

Nguyen Duc Thang

1700 ANIMATED MECHANICAL MECHANISMS

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

Part 3 Mechanisms of specific purposes

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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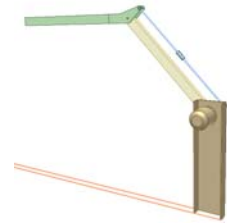
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11. Mechanisms for folding, contracting or stretching

Folding barrier 1

<http://www.youtube.com/watch?v=bq0iiqCSTFg>

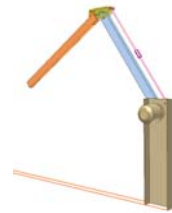
An application of parallelogram mechanism.
Folding barrier is used for height limited place.



Folding barrier 2

<http://www.youtube.com/watch?v=LF8kSTCZlXw>

A combination of parallelogram mechanism and 4-bar linkage.
Folding barrier is used for height limited place.



Folding barrier 3

<https://www.youtube.com/watch?v=j3RNoijvcD4>

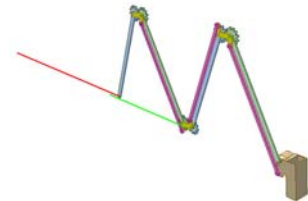
A combination of a parallelogram mechanism and gears.
The gears are fixed to the bars.
Folding barrier is used for height limited place.



Folding barrier 4 (Straight line drawing mechanism)

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

A combination of parallelogram mechanisms and gears.
The gears are fixed with the bars.
It can be applied for folding barriers, gates, eaves or lamps.
By similar connecting of bars the barrier can be very long.



Stretch and contraction mechanism

<http://www.youtube.com/watch?v=4UpjmxQ3900>

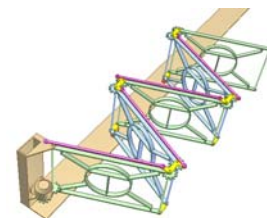
A combination of parallelogram mechanisms and gears.
Loci of various points on the bars are shown. They can be ellipse, circle or straight line.
By similar connecting of bars the stretch can be very long.



Penta-folding gate

<http://www.youtube.com/watch?v=6jSwpmr4k5l>

A combination of parallelogram mechanisms and gears.
There is no need of railway.
If the construction is not heavy, the wheels can be removed.
It is an application of mechanism shown in:
<http://www.youtube.com/watch?v=QNkODQMZfwc>



Bi-folding gate 1

<http://youtu.be/LG2-y4iVDB4>

Orange conrod, green and upper yellow cranks create a parallelogram mechanism.

R1: pitch radius of green gear

R2: pitch radius of blue gear

$i = R1 / R2 = 40 / 19$. This ratio is needed to meet requirement when green gate rotates $\alpha = 58$ deg., blue gate rotates 90 deg. in relation with the green gate.

i changes when α has different values. $i = 1$ if $\alpha = 90$ deg.

If necessary a supporting swivel wheel for the blue gate is mounted at its lower right corner.

This video was made on request of Mr. JC Lo from Malaysia.

The two gears can be replaced by a bar to get similar effect. See:

<http://www.youtube.com/watch?v=LF8kSTCZlXw>



Tetra-folding gate

<http://www.youtube.com/watch?v=II88I0AP6-Q>

A combination of slider-crank mechanisms and gears.

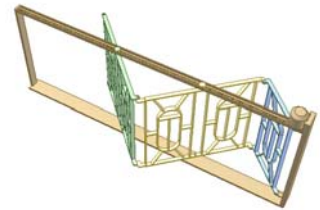
The gears are fixed with the two center gate panels.



Tri-folding gate

<http://www.youtube.com/watch?v=SoL0uq5K6fg>

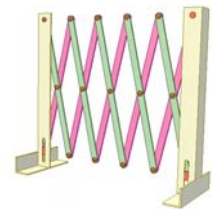
A combination of slider-crank mechanisms.



Folding scissor fence

<http://www.youtube.com/watch?v=Do1DwSgkZoM>

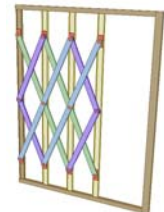
Combination of slider crank mechanism and parallelogram mechanism.



Folding scissor gate 1

<http://www.youtube.com/watch?v=opSblgV2pSE>

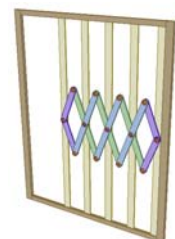
A combination of slider crank mechanisms and parallelogram mechanisms.



Folding scissor gate 2

<http://www.youtube.com/watch?v=GvjFwcl9rro>

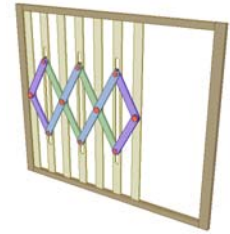
A combination of slider crank mechanisms and parallelogram mechanisms.



Folding scissor gate 3

http://www.youtube.com/watch?v=tb4H7Tr_W1s

A combination of slider crank mechanisms and parallelogram mechanisms.



Folding scissor gate 4

http://www.youtube.com/watch?v=_GApddnCKz4

A combination of slider crank mechanisms and parallelogram mechanisms.



Kite mechanism 5c

http://youtu.be/AD_0MACi44M

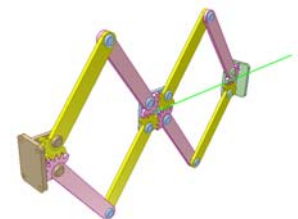
A way to connect two (or more) "Kite and spear-head mechanism 5b" by adding gear drive (in violet). Thus very long rectilinear motion of the end bar (in pink) can be obtained. This mechanism may be applied for retractable gates.



Gear and linkage mechanism 3b

<http://youtu.be/jFVh3nKOVf8>

Combination of linkage and gear drive. It shows the way to connect two (or more) mechanisms of "Gear and linkage mechanism 3a". The green part translates along an absolutely straight line.



Lazy tong 1

<http://youtu.be/Zm-4kJLdRcM>

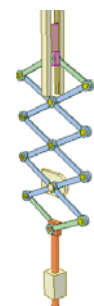
Input: pink slider.

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

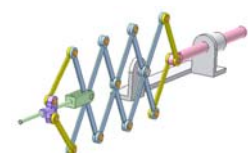
<http://youtu.be/UniRkbt0LOY>

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

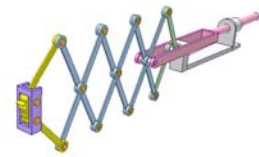
<http://youtu.be/cML0xKSmTPM>

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.



Telescopic sliding gate

<http://www.youtube.com/watch?v=ASAxH51ify8>

A roller cable mechanism is used.

A point on lower part of the cable is fixed with the grounded post.

A point on upper part of the cable is fixed with the blue panel 2 that moves twice faster than the yellow panel 1.



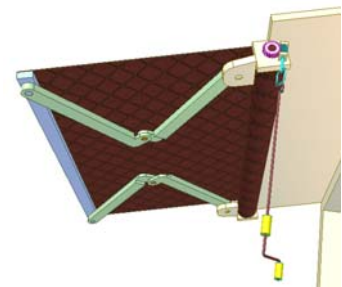
Contractible eave

<http://www.youtube.com/watch?v=YmcJmXpR7XM>

It is an application of the slider-crank mechanism.

Manual rotation of the detachable brown crank rolls the roof through a worm drive.

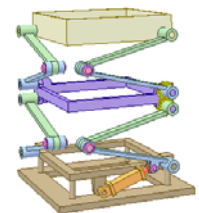
The roof has some slope so it keeps even during stretching.



Sarrus linkage 3

<http://youtu.be/FINFaiCQIAk>

A way to connect two (or more) Sarrus linkages by adding gear drive (in yellow). Thus very long up-down rectilinear motion of the top floor can be obtained by just small displacement of a piston (in orange).



Retractable device for fluid supply

<http://youtu.be/B3khF2IBUyU>

"Sarrus linkage 3" in combination with helical hose.



12. Mechanisms for controlling direction during motion

Keeping direction unchanged during rotation 1

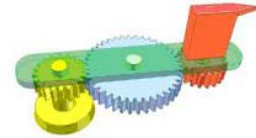
<http://www.youtube.com/watch?v=jMCBm9bG4EY>

The direction of the red object is unchanged.

Using spur gears.

The end gears have the same number of teeth.

The number of intermediate gears must be odd.



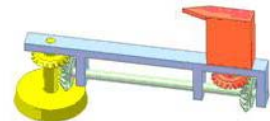
Keeping direction unchanged during rotation 2

http://www.youtube.com/watch?v=5Oa_7k1GMi0

The direction of the red object is unchanged.

Using bevel gears.

The gears have the same number of teeth.



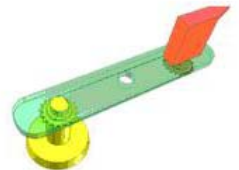
Keeping direction unchanged during rotation 3

<http://www.youtube.com/watch?v=BkZswBBbvD8>

The direction of the red object is unchanged.

Using chain (or tooth belt) drive.

The sprockets have the same number of teeth.



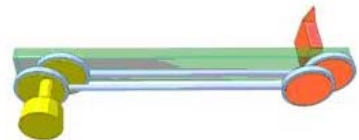
Keeping direction unchanged during rotation 4

<http://www.youtube.com/watch?v=N8jE8qLbHR4>

The direction of the red object is unchanged.

Using parallelogram mechanism.

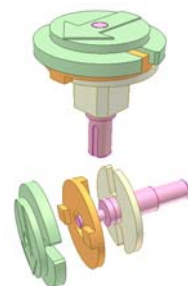
Overcoming dead point by adding second parallelogram mechanism



Keeping direction unchanged during rotation 5

<http://youtu.be/-XsHSvDqG8s>

The green disk receives motion from a pink eccentric shaft. Due to a Oldham mechanism that consists of three disks, the orientation of the green disk does not change during motion.



Keeping direction unchanged during rotation 6

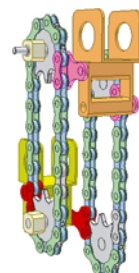
<http://youtu.be/D1IPLLEBuA>

Two chain drives are arranged with a large non-coaxiality A.

The yellow link connects two drives by two red chain pivot links. Center distance between two revolution joints of the yellow link is equal to A.

The direction of the yellow link is kept unchanged during motion. More of the connecting links and the pivot links is possible.

This mechanism can be applied for continuous lift.



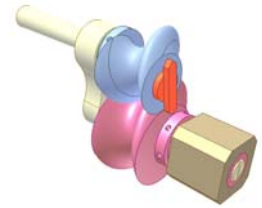
Pin coupling 6

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

A planetary mechanism from Pin Coupling 5.

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

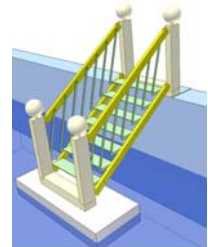
The direction of the red bar attached to the blue shaft is unchanged during the motion.



Application of parallelogram mechanism 6

<http://www.youtube.com/watch?v=PJQEkv4UESw>

Self-adjusting step ladder for wharfs. The steps remain horizontal whatever the water level rises or falls.

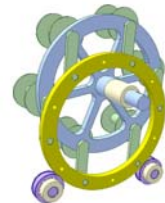


Application of parallelogram mechanism 7

http://www.youtube.com/watch?v=nn_v_DIZ6tY

Cable winding machine.

The bobbins rotate about the machine main shaft axle but not their own ones.



Application of parallelogram mechanism 8

<http://www.youtube.com/watch?v=hWNt1ZhnSnk>

Vertical blade paddle wheel.

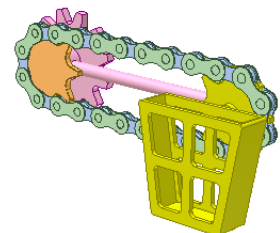
The blades are kept always upright giving the most propulsion effectiveness.



Chain drive 5A

<http://youtu.be/DI6DdKPXctY>

The orange sprocket is fixed. The orange and yellow sprockets have the same tooth number. The pink crank and gear is driving. The yellow basket, which is fixed with the yellow sprocket, stays vertically during rotation.



Gear and linkage mechanism 8a

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

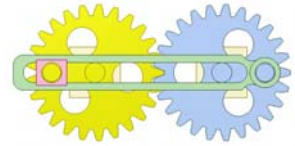
The green bar has unchanged direction during rotation.

The gears have the same tooth number and the same distance of their pins to their rotation axes.

Assembly requirement: there is mechanism position where pin axes and gear rotation axes are on a plane and both pins are in the middle (or outside) of the gear center distance.

If not the green bar has complicated motion as in:

<https://www.youtube.com/watch?v=wTG1Ai2S9l8>



Keeping direction unchanged during rotation 7

<http://youtu.be/VcLRHZAfc9o>

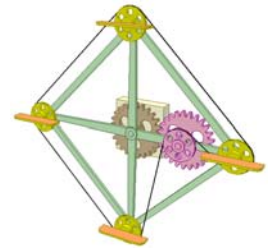
The gears have same tooth number.

Five pulleys have same pitch diameter.

Input: green carrier rotating regularly.

The yellow pulleys have unchanged direction during rotation.

Instead of belt drive using chain one is better.



Keeping direction unchanged during rotation 8

<http://youtu.be/W5tLTJraf84>

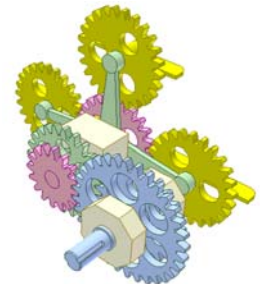
Pink gear, four yellow satellite gears and green carrier create a differential planetary drive.

Four yellow satellite gears and the big pink gear have same tooth number.

Input is the blue shaft having two gears.

Receiving rotation from the input shaft, the pink gears and the green carrier rotate in the same direction. The pink gears rotate twice faster than the green carrier.

The yellow gears have unchanged direction during rotation.



Keeping direction unchanged during rotation 9a

<http://youtu.be/q8HKd938yp0>

Pink gear, four yellow satellite gears, four blue gears and green carrier create a differential planetary drive.

The gears (except the green one) have same tooth number.

Input: green carrier rotating regularly.

The yellow gears have unchanged direction during rotation while the pink gear is immobile.

Use the orange worm to rotate the pink gear for adjusting the direction. The video shows 90 deg. adjustment.



Keeping direction unchanged during rotation 9b

<http://youtu.be/APdnbZI20S0>

Pink gear, four yellow satellite gears, two blue gears and green carrier create a differential planetary drive.

The yellow gears and the pink spur gear have same tooth number.

The blue gears have same tooth number.

Input: green carrier rotating regularly.

The yellow gears have unchanged direction during rotation while the pink gear is immobile.

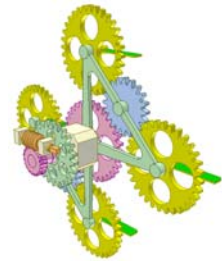
Use the orange worm to rotate the pink gear for adjusting the direction.

The video shows 45 deg. adjustment.

This mechanism is similar to the one in video:

<http://youtu.be/q8HKd938yp0>

but uses less gears.



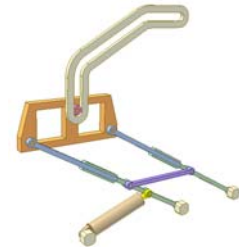
Keeping direction unchanged during motion 1a

http://youtu.be/xAYL_MtkEgM

Orange plate performs planar motion without rotation. Its upper edges are kept always horizontal thanks to a parallelogram mechanism driven by brown cylinder. Distance between two revolute joints on the orange plate is equal to length of the violet conrod.

Change of popcorn fixed cam profile gives various trajectories of a point on the orange plate.

The mechanism has an unstable position when violet conrod is perpendicular to the rockers. So avoid it or use measures to overcome it.



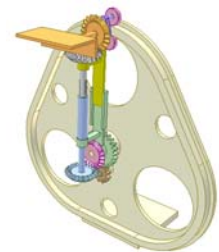
Keeping direction unchanged during motion 2

<http://youtu.be/iIYesahDn38>

Orange plate performs planar motion without rotation. Its upper surface is kept always horizontal thanks to 4 bevel gear drive of equal tooth numbers driven by brown spur gear. Sliding joints between green and yellow bars and between blue and grey shafts allow radial displacements of the orange plate. Pink gear is fixed.

Change of popcorn fixed cam profile gives various trajectories of a point on the orange plate.

4 bevel gear drive can be replaced by 4 screw gear drive in another embodiment of this mechanism.



Keeping direction unchanged during motion 3a

<http://youtu.be/4xGNB2jlcV/k>

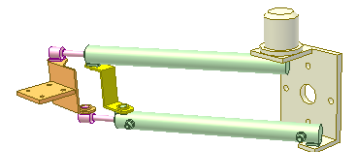
Orange plate performs planar motion without rotation.

The plate direction is kept unchanged thanks to a parallelogram mechanism driven by a motor. Distances between two revolute joints on the yellow conrod and between two revolute joints of the orange plate are equal.

Motion of the orange plate along sliding joint between green bar and pink bar is controlled by two green cylinders.

This mechanism can be applied for manipulator of polar coordinate system.

Disadvantage: the cylinders are not base-mounted.



Keeping direction unchanged during motion 4

<http://youtu.be/485OGPdp13g>

Orange plate performs planar motion without rotation.

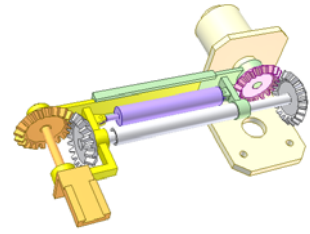
Its upper surface is kept always horizontal thanks to 4 bevel gear drive of equal tooth numbers driven by a motor. Pink gear is fixed.

Sliding joints between green and yellow bars and between grey shafts allow radial displacements of the orange plate that are controlled by violet actuator.

4 bevel gear drive can be replaced by 4 screw gear drive in another embodiment of this mechanism.

This mechanism can be applied for manipulator of polar coordinate system.

Disadvantage: the actuator is not base-mounted.



Keeping direction unchanged during motion 3b

<http://youtu.be/q2Foisj9re0>

Orange slider performs planar motion without rotation.

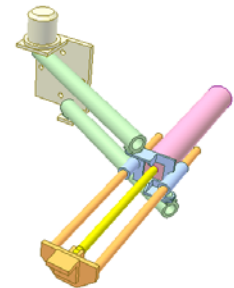
Its upper surface is kept always horizontal thanks to a parallelogram mechanism driven by a motor. Distances between two revolute joints on the blue conrod and between two revolute joints of the base are equal.

Motion of the orange slider along sliding joint on the blue conrod is controlled by pink actuator.

Disadvantages:

The actuator is not base-mounted.

The calculation of trajectory of a point on the orange slider can not be based on polar coordinate system.



Keeping direction unchanged during motion 6

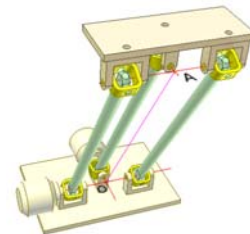
<http://youtu.be/iQ5TkU04Xdc>

Green bars are connected to lower and upper plates by universal joints of two degrees of freedom. The mechanism has two degrees of freedom based on computer test so two motors are used for controlling.

Upper plate is kept always horizontal during motion.

A point of the upper plate moves on a spherical surface.

Angle between motor rotary axes can be differ from 90 deg.



Keeping direction unchanged during motion 7

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

Blue upper table is kept always horizontal when moving in 3D space.

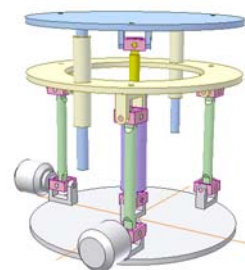
Motion of the popcorn disk is controlled by two base-mounted motors.

Motion of the blue table along sliding joint on the popcorn disk is controlled by violet actuator.

Disadvantages:

The actuator is not base-mounted.

The calculation of trajectory of a point on the blue table can not be based on spherical coordinate system.



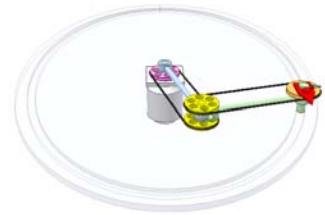
Keeping direction unchanged during motion 6

<http://youtu.be/inr1H2-mKS8>

Red plate performs planar motion without rotation thanks to two toothed belt drives. Tooth numbers of four pulleys are equal. Pink pulley is immobile. Two yellow pulleys are fixed together.

Change of glass fixed cam profile gives various trajectories (an ellipse in this video) of the red plate.

The belt drives can be replaced by chain ones.



Keeping direction unchanged during motion 7

<http://youtu.be/6NayQfZpSWY>

Pink and yellow plates perform planar motion without rotation thanks to gear drives. Tooth numbers of 5 gears are equal. Grey gear is immobile. Four others gears idly rotate on their bearings.

Change of glass fixed cam profile gives various trajectories (a hexagon in this video) of the pink plate.

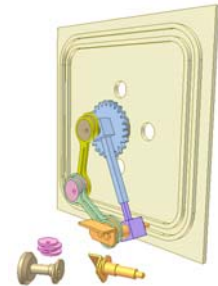


Keeping direction unchanged during motion 5

<http://youtu.be/M3qFSIEA1Rg>

Orange plate performs planar motion without rotation. Its upper surface is kept always horizontal thanks to a double parallelogram mechanism driven by blue gear. Each of brown and orange shafts has 2 eccentrics for overcoming dead positions of the parallelogram mechanisms. So the pink shaft has 4 eccentrics.

Change of popcorn fixed cam profile gives various trajectories of the orange plate.



Keeping direction unchanged during spatial motion 1

<http://youtu.be/Cu8oJTe8zrk>

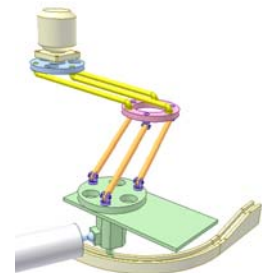
The green disk lower end moves along a 3D curve. When blue disk is immobile, green plate (fixed to green disk) performs spatial motion without rotation around all three coordinate axes thanks to yellow planar and orange spatial parallelogram mechanisms.

The grey cylinder is connected to the base via a spherical joint (not shown). The blue piston is connected to the green disk via a spherical joint.

Pay attention to violet universal joints (2 DoF).

Angular position of the green plate in horizontal plane can be adjusted by turning the blue disk. The video shows such adjustment occurring after first double strokes of the piston.

Gravity maintains contact between the green disk lower end and the groove bottom of the popcorn runway.



Planetary drive 1a

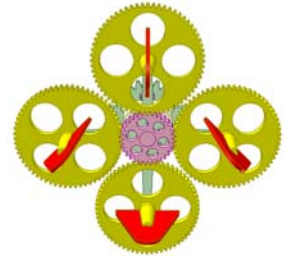
<http://youtu.be/k6ap5Yxmk7M>

Pink fixed gear, four yellow satellite gears and green carrier create a differential planetary drive. Tooth number of the yellow gears is double to the one of the pink gear.

Input: green carrier rotating regularly.

When the yellow gears reach highest position, their red plates are vertical. When the yellow gears reach lowest position their red plates are horizontal.

Use the orange worm for adjusting the direction of the plates.



Planetary drive 1b

<http://youtu.be/sLknrW47hzc>

Pink fixed pulley, yellow satellite big pulley and green carrier create a belt differential planetary drive. Diameter of the yellow big pulley is double to the one of the pink pulley.

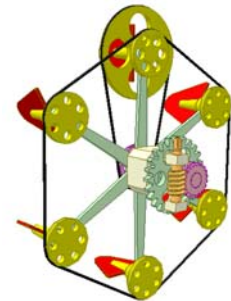
Six yellow small pulleys have same diameter. They are connected together by the black belt.

Using chain drive instead of belt one is better.

Input: green carrier rotating regularly.

When the yellow small pulleys reach highest position, their red plates are vertical. When the yellow small pulleys reach lowest position their red plates are horizontal.

The video also shows that after using the worm drive for adjusting the direction of the plates the situation is reversed.



Wind-mill 1a

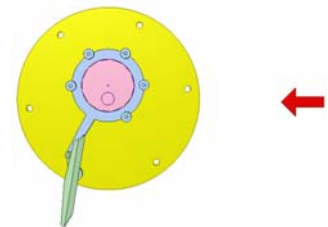
<http://youtu.be/7pN7hFZuUw>

Plan view.

It is a 4-bar linkage consisting of two cranks (blue bar, yellow disk) and a connecting rod (green sail). Blue bar rotates on the eccentric of a pink fixed shaft.

Such arrangement makes the green sail present its edge in returning toward the wind, but present its face to the action of the wind, the direction of which is supposed to be as indicated by red arrow.

Output motion (clockwise rotation) is taken from the yellow disk.



Wind-mill 1b

<http://youtu.be/Y1X2b-dU7mU>

Plan view.

Green sails are so pivoted as to present their edges in returning toward the wind, but to present their faces to the action of the wind, the direction of which is supposed to be as indicated by red arrow.

Blue bar rotates on the eccentric of a pink fixed shaft.

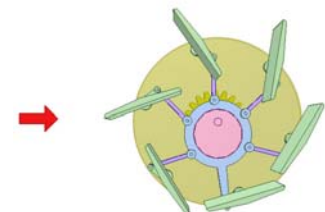
Output motion (clockwise rotation) is taken from a gear fixed to the yellow disk.

The mechanism can be applied for simple water turbines (no need of flow guide).

This mechanism is developed from "Wind-mill 1a":

<http://youtu.be/7pN7hFZuUw>

by adding more sails.



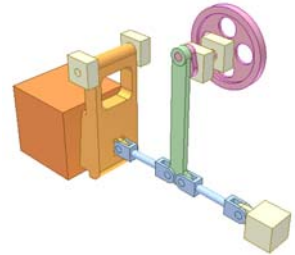
13. Toggle linkages

Toggle linkage 1a

<http://youtu.be/1MmgKShth7w>

Mechanism for a stone crusher.

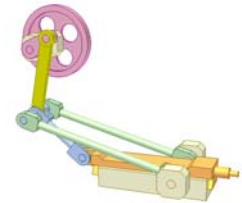
It has two toggle linkages in series to obtain a high mechanical advantage. When green link reaches the top of its stroke, it comes into toggle with the pink crank. At the same time two blue links come into toggle. This multiplication results in a very large crushing force of the orange jaw.



Toggle linkage 1b

<http://youtu.be/FOe7o0duel4>

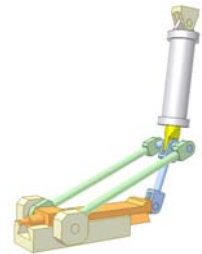
Two toggle links (the green and blue ones) can come into toggle by lining up on top of each other rather than as an extension of each other.



Toggle linkage 1c

<http://youtu.be/MpuejSIBvjM>

A riveting machine with a reciprocating piston produces a high mechanical advantage. With a constant piston driving force, the force of the orange head increases to a maximum value when green and blue links come into toggle.



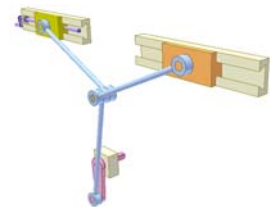
Toggle linkage 2

<http://youtu.be/dzcvYAQQSL4>

In one revolution of the pink input crank, the orange output slider performs two strokes, one long and one short. At the rightmost point of each stroke, the links are in toggle to get high mechanical advantage and low speed.

The violet screw and the yellow slider are for adjusting stroke position.

The mechanism is applied for cold-heading rivet machines where two consequent blows of hammer (the orange slider) are needed in one revolution of crankshaft.



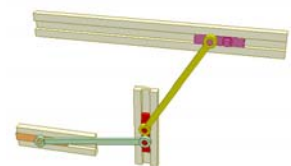
Toggle linkage 3

<http://youtu.be/U2-SPNLPMeE>

Input: pink slider.

Output: orange slider.

One double stroke of the pink slider corresponds two double strokes of the orange slider, that has long dwell at the left end of its stroke, when the yellow and green conrods come into toggle with the red and orange sliders.

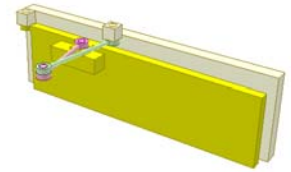


Toggle linkage 4a

<http://youtu.be/dmbLL-MSkyE>

Door check linkage gives a high velocity ratio during the stroke.

As the door swings closed, connecting link (in green) comes into toggle with the shock absorber arm (in pink), giving it a large angular velocity, which helps the shock absorber be more effective in retarding motion near the closed position.



Toggle linkage 4b

<http://youtu.be/TAPhhX3ti8s>

Pink crank rotates at constant velocity while orange crank moves slowly at the beginning and end of the stroke. It moves rapidly at the midstroke when the orange crank and the green conrod are in toggle. The accelerated weight on the orange crank absorbs energy and returns it to the system when it slows down.

This mechanism is used as an impact reducer in some large circuit breaker.



14. Mechanisms for snap motions

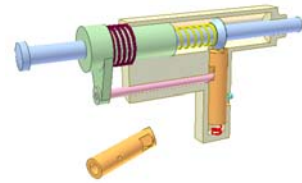
Snap motion 16

<http://youtu.be/BwABcO1k2I0>

When green part is pushed, pink wedge forces orange slider down and blue rod is shot to the right under action of yellow spring.

Pull back the blue rod for next shot.

Arrows show applied forces.



Spring toggle mechanism 1

<http://youtu.be/u4oW1ZiiRGA>

Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.

In this prototype a compression spring is used to bear tension.

The violet sector represents manual action.



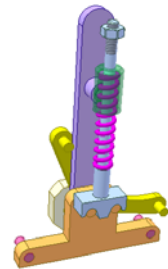
Spring toggle mechanism 2

<http://youtu.be/T4EoESBFYLw>

Toggle action here ensures that the gear shift lever (violet) will not inadvertently be thrown past its neutral position.

The pink pins are stoppers for the violet lever.

The yellow double crank represents manual action.

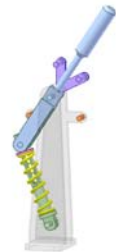


Spring toggle mechanism 3

http://youtu.be/l-G_uejx0Rs

Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.

The violet double crank represents manual action.



Spring toggle mechanism 4

<http://youtu.be/KaRBadgcUIU>

Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.

The violet double crank represents manual action.



Spring toggle mechanism 5

<http://youtu.be/vYSJn0U0kXI>

Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.

The violet double crank represents manual action.

The mechanism is used for electric switches.



Cam-guided latch

http://youtu.be/53_QBnREziY

Cam-guided latch has one cocked and two relaxed positions.
The violet double crank represents manual action.



Spring toggle mechanism 8

<http://youtu.be/ymgxwQHVQUw>

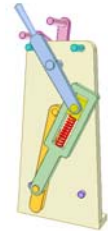
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
The pink double crank represents action from outside.



Spring toggle mechanism 9

<http://youtu.be/TEH9aKqVhOE>

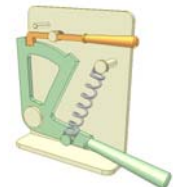
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
The pink double crank represents action from outside.



Snap motion 1

<http://youtu.be/7y-Oez0v2l8>

A orange latch and green cocking lever is spring-loaded so latch movement releases the cocking lever. The cocked position is held firmly. Studs in the frame provide stops, pivots or mounts for the springs.
A coil spring always forces the orange latch to rotate anticlockwise.



Snap motion 2

<http://youtu.be/tR1LWzVCjk0>

A latch mounted on a cocking lever (blue) allows both levers to be reached at the same time with one hand.

Rotate the latch clockwise to release the cocking lever.

Rotate the cocking lever anticlockwise to get the initial position.

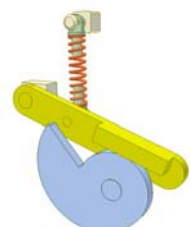
A coil spring always forces the pink latch to rotate anticlockwise.



Snap motion 6

http://youtu.be/k1BAA75eR_0

A latching cam cocks and releases the cocking lever with the same counterclockwise movement.



Snap motion 6B

<http://youtu.be/jeKxnC6DffQ>

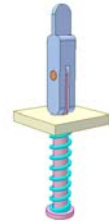
The cam hub has a semi-circular slot in which a pin of the blue driving shaft moves. Snap motion occurs when the moment from the follower spring applied to the cam changes its direction.



Snap motion 8

http://youtu.be/FYyIZXn_8-M

Push or pull the blue lever to get snap motion. Raise it to get the initial position.



Snap motion 10

<http://youtu.be/NMuZwvDJ27A>

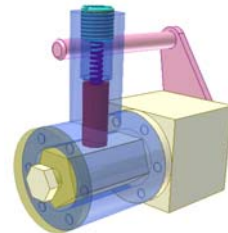
An identically shaped cocking lever and latch allow their functions to be interchangeable. The radii of the sliding faces must be dimensioned for a mating fit. Forces are alternatively placed on both levers.



Spring toggle mechanism 6a

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

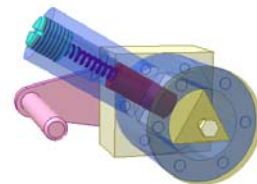
Indexing device. This spring toggle mechanism enables to reach five positions of a lever quickly and holds it there. The pink pin represents action from outside.



Spring toggle mechanism 6b

<http://youtu.be/VftCJ6mScNQ>

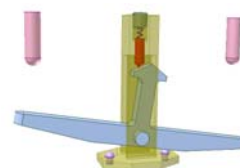
Indexing device. This spring toggle mechanism enables to reach three positions of a lever quickly and holds it there. The pink pin represents action from outside.



Spring toggle mechanism 7

<http://youtu.be/kjRbsF9gkyl>

Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly. The pink pins represent action from outside.



Cable drive for snap switching 1

<http://youtu.be/39GDCZB-vFU>

Pull and release brown tow for snap switching green arm.

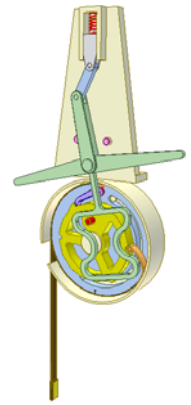
It is a combination of two mechanisms shown in:

<http://youtu.be/VzBulhvWsJY>

and

<http://youtu.be/ymgxwQHVQUw>

For reducing pulling stroke length, use three red pins arranged in a symmetric circular pattern then the yellow ratchet disk needs turn only 60 deg.



Barrel cam for snap switching 1

<http://youtu.be/rKSc1A8HE3Q>

Pull and release green slider for snap switching orange arm.

It is a combination of two mechanisms shown in:

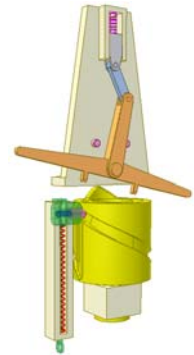
<http://youtu.be/SzoF0VMtc7w>

and

<http://youtu.be/ymgxwQHVQUw>

For reducing pulling stroke length, use three face protrusions (instead of one) arranged in a symmetric circular pattern then the yellow cam needs turn only 60 deg. The barrel cam looks like the one in:

<http://youtu.be/nMEpbyMCMdw>

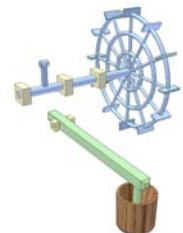


Snap motion 12

<http://youtu.be/tipTlkBLhdk>

Pestle powered by water flow.

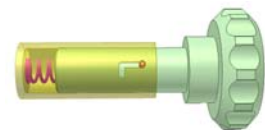
Water flow turns the wheel carrying a toe that raises and suddenly releases the pestle.



Snap motion 3

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

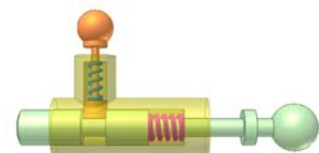
A yellow sleeve latch has an L-shaped notch. A pin in the green shaft rides in the notch. Cocking requires a simple push and twist.



Snap motion 4

<http://youtu.be/igdo6b4tq9s>

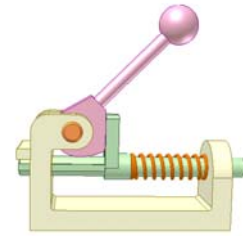
The latch and plunger depend on axial movement for setting and release. A circular groove is needed if the plunger is to rotate.



Snap motion 5

<http://youtu.be/p4kDKY3UNFI>

In this overcenter lock clockwise movement of the pink latching lever cocks and locks the green slide. A counterclockwise movement is required to release the slide.

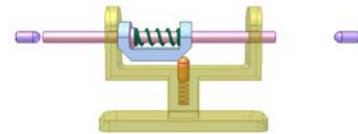


Snap motion 7A

<http://youtu.be/J8r2zXYFT84>

A blue spring-loaded cocking piece has chamfered corners. Axial movement of the pink push-rod forces the cocking piece against a spring-loaded pin set in frame. When cocking builds up enough force to overcome the pin spring, the cocking piece snaps over to the right.

Move the pink push-rod or the blue cocking piece to the left to get initial position. The violet pins represent manual action.



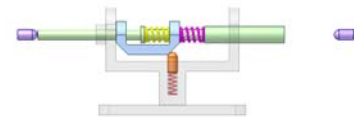
Snap motion 7B

<http://youtu.be/RYcTAr8j2P0>

A blue spring-loaded cocking piece has chamfered corners. Axial movement of the green push-rod forces the cocking piece against a spring-loaded pin set in frame. When cocking builds up enough force to overcome the pin spring, the cocking piece snaps over to the right.

The action can be repeated in either direction.

The violet pins represent manual action.

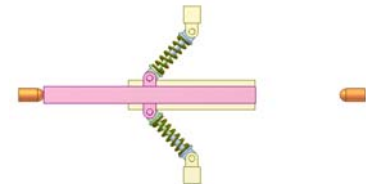


Snap motion 9

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

Push the pink slider to get snap motion. The action can be repeated in either direction.

The orange pins also play role of stoppers.

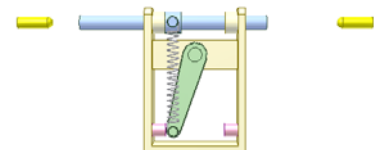


Spring toggle mechanism 10

<http://youtu.be/HtLDYQnP1QQ>

Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly. However the green lever is not forced against the pink button strongly.

The yellow pins represent action from outside.

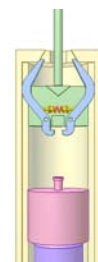


Snap motion 11

<http://youtu.be/bt58Gw82938>

Releasing-hook, used in pile-driving machines.

When the pink weight is sufficiently raised, the upper ends of the blue hooks, by which it is suspended, are pressed inward by the sides of the slot in the top of the frame. The weight is thus suddenly released and falls with accumulating force on to the pile-head.



Snap motion 14

<http://www.youtube.com/watch?v=yg1xDM0GDYM>

The blue plunger carrying a rack suddenly falls when the orange toothed sector leaves the rack.

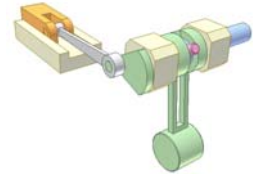
Small pins on the plunger and on the toothed sector are for maintaining a proper engagement of the rack-pinion drive.



Snap motion 13

http://youtu.be/p2pdrXalc_Y

The hub of a rotary weight has semi-circular slot in which a pin of the blue driving shaft moves. Snap motion occurs due to the falling of the weight.



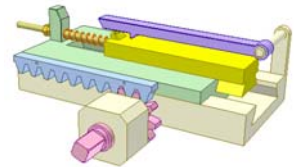
Snap motion 15

<http://youtu.be/uMwHehjRyVo>

The pink input gear has reciprocating rotary motion.

The green slider has reciprocating linear motion.

The yellow slider linearly reciprocates with dwell and snap motion.

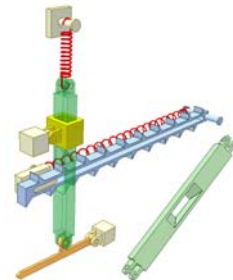


Interrupted linear motion 1

<http://youtu.be/oDIOwSwk1JQ>

Blue ratchet bar tends to move to the left under the action of red horizontal spring.

Push down and release orange lever to let the blue bar move one tooth pitch.



On-Off switch 1

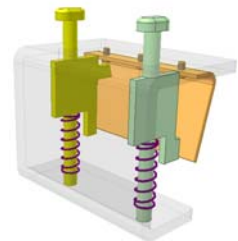
<http://youtu.be/LhaU0whb8Io>

Push green button to get ON.

Push yellow button to get OFF.

The orange part is a flat spring.

The green button is connected to electrical contacts (not shown).



Switch mechanism for speed selection 1

http://youtu.be/UwcpsEW_PqA

The mechanism is used for speed control of desk fans

Push first green button to get speed 1.

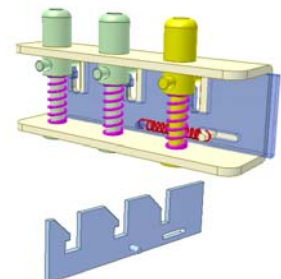
Push second green button to release the first one and get speed 2.

Push yellow button to release the green button in down position and get OFF.

Half way pushing of the green buttons (in up position) has the same effect as pushing the yellow button.

The green buttons are connected to electrical contacts (not shown).

Add further green buttons for more speeds.



15. Mechanisms for creating vibration

Gravity and spring pendulums

<http://youtu.be/NycJBVNkmGI>

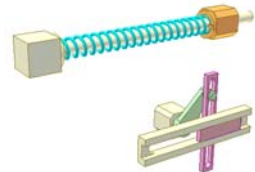
Two pendulums perform harmonic angular oscillations.
The right pendulum oscillates thanks to the gravity.
The left pendulum oscillates thanks to green disk and flat spiral spring. One end of the spring is fixed to the green disk hub, the other end to base.



Harmonic motions

<http://youtu.be/FRpUAQICblc>

Orange slider oscillates thanks to cyan spring.
Pink slider oscillates thanks to a sine mechanism.
Both perform harmonic linear oscillations.



Spring vibration 2

<http://youtu.be/bgzpOHozRPM>

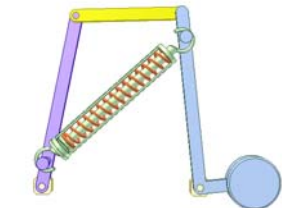
The mechanism is used for anti-vibration suspensions.



Spring vibration 3

<http://youtu.be/Q7eHZX1iaSQ>

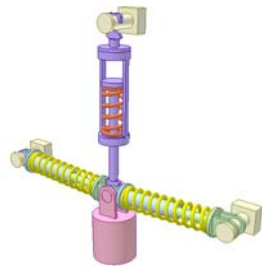
A four bar mechanism in conjunction with a spring has a wide variety of load or deflection characteristics.



Spring vibration isolation 1

<http://youtu.be/Kwm7c6kgQ70>

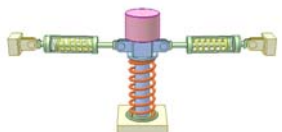
This basic spring arrangement has zero stiffness.
The mechanism is used for vibration isolation.
The pink part represents the weight to be vibration isolated.



Spring vibration isolation 2

<http://youtu.be/OpEjNNHcaEI>

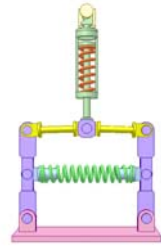
This basic spring arrangement has zero stiffness when the tension springs are in line. The pink part represents the weight to be vibration isolated.



Spring vibration isolation 3

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

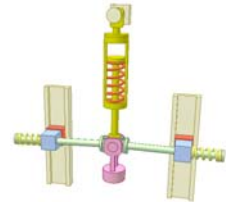
This spring arrangement has zero stiffness when the yellow bars are in line. The pink part represents the weight to be vibration isolated.



Spring vibration isolation 4

http://www.youtube.com/watch?v=OECw5X_geVE

This spring arrangement has zero stiffness when the yellow compression springs are in line. The pink part represents the weight to be vibration isolated.



Spring vibration isolation 5

<http://www.youtube.com/watch?v=0OB55DXQ5lw>

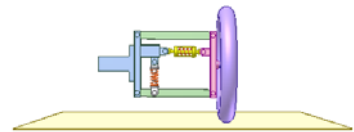
This spring arrangement has zero stiffness (torsion vibration) when the compression springs are in line. The pink part represents the weight to be vibration isolated.



Wheel spring suspension

http://www.youtube.com/watch?v=9A9ln_SbBfk

Coil spring suspension of automobiles can be reduced in stiffness by adding an horizontal spring.



Seat spring suspension

<http://youtu.be/sSJ-qizbep8>

Tractor seat stiffness and transmitted shocks can be reduced with this spring arrangement.



Eccentric vibrator 1A1

http://youtu.be/qPrDI5NYk_I

Vibrating conveyor.

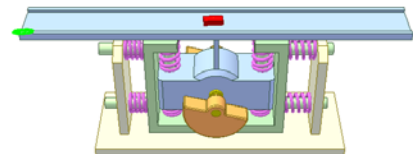
The blue part vibrates in two directions (vertical and horizontal) under centrifugal forces caused by the orange eccentrics and move the material (red).

Angle A between the two eccentrics affects vibration characteristics.

A = 0 deg. for this case.

The green line is locus of a point on the blue part (nearly a proper ellipse)

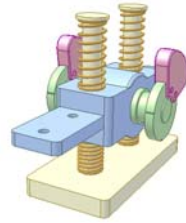
No vibration if A = 180 deg.



Eccentric vibrator 1A2

<http://youtu.be/7wWUhWTBlw0>

The blue part vibrates in vertical direction under centrifugal forces caused by the pink eccentrics. The mechanism is used in vibration hammers and rammers.



Eccentric vibrator 2A1

<http://youtu.be/7zFYThhjm3s>

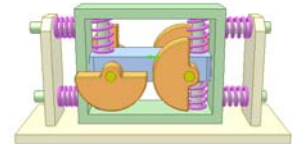
The blue part vibrates under centrifugal forces created by two shafts carrying eccentrics. Vibration characteristics depend on

- rotation direction and velocity of the shafts,
- angle A between the eccentrics on each shaft
- angle B between the eccentrics between the shafts (set before moving).

It is possible to set up the mechanism for vibration only in horizontal (or vertical) direction or in both directions.

For this case there is only horizontal vibration when

- The shafts rotate in opposite directions
- A = 90 deg.
- B = 90 deg.



Eccentric vibrator 2A2

<http://youtu.be/dHIVU5Uprzw>

Vibrating conveyor.

The blue part vibrates under centrifugal forces created by two shafts carrying eccentrics. Vibration characteristics depend on

- rotation direction and velocity of the shafts,
- angle A between the eccentrics on each shaft
- angle B between the eccentrics between the shafts (set before moving).

For this case there are vibrations in both directions when

- The shafts rotate in opposite directions
- A = 90 deg.
- B = 180 deg.

The green line is locus of a point on the blue part (nearly a slant line).



Eccentric vibrator 3A

<http://youtu.be/6ucruMiqzbY>

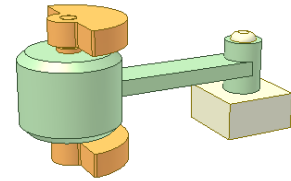
The blue part vibrates in vertical plane under centrifugal forces caused by the eccentrics and the gravity force.



Eccentric vibrator 3B

<http://youtu.be/uZVF7w9jwLk>

The green part rotates in horizontal plane under centrifugal forces caused by the eccentrics. The initial position of the eccentrics also affects the rotation characteristics.



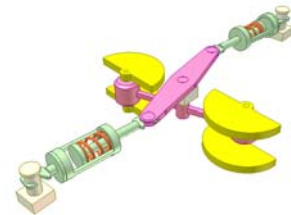
Eccentric vibrator 3C

<http://youtu.be/8r3M03JvvEq>

Vibrator for torsion vibration.

The pink crank oscillates under centrifugal forces caused by the yellow eccentrics that rotate in the same direction.

The oscillation will not occur if one eccentric shaft turns 180 deg. in relation with the other or the two shafts rotate in opposite directions.



Eccentric vibrator 4A

<http://youtu.be/zj9yAVBzRWw>

The blue part has complicated motion under centrifugal forces caused by the eccentrics.

The green line is locus of a point on the blue part.



Eccentric vibrator 4B

http://youtu.be/Nksp0f3O_uI

The blue part has complicated motion under centrifugal forces caused by the eccentrics.

The green line is locus of a point on the blue part.



Eccentric vibrator 6A1

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

With this lay-out of the eccentrics the blue part vibrates around vertical axle and reciprocates along vertical axle under centrifugal forces caused by the eccentrics.



Eccentric vibrator 6A2

http://youtu.be/CkdOZcf7v_8

With this lay-out of the eccentrics the blue part rotates around vertical axle and reciprocates along vertical axle under centrifugal forces caused by the eccentrics.



Eccentric vibrator 6A3

<http://youtu.be/8p66DsDp554>

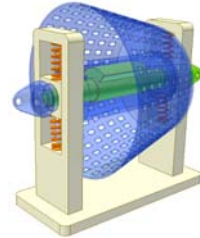
With this lay-out of the eccentrics the blue part only reciprocates along vertical axle (not rocks around it) under centrifugal forces caused by the eccentrics.



Vibrating screen machine 1

<http://youtu.be/JGF-8mG0OG0>

The green inner shaft carrying a long eccentric rotates in a screen of cone shape. The later rotates in bearings supported by springs. The inner shaft and the screen are driven through double cardan joints (not shown).



Vibrating screen machine 2

<http://youtu.be/KdycXXdN3M0>

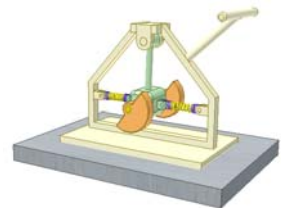
Oscilating screen is supported by flat springs. A motor carrying eccentrics is fixed to the screen.



Ramming machine 1

<http://youtu.be/bX8TEvxAlCo>

The machine frame vibrates in two directions: vertical and horizontal under centrifugal forces caused by the orange eccentrics. Angle A between the two eccentrics affects vibration characteristics. $A = 0$ deg. for this case. Only vertical vibration causes ramming effect. The horizontal one is born by the operator through the grips.



Ramming machine 2

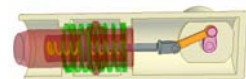
<http://youtu.be/M3foSpmDyEM>



Hand-held spring hammer

<http://youtu.be/2dg-x5POoAI>

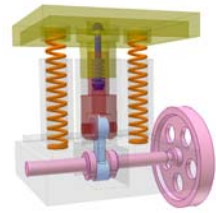
The red slider is born by two green springs, no contact between the slider and the hammer's house. It reciprocates under actions of two green springs, two yellow ones and the slider crank mechanism.



Sand mold vibrating machine

<http://youtu.be/lq5z7Zk1IPc>

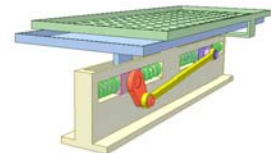
The yellow mold table reciprocates with vibration under actions of three springs and the slider crank mechanism.



Vibrating screen machine 3

<http://youtu.be/EjE1yw8odMw>

The bearing and the slider of a linkage mechanism supported by springs can slide in a runway. The sieves are fixed to them. The red crank is driven through a double cardan joint (not shown)



Vibration table

<http://youtu.be/2uMzqueot7Q>

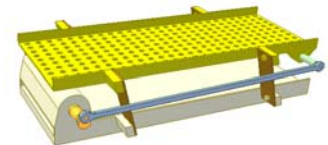
Blue table with a mould on it vibrates in vertical direction due to centrifugal forces caused by four yellow eccentrics.

The violet screw is for regulating table position that may change because of mould weight .



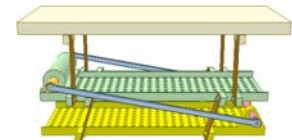
Vibrating screen machine 4

<http://youtu.be/kfw1IToK4So>



Vibrating screen machine 5

<http://youtu.be/zr99xgCvURM>



Poker concrete vibrator

<http://youtu.be/9dTlOL9WLI8>

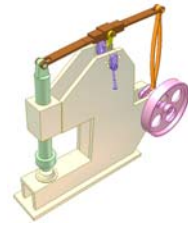
Vibration is created by the rotation of the orange shaft carrying an eccentric mass.



Leaf spring hammer 1

<http://youtu.be/ibmCejKObgM>

The violet part is an eccentric shaft for adjusting stroke of the green slider.



Leaf spring hammer 2

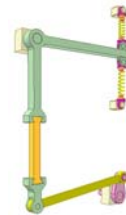
<http://youtu.be/ZxoXAZEbYv4>



Flex testing machine

<http://youtu.be/bSPbxa3flR0>

The specimen (in orange) is tested under variable load.



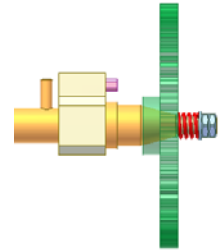
16. Safety clutches

Safety clutch 3

<http://youtu.be/b6uouA9Pqzo>

A cone clutch is formed by mating a taper on the shaft to a bevel central hole in the gear. Increasing compression on the spring by tightening the nuts increases the drive's torque capacity.

An overload condition is represented by the pink slider position.

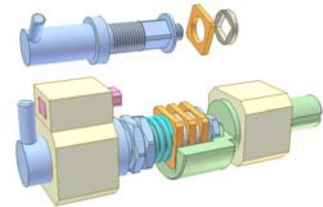


Safety clutch 4

<http://youtu.be/Rrpg253rWto>

Friction disks are compressed by an adjustable spring. Square disks are locked into the square hole in the right shaft and round disks onto the square rod on the left shaft.

An overload condition is represented by the pink slider position.

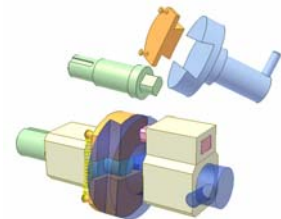


Safety clutch 5

<http://youtu.be/YSp9pUJTfZI>

Sliding wedges clamp down on the flattened end of the shaft. They spread apart when torque becomes excessive. The strength of the springs in tension that hold the wedges together, sets the torque limit.

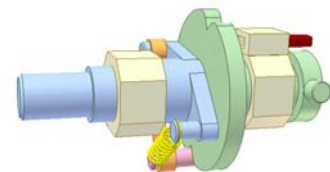
An overload condition is represented by the pink slider position.



Safety clutch 6 (spring arm)

<http://youtu.be/KJ4pp4CCnTc>

Torque is transmitted from the blue input shaft to the green output one through the pink pin on the orange arm. When overload (represented by position of a red slider), the pin jumps out of the slot on the green shaft, the transmission is interrupted.

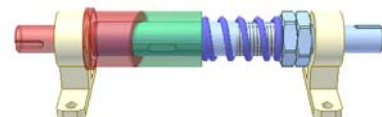


Safety clutch 7

<http://youtu.be/ynfwLNaXU08>

A cylinder cut at an angle forms a torque limiter. A spring clamps the opposing-angled cylinder faces together and they separate from angular alignment under overload conditions. The spring tension sets the load limit.

The animation has a weakness: the spring does not rotate as in reality.

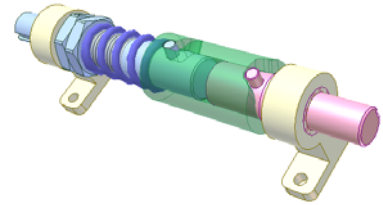


Safety clutch 8

<http://youtu.be/6-cJUOWY9q8>

A cammed sleeve (green) connects the input (pink) and output (blue) shaft of this torque limiter. A driven pin (blue) does not allow the sleeve move to the right. When an overload occurs, the driving pin (pink) pushes the sleeve to the left and the driven pin (blue) drops into the L-shaped slot to keep the shafts disengaged. The limiter is reset by turning the output shaft backwards.

The animation has a weakness: the spring does not rotate as in reality.

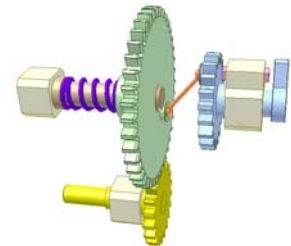


Safety clutch 9 (oblique arm)

<http://youtu.be/ZyfyPQlkXwc>

Input: yellow shaft. The axial force of a spring and the orange driving arm are in balance. An overload condition (represented by the pink slider position) overcomes the spring force to slide the green gear out of engagement.

The animation has a weakness: the spring does not rotate as in reality.

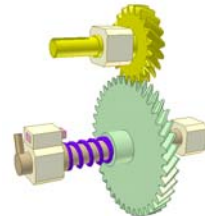


Safety clutch 10 (helical gears)

<http://youtu.be/sq9AjzaD7Ts>

Input: yellow shaft. The axial force of a spring and the axial component of gear force in the spur gear drive (helical teeth) are in balance. An overload condition (represented by the pink slider position) overcomes the spring force to slide the green gear out of engagement.

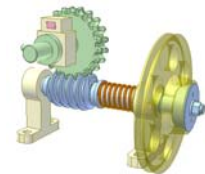
The animation has a weakness: the spring does not rotate as in reality.



Safety clutch 11

<http://youtu.be/plYw36oOPwY>

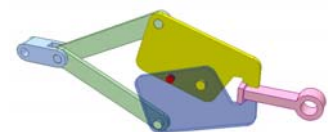
The yellow pulley is input, the green wormwheel is output. The blue worm rotates due to friction between a cone on the worm and a cone hole of the yellow pulley under spring force. When an overload occurs (represented by the pink slider), the blue worm is pushed to the right thus prevents cone contact and interrupts the transmission, reducing wear of cone surfaces.



Safety clutch 1

<http://youtu.be/IUZAmijQ7MA>

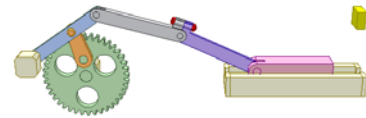
The shearing of a pin releases tension in this coupling. A toggled-operated blade shears a soft pin (red) so that the jaws open and release an excessive load.



Safety clutch 2

<http://youtu.be/trfFKC7xnTw>

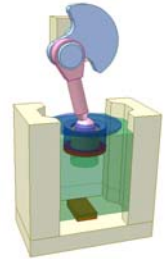
The grey and violet bars are fixed together by the red bolt. When the pink slider crashes with the yellow part, the red bolt is broken, the grey and violet bars are now connected by a revolute joint to prevent overload for other parts.



Safety clutch 2B

<http://youtu.be/YJbl6bSFY4U>

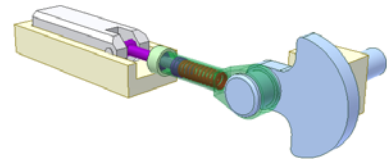
When the green slider of a press crashes onto the brown object, the red disk is sheared (a smaller disk is created) by the yellow cushion. This prevents damage of other parts.



Safety clutch 12

<http://youtu.be/zd1RT89jKVl>

The conrod consist of two parts that can slide on each other. A spring clamps them together under working condition. When the slider crashes with the red part, the spring is compressed, the two parts of the conrod slide on each other to prevent damage of other parts.



Safety clutch 13 - Spring pestle

<http://youtu.be/EriVQKos3k>

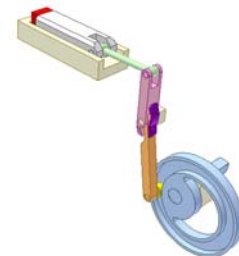
The spring between the slider and the pestle helps to avoid overload and to guarantee no gap between the pestle and the mostar at the lowest position of the pestle.



Safety clutch 14

<http://youtu.be/Apye3XXRpYU>

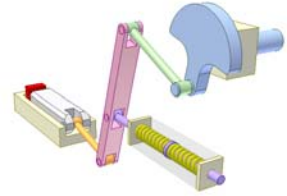
The cam follower consists of two parts (orange and pink) that can rotate in relation to each other. A leaf spring (violet) clamps them together under working condition. When the slider crashes with the red part, the spring is bended, the two parts of the follower rotate in relation to each other to prevent damage of other parts.



Safety clutch 15 (balance springs)

<http://youtu.be/aUTmtQZtLKo>

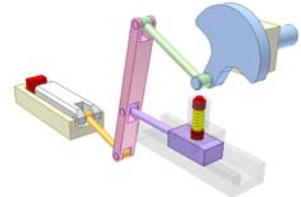
Under normal condition the violet rod is kept immobile by equal forces of the two springs. The pink bar rocks around a pin of the violet rod. When the slider crashes with the red part, the violet rod moves to the right to prevent damage of other parts.



Safety clutch 16 (friction)

<http://youtu.be/QBOjcSYDykk>

Under normal condition the violet rod is kept immobile due to friction generated by spring force. The pink bar rocks around a pin of the violet rod. When the slider crashes with the red part, the violet rod moves to the right to prevent damage of other parts. Repositioning of the violet rod is needed for mechanism restore.



Safety clutch 17

<http://youtu.be/3E0dW7UV9Ao>

Input: grey shaft having internal cylindrical surface with grooves.

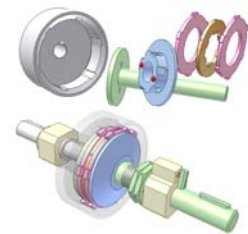
Output: green shaft having cylindrical joint with blue disk.

Pink friction disks engage with the grey shaft.

Orange friction disk engages with the blue disk.

In normal condition the green spring forces blue, pink and orange disks towards the disk of the green shaft to connect the clutch.

When overloading (represented by the pink pin position), the green shaft is kept immobile, the red balls (located in cone holes on faces of the green shaft and the blue disk) push the blue disk to the right, thus disconnect the clutch. At that time there is no contact between the disks so their wear is reduced remarkably.



17. Mechanisms for drawing lines

17.1. Straight lines

Straight line drawing mechanism 1

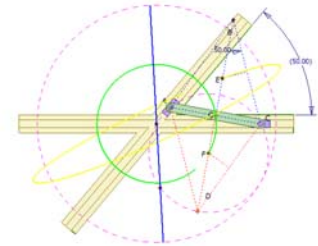
<http://www.youtube.com/watch?v=8WCee-fP9rg>

It is an ellipse mechanism.

Every point of the small magenta circle (circumcircle of isosceles triangle ACD) traces a straight line (in violet).

Circumcenter of triangle ACD traces a circle (in green).

The small magenta circle rolls inside the large fixed magenta one. They are Cardano circles.



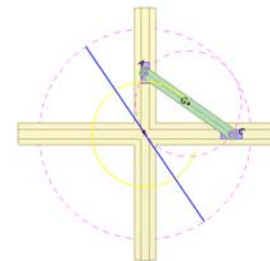
Straight line drawing mechanism 2

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

It is an ellipse mechanism.

Every point of the small magenta circle (AC diameter) traces a straight line (in violet).

The small magenta circle rolls inside the large fixed magenta one. They are Cardano circles.



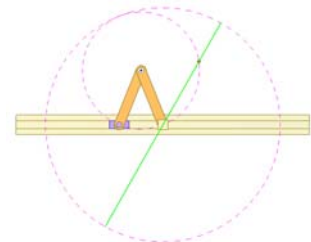
Straight line drawing mechanism 3

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

It is an isosceles slider-crank mechanism.

Every point of the small magenta circle (fixed with the conrod and its radius is equal to the conrod length) traces a straight line (in green).

The small magenta circle rolls inside the large fixed magenta circle. They are Cardano circles.



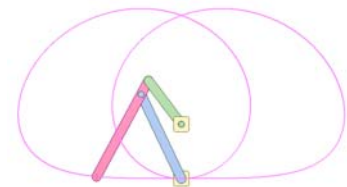
Four-bar linkage 1

<http://www.youtube.com/watch?v=afK8PpDYy4Y>

The connecting rod rotates fully.

A motion cycle of the linkage corresponds two revolutions of the connecting rod.

A part of the locus at the bottom is nearly straight.



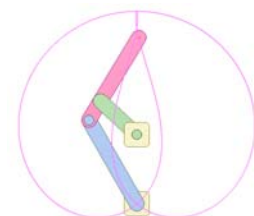
Four-bar linkage 2

<http://www.youtube.com/watch?v=SzwolVCGvu0>

The connecting rod rotates fully.

A motion cycle of the linkage corresponds two revolutions of the connecting rod.

A part of the locus at the top is nearly vertical straight.



Tchebicheff's four-bar linkage 3

<http://www.youtube.com/watch?v=IDDPW6NR5TE>

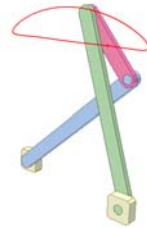
Length of the connecting rod: a

Length of the two cranks: $2.5a$

Distance between two fixed bearing houses: $2a$

The connecting rod rotates fully.

A part of the locus of the middle point of the connecting rod is approximately straight.



Robert's four-bar linkage 4

<http://www.youtube.com/watch?v=q69bxfp3On4>

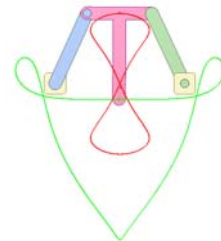
Length of the connecting rod: a

Length of the two cranks: not less than $1.2a$

Distance between two fixed bearing houses: $2a$

Not any links have full rotation.

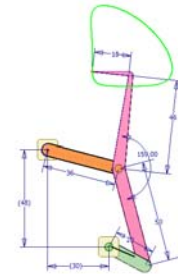
A part of the green locus of the lower point of the connecting rod is approximately straight.



D-drive four-bar linkage 5

<http://www.youtube.com/watch?v=7FRRGbw381k>

The green locus has two approximately straight parts perpendicular to each other.

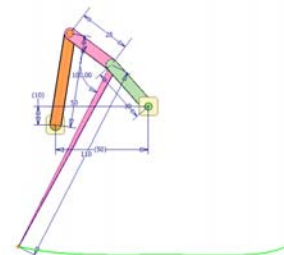


Four-bar linkage 6

<http://www.youtube.com/watch?v=f4N1R8MPZTI>

Four-bar linkage produces an approximately straight-line motion.

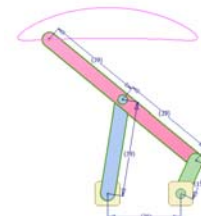
A small displacement of the orange crank results in a long, almost-straight line. It is used for the stylus on self-registering instruments.



Four-bar linkage 2B

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

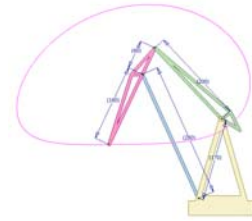
A part of the pink locus is a straight line.



Four-bar linkage crane

<http://www.youtube.com/watch?v=QGKnTEgHSS8>

The end point of the connecting rod draws a straight line. This is used for moving load in horizontal direction.



Watt's Linkage drawing straight line

<http://www.youtube.com/watch?v=KpDpP0ZgKt8>

Length of the two cranks: d

Length of the connecting rod: c

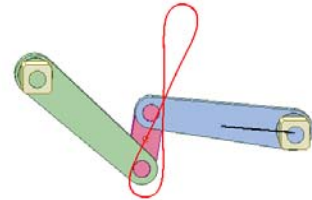
Horizontal distance between crank shafts: $2d$

Vertical distance between crank shafts: c

The middle point of the connecting rod traces a 8-shaped curve.

Length of the line segment: $3c/2$

Not any links have full rotation.



Tchebicheff's four-bar linkage 3B

<http://www.youtube.com/watch?v=xPVcL0fMBCK>

Length of the crank: $a = 30$ mm

Length of the two connecting rods: $2.6a = 78$ mm

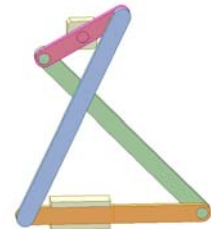
Length of the translating bar: $2a = 60$ mm

The mechanism can work if the crank oscillates ± 30 degrees around the horizontal direction and gap between the runway and the translating bar more than 0.044 mm.

The mechanism is deduced from the one of

Tchebicheff's four-bar linkage 3

<http://www.youtube.com/watch?v=IDDPW6NR5TE>



Double parallelogram mechanism 1

<http://www.youtube.com/watch?v=u5XA2-E9ZDk>

A combination of two parallelogram mechanisms.

The yellow bar has straight-line motion.

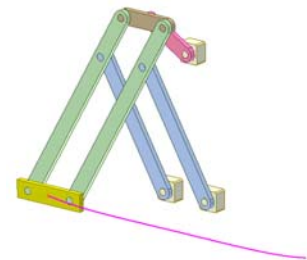
Lengths of the links:

Three shortest links: 8

Two blue links: 22

Two green links: $27 + 8 = 35$

Height of the upper fixed bearing to the two lower ones: 22.



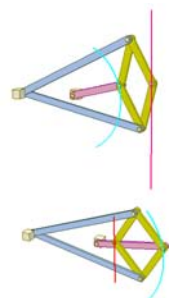
Peaucellier linkage 1

<http://youtu.be/6fgrTZnO-ZM>

Bars of identical colour are of equal length.

In each mechanism axle distance between the two fixed revolution joints and the pink bar length are equal.

An vertex of the yellow rhombus traces an absolutely straight line (in red).



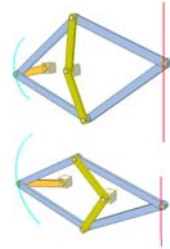
Peaucellier linkage 2

<http://youtu.be/LhC9RVl2ln8>

Bars of identical colour are of equal length.

In each mechanism axle distance between the two fixed revolution joints and the orange bar length are equal.

An vertex of the blue rhombus traces an absolutely straight line (in red).



Kite mechanism 1

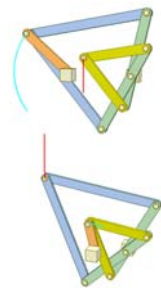
<http://youtu.be/lzacj8CRsNc>

A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.

Bars of identical colour are of equal length.

Axle distance between the two fixed revolution joints and the orange bar length are equal.

An vertex of the blue rhombus traces an absolutely straight line (in red).



Kite mechanism 2a

<http://youtu.be/kilYIEd7Gj4>

A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.

Length of blue bar: a

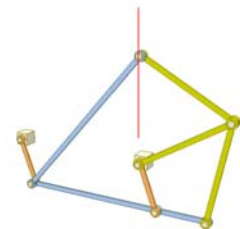
Length of blue bar of 3 joints: $0.75a + 0.25a$

Length of yellow bars: $0.5a$

Length of orange bars: $0.25a$

Axle distance between the two fixed revolution joints $0.75a$

An vertex of the big kite traces an absolutely straight line (in red).



Kite mechanism 2b

<http://youtu.be/wuKQcDh4MFw>

A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.

Length of blue bar: a

Length of blue bar of 3 joints: $0.75a + 0.25a$

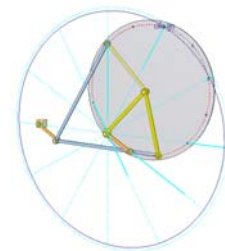
Length of yellow bars: $0.5a$

Length of orange bars: $0.25a$

Axle distance between the two fixed revolution joints $0.75a$

The grey disk is fixed to the upper yellow bar. On this disk all points

laid on small circle of diameter a (in pink) move along straight lines that are diameters of a big circle of $2a$ diameter (in cyan). The small circle rolls without slide in the big one. They are of Cardano.



Kite mechanism 3

<http://youtu.be/EQ0DLpqnN-g>

A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.

Length of blue bar: a

Length of green bar of 3 joints: $0.5a + 0.5a$

Length of pink bar of 3 joints: $0.25a + 0.75a$

Length of yellow bars: $0.5a$

Length of orange bars: $0.25a$

Axle distance between the three fixed revolution joints $0.75a + 0.25a$

The pink bar moves along an absolutely straight line.



Kite mechanism 4

<http://youtu.be/oKmy7CMYASA>

A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.

Length of blue bar: a

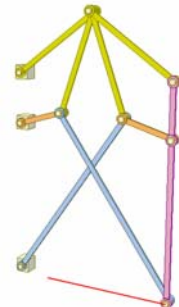
Length of pink bar of 3 joints: $0.25a + 0.75a$

Length of yellow bars: $0.5a$

Length of orange bars: $0.25a$

Axle distance between the three fixed revolution joints $0.25a + 0.75a$

The pink bar moves along an absolutely straight line.



Kite mechanism 5a

<http://youtu.be/ShmKYOnMuw4>

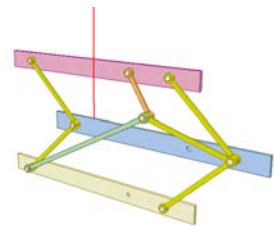
A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.

Length of green bars: a

Length of yellow bars: $0.5a$

Length of orange bars: $0.25a$

The pink plate moves along an absolutely straight line.



Kite mechanism 5b

http://youtu.be/oBgOfMio_LA

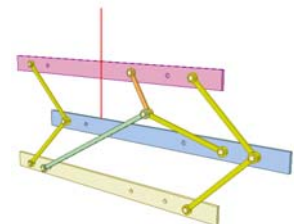
A modification of “Kite and spear-head mechanism 5a” proposed in 1877 by A. B. Kempe, London.

Length of green bars: a

Length of yellow bars: $0.5a$

Length of orange bars: $0.25a$

The pink plate moves along an absolutely straight line.



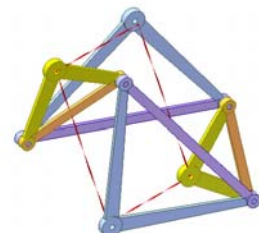
Inverse parallelogram mechanism 11

<http://youtu.be/S8slOrvrYJM>

This modification of inverse parallelogram (4 V-shaped arm mechanism) was proposed in 1877 by A. B. Kempe, London.

The original consists of two orange bars and two violet ones.

Each bar is modified by adding a V-shaped arm and becomes an isosceles right triangle. Their right angle vertices create a variable rectangular (in red).



4 V-shaped arm mechanism

http://youtu.be/-FPMdta-Y_A

This linkage was proposed in 1877 by A. B. Kempe, London.

It is a development of "Inverse parallelogram mechanism 11".

Revolution joint centers of the yellow (or blue) V-shaped arm create an isosceles right triangle.

Axle distance between the revolution joints of the green table, axle distance between the ground revolution joints and length of the pink bar are equal.

The green table moves along an absolutely straight line.

Pay attention to the red variable rectangular and two variable parallelograms.



Tchebicheff stool 1

<http://youtu.be/k0XrKv1B7h0>

This is a development of "Tchebicheff's four-bar linkage 3".

Bars of identical colour are of equal length.

Axle distance between the revolution joints of the green seat, axle distance between the ground revolution joints are equal.

The green seat has horizontal motion (not strictly rectilinear).



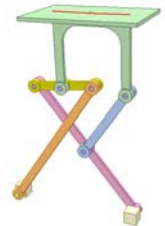
Tchebicheff stool 2

http://youtu.be/gV0xl_lbdDs

This is a development of "Tchebicheff's four-bar linkage 3".

Axle distance between the revolution joints of the green seat, axle distance between the ground revolution joints are equal.

The green seat has horizontal motion (not strictly rectilinear).



Gear and linkage mechanism 1

<http://youtu.be/muF6Y7TJz8>

A slider crank mechanism of two conrods and two cranks. The latters are fixed to two gears in mesh. Owing to the symmetric arrangement the piston axle moves rectilinearly (even if no cylinder (the left mechanism)). Lateral forces from piston applied to cylinder are negligible.



Gear and linkage mechanism 2

<http://youtu.be/IDKUj8MV9Xc>

Center of the yellow and pink bars revolution joint moves along an approximately straight line.

Radius of the small gear: a

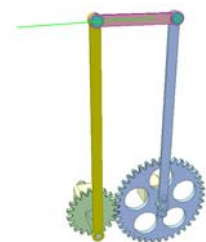
Length of the green crank: a

Radius of the big gear: $2a$

Length of the pink bar: $3a$

Length of the blue bar: $8a$

Length of the yellow bar: $9a$



Straight line drawing mechanism 4

<http://youtu.be/HmnA6E82-Wk>

Input: green crank of length L_1 .

Blue pulley of radius R_1 is stationary.

Yellow pulley of radius R_2 is fixed to yellow bar of length L_2 .

$R_1 = 2 \cdot R_2$

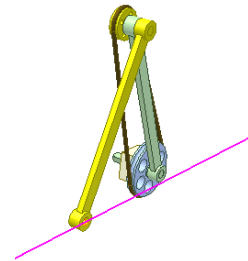
$L_1 = L_2$

A point on revolution joint of the yellow bar traces a straight line. Its length is $4 \cdot L_1$.

This mechanism has a relation with Cardano cycles.

The belt should be toothed.

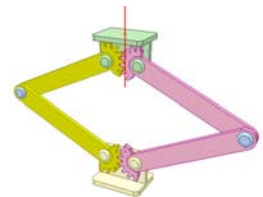
It is possible to use chain drive instead of belt one.



Gear and linkage mechanism 3a

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

Combination of linkage and gear drive. The green part translates along an absolutely straight line.

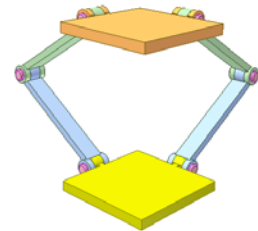


Sarrus linkage 1

<http://youtu.be/pQBJcgJe6t0>

A space linkage of only revolution joints and gives absolutely straight motion. It was invented in 1853, sooner than the planar Peaucellier linkage (1864).

It is the combination of two planar slider-crank mechanisms that lay in two perpendicular to each other planes.

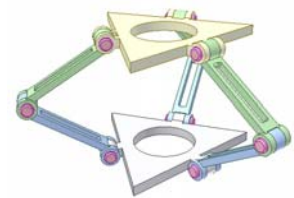


Sarrus linkage 2

<http://youtu.be/CPYbD1GUS1A>

An embodiment of "Sarrus linkage 1".

Two planes of two planar slider-crank mechanisms are not necessary to be perpendicular to each other. It is enough that they are not parallel.

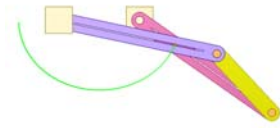


17.2. Conic curves

Inverse Parallelogram Mechanism 4

<http://www.youtube.com/watch?v=A4TvGoHsNyk>

The intersection point of the cranks traces an ellipse.



Conic section drawing mechanism 1

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

Drawing ellipses.

The four yellow bars create a rhombus.



Drawing Ellipse Mechanism 1

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

Lengths of the crank and the connection rod are equal.

The crank, the connection rod and two short links creates a rhombus.

Equation of traced ellipse: $(x.x)/(a.a) + (y.y)/((a - 2b). (a - 2b)) = 1$

the coordinate origin O is the fixed revolution joint center of the blue crank.

Axis Oy is vertical. Axis Ox is horizontal.

a is length of the crank.

b is length of the short link.

The blue bar can not turn full revolution because of interference between the orange long pin (connecting the pink and green bars) and the violet and blue bars. So the mechanism can draw only less than one-half of an ellipse (left or right).

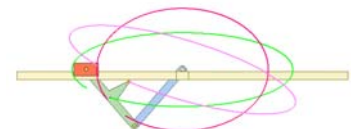


Drawing Ellipse Mechanism 2a

<http://www.youtube.com/watch?v=Ug7TK4YTRIY>

Lengths of the crank and the connection rod are equal.

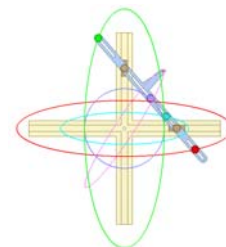
Each point of the green connection rod draws an ellipse.



Drawing Ellipse Mechanism 3

<http://www.youtube.com/watch?v=FoO2LIYLPEc>

Each point of the blue bar draws an ellipse.



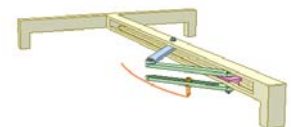
Drawing Ellipse Mechanism 2b

<http://youtu.be/csg08Sm8okA>

Lengths of blue crank and green conrod are equal.

Each point of the green conrod draws an ellipse.

Adjust position of the orange pen and move it to draw various ellipses. Push the crank or the conrod for overcoming dead points.

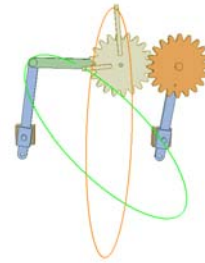


Drawing Ellipse Mechanism 4

<http://www.youtube.com/watch?v=rH7tMg9sR1w>

Tooth number ratio is 1.

Each point of the yellow gear draws an ellipse.



Belt satellite mechanism 2

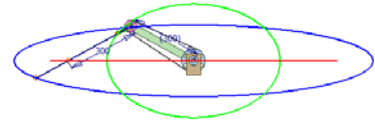
<http://www.youtube.com/watch?v=GBorVkFrhDQ>

Diameter ratio between the fixed large pulley and the small one is 2.

A point on the small sprocket draws an ellipse. For the special case (the red line) it is a straight line.

It is similar to the case of a gear satellite with sun internal gear.

<http://www.youtube.com/watch?v=2ER0rCFoITo>



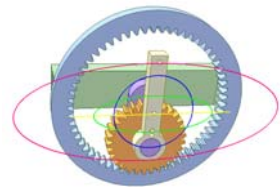
Drawing Ellipse Mechanism 5

<http://www.youtube.com/watch?v=2ER0rCFoITo>

Tooth number ratio is 2.

Each point of the small gear draws an ellipse.

A point on its rolling cycle draws a straight line (yellow).



Drawing ellipse mechanism 6

http://youtu.be/nPz6VfBF_-4

Combination of gear drive and linkage mechanism.

Two gears are identical. Axle distances between revolution joints on the pink and yellow bars are equal.

Equation of drawn ellipse:

$$(x/a)^2 + (y/b)^2 = 1$$

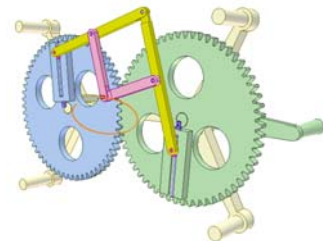
$$a = (m+n)/2$$

$$b = (m-n)/2$$

m, n: center distance of gear axle and its pink slider axle.

Use violet screws to alter m and n, which means a and b, for various ellipse shapes.

To get an ellipse axis coincident with the gear center line, the screws must be arranged in two sides of the line connecting gear centers with an equal angle.



Drawing ellipse mechanism 7

<http://youtu.be/Z5kFDYcoXS0>

Four slotted bars create a parallelogram. The blue bars rotate with a same speed but opposite directions due to three identical bevel gear drive.

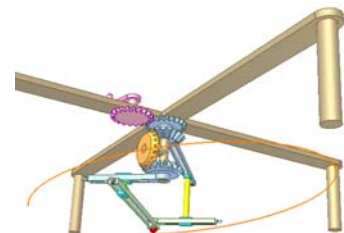
Equation of drawn ellipse:

$$(x/(a+b))^2 + (y/(a-b))^2 = 1$$

a: center distances between pivots of the long slotted bars.

b: center distances between pivots of the short slotted bars.

Use screws to alter a and b for various ellipse shapes.

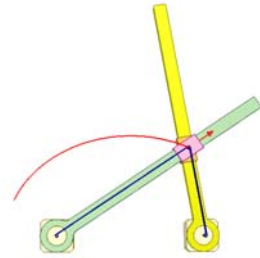


Cable mechanism for drawing ellipse

<http://youtu.be/UEIuvciAH7c>

The tow wraps on the pivot of small diameter of two sliders. It is possible that the tow passes through a hole of the pivot. The tow ends are fixed to rotation centers of the yellow and green bars. Turn the bars while keeping the tow strained, the center of sliders pivot traces an ellipse.

Basic definition: Ellipse is locus of point P moving in a plane, the sum of its distances from two fixed points is constant (the tow length).



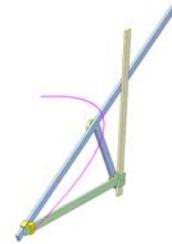
Drawing Parabola Mechanism 1

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

Equation of traced parabola: $y.y = b.x$

b: distance between the fixed revolution joint center of the T-bar (blue) O and the centerline of the fixed bar (popcorn).

Axis Oy is vertical. Axis Ox is horizontal.



Conic section drawing mechanism 2

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

Drawing parabolas

The four yellow bars create a rhombus.

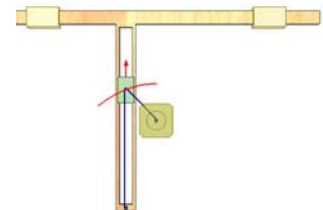


Cable mechanism for drawing parabola

<http://youtu.be/BsBRUoL2XKE>

The tow wraps on the pivot of small diameter of green slider. It is possible that the tow passes through a hole of the pivot. One tow end is fixed to a immobile point, the other end is fixed to a point of the orange bar. Move the bar while keeping the tow strained, the center of slider pivot traces an parabola.

Basic definition: Parabola is locus of point P moving in a plane, the sum of its distances from one fixed point and from one fixed straight line is constant (the tow length).



Conic section drawing mechanism 3

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

Drawing hyperbolas

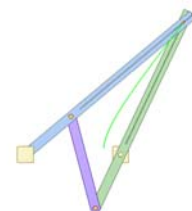
The four yellow bars create a rhombus.



Inverse Parallelogram Mechanism 5

http://www.youtube.com/watch?v=i5uj88NBq_s

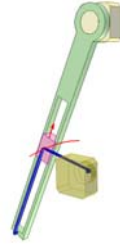
The intersection point of the cranks traces a hyperbola.



Cable mechanism for drawing hyperbola

<http://youtu.be/72bwAtzubiY>

The tow wraps on the pivot of small diameter of pink slider. It is possible that the tow passes through a hole of the pivot. One tow end is fixed to a immobile point, the other end is fixed to a point of the green bar. Turn the bar while keeping the tow strained, the center of slider pivot traces an hyperbola. Basic definition: Hyperbola is locus of point P moving in a plane, the difference of its distances from two fixed points is constant (the tow length).



Conic section compass 1

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

Drawing ellipses according to US Patent 5870830.

To adjust angles α and θ for each ellipse.

- α angle between the orange axis and the plane of paper
- θ : angle between the orange axis and the green arm

The green arm rotates around the orange axis to create a cone. Its intersection curve with the plane of paper is an ellipse.



Conic section compass 2

<http://www.youtube.com/watch?v=Mfi9SgAyrK4>

Drawing parabolas according to US Patent 5870830.

To adjust angles α and θ for each parabola.

- α angle between the orange axis and the plane of paper.
 - θ : angle between the orange axis and the green arm.
- α is equal to θ for parabola drawing.

The green arm rotates around the orange axis to create a cone. Its intersection curve with the plane of paper is a parabola.



Conic section compass 3

<http://www.youtube.com/watch?v=dsQE7onpTYs>

Drawing hyperbolas according to US Patent 5870830.

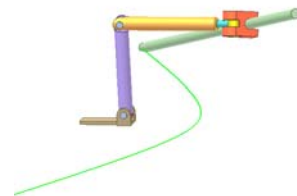
The violet axis is perpendicular to the plane of paper.

The orange axis is parallel to the plane of paper.

To adjust angles θ for each hyperbola.

- θ : angle between the orange axis and the green arm.

The green arm rotates around the orange axis to create a cone. Its intersection curve with the plane of paper is a hyperbola.

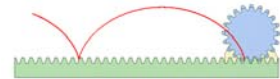


17.3. Other curves

Rack pinion mechanism 2

<http://www.youtube.com/watch?v=RN-6AH52V8U>

A point on the rolling circle of the pinion traces a cycloid.



Chain drive 4D

http://youtu.be/eby46_IIQnU

A chain drive rolls on the ground.

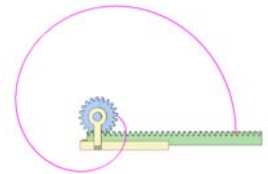
Loci of various points on a link (the pink one) are shown. The red line is for the link's pin center. The curve portions of the line are cycloids.



Rack pinion mechanism 3

http://www.youtube.com/watch?v=t_GxDXfQ0GA

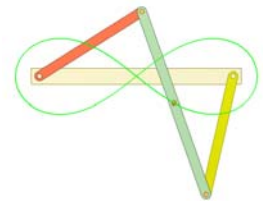
A point on the rolling line of the rack traces an involute.



Inverse Parallelogram Mechanism 6

<http://www.youtube.com/watch?v=rjxnoQz4xDs>

The middle point of the coupler link traces a figure-eight shaped curve, a lemniscate.



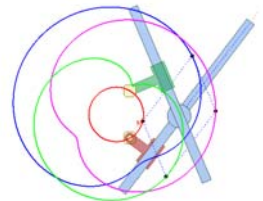
Oldham mechanism 1

<http://www.youtube.com/watch?v=Zb2wx3yaCeE>

It is the generalized case of Oldham mechanism

Loci of various points on the X-shaped bar are shown.

Point A traces a circle two times during 1 revolution of the cranks.



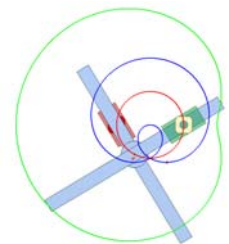
Oldham mechanism 2

<http://www.youtube.com/watch?v=TBYJwi4BTsM>

It is the standard case of Oldham mechanism

Loci of various points on the X-shaped bar are shown.

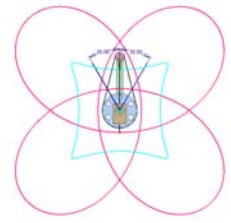
Remark: Point A traces a circle (in red) two times during 1 revolution of the cranks. Center of the circle is located in the middle of line segment connecting the two rotation joints.



Belt satellite mechanism 1

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

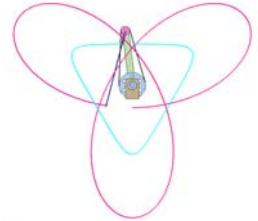
Diameter ratio between the fixed large pulley and the small one is 4.
If the green crank oscillates 60 degrees between the two blue lines,
the small pulley makes a 180 degree oscillation.
It is similar to the case of a gear satellite with sun internal gear.



Belt satellite mechanism 3

<http://www.youtube.com/watch?v=d0cYQsQJP4>

Diameter ratio between the fixed large pulley and the small one is 3.
The blue locus has three approximately straight parts.
It is similar to the case of a gear satellite with sun internal gear.



Loci in Epicyclic gearing A1

<http://youtu.be/usF8GCmD7xM>

R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

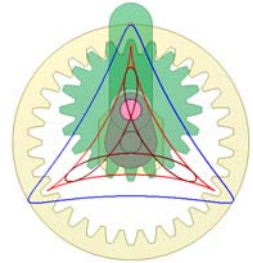
$$k = R/r = 1.5$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

It is a hypocycloid. The two other loci are hypotrochoid.

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



Loci in Epicyclic gearing A2

http://youtu.be/M4Sp2e6_BRw

R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

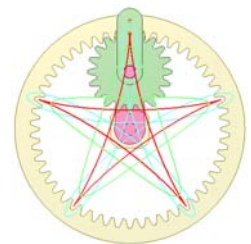
$$k = R/r = 2.5$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

It is a hypocycloid. The two other loci are hypotrochoid.

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



Loci in Epicyclic gearing A3

<http://youtu.be/U8vf3DEmWS0>

R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

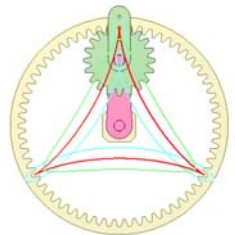
$$k = R/r = 3$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

It is a special hypocycloid: deltoid. The two other loci are hypotrochoid.

1 cycle of the mechanism corresponds 1 revolution of the input crank.



Loci in Epicyclic gearing A4

<http://youtu.be/hGu6yUYF8mc>

R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

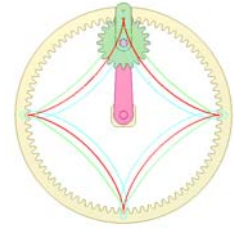
$$k = R/r = 4$$

Loci of various points on the planetary gear are shown.

The red locus is for a point on the pitch circle of the planetary gear.

It is a special hypocycloid: astroid. The two other loci are hypotrochoid.

1 cycle of the mechanism corresponds 1 revolution of the input crank.



Loci in Epicyclic gearing A4c

<http://youtu.be/4QYQy2akPY0>

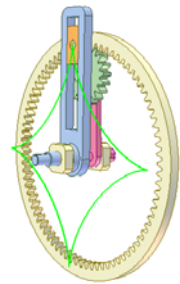
R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

$$k = R/r = 4$$

A point on pitch circle of the planetary gear traces a special hypocycloid: astroid (green)

The blue slotted crank has 4 dwells in a revolution.



Loci in Epicyclic gearing A4r

<http://youtu.be/xfwYbT46mKo>

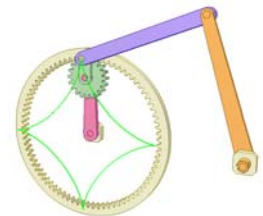
R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

$$k = R/r = 4$$

A point on pitch circle of the planetary gear traces a special hypocycloid: astroid (green)

The orange crank rocks with a dwell at its rightmost position.



Loci in Epicyclic gearing A4m

<http://youtu.be/B3eA9WydI24>

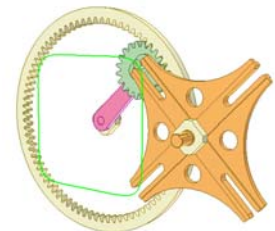
R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

$$k = R/r = 4$$

Distance between the pin axis and the gear axis of the planetary gear is $(11/30)r$ to get a square locus of straight side for the center of the pin.

This produces a smoother indexing motion of the orange Geneva disk rotates because the driving pin moves on a noncircular path, unlike in standard Geneva mechanism.



Loci in Epicyclic gearing A4mb

<http://youtu.be/t0243w69178>

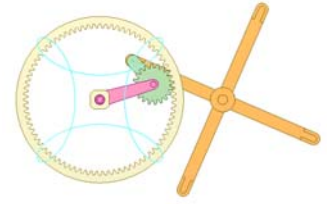
R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

$$k = R/r = 4$$

Distance between the pin axis and the gear axis of the planetary gear is $(5/3)r$ to get an appropriate loop locus for the center of the pin.

This produces a smoother indexing motion of the orange Geneva disk because the driving pin moves on a nearly circular curve, center of which is the rotation center of the Geneva disk.



Loci in Epicyclic gearing A3b

<http://youtu.be/BdXXi4fgli0>

Two identical hypocycloid mechanisms guide the point of the blue bar along the triangularly shaped path.

Distance between the bar holes is equal to distance between the two fixed bearings of the pink cranks.

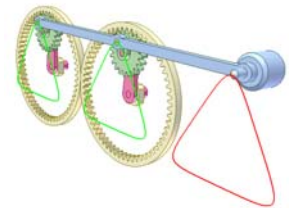
R: pitch diameter of the fixed sun gear

r: pitch diameter of the planetary gear

$$k = R/r = 3$$

Distance between the pin axis and the gear axis of the planetary gear is $(1/2)r$ for getting a triangle of straight sides.

The mechanism are useful where space is limited in the area where the curve must be described. The mechanism can be designed to produce other curve shapes.



Loci in Epicyclic gearing A2.1

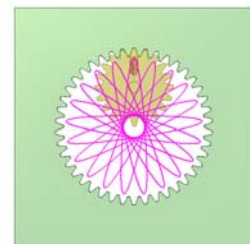
<http://youtu.be/VMG5039DKoo>

Drawing toy Spinograph.

This video shows how the pink pencil traces a 21 wing hypotrochoid.

Tooth number of green gear: 42.

Tooth number of yellow gear: 20.



Loci in Epicyclic gearing B1

<http://youtu.be/lkwYaPxSUgw>

r: pitch diameter of the fixed sun gear with external teeth.

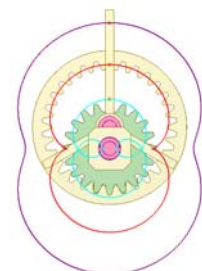
R: pitch diameter of the planetary gear with internal teeth

$$k = R/r = 1.5$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

1 cycle of the mechanism corresponds 3 revolutions of the input crank.



Loci in Epicyclic gearing B2

<http://youtu.be/QzP8eA1h91g>

r: pitch diameter of the fixed sun gear with external teeth.

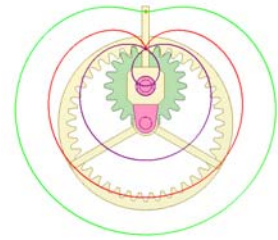
R: pitch diameter of the planetary gear with internal teeth

$$k = R/r = 2$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

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



Loci in Epicyclic gearing B3

<http://youtu.be/tzisrqQ8lls>

r: pitch diameter of the fixed sun gear with external teeth.

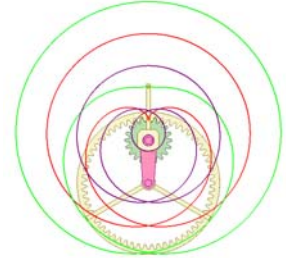
R: pitch diameter of the planetary gear with internal teeth

$$k = R/r = 3$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

1 cycle of the mechanism corresponds 3 revolutions of the input crank.



Loci in epicyclic gearing E1

http://youtu.be/rWe0P63_GjI

r: pitch diameter of the fixed sun gear.

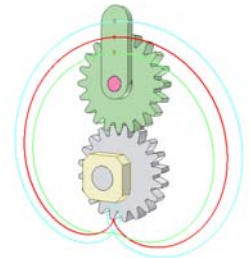
R: pitch diameter of the planetary gear.

$$k = R/r = 1$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

1 cycle of the mechanism corresponds 1 revolution of the pink input crank.



Loci in epicyclic gearing E2

<http://youtu.be/ljMCYyT84mY>

R: pitch diameter of the fixed sun gear.

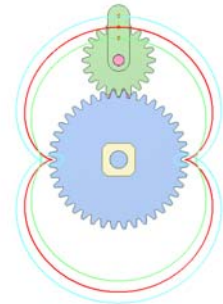
r: pitch diameter of the planetary gear.

$$k = R/r = 2$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

1 cycle of the mechanism corresponds 1 revolution of the pink input crank.



Loci in epicyclic gearing E2b

<http://youtu.be/sjJLXzc-vlk>

R: pitch diameter of the fixed sun gear.

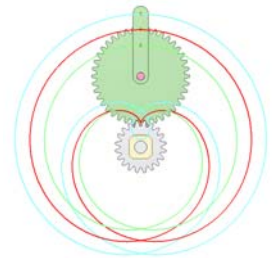
r: pitch diameter of the planetary gear.

$$k = R/r = 0.5$$

Loci of various points on the planetary gear are shown.

The red is for a point on the pitch circle of the planetary gear.

1 cycle of the mechanism corresponds 2 revolutions of the pink input crank.



Loci in epicyclic gearing E1.1

<http://youtu.be/jq4DZkcoR-A>

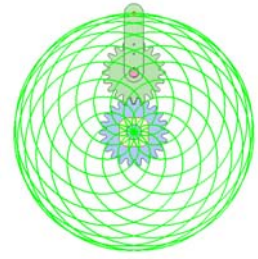
R: pitch diameter of the fixed sun gear.

r: pitch diameter of the planetary gear.

$$k = R/r = 1.1$$

The red curve is locus of point on the pitch circle of the green planetary gear.

1 cycle of the mechanism corresponds 10 revolutions of the pink input crank.



Drawing trapezium with Reuleaux triangle

<http://www.youtube.com/watch?v=HEiAhhQwNQ0>

The cam profile is a Reuleaux triangle with rounded vertices.

The mechanism is used for moving film in cameras.

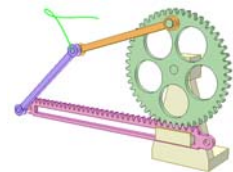


Rack and linkage mechanism 1

<http://youtu.be/67GjJMQaWgM>

The green input gear oscillates.

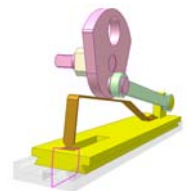
The orange and violet bars have complicated motions.



Cam and crank slider mechanism 1

<http://youtu.be/TRblqSk2ydl>

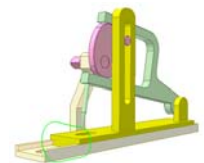
The output flat spring tip traces a trapezium for moving film in cameras.



Cam and sine mechanism 1

<http://youtu.be/o0bvLIWQYhk>

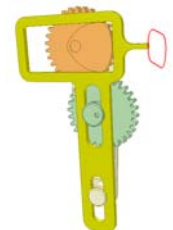
The tip of the green follower traces a green curve for moving film in cameras.



Cam and gear mechanism 7

<http://youtu.be/HbeuoAhQ3kE>

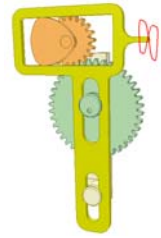
The yellow follower contacts with the orange cam fixed on the orange gear, eccentric portion of the green gear and the fixed lower pin. The cam is of constant width shape. A point of the frame follower traces the red curve that is used for moving film in cameras. Transmission ratio of the gear drive is 1.



Cam and gear mechanism 8

<http://youtu.be/Mv6IA8nlogs>

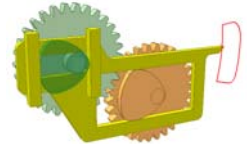
The yellow follower contacts with the orange cam fixed on the orange gear, eccentric portion of the green gear and the fixed lower pin. The cam is of constant width shape. A point of the frame follower traces the red curve that is used for moving film in cameras. Transmission ratio of the gear drive is 2.



Cam and gear mechanism 9

<http://youtu.be/8liGR-OqX1Q>

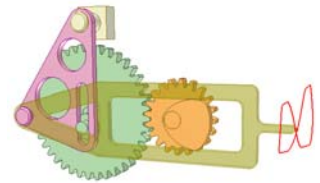
The yellow follower contacts with the orange cam fixed on the orange gear, concentric portion of the green gear and the green cam. The cams are of constant width shape. A point of the frame follower traces the red curve that is used for moving film in cameras. Transmission ratio of the gear drive is 1.



Cam and gear mechanism 10

<http://youtu.be/dDITwo4j4SA>

The yellow follower contacts with the orange cam fixed on the orange gear. The cam is of constant width shape. The pink plate has a slot in which an eccentric pin of the green gear slides. A point of the frame follower traces the red curve that is used for moving film in cameras. Transmission ratio of the gear drive is 2.



Gear and linkage mechanism 4

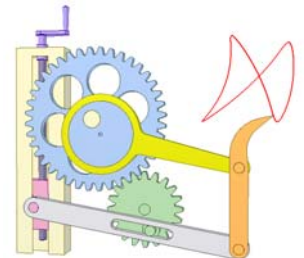
<http://youtu.be/-VLFKkYmY-0>

Orange bar tip traces red curve that is used for moving film in cameras.

Blue and green gears have eccentrics.

Transmission ratio of gear drive is 2.

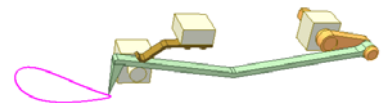
Move pink slider by turning violet screw for various positions of the red curve.



Spring linkage mechanism 3

<http://youtu.be/DQB1pY3lt08>

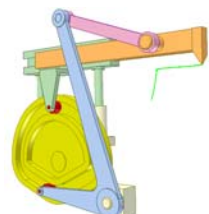
A slot on the green lever of an ordinary coulisse mechanism is not needed if a leaf spring is used to force the lever against the fixed pin.



Cam mechanism of 2 followers

<http://youtu.be/eOg1P04m8tM>

The yellow grooved cam controls motions of two followers (one translating and one rocking). Thus the orange slider has complicated motion.



Cam and crank slider mechanism 6

http://youtu.be/JAtnB_WAhOE

Input is the yellow cam. The green follower has two pink rollers, both in permanent contact with the cam. The orange output slider has complicated motion.



Double cam mechanism 1

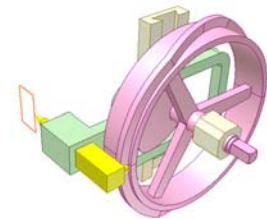
<http://youtu.be/hVaozVJ9C7w>

A combination of disk cam and barrel cam.

The disk cam moves green follower.

The barrel cam moves yellow follower.

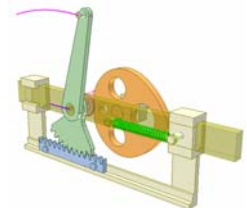
A point of the yellow follower traces the orange rectangle that is used for moving film in cameras.



Cam and gear mechanism 1

<http://youtu.be/nGqN-2ckst8>

Input is the orange cam. Due to gear rack drive, the green output crank has longer stroke (the pink curve, an extended cycloid) than the yellow follower (the violet line).

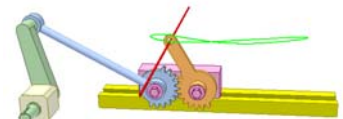


Gear slider crank mechanism

<http://youtu.be/wql18kbXN1c>

The hole center on the orange lever reciprocates according the motion rule (the green closed curve) that differs from the one of a ordinary slider-crank mechanism.

This mechanism is applied in wire drawing machines for guiding wire (in red) to its coil.



Gear and linkage mechanism 15

<http://youtu.be/9JErtHWgtk4>

The gears have a same tooth number.

Input : Blue gear rotating regularly.

The red pin traces a complicated curve in general.

This video is for special case, when a part of the red pin locus is linear:

Gear pitch diameters : 50

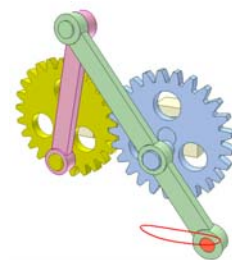
Crank radius of the blue gear : 5

Crank radius of the yellow gear : 18

Length of the pink bar : 62

Length of the green bar : 60 + 38

Assembly position: as start position of the simulation video.

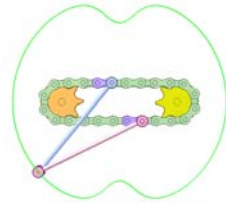


Chain drive 3E

<http://youtu.be/rCyWwj-QU54>

Two sprockets are identical.

Locus of center of the revolution joint between blue and pink bars is complicated.

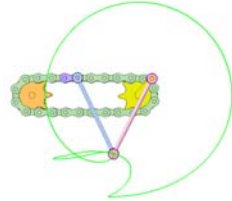


Chain drive 3F

http://youtu.be/fCTeC7_4bXI

Two sprockets are identical.

Locus of center of the revolution joint between blue and pink bars is complicated.



Chain drive 5D

<http://www.youtube.com/watch?v=KDUgrrAbn6Q>

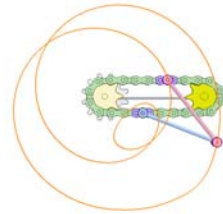
Satellite chain drive.

The popcorn sprocket is fixed.

The popcorn and yellow sprockets have the same tooth number.

The grey crank and gear is driving.

Locus of center of the revolution joint between blue and pink bars is complicated.



Chain drive 5E

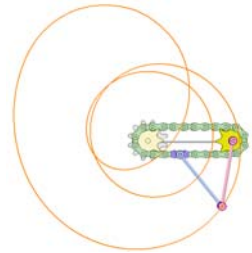
<http://www.youtube.com/watch?v=AOZXWyIFYFQ>

Satellite chain drive.

The popcorn sprocket is fixed. The popcorn and yellow sprockets have the same tooth number. The pink bar has a revolution joint with the yellow sprocket at its center.

The grey crank and gear is driving.

Locus of center of the revolution joint between blue and pink bars is complicated.



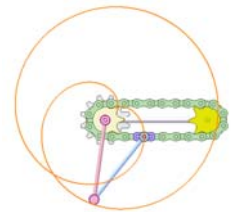
Chain drive 5F

<http://www.youtube.com/watch?v=FnWojsq3Ofo>

Satellite chain drive.

The popcorn sprocket is fixed. The popcorn and yellow sprockets have the same tooth number. The pink bar has a revolution joint with the popcorn sprocket at its center. The grey crank and gear is driving.

Locus of center of the revolution joint between the blue bar and the violet chain link is complicated. The pink bar rotates with dwell.

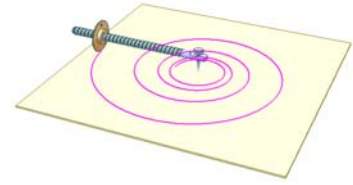


Instrument for drafting spiral

<http://youtu.be/S2ILP90ATKI>

The orange nut-wheel, by revolving about the fixed central point, describes a spiral by moving along the screw threaded axle either way, and transmits the same to drawing paper on which transfer paper is laid with colored side downward.

The obtained spiral is not an Archimedean one.



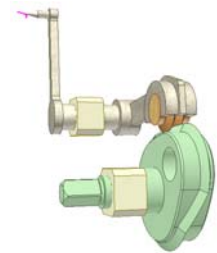
Double cam mechanism 2

<http://youtu.be/rZctm5qDcwU>

Input: green cam, a combination of disk cam and barrel cam.

Output: brown crank that oscillates and linearly reciprocates.

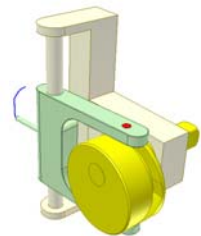
The gravity maintains contact between the cam and orange roller.



Barrel cam mechanism BR2

<http://youtu.be/jfHfx-gCERs>

The yellow cam is a combination of an eccentric cam and a barrel one. Contacting both cylinder surface (by two planes) and groove (by a red pin) of the yellow cam, the green follower has complicated motion.



Worm-rack drive 4

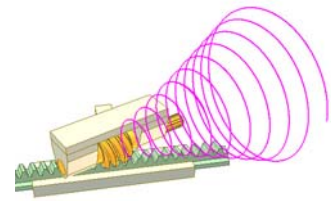
<http://youtu.be/Sm6OHgdqSKI>

The worm is stationary. Input is the rack runway fixed to the worm bearing. The pink curve is locus of a point on rack pitch line (a space involute of a circle?).

Worm: Helix angle $B1 = 30^\circ$, left hand

Rack: Helix angle $B2 = 0^\circ$.

Angle between worm axle and rack moving direction is $L = 30^\circ$.



18. Mechanisms for math operations and for object position control

Cable adding mechanism

<http://youtu.be/56mtxOTCezM>

Two ends of the cable are fixed to the base.

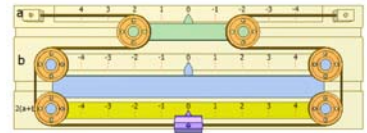
Move the green slider to enter value a.

Move the blue slider to enter value b.

The violet cursor (fixed to the cable) gives value $2(a+b)$.

The video shows the operation $2(0.5 + 1) = 3$ and the return to initial position.

For getting value $(a+b)$ to connect the violet cursor to further mechanism such as to the pink slider in video "Cable drive 3" of this channel.



Linkage adding mechanism 1

http://youtu.be/e_zW20jO48I

Turn the violet crank to enter value X.

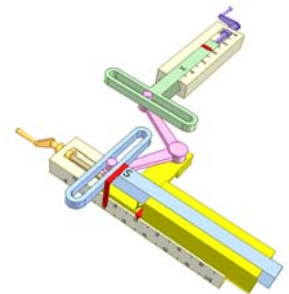
Turn the orange crank to enter value Y.

The red arrow on the blue slider shows $S = X + Y$ (algebraic addition).

The video shows the operation $2 + 4 = 6$ and the return to initial position.

The slot on the green slider must be parallel to the sliding direction of the blue slider in order to keep the independence between X and Y entering.

Angle of the pink arm is $A = 90^\circ$. Angle between sliding directions of the green and blue sliders is $B = 90^\circ$. This ensures that the displacements of the green slider and the blue one are equal when the yellow slider is immobile.



Linkage multiplication mechanism 1

<http://youtu.be/U262eypJ7ik>

Move blue T-bar to enter positive number x

Move yellow slider to enter positive number y

Orange T-bar shows $z = x*y$

At point C there are 3 pink sliders (sliding in slots of violet, orange and blue bars respectively) connected together by revolution joints. The screw lead must be large enough to avoid self-locking.

The video shows operation $40*50 = 2000$ and then $50*80 = 4000$.

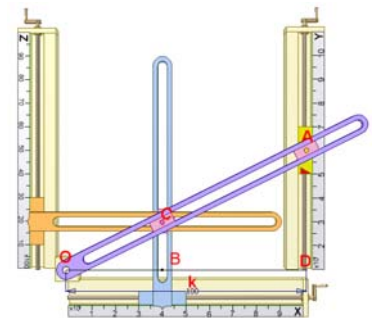
The mechanism works on congruent triangles rule. From triangles OBC and OAD: $OB/OD = BC/AD$

$OB = x$; $AD = y$; $BC = z$; $OD = k = 100 \text{ mm (constant)}$ then $z = (xy)/k$

For the X and Y scale, 1 mm corresponds 1 unit.

For the Z scale, 1 mm corresponds 100 units.

The division $x = z/y$ can be performed on this mechanism: enter z and y and get x.



Linkage square root mechanism 1

<http://youtu.be/mUGOtdwxvYI>

Move blue T-bar to enter positive number x to be squared.

Orange T-bar shows $z = x^2$

Move orange T-bar to enter positive number z to be rooted. Blue T-bar shows $x = \sqrt{z}$

At point C there are 3 pink sliders (sliding in slots of violet, orange and blue bars respectively) connected together by revolution joints. The screw lead must be large enough to avoid self-locking.

The video shows operation $40^2 = 1600$ or $\sqrt{1600} = 40$ and then $70^2 = 4900$ or $\sqrt{4900} = 70$.

The mechanism works on congruent triangles rule.

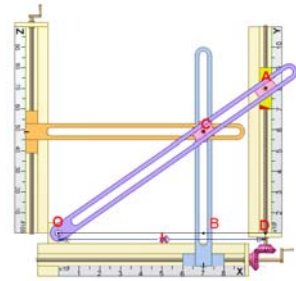
From triangles OBC and OAD: $OB/OD = BC/AD$

$OB = x$; $AD = y$; $BC = z$; $OD = k = 100$ mm (constant) then $z = (xy)/k$

Because pink bevel gears have the same tooth number and their screws have the same lead, so $x = y$ hence $z = (x^2)/k$ or $x = \sqrt{z \cdot k}$

For the X and Y scale, 1 mm corresponds 1 unit.

For the Z scale, 1 mm corresponds 100 units.



Converting polar coordinates to Cartesian coordinates

<http://youtu.be/uBMnVAMafgl>

Turn blue knob A to enter increment of polar angle DA

Turn orange knob R to enter increment of radius DR

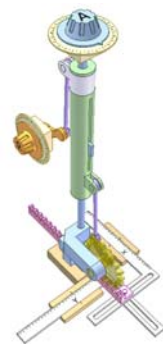
The X scale shows increment along the X axis: $DX = DR \cdot \cos(DA)$

The Y scale shows increment along the Y axis: $DY = DR \cdot \sin(DA)$

A pin of the pink rack slides in slots of sliders X and Y.

Two slider-crank mechanisms ensure rotation angles of orange knob and yellow gear equal.

The inverse operation (Cartesian coordinates to polar coordinates) is possible.



Compass for angle trisection

<http://youtu.be/sxwMGcshJl8>

The compass is created by connecting three similar inverse parallelograms. Similar ratio is 2. Numbering:

0 for the left first fixed prong,

1 for the next prong, ...

and 3 for the last prong,

A1 is angle between prong 1 and prong 0

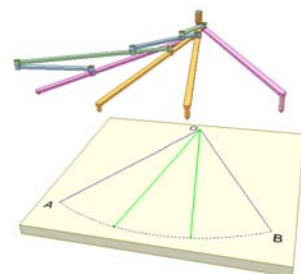
A2 is angle between prong 2 and prong 0

A3 is angle between prong 3 and prong 0

The compass maintains relation: $A_i = i \cdot A_1$

$i = 1$ to 3

i.e.: $A_2 = 2 \cdot A_1$; $A_3 = 3 \cdot A_1$



Polar planimeter 1

<http://youtu.be/kdxPEZnv-U0>

Instrument for determining the area (F) of an arbitrary two-dimensional shape (in red).

Move stylus B along the periphery of the shape (one complete round), the green roller gives two values:

B1: initial position angle (in radians)

B2: final position angle (in radians)

$$F = L \cdot R \cdot (B1 - B2)$$

$$L = BC$$

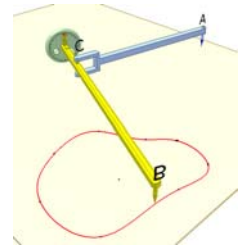
R: radius of rolling circle of the green roller.

The roller rotation axis must be parallel to BC.

Mathematical basis of the mechanism: integration in polar coordinates.

There must be sufficient friction between the green roller and the ground to prevent slipping.

In real planimeters there is reduction gear drive to ease reading angle values.



Linear planimeter

<http://youtu.be/qThV6gTaYMI>

Instrument for determining the area (F) of an arbitrary two-dimensional shape (in red).

The blue bar can move only linearly in the direction perpendicular to the blue rollers axis.

Move stylus B along the periphery of the shape (one complete round), the green roller gives two values:

B1: initial position angle (in radians)

B2: final position angle (in radians)

$$F = L \cdot R \cdot (B1 - B2)$$

$$L = AB$$

R: radius of rolling circle of the green roller.

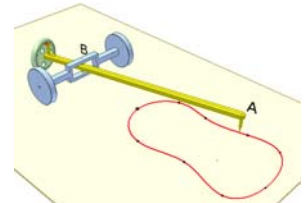
The roller rotation axis must be parallel to AB.

Mathematical basis of the mechanism: Green's theorem.

There must be sufficient friction between the green roller and the ground to prevent slipping.

Linear planimeters are used for the determination of stretched shapes.

In real planimeters there is reduction gear drive to ease reading angle values.



Planar motion control 1a

<http://youtu.be/tZj6O5biJ0M>

Orange object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.

This mechanism can deal with two linear ones.

Relations between coordinates of the object center A(x,y) and coordinates of pistons ends B(t,0) and C(0,s):

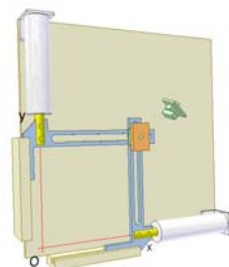
$$x = t$$

$$y = s$$

x and t are measured along Ox axis.

Large distance from point A to the runways is a disadvantage so ball bearing sliders should be used.

Angular position of the object is unstable and needs a control device (not shown).



Planar motion control 1b

<http://youtu.be/7OX351jGXeM>

Pink object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.

This pantograph can deal with two linear ones.

Relations between coordinates of the object center $A(X,Y)$ and coordinates of pistons ends $B(t,0)$ and $C(0,s)$:

$$x = (t+s.\cos\alpha)/2$$

$$y = (s+t.\cos\alpha)/2$$

α is angle between Ox and Oy

x and t are measured along Ox axis.

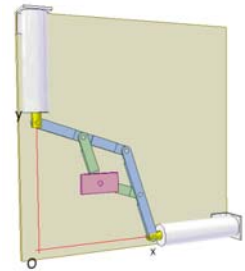
If $\alpha = 90$ deg.

$$x = t/2$$

$$y = s/2$$

Angular position of the object is unstable and needs a control device (not shown).

Advantage of pantograph: no prismatic joints.



Planar motion control 2a

<http://youtu.be/cMA1BmS-Ptk>

Pink object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.

Two white actuators deal with two linear ones. See:

"Planar motion control 1a"

<http://youtu.be/tZj6O5biJ0M>

Servo motor turns red shaft and controls angular displacement via a double parallelogram drive. Each of red and pink shafts has 2 eccentrics for overcoming dead positions of the parallelogram mechanisms. So the cyan shaft has 4 eccentrics. Transmission ratio between the red and pink shafts is 1/1. The pink shaft and the object are fixed together.

If the red shaft is immobile, the object does not rotate when moving along Ox and Oy axes.

The video shows how the pink object moves along Ox axis, along Oy axis and then rotates.

The parallelogram drive can be applied for "Planar motion control 1b"

<http://youtu.be/7OX351jGXeM> to control the pink object.



Planar motion control 2b

<http://youtu.be/GMVuvjjDMPs>

Pink object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.

Two white actuators deal with two linear ones via a pantograph (two violet and two blue bars). For more about pantograph see:

"Planar motion control 1b"

<http://youtu.be/7OX351jGXeM>

Servo motor turns red gear and controls angular displacement via 4 bevel gear drive.

Four gears have the same tooth number.

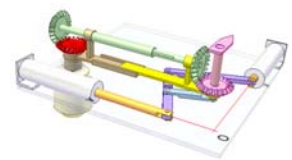
Transmission ratio between the red and pink gear is 1/1.

If the red gear is immobile, the object does not rotate when moving along Ox and Oy axes.

The video shows how the pink object moves along Ox axis, along Oy axis and then rotates.

The 4 bevel gear drive can be applied for "Planar motion control 1a"

<http://youtu.be/tZj6O5biJ0M> to control the orange object.



Planar motion control 1c

<http://youtu.be/c49hlov2C2I>

Orange object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.

This mechanism can deal with two linear ones.

For object center A(x,y):

Left motor controls x value via screw-nut drive.

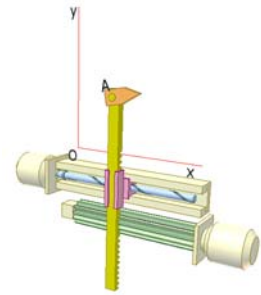
Right motor controls y value via rack-pinion drive.

Angular position of the object is unstable and needs a control device (not shown).

For angular control devices refer to:

<http://youtu.be/cMA1BmS-Ptk>

<http://youtu.be/GMVuvjjDMPs>



Planar motion control 1d

<http://youtu.be/wQz2YepAH4k>

Orange object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.

This mechanism can deal with two linear ones x, y.

They are controlled based on the polar coordinate system

The object center A is determined by distance r from a fixed point O and angle ϕ from fixed direction Ox.

$$x = r \cdot \cos\phi$$

$$y = r \cdot \sin\phi$$

The video shows how the mechanism moves the object to get distance r and then angle ϕ .

Lower motor controls r value.

Upper motor controls ϕ value.

There is a helical joint between pink slider and blue shaft.

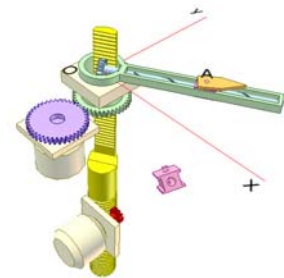
Round rack on lower half of the yellow shaft allows independent operation of the motors.

Angular position of the object is unstable and needs a control device (not shown).

For angular control devices refer to:

<http://youtu.be/cMA1BmS-Ptk>

<http://youtu.be/GMVuvjjDMPs>



Planar motion control 2c

<http://youtu.be/6jpgp8GXdgc>

Red object has 3 degrees of freedom in its planar motion: two linear x, y and one angular displacements.

Left motor controls x motion via screw-nut drive.

Right motor controls y motion via rack-pinion drive.

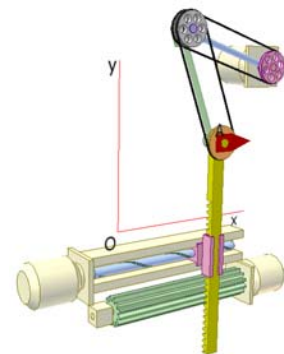
Upper motor turns pink pulley and controls angular displacement via two toothed belt drives (chain drives are possible).

Four pulleys have same diameter (same tooth number).

Transmission ratio between the pink and orange pulleys is 1/1.

If the pink pulley is immobile, the object does not rotate when moving along Ox and Oy axes.

The video shows how the red object moves along Ox axis, along Oy axis and then rotates.



Spatial motion control 1

<http://youtu.be/iNa6y4aXG3g>

It is a design of Goddard Space Flight Center, USA.

The position and orientation of the orange platform is governed uniquely, in all six degrees of freedom, by the positions of the drivers on the base plate.

The lower ends of the violet limbs are connected via universal joints (2 DoF) to the drivers.

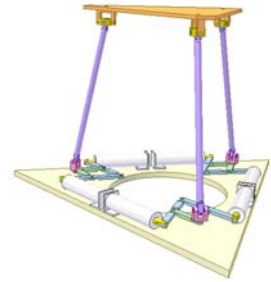
The upper ends of the violet limbs are connected via universal joints (2 DoF) to the platform.

In this video the drivers are pantographs of two degrees of freedom (2 DoF). See:

<http://youtu.be/7OX351jGXeM>

Other types of drivers of 2 DoF are possible.

This mechanism is used for a minimanipulator producing small, precise motions and high mechanical advantage.

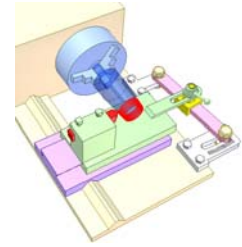


19. Mechanisms for processing metal and wood

Tapered turning attachment 1

<http://youtu.be/fm7uZqS3Oy0>

The green slider carries red tool and yellow slider which has revolution joint with the green slider and prismatic joint with pink taper ruler. When the violet power-fed carriage moves along the axis of rotation of the blue work, the tool moves along a line parallel to the ruler to create cone surface on the work.



Tapered turning by offsetting of the tailstock

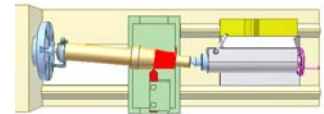
<http://youtu.be/z3iYhKFPHKc>

This method more suited for shallow tapers.

Approximately the set-over $S = L \cdot \sin \alpha$

L: distance between the blue centers

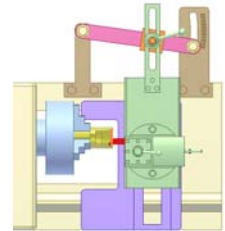
α : half of taper angle



Tapered turning attachment 2

<http://www.youtube.com/watch?v=9OcQW3Wc1eE>

The green slider carries red tool and orange slider which has revolution joint with the green slider and prismatic joint with pink taper ruler. When the violet power-fed carriage moves along the axis of rotation of the yellow work, the tool moves along a line parallel to the ruler to create inner cone surface on the work.

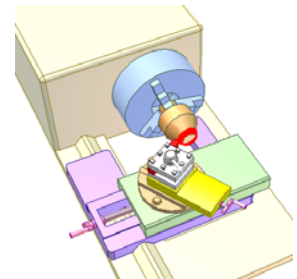


Tapered turning by using the compound slide 1

http://youtu.be/4LET_jHIZvM

The brown base of the yellow compound slide is turned an angle α (half of taper angle of cone surface to be created) and then fixed. This makes the tool moves along a line that creates an angle α with the axis of rotation of the orange work when turning the compound slide screw.

The green cross slide and the violet carriage are fixed during operation.

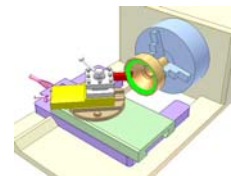


Tapered turning by using the compound slide 2

http://youtu.be/ysiVGfX4p_4

The brown base of the yellow compound slide is turned an angle α (half of taper angle of inner cone surface to be created) and then fixed. This makes the tool moves along a line that creates an angle α with the axis of rotation of the orange work when turning the compound slide screw.

The green cross slide and the violet carriage are fixed during operation.

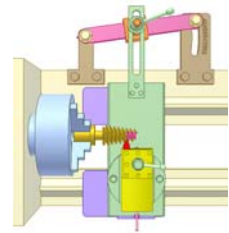


Taper thread turning 1

<http://youtu.be/hls4UHUUZdA>

Thanks to the tapered turning attachment the tool moves along a line that creates an angle α (half of taper angle) with the axis of rotation of the yellow work.

The lathe is set to get when the chuck turns 1 revolution, the violet carriage moves L mm (thread lead). The tool is retrieved a little during the reverse stroke.

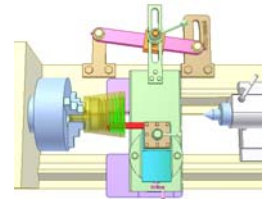


Taper thread turning 2

<http://youtu.be/8yX4Q78QO6M>

The green slider carries red tool and cyan slider which has revolution joint with the green slider and prismatic joint with pink taper ruler. When the violet power-fed carriage moves along the axis of rotation of the yellow work, the tool moves along a line parallel to the ruler to create inner taper thread on the work.

The lathe is set to get when the chuck turns 1 revolution, the violet carriage moves L mm (thread lead). The tool is retrieved a little during the reverse stroke.



Taper thread turning 3

<http://youtu.be/ttK0LNuwQTk>

Thanks to tailstock offsetting the tool moves along a line that creates an angle α (half of taper angle) with the axis of rotation of the orange work.

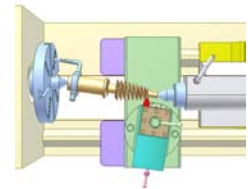
This method more suited for shallow tapers.

Approximately, the set-over $S = L \cdot \sin \alpha$

L: distance between the blue centers

α : half of taper angle

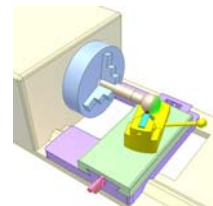
The lathe is set to get when the chuck turns 1 revolution, the violet carriage moves L mm (thread lead). The tool is retrieved a little during the reverse stroke.



External spherical turning

<http://youtu.be/PhM5rsGChTk>

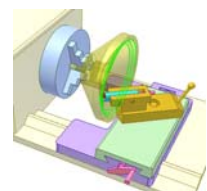
Axis of the revolution joint between the yellow tool post and the green slider must intersect axis of rotation of the work. If not, the created surface is toric, not spherical.



Internal spherical turning

<http://youtu.be/f0IYSAXJyBs>

Axis of the revolution joint between the orange tool post and the green slider must intersect the axis of rotation of the work.



Copying device on lathe 4

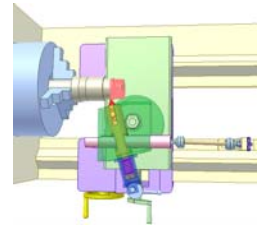
<http://youtu.be/Av-t9bY1wg>

The violet carriage is power-fed along the axis of rotation of the workpiece. The orange tool spindle carrying a red tool and a red tracer can slide in the green post that is fixed to the cross slide of the lathe.

The tracer is forced toward the pink sample by a spring. The sample position in relation with the workpiece can be adjusted owing to the violet nut and a conrod of spherical joints (on the right).

Use the green screw of the cross slide to increase the cutting depth.

The blue cam is used when moving the tracer to the initial position.



Manual copy turning

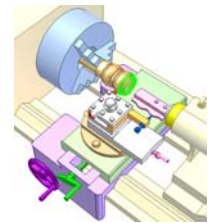
<http://youtu.be/3kEpkg9RdwE>

An immobile pink sample is fixed on the modified center of the tailstock.

When turning, the operator uses screws of the compound slide and the cross slide to let the blue screw-tracer follow the sample.

The red tool creates a surface of the orange work corresponding to the sample profile. Cutting depth is adjusted by the blue screw-tracer.

The sample position in relation with the workpiece can be adjusted by using the tailstock.



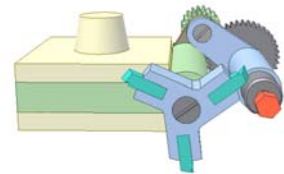
Making hexagon on a lathe

http://www.youtube.com/watch?v=3Kzk3_uzRAg

The tool shaft rotates twice faster than the workpiece shaft.

For details see:

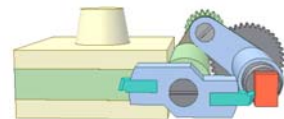
<http://meslab.org/mes/threads/13831-Gia-cong-luc-lang-tren-may-tien>



Making rectangle on a lathe

<http://www.youtube.com/watch?v=yr0VVtuPAIE>

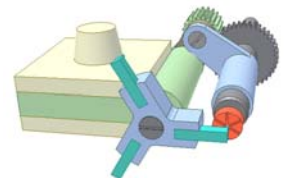
The tool shaft rotates twice faster than the workpiece shaft.



Making face slots on a lathe 1

<http://www.youtube.com/watch?v=KsMbm2mB7KI>

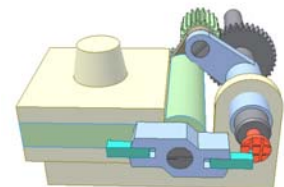
The tool shaft rotates twice faster than the workpiece shaft.



Making face slots on a lathe 2

http://www.youtube.com/watch?v=xQ_eQ2naSFc

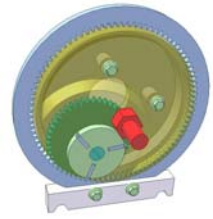
The tool shaft rotates twice faster than the workpiece shaft.



Device for making hexagon on a lathe

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

The tooth number of the fixed gear is double the one of the satellite gear.



Device for making hexagon on a lathe

<http://www.youtube.com/watch?v=AwkDB0ThXG8>

The tooth number of the fixed gear is double the one of the satellite gear.
The processing length is not limited.

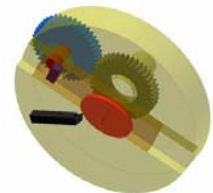


Device for turning ellipse 1

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

Beside rotation, the workpiece has radial linear motion of sine law.
For details, see

<http://meslab.org/mes/showthread.php?p=101930%23post101930>

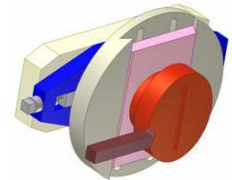


Device for turning ellipse 2

<http://www.youtube.com/watch?v=xBIBvF7C3bA>

Beside rotation, the workpiece has radial linear motion of sine law.
For details, see

<http://meslab.org/mes/showthread.php?p=101930%23post101930>



Nut-screw and bar mechanisms 5

<http://youtu.be/9Fn6mx2pLU>

Device for moving tool (in red) for turning a profile (in green).
To adjust position of revolution joint between the pink rocker and the blue conrod for various profiles.



Wood hand screw drill

<http://youtu.be/uBZWxZKDCDM>

Press on the button, move the green grip up and down to rotate the red bit.



Drilling square holes 1a

<http://www.youtube.com/watch?v=BnvT45CjD-E>

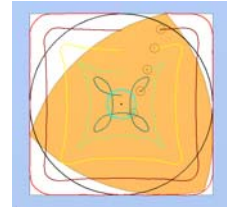
Reuleaux triangle rotates inside a square.

Loci of various points on the triangle are shown.

The red locus is the section of the drilled square hole.

Its corners are rounded.

An inscribed round hole of the square hole must be predrilled.



Drilling square holes 1b

<http://www.youtube.com/watch?v=TioBY-JGI4I>

Device for drilling square holes of rounded corners based on the principle shown in "Drilling square holes 1a"



Drilling hexagon holes 1a

<http://www.youtube.com/watch?v=oe8e-N3VusI>

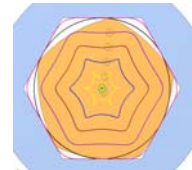
Reuleaux pentagon rotates inside a hexagon.

Loci of various points on the pentagon are shown.

The red locus is the section of the drilled hexagon hole.

Its corners are rounded.

An inscribed round hole of the hexagon hole must be predrilled.



Drilling hexagon holes 1b

http://www.youtube.com/watch?v=_5OgWbMH8D8

Device for drilling hexagon hole of rounded corners based on the principle shown in "Drilling hexagon holes 1a"



Drilling square holes 2a

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

Reuleaux triangle rotates inside a square.

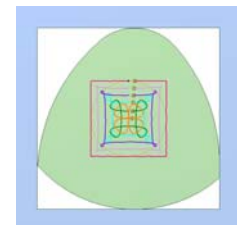
Loci of various points on the triangle are shown.

The red locus is the section of the drilled square hole.

Its corners are sharp.

An inscribed round hole of the square hole must be predrilled.

There are blade's points that trace knotty loci unfavorable for cutting.



Drilling square holes 2b

http://www.youtube.com/watch?v=pT1H_cPYGAE

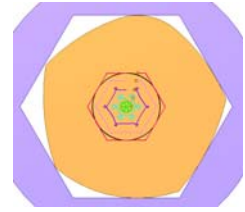
Device for drilling square holes of rounded corners based on the principle shown in "Drilling square holes 2a"



Drilling hexagon holes 2a

<http://www.youtube.com/watch?v=4HVj89C1bxw>

According to Barry Cox and Stan Wagon.
Reuleaux pentagon rotates inside a hexagon.
Loci of various points on the pentagon are shown.
The red locus is the section of the drilled hexagon hole.
Its corners are sharp.
An inscribed round hole of the hexagon hole must be predrilled.



Drilling hexagon holes 2b

<http://www.youtube.com/watch?v=W16f-qCXVkJM>

Device for drilling hexagon holes of sharp corners based on the principle shown in "Drilling hexagon holes 2a"



Drilling triangle holes 1a

<http://www.youtube.com/watch?v=gGNC3ItLJK4>

According to The Wolfram Demonstration Project.
An oval rotates inside a triangle.
Loci of various points on the oval are shown.
The red locus is the section of the drilled triangle hole.
Its corners are sharp.
An inscribed round hole of the triangle hole must be predrilled.



Drilling triangle holes 1b

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

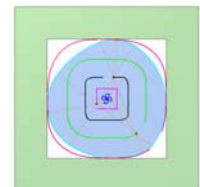
Device for drilling triangle holes of sharp corners based on the principle shown in "Drilling triangle holes 1a"



Irregular (scalene) Reuleaux triangle

<http://www.youtube.com/watch?v=K1ZddTjkfc0>

Irregular (scalene) Reuleaux triangle rotates inside a square.
Sketch of the Reuleaux triangle and loci of various points on the triangle are shown.



Making sphere on a milling machine 1

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

Workpiece is clamped in a dividing head's chuck and rotated by hand.
Tool is clamped in an arbor that allows it to be regulated radially.
For details see:
<http://meslab.org/mes/threads/12255-Gia-cong-mat-cau-loi-tren-may-phay-thuong>



Making sphere on a milling machine 2

<http://youtu.be/tx6b17qeOtg>

Machining convex asymmetric sphere surfaces.

Workpiece is clamped in a dividing head's chuck and rotated by hand.

Tool is clamped in an arbor that allows it to be regulated radially.

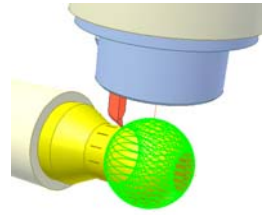
Axes of the workpiece and the arbor must be intersecting. The tool

point position in relation with the workpiece decides dimension of the

machined sphere surface.

For details see:

<http://meslab.org/mes/threads/12255-Gia-cong-mat-cau-loi-tren-may-phay-thuong>



Making sphere on a milling machine 3

<http://youtu.be/F22IBTB3cxY>

Machining concave sphere surfaces.

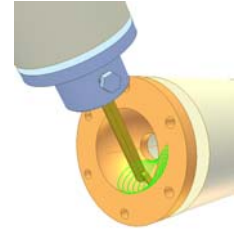
Workpiece is clamped in a dividing head's chuck and rotated by hand.

Tool is clamped in an arbor that allows it to be regulated radially. Axes

of the workpiece and the arbor must be intersecting. The tool point

position in relation with the workpiece decides dimension of the

machined sphere surface.



Jig for milling inner cylindrical surface

http://youtu.be/Vyqg7p_7HeE

The yellow work is clamped to the grey conrod of a parallelogram mechanism and has round translational motion.

Radius of inner cylindrical surface to be created is R_w (orange circle). Locus of center of the orange circle is the green circle of

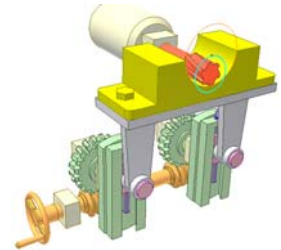
radius R_c (radius to be set of the green cranks by violet screws).

The red tool radius is R_t .

$R_w = R_c + R_t$

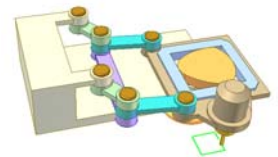
Tool setting position: as start position of the simulation video.

The jig is used for large inner cylindrical surfaces on bulky works.



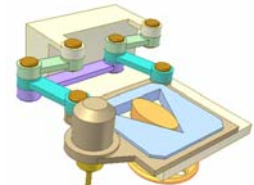
Milling square with Reuleaux polygon

<http://www.youtube.com/watch?v=DoKT2fR9Rms>



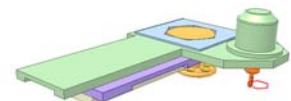
Milling triangle with Reuleaux polygon 1

<http://www.youtube.com/watch?v=LOr-lb7E2YM>



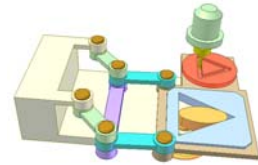
Milling hexagon with Reuleaux polygon

<http://www.youtube.com/watch?v=9j8mVfTS6M>



Milling triangle with Reuleaux polygon 2

<http://www.youtube.com/watch?v=4TIYYzs17B0>



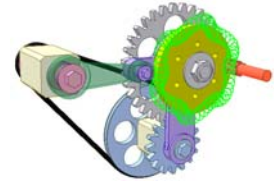
Milling profile 1

<http://youtu.be/kPA6xngrYE8>

Input is pink shaft having an eccentric.

Red cutter creates profile on yellow work that is fixed to grey gear shaft. Transmission ratio from pink pulley to the grey gear shaft is 6 so the created profile of star shape has 6 wings. The wing is not symmetric because the grey gear shaft rotates irregularly.

The profile shape also depends on relative position between the cutter and the work. The black belt represents tooth belt. Using chain drive instead of belt one is better.



Loci in Epicyclic gearing B5

<http://youtu.be/ydjl0RUng8I>

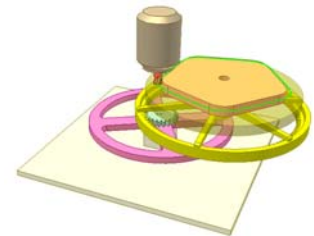
Device for milling a pentagon.

r : pitch radius of the fixed green sun gear

R : pitch radius of the yellow planetary gear

$$k = R/r = 5$$

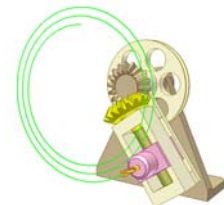
Distance between the red tool axis and the sun gear axis is $(8/30)r$ for getting a locus in shape of rounded corner pentagon (in relative motion between the tool and the yellow planetary gear). The input link is the pink disk. Select tool of larger diameter for getting a pentagon with sharp corners. Similar device permits to get other regular polygons.



Device for milling Archimedean spiral groove

http://youtu.be/6gnsM7u8_1c

Combination of bevel gear satellite drive and nut-screw one.



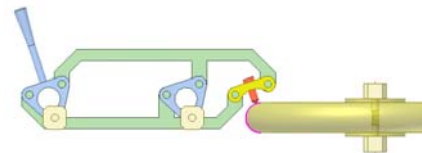
Device for Correcting Grinding Wheel

<http://youtu.be/yLGqlwvKinY>

This combination of two parallelogram mechanisms enables the tool point to describe a circular-arc curve.

The yellow link rotates around a virtual axis.

It is used when the arrangement of fixed bearings for the virtual axis is impossible.



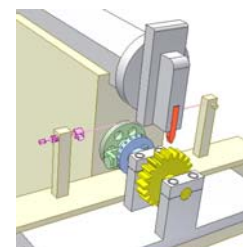
Cutting gear on the shaper 1

<http://youtu.be/W69m2cDaqvY>

The cable contact diameter of the green disk must be equal to the gear pitch diameter. The hole number on the blue disk is equal to the tooth number.

After completing a tooth slot to index the blue disk (fixed to the yellow workpiece) for cutting the next slot.

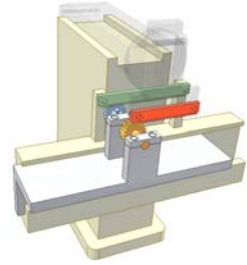
A gear-rack drive can be used instead of cable to avoid cable slipping.



Cutting gear on the shaper 2

<http://youtu.be/wkSI6H0-9XE>

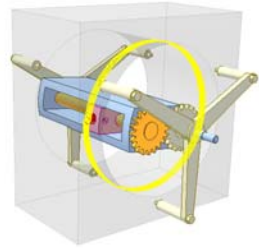
This method is applied only for gears of small module m and small tooth number Z . The tool is of rack shape. Indexing is not needed. Total displacement of the table carrying the workpiece must be more than $\pi \cdot m \cdot Z$.



Portable boring machine 1

<http://youtu.be/l2rstlly3PA>

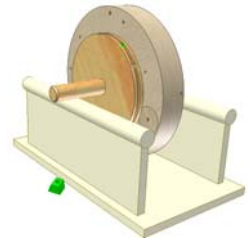
Combination of planetary gear drive and nut-screw one. Input is the blue shaft carrying the nut-screw drive. The red tool fixed on the pink nut-slider has helical motion of fine pitch. The machine is used for large workpieces (in glass) that are difficult to be processed on lathes or boring machines.



Grinding wheel equilibration 1

<http://youtu.be/NQxPukE9y48>

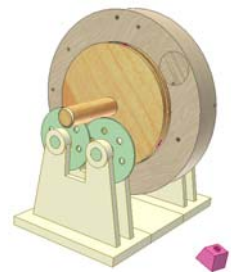
Grinding wheel assembly is laid on two horizontal shafts. If the assembly is static imbalanced, the gravity turns it to the position at which the center of mass is below the assembly axis. Move green contra-weights in circular dovetail groove of the assembly to upper positions and fixed them there for equilibrating, then test the assembly again.



Grinding wheel equilibration 2

<http://youtu.be/p6tEpwV9qJ4>

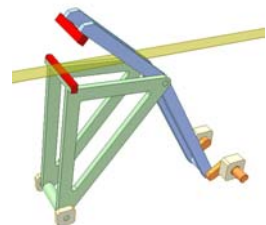
Grinding wheel assembly is laid on four green idly rollers. If the assembly is static imbalanced, the gravity turns it to the position at which the center of mass is below the assembly axis. Move pink contra-weights in circular dovetail groove of the assembly to upper positions and fixed them there for equilibrating, then test the assembly again. The structure of four roller helps to reduce the friction in rotary motion of the assembly to the least amount (in comparison with the assembly revolving in an ordinary bearing).



Web-cutting mechanism 2

<http://youtu.be/Oe1erEBdHL8>

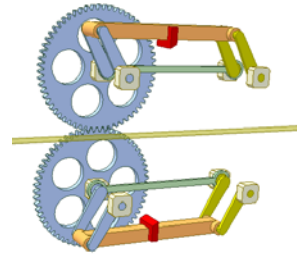
This 4-bar linkage with an extended coupler can cut a yellow web at high speeds. The linkage is dimensioned to give the knife a velocity during cutting operation that is equal to the linear velocity of the web.



Web-cutting mechanism 1

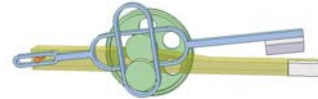
<http://youtu.be/VY8W3letECk>

This parallelogram mechanism with knife on coupler can cut a yellow web at high speeds. The mechanism is dimensioned to give the knife a velocity during cutting operation that is equal to the linear velocity of the web. The green bars help the mechanism overcome its dead positions.



Mechanism for slicing machine

<http://www.youtube.com/watch?v=F3hnQxzhZno>



Cam-driven scissors 1

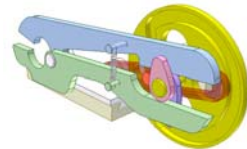
<http://youtu.be/kOMxi0W2r3g>



Cam-driven scissors 2

<http://youtu.be/Qx0UitGXFRQ>

The yellow grooved cam moves scissor's pivot through the red rod. The upper and lower blades oscillate due to the violet and pink cams that are fixed to the yellow cam.



Drop hammer

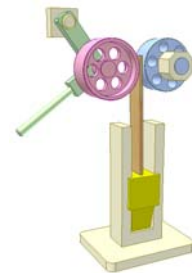
<http://youtu.be/NUIdUT32OaY>

Input: the blue roller.

The pink roller idly rotates on the green lever.

The yellow slider has plank tail that is in contact with the two rollers.

Up and down motion of the yellow slider is controlled by the green lever that causes the pressure at contact places of the plank.



Friction press 1

<http://youtu.be/ixZ78JGV0RE>

Input: the green pulley shaft.

There is a sliding key between the green shaft and the red hollow shaft of two discs.

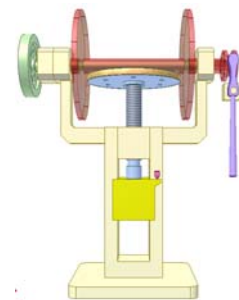
The blue disc - screw can contact with the two red discs alternately.

Up and down motion of the yellow slider is controlled by the violet lever that causes the pressure at contact places of the three discs.

Be noted that the violet lever represents a multi-bar mechanism used in practice.

The slider reaches max velocity at lower end of its stroke and min velocity at upper end of its stroke.

The pink stopper on the frame (and a not shown brake) sets the highest position of the slider.



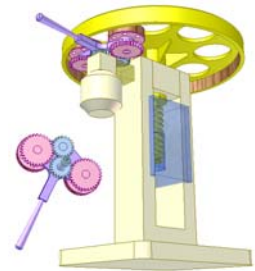
Friction press 2

<http://youtu.be/AQX6kVQK7OE>

Input: the small center gear receiving rotation from a motor.

The violet plate with a lever carries 4 gears and two rollers. The rollers alternately contact the yellow disc (its inside wall) and give the screw reciprocating rotation. The lever has three positions corresponding with up, down and dwell of the blue nut-slider motion. Be noted that the violet lever represents a multi-bar mechanism used in practice.

There is a brake to keep the disc immobile during its dwell (not shown).



Drop hammer

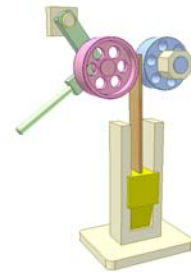
<http://youtu.be/NUIdUT32OaY>

Búa rơi – búa ván.

Khâu dẫn là con lăn màu xanh.

Con lăn hồng quay lồng không trên tay đòn màu lục.

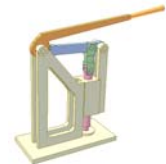
Đầu búa màu vàng có đuôi là tấm ván được điều khiển bởi tay đòn màu lục tạo áp lực ở chỗ tiếp xúc của tấm ván.



Hand punch machine 1

<http://youtu.be/N9ni9wzh3ql>

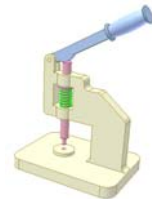
Combination of gear drive and slider-crank mechanism.



Hand punch machine 2

<http://youtu.be/9xB4J91--8w>

Disk cam and linear reciprocating follower.

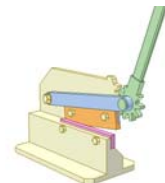


Hand shearing machine 1

<http://youtu.be/tp4qFdWDkT8>

A planetary gear is used.

Hand force is applied to the satellite gear. The other gear is fixed. The upper tool blade is fixed to the carrier.

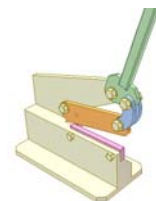


Hand shearing machine 2

<http://youtu.be/zLLgQCJ4vSQ>

A 4-bar linkage is used.

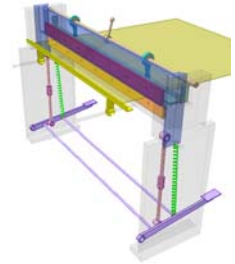
Hand force is applied to one crank. The upper tool blade is fixed to the other crank.



Foot shearing machine 1

<http://youtu.be/GlcygJIH2BM>

The blue slider carrying the red upper cutter is driven by a slider crank mechanism. The crank is the violet foot lever. The sheet is clamped before sheared by another slider crank mechanism of brown eccentric shaft. The orange lower cutter is fixed to the machine base. The red upper cutter has inclining cutting edge to reduce cutting force.



Foot shearing machine 2

<http://youtu.be/pyGNqP6ZNvA>

The blue slider carrying the red upper cutter is driven by a 6-bar mechanism. The sheet is clamped before sheared by a slider crank mechanism of brown eccentric shaft. The runway of the green slider is on the blue slider. The orange lower cutter is fixed to the machine base. The red upper cutter has inclining cutting edge to reduce cutting force.

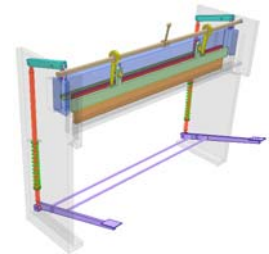


Table wood saw 1

<http://youtu.be/J800VDgFpKk>

Motions for position adjustment of orange circular blade are shown:

- Up and down by using pink nut. The motor turns around red pin.
- Leaning by using orange nut

The hinge (in red and cyan) for leaning must be arranged as closely as possible to the blade and to the table upper surface.

The mechanism is applied for light duty saw machines.

This video is a simulation of the machine in

http://woodgears.ca/homemade_tablesaw/index.html

by request of Mr. Spiros Kantas from Corfu, Greece.

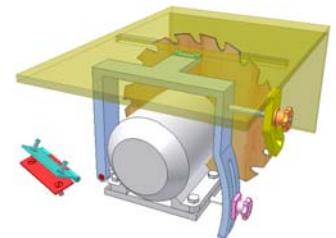


Table wood saw 2

<http://youtu.be/OK1gm558V4k>

Motions for position adjustment of orange circular blade are shown:

- Up and down by using pink screw. The motor and blade shaft turns around red pin.
- Leaning by using pink nut

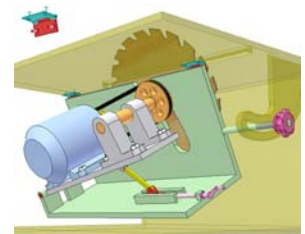
The hinge (in red and cyan) for leaning must be arranged as closely as possible to the blade and to the table upper surface.

The mechanism is applied for light duty saw machines.

This video is a simulation of the machine shown in

<http://woodgears.ca/reader/pekka/tablesaw.html>

on request of Mr. Spiros Kantas from Corfu, Greece.



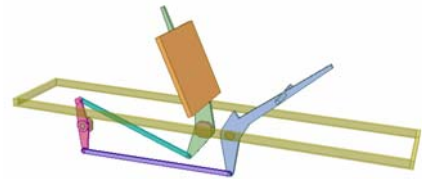
20. Mechanisms for manipulation and orientation of workpieces

Flipping mechanism 1

<http://www.youtube.com/watch?v=KCJa2zRWpwg>

This mechanism can turn over a flat piece by driving two four-bar linkage from one double crank. The two flippers are actually extensions of the fourth member of the four-bar linkage.

Link proportions are selected so that both flippers rise up at the same time to meet a line slightly off the vertical to transfer the piece from one flipper to the other by momentum of the piece.



Flipping mechanism 2

<http://www.youtube.com/watch?v=bBWARLe2StQ>

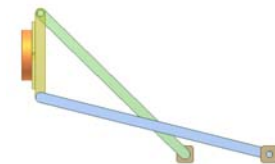
This is a four-bar linkage in which the orange workpiece fixed on the connecting rod is turned over (180 degrees).

Length of the connecting rod: 50

Lengths of the two cranks: 120 and 140

Distance between two fixed bearing houses: 50

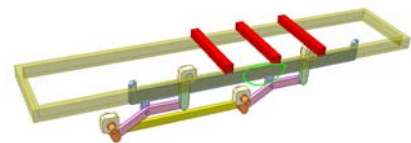
The 180 deg. rotation of the workpiece corresponds the 90 deg. rotation of the blue crank.



Transport mechanism 1

<http://youtu.be/MeQOVyR9a-E>

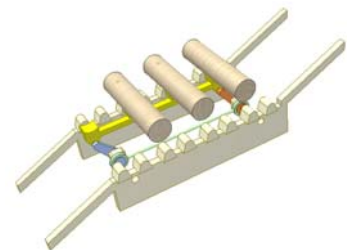
The blue transport has “egg-shape” motion that is used for moving the red works. It is the locus of a point on the pink 4-bar linkage’s connecting rod. The yellow connecting rod used for uniting the orange cranks creates a parallelogram mechanism.



Parallel-link feeder 1

<http://youtu.be/fK4sziwqOjo>

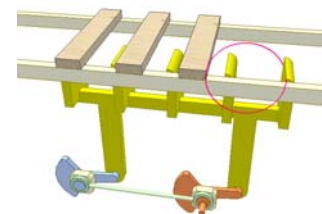
A parallelogram mechanism is used for transporting the workpieces. The green bar helps the mechanism overcome its dead positions.



Parallel-link feeder 2

http://youtu.be/e3S_AldcqHI

A parallelogram mechanism is used for transporting the workpieces. The green bar helps the mechanism overcome its dead positions. The red circle is locus of a point on the yellow transporter



Movable spring feed-duct

<http://youtu.be/t2QtIHVbU9U>

A close-wound spring attached to a hopper is used as a movable feed-duct for balls or short rollers.



Part orientation 1

<http://youtu.be/1Au-1cIVp2A>

This device makes the orange part to change its orientation after running haft-circle runway.



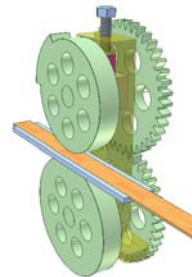
Mechanism for advancing a strip

<http://youtu.be/RaRESa4QS84>

Input: the lower green shaft to which a gear and a roller are fixed. The roller contacts with the orange strip through a rectangular hole in the blue runway.

The upper green shaft fixed with a gear and an incompleter roller rotates in a bearing that can slide in a vertical slot of the yellow base.

The friction forces at contact places between the strip and the rollers are created by the red spring. The strip is advanced periodically due to the incompleter circle profile of the upper roller.



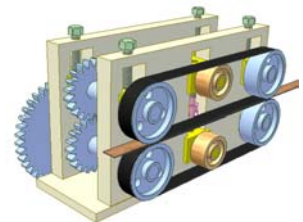
Band advancer

<http://youtu.be/1jUDKLD4fms>

Input: the blue shaft of two gears.

Friction force between the black belts and the band moves it forward.

The belt tensioner consists of two orange rollers and a pink screw of right and left hand threads at its ends.



Mechanism for bar advancing

http://youtu.be/X7xW8_aRckM

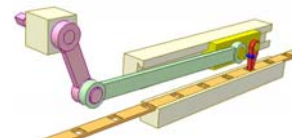
Friction forces caused by red springs move brown bar. Adjust angle position of lower roller to get various speeds of the bar. Max speed: when the two rollers are parallel.



Mechanism for advancing perforated strip 1

<http://youtu.be/UPkavC9eZPo>

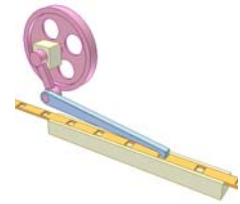
When moving to the right the red pawl is hold from rotation by the blue pin and pushes the orange strip to the right.



Mechanism for advancing perforated strip 2

<http://youtu.be/-T14cCu-p7Y>

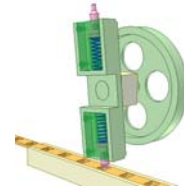
When the pink crank rotates the blue long pawl pushes the orange strip to the right.



Mechanism for advancing perforated strip 3

<http://youtu.be/MIBLtQEz4eE>

The pink pins rotate together with the green double crank and can move along it, thus they can get into the strip holes and push it.



Part orientation 2

http://youtu.be/cXkOMI_Jd1Y

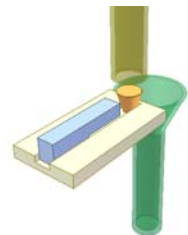
This device changes the orientation of the orange parts: from bottom down in the upper tube to bottom up in the lower tube. The yellow disk rotates interruptedly by an appropriate mechanism (not shown). The device also has function of part separating.



Part orientation 3

<http://youtu.be/0-USznSJAtw>

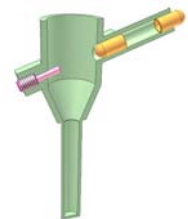
This device makes the orange parts to drop with large bottom down regardless of their initial orientation in the upper tube. The blind slot in the yellow plate is a key detail.



Part orientation 4

<http://youtu.be/blv09DJr70Q>

This device makes the orange parts to drop with closed bottom down regardless of their initial orientation in the upper tube. The pink screw is a key detail.



Part orientation 5

<http://youtu.be/yCa2j8d8KyE>

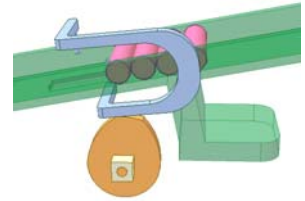
This device makes the violet parts to drop into the lower tube with small bottom down regardless of their initial orientation in the upper tube. The yellow shafts rotate with tendency to push up the parts to avoid their jam.



Part separation 1

<http://youtu.be/qNftCnJGsvU>

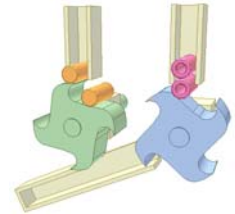
This device enables feeding parts one by one to the processing machine. The blue separator is driven by a cam.



Part mingling 1

<http://youtu.be/jXPQxMRaq8I>

This device enables mingling two kinds of parts in an alternate order. The rotors rotate in opposite direction.

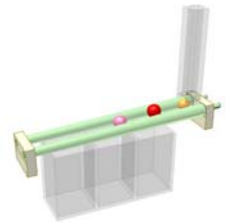


Part sorting 1

<http://youtu.be/nKZX6EuvfiM>

The balls are sorted on diameter. The first box receives smallest balls, the last box receives biggest ones.

The green conical shafts rotate in opposite direction with tendency to raise the balls.

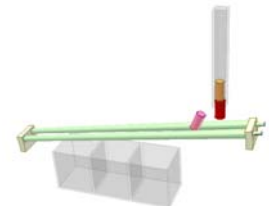


Part sorting 2

<http://youtu.be/ZUM5xUA1GUQ>

The rollers are sorted on diameter. The first box receives smallest rollers, the last box receives biggest ones.

The green conical shafts rotate in opposite direction with tendency to raise the rollers.



Paper cup dispenser

<http://youtu.be/HWDkaef7mZE>

Push and release the green slider to get cups one-at-a-time.

Red wedges on the green slider are for preventing the cup sticking.



Grapple frees loads automatically 1

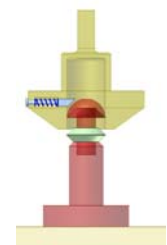
<http://youtu.be/9IBBBTgeB-4>

This self releasing mechanism is developed at Argonne National Laboratory in Illinois, USA, to remove fuel rods from nuclear reactors. It is useful also where human intervention is hazardous or inefficient, such as lowering and releasing loads from helicopters.

There are 3 blue latches disposed around the grapple's axle.

The green sliding collar is the design's key feature.

In original design a gasket spring is used instead of the 3 compressed springs.



Grapple frees loads automatically 2

<http://youtu.be/H-lrTZ2xQok>

This self releasing mechanism is used to put an object to desired lower place, such as lowering and releasing loads from boats to sea bottom. When the green rod strikes the ground, it is forced upward relatively to the grey rod and withdraws the pink catch from under the yellow object, which drops off and allows the grey rod to be lifted without it. The mechanism is not suitable for lifting objects.



Crane bucket

<http://youtu.be/ySAYljiSvKc>

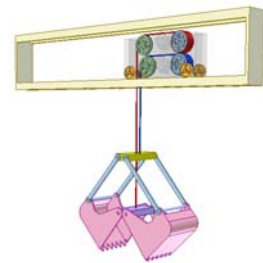
The blue cable is used for bucket moving up and down.

The red cable is used for bucket opening or closing.

Pay attention to the fact that the red cable must move when the bucket moves up and down to keep closing or opening state of the bucket.

Mechanism for moving the trolley is not shown.

To increase closing force (for stronger grabbing material), a system of two pulley blocks (not shown) for the red cable is installed between the yellow and violet bars of the bucket.



Automatic brake in worm hoist

<http://youtu.be/llm5aJLaSCs>

The red arrow represents load (to be raised or descended) applied to the hoist.

The blue arrows represent driving force applied to the hoist.

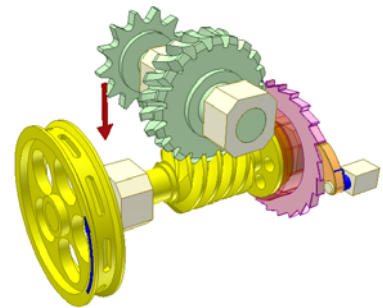
The yellow worm block can move axially a little so its male cone can contact with the female cone of the pink ratchet wheel.

The video shows three stages for the load:

1. Moving up: The worm is turned anticlockwise. Gearing force of the worm drive pushes the worm to the right to contact with the ratchet wheel. The cone clutch closes. The ratchet wheel rotates together with the worm.
2. Stop (no driving force): The load tends to turn the worm clockwise and pushes it towards the ratchet wheel. The cone clutch closes. The orange pawl prevents the load from descending.
3. Moving down: The worm is turned clockwise. Gearing force of the worm drive pushes the worm to the left: no more contact with the ratchet wheel. The cone clutch discloses. The worm wheel can rotate to descend the load. If the load descends faster than worm turning velocity, the situation said in item 2 happens. The moving down is a jerk process.

The key factor is the left hand thread of the worm in this case.

There is no need to use self locking worm drive.



Automatic brake in spur gear hoist

<http://youtu.be/5X9SoTP1z2E>

Input: Orange shaft of a threaded portion at its middle, on which a blue gear with a friction disk is mounted (helical joint). The blue gear can move axial a little. Its displacement is adjusted by white nuts. The pink ratchet wheel rotate idly on the input shaft. There is a green friction disk behind the ratchet wheel. It is fixed to the input shaft.

Output: grey shaft of a big gear and a chain wheel.

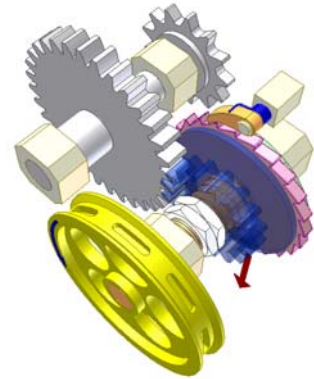
The red arrow represents load (to be raised or descended) applied to the input shaft.

The blue arrows represent driving force applied to the input shaft.

The video shows three stages for the load:

1. Moving up: The input shaft is turned anticlockwise. Force at the helical joint pushes the blue disk to the right to contact with the ratchet wheel (forces it to the green disk). The ratchet wheel rotates together with the input shaft.
2. Stop (no driving force): The load tends to turn the blue disk clockwise and pushes it towards the ratchet wheel. The orange pawl brakes the load from descending.
3. Moving down: The input shaft is turned clockwise. Force at the helical joint pushes the blue disk to the left: no more contact with the ratchet wheel. The output shaft can rotate to descend the load. If the load descends faster than input velocity, the situation said in item 2 happens. The moving down is a jerk process.

The key factor is the right hand thread of the input shaft in this case.



Safety crank for windlass

http://youtu.be/6QsLCAuC_B0

Output: blue gear with a male cone. The red arrow represents load (to be raised or descended) applied to the gear.

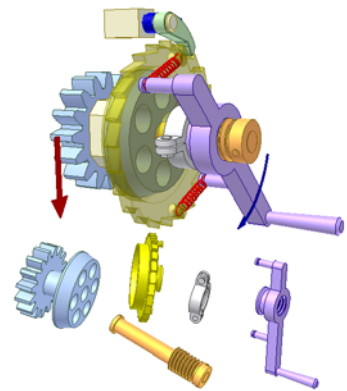
The yellow ratchet wheel with a female cone rotates idly. It is connected to the violet crank by the white ring and two red springs. The crank makes a helical joint with the orange shaft.

The video shows three stages for the load:

1. Moving up: The crank is turned clockwise (the blue arrow). Due to the helical joint the crank presses the ratchet wheel towards the blue gear to close the cone clutch, hence the gear rotates to move up the load. The crank, the ratchet wheel, the gear and the orange shaft rotate together.
2. Stop (no force applied to the crank): The load tends to turn the blue disk anticlockwise but the springs maintain the press from the crank, hence the closing state of the clutch is continued. The pawl brakes the load from descending.
3. Moving down: The crank is pushed (not turned) anticlockwise (the pink arrow). Due to the helical joint the crank moves a little to the right to disclose the cone clutch, hence the gear can rotate to move down the load. If the crank is released, the springs pull the crank to close the clutch to brake the load.

Thus the crank does not rotate during descending the load to avoid accidents.

The key factor is the right hand thread of the orange shaft in this case.



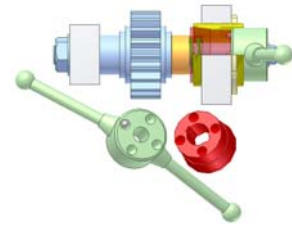
Automatic brake for hoist 1a

<http://youtu.be/IUntUq-0MBc>

When torque in any direction is applied to green crank, four balls try to move red bush to the left. Its outer cone stops contact with inner cone of yellow fixed socket, the crank and blue gear shaft can rotate together. The torque is transmitted to the gear shaft through the balls.

If the torque is removed, green spring moves the bush to the right. Its contact with the yellow fixed socket brakes the hoist instantly. Orange bush acts as a stopper for the red bush in its motion to the left.

Designer: Joseph Pizzo.



Automatic brake for hoist 1b

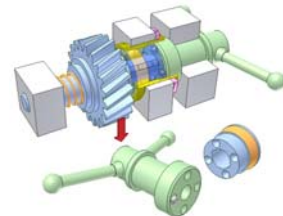
<http://youtu.be/aUO9Kyoj90E>

When torque in any direction is applied to green crank, four balls try to move blue gear shaft to the left. Its outer cone stops contact with inner cone of the yellow fixed socket, the crank and the gear shaft can rotate together. The torque is transmitted to the gear shaft through the balls.

If the torque is removed, orange spring moves the gear shaft to the right. Its contact with the yellow fixed socket brakes the hoist instantly.

Red arrow shows load torque applied to the shaft. By right choice of helix gear direction (left hand in this video) the load helps increasing brake force.

This brake is a suggestion based on the design of Mr. Joseph Pizzo.



Automatic brake for slider 1a

<http://youtu.be/5gYC986VqCA>

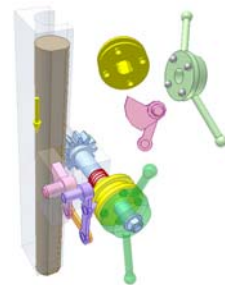
When torque in any direction is applied to green crank, four balls try to move red bush towards. The later via 4 bar linkage stops contact between pink eccentric cam and brown rack-slider, the crank rotating together with the blue gear shaft moves the rack-slider up down. The torque is transmitted to the gear shaft through the balls.

If the torque is removed, red spring moves the bush back and turns the pink cam to brake the rack-slider instantly.

Yellow arrow shows gravity force direction.

Pay attention to design the cam in order that friction between the rack-slider and the cam increases clamping force thanks the gravity force. If not the rack-slider will fall.

It can be used for moving a working table up down.



Safety stop for lifting apparatus

<http://youtu.be/-sDqXmD1sEw>

This mechanism is applied for hand powered lifting apparatus.

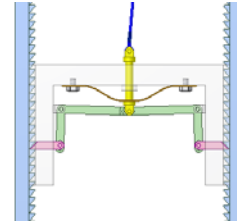
When there is a pulling force in blue cable, the yellow rod compresses brown leaf spring and the grey frame can move up down.

When there is no pulling force in blue cable or the cable is broken, the brown spring via yellow rod and green levers pushes two pink pawls into contact with two stationary racks thus the frame is kept immobile.

The moving down is a jerk process, pulling force in cable is only big enough to prevent the pawls from contact with the racks.

The video shows how the frame goes up, stops, goes down, stops, goes up again and stops when the cable is broken.

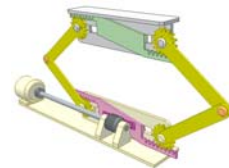
Leaf spring can be replaced with helical cylindrical one.



Lifting mechanism 1a

<http://youtu.be/vCm01leXh30>

A nut portion is created on the lower rack and receives motion from a motor via the grey screw.

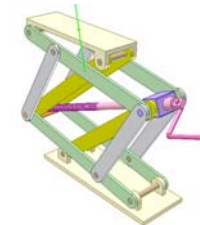


Car jack 1

<http://youtu.be/W70mJydYt0Q>

Upper plate is kept horizontal during motion.

Its up-down motion (green line) slightly differs from vertical direction.



Lifting mechanism 1b

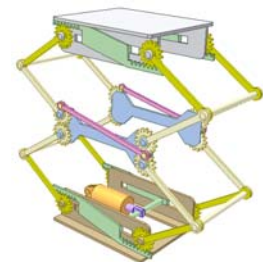
<http://youtu.be/SyN7Uex2PLA>

Serial connection of two mechanisms shown in “Lifting mechanism 1” <http://youtu.be/vCm01leXh30>

Instead of double racks on blue middle plates, parallelogram mechanisms of pink conrods are used. Pins of revolution joints of the conrods are fixed to the gears.

Blue piston of orange hydraulic cylinder pushes green lower rack to lift the grey deck.

It is possible to arrange the gears only on one side.



Planar manipulator 1

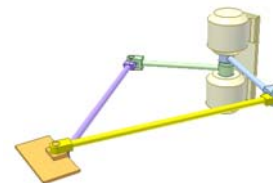
<http://youtu.be/CfKzBu-wDQo>

The mechanism has two degrees of freedom.

Orange plate performs planar motion.

Features:

- Actuators are base-mounted
- Direction of the orange plate is unstable.
- Position calculation of center of the revolute joint for the orange plate is complicated.



Planar manipulator 2

<http://youtu.be/GuWILurktAU>

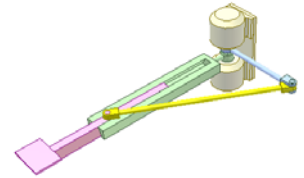
The mechanism has two degrees of freedom.

Pink slider performs planar motion.

Features:

- Actuators are base-mounted
- Pink slider and green bar have the same direction.
- Position calculation of center of the revolute joint for the pink plate is less complicated in comparison with "Planar manipulator 1".

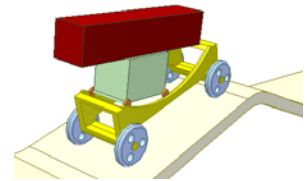
This is a design from Goddard Space Flight Center, USA.



Coffin carrier 1

http://youtu.be/3Bp_Z3Kovxc

Circular runways of the yellow chassis enable to keep the coffin always horizontal regardless of sloping road provided that the carrier does not move too fast. The carrier is used in funeral homes.

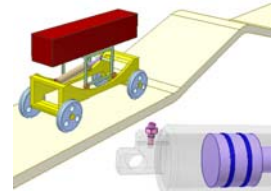


Coffin carrier 2

http://youtu.be/_vaAysAGf9g

Circular runways of the yellow chassis enable to keep the coffin always horizontal regardless of sloping road. The air cylinder is for damping, level of which is regulated by the pink screw.

The carrier is used in funeral homes.



21. Mechanisms for indexing and positioning

Indexing mechanism 1

<http://youtu.be/FktyDQTLi78>

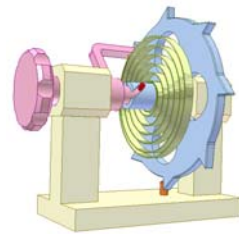
Input: blue rod, each push of which makes green disk rotate 90 deg.
Brown springs and square portion of the green disk contribute to the green disk rotation and to its positioning.
Orange flat spring maintains contact between the pink pawl and the green disk.



Indexing mechanism 2

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

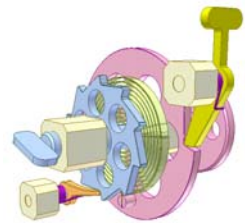
Input: pink knob, each around 45 deg. rotation of which makes blue disk rotate 45 deg. exactly.
Outer end of the spiral flat spring is fixed to the pink knob.
Inner end of the spiral flat spring is fixed to the blue disk hub.
The disk moves axially due to helical slot on the disk.



Indexing mechanism 3

<http://youtu.be/-6uhkv5A29w>

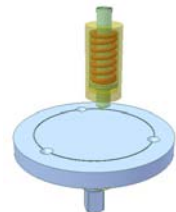
Output: pink ratchet wheel of two teeth, rotating 180 deg. each time when yellow pawl leaves it thanks to a spiral flat spring.
Outer end of the spiral flat spring is fixed to the pink wheel.
Inner end of the spiral flat spring is fixed to the blue ratchet wheel hub.
Orange pawl prevents clockwise rotation of the blue wheel.
The video shows also the winding up the flat spring by turning the blue wheel anticlockwise.



Positioning device 1

<http://www.youtube.com/watch?v=6YDWcjRVHzo>

It is used for positioning a disk that rotates interruptedly.



Positioning device 2

<http://www.youtube.com/watch?v=xwK8Oa4SmX8>

It is used for positioning a shaft that rotates interruptedly.



Positioning device 3

http://youtu.be/Uht_pvwbwVU

It is used for manual positioning a disk that rotates interruptedly.



Positioning device 4

<http://youtu.be/hLpilgtKdf4>

It is used for manual positioning a disk that rotates interruptedly.

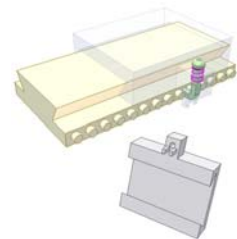
The green lever weight maintains its two extreme positions when creates contacts between the pink pin and the lever.



Positioning device 5

http://youtu.be/_01fYaAa56o

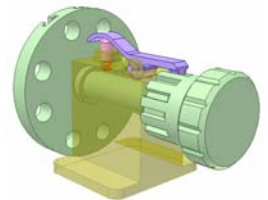
Push green button, move slider to new position and release the button.



Positioning device 6

<http://youtu.be/Edn0JsEvwn8>

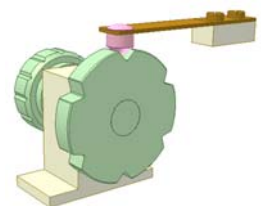
Press pink button via violet lever, turn green shaft to new position and release the button.



Positioning device 7

<http://youtu.be/pRVqH-dwAzc>

A leaf spring provides limited holding power.



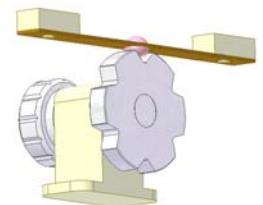
Positioning device 8

<http://youtu.be/9m3amDpR3Jw>

A leaf spring detent can be removed quickly.

Diameter of the hole for the ball is a little smaller than the ball diameter.

There are gaps in longitudinal direction between base pins and holes on spring ends that causes inaccurate positioning.



22. Jigs and fixtures

22.1. Clamping mechanisms

Drilling jig 1

<http://youtu.be/rUDF2cTRwbk>

This jig is for drilling a hole on pink work.

The work is located thanks to a V-block and red stopper. The work is clamped by blue plate having brown drill bushing.

The orange gear shaft has two cones that are located in cone holes of the base. The cone angle is around 11 deg.

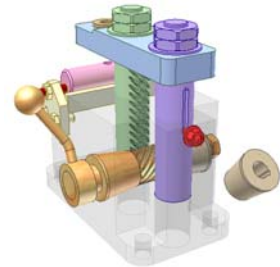
The shaft can move axially within small range.

Orange crank makes the plate go up and down via 45 deg. helical gear rack drive. The gear does not contact violet cylinder.

Turn the crank counterclockwise, the plate comes into contact with the work. Turn it further for clamping work. Axial gear force pulls orange gear shaft to the right to lock the shaft by action of the left cone.

Turn the crank clockwise, axial gear force pushes orange gear shaft to the left to unlock the shaft, the plate goes up.

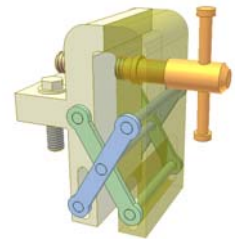
The red screw stops the plate at its highest position. Turn further the crank for locking the plate by action of the right cone (in brown).



Nut-screw and bar mechanisms 4

<http://youtu.be/IDvID90NT-A>

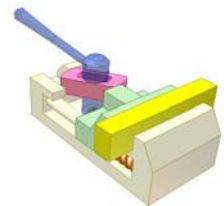
Vice without runway.



Disk cam mechanism DF10f F3

<http://youtu.be/xGQjTeLqTq0>

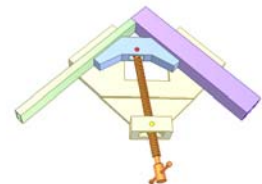
Cam vise. The pink cam has a rectangular slot at its center so it has linear motion during rotation. This helps move the green clamping head longer and faster.



Angular Vice

<http://youtu.be/Z2hujRfjv0U>

Revolute joints for the red bush and the yellow nut of the screw enable clamping bars of different sizes.

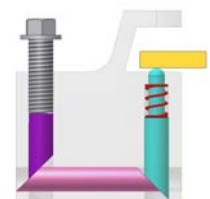


Wedge mechanism 11

<http://youtu.be/Q9feu8j4OZ0>

Double wedge mechanism.

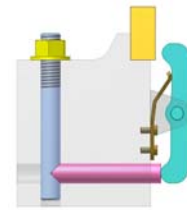
Device for clamping workpiece (in orange).



Wedge mechanism 12

<http://youtu.be/QXXe8tCdO1g>

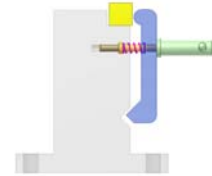
Device for clamping workpiece (in orange).



Wedge mechanism 25

<http://youtu.be/LKYEhscIjHc>

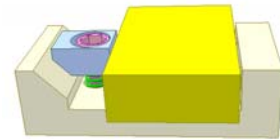
The wedge portion at lower end of the blue lever helps create vertical force component (friction) to press down the yellow workpiece (beside the horizontal one).



Wedge mechanism 26

<http://youtu.be/fjdgmyK-WT8>

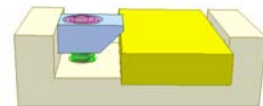
The blue wedge helps create at the same time vertical (friction) and horizontal force components for clamping the workpiece.



Wedge mechanism 27

http://youtu.be/pzj_AdvYZ7c

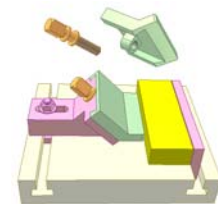
The blue wedge helps create at the same time vertical and horizontal force components for clamping the workpiece.



Machine tool fixture 5

<http://youtu.be/H1utvZAUBUA>

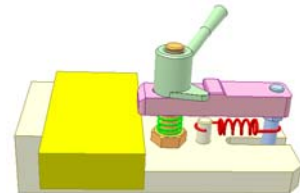
The green slider moves obliquely and creates at the same time vertical (friction) and horizontal force components for clamping the yellow workpiece.



Machine tool fixture 1

<http://youtu.be/F25gl0luThM>

Turn the green cam-nut to tighten or release the workpiece and to clear space for its removing. Adjust positions of the green nut and the blue screw for adapting to the workpiece's thickness.



Machine tool fixture 2

<http://youtu.be/geLVsyj88so>

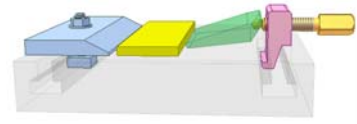
At the same time vertical and horizontal force components for clamping the yellow workpiece are created.



Machine tool fixture 3

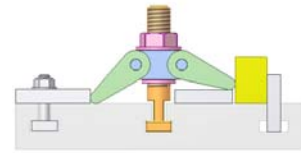
<http://youtu.be/JXT47Kpr8K0>

It is used for clamping workpieces of small thickness.



Machine tool fixture 4

http://youtu.be/BRkf-bi6_zM



Machine tool fixture 9

http://youtu.be/B69K_33kapg

Turn the pink nut to clamp the yellow workpiece at two points.

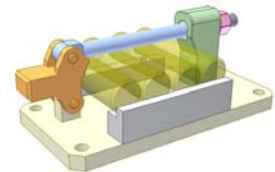


Machine tool fixture 17

<http://youtu.be/C-EqQPTgXXQ>

Multi-piece clamping.

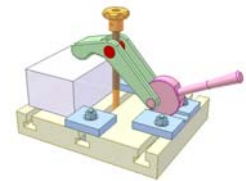
Turn the pink nut to tighten or release the yellow cylindrical workpieces.



Machine tool fixture 6

<http://youtu.be/RZIIRs0WWcw>

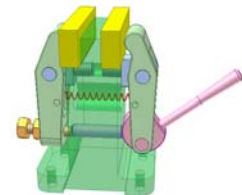
The helix joint between the orange screw and the red pin-nut adapts the fixture to various thickness of workpieces.



Machine tool fixture 10

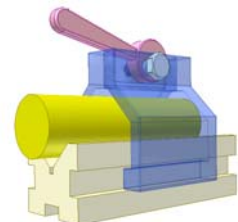
<http://youtu.be/Gq-Fe8A6ur0>

The violet flowing pin enables firm clamping two yellow workpieces.



Machine tool fixture 12

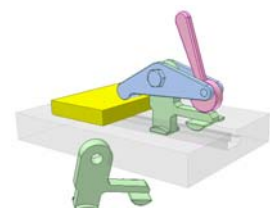
<http://youtu.be/rRajZ1XBzaY>



Machine tool fixture 13

<http://youtu.be/H5W4armCPE>

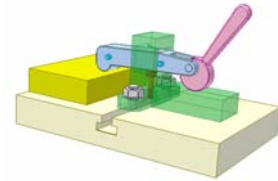
The green column is inserted into the table's T-slot. Its fixing to the table happens at the same time with the workpiece clamping.



Machine tool fixture 14

<http://youtu.be/ip7SyiZd7h4>

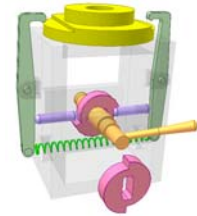
The blue lever can move back to clear space for removing the yellow workpiece. The contact surfaces of the blue lever and the workpiece must be rough enough for the mechanism's good performance.



Machine tool fixture 8

<http://youtu.be/wNckTzjwn4E>

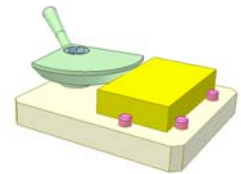
The pink double eccentric cam has a prismatic joint with the orange lever shaft. It enables firm clamping the yellow workpiece at two points.



Machine tool fixture 11

http://youtu.be/_cPwggrKJ-E

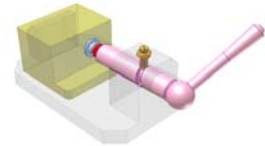
The green eccentric with a chamfer creates 3 force components including the down one to press the yellow workpiece toward locating elements.



Machine tool fixture 15

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

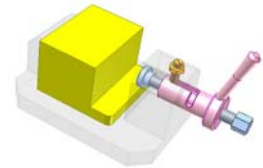
The pink lever can move back to clear space for removing the yellow workpiece. The clamping head's position can be adjusted by the red screw.



Machine tool fixture 16

http://youtu.be/_d2u8TEBMug

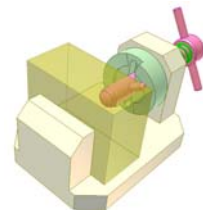
Use the blue screw to clamp or release the yellow workpiece. Use the pink lever to move the pink nut for clearing space for removing the workpiece.



Machine tool fixture 7

<http://youtu.be/L3Z5D3Ntor8>

The green face cam is fixed. Push and turn the pink pin to tighten the workpiece. Turn the pink pin to release the workpiece. The cam slot and spring pushes back the pink pin quickly to clear space for removing the workpiece.

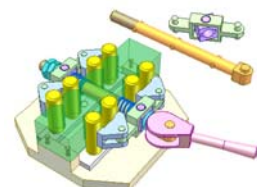


Machine tool fixture 18

<http://youtu.be/HRxKJkVraLc>

Multi-piece clamping.

Turn the pink lever to tighten or release the yellow cylindrical workpieces.



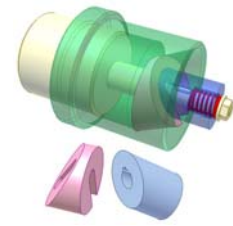
Wedge mechanism 16

<http://youtu.be/oXIYX4AwXT0>

Double wedge mechanism.

The green input slider and the blue output one move in opposite directions. The pink wedge moves perpendicularly to them.

This mechanism can be applied for rotating clamping device.

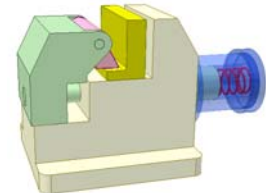


Machine tool fixture 19

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

Adding a pink bar that has a revolution joint with the green movable jaw enables clamping the workpiece from top side and left side simultaneously.

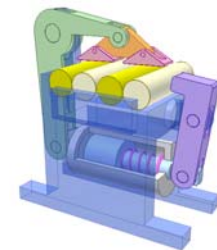
The movable jaw is fixed to the piston of a hydraulic cylinder.



Machine tool fixture 20

<http://youtu.be/U9fi2DJrIZY>

Floating cylinder enables clamping 4 workpieces from top side and right side simultaneously.



Machine tool fixture 21

<http://youtu.be/fzz7-g6Qr1o>

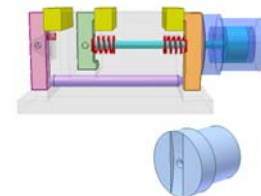
Floating cylinder enables clamping 3 workpieces simultaneously.

To clamp: Pressure fluid enters left space of the piston.

To unclamp: Pressure fluid enters right space of the piston.

Each workpiece has its vertical datum plane positioned directly to the base (to get better machining accuracy).

The orange bar has a revolution joint with the blue cylinder.



Wedge mechanism 19

<http://youtu.be/pe3wTSXQa2c>

Bicycle handlebar stem and fork coupling.

Wedge mechanism creates forces between the stem (yellow) and the fork (grey) and between the wedge (blue nut) and the fork to fix the stem to the fork.

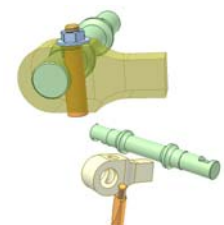


Wedge mechanism 20

<http://youtu.be/fO-NIQ-YFmA>

Bicycle bottom axle and crank joint.

The orange cotter pin plays role of a wedge. The prestress is added by rotating the blue nut.



Wedge mechanism 21

<http://youtu.be/Ybm4xZNfA9o>

Cotter joint between two shafts. The slopes on the pink wedge and on the green shaft slot are equal. The prestress is created by collar of the green shaft.



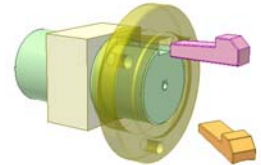
Wedge mechanism 22

http://youtu.be/6N0YcXU_0vc

Sunk taper key in strained joint.

The slopes on the pink key and on the yellow disk slot are equal.

Possible case for the taper key (in orange): no slot on the shaft and bottom surface of the taper key is cylindrical.



Wedge mechanism 23

<http://youtu.be/qIPg8I8ZB1U>

Tangential taper key in strained joint.

The slopes on two pink keys are equal.

If the green shaft is driving, the rotation direction must be clockwise.

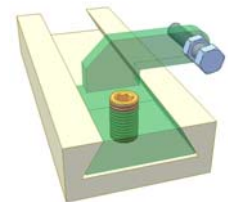


Wedge mechanism 24

<http://youtu.be/tGYsP0KyO5k>

Loose the screw for moving the stopper to new position and then tighten it.

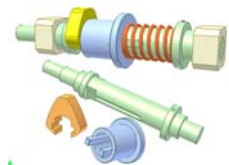
The stopper is kept immobile by wedge mechanism.



Quick changeable cam

http://youtu.be/TOi_2Xla5Xc

Move the blue sliding bush to free the cam for its change.



Fastener 1

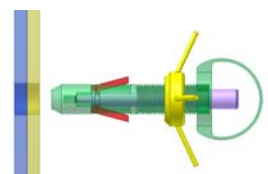
<http://youtu.be/wHIPzLlxdfl>

Push the violet pin to retract the red wings.

Rotate the yellow nut to tighten the plates.

Pull the green ring to remove the fastener.

This NASA's invention is used for fasten things to a plate, back surface of which is inaccessible.



Self locking pressing device

<http://youtu.be/cKJ9GfKJljq>

In pressing stage the self locking occurs because the yellow slider causes a force that goes towards the blue lever pivot.

This mechanism can be used for belt tensioning: an idle pulley mounted on the pink lever is pressed towards the belt in self locking state.

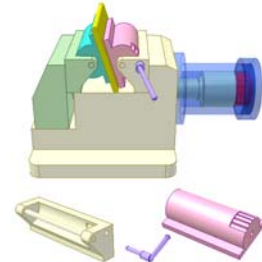


Machine tool fixture 22

<http://youtu.be/9f1NoIQBM94>

A way for clamping a workpiece at an angle or clamping workpiece of non parallel planes.

Pink bar has revolution joint with the base. Its tilting angle is fixed by violet pin.



Machine tool fixture 23

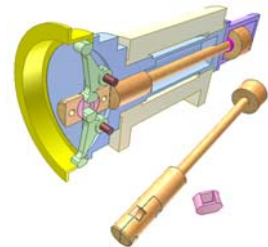
<http://youtu.be/YURD5Jf34EQ>

Clamping a workpiece (in yellow) for lathes by a hydraulic cylinder (in violet).

In unclamping position green levers turn back and give space for mounting or removing the workpiece.

Revolution joint between pink cushion and orange piston is needed to compensate dimension error of the workpiece.

Most parts of the mechanism are cut off half for easy understanding.



Machine tool fixture 24

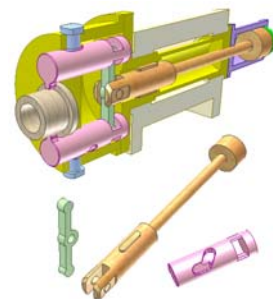
<http://youtu.be/UX5pEuTJGrY>

Clamping a workpiece (in brown) for lathes by a hydraulic cylinder (in violet).

In unclamping position pink pins turn a little (thanks its helical groove) and give space for mounting or removing the workpiece.

Revolution joint between green arm and orange piston is needed to compensate dimension error of the workpiece.

Most parts of the mechanism are cut off half for easy understanding.

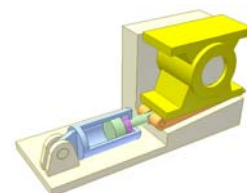


Machine tool fixture 25

<http://youtu.be/ksDw--3vuhc>

Clamping a workpiece (in yellow) by a hydraulic cylinder (in blue).

Orange wedge having revolution joint with green piston slides on the base. The cylinder has revolution joint with the base.



Machine tool fixture 26

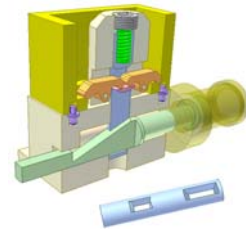
<http://youtu.be/OxDQFP5uAYo>

Clamping a workpiece by a hydraulic cylinder through a wedge and two orange levers.

In unclamping position orange levers turn back and give space for mounting or removing the workpiece.

Revolution joint between pink cushion and blue vertical shaft is needed to compensate dimension error of the workpiece.

Most parts of the mechanism are cut off half for easy understanding.

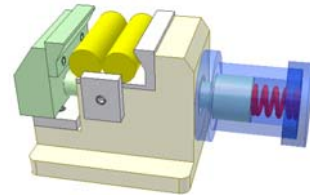


Machine tool fixture 27

<http://youtu.be/p-dlg8lPLh4>

Clamping two workpieces (in yellow) by a hydraulic cylinder (in blue).

Thanks to wedge-shaped plates (in green and grey) the workpieces are clamped firmly.



Robot gripper 1

<http://youtu.be/itFsXPtNboA>

A hydraulic or pneumatic cylinder via a rack and pinion mechanism opens and closes the jaws, permitting it to grasp and release objects.



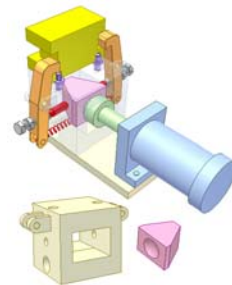
Machine tool fixture 28

<http://youtu.be/nwEsGuGf6wQ>

Clamping a workpiece (in yellow, cut off half for easy understanding) by a hydraulic cylinder through a wedge and two orange levers. Two violet pins are for positioning the workpiece.

In unclamping position orange levers turn back and give space for mounting or removing the workpiece.

Spherical joint between the wedge and the green piston rod is needed to compensate dimension error of the workpiece.

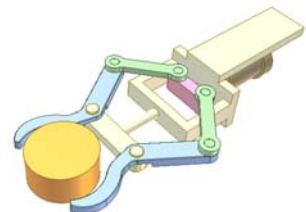


Robot gripper 2

<http://youtu.be/YGIT0LtRzMw>

A hydraulic or pneumatic cylinder opens and closes the jaws, permitting it to grasp and release objects.

Blue jaw, green conrod and pink slider create a slider crank mechanism.

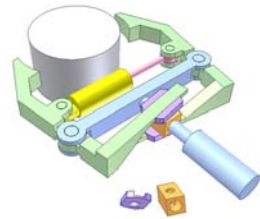


Robot gripper 3

<http://youtu.be/oCVqapAj-7s>

A hydraulic or pneumatic cylinder opens and closes the jaws, permitting it to grasp and release large objects.

Green jaw, violet swivel and orange slider create a tangent mechanism. There are revolution joints between violet swivels and orange slider.



Machine tool fixture 29

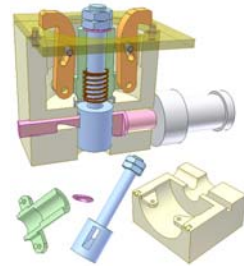
<http://youtu.be/VPxWWqFwRQo>

Clamping a workpiece (in yellow) by hydraulic cylinder through a wedge and two orange levers. Two vertical violet pins are for positioning the workpiece.

In unclamping position orange levers turn back (thanks to their grooves and fixed horizontal violet pins) and give space for mounting or removing the workpiece.

Pink spherical washer is needed to compensate dimension error of the workpiece.

Most parts of the mechanism are cut off half for easy understanding.

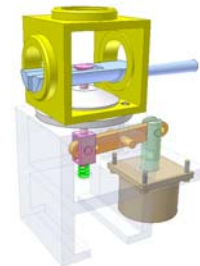


Machine tool fixture 30

<http://youtu.be/xbQECJ3byeg>

Clamping a workpiece (in yellow) by hydraulic cylinder through a orange lever, pink rod and blue detachable traverse. Violet pin is for angle positioning the workpiece.

Spherical portion on the pink rod is needed to compensate dimension error of the workpiece.



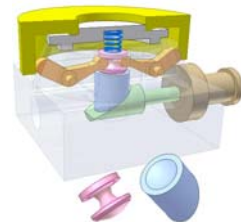
Machine tool fixture 31

<http://youtu.be/QtFkUqAtxr0>

Clamping a workpiece (in yellow) by hydraulic cylinder through a blue wedge and orange levers.

Spherical portions on the pink cushion and the blue wedge are needed to compensate dimension error of the workpiece.

The workpiece and the grey positioning disk are cut off half for easy understanding.



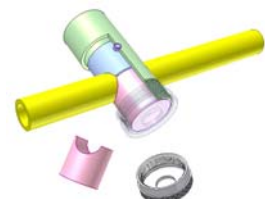
Fastener 2

<http://youtu.be/6dSCQNG35Nc>

Green tube and blue fixed jaw are fixed together.

Tight or release grey nut for clamping or repositioning yellow tube.

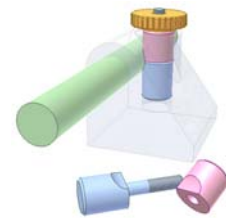
The green tube is cut off for easy understanding.



Fastener 3

<http://youtu.be/ypf7OvwAJ8I>

Tight or release orange nut for clamping or repositioning green bar.



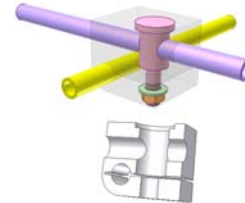
Fastener 4

<http://youtu.be/abj9X8kSYP0>

Tight or release orange nut for clamping or repositioning violet and yellow tubes simultaneously.

The yellow tube is released thanks to the flexibility of the white support.

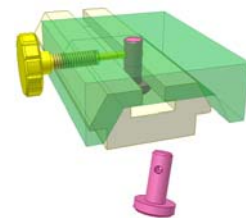
The part below the mechanism is the support, which is cut off half.



Slider clamp 1

<http://youtu.be/uEAekWR-CsY>

Turn yellow screw for clamping or releasing green slider. Cone portion of the screw raises pink stud for clamping.

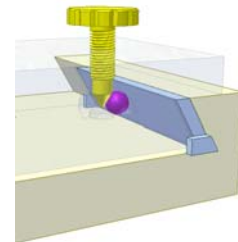


Slider clamp 2

http://youtu.be/Nl45sSsPk_s

Turn yellow screw clockwise for clamping or counterclockwise for releasing the transparent slider.

Vertical hole of the slider is tapped. Horizontal hole of the slider contains violet ball that contacts with blue bar of a dovetail runway.

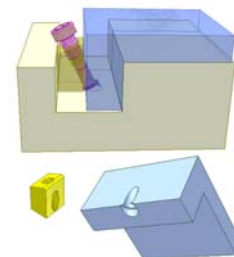


Slider clamp 3

<http://youtu.be/Vo7-f7tCh4M>

Turn pink screw clockwise for clamping or counterclockwise for releasing the blue slider.

Lower spherical head of the screw contacts with the runway. However its contact with the slider is possible for an embodiment of this mechanism. Axial displacement of the screw is restricted.



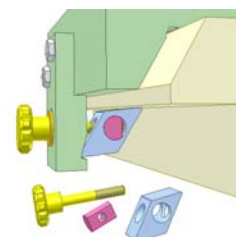
Slider clamp 4

http://youtu.be/dx_jKVq0gCo

Turn yellow screw for clamping or releasing green slider.

Blue clamp has revolution joint with the green bracket.

Yellow screw, pink nut and blue clamp create a sine mechanism.



Fastener 5

<http://youtu.be/8MnLVIU4Vuo>

A way to fix a gear on a shaft thanks to a flexible split bush and two screws.

The bush has a tapered outer diameter.

The gear has a tapered inner diameter.

Only one hole among the two holes in the bush or in the gear is tapped.

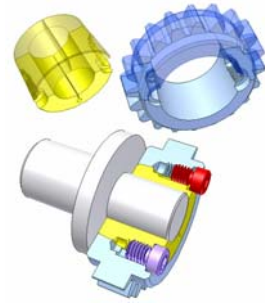
Split tapped hole in the bush align with split un-tapped hole in the gear and vice versa.

Violet screw is for releasing the gear.

Red screw is for tightening the gear.

Use two symmetrical violet screws and two symmetrical red screws to avoid eccentric clamping and releasing forces.

This mechanism is used when the angular adjustment between gear and shaft is needed.



Slider clamp 5

<http://youtu.be/tFh3CFgFBZQ>

Press or release yellow flat springs for repositioning or clamping blue slider.

When pressing, the spring holes are coaxial with the popcorn shaft and the springs do not brake the slider.

When releasing, the spring holes contact the popcorn shaft and friction forces created do not allow the slider moving in both directions.

Motion to the left is prevented by the right spring and vice versa.

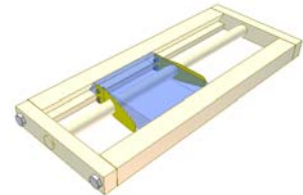


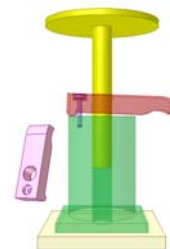
Table clamp

<http://youtu.be/uzqd1rKp5qQ>

Raise the pink latch to prevent its contact with the yellow table post for moving up down the table.

When releasing the latch, it turns down and comes into contact with the table post. Friction between them stops the table falling. There must be an adequate gap in sliding joint between the latch and the table post.

It is said that the table can support 350 kg.



Toggle clamp 1a

http://youtu.be/dA_j05ut0FE

Toggle clamp using slider-crank mechanism.

Orange lever: crank. Green link: connecting rod. Yellow plate: slider.

The green link and the orange crank come into toggle by lining up on top of each other to hold the yellow plate firmly.

Red arrow represents resisting force.

The clamping force is applied to the crank.



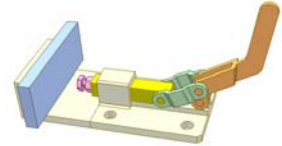
Toggle clamp 1b

<http://youtu.be/lpjHsMKISB0>

Toggle clamp using slider-crank mechanism.

Green conrod and orange crank come into toggle by an extension of each other.

The clamping force is applied to the crank.



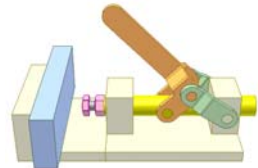
Toggle clamp 1c

<http://youtu.be/Pjdb0CAj4Bc>

Toggle clamp using slider-crank mechanism.

Green bar and orange conrod come into toggle by an extension of each other.

The clamping force is applied to the conrod.



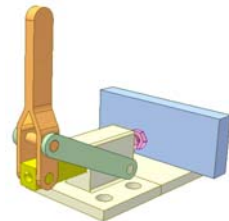
Toggle clamp 1d

<http://youtu.be/cv8sqEfxCSs>

Toggle clamp using slider-crank mechanism.

Green bar and orange conrod come into toggle by lining up on top of each other.

The clamping force is applied to the conrod.



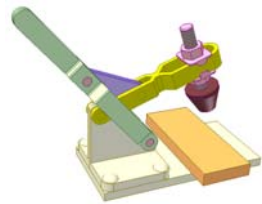
Toggle clamp 2a

http://youtu.be/Nmp_U-tkoH8

Toggle clamp using four bar linkage.

Green lever and violet conrod come into toggle by lining up on top of each other.

The clamping force is applied to the lever.



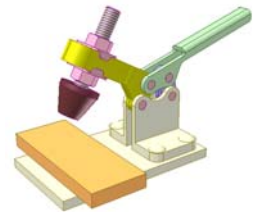
Toggle clamp 2b

http://youtu.be/lrL2_5tj1IE

Toggle clamp using four bar linkage.

Green conrod and violet lever come into toggle by an extension of each other.

The clamping force is applied to the conrod.



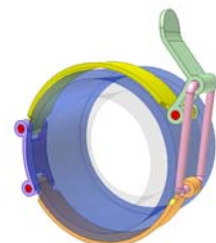
Toggle clamp 2c

<http://youtu.be/k9tMxQfo2zo>

Toggle clamp using four bar linkage.

Green conrod and pink lever come into toggle by lining up on top of each other.

The clamping force is applied to the conrod.



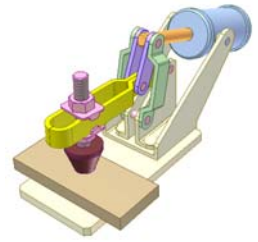
Toggle clamp 2d

<http://youtu.be/ZtiW90wThO4>

Toggle clamp using four bar linkage.

Violet conrod and green lever come into toggle by lining up on top of each other.

The clamping force of an air cylinder is applied to revolution joint between the violet conrod and the green lever.



22.2. Self-centering mechanisms

Self-centering chuck for lathes

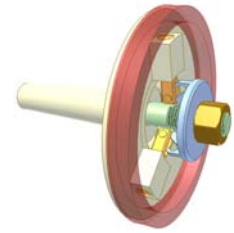
<http://www.youtube.com/watch?v=QerPu2BaUNA>

A combination of translation cam and nut-screw clamping.

The red ring is a workpiece.

The input nut is rotated and translated.

The screw is fixed.



Three-jaw self-centering chuck 1

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

Combination of bevel gear drive and spiral rack (scroll gear) mechanism.

Turn any one of the three blue bevel pinions for moving the jaws.

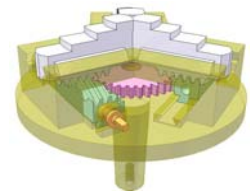


Three-jaw self-centering chuck 2

<http://youtu.be/IPAfyZ5jCuA>

Combination of screw-nut, gear-rack and rack-rack mechanisms.

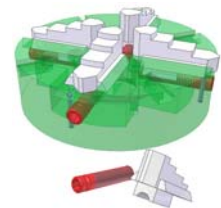
Turn the sole orange screw for moving the jaws.



Four-jaw independent chuck 1

http://youtu.be/U_U0Cxrd_KE

Turn each red screw for moving the corresponding jaw.



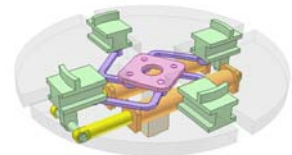
Four-jaw self-centering chuck 1

<http://youtu.be/SEgw6hcujwk>

An application of crank slider mechanism.

The pistons are connected to a green slider and the cylinders to opposite one. The cylinders can be connected to the rotary table in order to reduce pistons' displacement.

This chuck is used in tire mounting equipments.

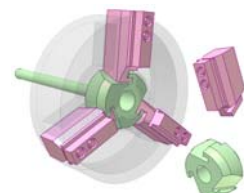


Three-jaw self-centering chuck 3

<http://youtu.be/xUUeWQoY4CI>

An application of the wedge mechanism.

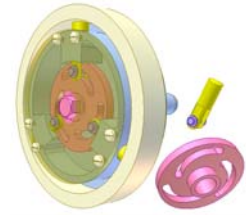
The green rod is connected to a pneumatic cylinder (not shown) to get reciprocating motion.



Three-jaw self-centering chuck 4

<http://youtu.be/zzcj0-C6Njo>

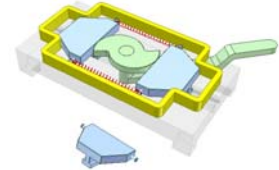
Turn the pink cam of three eccentric slots for clamping or releasing the popcorn workpiece. This chuck should be used only for operation of light cutting force.



Self-centering fixture 1a

<http://youtu.be/VQLBovXF9Uw>

The green double eccentrics and two blue wedge-sliders center the yellow workpiece along transversal and longitudinal direction.

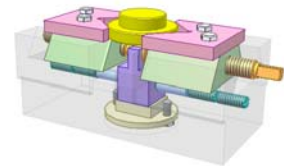


Self-centering fixture 1b

<http://youtu.be/0kFUfX1m5aI>

The orange screw having threads of right and left hand move the V blocks to center the yellow workpiece along transversal and longitudinal direction.

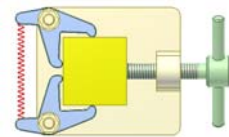
The blue pins and screws (in lower part of the base) are used for adjusting the center position along longitudinal direction.



Self-centering fixture 2b

<http://youtu.be/8UrBjWE96vc>

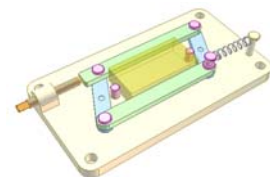
Two symmetric V-shaped levers center the yellow workpiece along longitudinal direction.



Self-centering fixture 2c

<http://youtu.be/GzweOeQAiqM>

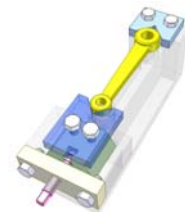
The green connecting rods of a parallelogram mechanism center the yellow workpiece along longitudinal direction.



Self-centering fixture 2d

<http://youtu.be/FpdSiDXOOCA>

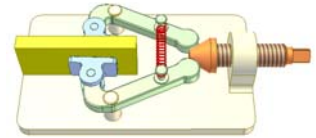
The V blocks (one is fixed, the other is movable) center the yellow workpiece along longitudinal direction.



Translating cam mechanism 5

<http://youtu.be/w8Hk3E5gfj0>

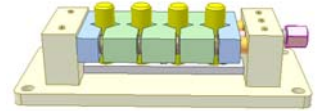
Device for clamping workpiece (in yellow).
Wedge is the orange screw of cone head that has helical motion.



Self-centering fixture 4a

http://youtu.be/Oa5_0RAEbC0

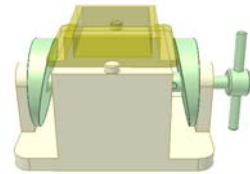
Multi-piece clamping.
The V-blocks center the yellow workpieces along longitudinal direction. There are compression springs between the V-blocks.



Self-centering fixture 2a

<http://youtu.be/4tM1zNKiQPI>

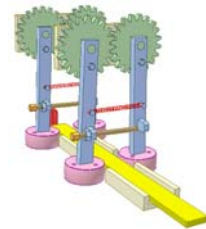
Two symmetric face cams center the yellow workpiece along longitudinal direction.



Self-centering fixture 3a

<http://youtu.be/GF1Lw16lwco>

The yellow running workpiece is centered along longitudinal direction when contacting with all the two pink roller couples. The fixture is used in a bamboo slitting machine. The red knife is stationary.



Self-centering fixture 4

<http://youtu.be/IT49olsv-EU>

Turn the block of orange and yellow gears to clamp brown work.
Two grey pads center the work along its longitudinal direction.

Condition for centering:

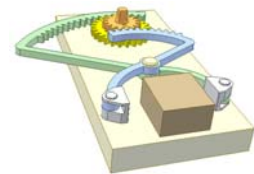
$$R1/R3 = R2/R4$$

(angle speeds of blue and green gears are equal)

Relation of gear pitch radius:

$$R4 = R1 + R2 + R3$$

$R1$, $R2$, $R3$ and $R4$ are pitch radius of the orange, yellow, blue and green gear respectively.

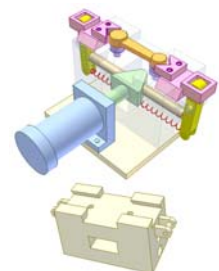


Self-centering fixture 5

<http://youtu.be/L0BbQPfpMd0>

Clamping a workpiece (in orange) by hydraulic cylinder through green wedge on the piston, two pins and two yellow levers.

Pink V blocks center the workpiece along its longitudinal direction.



23. Measurement and quality control

Male taper measurer 1

<http://youtu.be/dduZx61R-eg>

The taper to be measured is in pink color. It is mounted between two centres that are installed on a blue sine bar of two brown rollers. The rollers are always fixed to the bar.

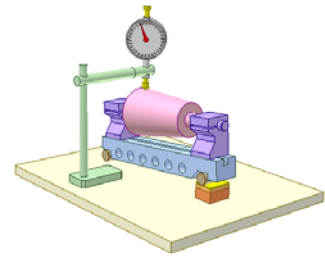
Use slip gauge combination to make the highest generatrix of the taper parallel to the surface plate. The parallelism is checked by a dial indicator. Then

$$\sin \alpha = H/L$$

α : haft taper angle

H: thickness of the slip gauge combination

L: center distance of the sine bar rollers



Male taper measurer 2

<http://youtu.be/AOTUgFgU2U0>

The taper to be measured is in blue color.

Let the yellow and red tubes contact with the taper to get A dimension (distance between two faces).

$$\tan \alpha = ((D2-D1)/(A+L2-L1))/2$$

α : haft taper angle

D2 and L2: inner diameter and length of the yellow tube

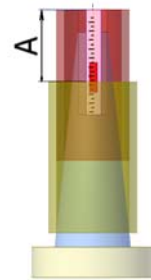
D1 and L1: inner diameter and length of the red tube

If $L2 = L1$ then

$$\tan \alpha = ((D2-D1)/A)/2$$

In case of go-no and go control the red area on the scale of the red tube should be used. It is determined according to the tolerance of taper angle α .

This measurement is faster but less precise than other known methods (using sine bar)



Female taper measurer 1

<http://youtu.be/QiDu1k-6HUs>

The taper to be measured is in blue color.

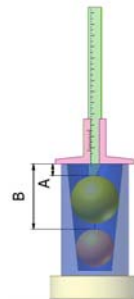
Use a depth gauge to get A and B dimensions

$$\sin \alpha = (R-r)/((B-A)/(R-r))$$

α : haft taper angle

R: radius of the large ball

r: radius of the small ball



Female taper measurer 2

<http://youtu.be/SvmRPrN7Zd4>

The taper to be measured is in blue color.

Let the yellow and orange tubes contact with the taper to get A dimension (distance between two faces).

$$\tan \alpha = ((D2-D1)/(L1-L2-A))/2$$

α : haft taper angle

D2 and L2: outer diameter and length of the yellow tube

D1 and L1: outer diameter and length of the orange tube

In case of go-no and go control the red area on the scale of the orange tube should be used. It is determined according to the tolerance of taper angle α .

This measurement is faster but less precise than other known method (using balls)



Checking coaxiality between two holes

<http://youtu.be/DkmLCiVo-1Y>

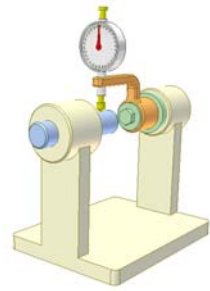
Two holes of the popcorn base is checked for coaxiality.

A blue shaft, a green shaft, an orange arm and a dial indicator are used.

Ensure no gap between shafts and holes.

Error in coaxiality is $P = (E1 - E2)/2$

E1 and E2 are max and min values shown by the indicator during one revolution.



Checking eccentricity and face perpendicularity of a shaft

<http://youtu.be/1JNCe9fwRUw>

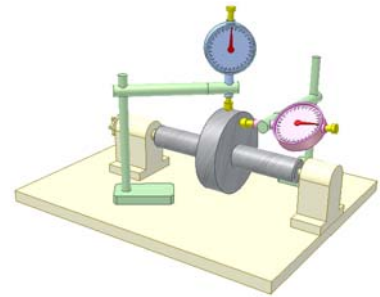
The blue indicator shows the eccentricity of the large cylindrical surface to the shaft centerline $E = (E1 - E2)/2$.

E1 and E2 are max and min values shown by the indicator.

The pink indicator shows the error in perpendicularity of the large face to the shaft centerline $P = (E1 - E2)/2A$.

E1 and E2 are max and min values shown by the indicator.

A: distance between measuring point and the shaft centerline.

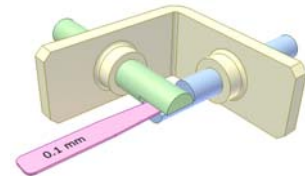


Checking intersection of two holes centerlines

<http://youtu.be/7WBpFGT1ISo>

Ensure no gap between shafts and holes.

The flat portion of each shaft must contain shaft centerline. Insert a feeler gauge (as thick as possible) into the gap between the shaft flat portions to get the error in intersection (feeler gauge thickness). Turn the shafts 180 deg. if no gap appears.



Measuring distance between 90 deg. skew holes

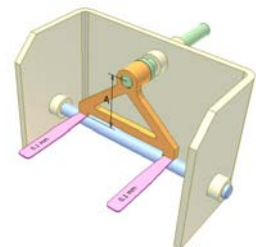
<http://youtu.be/bLfvlWIZZBc>

Ensure no gap between shafts and holes.

A is distance between the flat portions and the centerline of the orange part. It is determined according to allowed smallest value of the distance to be measured.

Insert two feeler gauges (of equal thickness and as thick as possible) into both gaps between the blue shaft and the flat portions of the orange part to get the value B (feeler gauge thickness).

Measuring result: $D = A + B$



Checking parallelism between two planes 1

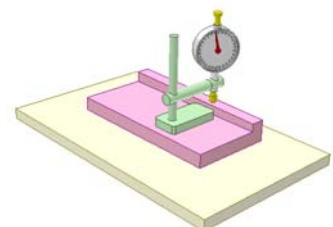
<http://youtu.be/TYUZZ99Un1w>

One plane is large enough for laying the indicator base.

Move the indicator set longitudinally to get values E1 and E2 at two points, distance between which is A.

Non-parallelism $P = (E1 - E2)/A$

Using height gauge gives less accurate result.



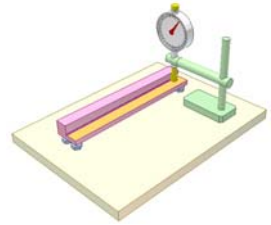
Checking parallelism between two planes 2

<http://youtu.be/YedyhVrmThk>

The planes are small so the indicator base can not be laid on one of them.

Make the orange plane parallel to the surface plate using the blue jack pins. Check the parallelism by the indicator, base of which moves on the surface plate.

Then check the parallelism of the pink plane to the orange one through its parallelism to the surface plate.



Checking parallelism between hole and bottom

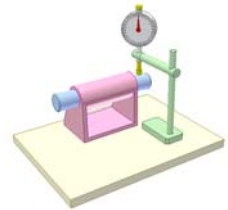
<http://youtu.be/OfmDN3FuWRs>

Insert a shaft into the hole to be checked.

Ensure no gap between shaft and hole.

Non-parallelism $P = (E1 - E2) / A$

E1 and E2 are extremal values shown by the indicator at two measuring positions distance of which is A.



Checking parallelism between two holes

<http://youtu.be/eEGu7azvNow>

Insert a shaft into one hole of the green object.

Ensure no gap between shaft and hole.

Get the highest value E1 of the shaft at the measuring position.

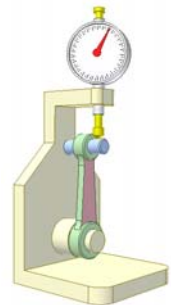
Turn the object 180 deg.

Get the highest value E2 of the shaft at the measuring position.

Non-parallelism $P = (E1 - E2) / (A - B/2)$

A: distance from indicator centerline to the positioning face of the basic axle.

B: length of the lower hole of the object.



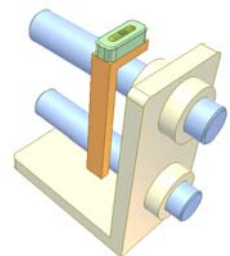
Checking parallelism in horizontal plane between two holes

<http://youtu.be/HONVeJB7Rsk>

Insert two shafts into the holes to be checked. Ensure no gaps between shafts and holes.

Move the orange square of a spirit level along the shafts while keeping continuous contact between the shafts and the square.

The spirit level shows the error in parallelism between two holes in horizontal plane (not in vertical one).



Checking parallelism in vertical plane between two holes

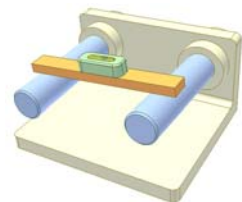
<http://youtu.be/svSkqNaTHBE>

Insert two shafts into the holes to be checked. Ensure no gaps between shafts and holes. Move the orange bar of a spirit level along the shafts.

The spirit level shows the error in parallelism between two holes in vertical plane (not in horizontal one).

Another way for checking (without the orange bar):

Put the spirit level directly on each blue shaft (along its length) and compare two values shown by the spirit level.



Checking perpendicularity between hole and face

<http://youtu.be/BEumouFrAj4>

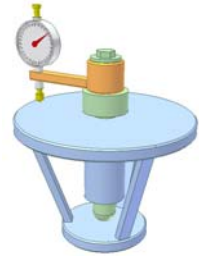
The top face the blue object is checked for perpendicularity to its hole. Ensure no gap between shafts and holes.

Error in perpendicularity is

$$P = (E1 - E2)/A$$

E1 and E2 are max and min values shown by the indicator during one revolution

A: center distance of two holes of the orange crank.

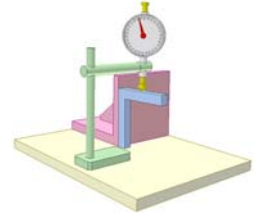


Checking perpendicularity between two surfaces

<http://youtu.be/ZRvdzfM9ISo>

Bottom surface and vertical one of the pink object is checked for perpendicularity.

Use a blue square that is pressed against the vertical surface of the object, thus perpendicularity checking is turned into parallelism one.



Checking perpendicularity between face and centerline of a shaft 1

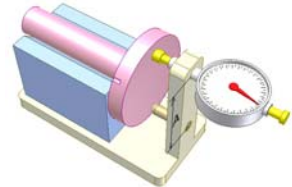
<http://youtu.be/R7u0Af9dslA>

Turn the shaft several revolutions on the blue V-block while keeping a continuous contact between the shaft face and the brown pin (for example by setting the base inclined).

Get max and min values (E1 and E2) shown by the indicator.

Non-perpendicularity $P = (E1 - E2)/2A$

A: center distance of indicator and the brown pin.



Checking perpendicularity between face and centerline of a shaft 2

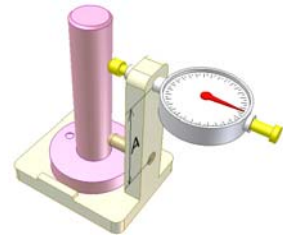
<http://youtu.be/ZUurxNlb8r0>

The face to be checked is the pink shaft bottom.

Turn the shaft several revolutions while keeping a continuous contact between the shaft and the brown pin (for example by setting the base inclined). Get max and min values (E1 and E2) shown by the indicator.

Non-perpendicularity $P = (E1 - E2)/2A$

A: center distance of indicator and the brown pin.



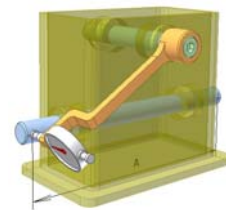
Checking perpendicularity between 90 deg. skew holes

<http://youtu.be/VKfFRS0H3Wc>

Ensure no gap between shafts and holes and keep the shafts immobile. Get values E1 and E2 shown by the indicator at two positions, distance between which is A.

Non-perpendicularity $P = (E1 - E2)/A$

With little modification this method can be applied for checking perpendicularity between 90 deg. intersecting holes centerlines.



Checking perpendicularity between shaft and its hole 1

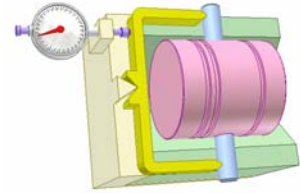
<http://youtu.be/3TwxF7t4-U>

A blue shaft is inserted into the gudgeon pin hole. Ensure no gap there. Move the piston until contact with both edges of the yellow arm to get value E1 shown by the indicator.

Turn the piston 180 deg. and do the same for value E2.

Error in perpendicularity is $P = (E1 - E2)/2A$

A is center distance between the indicator and pivoting axle of the yellow arm.



Checking perpendicularity between shaft and its hole 2

<http://youtu.be/yr-MTaKDuis>

A blue round bar is inserted into the hole of the grey shaft.

Ensure no gap there.

V-block and the shaft are arranged vertically.

Small error in verticality does not affect the checking result.

The shaft always contacts V-block thanks to two pink springs.

There is a red ball at the shaft bottom.

Checking steps:

1. Put a bubble level (in orange) on the bar to get angle between bar axis and horizontal direction E1.

2. Turn the product 180 degrees.

3. Put the bubble level on the bar to get angle between bar axis and horizontal direction E2.

Error in perpendicularity P:

If the level's bubble moves in opposite directions for the two attempts:

$$P = (E1 + E2)/2$$

If the level's bubble moves in the same direction (it may happen when the shaft is not absolutely vertical):

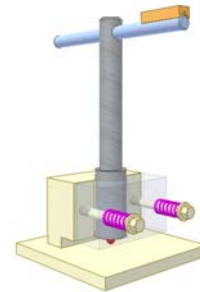
$$P = (E1 - E2)/2$$

Here the error in perpendicularity P is understood as an angular error:

$$P = (B - 90) \text{ deg.}$$

B is real angle between shaft axis and hole axis.

This method has advantage for checking bulky products.



Friction torque measuring

<http://www.youtube.com/watch?v=QQfhv9AuYuM>

A simple method to measure friction torque M generated in revolution joint of the grey inner ring and the orange outer one. The grey ring is fixed on the blue shaft, the orange ring is fixed on the green hand assembly.

$$M = PL \sin \alpha$$

P: weight of the pink weight

L: distance from the pink weight to the rotation axis

α : angle shown by the green hand

Force applied to the revolution joint is the weight of the hand assembly including the pink weight.

The hand assembly (without the pink weight) must be adjusted with the violet nuts to be in static balance.



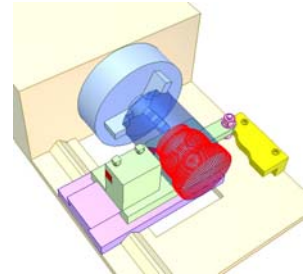
24. Mechanisms for copying

Copying device on lathe 1

<http://youtu.be/kR-dbUTMNuU>

The violet carriage is power-fed along the axis of rotation of the blue workpiece. The green slider carrying pink roller is forced by a spring (between violet and green sliders, not shown) towards the yellow template.

The tool traces a curve that corresponds to the template profile.

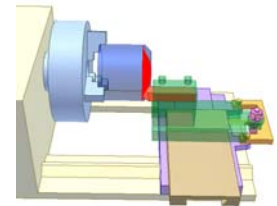


Copying device on lathe 2

<http://youtu.be/DOd6PZm0iQY>

The brown cross slide is power-fed square to the axis of rotation of the blue workpiece. The green upper slide carrying pink roller is forced by yellow spring towards the orange template.

The tool traces a curve that corresponds to the template profile.

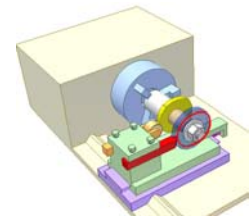


Copying device on lathe 3

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

The violet carriage is power-fed along the axis of rotation of the blue workpiece. The green slider carrying pink roller and red tool is forced by a pink spring towards the yellow template.

The tool traces a curve that corresponds to the template profile.



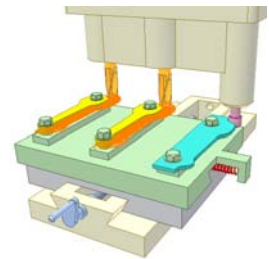
Copying device on vertical milling machine 1

<http://youtu.be/4xFMKC-NgBE>

Grey table moves in cross direction by a screw drive. Green upper table moves longitudinally by the contact between cyan template and pink immobile tracer. Red spring forces the template towards the tracer. Yellow works are fixed to the upper table.

Orange cutters create surface on the yellow works corresponding to the template profile.

The tracer and the cutter diameters must be equal if profiles of the template and the work are requested to be the same.

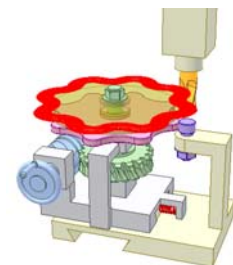


Copying device on vertical milling machine 2

<http://youtu.be/llOgnO-dzOE>

Grey slider carries a worm drive (rotary table in practice). Pink template and yellow work are fixed to worm wheel shaft of the drive. The template contacts violet stationary pin under pressure of red spring and makes the slider move longitudinally when the blue worm is rotated by hand. Orange cutter creates a surface on the yellow work corresponding to profile of the template.

The pin and the cutter must be coaxial and their diameters must be equal if profiles of the template and the work are requested to be the same.



Wood 2D copy milling machine 1

<http://youtu.be/WJeliwU6OzU>

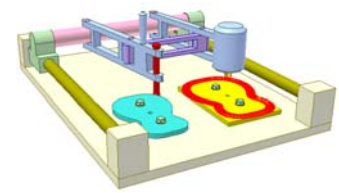
A parallelogram mechanism of violet conrod and two blue cranks can slide on two yellow rods.

Red tracer is on one crank, orange cutter is on the other. Their distances to pink bar pivots are equal (the tracer and cutter can be on the violet conrod also)

Move (by hand) the tracer along profile of fixed cyan template, the cutter creates a surface on fixed yellow work corresponding to the profile of the template.

The tracer and the cutter are kept perpendicular to the ground.

The tracer and the cutter diameters must be equal if profiles of the template and the work are requested to be the same.



Wood 3D copy milling machine 1

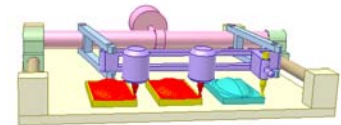
<http://youtu.be/TzBM9iJa5mM>

A parallelogram mechanism of violet conrod and two blue cranks can slide on two brown rods. The pink tube can pivot around the axle that connects green sliders.

Yellow stylus and red spherical milling cutters are on the violet conrod.

Move (by hand) the stylus on upper surface of cyan model, the cutters create corresponding surfaces on yellow works.

The stylus and the cutter diameters must be equal to get cut surfaces and model one identical.



Wood 3D copy milling machine 2

http://youtu.be/dxN5TNR_4WY

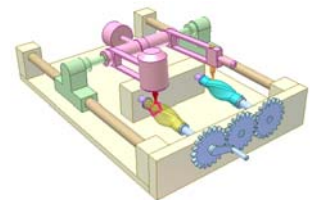
Pink double crank carrying orange stylus and red spherical milling cutter can pivot on axle of green double slider that can move along two brown rods.

Move (by hand) the stylus along the cyan model and turn (by hand) blue gear crank, the cutter create 3D surface on yellow work corresponding to the model surface.

Distances from the stylus and the cutter to base plan must be equal and their spherical diameters must be equal to get cut surface and model one identical.

Practice:

<http://www.youtube.com/watch?v=dskTOImPJ0o>



Wood 3D copy milling machine 3

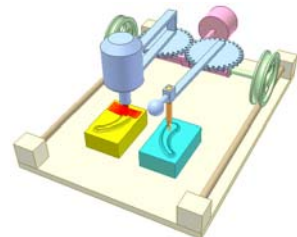
<http://youtu.be/x4zuhNgtR5I>

Pink tube can pivot on axle of green wheels that can roll along two brown rods.

The pink tube carries a drive of two identical gears. Motor with red spherical milling cutter is on one gear, orange stylus is on the other.

Move (by hand) the stylus on upper surface of cyan model, the cutter creates on yellow work a corresponding symmetrical surface.

Distances from the stylus and the cutter to base plan must be equal and their spherical diameters must be equal to get cut surface and model one identical (symmetrically).



Bar pantograph 1

<http://youtu.be/9H5hSLaRPTQ>

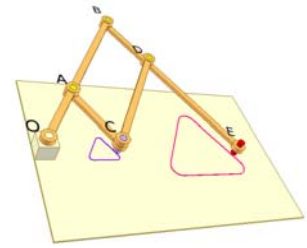
ABCD: parallelogram.

OCE: straight line

O: immobile

$OE/OC = BE/BD = k = \text{constant}$

Figures traced by pen E and pen C are similar. Scale factor is k.



Bar pantograph 2

<http://youtu.be/p8SDBkLV4mg>

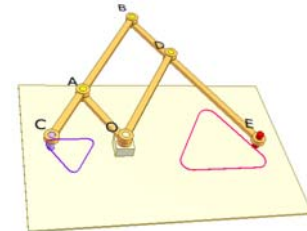
OABD: parallelogram.

COE: straight line

O: immobile

$OE/OC = DE/BD = k = \text{constant}$

Figures traced by pen E and pen C are similar but upside down each other when O is between C and E. Scale factor is k.



Bar pantograph 3

<http://youtu.be/-Y8lyDkJpL0>

OBCD: parallelogram.

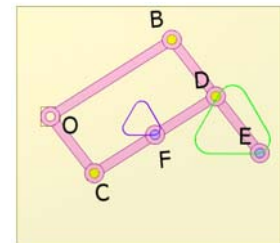
OFE: straight line

O: immobile

$OE/OF = BE/BD = k = \text{constant}$

Point O or F do not necessarily coincide with a vertex of the parallelogram.

Figures traced by pen E and pen C are similar. Scale factor is k.



Bar pantograph 4

<http://youtu.be/kjIwFXx2GI4>

ABDC: parallelogram.

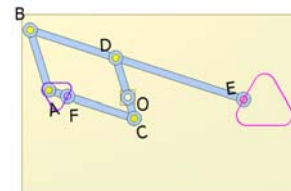
FOE: straight line

O: immobile

$OE/OF = OD/OC = k = \text{constant}$

Point O or F do not necessarily coincide with a vertex of the parallelogram.

Figures traced by E and F are similar but upside down each other when O is between F and E. Scale factor is k.



Bar pantograph 5a

<http://youtu.be/oAhVbY0CBAk>

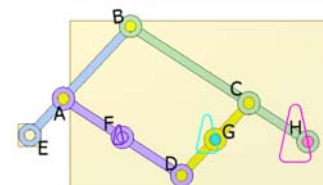
ABDC: parallelogram.

EFGH: straight line

E: immobile

Point E, F, G and H do not necessarily coincide with vertices of the parallelogram.

Figures traced by pens F, G and H are similar.



Bar pantograph 5b

<http://youtu.be/N0qrDs9phHg>

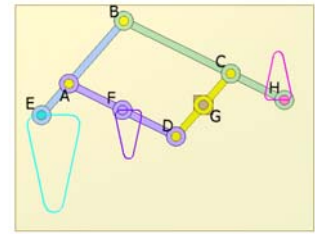
ABDC: parallelogram.

EFGH: straight line

G: immobile

Point E, F, G and H do not necessarily coincide with vertices of the parallelogram.

Figures traced by pens E, F and H are similar.



Bar pantograph 6

<http://youtu.be/pGTyCtDlqBU>

OABC: parallelogram.

Triangles ADB and CBE are similar.

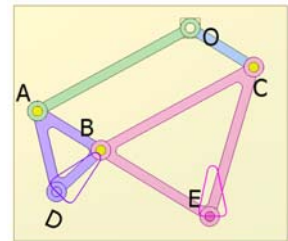
Triangles DAO, DBE and OCE are similar.

Triangles ODE and ABD are similar.

O: immobile

Figures traced by pen E and pen D are similar but figure D is turned an angle DAB in comparison with figure E.

Scale factor is $k = AD/AB = CB/CE = \text{constant}$.



Bar pantograph 7a

<http://youtu.be/ZHWPj2dmMA8>

ABCD: parallelogram

OCE: straight line

O: immobile

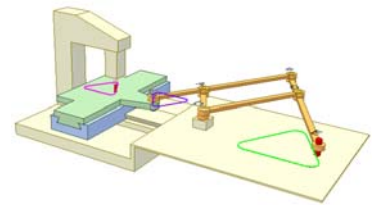
$OE/OC = BE/BD = k = \text{constant}$

Figures traced by pointer E and pin C are similar. Scale factor is k.

This is the case when the red tool is immobile (not installed in place of pin C) and the orange pantograph is connected to a system of two sliders (by pin C and a hole of the green plate). The tool traces pink figure on the upper slider. It has same size with the figure traced by pin C but upside down each other.

Instead of system of two sliders an other one can be used, provided that it enables the green plate to move translationally.

Several workpieces can be machined at the same time when many tool spindles are arranged.



Bar pantograph 7b

<http://youtu.be/E2t-rz36CcM>

ABCD: parallelogram

OCE: straight line

O: immobile

$OE/OC = BE/BD = k = \text{constant}$

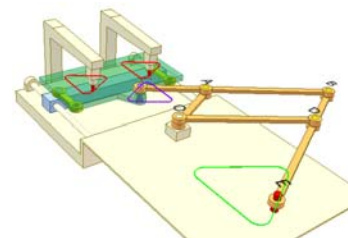
Figures traced by pointer E and pin C are similar.

Scale factor is k.

This is the case when the red tools are immobile (not installed in place of pin C) and the orange pantograph is connected to system of slider and parallelogram (by pin C and a hole of the green plate). The system enables the green plate to move translationally.

Red tools trace red figures on the green plate. They have same size with the figure traced by pin C but upside down.

Two workpieces are machined at the same time.



Bar pantograph 8

<http://youtu.be/3h3NMbycOkk>

ABCD: parallelogram

OCE: straight line

O: immobile

$OE/OC = BE/BD = k = \text{constant}$

Figures traced by pointer E and pin C are similar.

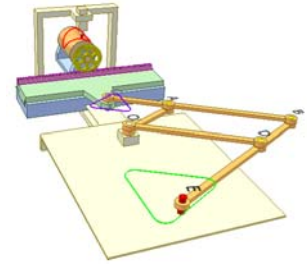
Scale factor is k.

This is the case when red tool is immobile (not installed in place of pin C) and the orange pantograph is connected to system of two sliders (by pin C and a hole of the green plate).

A rack-pinion drive turns orange cylinder installed on the blue lower slider. Pitch diameter of the pinion and diameter of the cylinder are equal.

The tool traces red figure (having same size with the figure traced by pin C) on cylindrical surface of the cylinder.

Meshing place of the rack-pinion drive (at upper or lower portion of the pinion) affects direction of the figure traced on the cylinder.



Gear pantograph 1

<http://youtu.be/slQuUX2kgxo>

Green and blue gears have same tooth number.

OCD: straight line

AC and BD are parallel.

Triangles OAC and OBD are similar.

$OC/OD = OA/OB = AC/BD = k = \text{constant}$

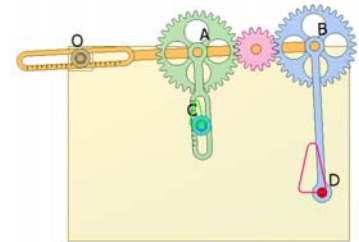
O: immobile

Figures traced by pen E and pen C are similar. Scale factor is k.

Adjust OA and AC to get various values of k.

Bar linkage in a conventional pantograph is replaced by gear drive.

Instead of 3 gear drive a rack and two pinion drive can be used.



Gear pantograph 2

<http://youtu.be/tVe5YADt4KE>

Green and blue gears have same tooth number.

COD: straight line

AC and BD are parallel.

Triangles OAC and OBD are similar.

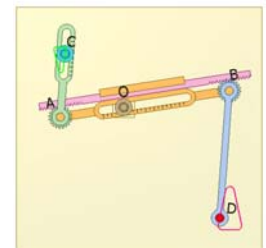
O: immobile

$OC/OD = OA/OB = AC/BD = k = \text{constant}$

Figures traced by pen D and pen C are similar but upside down each other. Scale factor is k.

Adjust OA and AC to get various values of k.

Bar linkage in a conventional pantograph is replaced by rack pinion drive.



Belt pantograph 1

[http://youtu.be/ 5G4Qb3VeUA](http://youtu.be/5G4Qb3VeUA)

Green and blue pulleys have same diameter.

COD: straight line

AC and BD are parallel.

Triangles OAC and OBD are similar.

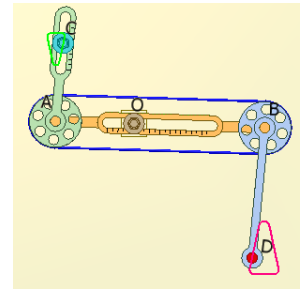
O: immobile

$OC/OD = OA/OB = AC/BD = k = \text{constant}$

Figures traced by pen D and pen C are similar but upside down each other. Scale factor is k.

Adjust OA and AC to get various values of k.

Bar linkage in a conventional pantograph is replaced by belt drive.



25. Mechanisms for opening and closing entrances

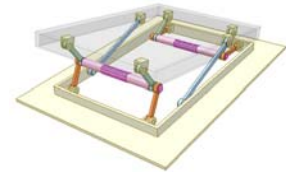
Car roof window

<http://youtu.be/Url8JhauPYA>

This mechanism (group of 4 bars and 6 revolution joints + two cranks) has 2 degrees of independence.

Use two pink grips to open the window to the desired direction.

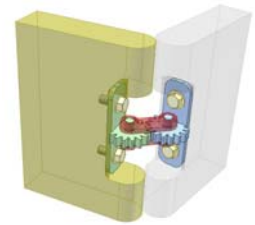
Measure to create friction in the joints is needed for holding the window at adjusted position.



Hinge enabling 360 degree rotation 1

<http://www.youtube.com/watch?v=pl8tg3Z76is>

Ordinary hinges can not rotate 360 degrees because of thickness of moving and grounded parts. The proposed design does not have that limitation. A satellite gear drive is applied here.



Hinge enabling 360 deg. rotation 2

<http://youtu.be/gltkHi0Rink>

Ordinary hinges can not rotate 360 degrees because of thickness of moving and grounded parts. The proposed design does not have such limitation.

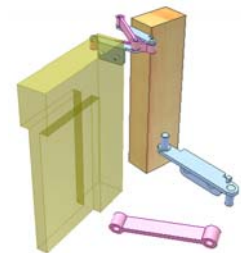
An anti-parallelagram mechanism is used here.

Lengths of blue and pink parts are 80 and 95 respectively.

There is a stopper on the blue part to prevent death positions so the rotation angle is a little less than 360 deg.

STEP files of this video are available at:

<http://www.mediafire.com/download/9t6a7uvkrwi5b8g/360dHinge2STEP.zip>



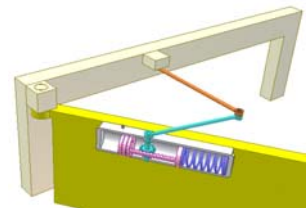
Door closer 1

<http://youtu.be/vBDIDc9Mml4>

The cyan arm is connected to cyan gear that engages with pink rack-piston. At one end of the rack-piston is violet spring that accumulates energy during door opening and releases it during closing.

The spaces around the rack-piston contain oil. There are oil ways connecting the oil spaces including adjustment valves that regulate opening and closing speeds.

As the door swings closed, connecting link (in orange) comes into toggle with the cyan arm, giving it a large angular velocity, which helps the oil damping be more effective in retarding motion near the closed position.



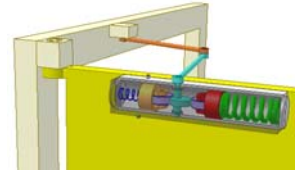
Door closer 2

<http://youtu.be/ppgPrFq6WXw>

The cyan arm is connected to a cam (eccentric circle profile) that contacts with rollers of two pistons. The red piston has green spring that accumulates energy during door opening (the spring length is reduced) and releases it during closing. The orange piston has a blue spring that ensures its permanent contact with the cam. The cam must be arranged in such a way as to avoid self-locking during closing.

The spaces around the pistons contain oil. There are oil ways connecting the oil spaces including adjustment valves that regulate opening and closing speeds.

As the door swings closed, connecting link (in orange) comes into toggle with the cyan arm, giving it a large angular velocity, which helps the oil damping be more effective in retarding motion near the closed position.



Cover for basement entrance 1a

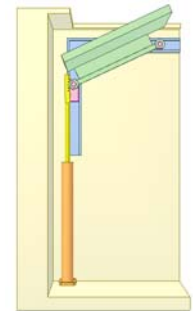
<http://youtu.be/KHyIXFYptfA>

Green cover is a connecting rod of an ellipse mechanism of two pink sliders. Driving force from fixed cylinder is applied to the connecting rod via a pinion rack drive (instead of to pink lower slider) ensures smooth motion of the mechanism even at death position when the connection rod is vertical.

Gap between the floor and the cover is rather small.

The cover occupies rather small space during motion.

The mechanism can be used for a door with ceiling arrangement of the runways.



Cover for basement entrance 1b

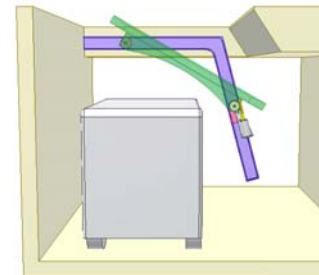
<http://youtu.be/iRH5lwF-1VE>

Green cover is a connecting rod of an ellipse mechanism of two pink sliders. A green pinion is fixed to the cover. A grey actuator of yellow rack is fixed to the right slider. Driving force from the actuator is applied to the connecting rod via the pinion rack drive. That ensures smooth motion of the mechanism.

The obtuse angle of violet runway and the mounting actuator on the slider are measures to overcome limited height of the basement. Moving actuator causes some difficulties for connection with hydraulic or electric source.

The mechanism is cut off half for easy understanding.

The car is moved from the basement to the ground floor by a lift (not shown).

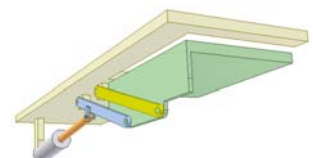


Cover for basement entrance 2

<http://youtu.be/MeeW9S2qojE>

Green cover is a connecting rod of a four bar linkage.

There must be a considerable gap between floor and the cover at two short sides of the cover. The cover occupies large space during motion.



Cover for basement entrance 3

<http://youtu.be/VN9ERN1UK1s>

An application of double parallelogram mechanism shown in.

<http://www.youtube.com/watch?v=U-Vn5SoRWCg>

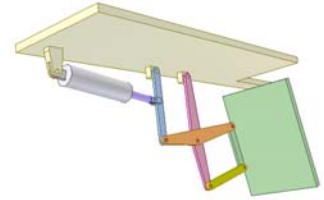
Green cover is a connecting rod of one parallelogram mechanism and rotates around a virtual axis that lies on the upper surface of the floor (or better, within the thickness of the floor).

Gap between the floor and the cover is rather small.

The cover occupies rather large space during motion.

The mechanism is cut off half for easy understanding.

The mechanism of two opposite moving covers is possible.



Cover for basement entrance 1c

<http://youtu.be/Wnkzo14aA3o>

The cover is divided into green and violet halves in order to reduce its occupied space in moving or to ease the manufacture.

The green half has two pink rollers rolling in blue runway.

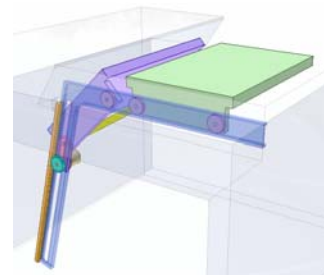
The violet half has a pink roller rolling and a pink slider sliding in the runway.

Yellow conrod has revolute joints with the two halves and the slider. Length of the conrod is reduced to minimum due to the said reason.

Brown motor fixed to the slider has cyan pinion which engages with orange rack fixed to the runway. So driving force from the motor is applied to the slider. The obtuse angle of blue runway is a key factor and it should be as large as possible to ease the motion.

Because of the moving motor, electric cable connected to it must be movable.

The mechanism is cut off half for easy understanding.



Cover for basement entrance 4

<http://youtu.be/rfnXYbCxIQg>

Yellow frame reciprocates linearly under action of grey cylinder.

Thanks to parallelogram mechanism of two orange rockers, the green cover can raise up to level of the floor.

In motion to the left the cover falls down due to the gravity.

Pay attention to two red pins, pink and brown plates that act as stoppers.

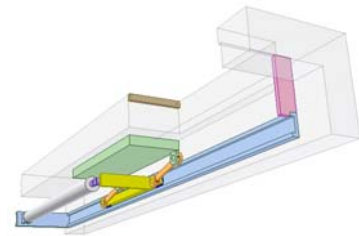
Gap between the floor and the cover is minimum.

The cover occupies small space during motion.

Center of mass of the cover moves up only a little so the mechanism is good in term of saving energy.

The mechanism is cut off half for easy understanding.

The mechanism of two opposite moving covers is possible.



Door for limited space 1

http://youtu.be/jWxtaYE_5n0

Each door panel has revolute joints with a slider and a roller. The sliders and rollers move in violet runway.

Yellow conrod has revolute joints with the sliders and cyan piston.

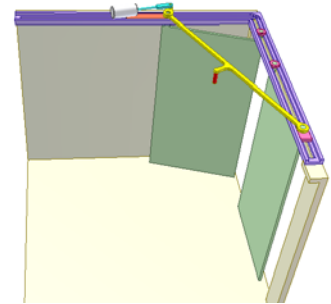
Grey cylinder has revolute joint with the orange left slider. So driving force from the cylinder is applied to the conrod.

Because of the moving cylinder, its hydraulic hoses must be movable.

In case of power interruption:

- Move red grip of the conrod to open the door.
- The door can not be opened from outside.
- At completely closed or opened positions of the door, force applied to the panels can not move them.

This mechanism can be applied for up & down garage doors.

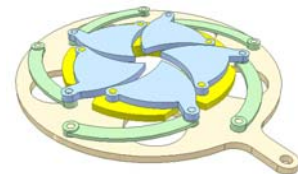


Diaphragm shutter 1

<http://youtu.be/P1ghKADv78>

Turn outer disk to open or close the aperture of a camera.

The outer disk, yellow conrod and blue blade create a 4-bar mechanism.



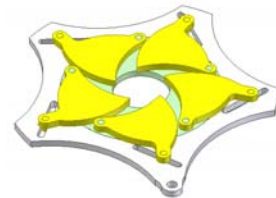
Diaphragm shutter 2

<http://youtu.be/msWygariBbs>

Turn outer disk cam to open or close the aperture of a camera.

Green inner disk is fixed.

Yellow blades play role of cam followers.



Diaphragm shutter 3

<http://youtu.be/VUoVnl9PiPU>

Turn glass outer disk cam to open or close the aperture of a camera.

Green inner disk is fixed.

Overlapping curved blades play role of cam followers.

See real colossal iris:

<https://www.youtube.com/watch?v=jvEL3KahFsk>



Diaphragm shutter 4

<http://youtu.be/IW5Wbic1D64>

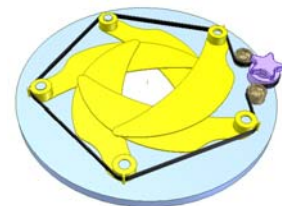
Turn violet knob to open or close the aperture.

Belt drive forces all yellow blades to rotate synchronously.

It is possible to replace belt drive with a gear one (internal gear ring and 5 pinions).

The mechanism can be used for windows:

<https://www.youtube.com/watch?v=-qlgsCU2NJo>



Diaphragm shutter 5a

<http://youtu.be/k4m6TRTSzGo>

It is a disk cam mechanism of translation follower.

Turn grey disk cam to open or close the aperture.

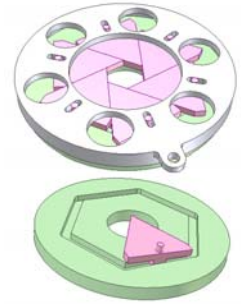
Fixed green disk has a hexagon slot.

Each blade (follower) slides along one side of the hexagon.

Instead of the hexagon 6 symmetrical suitable curves are possible.

The mechanism can be used for control valves:

<https://www.youtube.com/watch?v=3w7SSUFHjWE>



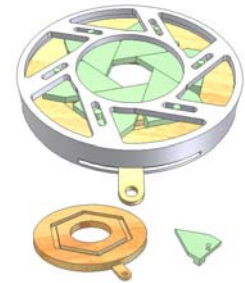
Diaphragm shutter 5b

<http://youtu.be/bWScqSHEvqc>

Turn orange disk of hexagon slot to open or close the aperture.

Instead of the hexagon 6 symmetrical suitable curves are possible.

The variable hexagon created by green blades rotates when expanded or contracted.



Diaphragm shutter 6

http://youtu.be/RoTgZw_nqPM

Yellow bars of flexible material are fixed to grey upper and brown lower disks.

Turn upper disk to open or close the aperture.

In practice the yellow bars are replaced with a flexible tube.

The mechanism finds application in valves for handling powder or granule materials. See:

https://www.youtube.com/watch?v=A-4V_V4Hi0g



26. Mixing machines

Stirring Machine with Satellite Bevel Gear

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



Mixing Machine 1

http://www.youtube.com/watch?v=E_QsGY1Rz7E

A second motor rotates the bowl.

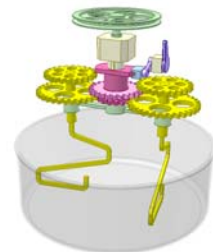
The locus lower part of the mixing bar's lower end follows the bowl bottom profile.



Mixing machine 3

<http://youtu.be/ZJdrYD-DPnM>

A planetary drive is used for the machine. The block of two pink gears plays role of the sun. Move the block to change mixing speed.



Mixing machine 4

<http://youtu.be/6ktLcEOzY9o>

Blue gear and violet worm are input links.



Mixing machine 5

http://youtu.be/iNI0R_26HSE

Blue gear and violet worm are input links.



Mixing machine 6

<http://youtu.be/M4zgWuNkLrA>

Green gears and orange bar create a parallelogram mechanism.

Pink gear and violet worm are input links.

The bar performs rotary translatory motion.



Dough-Kneading Mechanism

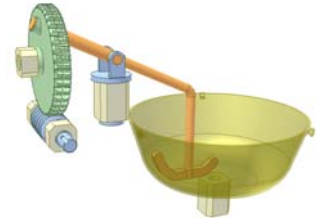
<http://youtu.be/qYksowpFhFY>

It is spherical 4R mechanism.

4R: 4 revolute joints.

Spherical: Joint center lines intersect at a common point.

The wobbling motion of the orange link is used to knead dough in the tank.



Agitator Mechanism

<http://www.youtube.com/watch?v=aHEz0qNzyJ8>

It is R-S-C-C space 4-bar mechanism.

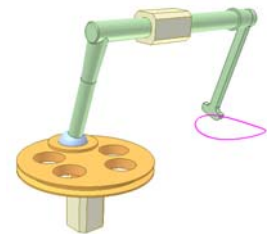
R-S-C-C: Joint symbols from input to output joint.

R: revolute

S: sphere

C: cylinder

The output link rotates and translates, performs a twisting motion.



Mixing machine 2

<http://youtu.be/FyOH3jwSDFY>

Input is the orange shaft.

The yellow propeller has reciprocating linear translation and continuous rotation at the same time owing to the rack of ring teeth.



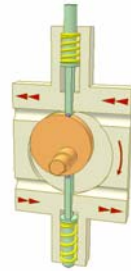
27. Pumps, engines

Pump with eccentric 1

<http://www.youtube.com/watch?v=RVORJ91ELEE>

The red arrows indicate the rotation direction of the eccentric shaft and the fluid moving direction.

The front half case is removed.

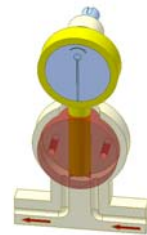


Pump with eccentric 2

<http://www.youtube.com/watch?v=lvzHnE26P1o>

The red arrows indicate the rotation direction of the eccentric shaft and the fluid moving direction.

The front half case is removed.



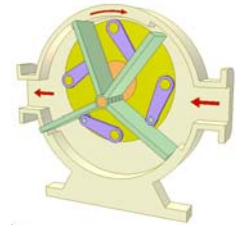
Pump with 4-bar mechanism 1

<http://www.youtube.com/watch?v=RrDJzv699aA>

The red arrows indicate the fluid moving direction.

The front half case is removed.

The space between adjacent sectors is expanded on the suction side and decreased on the discharge side.



Pump with 4-bar mechanism 2

<http://www.youtube.com/watch?v=YFb6tVo8rfq>

The arrows indicate the fluid moving direction.

The front cover is removed.

An expanding cavity is created on the suction side and a decreasing cavity is created on the discharge side.



Pump with rotating square piston

<http://www.youtube.com/watch?v=WiYK04vVPRY>

Input: green disk.

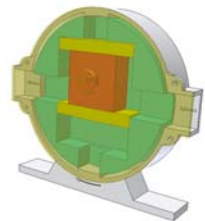
Yellow slider slides in slot on the green disk.

Red piston slides in slot on the yellow slider.

The piston axle is fixed eccentrically on the yellow cover.

The arrows indicate the fluid moving direction.

The piston creates an expanding cavity on the suction side and a decreasing cavity on the discharge side.

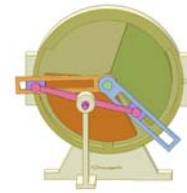


Pump with 4-bar mechanism 3

<http://youtu.be/RSAYvgL03po>

The arrows indicate the rotation direction of the sectors and the fluid moving direction. Each sector is fixed with a coulisse.

The rotating sectors create an expanding cavity on the suction side and a decreasing cavity on the discharge side.

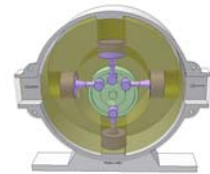


Pump with rotating cylinder

<http://youtu.be/Bu7000931oQ>

The arrows indicate the rotation direction of the yellow cylinder and the fluid moving direction. Green disk is fixed eccentrically on the case

The pistons create an expanding cavity on the suction side and a decreasing cavity on the discharge side.

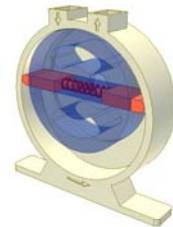


Pump with eccentric 3

<http://www.youtube.com/watch?v=w8MDLutvcZo>

The arrows indicate the rotation direction of the eccentric and the fluid moving direction.

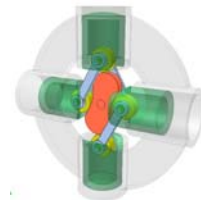
The eccentric creates an expanding cavity on the suction side and a decreasing cavity on the discharge side. The front cover is removed.



Cam mechanism of follower's planar motion 2

<http://youtu.be/sJoL85j44Ro>

The blue followers, connecting rods of ellipse mechanisms, have planar motion. This mechanism can be used for air compressors or engines.



Pump with eccentric ring 1

<http://youtu.be/LSklEa4tjrk>

Input: orange rotor.

Green ring is mounted eccentrically on the rotor.

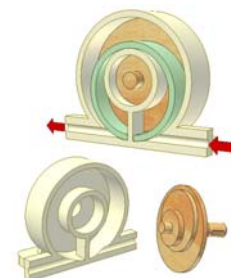
A vertical wall of the base prevents the green ring from rotating.

There should be a soft contact (elastic seal) between the ring and the wall.

The arrows show fluid flows.

An amount of fluid is sucked into the pump during its first revolution and discharged during the next revolution.

The pump is cut off half for easy understanding.



Scroll compressor

<http://youtu.be/V5sXKMqWw9s>

The grey disk with an Archimedean rib is fixed.

The green disk with the same rib receives motion from a pink eccentric shaft. Due to a Oldham mechanism with the orange disk the orientation of the green disk does not change during motion.

Suction place is at disk periphery and discharge one is at center of the fixed disk. For more see:

<http://www.youtube.com/watch?v=Nv1zAXKGkig>

The eccentricity of the pink shaft $e = (p - 2a)/2$

p: pitch of Archimedean spiral

a: thickness of the Archimedean rib

Instead of Archimedean spiral, other spirals can be used, for example, involute one.



Pump with rollers 1

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

Input: green rotor that rotates eccentrically in the housing.

Three pink rollers can slide in the rotor slots.

Centrifugal forces push the rollers toward the interior cylindrical surface of the housing.

The arrows show fluid flows.

The pump is cut off half for easy understanding.



Pump with eccentric 3

<http://youtu.be/f-0yLg63tml>

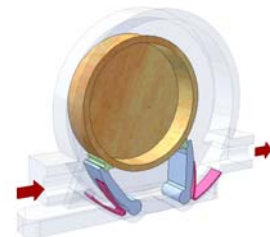
Input: orange rotor that rotates eccentrically in the housing.

Two blue levers with green cushions are forced toward the rotor by pink springs.

It is an application of a 4-bar linkage where green cushions are the connecting rods.

The arrows show fluid flows.

The pump is cut off half for easy understanding.



Pump with sliders 1a

<http://youtu.be/S7qE55UJJXI>

Input: green rotor that rotates eccentrically in the housing.

Orange sliders can slide in the rotor slots.

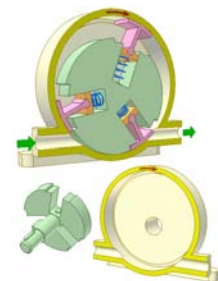
Pink sliders can slide in circular grooves of the housing.

There are revolution joints between orange sliders and pink ones.

It is an application of a coulisse mechanism where green rotor and pink sliders are the cranks.

The green arrows show fluid flows.

The pump is cut off half for easy understanding.



Pump with eccentric 4a

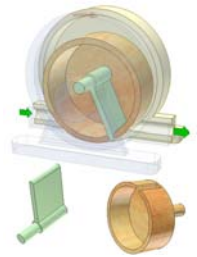
<http://youtu.be/t5BQStcdqTo>

Input: orange rotor that rotates eccentrically in the housing. Its bearing is located in the back half of the housing.

Green plate rotates concentrically in the housing. Its bearing is located in the front half of the housing.

There should be a soft contact (elastic seal) between the plate and the rotor.

The arrows show fluid flows.



Pump of three shafts

<http://youtu.be/jtWM5zclqfw>

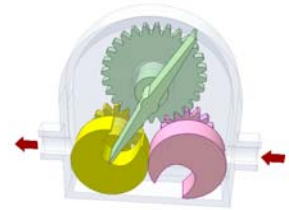
Input: green shaft

Curves on yellow and pink rotors are epitrochoids.

Tooth number of the green gear is twice the one of the other gears.

The arrows show fluid flows.

The pump is cut off half for easy understanding.



Pump with eccentric 4b

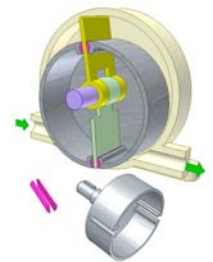
<http://youtu.be/OiSO7FKtITw>

Input: grey rotor that rotates eccentrically in the housing.

Its bearing is located in the back half of the housing.

Green and yellow plates rotate concentrically in the housing. The pink parts have revolution joints with the rotor. The violet shaft is fixed to the front half of the housing (not shown).

The arrows show fluid flows.



Pump of fixed disk cam

<http://youtu.be/DHJiK1lfzNc>

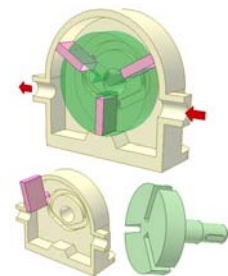
Input: green shaft

The pump housing has a groove (disk cam).

Each pink plate has a pin sliding in the groove.

The arrows show fluid flows.

The pump is cut off half for easy understanding.



Pump with sliders 1b

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

Input: green rotor that rotates eccentrically in the housing.

Pink sliders can slide in the rotor slots.

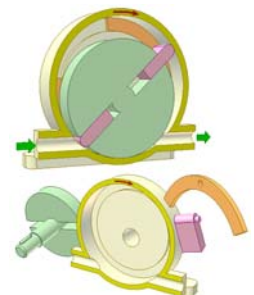
Orange sliders can slide in circular grooves of the housing.

There are revolution joints between orange sliders and pink ones.

It is an application of a coulisse mechanism where green rotor and pink sliders are the cranks.

The green arrows show fluid flows.

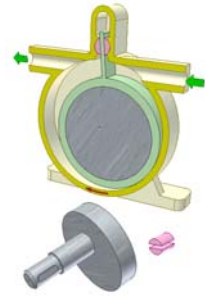
The pump is cut off half for easy understanding.



Pump with eccentric 5a

<http://youtu.be/BoXO-7R51co>

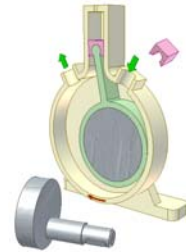
Input: grey rotor that rotates eccentrically in the housing.
Green conrod separates suction and discharge spaces of the pump.
The pink parts have revolution joints with the housing.
The arrows show fluid flows.
The pump is cut off half for easy understanding.



Pump with eccentric 5b

<http://youtu.be/LJDs5Er6zJs>

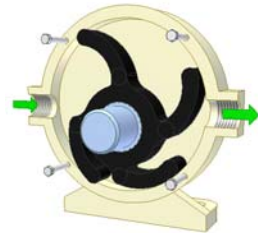
Input: grey rotor that rotates eccentrically in the housing.
Green conrod separates suction and discharge spaces of the pump.
The rotor, conrod and pink slider create a slider crank mechanism.
The arrows show fluid flows.
The pump is cut off half for easy understanding.



Flexible impeller pump 1a

<http://youtu.be/JtQ-0ZYkH2c>

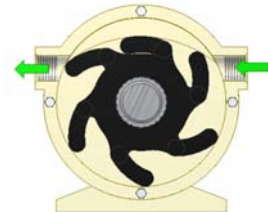
Black rubber impeller, eccentrically rotating clockwise in the housing, transports fluid from inlet to outlet. The front half housing is removed for easy understanding.
Green arrows show fluid flow.



Flexible impeller pump 1b

<http://youtu.be/x90OtAgbBp0>

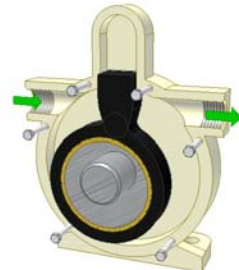
Black rubber impeller, concentrically rotating clockwise in the housing, thanks to inner noncircular profile of the housing, transports fluid from inlet to outlet. The front half housing is removed for easy understanding.
Green arrows show fluid flow.



Flexible impeller pump 2

<http://youtu.be/rV1cdVGnU5Y>

Grey shaft rotates anticlockwise in the housing. Black rubber impeller having revolution joint with an eccentric of the grey shaft, transports fluid from inlet to outlet. The front half housing is removed for easy understanding.
Green arrows show fluid flow.



Trochoid gear pump

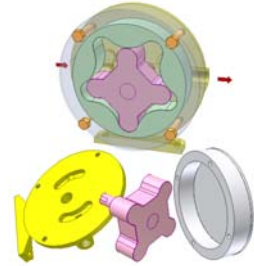
<http://youtu.be/Xd3s5xEPSIA>

A pin drive is applied for this pump. The pink driving rotor rotates 5 rev. while the green driven rotor rotates 4 rev.

Profile of the green rotor consists of trochoid curves.

If the pink driving rotor rotates clockwise the left space between teeth of the two rotors is of low pressure and the right one is of high pressure.

The two gears rotate clockwise. Red arrows show fluid flow.

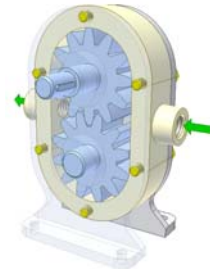


External gear pump

<http://youtu.be/EPCI8poQAol>

Liquid between teeth and housing wall is transported from inlet to outlet.

The upper gear rotates anti-clockwise. Green arrows show fluid flow.



External gear pump 2

<http://youtu.be/gp6SJiEsUu4>

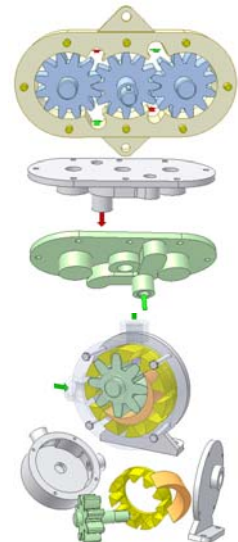
The driving middle gear rotates anti-clockwise.

Liquid between teeth and housing wall is transported from inlet (green arrows) to outlet (red arrows).

The inlet is on grey back cover.

The outlet is on green front cover.

In comparison with 2-gear pump, this 3-gear pump has double flow rate (like parallel connection of two 2-gear pumps).



Internal gear pump

<http://youtu.be/fZk87T9Tiy0>

Liquid in the space between teeth, orange fixed crescent and housing wall is transported from inlet to outlet.

The two gears rotate anti-clockwise. Green arrows show fluid flow.



Cable drive 23

<http://youtu.be/HoGTiXtCKmY>

A liquid pumpjack. The 4-bar mechanism converts continuous rotation to reciprocating rotation that the cable drive converts to reciprocating translation of a pump piston.

The ball valves open and close automatically due to fluid pressure alteration in the space under the piston.

When the piston moves up, the lower valve opens, the upper valve closes. The outside liquid is sucked into the space under the piston. The liquid above the piston is pushed up.

When piston moves down, the lower valve closes, the upper valve opens. The liquid is pressed from the space under the piston into the space above the piston.

For more about valve action see:

<http://www.youtube.com/watch?v=SFJFiyXTOa0>



Hand water pump 1a

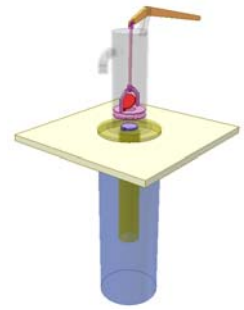
<http://youtu.be/8xv21E7XKBU>

Slider crank mechanism converts oscillation of orange crank to reciprocating translation of pink piston. Hand force is applied to the crank. Disk valves open and close automatically due to fluid pressure alteration in the space under the piston.

When the piston moves up, the lower valve opens, the upper valve closes. The outside liquid is sucked into the space below the piston. The liquid above the piston is pushed up and flows outside. When piston moves down, the lower valve closes, the upper valve opens. The liquid is pressed from the space below the piston into the space above the piston.

For more about valve action see:

<http://www.youtube.com/watch?v=SFJFiyXTOa0>



Hand water pump 1b

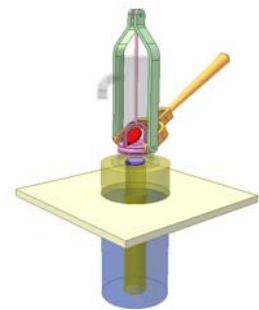
<http://youtu.be/NtMlwYN7EeU>

Slider crank mechanism converts oscillation of orange crank to reciprocating translation of pink piston. Hand force is applied to the crank.

Disk valves open and close automatically due to fluid pressure alteration in the space under the piston. When the piston moves up, the lower valve opens, the upper valve closes. The outside liquid is sucked into the space below the piston. The liquid above the piston is pushed up and flows outside. When piston moves down, the lower valve closes, the upper valve opens. The liquid is pressed from the space below the piston into the space above the piston.

For more about valve action see:

<http://www.youtube.com/watch?v=SFJFiyXTOa0>



Hand water pump 2a

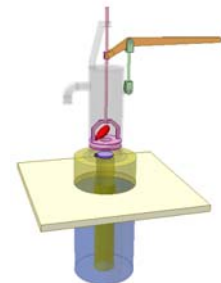
<http://youtu.be/adMu9Yo0nCA>

Slider crank mechanism converts oscillation of orange conrod to reciprocating translation of pink piston. Hand force is applied to the conrod.

Disk valves open and close automatically due to fluid pressure alteration in the space under the piston. When the piston moves up, the lower valve opens, the upper valve closes. The outside liquid is sucked into the space below the piston. The liquid above the piston is pushed up and flows outside. When piston moves down, the lower valve closes, the upper valve opens. The liquid is pressed from the space below the piston into the space above the piston.

For more about valve action see:

<http://www.youtube.com/watch?v=SFJFiyXTOa0>



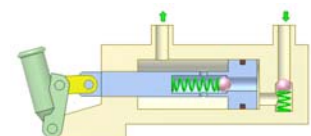
Hand piston pump 1

<http://youtu.be/5a-UdtYEVs>

Spring ball valves are operated automatically thanks to fluid pressure.

The arrows show fluid flows.

The cylinder and the piston are cut off half for easy understanding.



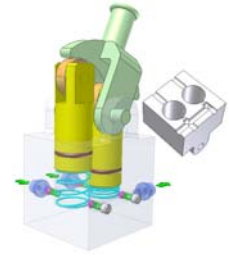
Hand piston pump 2

<http://youtu.be/cVwOS5cd4Oo>

Green double cam lever controls two pistons.

Spring ball valves are operated automatically thanks to fluid pressure.

The arrows show fluid flows.



Gravity engine 1

<https://www.youtube.com/watch?v=tsT-MVZudV4>

A way to bring some weights into action consecutively in a gravity engine.

Press pink arm, red slider moves back, to start the engine.

When the first yellow weight contacts cyan lever, it brings the second weight into action.

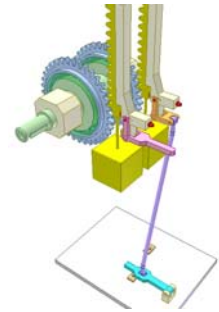
Turn the green shaft counterclockwise to get initial position.

Blue gears are connected to the output shaft by one-way clutches of ratchet pawl (or roller) type.

The output speed control device (retarder) is not shown.

Springs that force red sliders towards yellow racks are not shown.

Instead of rack pinion drive a cable drive can be used.



Speed control of spring motor

<http://youtu.be/ehjgr3AYKvM>

Orange leaf springs tend to get their neutral position and push violet flange to the left. Centrifugal forces of pink weights tend to move the violet flange to the right when the speed increases and cause the friction at the contact place between brown pad and violet flange.

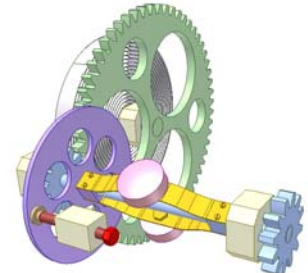
Grey coil spring tends to free accumulated elastic energy and to make the blue output shaft rotate very fast.

The said friction reduces speed of the output shaft.

Red screw sets position of the pad. Move pad to the right to increase the output speed.

This mechanism is used in gramophones.

It is possible to replace the gear drive by a worm drive of large lead angle.



Flyball governor for flow control.

<http://youtu.be/SiYEtnlZLSs>

A water turbine spins the governor, which control the water flow, which feeds the turbine, creating a speed-regulated machine.

When the flow is too strong, the water turbine and the violet governor shaft rotates faster than the set velocity. By centrifugal force, the green arms regulates the orange valve to reduce the flow.



28. Hydraulic and pneumatic mechanisms

Hydraulic lift 1

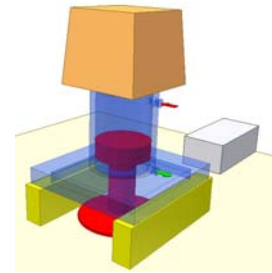
<https://www.youtube.com/watch?v=ITnEJLjQsAk>

This is a way to lift an object (in orange) to large height using cylinder of small stroke by alternately conducting pressure fluid into upper and lower spaces of the piston.

Yellow cushions support blue cylinder.

Grey cushions support red piston.

Arrows show fluid flows. Red arrow is for pressure flow.



Hydraulic cylinder with fixed piston

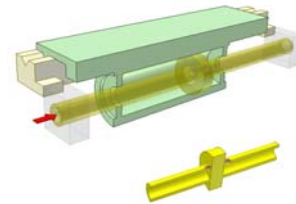
https://www.youtube.com/watch?v=yX_rCTcAPi4

Green cylinder with machine table reciprocates.

Pressure fluid is conducted into cylinder via holes on fixed piston rod. The hoses can be stationary.

In case using holes on the cylinder the hoses have to move with the cylinder.

The arrows show flows of pressure fluid.



Hydraulic telescopic cylinder

<http://youtu.be/icaqvAtccY>

Red arrow shows pressure flow.

The gravity brings pistons to their lowest positions.



Hydraulic cylinder with three piston positions

http://youtu.be/SPD62mJ_ViM

By alternately conducting pressure fluid into cylinder through its three holes the pink piston can reach one of its three stable positions: center, left and right.

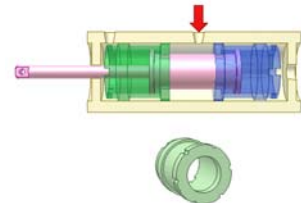
Green and blue floating pistons are identical.

The arrows show flows of pressure fluid.

When pressure fluid enter through the medium hole, green and blue pistons are pushed apart from each other, pink piston gets center position.

When pressure fluid enter through the left hole, pink and blue pistons are pushed to the right, pink piston gets right position.

When pressure fluid enter through the right hole, pink and green pistons are pushed to the left, pink piston gets left position.



Liquid dispenser 1

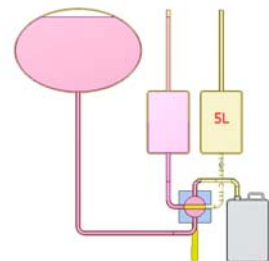
<http://youtu.be/4fbc1ISroU>

Liquid from the oval tank flows to two meter containers and then to the grey bottle alternately subject to handle positions of the blue four port valve.

The principle of communicating vessels is applied here.

No electricity is required.

Volume error depends on the oscillation of liquid level in the oval tank and the inside diameter (should be minimum) of the air pipes of the meter containers.

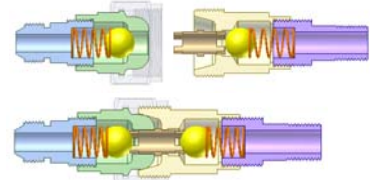


Pipe connection 1

<http://youtu.be/Nn4P3z589B4>

In disconnected state the fluid can not flow out due to the contact of yellow balls with green and popcorn parts under spring forces.

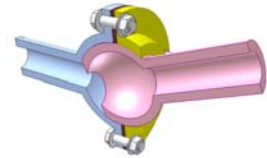
In connected state brown part pushes the balls, thus prevent the above mentioned contact and the fluid flows through holes on the brown part. Most parts are cut off half for easy understanding.



Pipe movable connection 1

<http://youtu.be/DwrlPPTBrPA>

Spherical joint, arranged for tubing.
The brown gasket is for sealing.



Liquid dispenser 2

<http://youtu.be/4E1AnCBeeQ4>

The upper surface of yellow cup at its lowest position is lower than the liquid surface in the tank. So the cup is filled fully with the liquid.

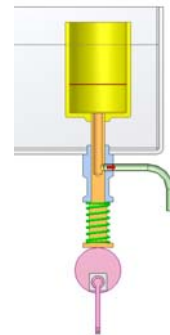
Turn pink cam to raise the cup to its highest position to get:

1. The coincidence of cross holes on the orange bar and on the blue support.
2. The upper surface of yellow cup is higher than the liquid surface in the tank.

Then the liquid amount contained in the cup flows out through green pipe (red arrow). The red line shows liquid surface in the cup.

For dispenser of large liquid amount see "Liquid dispenser 1":

<http://youtu.be/4fbcr1ISroU>



Liquid dispenser 3

http://youtu.be/m_8wjkpjYLY

Pink continuously rotating cam moves green cylinder to pump out a determined liquid amount during each revolution.

Ball valves are operated automatically thanks to fluid pressure and their own weights. Orange screw is for adjusting liquid amount to be pumped. Red arrow shows time when the liquid flows out.



Swinging cylinder

<http://youtu.be/Hlq3ZeaeoGU>

A way to connect fluid to a swinging cylinder.

Fluid enters and leaves the swinging cylinder through its stationary pivot so flexible pipes are not needed.

All pink parts are stationary. The arrows show fluid flows.



Rotary cylinder

<http://youtu.be/ytR2ku1wBgA>

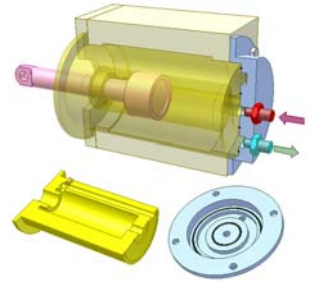
A way to connect fluid to a rotary cylinder.

The red fitting is connected to the rear cylinder space through rear center hole of the cylinder.

The cyan fitting is connected to the front cylinder space through circular groove on the inner face of the blue connector and long eccentric hole of the cylinder.

It is possible to arrange the groove on cylindrical surface.

The cylinder and the piston rotate together with an operational device (not shown). The arrows show fluid flows.



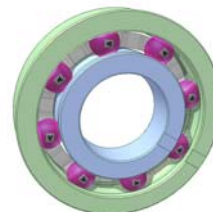
29. Study of mechanisms

29.1. Mechanical joints

Ball bearing simulation 1

<http://www.youtube.com/watch?v=hxUXX0tYMHM>

Outer race stationary



Ball bearing simulation 2

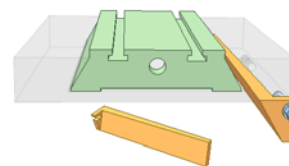
<http://www.youtube.com/watch?v=hxUXX0tYMHM>

Inner race stationary

Wedge mechanism 17

<http://youtu.be/I3PPtIjC8>

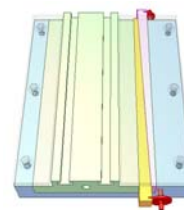
The gap between the green slider and the runway is adjusted by moving the orange wedge. The slopes on the wedge and on the runway are equal.



Wedge mechanism 28

<http://youtu.be/rM8FcOcZ9M8>

The gap between the green slider and the runway is adjusted by moving the orange and pink wedges. The slopes on the wedges are equal.



Stamp joint

<http://youtu.be/Wk-JYJHr6u0>

Insert and turn the brass stamp for fixing it to green handle.
Helical groove on the handle and a pin on the stamp are key factors.



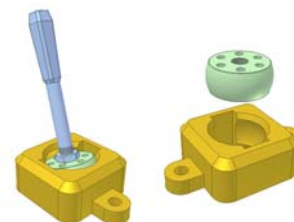
Assembling sphere joint having unsplit outer part

<http://youtu.be/qWzPxNvG0Dw>

Length of rectangular slot on the yellow outer part must be larger than the diameter of green sphere.

For drawings see:

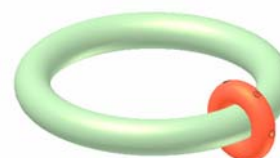
<http://meslab.org/mes/showthread.php?p=93888#post93888>



Mechanical Torus Joint 1

<http://youtu.be/uCEPAw4jxCA>

The joint allows two degrees of freedom (rotations) of relative movement.



Mechanical Torus Joint 2

<http://youtu.be/mHkdwnrhsPU>

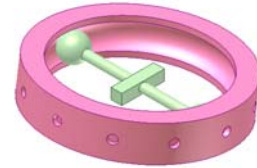
The joint allows two degrees of freedom (rotations) of relative movement.



Mechanical Torus Joint 3

<http://youtu.be/BbsGHSC1i5c>

The joint allows two degrees of freedom (rotations) of relative movement.



Helix torus joint 1a

<http://youtu.be/3Yw3Hr9WKdg>

There are a helix groove of half rev. ($n = 1/2$) on the big torus. The small torus makes 1 rev. around its axis during 2 rev. around the big torus axis. In other words, the small torus has two interdependent rotary motions.

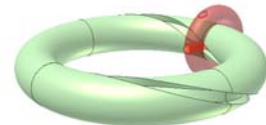
It is case of Mobius strip (figure on the upper left corner), an ant must crawl two rev. to get the start point.



Helix torus joint 1b

<http://youtu.be/CvsviKzNogs>

There are a helix groove of two rev. ($n = 2$) on the big torus. The small torus makes 2 rev. around its axis during 1 rev. around the big torus axis.



Helix torus joint 1c

<http://youtu.be/6vWSI5JYUoI>

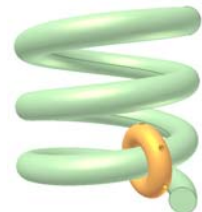
There are a helix groove of one third rev. ($n = 1/3$) on the big torus. The small torus makes 1 rev. around its axis during 3 rev. around the big torus axis.



Helix torus joint 2

<http://youtu.be/6s-giKB1TBE>

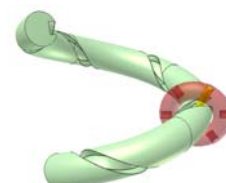
The orange torus can turn around its own axis. It has also a helical motion around axis of the green spring-shaped part. So this joint has two degrees of freedom.



Helix torus joint 3

http://youtu.be/glGF-C_5FNE

The red torus carrying a pin has two interdependent helical motions around its own axis and around axis of the green spring-shaped part. The pin slides in a helical groove of the green spring-shaped part.



29.2. Planar mechanisms

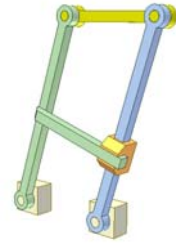
Equivalency of parallelogram and Oldham mechanisms

<http://youtu.be/wi0NyZNd7I4>

When removing orange slider, it is a parallelogram mechanism.

When removing yellow conrod, it is a Oldham mechanism.

For both cases the motion transmission between two rockers is the same.



Four bar linkage 8a

<http://youtu.be/ADofvwxYImA>

A special case of the 4-bar linkage.

Input: pink crank

Output: green crank.

The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the input. Output oscillating angle is larger than 180 deg., a thing that is hard to get by using an ordinary 4-bar linkage. It happens because:

1. The sum of the lengths of the two adjacent links is equal to the sum of the lengths of the other two links.

$$A + B = C + D$$

A: length of pink crank (=10)

B: length of yellow conrod (=40)

C: length of green crank (=20)

D: distance between fixed axes of pink and green cranks (=30)

2. There are measures to overcome dead position (when green crank and yellow conrod are in line). For example, inertia of the green crank must be big enough.



Four bar linkage 8b

<http://youtu.be/Y5IMzmEPOX0>

A special case of the 4-bar linkage.

Input: pink conrod.

Output: oscillating green and yellow cranks.

The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the driving crank (in pink) Output oscillating angles are larger than 180 deg., a thing that is hard to get by using an ordinary 4-bar linkage. It happens because:

1. The sum of the lengths of the two adjacent links is equal to the sum of the lengths of the other two links.

$$A + B = C + D$$

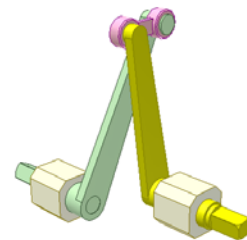
A: length of green crank (=40)

B: length of pink conrod (=10)

C: length of yellow crank (=36)

D: distance between fixed axes of cranks (=14)

2. There are measures to overcome dead positions (when cranks are in line with pink conrod). For example, inertia of the cranks must be big enough.



Four bar linkage 8c

<http://youtu.be/BOJSJvOUyAE>

A special case of the 4-bar linkage.

Input: pink crank.

Output: green crank rotating irregularly.

The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the input. It happens because:

1. The sum of the lengths of the two adjacent links is equal to the sum of the lengths of the other two links.

$$A + B = C + D$$

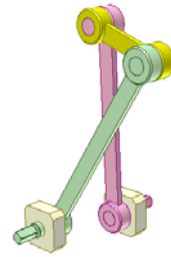
A: length of pink crank (=35)

B: length of yellow conrod (=15)

C: length of green crank (=40)

D: distance between fixed axes of cranks (=10)

2. There are measures to overcome dead positions (when the cranks are in line with yellow conrod). For example, inertia of the cranks must be big enough.



Four bar linkage 9a

http://youtu.be/nP_tGreHHEY

A special case of the 4-bar linkage.

Input: pink crank.

Output: oscillating green crank.

The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the input. Output oscillating angles are larger than 180 deg., a thing that is hard to get by using an ordinary 4-bar linkage. It happens because:

1. The sum of the lengths of the two opposite links is equal to the sum of the lengths of the other two links.

$$A + B = C + D$$

A: length of pink crank (=10)

B: length of green crank (=40)

C: length of yellow conrod (=35)

D: distance between fixed axes of cranks (=15)

2. There are measures to overcome dead positions (when green crank is in line with yellow conrod). For example, inertia of the green crank must be big enough.



Four bar linkage 9b

<http://youtu.be/Agg7tl4ife8>

A special case of the 4-bar linkage.

Input: pink crank.

Output: green crank rotating irregularly.

The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the input. It happens because:

1. The sum of the lengths of the two opposite links is equal to the sum of the lengths of the other two links.

$$A + B = C + D$$

A: length of pink crank (=15)

B: length of green crank (=35)

C: length of yellow conrod (=40)

D: distance between fixed axes of cranks (=10)

2. There are measures to overcome dead positions (when green crank is in line with yellow conrod). For example, inertia of the green crank must be big enough.



Four bar linkage 9c

<http://youtu.be/4rTbsT7hTcg>

A special case of the 4-bar linkage.

Input: pink conrod.

Output: oscillating cranks.

The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the input. Oscillating angle of the yellow crank is larger than 180 deg., a thing that is hard to get by using an ordinary 4-bar linkage. It happens because:

1. The sum of the lengths of the two opposite links is equal to the sum of the lengths of the other two links. $A + B = C + D$

A: length of pink conrod (=10)

B: length of green crank (=35)

C: length of yellow crank (=15)

D: distance between fixed axes of cranks (=40)

2. There are measures to overcome dead positions (when cranks are in line with pink conrod). For example, inertia of the cranks must be big enough.



Study of parallelogram mechanism 1a

<http://youtu.be/wraqhhhe-h8>

Two mechanisms are identical.

Lengths of three cranks are equal.

Yellow, green and blue links create a parallelogram.

Input: yellow cranks. Output: orange cranks.

Besides the dead positions (when the cranks and the bars are in line) the mechanisms have unstable positions when the cranks are perpendicular to white and green bars.

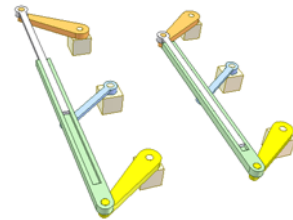
When the mechanisms overcome unstable positions output motions may change.

The mechanisms can work stably in the range of less than 90 deg. of the input.

For the left mechanism the input and output turn in opposite directions.

For the right mechanism the input and output turn in the same direction.

This phenomenon depends on initial relative position between input and output cranks.



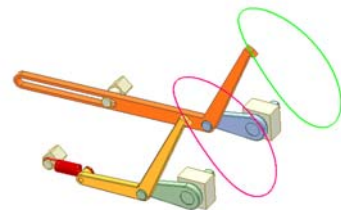
Spring linkage mechanism 1

<http://youtu.be/XVoarCYMIVc>

The behind is a coulisse mechanism. The front one is the same but the prismatic joint is replaced by a pull spring.

Tips of the orange levers trace similar curves.

However different loads applied to the orange lever of the spring mechanism may alter curve shape.



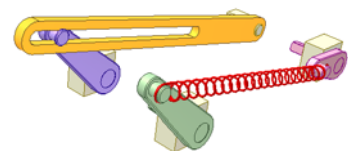
Spring linkage mechanism 2

<http://youtu.be/wVKjmL3iOQo>

The behind is a coulisse mechanism. The front one is the same but the prismatic joint is replaced by a pull spring.

The orange lever and the pink crank oscillate with similar motion rules.

However loads applied to the pink crank of the spring mechanism may alter its motion rule.



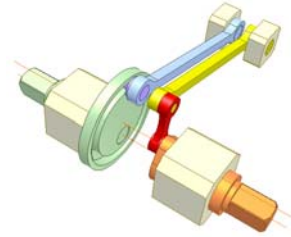
Equivalency of circular cam and linkage mechanisms 1

https://www.youtube.com/watch?v=AO_h10UqLIQ

Eccentricity of the green circular cam = length of the orange crank

Radius of cam pitch circle = length of the red conrod.

The blue follower and the yellow rocker have the same motion.



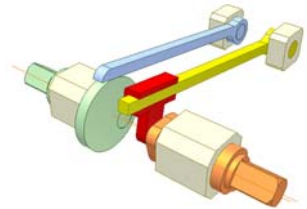
Equivalency of circular cam and linkage mechanisms 3

<https://www.youtube.com/watch?v=4DyP4Vo6cVU>

Eccentricity of the green circular cam = length of the orange crank

Radius of cam circle = length of the red conrod.

The blue follower and the yellow slider have the same motion.



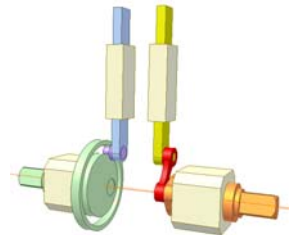
Equivalency of circular cam and linkage mechanisms 2

<http://youtu.be/DQB1pY3lt08>

Eccentricity of the green circular cam = length of the orange crank

Radius of cam pitch circle = length of the red conrod.

The blue follower and the yellow slider have the same motion.



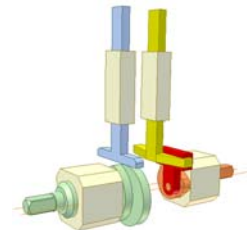
Equivalency of circular cam and linkage mechanisms 4

<http://youtu.be/DQB1pY3lt08>

Eccentricity of the green circular cam = length of the orange crank

Radius of cam circle = length of the red conrod.

The blue follower and the yellow slider have the same motion.



29.3. Spatial mechanisms

Space 4-bar mechanism 10

<http://youtu.be/q433oAXwHuU>

Bennett 4R mechanism

It is Bennett 4R mechanism (not spherical 4R mechanism)

4R: 4 revolute joints. It does not meet Kutzbach criterion.

The conditions that the mechanism must satisfy to be able to move:

1. The opposite sides of the mechanism (i.e. links that are not concurrent) have the same lengths, denoted by a, b.
2. The angles of twist are denoted by A, B and they are equal on opposite sides but with different sign.
3. The link lengths and link twist angles must satisfy the relation:

$$\sin A/a = \sin B/b$$

For the blue and yellow (fixed) link: $a = 17.599$, $A = 15^\circ$.

For the orange and green link: $b = 34$, $A = 30^\circ$.



Space 4-bar mechanism 1

<http://youtu.be/9mcEF2s8QZU>

R-C-C-C mechanism. Input: the orange link. Output: the green link.

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

R: revolute

C: cylinder



Space 4-bar mechanism 2

<http://youtu.be/nK66lwNJG78>

P-C-C-C mechanism. Input: the orange link. Output: the green link.

P-C-C-C: Joint symbols from input to output joint.

P: prism

C: cylinder



Space 4-bar mechanism 3

<http://youtu.be/aUilcT74mXM>

H-C-C-C mechanism. Input: the orange link. Output: the green link.

H-C-C-C: Joint symbols from input to output joint.

H: helix

C: cylinder



Space 4-bar mechanism 4

<http://youtu.be/xZcAUtW8XVc>

R-S-C-R mechanism. Input: the orange link. Output: the green link.

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

R: revolute

S: sphere

C: cylinder



Space 4-bar mechanism 5

<http://youtu.be/nJyS6zxSsMo>

R-S-C-P mechanism. Input: the orange link. Output: the green link.

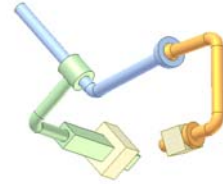
R-S-C-P: Joint symbols from input to output joint.

R: revolute

S: sphere

C: cylinder

P: prism



Space 4-bar mechanism 6

<http://youtu.be/Gg8Q6nUZc1c>

R-S-C-H mechanism. Input: the orange link. Output: the green link.

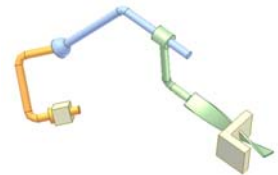
R-S-C-H: Joint symbols from input to output joint.

R: revolute

S: sphere

C: cylinder

H: helix



Space 4-bar mechanism 7

http://youtu.be/H_5D9wsdPM4

P-P-S-C mechanism. Input: the orange link. Output: the green link.

P-P-S-C: Joint symbols from input to output joint.

P: prism

S: sphere

C: cylinder



Space 4-bar mechanism 8

<http://youtu.be/4k5WcYcqoQg>

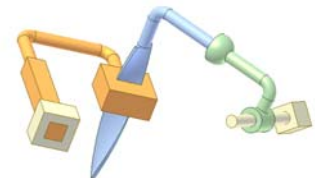
R-H-C-H mechanism. Input: the orange link. Output: the green link.

R-H-C-H: Joint symbols from input to output joint.

R: revolute

H: helix

C: cylinder



Space 4-bar mechanism 9

<http://youtu.be/aiAdhly2Guo>

H-H-S-C mechanism. Input: the orange link. Output: the green link.

H-H-S-C: Joint symbols from input to output joint.

H: helix

S: sphere

C: cylinder



Space 4-bar mechanism 12

http://youtu.be/m0xG_u63WH0

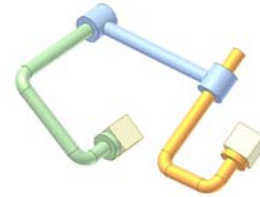
R-C-C-R mechanism

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

R: revolute

C: cylinder

It does not meet Kutzbach criterion.



Space 4-bar mechanism 13

<http://youtu.be/ccvYpANAWPE>

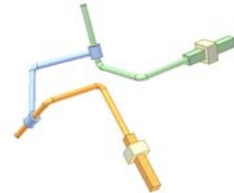
P-C-C-P mechanism

P-C-C-P: Joint symbols from input to output joint.

P: prism

C: cylinder

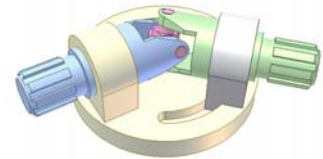
It does not meet Kutzbach criterion.



Study of Cardan universal joint 1

<http://youtu.be/ZQt6cAmsgXQ>

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

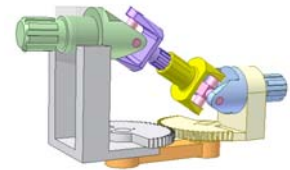


Study of double cardan universal joint 1a

http://youtu.be/gBoJT_PI-RA

Double Cardan drives allow to adjust relative linear positions between the input and output shafts even during rotary transmission. The output velocity is always equal to the input one (constant velocity joint) because their shafts are kept parallel each other.

The pin axes on the intermediate half shafts (in yellow and in violet) must be parallel each other.



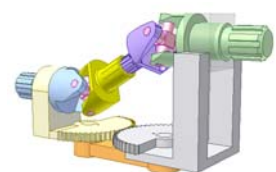
Study of double cardan universal joint 1b

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

This is wrong case of a double Cardan joint: the pin axes on the intermediate half shafts (in yellow and in violet) are perpendicular each other.

The joint loses the feature of velocity constant when the input and output shafts are not in a straight line although they are kept parallel each other.

So pay attention to assembling the intermediate shaft.



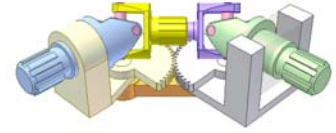
Study of double Cardan universal joint 2a

<http://youtu.be/cydmR0IX2t8>

Double Cardan joints allow to adjust angle A between input and output shafts even during rotary transmission. This case shows $\pm 90^\circ$ deg regulation and proves that double Cardan joints are of constant velocity.

Due to the gear planetary drive of two gear sectors and orange crank, angle between input (or output) shaft and the yellow intermediate shaft is always equal to $A/2$.

The pin axles on the yellow-violet intermediate shaft must be parallel each other.



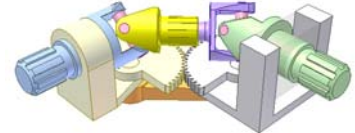
Study of double Cardan universal joint 2b

<http://youtu.be/lftUsogU4AQ>

This is wrong case of a double Cardan joint: the pin axles on the yellow-violet intermediate shaft are perpendicular each other.

Although due to the gear planetary drive of two gear sectors and orange crank, angle between input (or output) shaft and the yellow intermediate shaft is always equal to $A/2$ (A is angle between input and output shafts), the joint loses the feature of velocity constant when the input and output shafts are not in a straight line (A differs from 0°).

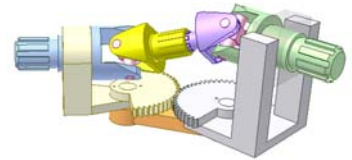
So pay special attention to assembling the intermediate shaft.



Study of double Cardan universal joint 3

<http://youtu.be/Qf88nPtm2h4>

Double Cardan joints allow to adjust relative positions between the input and output shafts even during rotary transmission. This is case when the input and output shafts are skew. The joint loses the feature of velocity constant. The output velocity is not constant.



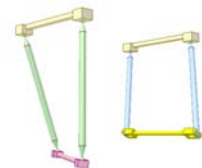
Study of spatial parallelogram mechanism 1a

<http://youtu.be/uP6lyl5OqtY>

There are two spatial parallelogram mechanisms (lengths of opposite links are equal).

For the left one of 4 spherical joints the opposite links may be not parallel during motion.

For the right one of 2 spherical and 2 revolute joints the opposite links are always parallel. Direction of longitudinal axis of the yellow conrod is kept unchanged during motion.



Study of spatial parallelogram mechanism 1b

<http://youtu.be/DgVxKULp6zE>

Blue and green rockers, yellow conrod and the base create a parallelogram.

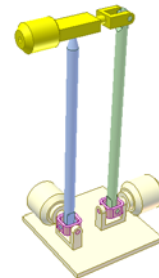
The two rockers are connected to the base by universal joints of 2 degrees of freedom.

The yellow conrod is connected to the green rocker by a revolute joint and to the blue rocker by a spherical joint.

The mechanism has two degrees of freedom (by computer testing) so two actuators are needed for controlling two pink frames.

Longitudinal axis direction of the yellow conrod is kept unchanged during motion. However its upper surface is not kept always horizontal.

The yellow conrod with two revolute joints has been tested but no success.



Study of spatial parallelogram mechanism 1c

<http://youtu.be/KyBAxYmBmYA>

Long bars are identical.

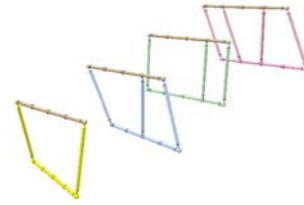
Short bars are identical.

Brown bars are fixed.

All joints are spherical.

The video shows 4 mechanisms during motion.

1. The yellow one in general can not always gives a parallelogram.
2. The blue one in general can not always gives a parallelogram.
3. The green one always gives a variable parallelogram (distance between two long bars is variable).
4. The pink one of one DoF always gives a stable, invariable parallelogram.



Study of spatial parallelogram mechanism 2a

<http://youtu.be/gnFIyQgdm0>

Lower and upper regular triangle plates are identical.

Green vertical bars are identical.

All joints are spherical.

When the upper plate moves, it may not be parallel to the lower plate.

Computer testing shows that the mechanism has 3 degrees of freedom (DoF) excluding passive DoF (rotation of each bar around the line joining its two joints).



Study of spatial parallelogram mechanism 2b

<http://youtu.be/R38F202W0eY>

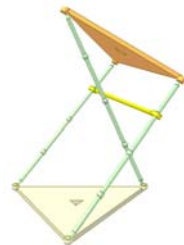
Lower and upper plates are identical.

Green vertical bars are identical.

All joints are spherical.

Distance between two joints of the plates and of yellow horizontal bar are equal.

In general lower and upper plates are kept parallel but there is the case shown in this video.



Study of spatial parallelogram mechanism 2c

<http://youtu.be/tttYnzX1t74>

Lower and upper plates are identical.

Green vertical bars are identical.

All joints are spherical.

Distance between two joints of the plates and of yellow horizontal bars are equal.

Lower and upper plates are always parallel.

Computer testing shows that the mechanism has 2 degrees of freedom (DoF) excluding passive DoF (rotation of each bar around the line joining its two joints)..



30. Sundries

30.1. Springs

Using compression spring to bear tension 1

<http://youtu.be/KU4JKCrpjGw>

Reason: the hooks of a extension spring are difficult for production and easy to be broken in operation.



Using compression spring to bear tension 2

<http://youtu.be/7QWoF76HuXs>

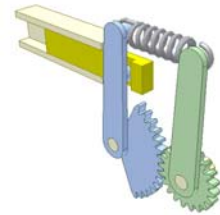
Reason: the hooks of a extension spring are difficult for production and easy to be broken in operation.



Spring increased tension

http://youtu.be/m_XVJT-4T4o

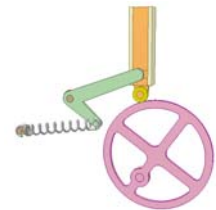
Increased tension for the same movement is gained by providing a movable spring mount and gearing it to the other movable lever.



Constant tension from spring 1

<http://youtu.be/YzvwrYgNOH0>

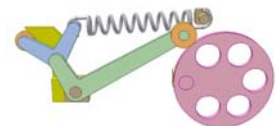
The spring force applied along the orange slider is nearly constant because when the spring length is increased, the action radius of spring force around the pivot of green lever is reduced.



Constant tension from spring 2

<http://youtu.be/W8R-BN6WXXg>

Spring constant tension for large movement of the green lever is gained by providing a movable spring mount on the blue lever that is controlled by the yellow stationary cam.



Spring combination 2

<http://youtu.be/HX0Rd2NpduY>

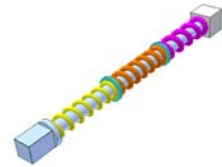
This compressing mechanism has a dual rate for double-action compacting. In one direction pressure is high, but in the reverse direction pressure is low.



Spring combination 1

<http://youtu.be/UOnMKvGGW3U>

This mechanism provides a three-step rate change at predetermined positions. The lighter springs will always compress first, regardless of their position.



Spring damping mechanism 1

<http://youtu.be/qaHBql6ycaE>

Two springs at both sides of a piston play anti-shock role well.



30.2. Sundries

Hammer for striking bell 1

<http://youtu.be/gT-QpkZ6dA>

Arrangement of hammer for striking bells. Spring below the hammer raises it out of contact with the bell after striking and so prevents it from interfering with the vibration of the metal in the bell.



Hammer for striking bell 2

<http://youtu.be/xikwuK-axb8>

Input: green gear rotating continuously.

Output: pink oscillating shaft having a flat spring and a hammer.



Rotary table 1

<http://youtu.be/JcLWmeCcTTI>

Violet piston makes orange table go up and down.

At any height the table can receive the rotation from a stationary motor via belt drive and two long pins that can slide in two tubes of blue pulley.



Rotary table 2

<http://youtu.be/Ghtlc-rLfbE>

Bevel gear drive makes orange table go up and down.

At any height the table can receive the rotation from a stationary motor via belt drive and two long pins that can slide in two tubes of blue pulley.



Passing river by its flow

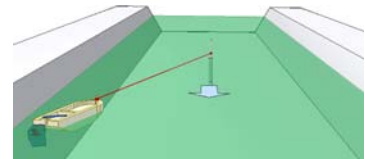
<http://www.youtube.com/watch?v=ctT6mFDIHJl>

Illustration of movement 447 in the book "507 mechanical movements", 1908

"This method of passing a boat from one shore of a river to the other is common on the Rhine and elsewhere, and is affected by the action of the stream on the rudder, which is carries the boat across the stream an the arc of a circle, the center of which is the anchor which is holds the boat from floating down the stream."

The big arrow shows the flow direction.

The small arrow shows the direction of the flow's force that applies to the rudder and pushes the boat.



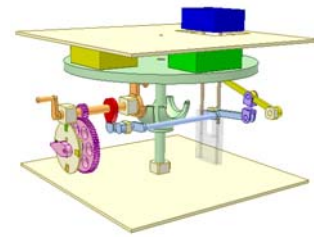
Magic chest 1

<http://youtu.be/aJnnoExw77s>

It is a toy. Once opening the chest (its cover and surrounding plates are not shown) a box among blue, green, yellow and orange ones appears. Turn orange crank to select the target box based on its color shown on the dial.

Spatial Geneva mechanism is applied here.

This toy was made on request of Mr. Mladen Radolovic from Croatia.



Inventor dragonfly

<http://www.youtube.com/watch?v=iQEK0CuneTY>

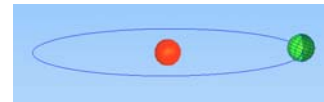
Stable balance. The center of gravity is lower than the fulcrum.



Inventor Earth motion

<http://www.youtube.com/watch?v=atf-vuDhC58>

When the Earth is on the right, it is Summer in the Northern hemisphere.



Inventor writing robot

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

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

For details see:

<http://meslab.org/mes/threads/21088-Robot-viet-chu-meslab>

