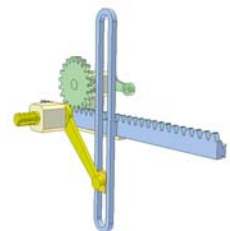


### Sinus and rack pinion drive

<http://youtu.be/BLTQ4cNahXs>

Combination of a sinus mechanism (yellow crank and blue rack-slider) and rack-gear drive makes the green shaft oscillate with amplitude of 1 revolution.

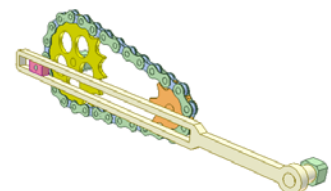
The radius of the yellow crank is equal to  $\frac{\pi \cdot D}{2}$ . D is pitch diameter of the green gear.



### Chain drive 3A

[http://youtu.be/WN01eHdUk\\_4](http://youtu.be/WN01eHdUk_4)

The coulissee rocks with long dwells at the ends of the stroke.

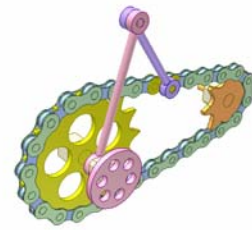


### Chain drive 3B

<http://youtu.be/Xq5SSljUwM>

The orange sprocket is driving.

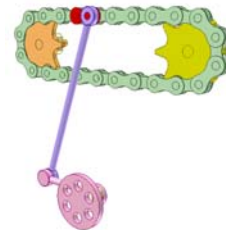
The motion of pink crank and disk depends on the ratio of tooth numbers of the two sprockets (8/16) and the chain link number (28).



### Chain drive 3C

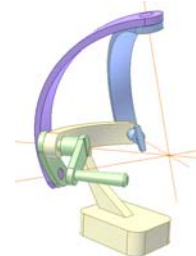
<http://youtu.be/V7sbSglTXVA>

The orange sprocket is driving. The pink crank oscillates.



### Spherical 4-bar linkage mechanism 1

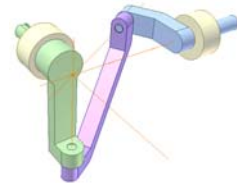
<http://www.youtube.com/watch?v=fO4-0G0mS0>



### Spherical 4-bar linkage mechanism 4

[http://www.youtube.com/watch?v=OE\\_BTQP3mE8](http://www.youtube.com/watch?v=OE_BTQP3mE8)

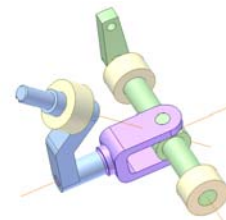
Axes of all revolution joints intersect at a common point.



### Spherical 4-bar linkage mechanism 5

<http://www.youtube.com/watch?v=M7r-6CFFuK8>

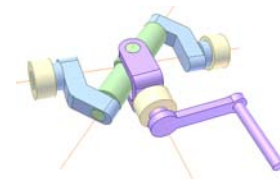
Axes of all revolution joints intersect at a common point.



### Spherical 4-bar linkage mechanism 6

<http://www.youtube.com/watch?v=E8WxHclAyMw>

Axes of all revolution joints intersect at a common point.



### Spherical 6-bar linkage mechanism

<http://www.youtube.com/watch?v=IF2btFdXEOA>

Axes of all revolution joints intersect at a common point.





### Spherical 4R mechanism 1

<http://youtu.be/NnWwkSXICBw>

4R: 4 revolute joints.

Spherical: Joint center lines intersect at a common point.

Angle between center lines of revolute joints:

for the orange input link is  $\gamma = 20$  deg.

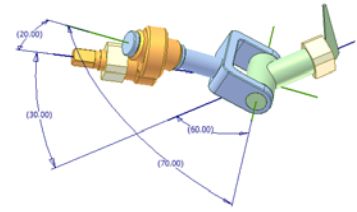
for the green output link is  $\beta = 60$  deg.

for the blue link is  $\alpha = 70$  deg.

for the base link is  $\delta = 30$  deg.

The output link oscillates.

Oscillation period is 2 rev. of the orange input link.



### Spherical 4R mechanism 1a

<http://youtu.be/mUB5VDFCZ44>

4R: 4 revolute joints.

Spherical: Joint center lines intersect at a common point.

Angle between center lines of revolute joints:

for the orange input link is  $\gamma = 20$  deg.

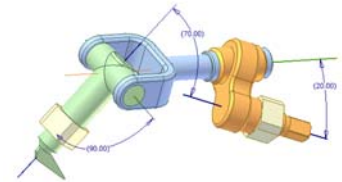
for the green output link is  $\beta = 90$  deg.

for the blue link is  $\alpha = 90$  deg.

for the base link is  $\delta = 70$  deg.

The output link oscillates.

Oscillation period is 1 rev. of the orange input link.



### Space 4-bar mechanism 11 r

<http://www.youtube.com/watch?v=-KYomnT8xSc>

R-S-S-R mechanism

R-S-R-R: Joint symbols from input to output joint.

R: revolute

S: sphere

It does not meet Kutzbach criterion.

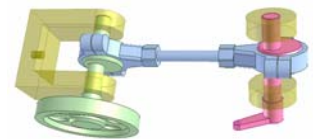


### Spatial 4-bar linkage mechanism 2

<http://www.youtube.com/watch?v=n44LvAEzovk>

Shaft of bigger eccentricity is rocker.

Angle between two shafts is arbitrary.



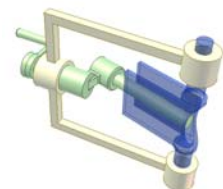
### Spatial 4-bar linkage mechanism 4

<http://www.youtube.com/watch?v=ZWgupzGoUP8>



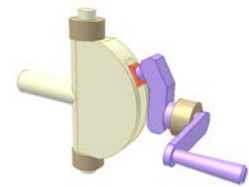
### Oblique Crank - Rocker mechanism 1

[http://www.youtube.com/watch?v=aYYJ-x\\_1nLg](http://www.youtube.com/watch?v=aYYJ-x_1nLg)



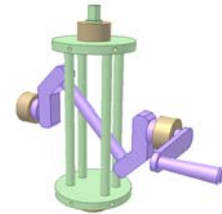
### **Oblique Crank - Rocker mechanism 2**

<http://www.youtube.com/watch?v=pxQlrf1U7G8>



### **Oblique Crank - Rocker mechanism 3**

<http://www.youtube.com/watch?v=mrxWgPrdWNw>



### 3.2. Gears

#### Transmission with teeth-uncompleted gears 12

<http://youtu.be/ndwCVs9sslo>

The blue gear with external and internal teeth is driving. The orange gear oscillates with dwell. The dwell period is varied depending the tooth numbers of the blue gear.

The oscillation forward and backward angles may be different depending on numbers of external and internal teeth and stop positions of the orange gear.

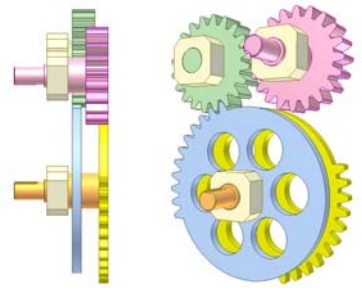


#### Transmission with teeth-uncompleted gears 11

<http://youtu.be/cGcQhXtpFoY>

The orange shaft splined with the blue and yellow gears is driving. The pink output shaft oscillates with dwell. The forward and backward angles may be different depending on the tooth numbers of the blue and yellow gears and stop positions of the pink and green gears.

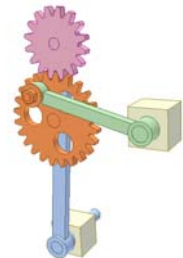
The device to keep the output shaft immobile during its dwell is not shown.



#### Gear and linkage mechanism 5

<http://www.youtube.com/watch?v=zYdwKg6bYlc>

Pink and orange gears (tooth numbers: 16 and 24) have revolution joints with the blue rocker. The orange gear has revolution joint with green rocker. The two rocker and the orange gear create a 4-bar linkage. When the pink input gear rotates regularly, two rockers (green and blue) oscillate. Their motion depends on the 4-bar linkage dimension.



#### Drive for weaving machine beater

<http://youtu.be/n0rcMMRWuJk>

Input is pink gear.

Output is yellow beater of a weaving machine.

Green gear rotates on its eccentric portion. The red bar has a revolution joint with the concentric portion of the green gear.

The drive enables the beater to perform a quick push on the right and a long rest on the left.



### Gear and linkage mechanism 16

<http://youtu.be/pPxXYyWJE44>

Orange gear pitch diameter :  $1.5R$

Pink gear pitch diameter :  $0.75R$

Crank radius of orange gear :  $R$

Crank radius of pink gear :  $0.75R$

Length of blue and green bars :  $2.9R$

Length of yellow bar :  $2.6R$

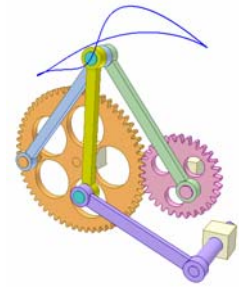
Length of violet crank :  $2.5R$

Distances between bearings:  $2.25R + 1.5R + 3.2R$

Assembly position: as start position of the simulation video.

Input : pink gear rotating regularly.

The violet crank oscillates with two dwells in one working period of 2 revolutions of the pink gear because the locus (in blue) of a cyan pin contains two portions of radius that is approximately equal to the yellow bar length.



### Triangular gear 1

<http://youtu.be/y99G7vej3-Y>

An input pink gear, rotating around fixed axis, engages with a gear of triangular shape. The latter has revolution joint with blue output crank.

The crank oscillates with dwell. The gravity maintains gear engagement.



### Oval gear 2

<http://youtu.be/c3qual5r2ks>

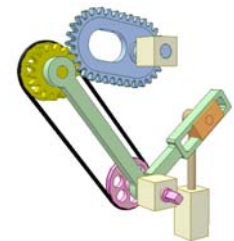
A blue gear of oval shape, rotating around fixed axis, engages with yellow gear of a gear-pulley block. The latter has revolution joint with the green angle arm that can rock around a fixed axis.

Orange slider can reciprocate in the slot of the green angle arm.

Input is pink pulley. The blue oval gear rotates irregularly. Brown bar reciprocates with dwell.

Weight of the brown bar (or spring) maintains permanent engagement of the gear drive.

Input can be the blue oval gear. In that case the belt drive isn't needed.



### Transmission with teeth-uncompleted gears 14

<http://youtu.be/ya7lC-0JyTg>

The yellow gear is driving. The orange output shaft oscillates with dwell.

The tooth number of the yellow gear decides the oscillation angle and dwell time of the output.



### Transmission with teeth-uncompleted gears 15

<http://youtu.be/eBIsbAaOOFc>

The green gear is driving. The blue output shaft oscillates with dwell.

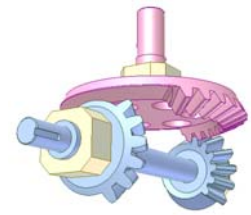
The tooth number of the green gear decides the oscillation angle and dwell time of the output.



### Transmission with teeth-uncompleted gears 16

<http://youtu.be/pZihUvOKYko>

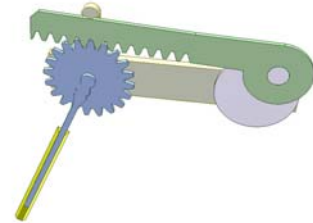
The pink gear is driving. The blue output shaft oscillates with dwell. The tooth numbers of the pink gear and the blue gears decide the oscillation angle and dwell time of the output.



### Application of rack pinion mechanism 2

[http://www.youtube.com/watch?v=jNqET\\_RBLrs](http://www.youtube.com/watch?v=jNqET_RBLrs)

Car windscreen wiper mechanism.



### Rack and gear sector

<http://youtu.be/lZddfZssoco>

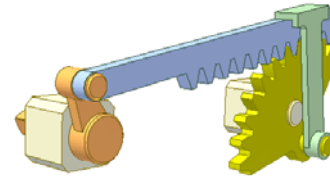
Input: orange crank

Output: yellow gear sector oscillating.

Green part maintains the engagement between blue rack and the gear sector.

The unusualness is: the gear sector oscillates around an eccentric axis, not its geometrical one. For comparison see:

[http://www.youtube.com/watch?v=jNqET\\_RBLrs](http://www.youtube.com/watch?v=jNqET_RBLrs)

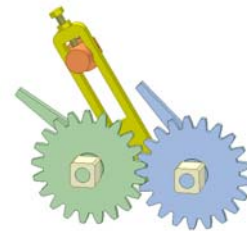


### Reverse gear drive with dwell 1

<http://www.youtube.com/watch?v=2fVz5KIZllo>

Oscilating angle of two gears depends on:

- Position of the orange pin on the yellow input crank.
- Length of the bars attached to the gears.



### Two rocker mechanism with bevel gears

<http://youtu.be/zv-yK7XECYE>

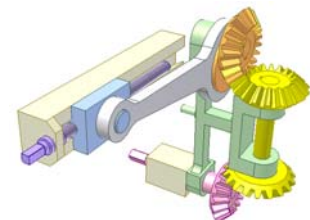
Two rockers (in grey and green) oscillate while the input pink gear rotates continuously.

Bevel gears have the same tooth number. The orange gear shaft has an eccentric for the grey rocker. It is case of four-bar linkage, in which the conrod (orange eccentric) is the driving link.

To slow down the rocker oscillation, the transmission ratio of bevel gear drives can differ from 1.

Move the blue slider by turning the violet screw for getting various course positions of the green rocker.

Instead of bevel gear drives, worm or helical gear ones can be used.

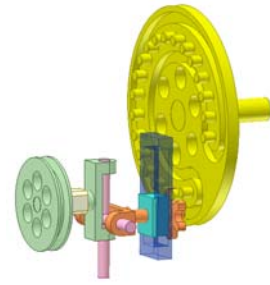


### Pin gear drive 4A

<http://youtu.be/kz2vm9FCtjY>

The orange pinion is input. Its shaft has an end sliding in the closed circular slot of the yellow pin wheel. Because of meshing force the cyan slider carrying the orange pinion reciprocates. The yellow pin wheel oscillates with constant speed.

The rotation from a stationary source (the green pulley) is transmitted to the orange pinion through the Oldham coupling.

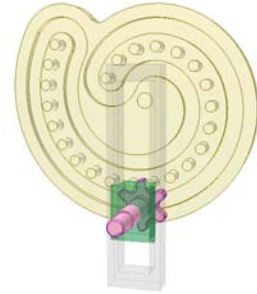


### Pin gear drive 4B

<http://youtu.be/lo1c0V4GO-I>

The pink pinion is input. Its shaft has an end sliding in the closed curved slot of the yellow pin wheel. Because of meshing force the green slider carrying the pink pinion reciprocates. The yellow pin wheel oscillates with varied speed. The angle of oscillation can be more than 360 deg.

The rotation from a stationary source is transmitted to the pink pinion by suitable mechanisms: double Hook's joint, Oldham coupling, ...





### 3.3. Cams

#### Disk cam mechanism DRr1

<http://youtu.be/vWlyxkMVBwc>

Dual cam.

The main cam is orange. The yellow one is added for cam geometrical closure.

Its profile must be designed to maintain permanent contact of both rollers with cams.



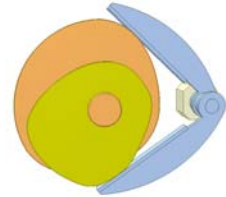
#### Disk cam mechanism DRp1

<http://youtu.be/a9GfqALs1Q>

Dual cam.

The main cam is orange. The yellow one is added for cam geometrical closure.

Its profile must be designed to maintain permanent contact of both follower's planes with cams.



#### Cam mechanism of output with large oscillation angle

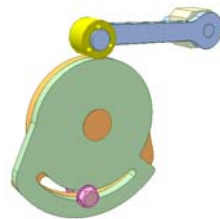
<http://youtu.be/e6jSX1CbgVw>



#### Disk cam assembly 1

<http://youtu.be/Fo1XpEgY6MY>

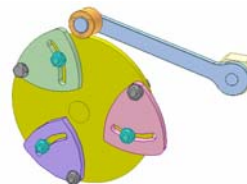
The cam assembly consists of orange cam and green one. They are fixed together by pink bolt. Their relative position can be adjusted to get various dwell times of the blue follower. Gravity maintains permanent contact between rollers and cam.



#### Disk cam assembly 2

[http://youtu.be/paCOPz\\_h4iM](http://youtu.be/paCOPz_h4iM)

The cam assembly consists of a yellow round disk and some triangular cams. They are fixed together by cyan bolts. Their relative position can be adjusted to get various motions of the blue follower. Gravity maintains permanent contact between rollers and cam.



### Disk cam mechanism DR1a

<http://youtu.be/Ru1jSCA9pfk>

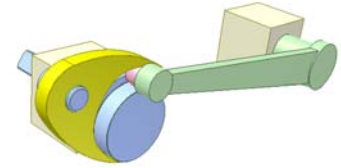
The cam consists of two parts: blue round disk and yellow cam. Green follower moves one time during two revolutions of the cam.

The weight forces the follower toward the cam. Spring force is another possible way. There must be sufficient friction between the yellow cam and the blue pin to avoid accidental motion of the yellow cam.

The idea of this video is taken from

<http://www.youtube.com/watch?v=M7H-wnHxxXU>

by the introduction of a Youtube user, TheWindGinProject.



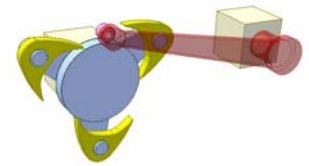
### Disk cam mechanism DR1b

<http://youtu.be/eNyDPvgZBVs>

The cam consists of a blue round disk and  $n (=3)$  yellow cams.

The red follower is immobile during one revolution of the blue disk and then moves  $n (=3)$  times during the next revolution.

The weight forces the follower toward the cam. There must be sufficient friction between the yellow cams and the blue pins to avoid accidental motions.



### Fast cam follower motion

<http://youtu.be/Zs4gKdqFwGk>

Input: blue shaft with two gears fixed on it.

Yellow block and pink block rotates idly on a fixed shaft. Each block has identical cam. The yellow rotates faster than the pink.

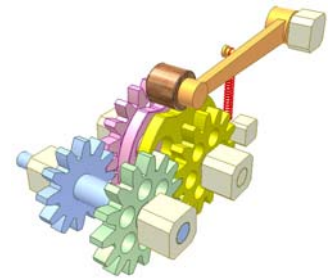
Output: orange rocker. Its roller contacts both cams. Motion of the follower is as fast as in case there is no the pink cam but the working cycle is long (every three revolutions of the yellow cam).

Tooth number of the blue gear 12

Tooth number of the pink gear 18

Tooth number of the green and yellow gears: 15

The cycle can be very long by altering gear tooth numbers.

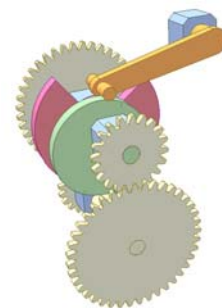


### Cut-out cam

<http://www.youtube.com/watch?v=4RJhFvLrOo>

A rapid rise and fall within 90 deg. was desired. This originally called for the pink cam contour but produced severe pressure angles. The condition was improved by providing an additional green cam which rotates 4 times faster than the pink cam.

The pink cam was then completely cut away for the 90 deg. The desired motion, expanded over 360 deg. ( $90 \times 4 = 360$ ), is now designed into the green cam. This results in the same pressure angle as would occur if the pink cam rise occurred over 360 instead of 90 deg.



### Sphere cam 1

[http://youtu.be/\\_Uld85q0hCc](http://youtu.be/_Uld85q0hCc)

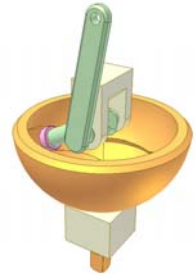
Roller axis, crank axis and cam rotary axis intersect at the center of the cam sphere.



### Sphere cam 2

<http://youtu.be/Hslk7-EIVis>

Roller axis, crank axis and cam rotary axis intersect at the center of the cam sphere.



### Sphere cam 3

<http://youtu.be/scnSa6f6QCE>

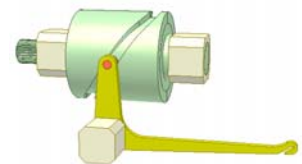
Roller axis, crank axis and cam rotary axis intersect at a point that is not the center of the cam sphere. The roller must be long enough to maintain contact between follower and cam that are of gravity constraint:



### Barrel cam mechanism BR1

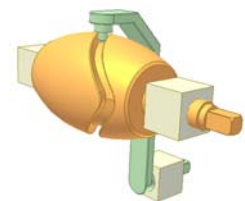
<http://youtu.be/qYRU5eu1HHI>

A barrel cam with milled grooves is used in sewing machines to guide thread. This kind of cam is also used extensively in textile manufacturing machines such as looms and other intricate fabric-making machines.



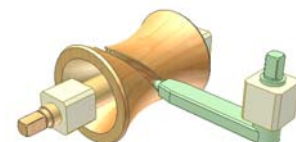
### Globoid cam 1

<http://youtu.be/sYJ3BoLOXBw>



### Globoid cam 2

<http://youtu.be/jHDk9hKQ4M8>

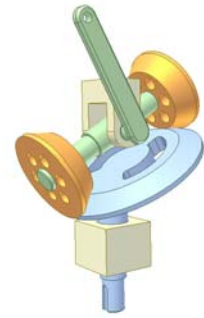


### Oblique disk-rocker mechanism

[http://www.youtube.com/watch?v=6CxfiO\\_afzo](http://www.youtube.com/watch?v=6CxfiO_afzo)

A spherical mechanism: axes of all revolution joints intersect at a common point.

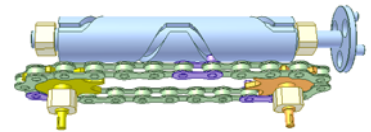
Rotation of the small bevel wheels around their axes is irregular.



### Barrel cam mechanism BT7

<http://youtu.be/qV9H8Gjp8KU>

Rotational motion is converted into oscillating motion with dwells. When moving in the cam's groove, the violet chain's pins has linear motion.

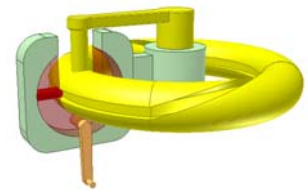


### Torus cam

<http://youtu.be/mCRdbEv3ACI>

Helix torus joint.

Converting continuous rotation into oscillation between two 90 deg. skew shafts. The oscillating angle can be more than 180 deg.



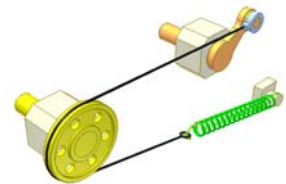
### 3.4. Belts and cables

#### Cable drive 13a

<http://youtu.be/cHOMfNQPTThY>

A simple way to convert continuous rotation to oscillatory motion. The spring creates friction between the yellow wheel and the cable. It acts like the mechanism in video “Application of rack pinion mechanism 2” of this channel.

However in case of large motion the spring deformation is too big that causes unnecessary load on the bearings. See “Cable drive 12b” and “Cable drive 12c” of this channel for the ways to overcome this weakness. The oscillatory angle can be more than 360 deg. by reducing the yellow wheel diameter.



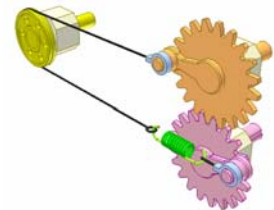
#### Cable drive 13b

<http://youtu.be/7lOxH017ZvU>

Converting continuous rotation to oscillatory motion.

Using one crank more and gear drive reduces the spring deformation. See “Cable drive 12a” of this channel for comparison.

Beside creating friction between the yellow wheel and the cable, the spring compensates velocity difference of the cable ends caused by the two cranks.



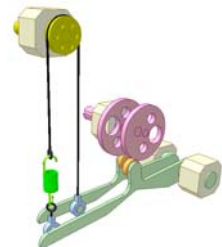
#### Cable drive 13c

[http://youtu.be/2ECoeKLEj\\_c](http://youtu.be/2ECoeKLEj_c)

Converting continuous rotation to oscillatory motion.

Using twincam and two levers reduces the spring deformation. See “Cable drive 12a” of this channel for comparison.

Beside creating friction between the yellow wheel and the cable, the spring ensures a permanent contact between rollers and cam and compensates velocity difference of the cable ends caused by the two levers.



#### Chain drive 8B

<http://youtu.be/yuTpslrriY>

Converting continuous rotation into oscillation with dwells at one end of the course.

Three sprockets are identical. The pink one is driving. The violet chain link has an axle for a revoluton joint with the red slider.

The dwell time depends on axle distance of two blue sprockets.



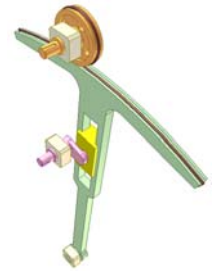
### Cable drive 25

<http://youtu.be/y8Squ43mUrE>

Converting continuous rotation of the pink crank to reciprocating rotation of the orange pulley.

The brown cable wraps 1 revolution around the orange pulley. Two cable ends are fixed to the green sector.

Rotation angle of the output orange pulley can be more than 1 revolution.





## 4. Altering rotary oscillations

### Typewriter drive

<http://www.youtube.com/watch?v=jYhkRX--2zl>

Two four-bar linkages are connected in series. The finger force of a typewriter is multiplied producing a strong hammer action at the roller from a light touch.

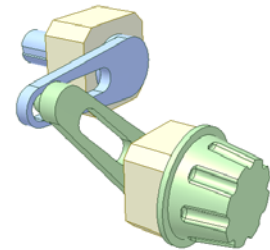


### Angle doubling drive

<http://youtu.be/zwYQ9fy5CtQ>

This angle doubling drive will enlarge the oscillating motion of one machine member into an output oscillation of the other. If gears are employed, the direction of rotation cannot be the same unless an idler gear is installed. In that case, the centers of the input and output shafts cannot be too close. Rotating the input link clockwise causes the output to follow in a clockwise direction. For any set of link proportions, the distance between the shafts determines the gain in angle multiplication.

The video shows case when the green link rotates 90 deg., the blue rotates 180 deg.



### Slider crank and coulisse mechanism 1

<http://youtu.be/SdwlGoJ-3aq>

Input: blue crank that has turning angle  $\alpha$ .

Output: orange bar that has turning angle  $\beta$ .

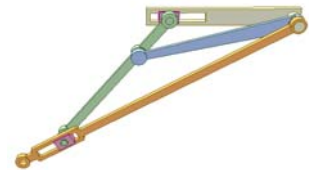
$\alpha, \beta = 0$  when the blue crank and the orange bar are in line with the fixed runway.

Distance between revolution joints of the green bar is  $16 + 6$ .

Distance between revolution joints (length) of the blue crank is 20.

In the  $\alpha$  range from 0 to 20 deg.,  $\beta$  is nearly double  $\alpha$  with max error of 5%.

The mechanism can be applied for controlling ball retainer in Rzeppa joints.



### Cable drive 14

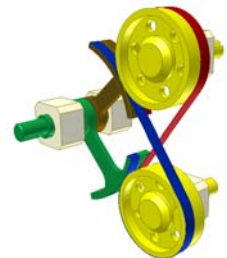
[http://youtu.be/DaQR9ll\\_YMo](http://youtu.be/DaQR9ll_YMo)

Input: The brown crank having oscillating rotational motion.

The green crank has the same motion but of inverse direction.

Two yellow wheel has oscillating rotational motion of opposite direction.

Each belt (red and blue) has one end fixed to the brown crank, the other to green one.



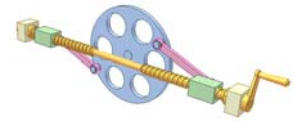
### Nut-screw and bar mechanisms 1a

<http://youtu.be/gFAj1TZCLMs>



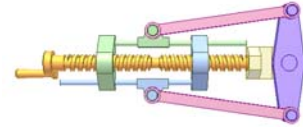
**Nut-screw and bar mechanisms 1b**

<http://youtu.be/asan09b1Gsc>



**Nut-screw and bar mechanisms 1c**

[http://youtu.be/oA487meC\\_1w](http://youtu.be/oA487meC_1w)



**Nut-screw and bar mechanisms 2a**

<http://youtu.be/xE8pSM9Mlyo>



**Nut-screw and bar mechanisms 6**

[http://youtu.be/\\_q5iKo63rjQ](http://youtu.be/_q5iKo63rjQ)

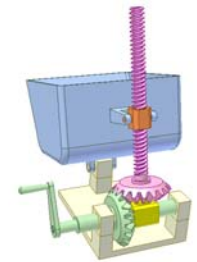
Nut-screw brake.



**Nut-screw and bar mechanisms 2b**

<http://youtu.be/FVahglFr51c>

Device for emptying a tank.



**Nut-screw and bar mechanisms 3**

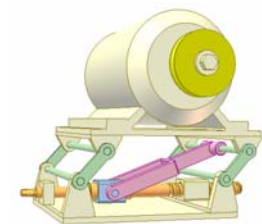
<http://youtu.be/o4N6iviUdgs>



**Nut-screw and bar mechanisms 7**

<http://youtu.be/fBJr9DMLQtQ>

Belt tensioner.



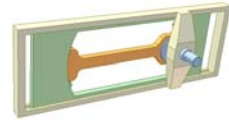
## 5. Converting continuous rotation into linear motion

### 5.1. Bars

#### Slider-crank mechanism

<http://www.youtube.com/watch?v=OltIA-RI86A>

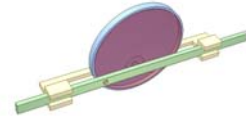
Rotary joint between the conrod (in orange) and the slider (in green) is larger than the conrod length.



#### Slider-crank mechanism

<http://www.youtube.com/watch?v=0nnS8ycMVNA>

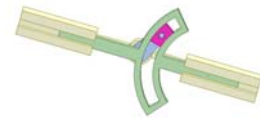
Rotary joint between the conrod (in violet) and the crank (in blue) is larger than the conrod length.



#### Slider-crank mechanism

<http://www.youtube.com/watch?v=aJx1iQHdB6E>

Rotary joint between the conrod (in pink) and the slider (in green) is larger than the conrod length.



#### Crank slider mechanism 2

<http://youtu.be/Dv6m1AFejJ4>

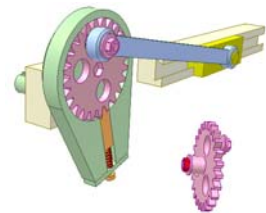
Blue piston-rod is prolonged and works in a guide, which is in line with the center of yellow fixed cylinder. The lower part of green connecting-rod is forked to permit the upper part of the piston-rod to pass between. So the piston is guided very well.



#### Mechanism for adjusting crank radius 1a

<http://youtu.be/xaMjCiWGpws>

Radius of green crank is adjusted by turning pink gear after retracting the orange pin. The red nut at the back of the pin gear is for clamping the gear after adjustment.



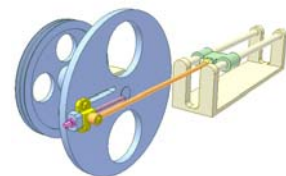
#### Mechanism for adjusting crank radius 2a

<http://youtu.be/MCoOX06KnGo>

Input: blue shaft.

Output: green slider linearly reciprocating.

The video shows the changing stroke length of the green slider by turning pink screw to change crank radius.



### Mechanism for adjusting crank radius 2b

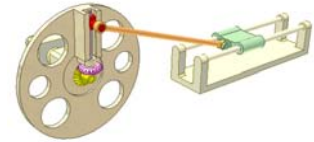
<http://youtu.be/gpLN-fB08Vs>

Input: beige disk carrying red slider-pivot.

Output: green slider linearly reciprocating.

Turn yellow bevel gear to change position of the red slider-pivot on the disk (to adjust crank radius) to get various output strokes.

Device for fixing the red slider-pivot to the disk after adjusting is not shown.



### Mechanism for adjusting crank radius 1b

<http://youtu.be/jLMNtKjM2CE>

Input: pink eccentric shaft.

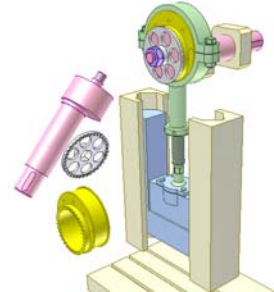
Output: blue slider linearly reciprocating.

Yellow eccentric bush is idly mounted on the eccentric of the pink shaft. Turn the yellow bush to get various angular positions in relation with the pink shaft, corresponding various stroke lengths of the output.

The grey gear disk and violet nut are for fixing the yellow bush and the pink crank together after adjustment.

Stroke position can be adjusted thanks to screw and round nut of the green conrod.

The video shows the process to reduce stroke length from max value to shorter one.



### Slider-crank mechanism for adjusting stroke position 1

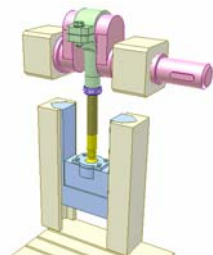
<http://youtu.be/JMIEaNwuMEk>

Input: pink crankshaft.

Output: blue slider linearly reciprocating.

Turn yellow screw to alter length of the assembly conrod (yellow screw, green bush and violet nut) for adjusting stroke position of the blue slider.

The violet nut is for fixing the conrod members together after adjusting.



### Slider-crank mechanism for adjusting stroke position 2

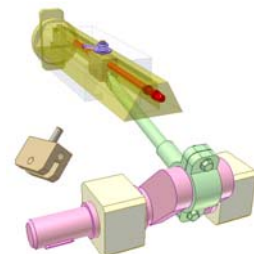
<http://youtu.be/6iNz9Q6-0oc>

Input: pink crankshaft.

Output: yellow slider linearly reciprocating.

Turn red screw to alter position between the yellow slider and the brown inner slider for adjusting stroke position of the yellow slider.

The violet nut is for fixing the two sliders together after adjusting.



### Slider-crank mechanism having a pause at both ends of stroke 2

<http://www.youtube.com/watch?v=TTbWZcg1N6c>

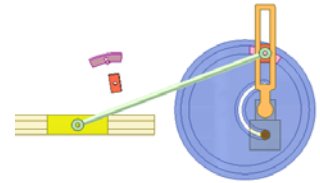


### Slider crank mechanism with eccentric

[http://youtu.be/zR\\_iDdRIIm0](http://youtu.be/zR_iDdRIIm0)

Input is the orange crank.

Turn the blue eccentric and fix it to get various positions of the slider course.

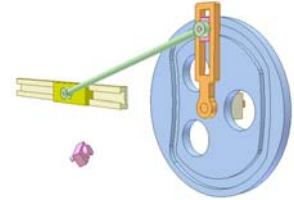


### Slider crank mechanism with face groove cam

<http://youtu.be/RFaLPuKkyAE>

Input is the orange crank.

The blue cam is fixed. The cam profile has two portions, radii of which are equal to the length of the green connecting rod. Thus the yellow slider reciprocates with dwells at both ends of its course.



### Slider-crank mechanism having a pause at both ends of stroke 3

<http://youtu.be/s0Lx-6c9JYk>

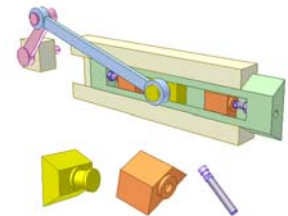
Input: pink crank.

Output: green slider that linearly reciprocates with dwell at both ends of stroke.

Yellow slider moves along the dovetail shaped groove of the green slider.

Violet screws are for adjusting positions of orange sliders to get various stroke lengths of the green slider.

Ball spring devices for positioning the green slider at its end positions are not shown.



### 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.

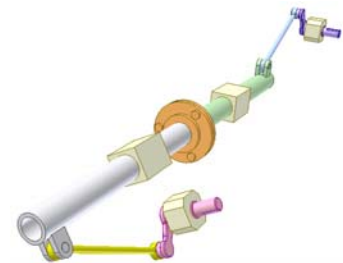
- If the two cranks rotate in the same direction, the output crank rotates irregularly.

This phenomenon has been seen for parallelogram and anti-parallelogram 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.

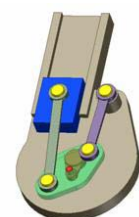
The revolution joint (in orange) between two sliders is for easy setting relative position of two crank shafts.



### Slider-crank mechanism with added double crank

<http://www.youtube.com/watch?v=fBS00ak30OU>

The slider's stroke length is nearly 4 times of the red crank length.

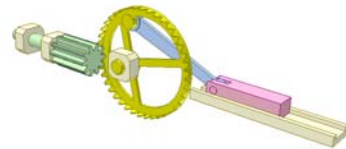


### Face gear 15

<http://youtu.be/2Y8jBdF8U-4>

The face gear is placed eccentrically to the shaft, therefore the relative radius changes. Due to variable circular motion of the face gear the pink slider's left to right motion is faster than right to left one.

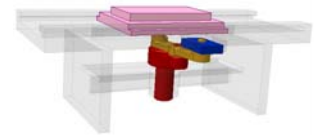
The face width of the face gear must be small to enable gear meshing.



### Slider-crank mechanism with added double crank

<http://www.youtube.com/watch?v=Glm8FxmNI>

The slider's stroke length is 4 times of the red crank length.



### Dwell Slider Mechanism 2

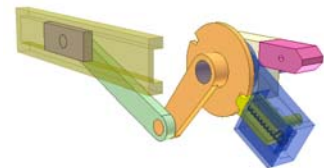
<http://youtu.be/mq3jsfBg2OI>

The input blue crank carries the yellow pawl which engages two slots of the orange disk to make the violet slider reciprocate with dwell in the middle of its stroke. The pink cam controls the pawl by pushing the pawl pin.

1 working cycle of the mechanism corresponds 2 revolutions of the blue input crank.

Angle between the two slots on the orange disk is not 180 deg.

The device (a ball plunger) to keep the slider immobile during its dwell is not shown.



### Inverse parallelogram mechanism 15

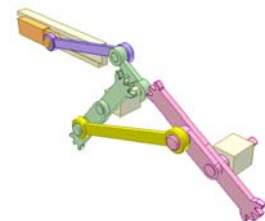
<http://youtu.be/QmEalhiP8f0>

Input: pink crank rotating regularly.

Output: orange slider.

Combination of inverse parallelogram mechanism and slider crank one gives the output an almost regular velocity during its forward stroke.

Added gears help the inverse parallelogram mechanism overcome unstable positions.



### Slider-twin crank mechanism having a pause at both ends of stroke

<http://www.youtube.com/watch?v=lkwYHs2Lba0>

Angle between two cranks is 90 degrees.

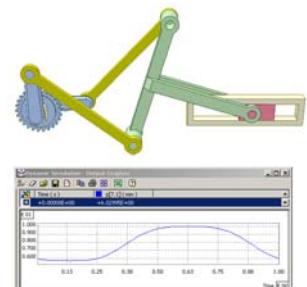
Crank length = 8, Conrod length = 21

T-shape link is an isosceles triangle. Length of the bottom side = 21. Length of altitude to the bottom side = 18

Eccentricity = 0

The dwell period at each end of stroke is around 10% of cycle time.

The graph shows slider position.



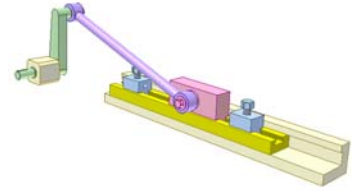


#### Dwell slider mechanism 4

<http://youtu.be/YJhMMj3u73M>

The green crank is driving. The yellow output slider reciprocates with dwell at its stroke ends.

The stroke length and dwell time of the output slider depend on positions of the blue adjustable stoppers. For max stroke length: distance between the stoppers equals to the pink slider length.

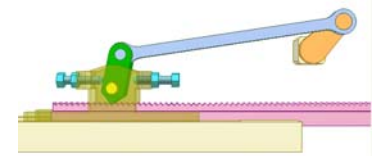


#### One way linear clutch 1

<http://youtu.be/beMNGEcYTvc>

The yellow slider reciprocates but the pink rack moves to the left only.

To adjust the blue screws positions for the move to the right.

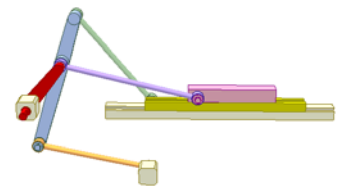


#### Double slider crank mechanism

<http://youtu.be/r92k9A3sgrg>

The pink slider moves on the yellow one. The latter moves on stationary runway. Both sliders are driven from the red driving crank. The stroke of the yellow slider is longer than the one of the pink slider. Their dead points are a little different in term of phase.

This mechanism is applied in wire bending machines.



#### Shaper with Coulissee mechanism 1

<http://www.youtube.com/watch?v=hZEdBbc-JMo>

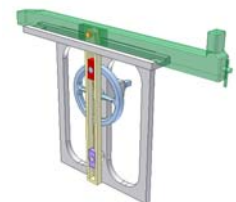
Reciprocating motion having working stroke slower than return one.



#### Shaper with Coulissee mechanism 2

<http://www.youtube.com/watch?v=5cb7D9pLcq4>

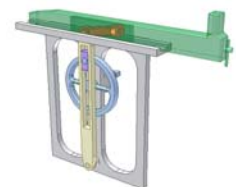
Reciprocating motion having working stroke slower than return one.



#### Shaper with Coulissee mechanism 3

<http://www.youtube.com/watch?v=lcbya3378qE>

Reciprocating motion having working stroke slower than return one.



### Mechanism for increasing stroke length 3

<http://youtu.be/ITYKyGwMD9Q>

Input: orange crank rotating regularly.

Output: grey bar linearly reciprocating with adjustable stroke length.

Yellow lower slider has revolution joint with pink slider.

Adjust position of the pink slider on the fixed runway to get various stroke lengths of the output.

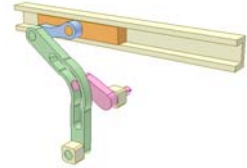
The video shows stroke length reducing process when the mechanism is running.



### Coulisse mechanism of curved slot

<http://youtu.be/J7BHvTM7gcA>

The circular arc on the oscillating link permits the link to reach a dwell during the right position of the output slider.

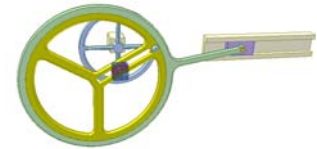


### Coulisse mechanism 4

<http://www.youtube.com/watch?v=zPh2EzvuVnc>

Combination of a coulisse mechanism and a slider-crank mechanism.

Reciprocating motion has working stroke slower than return one.

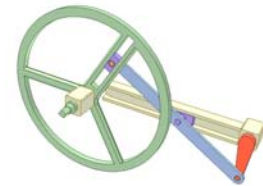


### Coulisse mechanism 5

<http://www.youtube.com/watch?v=yha4fgFOP0k>

Combination of a coulisse mechanism and a slider-crank mechanism.

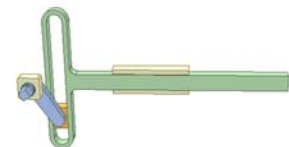
The green wheel has complicated rotation.



### Sine mechanism 1

<http://youtu.be/VALy2PIBuM4>

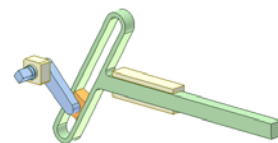
Relation between the rotation angle of the crank and the position of the green slider is a sinus function.



### Sine mechanism 2

<http://youtu.be/5GXZ2AzRJqE>

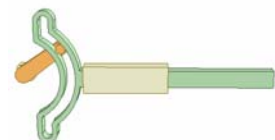
Sine mechanism of inclined slot has the same stroke length as the one of uninclined slot but the rotation angles of the crank to reach the extremities of the slider are different.



### Sine mechanism of curved slot 1

<http://youtu.be/VPZO7txZIZU>

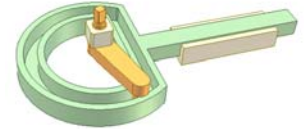
The circular arc on the reciprocating link permits the link to reach a dwell during its right position.



### Sine mechanism of curved slot 2

<http://youtu.be/BpU7YqW2eH4>

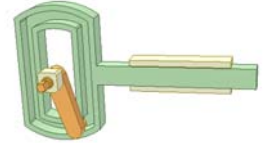
The circular arc on the reciprocating link permits the link to reach dwell at its left position.



### Sine mechanism of curved slot 3

<http://youtu.be/Jb03Ru6E-UA>

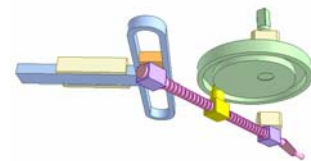
The circular arc on the reciprocating link permits the link to reach dwell at its center position.



### Sine mechanism 4

<http://youtu.be/O4qYJ77Zbq0>

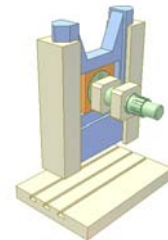
Rotate the pink screw to adjust stroke of the blue slider.



### Sine mechanism 3: Press

<http://youtu.be/TZR7ccjy9VQ>

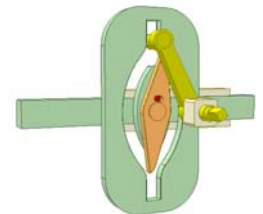
This kind of press can give 2500 ton forging force, 40 strokes per minute.



### Cam and sine mechanism 2

<http://youtu.be/CufL-cYm6eM>

The green slider reciprocates with dwells at both ends of its stroke. The orange rhomb-shaped guide helps the yellow crank's pin enter into both round slots alternately. A spring forcing the guides against the red pin clockwise is not shown.



### One way clutch 7: Press

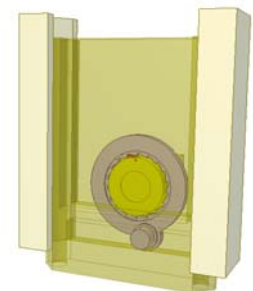
<http://youtu.be/pOY0Sy33Lg4>

The yellow input shaft carrying the red pawl rotates continuously anti-clockwise. The violet disk (ratchet wheel) has a pin that slides in a slot of the yellow slider.

The slider goes up by the ratchet mechanism action but goes down by its weight (when the slider moves faster than the input shaft) so that the motion cycle time is reduced. For this prototype, 4 revolutions of the input shaft correspond 7 double strokes of the slider.

The ratchet mechanism can be replaced by a roller clutch of video:

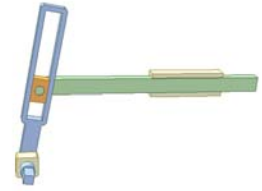
<http://youtu.be/umaTet0aAao>



### Tangent mechanism

<http://youtu.be/DymKkYp-W-A>

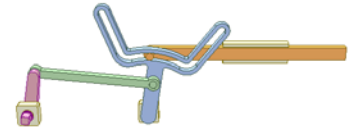
Relation between the rotation angle of the blue crank and the position of the green slider is a tangent function. No link can have full rotation



### Tangent mechanism of curved slot

<http://youtu.be/0wMIH4x0OKo>

Combination of 4R mechanism and tangent mechanism. The latter has curved slot so the slider has a dwell in the middle of its stroke.

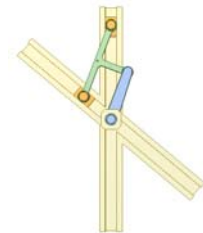


### Ellipse mechanism 1a

<http://youtu.be/gnJSN0T4AUw>

Ellipse mechanism with non 90 deg. angle between sliding directions. Position of joint between the blue crank and the green connecting rod and radius of the blue crank must be selected based on the description in

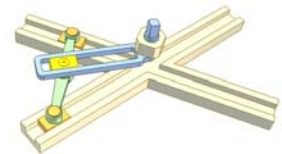
<http://www.youtube.com/watch?v=8WCee-fP9rg>



### Ellipse mechanism 1b

<http://youtu.be/0h0ofdDauQE>

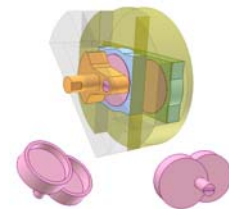
Ellipse mechanism with non 90 deg. angle between sliding directions.



### Ellipse mechanism 2

<http://youtu.be/n59bLDYTEFE>

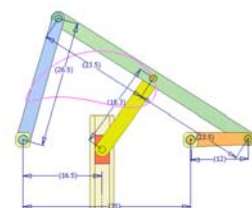
Ellipse mechanism with 90 deg. angle between sliding directions. Stroke length of the blue and green sliders equal four times of the pink crank radius.



### Dwell Slider Linkage 1

<http://youtu.be/IDL-D7DMOc0>

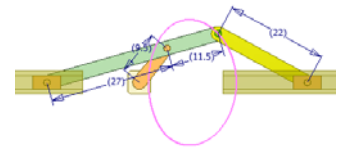
Length of the yellow conrod approximates to the radius of curve segment of the pink locus. The orange slider has dwell at its upper position.



### Dwell Slider Linkage 2

<http://youtu.be/bAhpXjeDOBY>

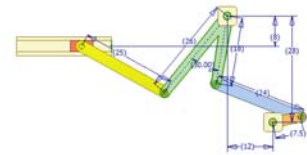
Length of the yellow conrod approximates to the radius of curve segment of the pink locus. The orange right slider has dwell at its left position.



### Dwell Slider Linkage 3

[http://youtu.be/UBwra\\_MjI5g](http://youtu.be/UBwra_MjI5g)

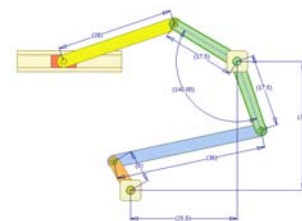
The slider dwells at its leftest position, when toggle positions of the conrods happen one after another at the same time. The mechanism is used in screw making machines



### Dwell Slider Linkage 4

<http://youtu.be/XI0HrvyT504>

The slider dwells at its leftest position, when toggle positions of the conrods happen one after another at the same time.

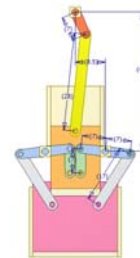


### Dwell Slider Linkage 5

<http://youtu.be/hP4hEeigS4Y>

This mechanism is used in deep stamp machines.

The outer slider has long dwell during 1/3 revolution of the red crank.



### Double coulisse mechanism 1

[http://youtu.be/m2\\_HCp8DmNU](http://youtu.be/m2_HCp8DmNU)

Input is pink crank of constant velocity.

Output is green slider of forwards slow constant velocity motion to the left and quick return. The mechanism can be applied for shapers (machine tools)



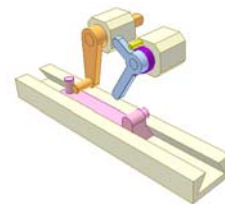
### Slider crank mechanism with elbow-lever 1

<http://youtu.be/QHqbYz8IBTI>

Input: orange crank having a stud.

Output: pink slider linearly reciprocating with dwell at its leftest position.

Blue elbow-lever returns to its initial position thanks to violet coil spring.



### Slider crank mechanism with elbow-lever 2

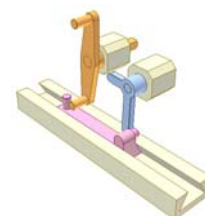
[http://youtu.be/fOO\\_7RDauIM](http://youtu.be/fOO_7RDauIM)

Input: orange crank having two studs.

Output: pink slider linearly reciprocating.

Blue elbow-lever returns to its initial position thanks to the gravity.

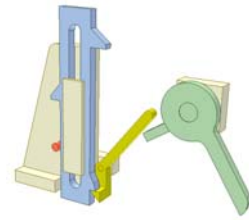
In one revolution of the input the slider performs two double strokes.



### Dwell Slider Mechanism 3

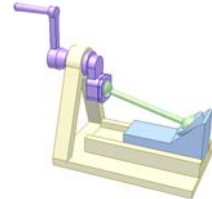
<http://youtu.be/-QT0RL93ST4>

The green twin crank rotates with slow speed. The blue slider reciprocates with quick return and dwells at its end positions. The slider and the yellow pawl return by their weight or by springs force (not shown). Angle between the levers of the twin crank decides dwell time.



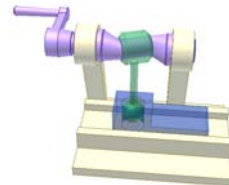
### Spatial slider crank mechanism 1

<http://www.youtube.com/watch?v=qAGZCB3vZDI>



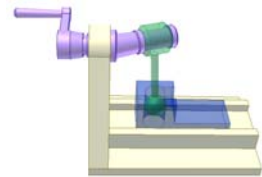
### Spatial slider crank mechanism 2

<http://www.youtube.com/watch?v=PM--PK5ROkg>



### Spatial slider crank mechanism 3

<http://www.youtube.com/watch?v=oqtN3Zrf9Nk>



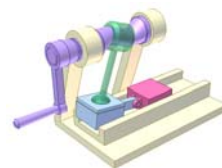
### Spatial slider crank mechanism 4

<http://www.youtube.com/watch?v=bBBuLt0Vz3k>



### Spatial slider crank mechanism 5

<http://www.youtube.com/watch?v=sc-qsmidXVw>



### In-line reciprocator

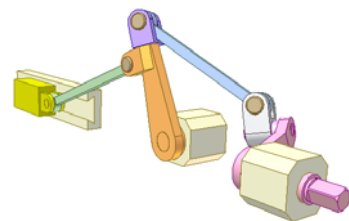
<http://youtu.be/EG7j2koS9DQ>

Input: pink shaft.

This is a simple way to convert rotary motion to reciprocating motion. Both input and output shafts are in line with each other.

The right half of the device is a spatial reciprocator. Rotating the input crank causes its link to oscillate. A second connecting link then converts that oscillation into the desired in-line output motion.

Rotary axes of the pink shaft and the orange crank, axis of revolution joint between the orange crank and violet part, axis of revolution joint between the pink shaft and grey part must be concurrent.





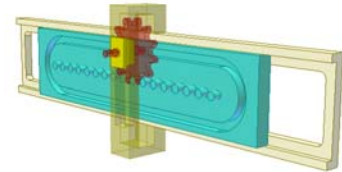
## 5.2. Gears

### Pin rack drive 2A

<http://youtu.be/RxgB1xEv5UM>

The red pinion is input. Its shaft has an end sliding in the running track shape slot of the cyan pin rack. Because of gear forces the cyan pin rack and the yellow slider carrying the red pinion reciprocate.

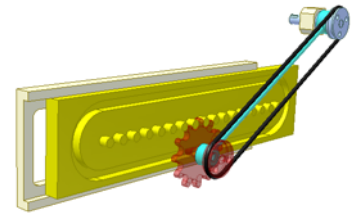
The rotation from a stationary source is transmitted to the red pinion by suitable mechanisms: double Hook's joint, Oldham coupling, ...



### Pin rack drive 2B

[http://youtu.be/itP\\_dBADciU](http://youtu.be/itP_dBADciU)

The blue pulley is input. The red pinion shaft has an end sliding in the running track shape slot of the yellow pin rack. Because of gear forces the yellow pin rack reciprocates and the cyan arm oscillates.

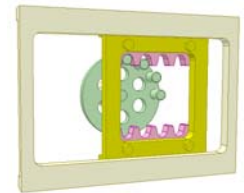


### Pin rack drive 3

<http://youtu.be/ohRko--KoKc>

The green pin wheel is input. The yellow frame carrying two pink racks reciprocates with constant velocity. The dwell at the stroke ends is possible by cutting the pins.

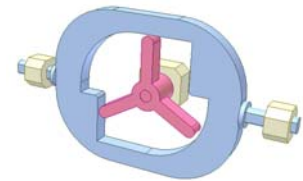
Max stroke length =  $\frac{1}{2}$  circumference of the pin wheel rolling circle.



### Pin rack drive 4

<http://youtu.be/q7hpu95C-2M>

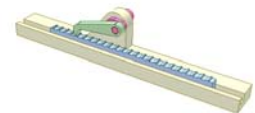
The pink rotor (3-pin wheel) is driving. The blue frame (assembly of two racks of one tooth each) reciprocates with dwell.



### Ratchet mechanism 6

<http://youtu.be/GSABM0GR-j8>

This mechanism directly converts the continuous rotary motion of a drive shaft into the intermittent linear motion of a rack.

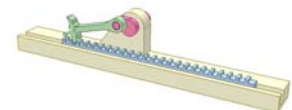


### Ratchet mechanism 7

[http://youtu.be/mDbLJR\\_bcZU](http://youtu.be/mDbLJR_bcZU)

This mechanism directly converts the continuous rotary motion of a drive shaft into the intermittent linear motion of a rack.

To flop the green pawl to change the motion direction of the rack without changing the input motion direction.



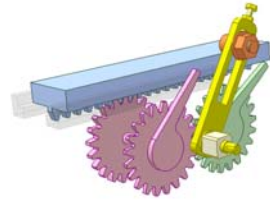
### Reverse gear drive with dwell 2

<http://youtu.be/1vQCTBensQc>

The pink output gear mesh with the blue rack that reciprocates with dwell at both ends of its stroke.

The stroke length of the blue rack depends on:

- Adjustable position of the orange pin on the yellow input crank.
- Length of the bars attached to the gears.



### Slider-crank mechanism with satellite gear 1

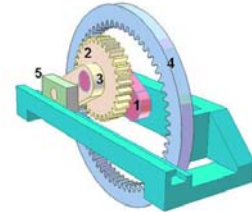
<http://www.youtube.com/watch?v=cfVyZkUzzyE>

The slider's stroke length is 4 times of the crank length.

The tooth number of internal gear is two times of the one of satellite gear.

Radius of cranks =  $1/2$  Pitch diameter of the satellite gear.

An application of Cardano cycles.



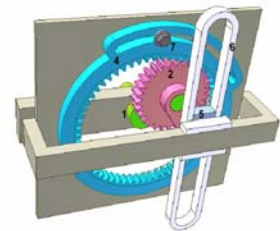
### Regulatable Slider-crank mechanism with satellite gear 1

[http://www.youtube.com/watch?v=3q3Ke\\_1YmpM](http://www.youtube.com/watch?v=3q3Ke_1YmpM)

The tooth number of internal gear is two times of the one of satellite gear.

Radius of cranks =  $1/2$  Pitch diameter of the satellite gear.

The slider's stroke length can be regulated from 4 times of the crank length to 0 by rotating the internal gear from 0 to 90 degrees.



### Regulatable slider-crank mechanism with satellite gear 2

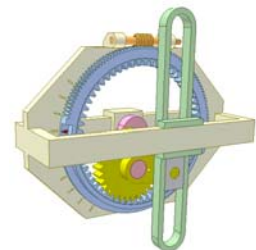
<http://youtu.be/5cbfFIIPENI>

Pitch diameter of yellow satellite gear =  $1/2$  Pitch diameter of blue internal gear. Their rolling circles are Cardano ones.

Radius of cranks (pink and yellow) =  $1/2$  Pitch diameter of the satellite gear.

The green slider's stroke length can be regulated from 0 to 4 times of the crank radius by turning the internal gear via orange worm from 0 to 90 degrees.

The video shows regulating process: blue gear turns from 0 to 30 deg. for medium stroke then from 30 to 90 deg. for max stroke.



### Rotation to translation mechanism 1

[http://www.youtube.com/watch?v=wtn\\_T-WMDR4](http://www.youtube.com/watch?v=wtn_T-WMDR4)

Spur gears have eccentric shafts. The eccentricity is  $e$ .

The slider's stroke length =  $4e$ .

Yellow plates have rotary translational motion



### Rotation to translation mechanism 2

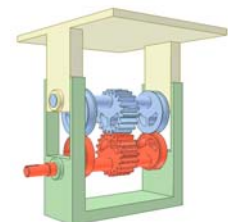
[http://www.youtube.com/watch?v=kOyRtiDRZ\\_o](http://www.youtube.com/watch?v=kOyRtiDRZ_o)

The spur gears and the round cams have eccentric shafts.

The eccentricity is  $e$ .

The lifting height of the working desk =  $4e$ .

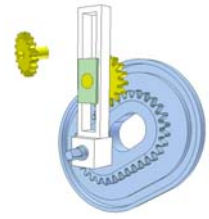
The cams bear lifting forces.



### Oval gear 1a

<http://youtu.be/CL-np3ocEgc>

An input blue gear of oval shape, rotating around fixed axis, engages with an yellow gear. The latter has revolution joint with green slider. The slider reciprocates with dwell. In case without teeth, the mechanism acts like an oval cam with possible slip.



### Oval gear 1b

<http://youtu.be/MNDcRZvtTI>

An input yellow gear, rotating around fixed axis, engages with a gear of oval shape. The latter has revolution joint with green slider. The slider reciprocates with dwell.

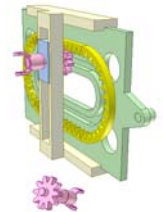


### Oval gear 2a

<http://youtu.be/HhNPb9MF1Hc>

An input pink gear, rotating around movable axis of blue slider, engages with a yellow oval gear of green slider. The latter has reciprocating linear motion. Its speed is constant when the engagement takes place on straight portions of the yellow oval gear.

The input gear gets rotation from a double Cardan joint.



### Oval gear 2b

<http://youtu.be/nigX7iAH2ss>

An yellow oval gear engages with a pink gear rotating around fixed axis.

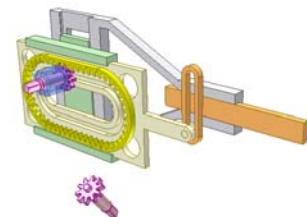
A popcorn slider fixed to the yellow oval gear slides in groove of a green slider. The latter moves along runway of the grey base.

A pin on the pink gear face slides in an oval groove of the popcorn slider.

A pin on the right of the popcorn slider slides in the slot of orange slider. The latter moves along other runway of the grey base.

The green slider reciprocates linearly with dwells at both ends of its stroke.

The orange slider reciprocates linearly. Its speed is constant when the pink gear engages with the straight portions of the yellow oval gear.



### Oval gear 2c

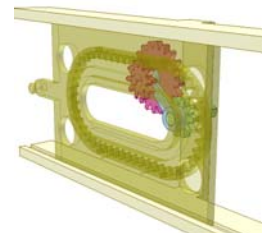
<http://youtu.be/pNcr06qe968>

Green gear, pink large satellite gear and blue carrier create a differential planetary drive.

A pink small gear, which fixed to the pink large satellite gear, engages with a oval gear of yellow slider. A pin on the pink small gear face slides in an oval groove of the yellow slider.

The blue carrier is driving.

The yellow slider reciprocates linearly with dwell at one end of its stroke. Its speed is constant when the pink small gear engages with the straight portions of the yellow oval gear.

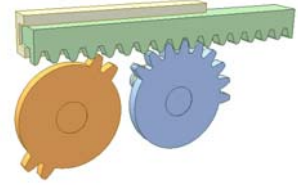


### Transmission with teeth-uncompleted gears 13

<http://youtu.be/Tt06tAkyHJQ>

The orange gear is driving. The green rack reciprocates with dwell.

The forward and backward displacement may be different depending on the tooth numbers of the orange gear and stop positions of the rack and the blue gear.



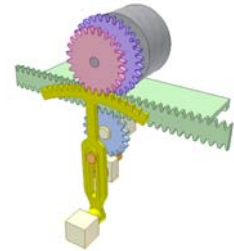
### Drive for rotary printing press

<http://youtu.be/PkBikUF369E>

Input: the orange crank.

Output: the green printing bed which translates and the grey printing cylinder which rotates.

The blue gear is for additional supporting the bed.



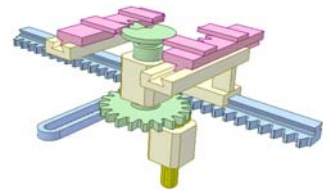
### Rack pinion mechanism 5

<http://youtu.be/CBsb2Pdf2Jk>

The sinus mechanism of yellow crank and blue rack-slider makes the green shaft oscillate with amplitude of 1 revolution (see "Sinus and rack pinion drive").

The green teeth-uncompleted gear gives the pink racks dephasing reciprocating motions with pauses at both ends of stroke.

The green sector and 4 pink plates are for blocking pink output racks when pausing.



### Linkage mechanism and planetary gear drive

<http://youtu.be/Pc10Hwileik>

An Artobolevski's invention: combination of planetary gear drive and double parallelogram mechanism.

Lengths of blue bars are equal.

Lengths of green bars are equal.

Lengths of orange and violet bars and center distance of green bar fixed pivots are equal.

Pitch radius of the internal gear:  $R$

Pitch radius of the external gear:  $r$

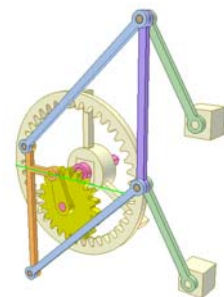
$R = 2r$  (Cardano circles)

Length of pink crank:  $r$

Length of yellow crank (fixed to the external gear):  $r$

The orange bar translates linearly.

The violet bar translates circularly.



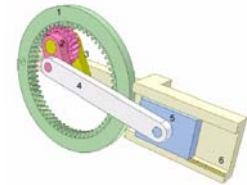
### 5.3. Bars and gears

#### Slider-crank mechanism having a pause at the end of stroke.

<http://www.youtube.com/watch?v=ObmXPNQh11k>

The tooth number of internal gear is 3 times of the one of satellite gear.

The short crank's length is half of the long crank's one. One axle of the connecting rod draws a deltoid that consists of 3 nearly round curves. The length of the connecting rod is equal the radius of the curve.

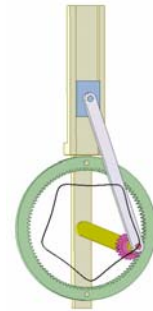


#### Slider-crank mechanism having a pause at the end of stroke 2.

<http://www.youtube.com/watch?v=MhFiRHWSouC>

The tooth number of internal gear is 5 times of the one of satellite gear.

The short crank's length is half of the long crank's one. One axle of the connecting rod draws a closed curving line that consists of 5 nearly round curves. The length of the connecting rod is equal the radius of the curve.



#### Worm drive and linkage mechanism 1

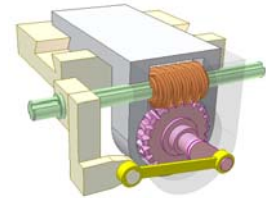
<http://youtu.be/ihXqTX91n18>

Input: green shaft rotating regularly.

Orange worm has sliding joint with the green shaft.

Output: the grey slider carrying the worm drive reciprocates.

The mechanism performs two functions: reducing speed and converting rotation into linear translation.



#### Gear and linkage mechanism 9a

<http://youtu.be/rGYGc-Qtqgk>

Tooth numbers of the gears are 50 and 25.

The gears have the same distance of their pins to their rotation axes (crank radius).

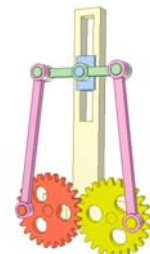
The blue slider has complicated motion that depends on dimensions of the orange and violet bars, tooth numbers, crank radii and relative positions of the gear pins.



#### Gear and linkage mechanism 9b

[http://youtu.be/Se3318gM\\_cg](http://youtu.be/Se3318gM_cg)

The mechanism is symmetric in term of dimension and assembly conditions so transverse force applied to the slider is limited. The pink conrods can be directly connected to the blue slider. The green bar is added for reducing the influence of manufacturing errors.

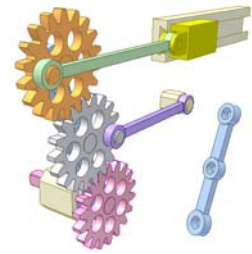


### Three-gear stroke multiplier

<http://youtu.be/w2sHE327EXk>

Input: pink gear.

The rotation of the input gear causes violet conrod, attached to the machine frame to oscillate. This action produces a large-stroke reciprocating motion and fast return in the yellow output slider.



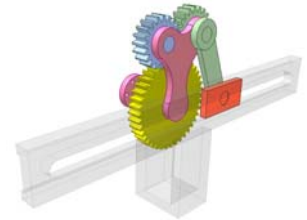
### Slider crank mechanism with satellite gear 2b

<http://www.youtube.com/watch?v=NctpLKvdneE>

Tooth number of yellow gear is double one of green gear.

The gears axle distance = crank length = R

The slider's stroke length =  $4R$



### Slider crank mechanism with satellite pulley

<http://www.youtube.com/watch?v=T3pHRBBUSWo>

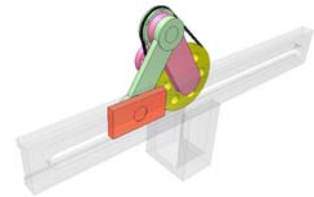
The diameter of the big pulley is double the one of the green pulley.

The length of each crank = R

The slider's stroke =  $4R$

The belt should be toothed.

It is possible to use chain drive instead of belt one.

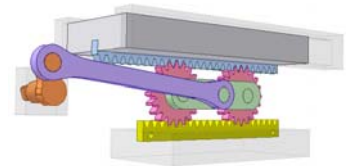


### Reciprocating-table drive

[http://www.youtube.com/watch?v=VzzaT\\_eqcmc](http://www.youtube.com/watch?v=VzzaT_eqcmc)

A combination of slider-crank mechanism and rack-gear drive.

When the input crank rotates, the table will move out to a distance of 4 times the crank length.



### External gear slider mechanism 1

<http://youtu.be/1N7XVZPPFj8>

The yellow gear ( $Z_2 = 20$  teeth) is fixed to the connecting rod.

The green gear ( $Z_1 = 20$  teeth) is not fixed to the pink input crank.

The green output gear irregularly continuously rotates faster than the pink output crank in the same direction.

1 revolution of the pink output crank corresponds 2 revolutions of the green output gear.





### External gear slider mechanism 2

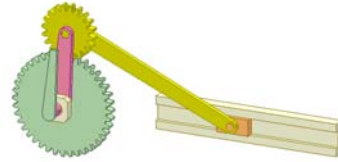
<http://youtu.be/QSRgQfbgLiI>

The yellow gear ( $Z_2 = 20$  teeth) is fixed to the connecting rod.

The green gear ( $Z_1 = 40$  teeth) is not fixed to the pink input crank.

The green output gear irregularly continuously rotates faster than the pink output crank in the same direction.

1 revolution of the pink output crank corresponds 1.5 revolutions of the green output gear.



### External gear slider mechanism 3

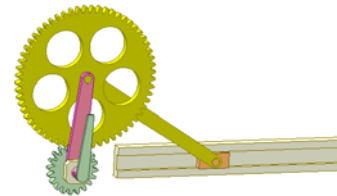
<http://youtu.be/rzXoR-OXLtA>

The yellow gear ( $Z_2 = 60$  teeth) is fixed to the connecting rod.

The green gear ( $Z_1 = 20$  teeth) is not fixed to the pink input crank.

The green output gear irregularly continuously rotates faster than the pink output crank in the same direction.

1 revolution of the pink output crank corresponds 4 revolutions of the green output gear.



### Internal gear slider mechanism 1

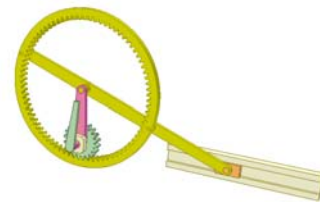
<http://youtu.be/tup8vGK4smA>

The yellow gear ( $Z_2 = 80$  teeth) is fixed to the connecting rod.

The green gear ( $Z_1 = 20$  teeth) is not fixed to the pink input crank.

The green output gear irregularly continuously rotates faster than the pink output crank in the opposite direction.

1 revolution of the pink output crank corresponds 3 revolutions of the green output gear.



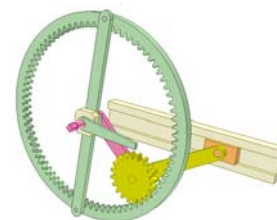
### Internal gear slider mechanism 2

<http://youtu.be/CbFPxpRHyRI>

The yellow gear ( $Z_2 = 20$  teeth) is fixed to the connecting rod.

The green gear ( $Z_1 = 80$  teeth) is not fixed to the pink input crank.

The green output gear irregularly continuously rotates slower than the pink crank in the opposite direction.



### Internal gear slider mechanism 3

<http://youtu.be/diW797QmiyA>

The yellow gear (radius  $r_2 = 30$ ) is fixed to the connecting rod.

The green gear (radius  $r_1 = 60$ ) is not fixed to the pink input crank.

Crank length:  $R = 60$

Connecting rod length:  $L = 90$

( $r_1 = L - R$ )

The green output gear irregularly rotates (with dwell) 2 revolutions when the pink crank rotates 1 revolution in the opposite direction.



#### Internal gear slider mechanism 4

<http://youtu.be/W8Hv6cRyUTU>

The yellow gear (radius  $r_2 = 30$ ) is fixed to the connecting rod.

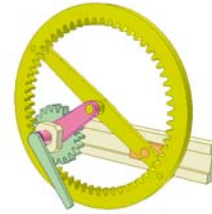
The green gear (radius  $r_1 = 60$ ) is not fixed to the pink input crank.

Crank length:  $R = 60$

Connecting rod length:  $L = 70$

( $r_1$  longer than  $L - R$ )

The green output gear irregularly rotates (with going back) 2 revolutions when the pink crank rotates 1 revolution in the opposite direction.



#### Three-gear-slider-crank mechanism 1

[http://www.youtube.com/watch?v=jq\\_Jl7BmXec](http://www.youtube.com/watch?v=jq_Jl7BmXec)

Modified-Watt's reverser

Teeth numbers of two large gears  $Z_1 = Z_2 = 40$

Teeth number of the small gear  $Z_0 = 20$

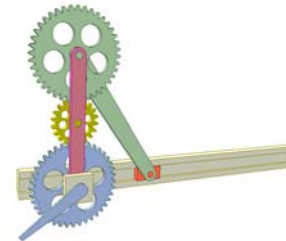
Gear module  $m = 2$

Length of the pink crank  $a = 180$

Length of the green connecting rod  $b = 220$

The output blue gear reverses after each 180-degree rotation of the input pink crank.

The output gear oscillates through the same angle as the green connecting rod.



#### Three-gear-slider-crank mechanism 2

<http://youtu.be/DD5w0B8hpCq>

Teeth numbers of two small gears  $Z_1 = Z_2 = 20$

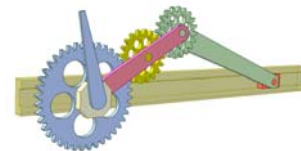
Teeth number of the large gear  $Z_0 = 40$

Gear module  $m = 2$  mm

Length of the pink crank  $a = 150$  mm

Length of the green connecting rod  $b = 220$  mm

The output blue gear irregularly continuously rotates slower than the pink crank in the same direction. 2 revolutions of the pink crank corresponds 1 revolution of the output blue gear.



#### Three-gear-slider-crank mechanism 3

<http://youtu.be/aZl5tY-00J4>

Teeth numbers of two small gears  $Z_1 = Z_2 = 20$

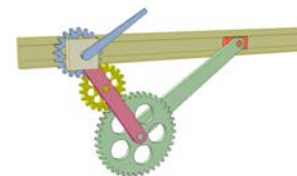
Teeth number of the large gear  $Z_0 = 40$

Gear module  $m = 2$  mm

Length of the pink crank  $a = 150$  mm

Length of the green connecting rod  $b = 220$  mm

The green gear irregularly rotates (with going back) 1 revolution when the pink crank rotates 1 revolution in the opposite direction.



#### Dwell Slider Mechanism 1

<http://youtu.be/LjLH45PSf-s>

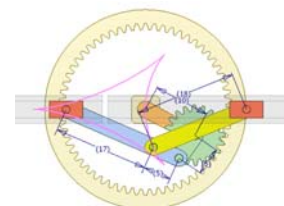
Tooth number of the fixed internal gear: 60

Tooth number of the planetary external gear: 20

Gear module: 0.5 mm

The pink curve is locus of the yellow conrod point.

Length of the yellow conrod approximates to the radius of curve segment of the pink locus. The red right slider has dwell at its right position.



### Slider-crank mechanism having a pause at both ends of stroke 1

<http://www.youtube.com/watch?v=7Ewb5C-UNfo>

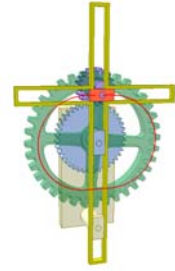
Tooth number of the satellite gear Z1: 20

Tooth number of the fixed gear Z2: 100

$e/A = 0.1$

e: crank length

A: axle distance between gear Z1 and gear Z2.



### Loci in Epicyclic gearing A4b

<http://youtu.be/ft9gntesYUE>

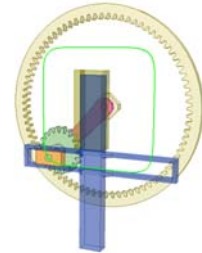
R: pitch radius of the fixed sun gear

r: pitch radius of the planetary gear

$k = R/r = 4$

Distance between the hole axis of the orange slider and the planetary gear axis is  $(11/30)r$  for getting a square of straight sides.

The blue cross has linear reciprocating motion with dwell at both stroke ends.



### Loci in Epicyclic gearing B4

<http://youtu.be/zMOeztecSu4>

r: pitch radius of the fixed sun gear

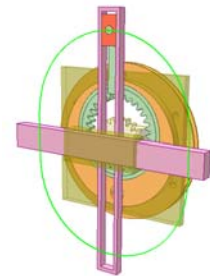
R: pitch radius of the green planetary gear

$k = R/r = 1.5$

Distance between the hole axis of the orange slider and the planetary gear axis is  $(124/30)r$  for getting a curve having two straight segments.

The input link is the orange disk.

The pink cross has linear reciprocating motion with dwell at both stroke ends.

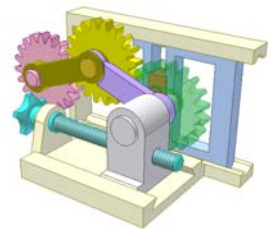


### Sine mechanism 5

<http://youtu.be/dtaLfwzwcDQ>

Green gear-crank, red slider and blue slider create a sine mechanism. The green gear-crank receives rotation from pink input gear through yellow gear. The bars maintain gear engagement

The blue output slider has reciprocating linear motion. Its stroke position can be adjusted during motion by cyan screw.



### Gear and linkage mechanism 13

<http://youtu.be/i9ayXz9tEXU>

Tooth number of pink crank gear: 20

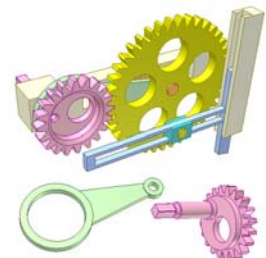
Tooth number of yellow gear: 40

The crank gear, green conrod and orange slider create a slider crank mechanism. Input is the crank gear rotating regularly.

The green conrod length = Center distance of the gear drive.

The blue slider has linear motion of complicated velocity rule.

Beside geometric dimensions of the links, its motion also depends on the position between the pin of the yellow gear and the crank gear when assembling.



### Gear and linkage mechanism 10

[http://youtu.be/Pe\\_nNqVXAek](http://youtu.be/Pe_nNqVXAek)

Pitch radius of red gear:  $R_1$ .

Pitch radius of green gear:  $R_2 = 2R_1$ .

The rotation axis of the red gear is eccentric.

Its eccentricity is  $E_1 = 0.125 R_1$ .

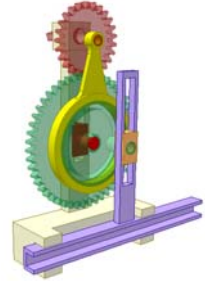
Distance between rotation axis of the green gear and the pin for orange slider is  $E_2 = R_1$ .

Length of the yellow conrod  $L = 3R_1$

The red gear, the yellow conrod and the red slider create a slider –crank mechanism.

The violet slider has linear motion with approximately uniform speed in the middle of its stroke.

Assembly condition: There is mechanism position when gear rotation axes, pin axes are on the same plane.



### Slider-crank mechanism with gears on conrod

<http://youtu.be/doSUZ1AdKU8>

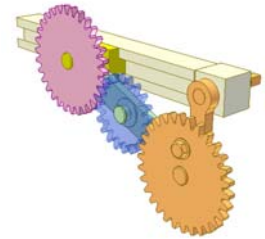
Cơ cấu tay quay con trượt có bánh răng ở thanh truyền.

Bánh răng và tay quay dẫn màu cam ghép cố định với nhau.

Bánh răng hồng và xanh mỗi cái quay lồng không trên trục của nó.

Bánh răng màu cam và màu hồng có cùng số răng.

Tay quay dẫn quay đều còn bánh răng xanh và hồng quay không đều.



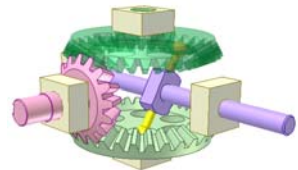
### Bevel gear and slider mechanism

<http://youtu.be/jrYQ6wZDRbw>

Input is pink gear of constant velocity.

Yellow bars have spherical joints with green gears and cylindrical joints with violet slider.

The slider linearly reciprocates.



## 5.4. Cams

### Disk cam mechanism DF9

<http://youtu.be/F3scqTa1CDw>

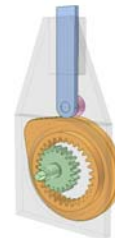
The cam profile is an archimedean spiral so the follower's speed is constant. Gravity maintains permanent contact between follower and cam.



### Gear cam

<http://youtu.be/4p-6tIA-kuc>

The orange cam is a combination of disk cam and internal gear.



### Disk cam mechanism DF1

<http://youtu.be/AWq7r9YwU48>

The roller is bigger than the cam.

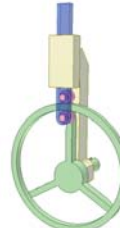


### Disk cam mechanism DF2

[http://youtu.be/qAyj\\_MAqmrQ](http://youtu.be/qAyj_MAqmrQ)

The follower has two rollers contacting both sides of the cam rim of thickness  $A$ . If  $A$  is constant, distance between the rollers is slightly bigger than  $A$ .

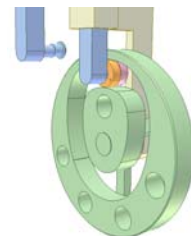
If backlashless is required,  $A$  must be inconstant.



### Disk cam mechanism DF3a

<http://youtu.be/QoMAMxIJRCo>

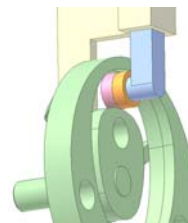
The follower has two rollers that move in the cam's slot. Rollers axles are slightly eccentric so the orange roller contacts with the outer wall of the slot; the pink roller contacts with the inner wall of the slot. This prevents the sliding of roller that happens in slot cam of one roller.



### Disk cam mechanism DF3b

<http://youtu.be/Wodc-C4a1m4>

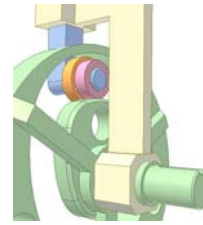
The follower has two rollers that move in the cam's slot. The slot is designed in the way that the orange roller contacts only with the outer wall of the slot; the pink roller contacts only with the inner wall of the slot (the slot outer wall is stepped). This prevents the sliding of roller that happens in slot cam of one roller.



### Disk cam mechanism DF3c

<http://youtu.be/-uQCJx5bwBg>

The follower has two rollers (of different diameters) that move in the cam's slot. The slot is designed in the way that the orange roller contacts only with the outer wall of the slot; the pink roller contacts only with the inner wall of the slot. This prevents the sliding roller that happens in slot cam of one roller.



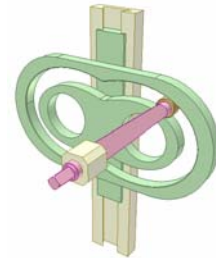
### Cam-slider mechanism

<http://youtu.be/NLNBzZuOZiA>

Input: pink crank.

Output: cam-slider that linearly reciprocates.

Its velocity is almost constant with the shown 8-shaped cam profile.



### Multi-profile cam

<http://youtu.be/TLZ2vqH31zo>

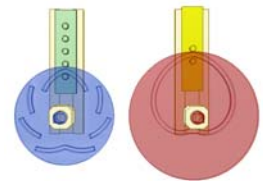
Left mechanism:

Blue cam contains various profiles. Its follower has some identical pins. This design helps reduce cam dimension and avoid cam-follower contact near to the cam center.

Geometric closure by pins causes a considerable backlash.

Right mechanism is shown for comparison purpose.

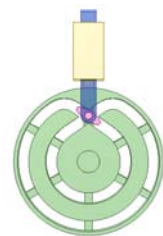
Red cam has continuous profile of Archimedean curves. Its dimension is to be large to reduce pressure angle at cam-follower contact points near to the cam center.



### Disk cam mechanism DF4a

<http://youtu.be/QFgPJGilbzY>

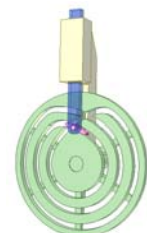
A working period of the mechanism corresponds two revolutions of the green slot cam. The pink rhomb-shaped part plays role of roller.



### Disk cam mechanism DF4b

[http://youtu.be/Sae9B\\_61i0I](http://youtu.be/Sae9B_61i0I)

A working period of the mechanism corresponds three revolutions of the green slot cam. The pink rhomb-shaped part plays role of roller.

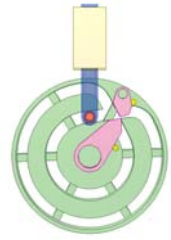




#### Disk cam mechanism DF4c

<http://youtu.be/jVQVF-SQea8>

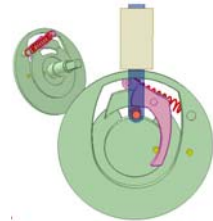
A working period of the mechanism corresponds two revolutions of the green slot cam. The pink guides help the roller go through the slot cross. Springs forcing the guides against the yellow pins are not shown. This roller concept is used instead of a rhomb-shaped slider when the slot's curvature is small.



#### Disk cam mechanism DF12

<http://youtu.be/ssvJhSpCISl>

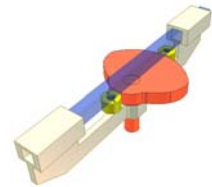
Working cycle of the mechanism is 2 revolutions of the green cam. The pink guide helps roller come into the outer groove one time in every two rev. A spring toggle device and two yellow pins maintain right positions of the guide.



#### Disk cam mechanism D8a

<http://youtu.be/AvxtHLCeykE>

Cam mechanism of geometrical closure. To maintain backlashless, the distance between any two points of the cam theoretic profile laying on the line through the cam's center (parallel to the sliding direction of the follower) must be constant.



#### Disk cam mechanism DF8b

<http://youtu.be/twiPc5QzxmM>

Cam mechanism of geometrical closure.

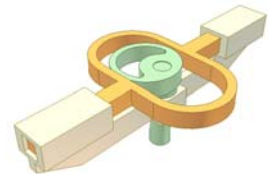
To maintain backlashless, the distance between any two points of the cam theoretic profile laying on the line through the cam's center (parallel to the sliding direction of the follower) must be constant. The cam profile is a  $n$ -fold rotational symmetric closed curve,  $n$  is an odd number (here  $n = 3$ ).



#### Disk cam mechanism DF10a

<http://youtu.be/mCbe9RD61aA>

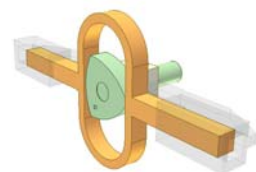
With eccentric round cam the follower gets harmonic motion.



#### Disk cam mechanism DF10b

<http://youtu.be/DhKg3nntPIA>

Reuleaux triangle cam. The rotation center and the curved triangle's one are coincident. The follower goes forward and backward three times in one cam revolution.



#### Disk cam mechanism DF10c

<http://youtu.be/hLEnUOu2-kU>

Reuleaux triangle cam. The follower goes forward and backward one time in one cam revolution with short dwell at stroke's ends.

Stroke length = DB



#### Disk cam mechanism DF10e

<http://youtu.be/8NKh9lxNnTI>

Reuleaux triangle cam. The follower goes forward and backward one time in one cam revolution with long dwell at stroke's ends.

Stroke length = DB + R

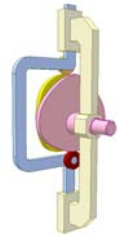


#### Disk cam mechanism DF8d

<http://youtu.be/61oZWpqJ2yl>

Dual cam.

The main cam is pink. The yellow one is added for cam geometrical closure. Its profile must be designed to maintain permanent contact of both rollers with cams.



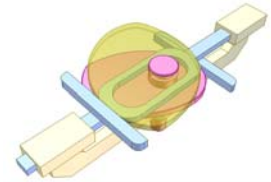
#### Disk cam mechanism DF8e

<http://youtu.be/kjo85swsOrU>

Dual cam.

The main cam is pink. The yellow one is added for cam geometrical closure.

Its profile must be designed to maintain permanent contact of both follower's planes with cams.



#### Cam driven press

<http://youtu.be/hbTKTa6rCWq>

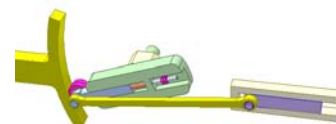
Cam in combination with toggle mechanism gives high pressing force.



#### Fixed cam mechanism 4

<http://youtu.be/0ZTaScDawKs>

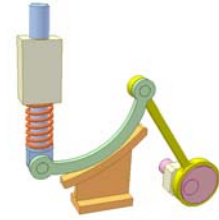
The yellow cam is fixed. The blue follower moves in a groove of the input crank. Length of the yellow rod plus radius of the magenta roller equals profile radius of the yellow cam. The violet slider reciprocates with dwell at its leftest position. Adjust position of the magenta nuts for various stroke lengths and dwell times.



### Fixed cam mechanism 5

<http://youtu.be/1HdJEO3iHrM>

The orange cam of contact radius  $R$  is fixed. The green follower of contact radius  $r$  has planar motion. If  $R = 2r$  and the axis of the contact cylindrical surface of the fixed cam intersects sliding axis of the blue slider (case of Cardano circles), the green follower rolls without sliding on the fixed cam.



### Cam mechanism of follower's planar motion 3

<http://youtu.be/z3rnRgAbRBo>

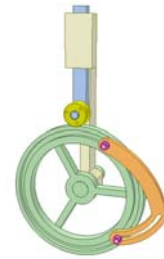
The orange cam is a triangle of six curves (curved polygon of constant width). The green follower has planar motion and the pink slider reciprocates with dwells at both stroke ends.



### Disk cam assembly 3

<http://youtu.be/0xx98A1VFlq>

Cam 1 is a green round disk. The orange cam 2 is fixed on cam 1. Its position can be adjusted to get various motions of the follower, both in stroke length and in phase by moving the two pink T-slot bolts. Gravity maintains permanent contact between rollers and cam.



### Disk cam mechanism DF5

<http://youtu.be/QBGc2VD-drM>

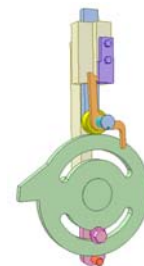
Adjust rollers distance to alter dwell time of the follower.  
Gravity maintains permanent contact between rollers and cam.



### Disk cam mechanism DF6

<http://youtu.be/rvAWqUyXKLE>

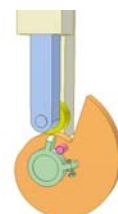
The green main cam moves the plunger to up position which is maintained by orange latch. The cyan springs forces the latch against the violet catch. The red pin lets the plunger go down by unlatching the orange latch. Dwell time is obtained by adjusting the red pin's position on the main cam.



### Disk cam mechanism DF7

<http://youtu.be/BkPOyRcEZVA>

Input is the green shaft, on which the orange cam rotates idly. Motion is transmitted to the cam through the pink pin. A quick drop of the follower is obtained by permitting the cam to be pushed out of the way by the follower itself as it reaches the edge of the cam. Gravity maintains permanent contact between follower and cam.



### Disk cam mechanism DF11 F4

<http://youtu.be/D2iXGzzfxiU>

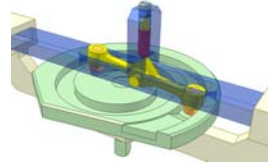
Beside the pink roller, the follower also has flat portion that contacts the cam after the roller leaves the cam at the follower's highest position. This helps increase dwell time at the highest position and speed up the follower's return. Gravity maintains permanent contact between follower and cam.



### Archimedes groove cam

<http://youtu.be/rJtRcneZ71A>

The green cam rotates continuously. The motion reverse of the blue follower is due to the yellow toggle arm carrying two orange pins and the cam groove depth reduction at groove outer end.



### Cam and crank slider mechanism 2

<http://youtu.be/bZR6D3-jCDA>

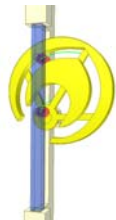
Input is the orange crank. The blue output slider performs two double strokes during one revolution of the input.



### Disk cam mechanism DF8c

<http://youtu.be/Y5mNeE00O58>

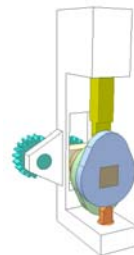
Two rollers and special shape of the cam slot help to increase stroke length.



### Radial cam

<http://www.youtube.com/watch?v=UITxt0RGG84>

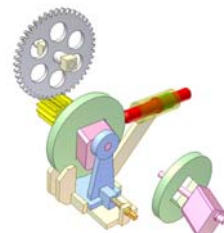
A measure to increase follower stroke while unchanged pressure angle. Shortcoming: to transmit rotation to a moving shaft.



### Cam and wedge mechanism

[http://youtu.be/ChVw3\\_NZ3B8](http://youtu.be/ChVw3_NZ3B8)

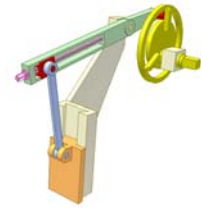
The eccentricity of the green eccentric can be adjusted by turning the orange screw to move the pink wedge shaft. The latter and the yellow gear are fixed together. Input: the grey gear. Output: the red follower.



### Cam and crank slider mechanism 3

<http://youtu.be/86dNyTDILkA>

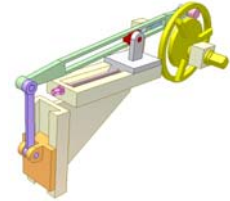
Input is the yellow cam. Stroke length of the orange output slider can be adjusted by moving the red slider.



### Cam and crank slider mechanism 4

<http://youtu.be/SXp3gx46f7w>

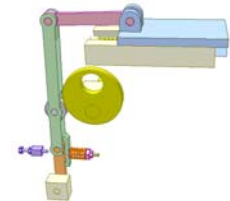
Input is the yellow cam. Stroke length of the orange output slider can be adjusted by moving the grey slider.



### Cam and crank slider mechanism 5

<http://youtu.be/9wReecQgkic>

Input is the yellow cam. The follower consists of two bars connected together by a revolution joint and the orange spring. Once the orange bar collides with the violet screw, oscillating center of the follower is changed. Stroke length of the blue output slider can be varied by adjusting the violet screw.

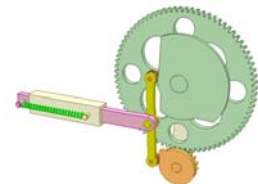


### Cam and gear mechanism 3

<http://youtu.be/lzJTBC3wkj8>

Input is the orange gear to which a small cam is fixed. The green gear and large cam are fixed together. Transmission ratio of the gear drive is 4.

The output pink slider, in its right to left course, has added motions during its three dwells.

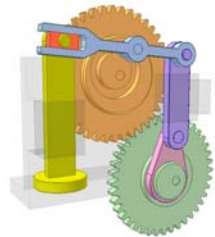


### Cam and gear mechanism 5

<http://youtu.be/UI5KDnQ9gTM>

Input is the green shaft with a green gear and an eccentric portion on which the pink conrod idly rotates. The yellow output slider receives motion from the blue arm that has a pin sliding in the groove of the cam fixed on the orange gear. Transmission ratio of the gear drive is 1. The blue arm is also connected to the violet slider that received motion from the pink conrod.

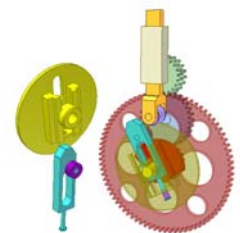
The motion combination gives long stroke of the yellow slider, a slotter's ram.



### Cam and gear mechanism 6

<http://youtu.be/CbPPV0D2fGM>

Input is the yellow shaft having a gear and a disk. The cyan slider (a cam) reciprocates in a slot on the disk due to the red cam that fixed to the red gear. The red gear receives motion from the yellow gear through the blue and the green gears. The orange slider's roller can contact with the yellow disk and the cyan slider. Motion of the orange output slider depends on the cam's shape, its angle position on the red gear and the transmission ratio (= 4 for this case) of the 4-gear drive.



### Inclining disk mechanism 1

<http://www.youtube.com/watch?v=zrpZcZCRA1s>

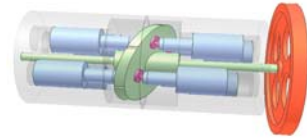
Flat contact. The follower rotates during reciprocation.



### Inclining disk mechanism 2

<http://www.youtube.com/watch?v=YsUQDb3cdhE>

Application for engine. Flat contact with added spherical joints.

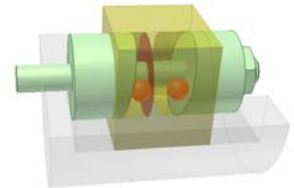


### Inclining disk mechanism 3

<http://www.youtube.com/watch?v=PkvVoCKGB5w>

Two balls are inserted between contact faces of the disks and the slider.

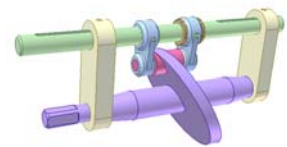
Stroke time corresponds two revolutions of the disk.



### Inclining disk mechanism 4

<http://www.youtube.com/watch?v=dafYYCB04VU>

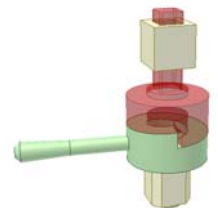
A rational design: flat contact, joint geometric closing, possibility of gap regulation.



### End cam mechanism ET1

<http://youtu.be/qmABJ5lbnhc>

The identical helical surfaces of the cam and the follower increases contact area and load capacity considerably. Gravity maintains permanent contact between follower and cam.



### End cam mechanism ET2

<http://youtu.be/5jE6yDqVbek>

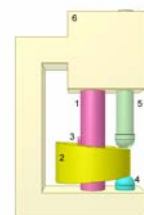
This steel-ball cam can convert the high-speed rotary motion of an electric drill into high-frequency vibrations that power the drill core for use as a rotary hammer for cutting masonry and concrete.



### Facial cam

<http://www.youtube.com/watch?v=hBh7dd36Vrc>

A measure to increase follower stroke while unchanged pressure angle.

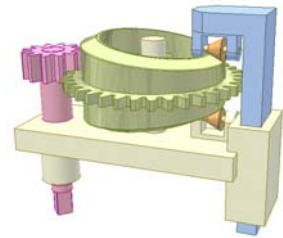




### Facial cam 1b

[http://youtu.be/THHIXrYS\\_-4](http://youtu.be/THHIXrYS_-4)

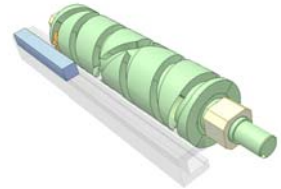
A measure to increase follower stroke while unchanged pressure angle. Gravity maintains contact between rollers and cam.



### Barrel cam mechanism BT1a

<http://youtu.be/LLlwVdaRViM>

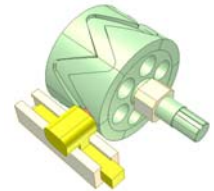
The space cam of helical slots of two opposite hands and different pitches (screw of two opposite hand threads) gives the blue follower reciprocal linear motion. The go speed is slow and the back one is fast.



### Barrel cam mechanism BT2a

<http://youtu.be/Atvhzqple5l>

Rotational motion is converted into linear reciprocating one.



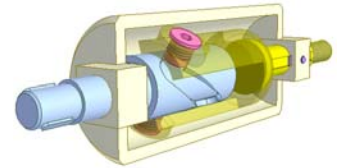
### Barrel cam mechanism BT2b

<http://youtu.be/HEJNQgBowHw>

A development of mechanism shown in:

<http://youtu.be/Atvhzqple5l>

Rotational motion is converted into linear reciprocating one. Input and output shafts are in line.



### Barrel cam mechanism BT3

<http://youtu.be/RuioMWd1NXU>

A mixing drum has a small oscillating motion while rotating due to a barrel mechanism at the end of its shaft. It finds application in mixing paint, candy or food.

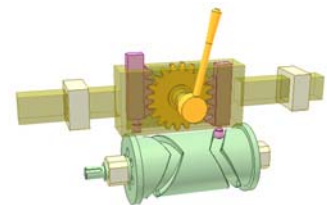


### Barrel cam mechanism BT8

<http://youtu.be/rmBnpM7K6To>

The green barrel cam has two grooves. Motion of the yellow slider can be altered by rotating the orange gear to let one of two rack's rollers come into contact with its corresponding cam's groove.

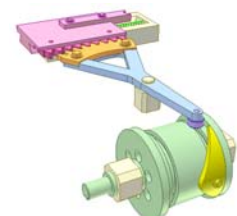
The positioning device for the orange gear is not shown.



### Barrel cam assembly 1

<http://youtu.be/jsgA7GFfM8E>

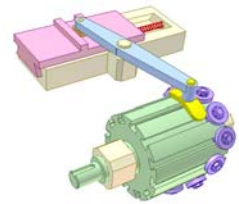
The yellow cam is fixed to the green cam drum by T-slot bolt that enable to change the cam or adjust its position on the drum.



### Barrel cam assembly 2

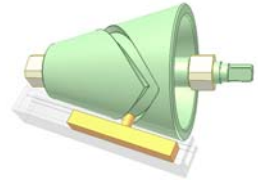
<http://youtu.be/sSXEkDnkbqc>

By T-slot bolts the positions of violet rollers on the green cam drum can be adjusted to get various motions of the pink slider,



### Cone cam 1

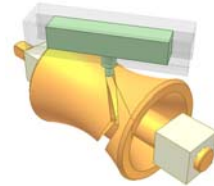
[http://youtu.be/p2\\_4CQA2QT0](http://youtu.be/p2_4CQA2QT0)



### Hyperboloid cam

<http://youtu.be/F9eP9wh0KqQ>

The follower sliding line and the cam rotary axis are skew.



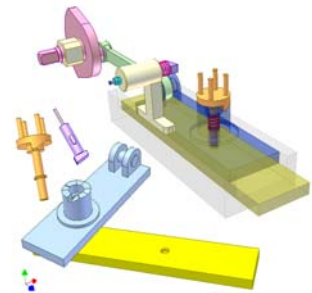
### End cam mechanism ET3

[http://youtu.be/CCu\\_U7kZhEQ](http://youtu.be/CCu_U7kZhEQ)

The blue slider during its every four double stroke gives the yellow slider only one double stroke by meshing lower end of the orange pin with a hole on the driven yellow slider.

The violet pin makes the orange pin rotate 90 deg. interruptedly. The end cam on the blue slider makes the orange pin move up/down.

A device for positioning the yellow slider at its rest position is not shown.



## 5.5. Chains

### Chain drive 2A

<http://youtu.be/iXbi7jod57Y>

Rotation to linear reciprocation. The two sprockets have the same tooth number.

This mechanism is applied in bamboo cleavage machine.

See a machine made in Vietnam:

[http://www.youtube.com/watch?v=MUzykcMLtdo&feature=player\\_embedded](http://www.youtube.com/watch?v=MUzykcMLtdo&feature=player_embedded)



### Chain drive 2B

<http://youtu.be/0jGOkJHN574>

The orange sprocket is driving. The two sprockets have the same tooth number. The pink slider reciprocates with constant velocity.

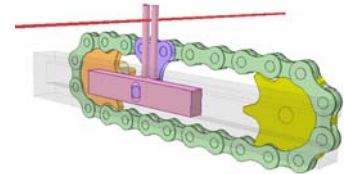


### Chain drive 2C

<http://youtu.be/6Je0ol6CKcg>

Rotation to linear reciprocation with dwell at the ends of the stroke. The two sprockets have the same tooth number. The pink slider reciprocates with constant velocity.

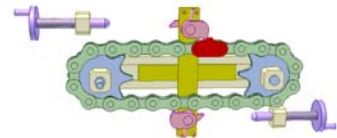
This mechanism is applied in wire drawing machines for leading wire (in red) to its coil.



### Chain drive 2D

<http://youtu.be/vzGjNXuiqp0>

Rotation to linear reciprocation with dwell at the ends of the stroke of the yellow slider. The two sprockets have the same tooth number. The pink pawls tend to rotate clockwise by springs (not seen). The red chain link pushes the yellow slider through the pawls and leave them when the pawls hit the violet adjustable stoppers.



### Chain drive 2E

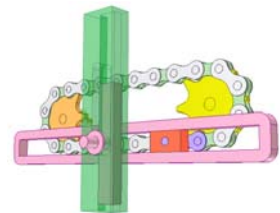
<http://youtu.be/MsCYaTDbZsl>

Converting continuous rotation into reciprocating translation with dwells at both ends of the course.

Two sprockets are identical.

The course length is equal to sprocket pitch diameter.

The dwell time depends on the axle distance of two sprockets.



### Chain drive 2F

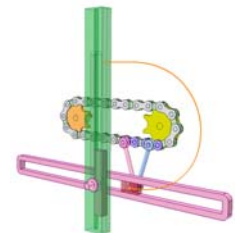
<http://youtu.be/VGUs5yiObmQ>

Converting continuous rotation into reciprocating translation with dwells at both ends of the course.

Two sprockets are identical.

The course length depends on sprocket pitch diameter and lengths of the blue and pink bars.

The dwell time depends on the axle distance of two sprockets.



### Chain drive 8A

<http://youtu.be/Or0k0VpDtBw>

Converting continuous rotation into reciprocating translation with dwells at one end of the course.

Three sprockets are identical. The pink one is driving. The violet chain link has an axle for a revolution joint with the red slider.

The course length depends on vertical axle distance between the pink sprocket and the orange ones.

The dwell time depends on axle distance of two orange sprockets.



### Chain drive 8C

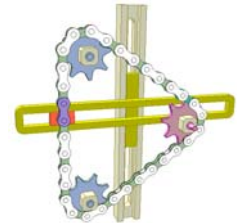
<http://youtu.be/7-0wXqRga4M>

Converting continuous rotation into reciprocating translation with different times of go and back strokes.

Three sprockets are identical. The pink one is driving. The violet chain link has an axle for a revolution joint with the red slider.

The sprockets are arranged at vertices of an equilateral triangle so the ratio of go and back times is 2.

The course length depends on sprocket axle distance.



### Chain drive 9

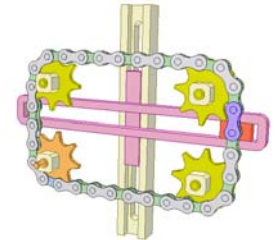
<http://youtu.be/TIkOzXQpVL4>

Converting continuous rotation into reciprocating translation with dwells at both ends of the course.

Three sprockets are identical. The orange one is driving. The violet chain link has an axle for a revolution joint with the red slider.

The course length depends on vertical axle distance between upper and lower sprockets.

The dwell time depends on horizontal axle distance between right and left sprockets.



### Chain drive 10

[http://youtu.be/V0\\_wqv0y7rg](http://youtu.be/V0_wqv0y7rg)

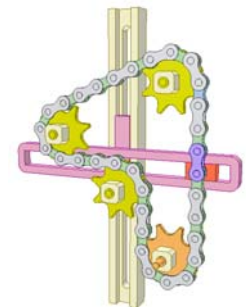
Converting continuous rotation into reciprocating translation with dwells in the middle of the course.

Four sprockets are identical. The orange one is driving. The violet chain link has an axle for a revolution joint with the red slider.

The course length depends on vertical axle distance between the orange sprocket and the top one.

The dwell time depends on horizontal axle distance of two middle sprockets.

This video shows the possibility to create reciprocating translation with dwell at any point of the course by using chain drive with four sprockets and arranging them at appropriate positions.

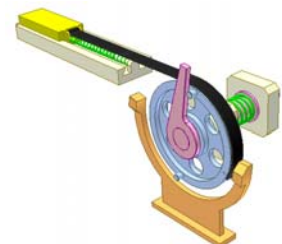


### Cable drive 22

<http://youtu.be/F5vEXHPw6o>

Converting continuous rotation to reciprocating translation.

An arm on the pink shaft turns the blue wheel when contacting with its pins. The arm moves axially to release the wheel when contacting with the orange wedges.



## 5.6. Friction drives

### 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  $\lambda$  between axes of the input shaft and the roller.

$$V = \omega \cdot R \cdot \tan(\lambda)$$

$\omega$ : angular velocity of the input shaft

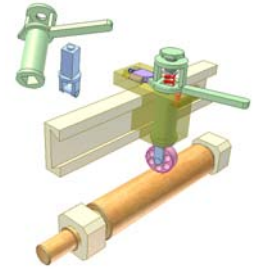
$R$ : contact radius of the input shaft

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.



### Spatial friction drive for translating motion 1b

<http://youtu.be/XZy856ocYgk>

Input: orange shaft rotating regularly.

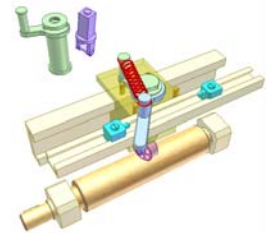
Output: yellow slider linearly reciprocating.

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/KaRBadgcUIU>



## 6. Converting rotary oscillation into linear motion

### 6.1. Gears

#### Rack pinion mechanism 1

<http://www.youtube.com/watch?v=9hl85qZ5zKA>

#### Sheet metal gears 2

[http://youtu.be/b01b8Df4\\_88](http://youtu.be/b01b8Df4_88)

For light loads.

Low cost.

Adaptability to mass production.

#### Rack with ring teeth

[http://youtu.be/1qpLembF\\_mU](http://youtu.be/1qpLembF_mU)

The mechanism acts as an ordinary rack pinion drive, furthermore the rack can rotate around its axis during transmission.

#### Pin rack drive 1A

<http://youtu.be/ZyhJPFERP-k>

The pinion tooth profile is the envelope of a family of the pin circles, centers of which are on an involute traced by pin circle center when the pin rack rolls without slipping on the pinion.

The pinion can engage both sides of the pin rack. It is impossible for the tooth rack.

#### Pin rack drive 1B

<http://youtu.be/kMXqu5HfcBq>

The rack tooth profile is the envelope of a family of the pin circles, centers of which are on a cycloid traced by pin circle center when the pin wheel rolls without slipping on the rack.

#### Chain drive 1D

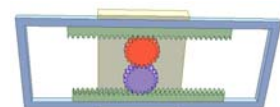
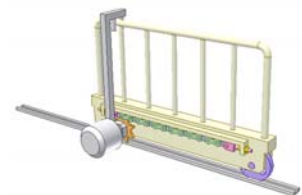
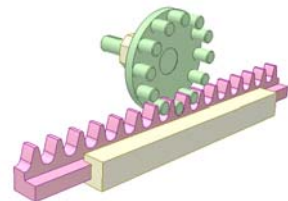
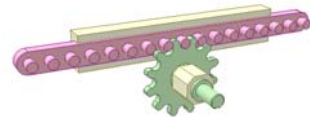
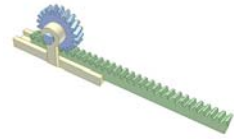
[http://youtu.be/D70s\\_01VTGo](http://youtu.be/D70s_01VTGo)

Using chain rack instead of ordinary one reduces production costs.

#### Application of rack pinion mechanism 4

<http://www.youtube.com/watch?v=uEGpsi4upw8>

A measure to reduce force applied to the runway.



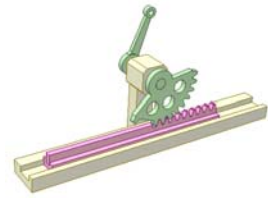


#### Rack pinion mechanism 4b

<http://youtu.be/MSq2xD6OcMA>

The pink input rack reciprocates. The green output shaft oscillates with dwell at one end of its stroke.

The rack flat portion prevents spontaneous motion of the shaft.

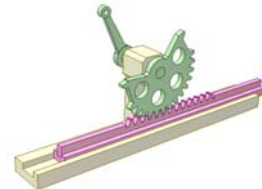


#### Rack pinion mechanism 4c

<http://youtu.be/BjmKHHR18w8>

The pink input rack reciprocates. The green output shaft oscillates with dwell at both ends of its stroke.

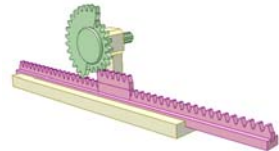
The rack flat portions prevent spontaneous motion of the shaft.



#### Rack pinion mechanism 4e

<http://youtu.be/f7J54RvmApc>

The green input shaft rotary reciprocates. During the go or back motion the velocity of the pink output slider changes in steps.

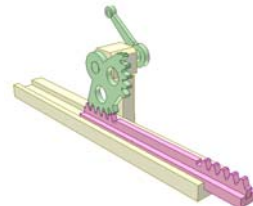


#### Rack pinion mechanism 4a

<http://youtu.be/v46JRgJ2zbU>

The pink input rack reciprocates. The green output shaft oscillates with dwell in the middle of its stroke.

The rack flat portion prevents spontaneous motion of the shaft.

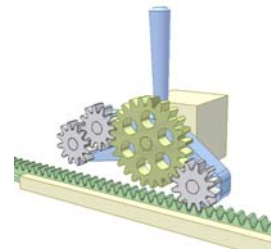


#### Reverse mechanism for rack

[http://youtu.be/Bxtthb\\_6bO8](http://youtu.be/Bxtthb_6bO8)

The large gear rotates continuously.

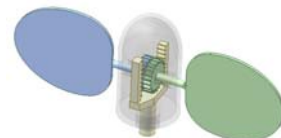
Use the blue lever to control motion of the rack: stop, forward, back. Positioning device for the lever is not shown.



#### Application of rack pinion mechanism 5

[http://www.youtube.com/watch?v=3\\_3\\_XFwMplo](http://www.youtube.com/watch?v=3_3_XFwMplo)

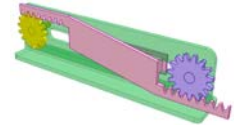
Controlling angle of the ship propeller blades



### Rack pinion mechanism 6a

<http://youtu.be/3fAMK2phOWE>

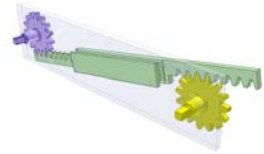
Transmission of limited rotation between distant shafts.  
Input and output rotary directions are opposite.



### Rack pinion mechanism 6b

<http://youtu.be/M0M-NKzOsZM>

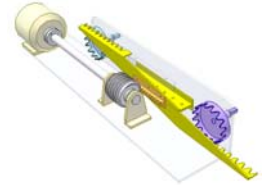
Transmission of limited rotation between distant shafts.  
Pitch lines of two rack portions are coincident.  
Input and output rotary directions are opposite.



### Rack pinion mechanism 6c

<http://youtu.be/5lhNjpdCX8M>

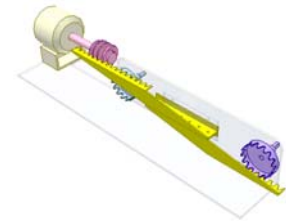
Yellow double rack receives motion from motor via grey worm and orange rack. In fact the orange rack is part of a nut.  
The yellow double rack makes two face gears rotate in opposite directions.  
Gears and racks are made of sheet metal.



### Rack pinion mechanism 6d

<http://youtu.be/uf8BFrcmPgE>

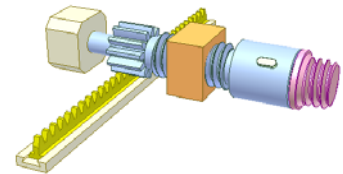
Yellow double rack receives motion from motor via pink worm.  
The left rack engages with the pink worm and the blue gear.  
The yellow double rack makes two face gears rotate in opposite directions.  
Gears and racks are made of sheet metal.



### Mechanism for moving thread core of a plastic injection mould 1

<http://youtu.be/7bVTvWGAdAA>

Yellow rack is connected to the movable half mold.  
When the movable half mold moves, the rack pinion drive and the screw drive (blue screw and orange fixed nut) make blue shaft carrying the pink thread core rotate and translate.  
Thus the thread core is inserted into or removed from the plastic injection part (not shown).  
The blue gear must have enough length to enable its meshing with the rack when the blue screw translates.  
Thread leads of thread core and the blue screw must be equal.



## Mechanism for moving thread core of a plastic injection mould 2

<http://youtu.be/WZHfFLtYCpg>

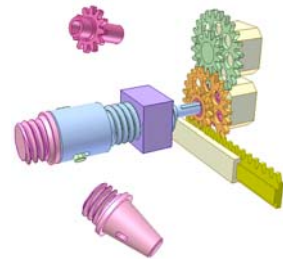
Yellow rack is connected to the movable half mold.

When the movable half mold moves, the rack pinion drive, two gear drives and the screw drive (blue screw and violet fixed nut) make blue shaft carrying the pink thread core rotate and translate. Thus the thread core is inserted into or removed from the plastic injection part (not shown).

The pink gear has sliding key joint with the blue screw.

Thread leads of thread core and the blue screw must be equal.

In consideration of short stroke of the movable half mold, two gear drives are used for increasing revolutions of the blue screw.

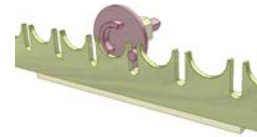


## Rack–pinwheel drive 1

<http://youtu.be/wGdxybcaRbo>

Input: pink disk of a pin and a lock arc that rotates reciprocally.

Output: rack that has linear reciprocating motion of sinusoid law.



## Pin rack drive 5

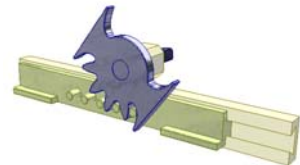
<http://youtu.be/BM7hnxt6Y0>

Input: rack that has linear reciprocating motion.

Output: blue gear oscillating 180 deg. with dwells at both ends.

Its motion is of constant speed. Its gear profiles are involutes.

Flat portions on the gear and the rack are for keeping the gear immobile during dwells.

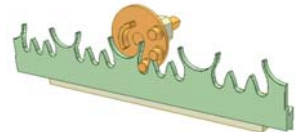


## Rack–pinwheel drive 2

<http://youtu.be/nKF5GybAtjU>

Input: pink disk of pins and a lock arc that rotates reciprocally.

Output: rack that has linear reciprocating motion. Its motion is of constant speed. Its gear profiles are cycloids.



## Ratchet mechanism 28

<http://youtu.be/drAELRHyHgl>

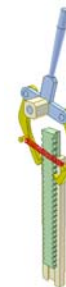
Input: blue crank oscillating.

Output: green ratchet rack.

Both go and back motions of the crank make the rack go up.

The pawls pull the rack.

Spring maintains contact between pawls and ratchet rack.



## Ratchet mechanism 29

<http://youtu.be/SM7QVSAWztk>

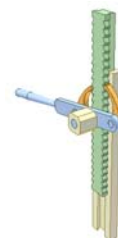
Input: blue crank oscillating.

Output: green ratchet rack.

Both go and back motions of the crank make the rack go up.

The pawls push the rack.

The gravity maintains contact between pawls and ratchet rack.



### Ratchet mechanism 30

<http://youtu.be/eL2QIyGE2Sg>

Distance between two hooks can be adjusted easily thanks to a round rack and two pawls.



### Ratchet mechanism 34

<http://youtu.be/UifSW78QEeU>

Orange roller allows green round rack to move up and prevents it from falling.



### Round rack jack 1

<http://youtu.be/dKJP2kc4pMA>

Red pawl pushes yellow rod up when pushing blue lever down.

Orange pawl prevents the rod from falling during the red pawl return.



### Space gear and rack 1a

<http://youtu.be/54kRNC7K7KI>

This drive consists of a pinion of helical teeth and a rack of helical teeth.

Normal module  $m_n = 2 \text{ mm}$

Pinion:

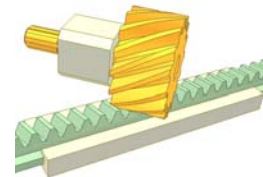
- Helix angle  $B_1 = 30 \text{ deg.}$ , left hand
- Face module  $m_{s1} = 2.31 \text{ mm}$
- Tooth number  $Z_1 = 15$
- Pitch circle dia.  $D_1 = 34.64 \text{ mm}$

Rack:

- Helical teeth,  $B_2 = 13.69 \text{ deg.}$

Angle between pinion axle and rack moving direction is  $L = B_1 + B_2 = 43.69 \text{ deg.}$

1 pinion revolution makes rack move  $\text{Pi} \cdot D_1 \cdot \cos B_1 / \cos B_2 = 97.00 \text{ mm}$



### Space gear and rack 1b

<http://youtu.be/ri7evOSAbQ>

This drive consists of a pinion of straight teeth and a rack of helical teeth.

Normal module  $m_n = 2 \text{ mm}$

Pinion:

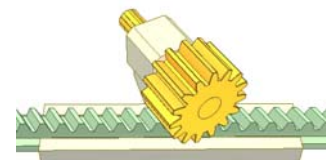
- Helix angle  $B_1 = 0 \text{ deg.}$
- Tooth number  $Z_1 = 15$
- Pitch circle dia.  $D_1 = 30 \text{ mm}$

Rack:

- Helical teeth,  $B_2 = 30 \text{ deg.}$

Angle between pinion axle and rack moving direction is  $L = B_1 + B_2 = 30 \text{ deg.}$

1 pinion revolution makes rack move  $\text{Pi} \cdot D_1 \cdot \cos B_1 / \cos B_2 = 108.83 \text{ mm}$



### Screw gear and rack 1c

[http://youtu.be/Mulq\\_PUAbeY](http://youtu.be/Mulq_PUAbeY)

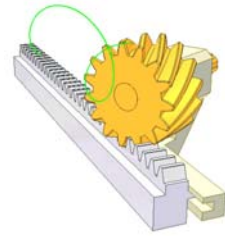
This drive consists of a pinion of helical teeth and a rack of straight teeth.

The rack is stationary. The green curve is locus of a point on pinion pitch circle (a space cycloid?).

Pinion: Helix angle  $B1 = 30$  deg., left hand

Rack: Helix angle  $B2 = 0$  deg.

Angle between pinion axle and rack moving direction is  $L = 30$  deg.



### Space gear and rack 1e

[http://youtu.be/5IJS\\_bfkcxI](http://youtu.be/5IJS_bfkcxI)

Angle between pinion axle and rack moving direction is  $0$  deg.

Normal module  $m_n = 2$  mm

Pinion:

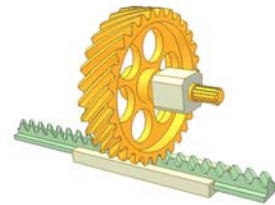
- Helix angle  $B1 = 45$  deg.
- Tooth number  $Z1 = 30$
- Pitch circle dia.  $D1 = 84.85$  mm

Rack:

- Helical teeth,  $B2 = 45$  deg.

1 pinion revolution makes rack move  $\pi \cdot D1 \cdot \cos B1 / \cos B2 = 266.56$  mm

This drive resembles a screw-nut one when consider: the gear as a screw, the rack as a bar cut out longitudinally (axially) from a nut.

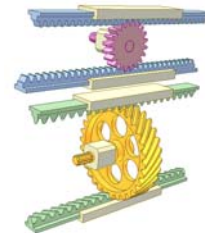


### Space gear and rack 1f

<http://youtu.be/h5avf2JatzE>

Lower drive: Space gear and two rack drive, angle between gear axle and rack moving direction is  $0$  deg. Its two racks move in the same direction.

Upper drive: Planar gear and two rack drive. Its two racks move in opposite directions.



### Worm-rack drive 1

<http://youtu.be/nHkfWu0sYc0>

Normal module  $m_n = 2$  mm

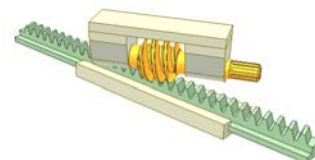
Input worm:

- Number of starts  $Z = 2$
- Lead Angle  $LA = 10.81$  deg.
- Direction of thread: right hand
- Pitch circle dia.  $D = 20$  mm

Rack:

- Helical,  $B2 = 13.69$  deg.

Angle between worm axle and rack moving direction is  $L = LA + B2 = 24.50$  deg.



### Worm-rack drive 2

<http://youtu.be/FTKTd3EfORo>

Normal module  $m_n = 2 \text{ mm}$

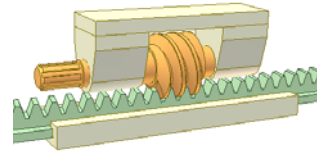
Input worm:

- Number of starts  $Z = 2$
- Lead Angle  $LA = 10.81 \text{ deg.}$
- Direction of thread: right hand
- Pitch circle dia.  $D = 20 \text{ mm}$

Rack:

- Helical teeth,  $B2 = -10.81 \text{ deg.}$

Angle between worm axle and rack moving direction is  $L = LA + B2 = 0 \text{ deg.}$



### Worm-rack drive 3

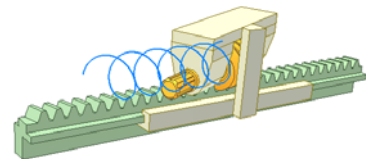
<http://youtu.be/cZEc5gwrTM>

The rack is stationary. The blue curve is locus of a point on worm pitch circle (a space cycloid?).

Input worm: Helix angle  $B1 = 30 \text{ deg.}$ , left hand

Rack: Helix angle  $B2 = 0 \text{ deg.}$

Angle between pinion axle and rack moving direction is  $L = 30 \text{ deg.}$



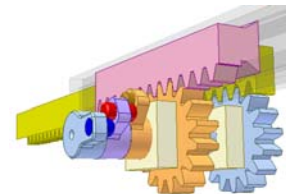
### Motion delay mechanism 1

<http://youtu.be/ju3c0naRhhM>

Input: yellow rack reciprocating.

Output: pink rack that moves only after the blue gear makes around two revolutions.

The violet crank rotates idly on the blue gear shaft. Add more violet cranks to increase delay time.





## 6.2. Bars, cams

### Regular oscillation to regular translation with bar mechanism

<http://youtu.be/JmMer5vCIP4>

The blue pin slides on flat portions of the red lever and of the yellow slider.

Input: the red oscillate lever.

Output: the yellow slider.

Dimension condition:  $d = 0.34b$

$d$ : center distance between two revolution joints of the red and green levers.

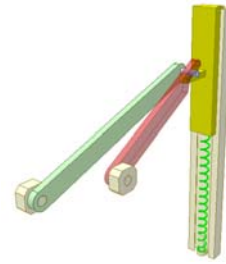
$b$ : center distance between the blue pin and revolution joint of the green lever.

The slider velocity is constant if the red lever oscillates with a constant velocity in the range  $\pm 30$  degrees (angle  $\alpha$ ) around the line connecting two revolution joints of the red and green levers.

Otherwise stated, the displacement relation between the red lever and the yellow slider is linear. This feature can be used for length measuring tools where the indicator graduation must be even.

In case without the green bar (the red bar has a pin that contact with the flat portion of the yellow slider) the slider velocity alters (cosine function of angle  $\alpha$ ).

Advantage over rack-pinion drive: high precision of transmission at low manufacture cost.



### Double parallelogram mechanism 3

<http://www.youtube.com/watch?v=RJBoh5k4KDs>

The mechanism is used for a disappearing platform in a theater stage. The platform moves approximately vertically and has a contra-weight on the blue input link.



### Press using spatial slider crank mechanism

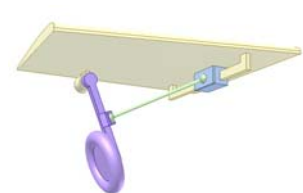
[http://www.youtube.com/watch?v=613\\_NYKz68I](http://www.youtube.com/watch?v=613_NYKz68I)



### Airplane wheel retracting

<http://www.youtube.com/watch?v=Te8UltGmcQQ>

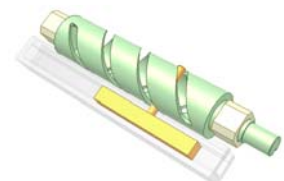
A spatial slider crank mechanism is used.



### Barrel cam mechanism BT6

<http://youtu.be/pln-xTLa1sQ>

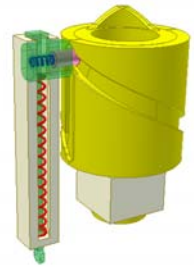
This mechanism converts linear reciprocating motion into oscillating motion or vice versa.



### Barrel cam for 180 deg. rotation 1

<http://youtu.be/SzoF0VMtc7w>

Pull and release green slider to let yellow barrel cam turn 180 deg.  
Blue spring forces pink pin towards the cam. Key factor is different depths of the cam grooves.



### Barrel cam for 180 deg. rotation 2

<http://youtu.be/l25QNREEYRM>

Pull and release blue frame to let green barrel cam linearly reciprocate and turn 180 deg. for each stroke.  
Blue spring forces orange pin towards the cam. Key factor is different depths of the cam grooves.



## 6.3. Screws

### Screw mechanism 1

<http://www.youtube.com/watch?v=zIAm3MVDAc0>

The mechanism consists of 2 movable links and 3 screw joints.

In 1 rev of the blue crank:

The nut's displacement  $s = h_3 \cdot (h_1 - h_2) / (h_3 - h_2)$

The nut's rotation  $\phi = (h_1 - h_2) / (h_3 - h_2)$  revs.

$h_1$ : pitch of the screw joint of the blue screw and the base.

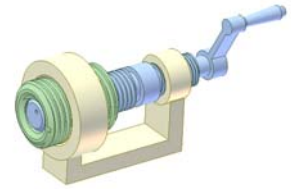
$h_2$ : pitch of the screw joint of the blue screw and the green nut.

$h_3$ : pitch of the screw joint of the green nut and the base.

$h_1, h_2, h_3$  carry negative sign in case of left-handed thread and vice-versa.

For this case,  $h_1 = 2, h_2 = 3$  and  $h_3 = 4$  so  $s = -4, \phi = -1$

Wanted  $s$  and  $\phi$  values can be obtained by combination of appropriate  $h_1, h_2, h_3$  and the thread direction.



### Screw mechanism 2

<http://www.youtube.com/watch?v=0P-ao2F3jvc>

The mechanism consists of 2 movable links, 2 screw joints and 1 revolution joint.

In 1 rev of the blue crank:

The nut's displacement  $s = -h_2 \cdot h_3 / (h_3 - h_2)$

The nut's rotation  $\phi = -h_2 / (h_3 - h_2)$  revs.

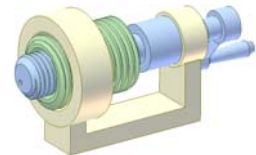
$h_2$ : pitch of the screw joint of the blue screw and the green nut.

$h_3$ : pitch of the screw joint of the green nut and the base.

$h_2, h_3$  carry negative sign in case of left-handed thread and vice-versa.

For this case,  $h_2 = 3$  and  $h_3 = 4$  so  $s = -12, \phi = -3$

Wanted  $s$  and  $\phi$  values can be obtained by combination of appropriate  $h_2, h_3$  and the thread direction.



### Screw mechanism 3

<http://www.youtube.com/watch?v=Jhzh7CLr0cQ>

The mechanism consists of 2 movable links, 2 screw joints and 1 prismatic joint.

In 1 rev of the blue crank:

The nut's displacement  $s = (h_1 - h_2)$ .

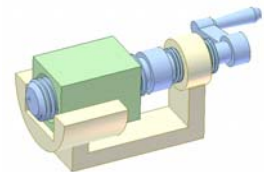
$h_1$ : pitch of the screw joint of the blue screw and the base.

$h_2$ : pitch of the screw joint of the blue screw and the green nut.

$h_1, h_2$  carry negative sign in case of left-handed thread and vice-versa.

For this case,  $h_1 = -2$  and  $h_2 = 3$  so  $s = -5$ .

Wanted  $s$  values can be obtained by combination of appropriate  $h_1, h_2$  and the thread direction.



### Nut-screw differential mechanism 1

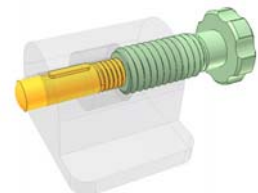
<http://youtu.be/-ZN6Kj3sXtc>

Thread on the orange screw is M5x0.8 (right hand).

External thread on the green knob is M8x1.25 (right hand).

The orange screw moves  $1.25 - 0.8 = 0.45$  mm during 1 rev. of the knob.

It is possible to reduce this difference by choosing appropriate leads.



### Nut-screw differential mechanism 2

<http://youtu.be/jbF4Jujf4Os>

Thread on the orange screw is M5x0.8 (right hand).

External thread on the pink nut is M8x1.25 (right hand).

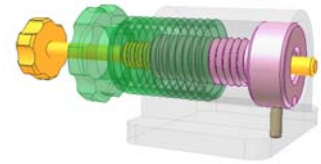
External thread on the green knob is M14x1.5 (right hand).

The brown pin is for preventing rotation of the pink nut.

Turn the orange screw for rough adjustment: the orange screw moves 0.8 mm for 1 rev. of the screw.

Turn the green knob for fine adjustment: the orange screw moves  $1.5 - 1.25 = 0.25$  mm for 1 rev. of the knob.

It is possible to reduce this difference by choosing appropriate leads.



### Differential screw mechanism

<http://youtu.be/YFzov0PbjpM>

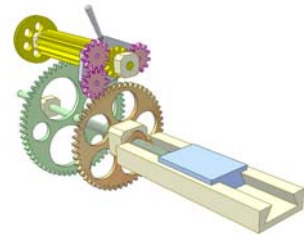
Input: yellow gear shaft.

Output: blue slider.

Orange gear creates a helical joint with green screw.

The video shows 3 motions of the blue slider: backward, fast backward and slow forward corresponding 3 positions of the grey lever carrying 3 pink pinions for controlling the orange gear rotation.

Braking device for the orange gear is not shown.



### Adjustable tool for lathes

<http://www.youtube.com/watch?v=l2f6AjUdNBw>

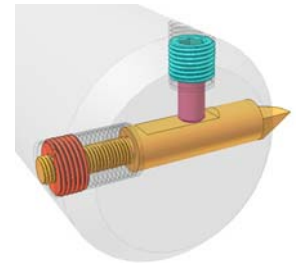
A lathe turning tool in a drill rod is adjusted by a differential screw. When turning the red nut, it is advanced and the tool is retracted simultaneously. The resultant displacement of the tool is very small,  $(t_2 - t_1)$  mm in 1 rev. of the nut.

$t_2$ : pitch of the nut external thread.

$t_1$ : pitch of the nut internal thread.

The threads are right hand.

The tool is clamped by a setscrew after adjusting.



### Nut-Screw drive 1

<http://www.youtube.com/watch?v=q1DcU5txgJk>

The input nut fixed to the green button is translated.

The output screw is rotated.

The screw is made by twisting a metal strip.

The mechanism has been used for winding cameras.



### Tensioner 1a

[http://www.youtube.com/watch?v=TvsxYUj\\_6wI](http://www.youtube.com/watch?v=TvsxYUj_6wI)

The screws have opposite-hand threads.

Measure to keep the orange screw from rotation is not shown.



### Tensioner 1b

<http://www.youtube.com/watch?v=G2Urv8dambI>

The screws have opposite-hand threads.

Flats on the screw ends restrain the orange screw against rotation.



### Tensioner 2

<http://www.youtube.com/watch?v=bwppbab9XITg>

The green nut has opposite-hand threads on its internal and external cylinder surface. The mechanism occupies less longitudinal space than "Tensioner 1a":

[http://www.youtube.com/watch?v=TvsxYUj\\_6wI](http://www.youtube.com/watch?v=TvsxYUj_6wI)

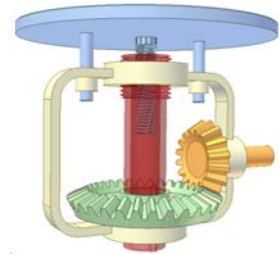
Measure to keep the orange screw from rotation is not shown.



### Precise height adjustable table

<http://www.youtube.com/watch?v=PRYNpNA8elw>

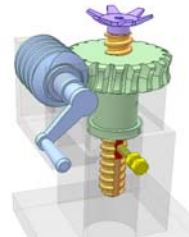
A measuring table goes up and down very slowly for many turns of the input bevel gear. All the threads has the same hand. Their pitches are  $t_1$  mm and  $t_2$  mm. In 1 revolution of the green bevel gear the table moves  $(t_2 - t_1)$  mm.



### Nut-screw and worm jack

<http://youtu.be/kp-dNLE8pMI>

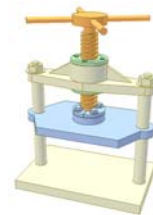
Combination of nut-screw and worm mechanisms gives the jack a high mechanical advantage.



### Manual screw press 1

<http://www.youtube.com/watch?v=GrK5bhJjex4>

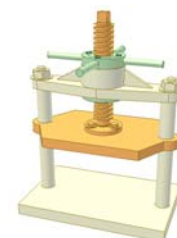
The green nut is fixed. The orange screw is rotated and translated.



### Manual screw press 2

<http://www.youtube.com/watch?v=-DAtwJzmFdM>

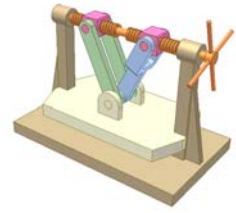
The green nut is rotated. The screw is translated.



### Manual screw press 3

<http://www.youtube.com/watch?v=nGiS4ZScxII>

The orange screw has right hand and left hand threads with the same pitch and is rotated. The pink nuts are translated.



### Manual screw press 4

[http://www.youtube.com/watch?v=S7OIx\\_liVqY](http://www.youtube.com/watch?v=S7OIx_liVqY)

A combination of slider-crank mechanism and nut-screw one gives a high mechanical advantage.

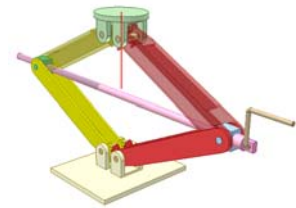
The orange screw is rotated. The pink nuts are translated. Both move slightly in vertical plan.



### Gear and linkage mechanism 3c

<http://youtu.be/78T8ufcyGjY>

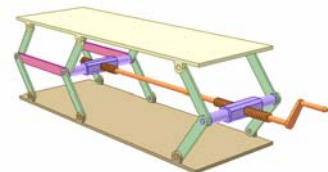
This jack is a combination of linkage, gear drive and nut screw one. The green disk moves along an absolutely straight line, its top plane is always horizontal.



### Double parallelogram mechanism 4

<http://www.youtube.com/watch?v=nd8MWd1rz88>

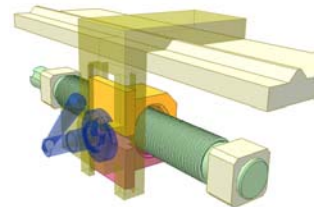
Raise or lower the table by turning the orange screw that has right hand and left hand threads with the same pitch.



### Half nuts for lathes

<http://www.youtube.com/watch?v=yqYd2-52R5U>

The haft nuts get engaged with the leadscrew by the blue slot face cam. The mechanism is used for turning threads.

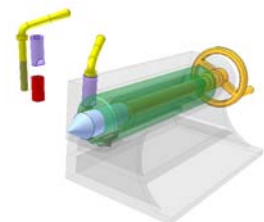


### Lathe tailstock 1

<http://youtu.be/pgsJJl5-zow>

Use the yellow lever to release or tighten the green spindle.

Turn the orange screw to move the spindle that has a hole with internal thread. At right end position of the spindle, the screw pushes the blue center for its removing.

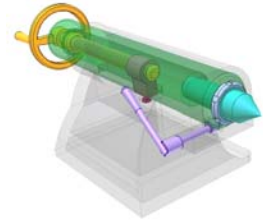




### Lathe tailstock 2

<http://youtu.be/qGVdUasdM9A>

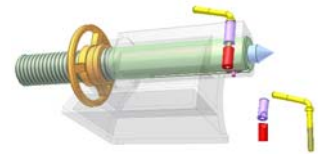
Use the violet lever (eccentric) to release or tighten the green spindle. Turn the orange screw to move the spindle. The pink nut is fixed to the tailstock house. The blue round nut is for removing the center.



### Lathe tailstock 3

<http://youtu.be/Sf-WVtx5mio>

Use the yellow lever to release or tighten the green screw-spindle. Turn the orange nut-wheel to move the spindle.



### Twin screw mechanism 1

<http://youtu.be/gxNnRek2tzM>

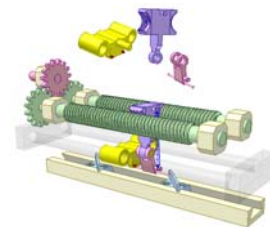
Input: pink gear making two green screws rotate in the same direction. Threads of the screws have opposite helical directions. Violet lever carrying two half nuts contacts with one of the two screws. The contact is controlled by a toggle mechanism of pink lever, blue spring and two blue stoppers.

Output: yellow slider having linear reciprocating motion. Its length and position can be adjusted by setting positions of the two blue stoppers.

Thread form must be square in order not to cause radial force that tends to push the nuts from the screws.

In case two green screws rotate in opposite directions, threads of the screws have the same helical direction.

Created only on computer, this mechanism needs to be verified in practice.



### Twin screw mechanism 2

<http://youtu.be/GBg--a5prRc>

Input: pink gear making two green screws rotate in opposite directions. Threads of the screws have the same helical direction.

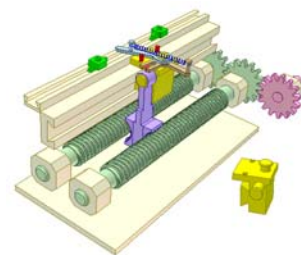
Violet lever carrying two half nuts contacts with one of the two screws. The contact is controlled by a toggle mechanism of blue spring, brown and blue levers and two green stoppers.

The violet lever has a red spherical pin that contacts the brown lever groove.

Output: yellow slider having linear reciprocating motion. Its length and position can be adjusted by setting positions of the two green stoppers.

Thread form must be square in order not to cause radial force that tends to push the nuts from the screws.

Created only on computer, this mechanism needs to be verified in practice.



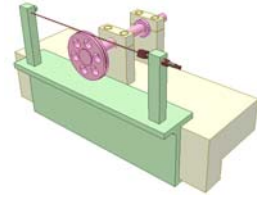
## 6.4. Belts and cables

### Cable drive 1

[http://youtu.be/MDsTRN\\_a9hs](http://youtu.be/MDsTRN_a9hs)

The brown cable is wound 1 rev. around the pink pulley. Its two ends are fixed to the green slider.

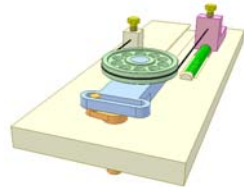
It is simplest way to convert rotation to translation and vice versa (as a rack-pinion drive).



### Cable drive 2

<http://youtu.be/d2qLx8KYK1q>

The pink slider moves twice faster than the blue one.



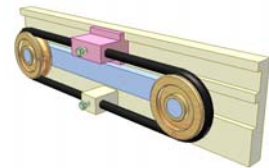
### Cable drive 3

<http://youtu.be/cbENTxMiRk0>

The blue slider carries two orange identical pulleys.

A point (middle) of the lower cable branch is fixed (immobile).

The upper branch is fixed to the pink slider, velocity of which is double the one of the blue slider.



### Cable drive 4

[http://youtu.be/Kwobt2n7\\_HY](http://youtu.be/Kwobt2n7_HY)

The blue and brown cables each wraps 1 rev. round the orange pulley of two radii ( $R$  and  $r$ ,  $R$  is larger than  $r$ ).

The pulley has a revolution joint with the blue slider.

Two ends of the blue cable are fixed to the yellow slider.

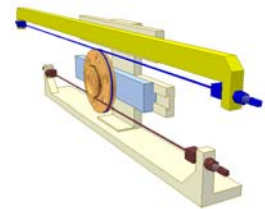
Two ends of the brown cable are fixed to the immobile base.

Velocity ratio between the yellow slider ( $V_y$ ) and the blue one ( $V_b$ ):

$$V_y/V_b = (R + r)/r$$

For this case  $R = 2r$  so  $V_y = 3V_b$

If  $R = r$  then  $V_y = 2V_b$



### Cable drive 5

<http://youtu.be/JkqfoA5LXR4>

The green pulleys are identical. The yellow pulleys are identical.

The blue cable with two fixed ends wraps round the green pulleys.

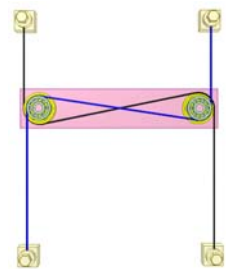
The black cable with two fixed ends wraps round the yellow pulleys.

Four vertical cable branches must be parallel.

The pink slider has vertical translational motion (with or without guideway).

Eccentric arrangement between the green pulleys and the yellow pulleys in vertical direction is possible.

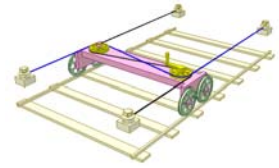
This mechanism was used for drawing parallel horizontal straight lines.



### Cable truck

<http://youtu.be/fks4ziPym18>

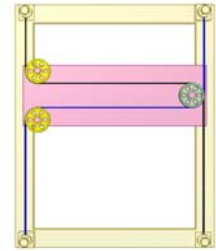
Turn the yellow crank to move the pink truck on a straight railway.  
The yellow pulleys have two round grooves for wrapping the black and blue cables.



### Cable drive 6

<http://youtu.be/uju7Ut2n9fM>

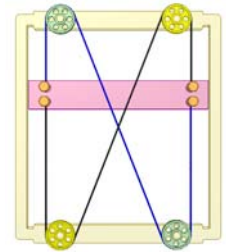
The yellow pulleys have 1 round groove.  
The green pulley has 2 round grooves.  
The black cable wraps on upper yellow pulley and the green one.  
The blue cable wraps on lower yellow pulley and the green one.  
All pulleys have the same contact (with the cables) diameter.  
The pink slider have vertical translational motions (with or without guideway).



### Cable drive 7

<http://youtu.be/e4Wgiyk02U4>

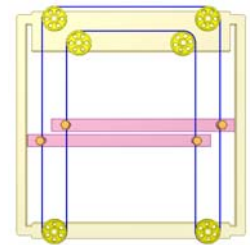
The yellow and green pulleys are identical.  
The blue cable with two ends fixed to the pink slider wraps on the green pulleys.  
The black cable with two ends fixed to the pink slider wraps on the yellow pulleys.  
The pink slider has vertical translational motion (with or without guideway).



### Cable drive 8

<http://youtu.be/BpkbSWNvvSA>

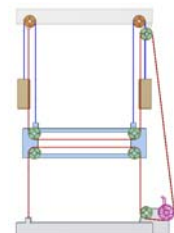
The yellow pulleys are identical.  
The blue endless cable wraps on all the pulleys.  
Each of two pink bars is fixed to the cable at two points.  
The bars have vertical translational motions in opposite directions (with or without guideway).



### Cable drive 9A

[http://youtu.be/5Ft3\\_hqnt30](http://youtu.be/5Ft3_hqnt30)

Mechanism for vertical moving a working platform (in blue).  
The blue cables carrying weights for platform equilibration. Turn the pink pulley to make the platform go up and down (through red cable).



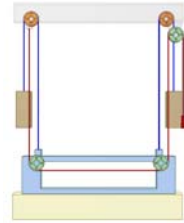
### Cable drive 9B

[http://youtu.be/7\\_0lsmI0qDs](http://youtu.be/7_0lsmI0qDs)

Mechanism for vertical moving a working platform (in blue).

The platform tends to get lowest position.

The blue cables carry contraweights. Pull the red cable to make the platform go up and fix it at desired position (fixing measure is not shown).



### Cable drive 9C

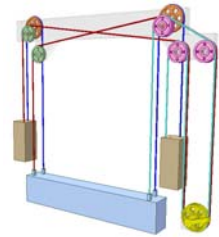
<http://youtu.be/NofhU1uEXJ4>

Mechanism for vertical moving a working platform (in blue).

There are four cables. The ends of each cable are fixed to the platform and to the contraweight.

The pink and yellow pulleys have two cable grooves.

Turn the yellow pulley to make the platform go up and down (through red and cyan cables).



### Cable drive 10

<http://youtu.be/hzsfHbpbQls>

Mechanism for vertical moving a working platform (in blue).

Only one endless cable is used.

The green, pink and orange pulleys are identical.

The green pulley and the yellow one are fixed together (two couples).

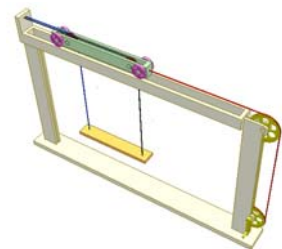
Turn one of the yellow pulleys to make the platform go up and down.



### Cable drive 11

<http://youtu.be/0KAmDnGBVJc>

Turn the yellow crank to move the green trolley along a horizontal rail. The orange platform, while moving horizontally, also moves vertically due to the black and blue cables. Angle between its rectilinear trajectory and the horizontal line is 45 deg.

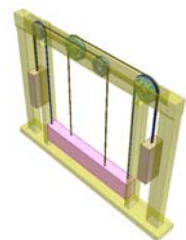


### Cable drive 12

<http://youtu.be/g9hmQTGQTO4>

This is a good way for mounting equilibratory weights to prevent jam of the pink slider.

Four cables are used. Each weight has two connected to it.



### Cable telescopic frame

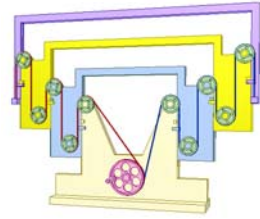
<http://youtu.be/yInMEfrQWwA>

Turn the pink pulley to make the violet frame go up and down.

Each of the red and blue cables has one end fixed to the pink pulley, the other to the violet frame. The green pulleys are identical. The weight of the moving parts ensures the cable tension.

The verticality of some cable branches is not compulsory.

In case of horizontal arrangement it is possible to add a second similar cable system for return motion.



### Cable drive 21

<http://youtu.be/R6fhA3ln8JU>

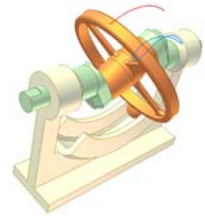
A simple way to convert reciprocating rotation to reciprocating translation.



## 7. Rotation to wobbling motion

### Wobbling disk mechanism 1a

<http://www.youtube.com/watch?v=59WtZtcHV6M>



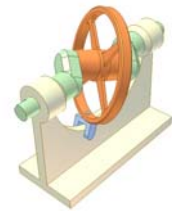
### Wobbling disk mechanism 1b

<http://www.youtube.com/watch?v=z1OxclWpmck>



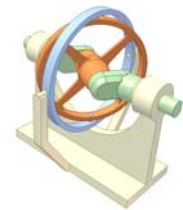
### Wobbling disk mechanism 1c

<http://www.youtube.com/watch?v=lgCKkvmwLoI>



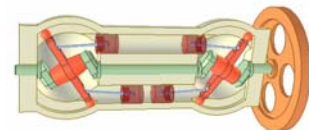
### Wobbling disk mechanism 1d

<http://www.youtube.com/watch?v=MqrIDAT-Agg>



### Application of wobbling disk mechanism 1

<http://www.youtube.com/watch?v=4MshdQtQFeA>

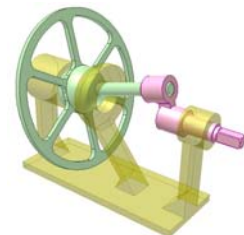


### Wobbling disk mechanism 4

<http://youtu.be/K7WahB1FD3g>

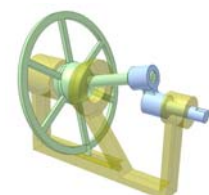
This mechanism has two degrees of freedom.

Two independent rotary motions are assigned to pink crank and green disk.



### Wobbling disk mechanism 2

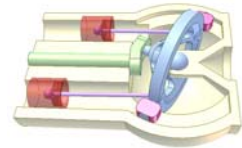
<http://www.youtube.com/watch?v=oBqxuEjRnDM>





### Application of wobbling disk mechanism 2

<http://www.youtube.com/watch?v=dygqFaX8srU>



### Wobbling disk mechanism 5

<http://youtu.be/k2CVF-L1W2I>

Input: pink crank.

The orange propeller performs a complicated motion that may find application for mixing machines.

There is a considerable backlash in the gear drive.



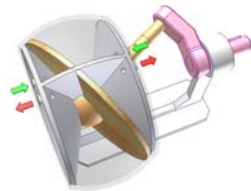
### Wobbling disk mechanism 6

<http://youtu.be/VpSXJkPBbQ4>

Input: pink crank.

A vertical wall prevents orange disk from rotating. The orange disk rolls on two cone surfaces.

The mechanism may be used for pumps. The arrows show fluid flows. An amount of fluid is sucked into the pump during its first revolution and discharged during the next revolution.

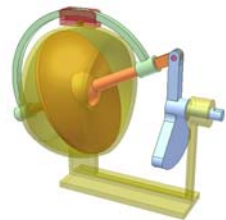


### Wobbling disk mechanism 3

<http://www.youtube.com/watch?v=TqBDpLp3RJq>

Steam engine of disk piston.

Steam is admitted alternately on either side of piston.



### Ceilling fan 1a

<http://youtu.be/YFyX6fxkvpA>

Two inputs: rotor carrying yellow propeller and pink crank (two electric motors).

Axes of all revolution joints of the pink crank and the green frame are concurrent.



### Ceilling fan 1b

<http://youtu.be/WN4ATS2XcVU>

Input: rotor carrying yellow propeller (electric motor).

Pink gear is fixed to the pink crank that is mounted idly on the fan base.

Motion is transmitted from the yellow propeller to the pink crank through two gear drives. Axes of revolution joints of the pink crank and the green frame are concurrent.

Use worm drives for large transmission ratio (for example: two worm drives and one spur gear drive).



### Rotary broaching 1

<http://www.youtube.com/watch?v=J2OAISkHHbI>

The workpiece is fixed.

Angle between axles of the workpiece and the tool is 1 degree.

The yellow tool has wobbling and axial movement.

The red portion is to be cut off.

An application of Wobbling Disk mechanism.



### Rotary broaching 2

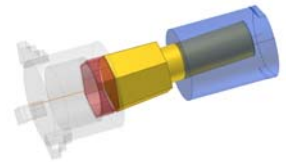
<http://www.youtube.com/watch?v=VcEhmpkMVRM>

The workpiece and the yellow tool is rotated

Angle between axles of the workpiece and the tool is 1 degree.

The tool also has axial movement.

The red portion is to be cut off.



## 8. Altering linear motions

### 8.1. Bars, wedges and cams

#### Transmission of linear displacement 1a

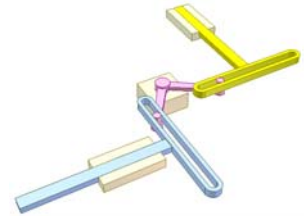
[http://youtu.be/pz\\_7UZRnMZM](http://youtu.be/pz_7UZRnMZM)

Angle of the pink twin equal crank is  $A = 90^\circ$ . The crank length is  $a$ . Angle between sliding directions of the runways is  $B = 90^\circ$ . Transmission ratio of linear displacement between the blue slider and the yellow one is 1. When the blue bar move regularly, so does the yellow.

Position of the crank bearing can be arbitrary.

Transmission ratio of 1 can not be kept if  $A$  differs from  $B$

Advantage over rack-pinion drive: high precision of transmission at low manufacture cost.



#### Transmission of linear displacement 1b

<http://youtu.be/XnZQS6qhtaE>

Angle of the orange twin equal crank is  $A = 60^\circ$ . The crank length is  $a$ . Angle between sliding directions of the runways is  $B = 60^\circ$ . Transmission ratio of linear displacement between the blue slider and the yellow one is 1. When the blue bar move regularly, so does the yellow.

Position of the crank bearing can be arbitrary.

Transmission ratio of 1 can not be kept if  $A$  differs from  $B$ .

Advantage over rack-pinion drive: high precision of transmission at low manufacture cost.



#### Transmission of linear displacement 2

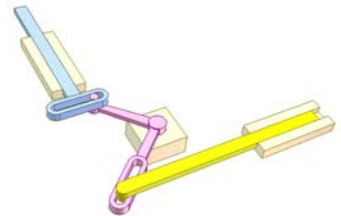
<http://youtu.be/Bz4anYbkXmY>

Angle of the pink twin arm is  $A = 90^\circ$ .

Angle between sliding directions of the runways is  $B = 90^\circ$ .

Transmission ratio of linear displacement between the blue slider and the yellow one is not 1.

When the blue bar move regularly, the yellow not.



#### Transmission of linear displacement 3a

<http://youtu.be/HnGQCIs07r0>

Angle of the orange twin equal crank is  $A = 60^\circ$ . Angle between sliding directions of the runways is  $B = A = 60^\circ$ .

The crank pivot center must be on the bisector of sliding directions of two sliders.

Transmission ratio of linear displacement between the blue slider and the yellow one is 1.

When the yellow bar move regularly, so does the blue.

Advantage over rack-pinion drive: high precision of transmission at low manufacture cost.



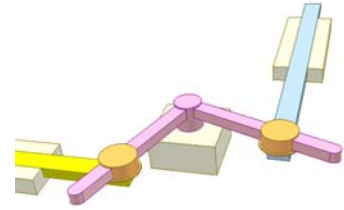
### Transmission of linear displacement 3b

<http://youtu.be/e51sMAdGS40>

An embodiment of "Transmission of linear displacement 3a"

$A = B = 90$  deg.

Orange parts have revolution joints with the sliders and prismatic joints with the pink arm.



### Transmission of linear displacement 4

<http://youtu.be/BwYzRrFOt9E>

Angle of the pink twin arm is  $A = 80$  deg..

Angle between sliding directions of the runways is  $B = A = 80$  deg..

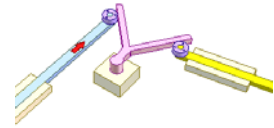
The crank pivot center must be on the bisector of sliding directions of two sliders.

For the pink crank, the distance between planes, that contact with the violet rollers, and the crank's pivot centerline must be equal to roller's radius.

Transmission ratio of linear displacement between the blue slider and the yellow one is 1.

When the yellow bar move regularly, so does the blue.

Red arrow represents resisting force.



### Transmission of linear displacement 5

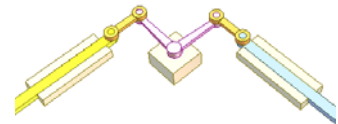
<http://youtu.be/9b6bNjXsBgo>

Angle of the pink twin arm is  $A = 90$  deg..

Angle between sliding directions of the runways is  $B = 90$  deg..

Transmission ratio of linear displacement between the blue slider and the yellow one is not 1.

When the yellow bar move regularly, the blue not.

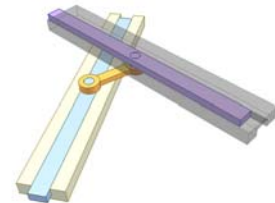


### Transmission of linear displacement 6

<http://youtu.be/qFjCFQ15ff8>

Transmission ratio of linear displacement between the blue slider and the violet one is not 1.

When the blue slider move regularly, the violet not.



### Transmission of linear displacement 7a

[http://youtu.be/VVRj9mh\\_JEc](http://youtu.be/VVRj9mh_JEc)

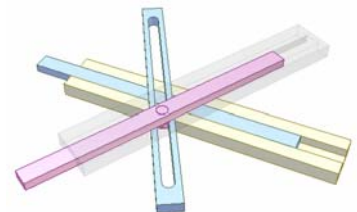
Angle between two sliding directions of the blue slider is  $A$  deg.

Angle between sliding directions of the runways is  $B = (180 - 2.A)$  deg.

Transmission ratio of linear displacement between the pink slider and the blue one is 1. When the pink slider moves regularly, so does the blue.

With other value of  $B$ , the transmission ratio differs from 1.

In substance it is a translating cam mechanism.



### Transmission of linear displacement 7b

<http://youtu.be/45DxLld4ZX0>

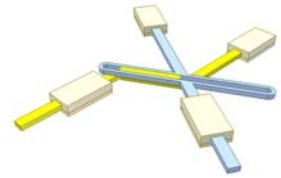
Angle between two sliding directions of the blue slider is A deg. Angle between sliding directions of the runways is  $B = (180 - 2.A)$  deg. Transmission ratio of linear displacement between the pink slider and the blue one is 1. When the pink slider moves regularly, so does the blue.

It is an embodiment of "Transmission of linear displacement 7a".

The pin of the pink slider is replaced by a rectangular key that creates an angle A with the sliding direction of the yellow slider.

With other value of B, the transmission ratio differs from 1.

In substance it is a wedge mechanism.



### Linkage for linear motions 1

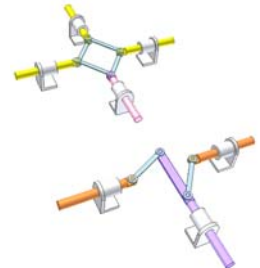
<http://youtu.be/-P8eOBkzuYw>

Back mechanism:

Input: pink slider. Opposite sliders move in opposite directions with the same speed.

Front mechanism:

Input: violet slider. Opposite sliders (in orange) move in the same direction with different speeds.



### Mechanism for increasing stroke length 1

<http://youtu.be/MbqEe-l3Z7M>

Input: blue slotted slider linearly reciprocating with constant stroke length.

Output: orange slider linearly reciprocating with adjustable stroke length.

Yellow slider has revolution joint with green slotted bar.

Adjust position of the yellow slider on the blue slider to get various stroke lengths of the output.

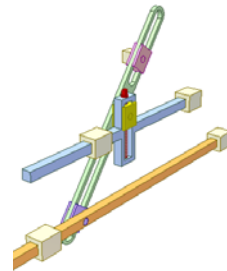
$$L_o = L_i \cdot (a/x)$$

$L_i$ : input stroke length

$L_o$ : output stroke length

$x$ : pivot center distance between pink and yellow sliders in vertical direction.

$a$ : distance from pivot center of the pink slider to sliding line of the orange slider in vertical direction.



### Mechanism for increasing stroke length 2

<http://youtu.be/4G6mSwPguK4>

Input: blue bar linearly reciprocating with constant stroke length.

Output: grey bar linearly reciprocating with adjustable stroke length.

Yellow slider has revolution joint with pink slider.

Adjust position of the pink slider on the fixed runway to get various stroke lengths of the output.

$$L_o = L_i \cdot (a+x)/x$$

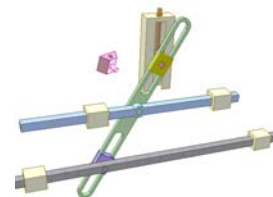
$L_i$ : input stroke length

$L_o$ : output stroke length

$a$ : distance between sliding lines of blue bar and grey bar.

$x$ : distance from pivot center of the pink slider to sliding line of the blue bar.

The adjustment can be performed when the mechanism is running.



### Lazy tong 1

<http://youtu.be/Zm-4kJLdRcM>

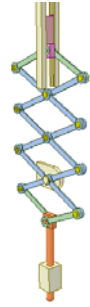
Input: pink slider.

Output: orange link.

Small longitudinal force on the input causes large one on the output (around 3 times in this case). The input and output move in opposite directions.

The mechanism finds application in lazy tong riveter:

<https://www.youtube.com/watch?v=7D7ECCps0h4>



### Lazy tong 2

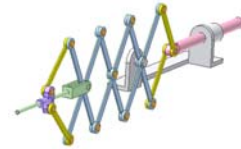
<http://youtu.be/UniRkbt0LOY>

Input: pink slider.

Output: violet link.

Short input motion gives a long output one (around 3 times in this video). The input and output move in opposite directions.

The green link is for keeping the violet link direction unchanged.



### Lazy tong 3

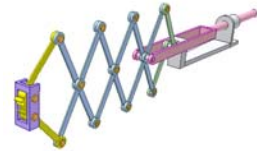
<http://youtu.be/cML0xKSmTPM>

Input: pink slider.

Output: violet link.

Short input motion gives a long output one (around 4 times in this video). The input and output move in the same direction.

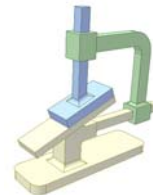
The gears on yellow links are for keeping the violet link direction unchanged.



### Wedge mechanism 1

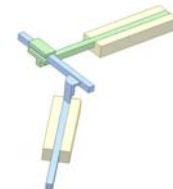
<http://youtu.be/IS5ivukXRrg>

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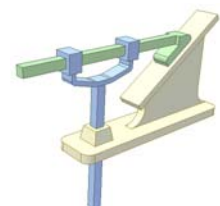
### Wedge mechanism

<http://www.youtube.com/watch?v=GeAEU2fGYKY>



### Wedge mechanism 2

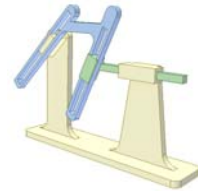
<http://youtu.be/6nWhE4ExegM>





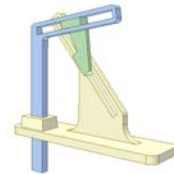
### Wedge mechanism 3

<http://youtu.be/9MTK6NNBCyc>



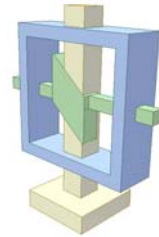
### Wedge mechanism 4

<http://youtu.be/A5a2mZNIHjw>



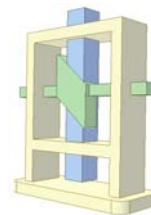
### Wedge mechanism 5A

<http://youtu.be/oP4Nljh8SIs>



### Wedge mechanism 5B

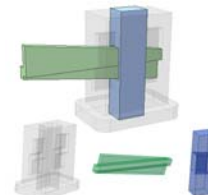
<http://youtu.be/2Zc6MzhJZi4>



### Wedge mechanism 6

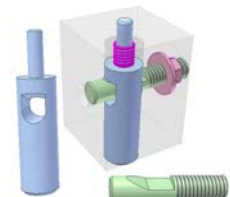
<http://youtu.be/vARgErImtro>

A construction measure for increasing course of the horizontal wedge.



### Wedge mechanism 7

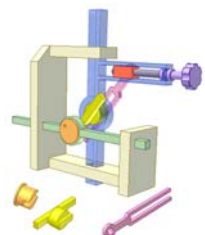
<http://youtu.be/laQA6cUrKAU>



### Wedge mechanism 8

<http://youtu.be/c3ep2XyCAow>

Input is the green horizontal bar. The stroke length of the blue vertical bar can be adjusted by choosing appropriate position of the red slider (altering the wedge angle of the mechanism).

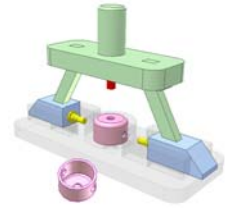


### Wedge mechanism 9

<http://youtu.be/uavruMk99v8>

Piercing die. Vertical and horizontal holes are created at the same time by punches fixed on vertical and horizontal sliders.

The vertical wedges (in green) can be of rectangular section or circular one.



### Wedge mechanism 10

<http://youtu.be/C5DWm0ab7BU>

The revolution joint between pink nut and green slider does not have kinematic significance. It is only for redeeming manufacture errors.

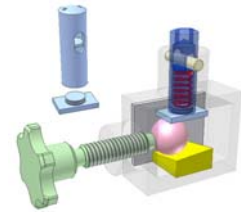


### Wedge mechanism 13

<http://youtu.be/f1FofjOrrP0>

Combination of screw and wedge mechanisms gives precise small displacement of a slider (in blue).

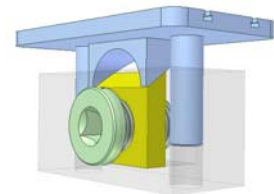
The yellow fixed wedge has slopes in two directions for positioning the pink ball. The spring is located inside the slider to reduce slider's length.



### Wedge mechanism 14

<http://youtu.be/XYjx0u75HNs>

Combination of screw and wedge mechanisms gives precise small displacement of a table (in blue).



### Wedge mechanism 15

<http://youtu.be/DIGLkp8Csq>

Hole diameter measuring device.

The object to be verified is the green. The violet fixed wedge transfers horizontal displacement into vertical one which can be read out on the indicator.



### Wedge mechanism 18

<http://youtu.be/3u9swq3XDSg>

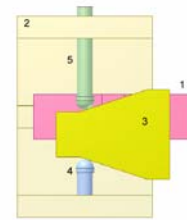
A bit of Morse taper tail can be removed easily by a wedge.



### Translational cam

<http://www.youtube.com/watch?v=f6ThkL0fQe8>

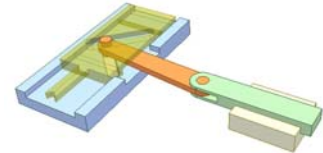
A measure to increase follower stroke while unchanged pressure angle.



### Stroke-multiplying mechanism

<http://www.youtube.com/watch?v=XDe0WAmb5aw>

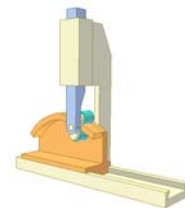
The second slot in the blue base helps double stroke of the yellow output slider. The green input slider is driven by a cam (not shown).



### Translating cam mechanism TTr1

<http://youtu.be/n6fXu9OAb6I>

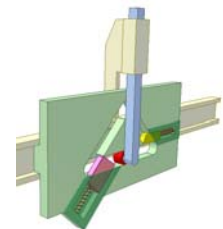
The follower has a twin arm carrying two rollers that contact both sides of the cam rim of constant thickness  $A$ . No backlash if clearance between the rollers =  $A$ .



### Translating cam mechanism TTr2a

<http://youtu.be/uMkATPVaA9Y>

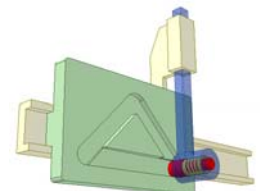
The green input cam reciprocates. The blue follower rests during cam's right to left stroke and moves during return. The pink and yellow plates help the roller move clockwise.



### Translating cam mechanism TTr2b

[http://youtu.be/nPcV9fF\\_h8A](http://youtu.be/nPcV9fF_h8A)

The green input cam reciprocates. The blue follower rests during cam's right to left motion and moves during return. The inconstant depth of the horizontal groove helps the red pin move clockwise.

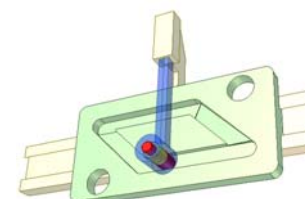


### Translating cam mechanism TTr3

<http://youtu.be/Bmp3OJiJQbw>

The green input cam reciprocates. The blue follower moves at the ends of forth and back strokes.

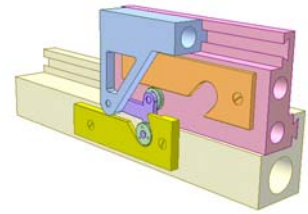
The various grooves' depths enable the red pin to move clockwise.



### Double translating cam mechanism 1

<http://youtu.be/1aQMPifguc4>

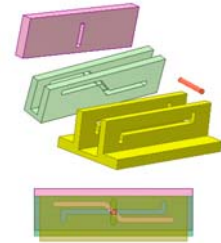
The input pink slider has linear reciprocating motion. Due to the violet T-shaped lever carrying two rollers and the slots on the orange and yellow plates, the output blue slider moves with dwell at right end of the input stroke.



### Double translating cam mechanism 2

[http://youtu.be/HK7u\\_ncfScM](http://youtu.be/HK7u_ncfScM)

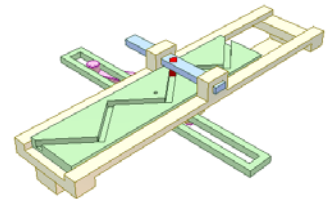
The input green slider has linear reciprocating motion. Due to the red pin moving in three slots of the parts, the output pink slider moves with dwell in the middle of the input stroke.



### Translating cam mechanism 4

<http://youtu.be/C053HbNN5-U>

If the cam pitch line is a symmetric zigzag, a rhomb-shaped pin can be used for the cam and follower contact to increase load capacity.



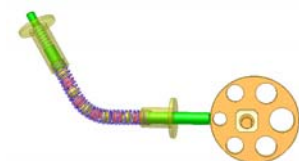
### Drive for small linear movement

<http://youtu.be/86ZG5x2IEEM>

Truyền chuyển động nhỏ.

Phương chuyển động giữa đầu vào và đầu ra có thể tùy ý, thậm chí chéo nhau.

Rất tiếc mô phỏng không thể hiện được rung động của ống dẫn lò xo.

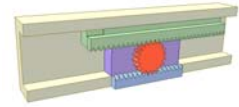


## 8.2. Gear drives

### Application of rack pinion mechanism 1

[http://www.youtube.com/watch?v=qdCOBf\\_gIGk](http://www.youtube.com/watch?v=qdCOBf_gIGk)

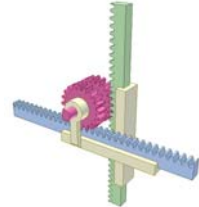
Velocity of the green slider is double the one of the violet slider



### Application of rack pinion mechanism 3

<http://www.youtube.com/watch?v=aF8vagao6CM>

Changing direction of a rectilinear motion



### Transmission of linear displacement 9

<http://youtu.be/hiEq-MAqPM0>

One slider is the driver and moves regularly. In general the driven slider moves irregularly.

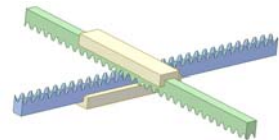
However there are exceptions.

For example, the video shows a case where the sliders move regularly, transmission ratio is 1. Sliding directions are perpendicular to each other. The assembly enables a position of the mechanism where the gear cranks and the runways create a rectangle.



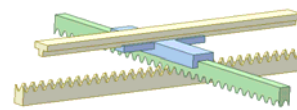
### Rack-Rack transmission 1

<http://www.youtube.com/watch?v=x1loh0bysM0>



### Rack-Rack transmission 2

<http://www.youtube.com/watch?v=ad9rl5sb-u8>



### Rack-Rack transmission 3

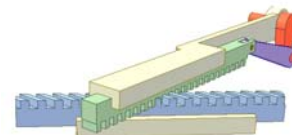
<http://www.youtube.com/watch?v=Ew9q6uQfZwY>

Tooth shape: rectangular.

Tooth inclined angle  $\beta_1 = 0^\circ$ ,  $\beta_2 = 45^\circ$ .

Angle between rack moving directions:  $\gamma = 45^\circ$ .

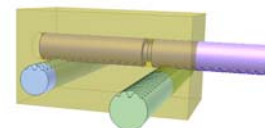
Displacement relation:  $s_2 = s_1 \cos \beta_1 / \cos \beta_2 = 1.41 s_1$



### Rack-Rack transmission 4

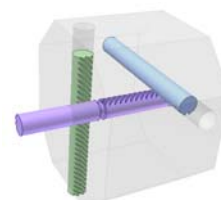
<http://www.youtube.com/watch?v=p2Pf1NVVhNY>

Tooth directions on the two gear parts of the violet rack are opposite.



### Rack-Rack transmission 5

[http://www.youtube.com/watch?v=r\\_G9Ho3FCJ8](http://www.youtube.com/watch?v=r_G9Ho3FCJ8)



### 8.3. Chains, belts and cables

#### Chain drive 4A

<http://youtu.be/grMBzq0YHH0>

This mechanism is applied in lifting trucks. The violet fork moves two times faster than the green piston.



#### Chain drive 4B

<http://youtu.be/sEp-K6eyYz8>

The pink plate is driving.

The yellow frame moves two times faster than the pink one.

The sprockets have the same tooth number.

The lower red link of the chains is fixed to the base.

The upper red link of the chains is fixed to the yellow plate.

The mechanism can be used for telescopic sliding gate of two panels. See:

<http://www.youtube.com/watch?v=ASAxH51ify8>



#### Chain drive 4C

[http://youtu.be/CjVJk\\_0uYhE](http://youtu.be/CjVJk_0uYhE)

The blue plate is driving.

The green plate moves two times faster than the blue one.

The violet plate moves two times faster than the green one or four times faster than the blue one.

The sprockets have the same tooth number.

The lower pink link of the front chains is fixed to the base.

The upper pink link of the front chains is fixed to the green plate.

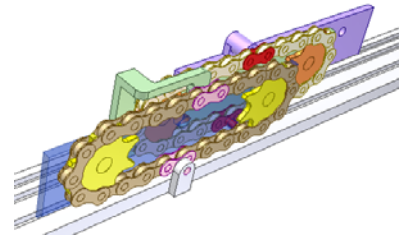
The lower red link of the back chains is fixed to the blue plate.

The upper red link of the back chains is fixed to the violet plate.

The blue plate carries the front chain drive.

The green plate carries the back chain drive.

The mechanism can be used for telescopic sliding gate of three panels.



#### Transmission of linear displacement 8

[http://youtu.be/HX\\_sU9Ye3VA](http://youtu.be/HX_sU9Ye3VA)

There are two belts. One belt end is fixed to pulley.

When the pink slider moves regularly, so does the yellow.

Transmission ratio of linear displacement between two sliders is 1 if two pulleys have the same belt contact diameter.

Spring may be cut down for the driving slider.

Angle between sliding directions is arbitrary.

This is similar to case of two rack-pinion mechanisms.

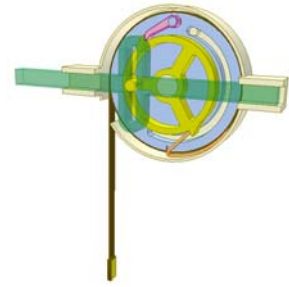




### Cable drive 15

[http://youtu.be/o2\\_0Ft6-Mq4](http://youtu.be/o2_0Ft6-Mq4)

Pull and release the brown tow twice to let the green coulisse move forth and back. One end of the tow is fixed to the blue disk. The orange spring ensures that the yellow ratchet wheel rotates in one direction. The circular slot on the blue disk and a pin on the case limit oscillating angle of the blue disk. A spiral spring (not shown) makes the blue disk rotate back when the tow is released. Another spring (not shown) always forces the pawl toward the ratchet wheel.



### Cable drive for changing direction of linear motion 1

<http://youtu.be/LGEt58cRzlc>

Input: yellow sliders moving along X axes.

Output: green sliders moving along axes Y or Z that are skew to X axes. Skew angles are 90 deg.

X, Y and Z are parallel to Ox, Oy and Oz of a Cartesian coordinate system Oxyz (not shown) respectively.



### Cable drive for changing direction of linear motion 2

<http://youtu.be/6Xt5xkjQQnY>

Input: yellow slider moving along X axis.

Output: green slider moving along axis Y that is skew to X axis. Skew angle can be arbitrary, for this case is 45 deg.



### Cable drive 16a

[http://youtu.be/1-M\\_5u\\_GqIE](http://youtu.be/1-M_5u_GqIE)

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 2



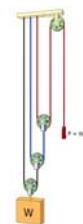
### Cable drive 16b

<http://youtu.be/Zqg0qqGG7NU>

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 8



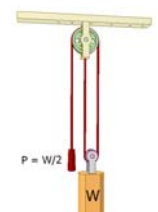
### Cable drive 17a

<http://youtu.be/BrUh4IK8oY0>

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 2



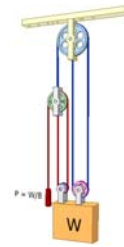
### Cable drive 17b

<http://youtu.be/bCWy9xnyZi8>

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 8



### Cable drive 18a

<http://youtu.be/ybHgot0jbUc>

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 3



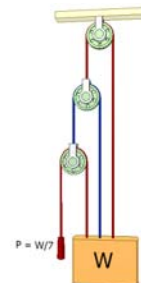
### Cable drive 18b

<http://youtu.be/XVXbkQ-DZSs>

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 7



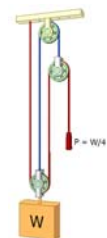
### Cable drive 19

[http://youtu.be/\\_1mvNDrcymk](http://youtu.be/_1mvNDrcymk)

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 4



### Cable drive 20

<http://youtu.be/MLWs-9-HqqU>

Four pulleys rotate independently.

W: weight of the load

P: pulling force for moving up the load.

Mechanical advantage: 4 (number of the cable branches that suspend the weight or twice number of movable pulleys)

Pulleys velocities:

$$V_g = 4V_b$$

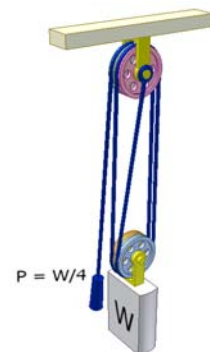
$$V_o = 3V_b$$

$$V_p = 2V_b$$

$V_g$ ,  $V_o$ ,  $V_p$  and  $V_b$  are velocities of green, orange, pink and blue pulleys, respectively.

Upper pulleys have the same rotation direction.

Lower pulleys have the same rotation direction, opposite to the one of the upper pulleys.



### Bowden cable 1

<http://youtu.be/HhzvytVW1kk>

It is used to transmit a pulling force over short distances.

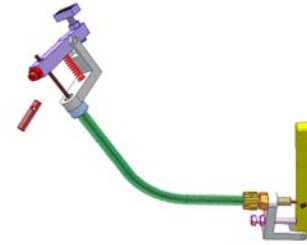
Input: yellow lever.

Moving direction of the violet output lever can be arbitrary.

The cable moves in green cable housing (a bended helical steel wire).

Orange inline hollow bolt (barrel adjuster) is for adjusting position of violet output lever.

Turning the bolt to the left means lengthening the cable housing relative to two grey fixed anchors and adjusting the output lever anticlockwise.



### Bowden cable 2

<http://youtu.be/wWdTjjE4usA>

Input: pink button.

Output: blue pin.

The brown cable housing (a bended helical steel wire in practice) moves outside grey fixed cable.

Position of the pink button can be arbitrary in the space.

The mechanism is used to transmit a pushing force over short distances. It finds application for cameras

The displacement of the input can not be long.

The mechanism is cut off half for easy understanding.

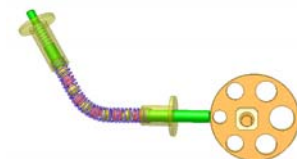


### Drive for small linear movement

<http://youtu.be/86ZG5x2IEEM>

Movement directions between the input and the output can be arbitrary, even skew.

Regretably the animation can not show the vibration of the spring duct.

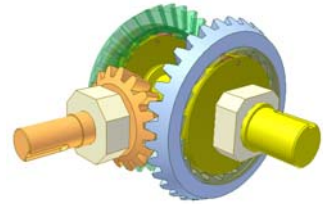


## 9. Converting reciprocating motion to continuous rotation

### Mechanism for converting two-way to one-way rotation 1

<http://youtu.be/N49LqVQChMg>

The yellow input shaft may change rotation direction but the rotation direction of the orange output gear keeps unchanged because of ratchet mechanisms placed between the yellow shaft and the big gears. Friction overrunning roller clutch can be used instead of ratchet mechanism to avoid noise and backlash.

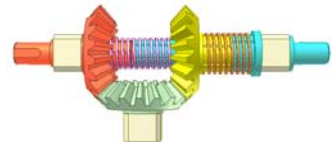


### Mechanism for converting two-way to one-way rotation 4

<http://youtu.be/AQRuCse7ENY>

The red input shaft may change rotation direction but the rotation direction of the cyan output gear shaft unchanged due to two spring clutches. One connects the red input shaft and the cyan output shaft. The other connects the yellow gear and the cyan output shaft. The yellow gear rotates free of the output shaft in absence of the orange spring.

The spring helix direction is the key factor for this mechanism.

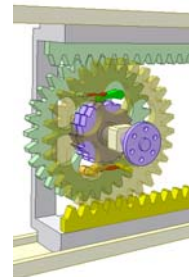


### Converting two way linear motion into one way rotation 1

<http://youtu.be/0dJC8lqa8K0>

The green and yellow gears idly rotate on the output violet shaft of ratchet wheel. Each gear has its pawl engaging with the ratchet wheel. Input grey frame carrying two racks has go and back linear motion. The green rack engages with the green gear. The yellow rack engages with the yellow gear. The red leaf springs force the pawls toward the ratchet wheel.

The ratchet wheel always rotate anti-clockwise regardless of go or back motion of the frame.



### Ratchet mechanism 11b

<http://youtu.be/Yb4wuEACcTk>

Converting linear reciprocating motion into continuous rotation.

Input: pink slider.

Output: orange ratchet wheel.

Springs for forcing the pawls towards the ratchet wheel are not shown.

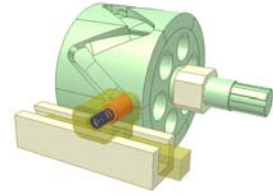
Both go and back motions of the pink slider are useful. Violet pawl pushes and green pawl pulls the wheel.



### Barrel cam mechanism BT5

<http://youtu.be/mNcr5Yv3pG8>

Linear reciprocating motion is converted into continuous rotation. Key factor is the inconstant depth of the slots. Stroke length of the yellow slider must be equal to axial length of the cam profile.



### Ratchet mechanism 10

<http://youtu.be/bj1UCX62Q-k>

This mechanism is used in hand powered electric torches to convert oscillatory motion into continuous rotation.



### Ratchet mechanism 11

<http://youtu.be/GFchrDEWYYo>

This mechanism is used for converting oscillatory motion into continuous rotation. Both go motion and back motion of the pink angle lever are useful.



### Cable drive 24

<http://youtu.be/BHapT2BMHC8>

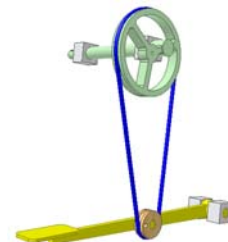
A simple way to convert reciprocating rotation to continuous rotation. The orange contraweight tends to set the blue pedal at its highest position. Driving force can make the output link rotate only half way, the contraweight and inertia do the rest way.



### Belt drive 15

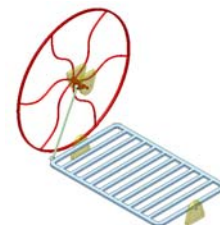
<http://youtu.be/-d8RDSBxHjY>

A simple way to convert oscillation to continuous rotation. Pedal down motion creates driving moment for the green shaft. During pedal up motion the green shaft rotates thanks to its inertia. Turning the green shaft at start-up is needed.



### Foot driven mechanism for sewing machine

<http://www.youtube.com/watch?v=rzdP9OZeaRU>

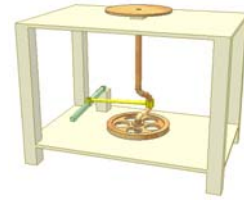


### Pottery wheel

<http://youtu.be/P-xT0xrK6AE>

Operator's left foot pushes green lever to rotate the wheel. Continuous rotation is possible thanks to flywheel inertia. At starting use hands to turn the upper disk to overcome mechanism dead point when needed.

In another embodiment the green lever and the yellow conrod are removed. The operator rotates the flywheel directly by his foot (right or left).



### Railway hand car

<http://youtu.be/ZpnMvKxk4lw>

Swing green double lever to move the car via a 4 bar linkage and a gear drive.

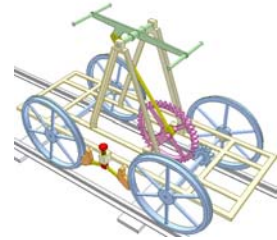
Reverse of swinging means reversing the car.

Step on the red knob to operate a crank slider mechanism for braking.

This video is made based on G.S. Sheffield's invention in 1882.

For a real car see:

[https://www.youtube.com/watch?v=rJq\\_9nxVc6A](https://www.youtube.com/watch?v=rJq_9nxVc6A)



### Mechanism for converting two-way to one-way rotation 2

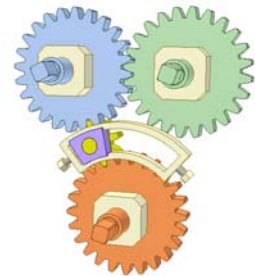
<http://youtu.be/esVq6jfTigM>

The orange input gear may change rotation direction but the rotation direction of the blue and green gears keeps unchanged.

The yellow idle gear moves in the curved slot because of gear forces.

There is a slight lag during the input gear's reverse.

The mechanism should be used only for low speed case because of gear collision.

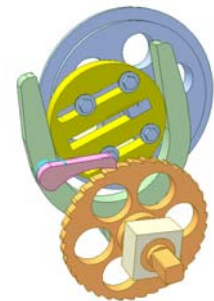


### Mechanism for converting two-way to one-way rotation 3

<http://youtu.be/qeotBGLVn7A>

The blue input disk may change rotation direction but the rotation direction of the orange output ratchet wheel keeps unchanged.

The yellow adjustable eccentric cam is fixed on the disk and rocks the green U-shaped follower carrying the pink pawl.



### Mechanism for converting two-way to one-way rotation 5

<http://youtu.be/x2JieVQlek0>

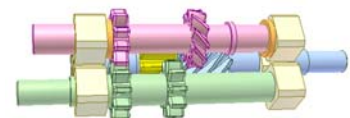
The blue input gear may change rotation direction but the rotation direction of the green output shaft keeps unchanged.

The yellow gear rotates idly on the blue shaft. The orange rings represent thrust bearings.

The pink shaft moves longitudinally when the input reverses because of axial component of gear forces.

There is a slight lag during the input shaft's reverse.

The mechanism should be used only for low speed case because of gear collision.





### Face gear 13

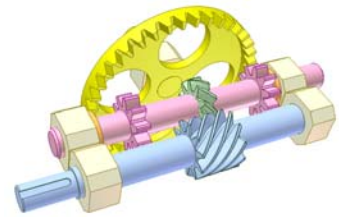
<http://youtu.be/h6upHEjsp74>

Mechanism for converting two-way to one-way rotation.

The blue input shaft may change rotation direction but the rotation direction of the yellow output gear keeps unchanged.

The pink shaft moves longitudinally when the input reverses because of axial component of gear force in the blue gear drive.

The mechanism should be used only for low speed case because of gear collision.



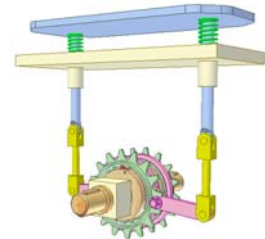
### Converting two way linear motion into one way rotation 2

<http://youtu.be/LjvhazEt0UA>

Two bicycle freewheels are fixed in the same direction on orange output shaft.

Their green sprockets are connected to blue sliding plate via pink levers and yellow conrods. When the blue plate goes up down the output shaft turns in one direction.

This is a design of Mr. Keshav Rai from New Delhi.



### Converting two way linear motion into one way rotation 3

<http://youtu.be/MswriP9QKxE>

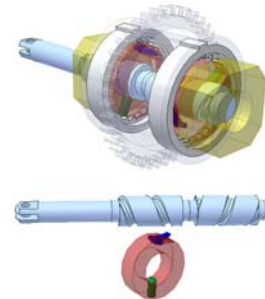
Input: blue screw having two threaded portions of opposite hands.

Output: glass gear having two ratchet wheels.

Two red bushes create revolution joint with the output gear and helical joints with the screw.

Reciprocate linear motion of the screw makes the two bushes oscillate in opposite directions. Ratchet mechanisms (two blue pawls) convert motions of the two bushes into one way rotation of the output gear.

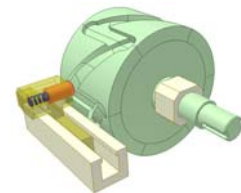
Using ball screw drives and roller overruning clutches instead of lead screw drives and ratchet mechanisms gives better output motion.



### Barrel cam mechanism BT4

<http://youtu.be/nMEpbyMCMdw>

This mechanism converts linear reciprocating motion into intermittent rotation. Key factor is the inconstant depth of the oblique slots.



## 10. Mechanisms for creating complicated motions

### Double parallelogram mechanism 2

<http://www.youtube.com/watch?v=U-Vn5SoRWCg>

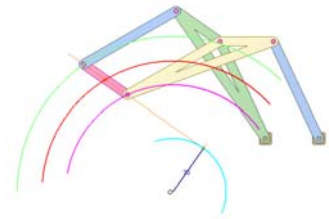
Length of two blue links is 140.

For the two triangular links lengths between the holes are 70 and 140 with angle of 150 degrees.

Lengths of the pink output and the grounded links is 70.

The pink output link rotates around point O.

This avoids the need for hinges at distant or inaccessible spots.

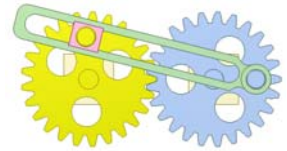


### Gear and linkage mechanism 8b

<http://youtu.be/wTG1Ai2S9I8>

The gears have the same tooth number and the same distance of their pins to their rotation axes.

The green bar has complicated motion in general.



### Slider-crank mechanism with gears on conrod

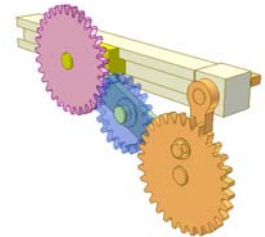
<http://youtu.be/doSUZ1AdKU8>

The orange gear and orange crank are fixed together.

The blue and pink gears, each rotates idly on its axle.

The orange and pink gear have the same tooth number.

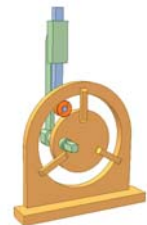
The input crank rotates regularly while the blue and pink gears rotates irregularly.



### Fixed cam mechanism 2

<http://youtu.be/LFpE2USzXsU>

The green input crank rotates. The orange cam is fixed. This example aims to prove that the cam does not always an input rotational link and the follower has planar motion.

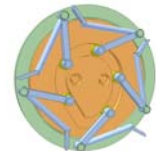


### Fixed cam mechanism 3

<http://youtu.be/MEfBhY9RI08>

A device of machines for unhearthng potato.

Input is the green disk. The orange grooved cam is fixed. The blue follower, at one end of which is fixed a hoe, has planar motion.

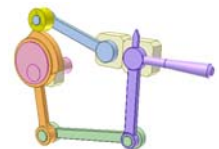


### Mechanism of cam's planar motion 1

<http://youtu.be/qGHpenVs6wg>

Input is the pink eccentric shaft. The orange cam has planar motion.

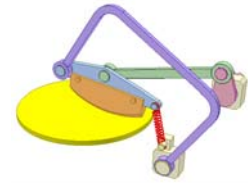
Output is the blue crank. Adjust position of the violet lever to get various motions of the output crank. Gravity maintains permanent contact between rollers and cam.



### Mechanism of cam's planar motion 2

<http://youtu.be/Gr-2Hbun0TA>

Input is the pink crank. The orange cam has planar motion.



### Cam mechanism of follower's planar motion 1

<http://youtu.be/NXA99a7HiXg>

The green follower, connecting rod of a parallelogram mechanism, has planar motion. Gravity maintains permanent contact between roller and cam.



### Fixed cam of parallelogram groove

<http://youtu.be/Rx32dbLwf2c>

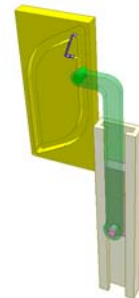
Input: pink slider reciprocating with constant stroke length.

Output: green rocker of complicated motion.

Green pin of the rocker moves clockwise along the groove on yellow fixed cam.

Violet flat spring does not allow the pin go counter-clockwise at the cam upper corner.

The gravity does not allow the pin go counter-clockwise at the cam lower corner.



### Cable drive 24

<http://youtu.be/nT0DdQAaf-k>

The pink crank and the pink pulley are fixed together. They are driving link of reciprocating rotation.

The red weight has a complicated motion.

It goes up and down under influence of the 4-bar mechanism and the cable drive of two pulleys.



### Cable drive 26

<http://youtu.be/7b0V0cHyQas>

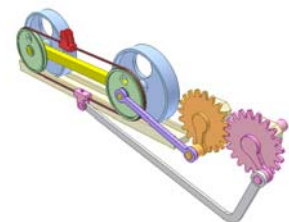
Converting continuous rotation of the pink gear crank to reciprocating translation of the red slider.

The red slider and the pink slider are fixed to the cable.

The blue wheels and the green pulleys rotate idly on axles of the yellow bar.

The red slider receives two motions:

- From the orange crank slider mechanism.
- From the pink crank slider mechanism and cable drive.

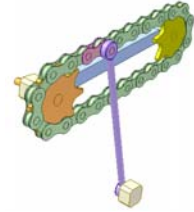


### Chain drive 6A

<http://www.youtube.com/watch?v=94rvs8aUWs8>

Satellite chain drive.

The blue bar plays role of a carrier. The orange and yellow sprockets have the same tooth number. Input is the orange sprocket that has reciprocating rotation. Full rotation is impossible. The violet bar has a revolution joint with a chain link. The carrier and the violet bar oscillate.



### Chain drive 6B

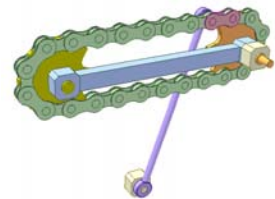
<http://www.youtube.com/watch?v=09Qz6ErIOEQ>

Satellite chain drive.

The blue bar plays role of a carrier. The orange and yellow sprockets have the same tooth number. The violet bar has a revolution joint with a chain link.

Input is the blue bar that has reciprocating rotation. More than 1 revolution is impossible.

The sprockets and the violet bar oscillate.



### Chain drive 7A

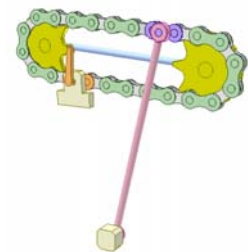
<http://youtu.be/s-H37-c1CP0>

Chain drive of two movable sprockets.

The yellow sprockets have the same tooth number.

The driving pink lever, having a revolution joint with the violet chain link, oscillates around a fixed pivot.

The orange link oscillates in a fixed house.



### Chain drive 7B

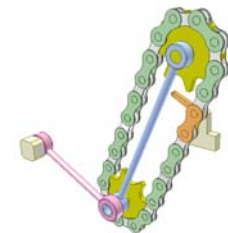
<http://youtu.be/OxLFWIWh5As>

Chain drive of two movable sprockets.

The yellow sprockets have the same tooth number.

The driving pink lever, having a revolution joint with the blue carrier, oscillates around a fixed pivot.

The orange link oscillates in a fixed house.



### Chain drive 11A

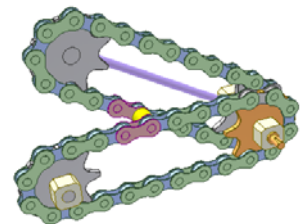
<http://youtu.be/ClxbhMnXTfI>

There are two chain drives. One is of satellite type.

They are connected together by two pink chain links and an yellow bush.

Input is the orange sprocket.

The video shows how complicatedly the satellite chain drive moves.



### Chain drive 11B

<http://youtu.be/Cv8h7LGBDm0>

There are two chain drives. They are of satellite type.

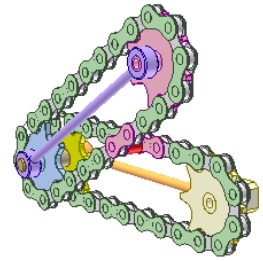
The chains are connected together by two pink chain links and a red bush.

The blue and yellow sprockets are coaxial but rotate independently.

The popcorn sprocket is fixed.

Input is the orange carrier.

The video shows complicate motions of two drives.

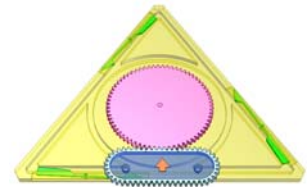


### Oval gear 3a

<http://youtu.be/jedbQnuuiy0>

An input pink gear, rotating around fixed axis, engages with blue gear of oval shape. The latter has two pins that slide in grooves of the base. In one cycle of motion the blue gear performs two revolutions around rotary axis of the pink gear and changes its direction twice.

Green arms that always turn clockwise due to springs (not shown) in coordination with the front pin of the blue gear allow the front pin follow the straight grooves and direct the rear pin follow the circular groove.



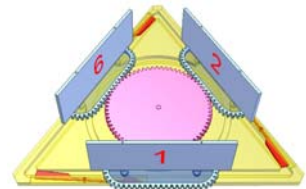
### Oval gear 3b

<http://youtu.be/9kjUcsqieRg>

An input pink gear, rotating around fixed axis, engages with blue gears of oval shape. The latter have two pins that slide in grooves of the base. In one cycle of motion the blue gears performs two revolutions around rotary axis of the pink gear and changes its direction twice.

Red arms that always turn clockwise due to springs (not shown) in coordination with the front pin of the blue gear allow the front pin follow the straight grooves and direct the rear pin follow the circular groove.

On each side of the triangular base numbers 1, 2, ..., 6 appear one after another.

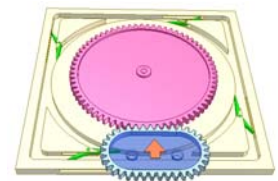


### Oval gear 3c

<http://youtu.be/dPif6o4yf18>

An input pink gear, rotating around fixed axis, engages with blue gear of oval shape. The latter has two pins that slide in grooves of the base. In one cycle of motion the blue gear performs four times of straight motion and four times of rotation alternately.

Green arms that always turn anticlockwise due to springs (not shown) in coordination with the front pin of the blue gear direct the front pin follow the straight grooves and the rear pin follow the circular groove.



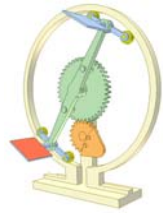
### Cam and gear mechanism 2

<http://youtu.be/-zOdLhISU1M>

Input is the green gear to which a long arm is fixed.

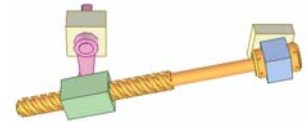
Two short arms (each carries two rollers) are connected to both ends of the long arm by revolution joints. Due to the orange gear cam and a slot in the base, the short arms change their directions after every revolution of the long arm.

Transmission ratio of the gear drive is 2.



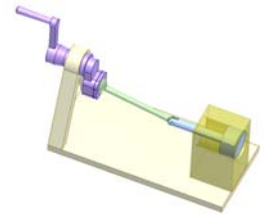
### Nut-screw and bar mechanisms 2a'

<http://youtu.be/W10IxIOMVpo>



### Spatial slider crank mechanism 6

<http://www.youtube.com/watch?v=3h9C7mjcwoU>



### Twisted slider

[http://www.youtube.com/watch?v=2\\_ioqY-O4Jo](http://www.youtube.com/watch?v=2_ioqY-O4Jo)

Standard four-bar linkage has a screw substituted for a slider. The output is helical rather than linear.

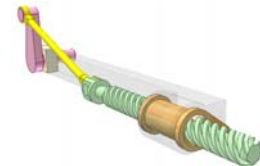


### Screw-slider-crank mechanism

<http://youtu.be/OTdcOR3Byws>

The helical joint between the green screw slider and the orange bush makes the latter have reciprocating rotation.

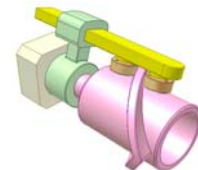
Screw lead angle must be big enough to avoid jerk.



### Barrel cam mechanism BT8

<http://youtu.be/hs07gwcfbwM>

The pink cam is fixed. The green crank rotates. The yellow follower slides in a rectangular hole of the crank.



### Double cam mechanism 3

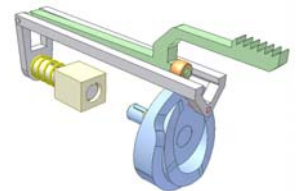
<http://youtu.be/5UUPAd39ZG0>

Four motion feed used on sewing machines for moving the cloth.

A combination of disk cam and face cam.

The grey fork carrying green bar translates thanks to blue face cam and pink pin. Yellow spring maintains their contact.

The green bar oscillates around a pivot on the fork thanks to blue disk cam and orange roller. Gravity maintains their contact.





### Converting Rotation to Rotary and Linear reciprocating motion 1

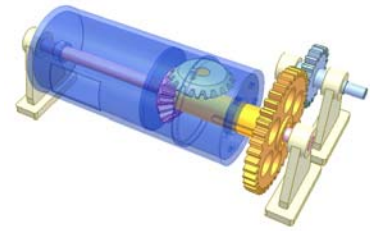
<http://youtu.be/YwpGA-5ID4k>

The pink shaft with a bevel gear is fixed.

The orange bush with a spur gear receives rotation from the input blue gear. The green satellite bevel gear has a pin sliding in a circular slot of the blue output cylinder.

The latter rotates and linearly reciprocates simultaneously.

If two bevel gears have the same tooth number, 1 revolution of the cylinder corresponds its 1 double stroke. This relation can be varied by using bevel gears with different tooth numbers.



### Converting Rotation to Rotary and Linear reciprocating motion 2

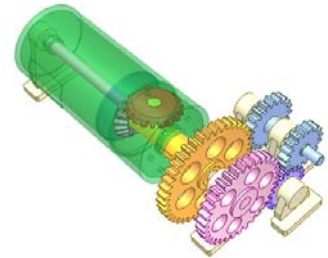
<http://youtu.be/TI5N3dX42mE>

The pink shaft, the pink bevel gear and the pink spur gear are fixed together and receive rotation from the input blue shaft.

The orange bush and the orange spur gear are fixed together and receive rotation from the input blue shaft.

The red satellite bevel gear has a pin sliding in a circular slot of the green output cylinder. The latter rotates and linearly reciprocates simultaneously.

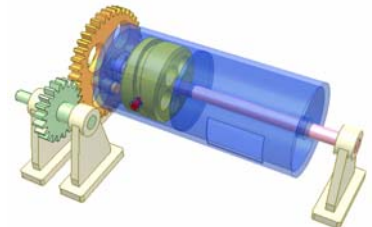
For this case, 1 revolution of the cylinder corresponds its 2 double strokes. This relation can be varied by altering speeds and rotary directions of the orange and pink spur gears.



### Converting rotation to rotary and linear reciprocating motion 3

<http://youtu.be/io1JL1U7kUs>

Input: the green gear. The pink shaft with yellow cam is fixed. The orange gear rotates without axial motion. The blue cylinder has a red pin that slides in the cam groove. The cylinder rotates and linearly reciprocates simultaneously.



### Helix torus cam

<http://youtu.be/tlhtEbzVj5g>

The green input part rotates. The yellow bush carrying a pin rotates around its own axis. The pink slider moves along a fixed runway.

