Nguyen Duc Thang

2700 ANIMATED MECHANICAL MECHANISMS

With

Images,
Brief explanations
and YouTube links

Part 3
Mechanisms of specific purposes

Renewed on 31 October 2017

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

Autodesk Inventor is used to create all videos in this document.
They are available on YouTube channel "thang010146".

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

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

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

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

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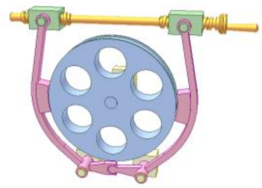
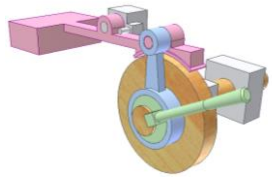
11. Brakes

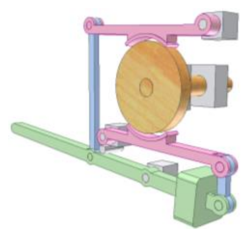
Nut-screw and bar mechanisms 6
http://youtu.be/_q5iKo63rjQ
Nut-screw brake.



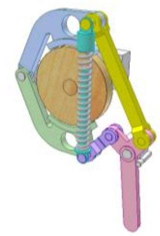
Shaft brake 1
https://youtu.be/Yn6FK7_5VjI
It is an application of 4-bar linkage.
Turn green lever to force pink brake shoes on orange drum for braking orange shaft.
The lever is fixed to an eccentric that has revolution joints with the shaft and blue conrod.
Although only one brake shoe is used but total bending force applied to the shaft is inconsiderable.



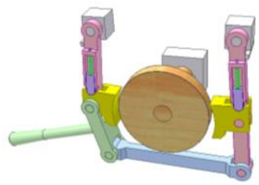
Shaft brake 2
https://youtu.be/TGLrUAvWDP4
It is an application of two 4-bar linkages.
Push down green lever to force pink brake shoes on orange drum for braking orange shaft.
Total bending force applied to the shaft is inconsiderable thanks to symmetric arrangement of the brake shoes.



Shaft brake 3
https://youtu.be/NDSj0KV6OvU
Turn pink lever clockwise to force blue and green brake shoes to orange drum for braking orange shaft.
Total bending force applied to the shaft is inconsiderable thanks to symmetric arrangement of the brake shoes.
Pushing spring (in grey) prevents the brake shoes from contact with the drum when not braking.



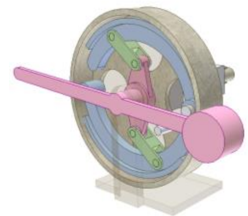
Shaft brake 4
https://youtu.be/39gu_7dTpkA
Turn green lever clockwise to force yellow brake shoes to orange drum for braking orange shaft.
Total bending force applied to the shaft is inconsiderable thanks to symmetric arrangement of the brake shoes.
Spring sliders (in violet) prevent the yellow shoes from contact with the drum when not braking.



Shaft brake 5

https://youtu.be/EiRoXm_SeYE

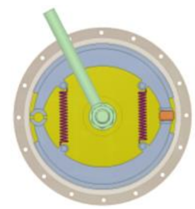
Turn pink lever counter-clockwise to force blue brake shoes to inner surface of brown rim for braking brown shaft.
Total bending force applied to the shaft is inconsiderable thanks to symmetric arrangement of the brake shoes.
A weight on the pink lever prevents the shoes from contact with the rim when not braking.



Motorcycle brake 1

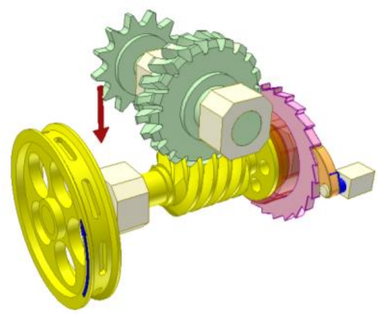
https://youtu.be/RwI1PthoGEY

Turn orange cam to force blue brake shoes to inner surface of grey hub for braking the motorcycle wheel.
Yellow brake body is fixed to the motorcycle fork (in green).
The cam is controlled by a pedal or by a handlebar lever



Automatic brake in worm hoist

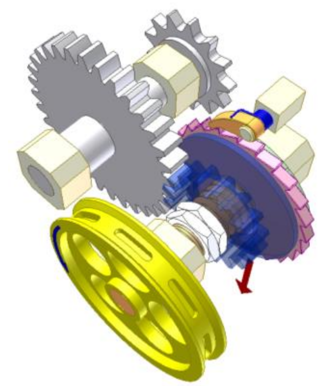
http://youtu.be/llm5aJLaSCs



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

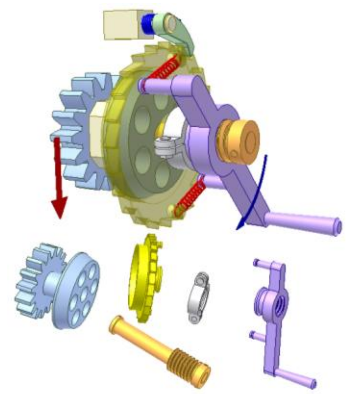
http://youtu.be/5X9SoTP1z2E



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

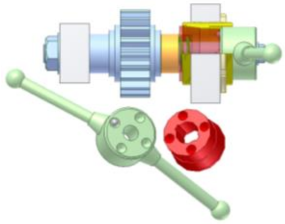
http://youtu.be/6QsLCAuC_B0



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 rotates 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

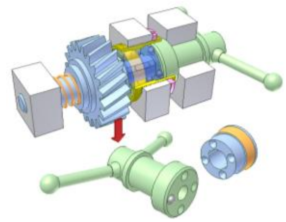
http://youtu.be/IUntUq-0MBc



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

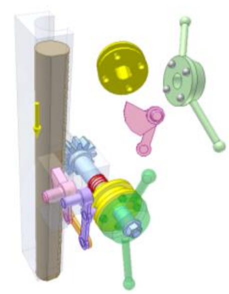
http://youtu.be/aUO9Kyoj90E



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

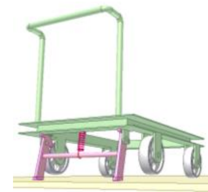


When torque in any direction is applied to green crank, four balls try to move red bush towards. The later via 4 bar linkage stops contact between pink eccentric cam and brown rack-slider, the crank rotating together with the blue gear shaft moves the rack-slider up down. The torque is transmitted to 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.

Parking brake for trolley

https://youtu.be/QayULYC79-A

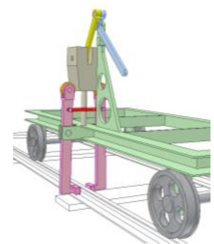
Raise the trolley and move forward the pink stand for unbraking.
Raise the trolley and move backward the pink stand for braking.



Parking brake for railway cart

https://youtu.be/g-NSih-IlII

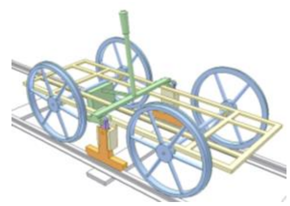
The brown weight causes braking forces applied to the rail. Thanks to a small gap in cylindrical joint between the weight and green chassis both pink brake bars can contact the rail at the same time.
Red spring ensures no contact between the brake bars and the rail when unbraking.
The weight, yellow conrod and blue lever create a slider crank mechanism.



Hand brake for rail cars

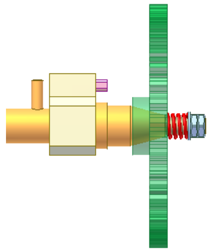
https://youtu.be/TM6ke9y5QmY

It is an application of slider crank mechanism.
The friction between orange brake shoes and the railway creates brake force.

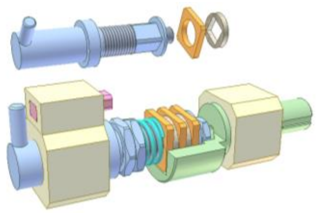


12. Safety clutches

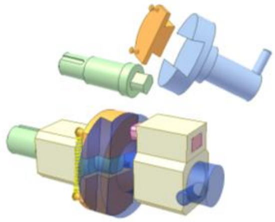
Safety clutch 3
http://youtu.be/b6uouA9Pqzo
A cone clutch is formed by mating a taper on the shaft to a bevel central hole in the gear. Increasing compression on the spring by tightening the nuts increases the drive's torque capacity.
An overload condition ir represented by the pink slider position.



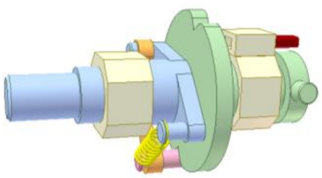
Safety clutch 4
http://youtu.be/Rrpg253rWto
Friction disks are compressed by an adjustable spring. Square disks are locked into the square hole in the right shaft and round disks onto the square rod on the left shaft.
An overload condition ir represented by the pink slider position.



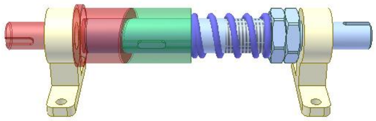
Safety clutch 5
http://youtu.be/YSp9pUJTfZI
Sliding wedges clamp down on the flattened end of the shaft. They spread apart when torque becomes excessive. The strength of the springs in tension that hold the wedges together, sets the torque limit.
An overload condition ir represented by the pink slider 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.

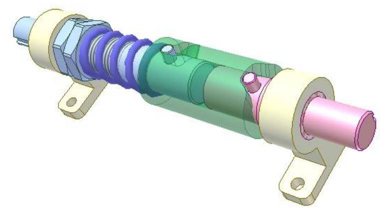


Safety clutch 7
http://youtu.be/ynfwLNaXU08
A cylinder cut at an angle forms a torque limiter. A spring clamps the opposing-angled cylinder faces together and they separate from angular alignment under overload conditions. The spring tension sets the load limit.
The animation has a weakness: the spring does not rotate as in reality.



Safety clutch 8

http://youtu.be/6-cJUOWY9q8

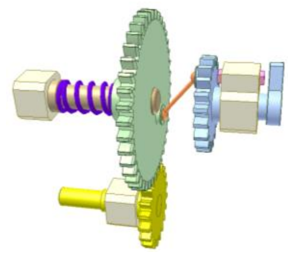


A cammed sleeve (green) connects the input (pink) and output (blue) shaft of this torque limiter. A driven pin (blue) does not allow the sleeve move to the right. When an overload occurs, the driving pin (pink) pushes the sleeve to the left and the driven pin (blue) drops into the L-shaped slot to keep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

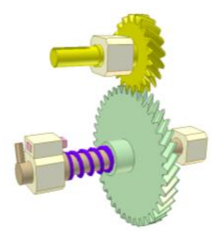


Input: yellow shaft. The axial force of a spring and the orange driving arm are in balance. An overload condition (represented by the pink slider position) overcomes the spring force to slide the green gear out of engagement.

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

Safety clutch 10 (helical gears)

http://youtu.be/sg9AjzaD7Ts

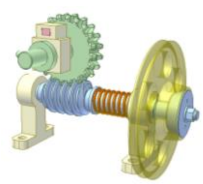


Input: yellow shaft. The axial force of a spring and the axial component of gear force in the spur gear drive (helical teeth) are in balance. An overload condition (represented by the pink slider position) overcomes the spring force to slide the green gear out of engagement.

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

Safety clutch 11

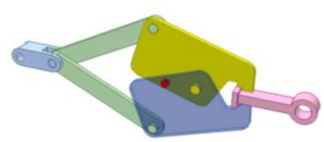
http://youtu.be/plYw36oOPwY



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.

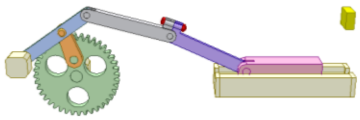
Safety clutch 1

http://youtu.be/IUZAmjjQ7MA

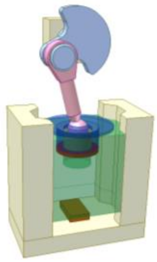


The shearing of a pin releases tension in this coupling. A toggled-operated blade shears a soft pin (red) so that the jaws open and realease an excessive load.

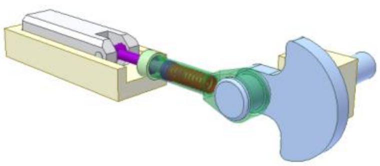
Safety clutch 2
http://youtu.be/trfFKC7xnTw
The grey and violet bars are fixed together by the red bolt. When the pink slider crashes with the yellow part, the red bolt is broken, the grey and violet bars are now conneted by a revolute joint to prevent overload for other parts.

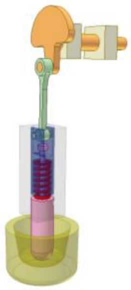


Safety clutch 2B
http://youtu.be/YJbl6bSFY4U
When the green slider of a press crashes onto the brown object, the red disk is sheared (a smaller disk is created) by the yellow cushion. This prevents damage of other parts.



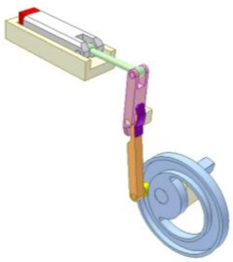
Safety clutch 12
http://youtu.be/zd1RT89jKVI
The conrod consist of two parts that can slide on each other. A spring clamps them together under working condition. When the slider crashes with the red part, the spring is compressed, the two parts of the conrod slide on each other to prevent damage of other parts.



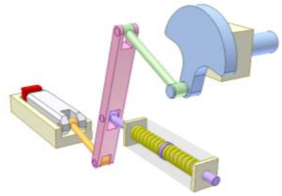


Safety clutch 13 - Spring pestle
http://youtu.be/_EriVQKos3k
The spring between the slider and the pestle helps to avoid overload and to guaranntee no gap between the pestle and the mostar at the lowest position of the pestle.

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.

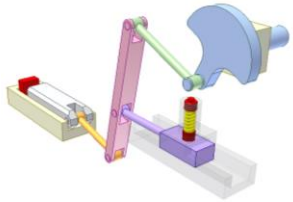


Safety clutch 15 (balance springs)
http://youtu.be/aUTmtQZtLKo



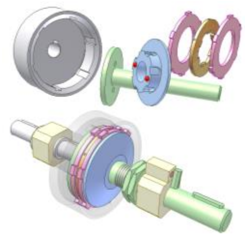
Under normal condition the violet rod is kept immobile by equal forces of the two springs. The pink bar rocks around a pin of the violet rod. When the slider crashes with the red part, the violet rod moves to the right to prevent damage of other parts.

Safety clutch 16 (friction)
http://youtu.be/QBOjcSYDykk



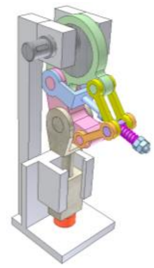
Under normal condition the violet rod is kept immobile due to friction generated by spring force. The pink bar rocks around a pin of the violet rod. When the slider crashes with the red part, the violet rod moves to the right to prevent damage of other parts.
Repositioning of the violet rod is needed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

Safety clutch 17
http://youtu.be/3E0dW7UV9Ao



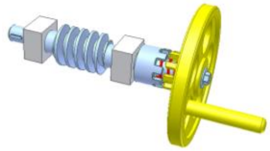
Input: grey shaft having internal cylindrical surface with grooves.
Output: green shaft having cylindrical joint with blue disk.
Pink friction disks engage with the grey shaft.
Orange friction disk engages with the blue disk.
In normal condition the green spring forces blue, pink and orange disks towards 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.

Safety clutch 18
https://youtu.be/HuHWl9kjFEc



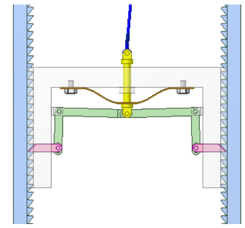
Input: grey eccentric shaft.
Output: brown slider.
When the overload happens (the slider crashes with the red part) pink spring is compressed to prevent damage of other parts.

Safe crank
https://youtu.be/vBD7xdkyvRA



Blue shaft receives motion from two sources: electric motor (not shown) at the left end and human force at the right end.
Red spring tends to disengage the yellow crank and the blue shaft.
When the motor makes the shaft rotate, the crank is idled on the shaft.
Push and turn the crank to make the shaft rotate when the motor is not in action.
Disadvantage: the operator has to push slightly the crank when turning.

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 proccess, 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.

13. Mechanisms for indexing, positioning and interlocking

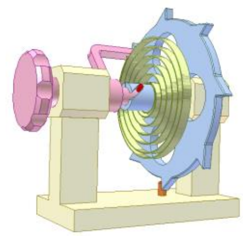
Indexing mechanism 1

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

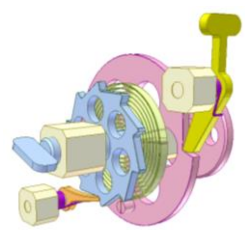
http://youtu.be/0bRevPdhEco



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

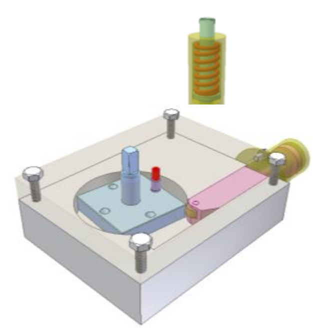
http://youtu.be/-6uhkv5A29w



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.

Mechanism for 90 deg. rotation 1

https://youtu.be/8DAIPTBPcME

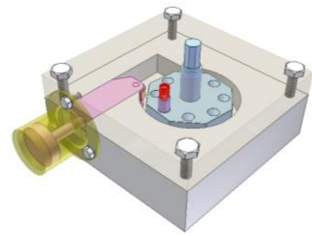


Input: pink slider-pawl driven by yellow pneumatic cylinder.
Output: blue square ratchet wheel (ratchet wheel teeth need not be saw-tooth shaped).
Key factor: when the pawl returns to its initial position, the violet spring pin turns the wheel a small angle but needed for the next 90 deg. rotation.
The mechanism is used only for light duty work because the violet spring pin can't turn the wheel of heavy load.
It is a simplified embodiment of the design of U.S. patent 3548684.

Mechanism for 45 deg. rotation 1

https://youtu.be/ma6HnHgnkHo

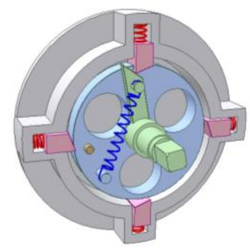
Input: pink slider-pawl driven by yellow pneumatic cylinder.
Output: blue octagon ratchet wheel (ratchet wheel teeth need not be saw-tooth shaped).
Key factor: when the pawl returns to its initial position, the violet spring pin turns the wheel a small angle but needed for the next 45 deg. rotation.
The mechanism is used only for light duty work because the violet spring pin can’t turn the wheel of heavy load.



Mechanism for 90 deg. rotation 2

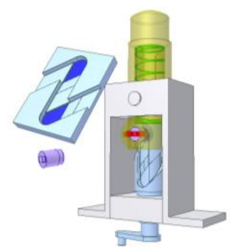
https://youtu.be/gng7qlqfOIM

Input: green shaft of a chamfered lever rotating continuously.
Output: one tooth blue ratchet wheel that quickly turns 90 deg. and then stops. One revolution of the input corresponds one revolution of the output.
The green lever pulls the wheel via blue spring.



Barrel cam for 180 deg. rotation 1b

https://youtu.be/HIwjY53FMHE

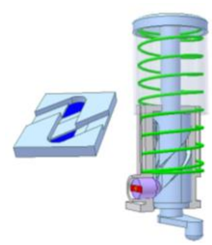


Each push makes blue cam shaft turn 180 deg.
Yellow button has prismatic joint with the base.
Violet pin has prismatic joint with the yellow button.
Red spring forces the pin toward the blue cam shaft.
Key factor is different deepths of the cam groove.
Developed cam is shown on the left. Portions in dark blue are deepest.

Barrel cam for 180 deg. rotation 2b

https://youtu.be/ML31YEnlODk

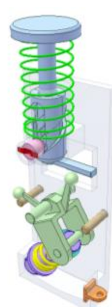
Each push makes blue cam shaft go down and turn 180 deg. when going up. Violet pin has prismatic joint with grey base.
Red spring forces the pin toward the blue cam shaft.
Key factor is different deepths of the cam groove.
Developed cam is shown on the left. Portions in dark blue are deepest. The base is cutt off half for easy understanding.



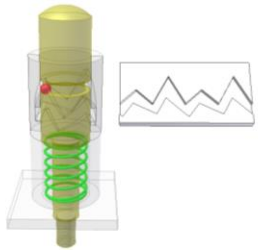
Push-push switch

https://youtu.be/qXnld2Yqf7I

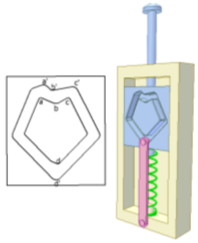
Each push makes blue cam shaft go down and turn 180 deg. For details see “Barrel cam for 180 deg. rotation 2b”:
https://youtu.be/ML31YEnlODk
Arm on the cam shaft switches on or off the contact between violet and orange parts.



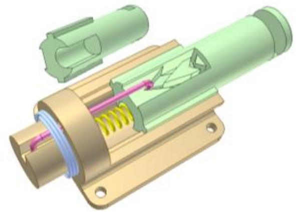
Push-push button 1
https://youtu.be/Meltd5Kclqs
Half of red ball is in circular groove on yellow button, the other half is in internal zigzag groove of grey bush.
Each button push gives one among its two axial positions.
Figure on the right is developed groove of the grey bush.
The button or the bush has assembly structure (not shown) for putting the ball into the grooves.



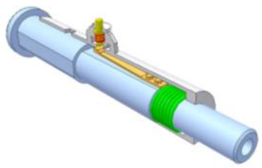
Push-push button 2
https://youtu.be/5JzjSsxSsb8
Pink bar is pivoted on the base.
The groove profile of blue slider ensures that the upper pink pin moves cloclwise along heart-shaped groove when the blue button is pushed and released.
Pay attention to the followings (the letters on the sketch denote corners of the profiles):
a' is on the right of a
b' is on the left of b
c' is on the right of c
d' is on the left of d
See related videos:
https://www.youtube.com/watch?v=0dDiXJsmDOQ
http://www.makerbothy.com/?page_id=220
See another mechanism of the same working principle "Push-push button 1":
https://youtu.be/Meltd5Kclqs



Push-push button 3
https://youtu.be/kJ0BlovBWtk
Pink lever is pivoted on the base and can move up-down. Blue spring forces the pink lever towards the green button.
Yellow spring forces the green button towards the right end of the pink bar.
The profile shape and various depths of groove on green button ensures that the right end of the pink bar moves counter-cloclwise along the groove when the green button is pushed and released.
The mechanism is used for locking small cabinet windows.
It is more compact than the mechanism shown in:
https://youtu.be/5JzjSsxSsb8

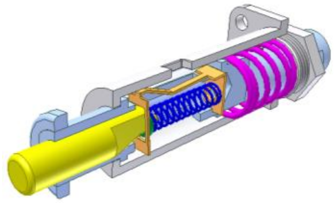


Two button mechanism 1
https://youtu.be/px64_pfu-7Q
Blue button has prizmatic joint with grey base.
Push blue button to reach its protrusive position.
Push yellow button to return the blue button to its hiding position.
The mechanism is applied for moving the tips of ballpoint pens.



Two button mechanism 2

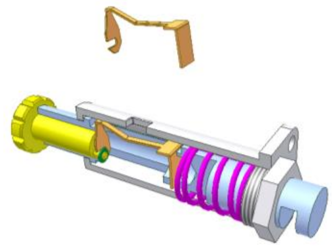
https://youtu.be/RAqWdhAVNI8



Press blue button to reach its forward position.
Orange leaf spring enters into a hole on the grey base to prevent the blue button go back under action of pink spring.
Press yellow button to return the blue button to its initial position. Wedge surface on the yellow button pulls the orange spring out of the hole on the grey base.

Push-turn button mechanism

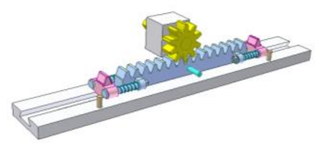
https://youtu.be/Iq3ICLRWXf8



Press yellow button to reach forward position of the blue pin.
Orange leaf spring enters into a hole on the grey base to prevent the blue button go back under action of pink spring.
Turn yellow button to return the blue pin to its initial position.
Eccentric pin of the yellow button pulls the orange spring out of the hole on the grey base.

Output positions subject to input motion direction 1

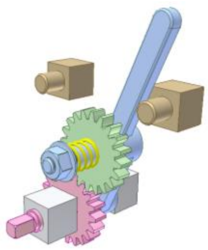
https://youtu.be/5xZKDlhF_os



Unlike centrifugal governor, where output position depends on input velocity, in this mechanism output position depends on input rotary direction.
When yellow pinion rotates clockwise, blue rack gets its left end position, stay there till the pinion changes its rotary direction and vice versa.
Pink movable teeth maintain rack - pinion engagement when the rotary direction is changed.
Two brown stoppers in accordance with the rack length set the rack end positions.
The mechanism can be used for automatic position control when input is motion direction.

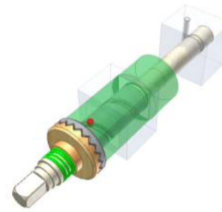
Output positions subject to input motion direction 2

https://youtu.be/nB-epdKNg8I

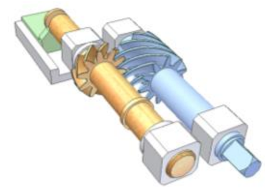


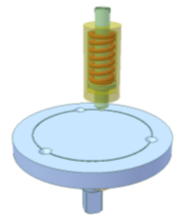
Unlike centrifugal governor, where output position depends on input velocity, in this mechanism output position depends on input rotary direction.
When pink pinion rotates clockwise, blue lever gets its right position, stays there till the pinion changes its rotary direction and vice versa.
Gear force makes the lever turn. Use blue nut via yellow spring to press green gear toward the lever for adjusting the friction between them, thus the gear force.
Torque from the gear force must be larger than the torque caused by gravity and possible load applied to the lever.
Two brown stoppers set the lever positions.
There is energy loss due to friction between green gear and the lever, if the pink pinion rotates continuously.
The mechanism can be used for automatic position control when input is motion direction.

Output positions subject to input motion direction 3
https://youtu.be/Zhz2hkQtg6U
Unlike centrifugal governor, where output position depends on input velocity, in this mechanism output position depends on input rotary direction.
When brown long shaft rotates counterclockwise, green nut gets its left end position, stays there till the shaft changes its rotary direction and vice versa.
Orange clutch has prismatic joint with the shaft and acts as a safety one.



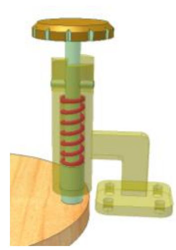
Output positions subject to input motion direction 4
https://youtu.be/J9kGUj8Nmzw
Unlike centrifugal governor, where output position depends on input velocity, in this mechanism output position depends on input rotary direction.
When blue shaft rotates clockwise, green slider gets its forward position, stays there till the shaft changes its rotary direction and vice versa.
Axial force of the helical gear drive moves the slider.
Applications:
http://youtu.be/x2JieVQlek0
http://youtu.be/h6upHEjsp74





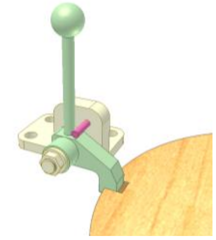
Positioning device 1
http://www.youtube.com/watch?v=6YDWcjRVHzo
It is used for positioning a disk that rotates interruptedly.

Positioning device 2
http://www.youtube.com/watch?v=xwK8Oa4SmX8
It is used for positioning a shaft that rotates interruptedly.

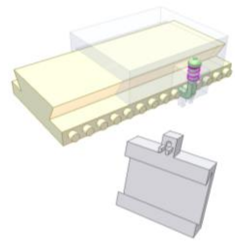


Positioning device 3
http://youtu.be/Uht_pvwbwVU
It is used for manual positioning a disk that rotates interruptedly.

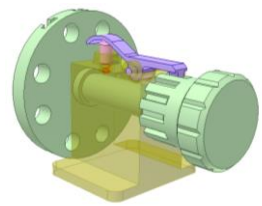
Positioning device 4
http://youtu.be/hLpjlgtKdf4
It is used for manual positioning a disk that rotates interruptedly.
The green lever weight maintains its two extreme positions when creates contacts between the pink pin and the lever.



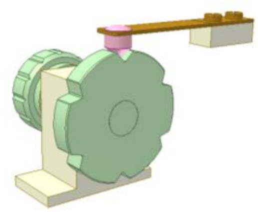
Positioning device 5
http://youtu.be/_01fYaAa56o
Push green button, move slider to new position and release the button.



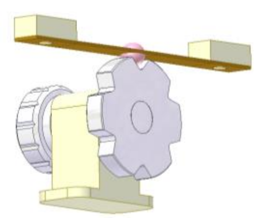
Positioning device 6
http://youtu.be/Edn0JsEvwn8
Press pink button via violet lever, turn green shaft to new position and release the button.



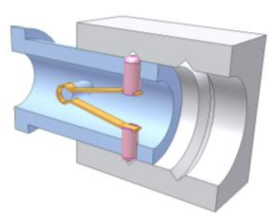
Positioning device 7
http://youtu.be/pRVqH-dwAzc
A leaf spring provides limited holding power.



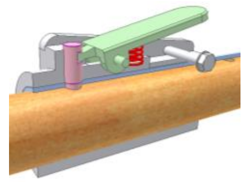
Positioning device 8
http://youtu.be/9m3amDpR3Jw
A leaf spring detent can be removed quickly.
Diameter of the hole for the ball is a little smaller than the ball diameter.
There are gaps in longitudinal direction between base pins and holes on spring ends that causes inaccurate positioning.



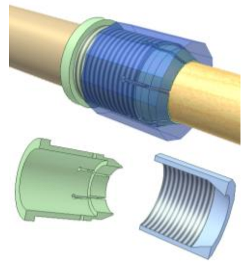
Positioning device 9
http://youtu.be/p7KsxHMHbC8
A V-shaped spring always forces two pink pins towards grey part, circular grooves of which allow rotary motion between the blue part and the grey one.
The parts are cut off half for easy understanding.



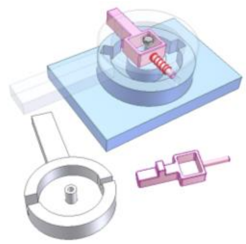
Positioning device 10
https://youtu.be/I1JCgkXpPjM
It is used for positioning orange movable tube in blue stationary tube.
Grey hub is fixed to the blue tube by grey bolt.
Push the green lever to remove the positioning. Move and release the lever for new position of the orange tube.



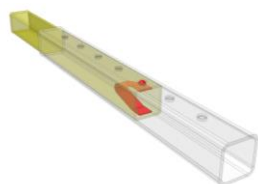
Positioning device 11
https://youtu.be/5U2Yns2J4IQ
Release blue nut and move orange inner tube to new position. Then tight the nut to fix the inner tube thanks to green flexible bush.
Pay attention to tapered portion and longitudinal slots on the green bush. The green bush is fixed to the outer pipe.



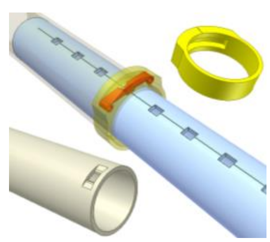
Positioning device 14
https://youtu.be/cl19RveRfII
Push pink button, turn white lever to new position and release the button.



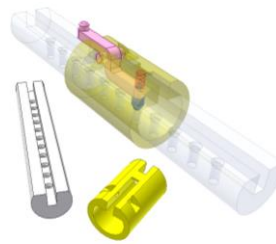
Positioning device 13
https://youtu.be/-ORWRYxFYAM
It is used for positioning glass movable tube along yellow stationary tube.
Push (blue arrow) the red spring to unlock, move the glass tube to new position and the red spring will locks it automatically.
See a real mechanism:
https://www.youtube.com/watch?v=y3V6o3eca0g



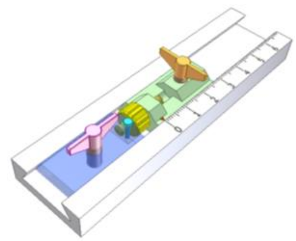
Positioning device 12
https://youtu.be/GjU4ucEkkj8
It is used for positioning blue movable tube along beige stationary tube, to which a yellow rim is fixed.
Turn the blue pipe to unlock, move it to new position and turn it back to lock.
At lock position the red spring prevents longitudinal motion of the blue tube but not its rotation.
See a real mechanism:
https://www.youtube.com/watch?v=0kvEeKIn-mI



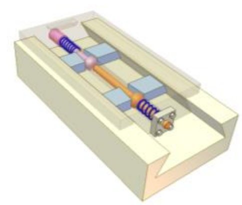
Positioning device 15
https://youtu.be/3Rn80vPBaVo
Push pink lever, move yellow slider to new position and release the lever. Move the slider slightly if the blue pin on the slider has not faced a base hole.



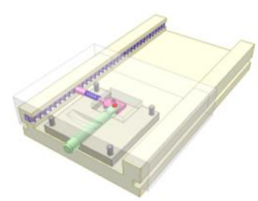
Two slider mechanism for quick and fine position adjustment
https://youtu.be/QPrsoSsHda4
The video shows in turn:
Turn pink screw anticlockwise to release blue slider.
Push the pink screw to move the blue and green sliders (rough adjustment).
Turn the pink screw clockwise to raise the blue slider for fixing the blue slider.
Turn yellow screw to move green slider (fine adjustment).
Cyan pin is for preventing axial motion of the yellow screw.
Orange screw is used for fixing the green slider after adjustment if needed.
This mechanism finds application in caliper-squares.



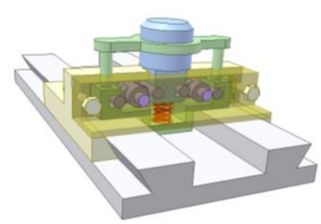
Slider lock 6a
https://youtu.be/u9GEOyneQQc
Push the pink button and move glass slider to its new position.
When releasing the button, blue springs push the pink and orange bars and their spheres force four blue wedges aside to clamp the slider thanks to friction.
The button is fixed to the bar by thread.
To ensure that all wedges always contact with the runway when clamping the cylindrical joints between the bars and the slider must have considerable gaps. For the same reason there must be enough longitudinal gap between the pink and orange bars.



Slider lock 6b
https://youtu.be/NxJs6HzO1eQ
Push green bar to retreat pink cross pin and move glass slider to its new position. Release the green bar to clamp the slider.
Red pin fixed to the green bar moves in 45 deg. inclined slot of the pink pin.
The detachable cover (in beige) is for easy assembling.

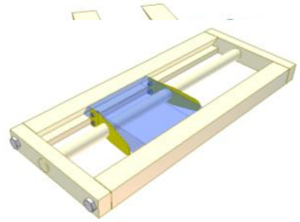


Slider lock 7
https://youtu.be/R2N-DOB3lOc
Push blue button (using thumb) and pull green part (using two fingers) to unlock yellow slider and move it to new position.
Release the blue button and the yellow part to lock the slider.
Red spring creates friction force for locking.



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.

Wedge mechanism 24

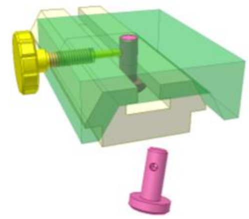
http://youtu.be/tGYsP0KyO5k

Loose the screw for moving the stopper to new position and then tighten it.

The stopper is kept immobile by wedge mechanism.

Slider clamp 1

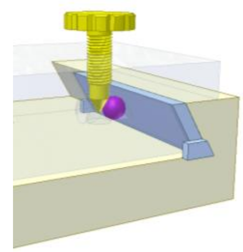
http://youtu.be/uEAekWR-CsY



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/NI45sSsPk_s

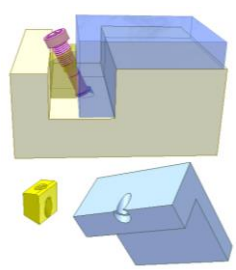


Turn yellow screw clockwise for clamping or counterclockwise for releasing the transparent slider.

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

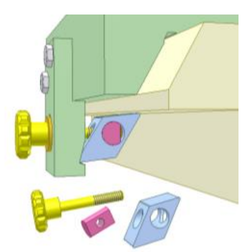


Turn pink screw clockwise for clamping or counterclockwise for releasing the blue slider.

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

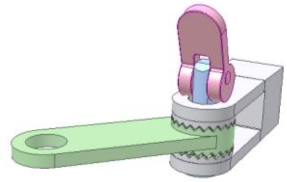


Turn yellow screw for clamping or releasing green slider.

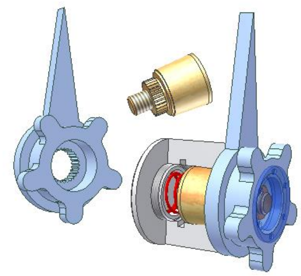
Blue clamp has revolution joint with the green bracket.

Yellow screw, pink nut and blue clamp create a sine mechanism.

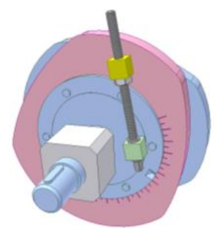
Mechanism for adjusting angular position of a lever
http://youtu.be/gK9jWWiTxYQ
Grey fixed flexible fork enables axial gap for adjusting position of green lever. Pink cam is for clamping the lever after adjustment. The mechanism can work in case without teeth (friction clamping).



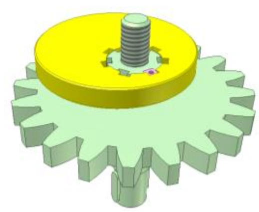
Stepless adjustment for angular position
https://youtu.be/O6oibE9P1R8
The friction at contact place between orange cone and cone hole of the housing locks the blue hand under red spring force.
Push blue hand to unlock, turn it to new position and release it to lock.
A torque applied to the hand can not turn it if the hand is not at pushed position.
The tapered angle should be small, around 1 to 3 deg.



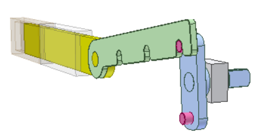
Angular adjustment of two coaxial cams
https://youtu.be/lGFk5ZYygsc
Turn grey screw to adjust angular position between pink and blue cams.
Green bearing of the screw has revolution with the blue cam.
Yellow nut has revolution with the pink cam.



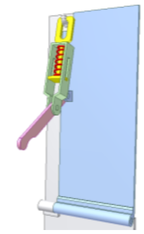
Differential angular adjustment 1
https://youtu.be/OWjTHBFNcGk
Way to get small angular adjustment.
Relative angle between green gear and yellow cam can be adjusted by turning the cam and fixed by pink key.
N1: number of slots on the gear.
N2: number of slots on the cam.
If N1 = N2 = 6, minimum adjusted angle A = 360/N1 = 60 deg.
If N2 = N1 + 1, minimum adjusted angle B = 360/(N1.N2) deg.
In this video: N1 = 6, N2 = 7, B = 360/42 = 8,57 deg.
Compare with ordinary way:
http://youtu.be/gK9jWWiTxYQ
that needs large number of slots to get small adjusted angle.



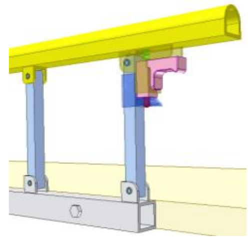
Rack pinwheel drive 3
https://youtu.be/NzX2CDXUJtY
Turn blue pin arm 360 deg. to move yellow latch for locking or unlocking.
Unlike conventional pin gear rack mechanisms this one does not allow the latch move if driving force is applied to the latch at its locking or unlocking positions.



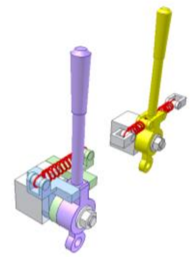
Lock for flipping window
https://youtu.be/CiXxF8VmGVc
Blue flipping window is locked at its closed position thanks to a lock mechanism consisting of pink lever, yellow slider and green conrod.



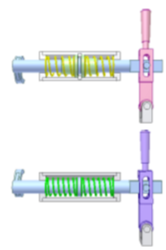
Lock for a parallelogram mechanism
https://youtu.be/aoCaDkI65Rw
Bed fence.
The red pin keeps the fence steadily at its raising position.
Put on pink trigger to pull its pin out of the hole on the blue glass part and lower the fence.



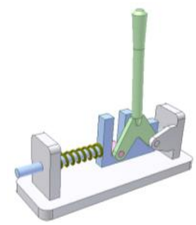
Lever of stable neutral position 1
https://youtu.be/Zq5ursxPGPg
Mechanism of yellow lever doesn't have stable neutral position and the position depends on stiffness of the two springs.
Mechanism of violet lever doesn't have such disadvantages thanks to the contact between the protrution of the fixed pivot and two auxiliary levers (in blue and green).



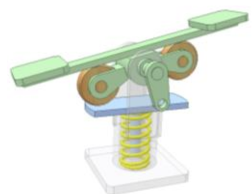
Lever of stable neutral position 2
https://youtu.be/8U76DPUmG8o
Mechanism of violet lever doesn't have stable neutral position and the position depends on stiffness of the two green springs.
Mechanism of pink lever doesn't have such disadvantages thanks to the contact between the rings (in grey and blue) and two green sliding bushes.



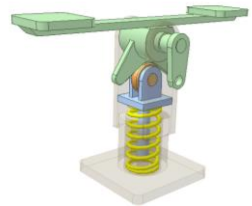
Slider of two positions 1
https://youtu.be/m6YHJn2tS6M
Green lever brings blue slider to one of its two positions.
The slider is kept firmly at each position thanks to the spring.
At left positon, axis of pink pin is lower than the one of the revolution joint of the green lever. Spring force tends to turn the green lever anticlockwise.
At right position the things are opposite.



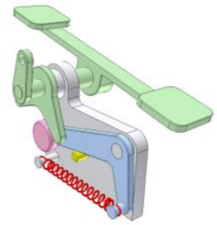
Lever of stable neutral position 3
https://youtu.be/gOKQISHL4pU
This mechanism keeps green lever firmly at its neutral position when no force applied to it.



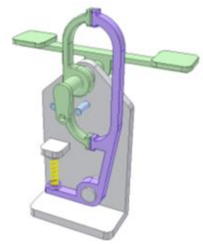
Lever of stable neutral position 4
https://youtu.be/oFSJE3bYgf0
This mechanism keeps green lever firmly at its neutral position when no force applied to it.



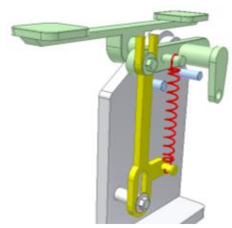
Lever of stable neutral position 5
https://youtu.be/b2GNBy5G1VA
This mechanism keeps green lever firmly at its neutral position when no force applied to it.



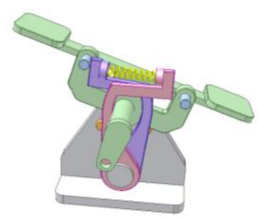
Lever of stable neutral position 6
https://youtu.be/5zoZn1KJKRE
This mechanism keeps green lever firmly at its neutral position when no force applied to it.



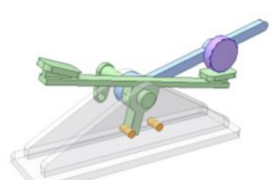
Lever of stable neutral position 7
https://youtu.be/SMoo4KdiNYg
This mechanism keeps green lever firmly at its neutral position when no force applied to it.



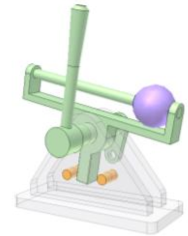
Lever of stable neutral position 8
https://youtu.be/CZ3KJVQSSXk
This mechanism keeps green lever firmly at its neutral position when no force applied to it.



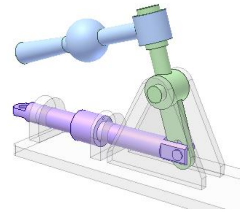
Lever of two positions 1
https://youtu.be/Cz3lf5XUAC8
Blue lever brings green lever to one of its two positions.
The green lever is kept firmly at each position thanks to the gravity.



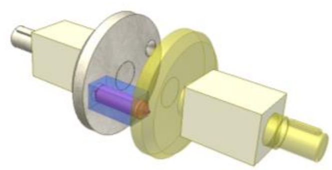
Lever of two positions 2
https://youtu.be/n3PEaU9v2P8
Turn green lever to change its position.
It is kept firmly at one of its two positions thanks to violet weight.



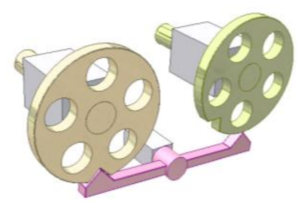
Lever of two positions 3
https://youtu.be/j1NAhQ6E5S8
Turn blue bar 180 deg. to change position of violet slider.
The slider is kept firmly at one of its two positions thanks to the gravity.



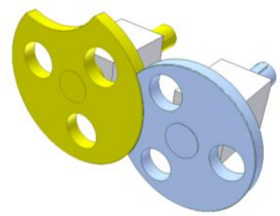
Interlocking shafts 1
http://youtu.be/5yr9OeGqnYo
The pink pin moving in a fixed hole allows only one shaft to turn at a time. The other shaft is locked due to the engagement of its hole with the pink pin. The mechanism is used in case the concurrent motions can cause damage.
Disadvantage: need to bring the mechanism to initial position for changing the moving shaft.



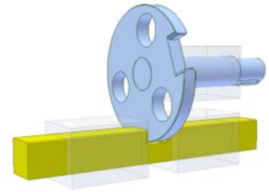
Interlocking shafts 2
http://youtu.be/U2Dpf91_Dlc
The pink lever allows only one shaft to turn at a time. The other shaft is locked due to the engagement of its groove with the pink lever. The mechanism is used in case the concurrent motions can cause damage.
Disadvantage: need to bring the mechanism to initial position for changing the moving shaft.



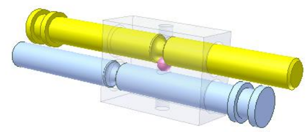
Interlocking shafts 3
http://youtu.be/oDN9V8v1cKM
Only one disk can rotate at a time. The second disk is locked due to the engagement of its concave arc with peripherical surface of the first disk. Radius of the concave arc of one disk is equal to outer radius of the other disk.
The mechanism is used in case the concurrent motions can cause damage.
Disadvantage: need to bring the mechanism to initial position for changing the moving shaft.



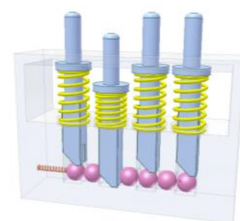
Interlocking shafts 4
http://youtu.be/uE8Yk5-Y0y4
Only one part can move at a time. The second part is locked due to the engagement of its concave portion with outer surface of the first part. The mechanism is used in case the concurrent motions can cause damage.
Disadvantage: need to bring the mechanism to initial position for changing the moving shaft.



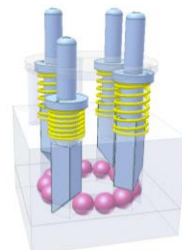
Interlocking shafts 5
http://youtu.be/TKpcZcEhjio
Only one shaft can move at a time. The second shaft is locked due to the engagement of its circular groove with the pink ball. The mechanism is used in case the concurrent motions can cause damage.
Disadvantage: need to bring the mechanism to initial position for changing the moving shaft.



Interlocking shafts 6a
http://youtu.be/YtbEjL9oOjE
Only one shaft can go down full stroke at a time. The other shafts are locked by pink balls.
The mechanism is used in case the concurrent motions can cause damage.



Interlocking shafts 6b
http://youtu.be/Qm-I7bLRgJg
Only one shaft can go down full stroke at a time. The other shafts are locked by pink balls.
The mechanism is used in case the concurrent motions can cause damage.



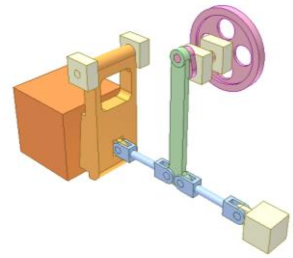
14. Toggle linkages

Toggle linkage 1a

http://youtu.be/1MmgKShth7w

Mechanism for a stone crusher.

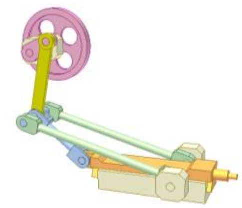
It has two toggle linkages in series to obtain a high mechanical advantage. When green link reaches the top of its stroke, it comes into toggle with the pink crank. At the same time two blue links come into toggle. This multiplication results in a very large crushing force of the orange jaw.



Toggle linkage 1b

http://youtu.be/FOe7o0dueI4

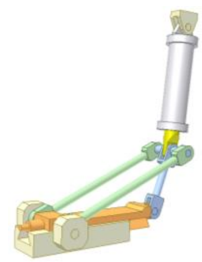
Two toggle links (the green and blue ones) can come into toggle by lining up on top of each other rather than as an extension of each other.



Toggle linkage 1c

http://youtu.be/MpuejSlBvjM

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.



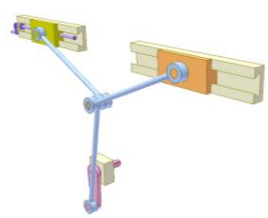
Toggle linkage 2

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 rightest 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.



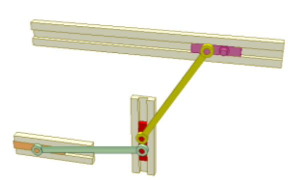
Toggle linkage 3

http://youtu.be/U2-SPNLPMeE

Input: pink slider.

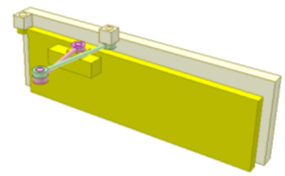
Output: orange slider.

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

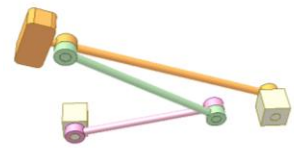
http://youtu.be/dmbLL-MSkyE



Door check linkage gives a high velocity ratio during the stroke.
As the door swings closed, connecting link (in green) comes into toogle 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

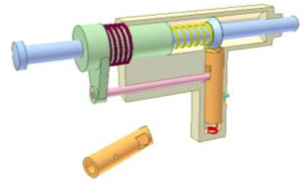
http://youtu.be/TAPhhX3ti8s



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.

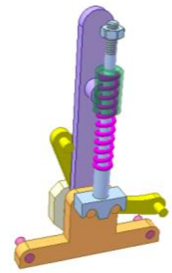
15. Mechanisms for snap motions

Snap motion 16
http://youtu.be/BwABcO1k2l0
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.

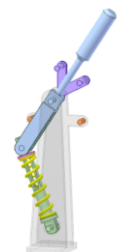


Spring toggle mechanism 1
http://youtu.be/u4oW1ZiiRGA
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
In this prototype a compression spring is used to bear tension.
The violet sector represents manual action.

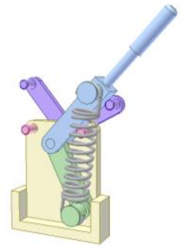
Spring toggle mechanism 2
http://youtu.be/T4EoESBFYLw
Toggle action here ensures that the gear shift lever (violet) will not inadvertently be thrown past its neutral position.
The pink pins are stoppers for the violet lever.
The yellow double crank represents manual action.



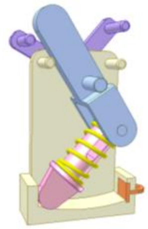
Spring toggle mechanism 3
http://youtu.be/l-G_uejx0Rs
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
The violet double crank represents manual action.



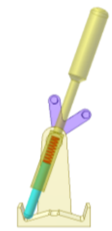
Spring toggle mechanism 4
http://youtu.be/KaRBadgcUlU
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
The violet double crank represents manual action.



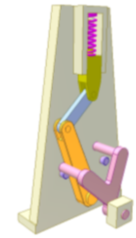
Spring toggle mechanism 5
http://youtu.be/vYSJn0U0kXI
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
The violet double crank represents manual action.
The mechanism is used for electric switches.



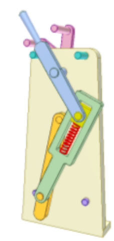
Cam-guided latch
http://youtu.be/53_QBnREziY
Cam-guided latch has one cocked and two relaxed positions.
The violet double crank represents manual action.



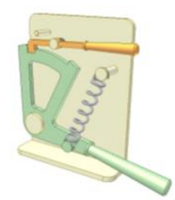
Spring toggle mechanism 8
http://youtu.be/ymgxwQHVQUw
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
The pink double crank represents action from outside.



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.

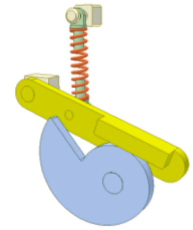


Snap motion 1
http://youtu.be/7y-Oez0v2l8
A orange latch and green cocking lever is spring-loaded so latch movement releases the cocking lever. The cocked position is held firmly. Studs in the frame provide stops, pivots or mounts for the springs.
A coil spring always forces the orange latch to rotate anticlockwise.

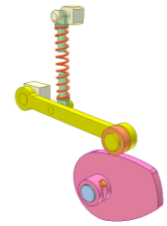


Snap motion 2
http://youtu.be/tR1LWzVCjk0
A latch mounted on a cocking lever (blue) allows both levers to be reached at the same time with one hand.
Rotate the latch clockwise to release the cocking lever.
Rotate the cocking lever anticlockwise to get the initial position.
A coil spring always forces the pink latch to rotate anticlockwise.

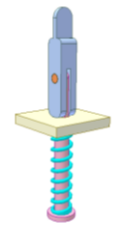
Snap motion 6
http://youtu.be/k1BAA75eR_0
A latching cam cocks and releases the cocking lever with the same counterclockwise movement.



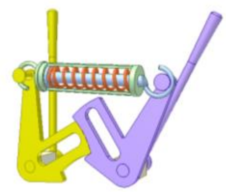
Snap motion 6B
http://youtu.be/jeKxnC6DffQ
The cam hub has a semi-circular slot in which a pin of the blue driving shaft moves. Snap motion occurs when the moment from the follower spring applied to the cam changes its direction.



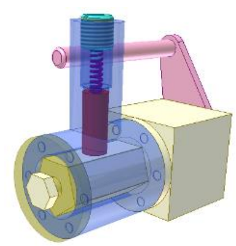
Snap motion 8
http://youtu.be/FYyIZXn_8-M
Push or pull the blue lever to get snap motion. Raise it to get the initial position.



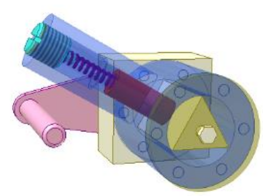
Snap motion 10
http://youtu.be/NMuZwvDJ27A
An identically shaped cocking lever and latch allow their functions to be interchangeable. The radii of the sliding faces must be dimensioned for a mating fit. Forces are alternatively placed on both levers.



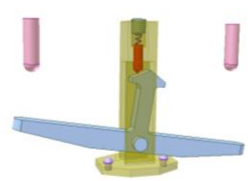
Spring toggle mechanism 6a
https://www.youtube.com/watch?v=YydcGLWbuZg
Indexing device. This spring toggle mechanism enables to reach five positions of a lever quickly and holds it there.
The pink pin represents action from outside.



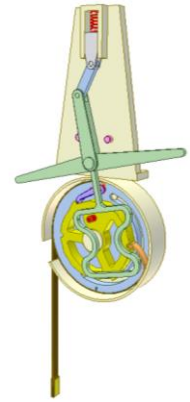
Spring toggle mechanism 6b
http://youtu.be/VftCJ6mScNQ
Indexing device. This spring toggle mechanism enables to reach three positions of a lever quickly and holds it there.
The pink pin represents action from outside.



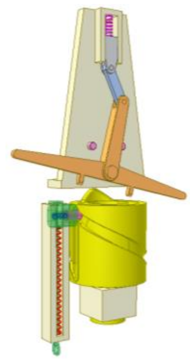
Spring toggle mechanism 7
http://youtu.be/kjRbsF9gkyI
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly.
The pink pins represent action from outside.



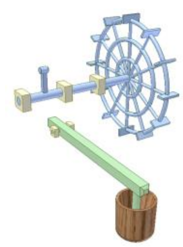
Cable drive for snap switching 1
http://youtu.be/39GDCZB-vFU
Pull and release brown tow for snap switching green arm.
It is a combination of two mechanisms shown in:
http://youtu.be/VzBuIhvWsJY
and
http://youtu.be/ymgxwQHVQUw
For reducing pulling stroke length, use three red pins arranged in a symmetric circular pattern then the yellow ratchet disk needs turn only 60 deg.



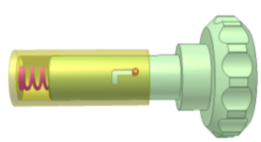
Barrel cam for snap switching 1
http://youtu.be/rKSc1A8HE3Q
Pull and release green slider for snap switching orange arm.
It is a combination of two mechanisms shown in:
http://youtu.be/SzoF0VMtc7w
and
http://youtu.be/ymgxwQHVQUw
For reducing pulling stroke length, use three face protrusions (instead 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



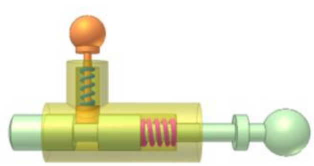
Snap motion 12
http://youtu.be/tipTlkBLhdk
Pestle powered by water flow.
Water flow turns the wheel carrying a toe that raises and suddenly releases the pestle.



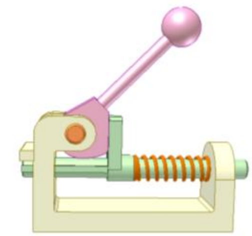
Snap motion 3
http://youtu.be/7APpIiiLziI
A yellow sleeve latch has an L-shaped notch. A pin in the green shaft rides in the notch. Cocking requires a simple push and twist.



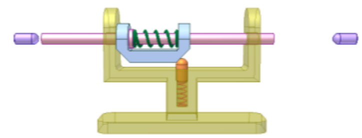
Snap motion 4
http://youtu.be/igdo6b4tg9s
The latch and plunger depend on axial movement for setting and release. A circular groove is needed if the plunger is to rotate.



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.

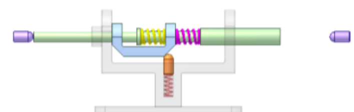


Snap motion 7A
http://youtu.be/J8r2zXYFT84
A blue spring-loaded cocking piece has chamfered corners. Axial movement of the pink push-rod forces the cocking piece against a spring-loaded pin set in frame. When cocking builts up enough force to overcom the pin spring, the cocking piece snaps over to the right.



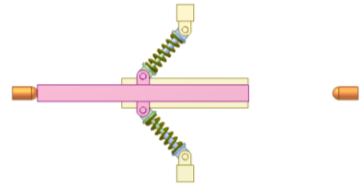
Move the pink push-rod or the blue cocking piece to the left to get initial position.
The violet pins represent manual action.

Snap motion 7B
http://youtu.be/RYcTAr8j2P0
A blue spring-loaded cooking 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 builts up enough force to overcom the pin spring, the cocking piece snaps over to the right.

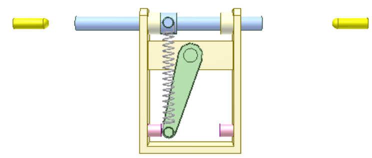


The action can be repeated in either direction.
The violet pins represent manual action.

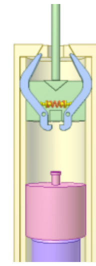
Snap motion 9
http://youtu.be/3ggXrotERfo
Push the pink slider to get snap motion. The action can be repeated in either direction.
The orange pins also play role of stoppers.



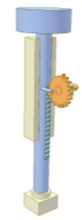
Spring toggle mechanism 10
http://youtu.be/HtLDYQnP1QQ
Spring toggle mechanism enables to reach end positions of a lever quickly and holds it there firmly. However the green lever is not forced against the pink button strongly.
The yellow pins represent action from outside.



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

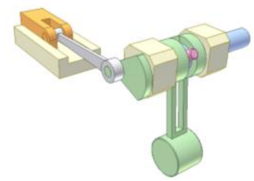


http://www.youtube.com/watch?v=yg1xDM0GDYM

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.

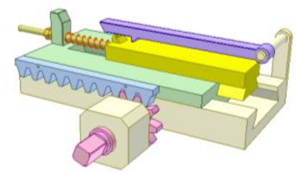
Snap motion 13



http://youtu.be/p2pdrXaIc_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.

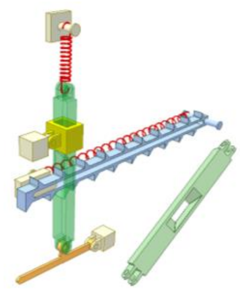
Snap motion 15



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

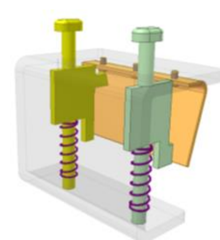


http://youtu.be/oDlOwSwk1JQ

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.

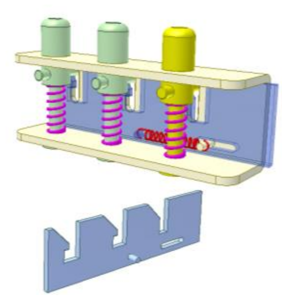
On-Off switch 1



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



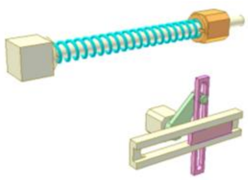
http://youtu.be/UwcpsEW_PqA

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.

16. Mechanisms for creating vibration

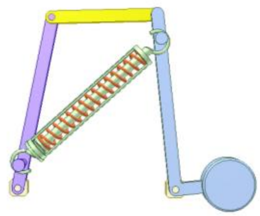
Gravity and spring pendulums
http://youtu.be/NycJBVNkmGI
Two pendulums perform harmonic angular oscillations.
The right pendulum oscillates thanks to the gravity.
The left pendulum oscillates thanks to green disk and flat spiral spring. One end of the spring is fixed to the green disk hub, the other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

Harmonic motions
http://youtu.be/FRpUAQlCbIc
Orange slider oscillates thanks to cyan spring.
Pink slider oscillates thanks to a sine mechanism.
Both perform harmonic linear oscillations.

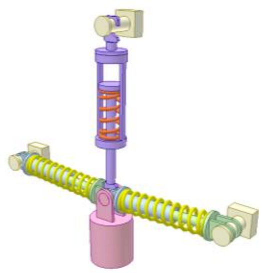


Spring vibration 2
http://youtu.be/bgzpOHozRPM
The mechanism is used for anti-vibration suspensions.

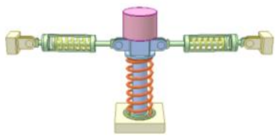
Spring vibration 3
http://youtu.be/Q7eHZX1iaSQ
A four bar mechanism in conjunction with a spring has a wide variety of load or deflection characteristics.



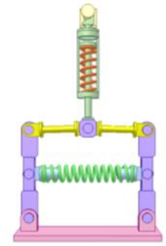
Spring vibration isolation 1
http://youtu.be/Kwm7c6kgQ70
This basic spring arrangement has zero stiffness.
The mechanism is used for vibration isolation.
The pink part represents the weight to be vibration isolated.



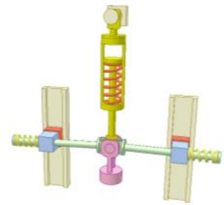
Spring vibration isolation 2
http://youtu.be/OpEjNNHcaEI
This basic spring arrangement has zero stiffness when the tension springs are in line. The pink part represents the weight to be vibration isolated.



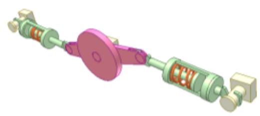
Spring vibration isolation 3
http://www.youtube.com/watch?v=vIltfnIVBEc
This spring arrangement has zero stiffness when the yellow bars are in line. The pink part represents the weight to be vibration isolated.



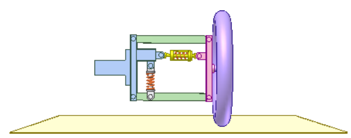
Spring vibration isolation 4
http://www.youtube.com/watch?v=OECw5X_geVE
This spring arrangement has zero stiffness when the yellow compression springs are in line. The pink part represents the weight to be vibration isolated.



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.

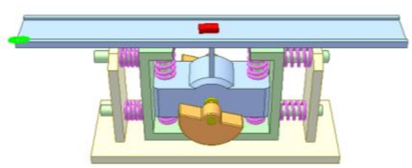


Wheel spring suspension
http://www.youtube.com/watch?v=9A9ln_SbBfk
Coil spring suspension of automobiles can be reduced in stiffness by adding an horizontal spring.

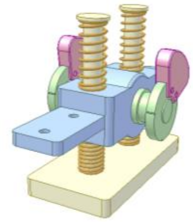


Seat spring suspension
http://youtu.be/sSJ-gizbep8
Tractor seat stiffness and transmitted shocks can be reduced with this spring arrangement.

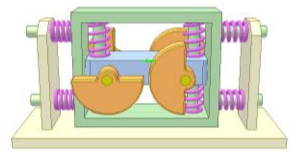
Eccentric vibrator 1A1
http://youtu.be/qPrDl5NYk_I
Vibrating conveyor.
The blue part vibrates in two directions (vertical and horizontal) under centrifugal forces caused by the orange eccentrics and move the material (red).
Angle A between the two eccentrics affects vibration characteristics.
A = 0 deg. 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/7wWUhWTBIw0
The blue part vibrates in vertical direction under centrifugal forces caused by the pink eccentrics. The mechanism is used in vibration hammers and rammers.

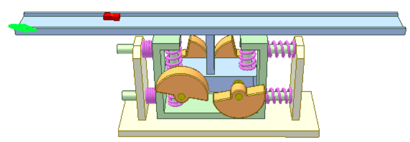


Eccentric vibrator 2A1
http://youtu.be/7zFYThhjm3s
The blue part vibrates under centrifugal forces created by two shafts carrying eccentrics. Vibration characteristics depend on
- rotation direction and velocity of the shafts,
- angle A between the eccentrics on each shaft
- angle B between the eccentrics 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/dHlVU5Uprzw
Vibrating conveyor.
The blue part vibrates under centrifugal forces created by two shafts carrying eccentrics. Vibration characteristics depend on

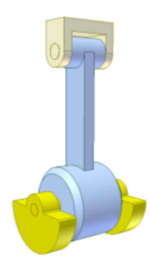


- rotation direction and velocity of the shafts,
- angle A between the eccentrics on each shaft
- angle B between the eccentrics between the shafts (set before moving).

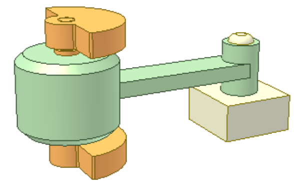
For this case there are vibrations in both directions when
- The shafts rotate in opposite directions
- A = 90 deg.
- B = 180 deg.

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

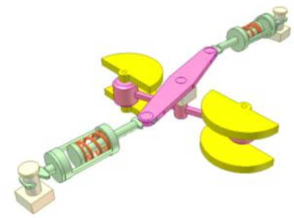
Eccentric vibrator 3A
http://youtu.be/6ucruMiqzbY
The blue part vibrates in vertical plane under centrifugal forces caused by the eccentrics and the gravity force.



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.

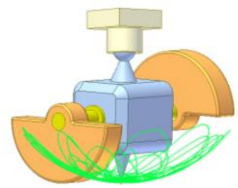


Eccentric vibrator 3C
http://youtu.be/8r3M03JvvEg
Vibrator for torsion vibration.
The pink crank oscilates under centrifugal forces caused by the yellow eccentrics that rotate in the same direction.
The oscilation will not occurs if one eccentric shaft turns 180 deg. in relation with the other or the two shafts rotate in opposite directions.

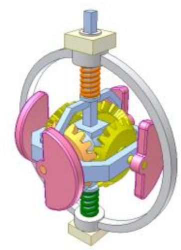


Eccentric vibrator 4A
http://youtu.be/zj9yAVBzRWw
The blue part has complicated motion under centrifugal forces caused by the eccentrics.
The green line is locus of a point on the blue part.

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.

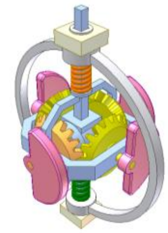


Eccentric vibrator 6A2
http://youtu.be/CkdOZcf7v_8
With this lay-out of the eccentrics the blue part rotates around vertical axle and reciprocates along vertical axle under centrifugal forces caused by the eccentrics.

Eccentric vibrator 6A3

http://youtu.be/8p66DsDp554

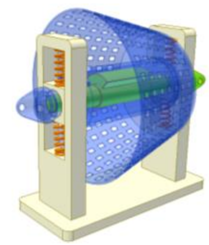
With this lay-out of the eccentrics the blue part only reciprocates along vertical axle (not rocks around it) under centrifugal forces caused by the eccentrics.



Vibrating screen machine 1

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

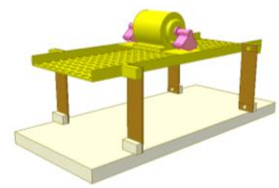
The green inner shaft carrying a long eccentric rotates in a screen of cone shape. The later rotates in bearings supported by springs. The inner shaft and the screen are driven through double cardan joints (not shown).



Vibrating screen machine 2

http://youtu.be/KdycXXdN3M0

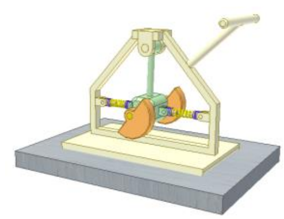
Oscilating screen is supported by flat springs.
A motor carrying eccentrics is fixed to the screen.



Ramming machine 1

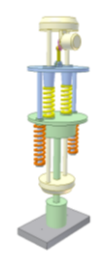
http://youtu.be/bX8TEvxAICo

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 horizotal one is born by the operator through the grips.



Ramming machine 2

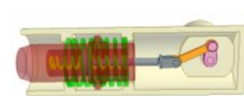
http://youtu.be/M3foSpmDyEM



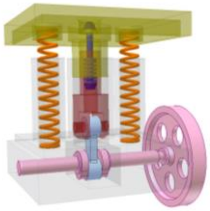
Hand-held spring hammer

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

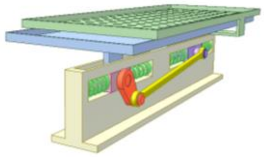
The red slider is born by two green springs, no contact between the slider and the hammer's house. It reciprocates under actions of two green springs, two yellow ones and the slider crank mechanism.



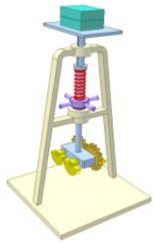
Sand mold vibrating machine
http://youtu.be/Ig5z7Zk1IPc
The yellow mold table reciprocates with vibration under actions of three springs and the slider crank mechanism.



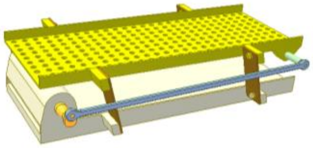
Vibrating screen machine 3
http://youtu.be/EjE1yw8odMw
The bearing and the slider of a linkage mechanism supported by springs can slide in a runway. The sieves are fixed to them. The red crank is driven through a double cardan joint (not shown)



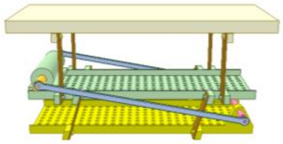
Vibration table 1
http://youtu.be/2uMzqueot7Q
Blue table with a mould on it vibrates in vertical direction due to centrifugal forces caused by four yellow eccentrics.
The violet screw is for regulating table position that may change because of mould weight .



Vibrating screen machine 4
http://youtu.be/kfw1lToK4So



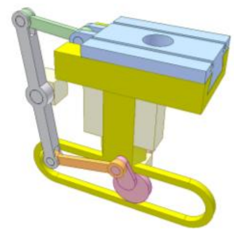
Vibrating screen machine 5
http://youtu.be/zr99xgCvURM



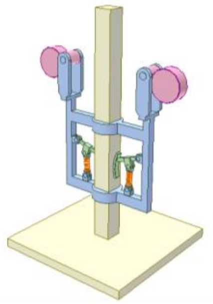
Poker concrete vibrator
http://youtu.be/9dTIoL9WLl8
Vibration is created by the rotation of the orange shaft carrying an eccentric mass.

Flex testing machine
http://youtu.be/bSPbxa3flR0
The specimen (in orange) is tested under variable load.

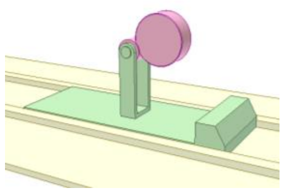
Vibration table 2
https://youtu.be/d34CJJQS-kc
Input: pink shaft having an eccentric and a crank.
Output: blue table oscillating vertically and horizontally simultaneously.



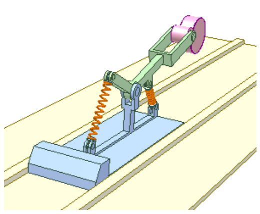
Vibration propulsor 1
https://youtu.be/LYhcXjH86cA
Input: two pink eccentrics rotating in opposite directions. They generate centrifugal forces. Sum of horizontal members of centrifugal forces is null.
Sum of vertical portions of centrifugal forces may point up or down.
In down case green levers and orange compression springs prevent blue frame moving down. In up case they allow it moving up.
Release the green levers time after time for moving down which is a jerk process.



Vibration propulsor 2
https://youtu.be/UIiytVIaZFQ
Input: pink eccentric rotating regularly. Change its rotary direction to reverse motion of blue frame.
Green frame moves when centrifugal force caused by the pink eccentric points up.



Vibration propulsor 3
https://youtu.be/0RJP5WO1ltI
Input: pink eccentric rotating regularly. Change its rotary direction to reverse motion of blue frame.
Motion of blue frame depends on many factors: geometry of the propulsor, springs parameters, centrifugal force caused by the pink eccentric.

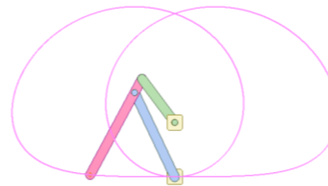


17. Mechanisms for drawing lines

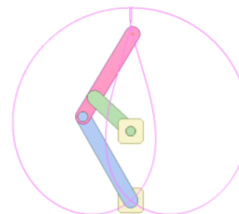
17.1. Straight lines

17.1.1. Straight lines by mechanisms of all revolute joints

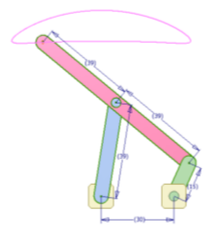
Four-bar linkage 1
http://www.youtube.com/watch?v=afK8PpDYy4Y
The connecting rod rotates fully.
A motion cycle of the linkage corresponds two revolutions of the connecting rod.
A part of the locus at the bottom is nearly straight.



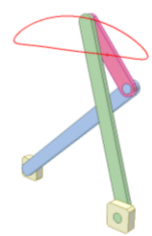
Four-bar linkage 2
http://www.youtube.com/watch?v=SzwoIVCGvu0
The connecting rod rotates fully.
A motion cycle of the linkage corresponds two revolutions of the connecting rod.
A part of the locus at the top is nearly vertical straight.



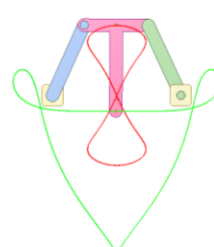
Four-bar linkage 2B
http://www.youtube.com/watch?v=nyALtYMTrAg
A part of the pink locus is a straight line.
Note: following dimensions are better than the ones given in the video:
Length of green crank: a
Length of blue bar : 2.5a
Length of pink bar: 2.5a + 2.5a
Distances between stationary bearings: 2a.



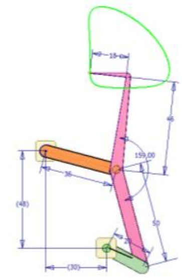
Tchebicheff's four-bar linkage 3
http://www.youtube.com/watch?v=IDDPW6NR5TE
Length of the connecting rod: a
Length of the two cranks: 2.5a
Distance between two fixed bearing houses: 2a
The connecting rod rotates fully.
A part of the locus of the middle point of the connecting rod is approximately straight.



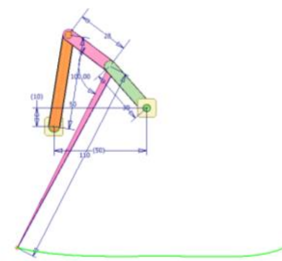
Robert's four-bar linkage 4
http://www.youtube.com/watch?v=q69bxfp3On4
Length of the connecting rod: a
Length of the two cranks: not less than 1.2a
Distance between two fixed bearing houses: 2a
Not any links have full rotation.
A part of the green locus of the lower point of the connecting rod is approximately straight.



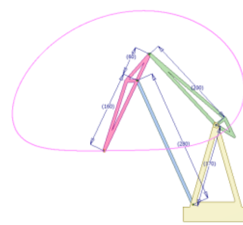
D-drive four-bar linkage 5
http://www.youtube.com/watch?v=7FRRGbw381k
The green locus has two approximately straight parts perpendicular to each other.



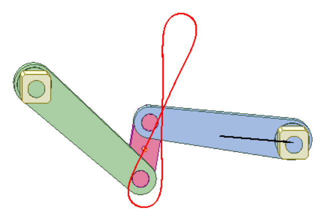
Four-bar linkage 6
http://www.youtube.com/watch?v=f4N1R8MPZTI
Four-bar linkage produces an approximately straight-line motion. A small displacement of the orange crank results in a long, almost-straight line. It is used for the stylus on self-registering instruments.



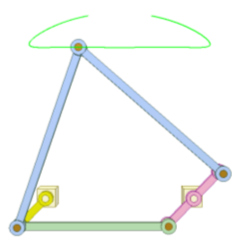
Four-bar linkage crane
http://www.youtube.com/watch?v=QGKnTEqHSS8
The end point of the connecting rod draws a straight line. This is used for moving load in horizontal direction.



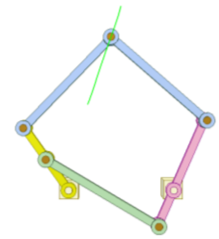
Watt's Linkage drawing straight line
http://www.youtube.com/watch?v=KpDpP0ZgKt8
Length of the two cranks: d
Length of the connecting rod: c
Horizontal distance between crank shafts: 2d
Vertical distance between crank shafts: c
The middle point of the connecting rod traces a 8-shaped curve.
Length of the line segment: 3c/2
Not any links have full rotation.



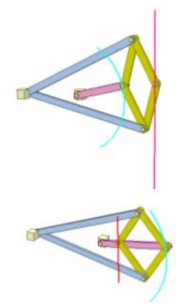
Straight line drawing mechanism 4a
https://youtu.be/6ZVUsxgcfYk
Yellow, green and pink links create a parallelogram mechanism.
Length of yellow link: a
Length of green link: 4a
Length of pink link: a + a
Length of blue links: 5a
Center of revolute joint between two blue links traces green line, lower portion of which is approximately straight.



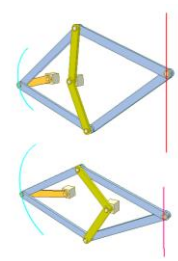
Straight line drawing mechanism 4c
https://youtu.be/fsxm2iCkvyg
Yellow, green and pink links create a parallelogram mechanism.
Length of yellow link: a + a
Length of pink link: a + 2a
Length of green link: 3,4a
Length of blue links: 3.25a
Center distance of two fixed revolute joints: 2.75a
Center of revolute joint between two blue links traces a curve, a portion of which is approximately straight (in green).



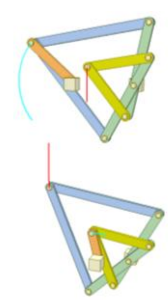
Peaucellier linkage 1
http://youtu.be/6fgrTZnO-ZM
Bars of identical colour are of equal length.
In each mechanism axle distance between the two fixed revolution joints and the pink bar length are equal.
A vertex of the yellow rhombus traces an absolutely straight line (in red).



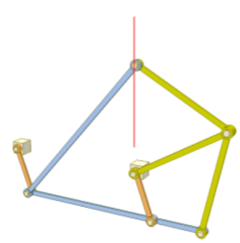
Peaucellier linkage 2
http://youtu.be/LhC9RVI2ln8
Bars of identical colour are of equal length.
In each mechanism axle distance between the two fixed revolution joints and the orange bar length are equal.
An vertex of the blue rhombus traces an absolutely straight line (in red).



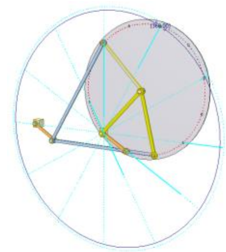
Kite mechanism 1
http://youtu.be/Izacj8CRsNc
A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.
Bars of identical colour are of equal length.
Axle distance between the two fixed revolution joints and the orange bar length are equal.
An vertex of the blue rhombus traces an absolutely straight line (in red).



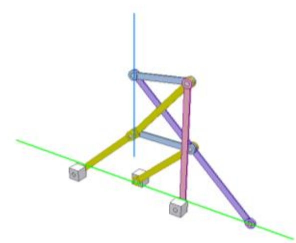
Kite mechanism 2a
http://youtu.be/kiIYlEd7Gj4
A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.
Length of blue bar: a
Length of blue bar of 3 joints: 0.75a + 0.25a
Length of yellow bars: 0.5a
Length of orange bars: 0.25a
Axle distance between the two fixed revolution joints 0.75a
An vertex of the big kite traces an absolutely straight line (in red).



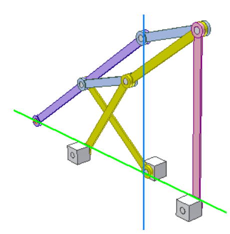
Kite mechanism 2b
http://youtu.be/wuKQcDh4MFw
A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.
Length of blue bar: a
Length of blue bar of 3 joints: 0.75a + 0.25a
Length of yellow bars: 0.5a
Length of orange bars: 0.25a
Axle distance between the two fixed revolution joints 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.



Linkage to draw two perpendicular straight lines 1
https://youtu.be/H8C3EVR_ezc
Input: one of two yellow bars that turns on stationary bearings.
Violet bar draws two perpendicular straight lines (in blue and green).
The green intersects axes of three stationary bearings.
The blue is perpendicular to the green at its intersection with the axis of the middle bearing.
Length of yellow bars: a.sqrt(2)
Length of blue bars: a
Length of pink bar: 2a
Length of violet bar: a.sqrt(2) + a.sqrt(2)
Horizontal distances between three stationary bearings: a
If the input turns 360 deg., the pink bar collides the left bearing similarly to case of video:
https://youtu.be/1H9VWSwfqWM



Linkage to draw two perpendicular straight lines 2
https://youtu.be/1H9VWSwfqWM
Input: one of two yellow bars that turns on stationary bearings.
Violet bar draws two perpendicular straight lines (in blue and green).
The green intersects axes of three stationary bearings.
The blue is perpendicular to the green at its intersection with the axis of the middle bearing.
Length of yellow bars: a.sqrt(2)
Length of blue bars: a
Length of pink bar: 2a
Length of violet bar: a.sqrt(2) + a.sqrt(2)
Horizontal distances between three stationary bearings: a
If the input turns 360 deg as shown in this video, the pink bar collides the left bearing. So the input can only turn less than 180 deg. similarly to case of video:
https://youtu.be/H8C3EVR_ezc



Six-bar linkage for tracing straight line

https://youtu.be/MNpdFbiuiSw

Input: one of the bars pivoted on the base.

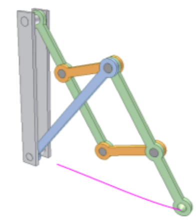
The point at the end of green bar traces a nearly straight line (in pink).

Length of the base bar: a

Length of blue bar: a

Length of green bars: 0.4a + 0.6a

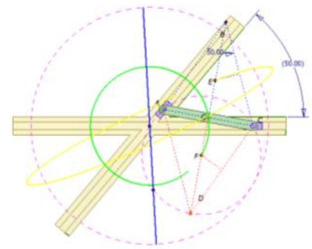
Length of orange bars: 0.4a



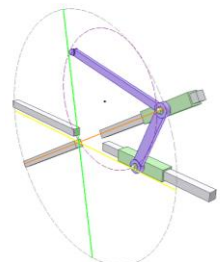
*** For all revolute joint mechanisms having linearly translating link see pages 118 – 120.**

17.1.2. Straight lines by other mechanisms

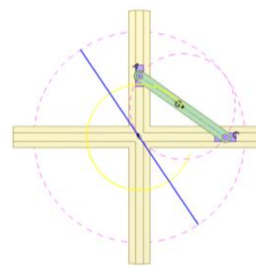
Straight line drawing mechanism 1
http://www.youtube.com/watch?v=8WCee-fP9rg
It is an ellipse mechanism.
Every point of the small magenta circle (circumcircle of isosceles triangle ACD) traces a straight line (in violet).
Circumcenter of triangle ACD traces a circle (in green).
The small magenta circle rolls inside the large fixed magenta one. They are Cardano circles.



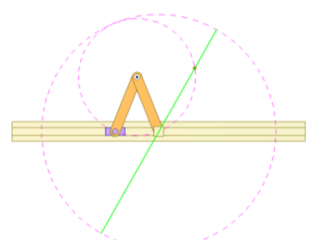
Straight line drawing mechanism 1b
https://youtu.be/aySMU4vkp-s
It is an ellipse mechanism and gives us possibility to draw a line (in green) concurrent with two intersecting lines (in yellow and pink).
Every point of the small circle traces a straight line.
The small circle rolls inside the large fixed one. They are Cardano circles.



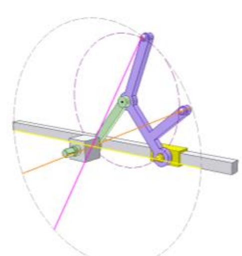
Straight line drawing mechanism 2
http://www.youtube.com/watch?v=zaJmNcmvGQQ
It is an ellipse mechanism.
Every point of the small magenta circle (AC diameter) traces a straight line (in violet).
The small magenta circle rolls inside the large fixed magenta one. They are Cardano circles.



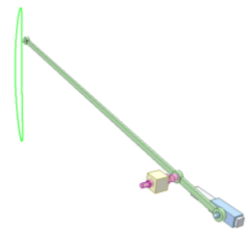
Straight line drawing mechanism 3a
http://www.youtube.com/watch?v=JmYyRuiMajw
It is an isosceles slider-crank mechanism.
Every point of the small magenta circle (fixed with the conrod and its radius is equal to the conrod length) traces a straight line (in green).
The small magenta circle rolls inside the large fixed magenta circle. They are Cardano circles.



Straight line drawing mechanism 3b
https://youtu.be/AaGIn6aEXtY
It is an isosceles slider-crank mechanism.
Every point of the small circle (fixed with the violet conrod and its radius r is equal to the conrod length) traces a straight line.
The small circle rolls inside the large fixed circle of 2r radius. They are Cardano circles.

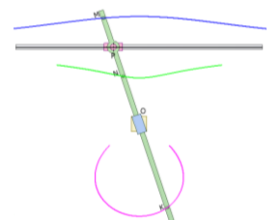


Straight line drawing mechanism 5



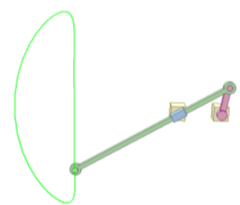
https://youtu.be/UX4yDeBxzWM
Pink, green and blue links create a slider-crank mechanism.
Length of pink link: a
Length of green link: 4a + 26a
An end of the green link traces green line, right portion of which is approximately straight. It is an absolutely straight, if center of the middle revolute joint of the green link moves along an ellipse. Refer to:
Drawing Ellipse Mechanism 3
http://www.youtube.com/watch?v=FoO2LIYLPEc

Conchoids of a straight line



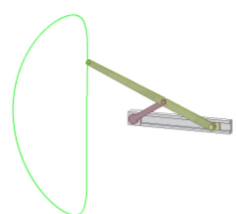
https://youtu.be/iah7aKMdIu8
Pink, green and blue links create a tangent mechanism.
Point P of the green link moves along a straight line.
Points M, N and L of the green link trace conchoids (in blue, green and pink) of the said straight line.

Straight line drawing mechanism 6a



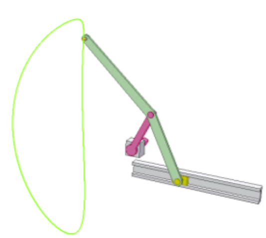
https://youtu.be/VZSZTB_OLPs
Pink, green and blue links create a coulisse mechanism.
Length of pink link: a
Length of green link: 6a
Center distance of two fixed revolute joints: 1.5a
An end of the green link traces green line, right portion of which is approximately straight.
It is an absolutely straight, if the other end of the green link moves along a conchoid of a straight line. See pink conchoid in video:
https://youtu.be/iah7aKMdIu8

Straight line drawing mechanism 7b



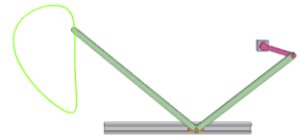
https://youtu.be/eKfEyo7YUVA
Input: pink crank of a radius.
Length of conrod: 1.4a + 2.2a
The conrod end traces closed curve, right portion of which is approximately straight. The portion corresponds ¼ revolution of the crank.

Straight line drawing mechanism 8

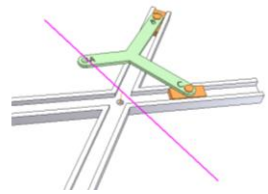


https://youtu.be/Vbcbno26IZ0
Input: pink crank of a radius.
Length of conrod: 1.52a + 2.13a + 3.59a
Eccentricity of the slider-crank mechanism: 0.47a
The conrod end traces closed curve, right portion of which is approximately straight.

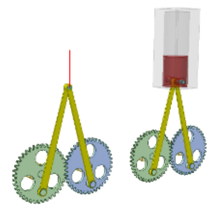
Straight line drawing mechanism 9
https://youtu.be/Zwwnr262Wlc
Input: pink crank of a radius.
Length of conrod: 4a + 5.25a + 7.15a
Eccentricity of the slider-crank mechanism: 2.83a
The conrod end traces closed curve, right portion of which is approximately straight.



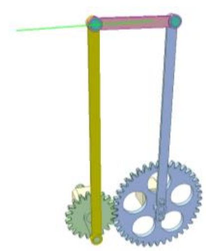
Straight line drawing mechanism 10
https://youtu.be/bbP1x33L1U4
When orange sliders move, point A of green bar traces a straight line.
Condition: ABC is an isosceles triangle (AB = AC) and angle BAC = angle between the two runways.
For more see:
http://www.youtube.com/watch?v=8WCee-fP9rg



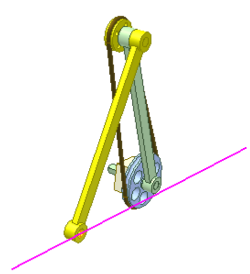
Gear and linkage mechanism 1
http://youtu.be/muF6Y7TUJz8
A slider crank mechanism of two conrods and two cranks. The latters are fixed to two gears in mesh. Owing to the symmetric arrangement the piston axle moves rectilinearly (even if no cylinder (the left mechanism)). Lateral forces from piston applied to cylinder are negligible.



Gear and linkage mechanism 2
http://youtu.be/lDKUj8MV9Xc
Center of the yellow and pink bars revolution joint moves along a 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

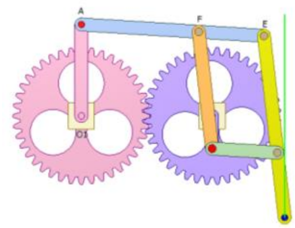


Straight line drawing mechanism 4a
http://youtu.be/HmnA6E82-Wk
Input: green crank of length L1.
Blue pulley of radius R1 is stationary.
Yellow pulley of radius R2 is fixed to yellow bar of length L2.
R1 = 2.R2
L1 = L2
A point on revolution joint of the yellow bar traces a straight line. Its length is 4.L1.
This mechanism has a relation with Cardano cycles.
If L1 ≠ L2, condition to get the said straight line: R1/R2 = 1 + (L1/L2)
The belt should be toothed.
It is possible to use chain drive instead of belt one.



Pantograph for drawing straight lines 1a

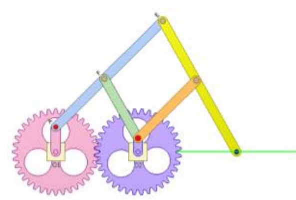
https://youtu.be/CMQ241yGFtQ



Blue, orange, green and yellow bars create a pantograph.
Two red pins and blue one are in line.
The blue pin traces a straight line (in green).
Condition for tracing a straight line:
R1/R2 = AE/EF
R1: radius of pink crank
R2: radius of violet crank
Its length L = 2R2 + 2 (R1 + R2)(FE/AF)
The direction of the line depends on angular position between pink and violet cranks at starting position of the mechanism.
For the starting position in this video, the line is vertical.

Pantograph for drawing straight lines 1b

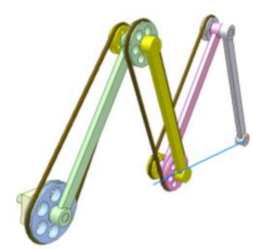
https://youtu.be/ZbiExQK6Crg



Blue, orange, green and yellow bars create a pantograph.
Two red pins and blue one are in line.
The blue pin traces a straight line (in green).
Condition for tracing a straight line:
R1/R2 = AE/EF
R1: radius of pink crank
R2: radius of violet crank
Its length L = 2R2 + 2 (R1 + R2)(FE/AF)
The direction of the line depends on angular position between pink and violet cranks at starting position of the mechanism.
For the starting position in this video, the line is horizontal, in line with O1O2.

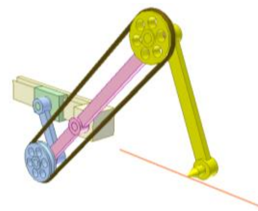
Straight line drawing mechanism 4b

https://youtu.be/SG5mt-yHwG4

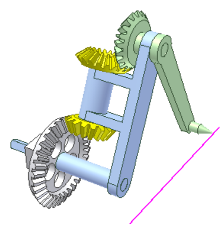


Input: green crank.
Blue pulley is stationary. Four cranks are of the same length L.
Belt drive on green crank has transmission ratio of 2.
Belt drives on yellow and pink cranks have transmission ratio of 1.
End point of grey bar traces a straight line. It can reach a distance D = 4L from the blue pulley center.
The belt should be toothed. Using chain drive is possible.
By connection of modules of two cranks and a 1/1 belt drive the distance D can be increased to 6L, 8L, …

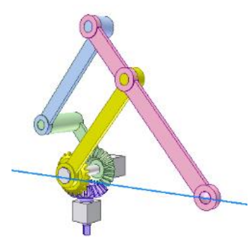
Straight line drawing mechanism 5
https://youtu.be/SG5mt-yHwG4
Input: green slider.
Blue pulley is fixed to blue bar of Lb length.
Yellow pulley is fixed to yellow bar of Ly length.
Distances between revolution joints of pink bar is Lp1 + Lp2
Lb/Ly = Lp1/Lp2
Belt drive on pink bar has transmission ratio of 1.
End point of yellow bar traces a straight line that intersects green slider pivot axis and fixed bearing axis.
It is necessary to set the blue bar parallel to yellow bar for getting the line straight.
The belt should be toothed. Using chain drive is possible.



Straight line drawing mechanism 6
https://youtu.be/PmJAGnE1hQI
Input: blue crank.
Grey gear is stationary.
Blue and green cranks are of the same length L.
Grey and yellow gear drive has transmission ratio of 2.
Green and yellow gear drive has transmission ratio of 1.
End point of green bar traces a straight line. Its length is 4L.

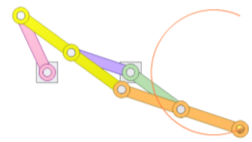


Straight line drawing mechanism 7a
https://youtu.be/N1Al-C6FxGM
Input: violet gear.
Green, blue, yellow and pink bars create a parallelogram mechanism.
Length of green bar: La
Lengths of blue and yellow bars: Lb
Length of pink bar: La + Lb
All gears have the same tooth number.
End point of pink bar traces a straight line.
Its length is less than 4Lb (green crank can't make a full revolution).
This mechanism has the same working principle of the mechanism shown in
http://youtu.be/Z5kFDYcoXS0



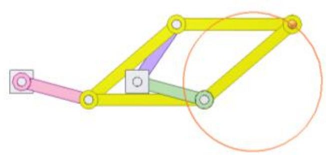
17.2. Conic curves

Mechanism for drawing circle 1



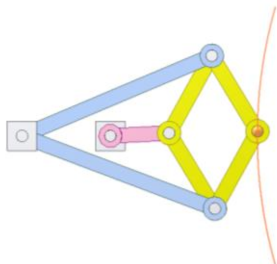
https://youtu.be/qhH-oLw-6CI
Lengths of short bars: a
Lengths of long bars: a + a
Distance between centers of the two fixed pivots is b.
Orange pen draws a portion of a circle of radius a (in orange)
If the pink crank rotates regularly, the pen moves regularly on the circle.
Circle center is on the line that connects centers of the fixed pivots. Distance between fixed pivot center of the pink bar and the circle center is 2b.
This avoids the need to arrange a pivot at the circle center.
The mechanism has dead positions when all bars (except the pink one) are in line.

Mechanism for drawing circle 2



https://youtu.be/KN7Rz7LWe7w
Lengths of short bars: a
Lengths of long bars: b
Pink, green bars and a yellow bar create a parallelogram mechanism.
Pink, violet bars and a yellow bar create an antiparallelogram mechanism.
Orange pen draws orange circle of radius a.
If the pink crank rotates regularly, the pen moves irregularly on the circle.
Circle center is on the line that connects centers of the fixed pivots.
Distance between fixed pivot center of the pink bar and the circle center is 2b.
This avoids the need to arrange a pivot at the circle center.
The mechanism has unstable positions when all bars (except the pink one) are in line.

Mechanism for drawing circle 3

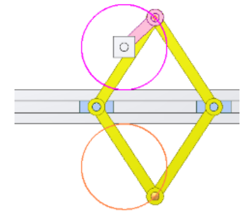


https://youtu.be/1VzRxG1Bg04
Lengths of yellow bars: a
Lengths of blue bars: b
Length of pink bar (input): c
Distance between centers of fixed pivots: d
Orange pen draws a portion of a circle of radius R (in orange).
Circle center is on the line that connects centers of the fixed pivots.
Distance between fixed pivot center of the pink bar and the circle center is L.
L = d.(b.b – a.a)/(d.d – c.c)
R = c.L/d = c.(b.b – a.a)/(d.d – c.c)
If (d - c) is chosen small, R can be very large.
This avoids the need to arrange a pivot at the circle center.
The mechanism has dead positions when all bars (except the pink one) are in line.
If (d – c) = 0 the circle becomes a straight line. See:
http://youtu.be/6fgrTZnO-ZM

Mechanism for drawing circle 4

https://youtu.be/i-boQdw_84c

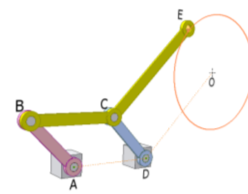
Yellow bars have the same length.
Orange pen draws a circle (in orange) that is symmetrical to the pink circle drawn by the pink bar about the centerline of the grey runway.
This avoids the need to arrange a pivot at the orange circle center.



Mechanism for drawing circle 5

https://youtu.be/BNSU_g-gHe4

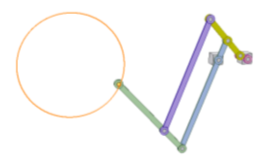
Pink, blue and yellow bars create a parallelogram mechanism.
Pen E draws orange circle of center O.
This avoids the need to arrange a pivot at the circle center.
Triangles OAD and EBC are equal.
If the pink crank rotates regularly, the pen moves regularly on the circle.
The mechanism has dead positions when all bars are in line.



Mechanism for drawing circle 6

https://youtu.be/0SSg6C8EbQY

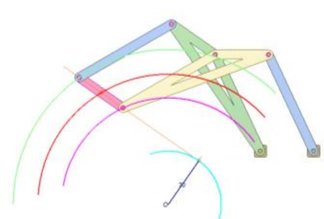
Violet, blue, yellow and green bars create a parallelogram.
Orange pen center, fixed pivot center of the blue bar and center of revolute joint between pink and yellow bars always create a straight line.
While the pink bar draws a cicle of radius a (length of the pink bar) the pen draws orange circle of radius R.
R/a = length ratio of the blue bar.
This avoids the need to arrange a pivot at the circle center.



Double parallelogram mechanism 2

http://www.youtube.com/watch?v=U-Vn5SoRWCg

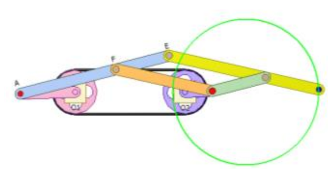
Length of two blue links is 140.
For the two triangular links lengths between the holes are 70 and 140 with angle of 150 degrees.
Lengths of the pink output and the grounded links is 70.
The pink output link rotates around point O.
This avoids the need for hinges at distant or inaccessible spots.



Pantograph for drawing circles

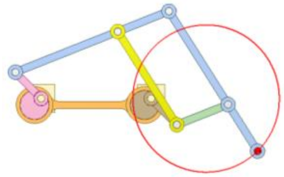
https://youtu.be/BsDpRfXi8-4

Blue, orange, green and yellow bars create a pantograph.
Two red pins and blue one are in line.
The blue pin traces a circle. Its center O lays on O1O2:
OO2 = O1O2(FE/AF)
Its radius R depends on angular position between pink and violet cranks and their radii.



Mechanism for drawing circle 7

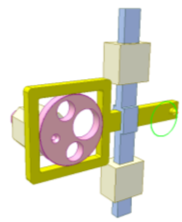
https://youtu.be/-5QuR-bS6xU



Blue, yellow and green bars create a pantograph.
Length of blue bars: a + b. Here a is larger than b.
Length of green bar: b
Length of yellow bar: a
Length of pink crank: e
Length of brown crank: f
Pink and brown eccentrics, orange conrod create a parallelogram mechanism to ensure that pink and brown cranks are parallel and rotate in the same direction and with the same speed. A gear drive of transmission ratio of 1 can be used instead.
The red pen traces a circle.
Its radius R = e + (e + f).(b/a)
Its center Or is on the line connecting rotary centers of pink and brown cranks OpOb.
Or is on the right of Ob,
ObOr = OpOb.(b/a)

Cam of two followers 1

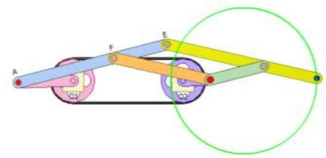
http://youtu.be/x_zg9cxr9o4



Input: pink eccentric cam (cam of constant width).
The blue follower linearly reciprocates.
The yellow follower has planar motion: circular translation. Each point on it traces a circle (in green). Its radius = cam eccentricity.

Pantograph for drawing circles

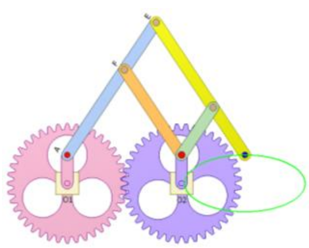
https://youtu.be/BsDpRfXi8-4



Blue, orange, green and yellow bars create a pantograph.
Two red pins and blue one are in line.
The blue pin traces a circle. Its center O lays on O1O2:
OO2 = O1O2(FE/AF)
Its radius R depends on angular position between pink and violet cranks and their radii.

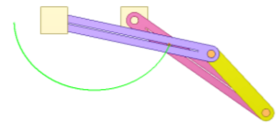
Pantograph for drawing ellipses

https://youtu.be/jjhh-qtCTUQ

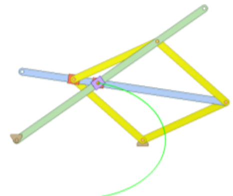


Blue, orange, green and yellow bars create a pantograph.
Two red pins and blue one are in line.
R1/R2 ≠ AE/EF
R1: radius of pink crank
R2: radius of violet crank
The blue pin traces an ellipse (in green).
Its size depends on radii of pink and violet cranks.
The direction of the ellipse depends on angular position between pink and violet cranks at starting position of the mechanism.
For the starting position in this video, the ellipse is horizontal.
Its semi axes:
d = R2 + (R2 + R1)(EF/AF)
c = R2 + (R2 - R1)(AE/AF)
Its center O lays on O1O2:
OO2 = O1O2(EF/AF)

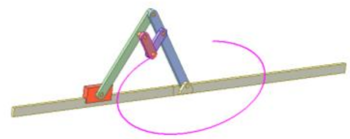
Inverse Parallelogram Mechanism 4
http://www.youtube.com/watch?v=A4TvGoHsNyk
The intersection point of the cranks traces an ellipse.



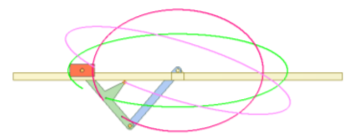
Conic section drawing mechanism 1
http://www.youtube.com/watch?v=4UhoyxrRquY
Drawing ellipses.
The four yellow bars create a rhombus.



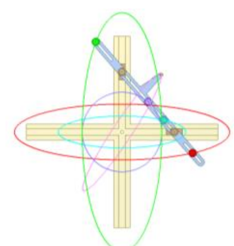
Drawing Ellipse Mechanism 1
http://www.youtube.com/watch?v=vbIYhFK_cYw
Lengths of the crank and the connection rod are equal.
The crank, the connection rod and two short links creates a rhombus.
Equation of traced ellipse: (x.x)/(a.a) + (y.y)/((a – 2b). (a – 2b)) = 1
the coordinate origin O is the fixed revolution joint center of the bue 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).



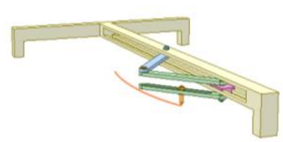
Drawing Ellipse Mechanism 2a
http://www.youtube.com/watch?v=Ug7TK4YTRlY
Lengths of the crank and the connection rod are equal.
Each point of the green connection rod draws an ellipse.



Drawing Ellipse Mechanism 3
http://www.youtube.com/watch?v=FoO2LIYLPEc
Each point of the blue bar draws an ellipse.

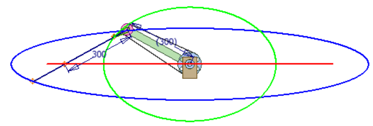


Drawing Ellipse Mechanism 2b
http://youtu.be/csg08Sm8okA
Lengths of blue crank and green conrod are equal.
Each point of the green conrod draws an ellipse.
Adjust position of the orange pen and move it to draw various ellipses. Push the crank or the conrod for overcoming dead points.



Belt satellite mechanism 2

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



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

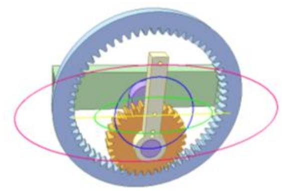
A point on the small sprocket draws an ellipse. For the special case (the red line) it is a straight line.

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



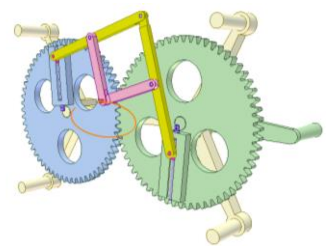
Tooth number ratio is 2.

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:

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

$a = (m+n)/2$

$b = (m-n)/2$

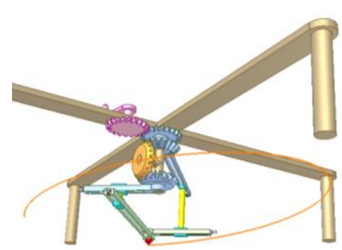
m, n: center distance of gear axle and its pink slider axle.

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:

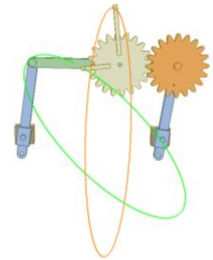
$(x/(a+b))^2 + (y/(a-b))^2 = 1$

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

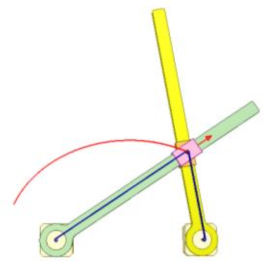
b: center distances between pivots of the short slotted bars.

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

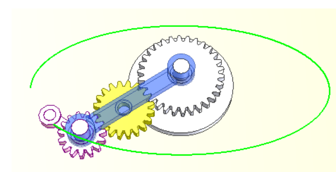
Drawing Ellipse Mechanism 4
http://www.youtube.com/watch?v=rH7tMg9sR1w
Tooth number ratio is 1.
Each point of the yellow gear draws an ellipse.



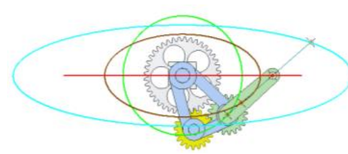
Cable mechanism for drawing ellipse
http://youtu.be/UEIuvciAH7c
The tow wraps on the pivot of small diameter of two sliders. It is possible that the tow passes through a hole of the pivot. The tow ends are fixed to rotation centers of the yellow and green bars. Turn the bars while keeping the tow strained, 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).



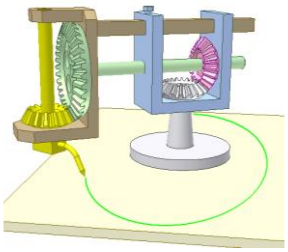
Drawing ellipse mechanism 8
http://youtu.be/GmUgfipRRsU
Grey gear of Z1 teeth is stationary. The pink crank is fixed to the pink gear of Z2 teeth. Z1 = 2.Z2
When blue crank turns, the point on the pink crank traces an ellipse (in green).
Semi minor axis = A - R
Semi major axis = A + R
A: center distance of the grey and pink gears.
R: radius of the pink crank.
It is possible to improve the mechanism in order that A and D are adjustable.



Loci in epicyclic gearing BB5
https://youtu.be/LHjLRiW7aYc
Input: blue crank.
It is an external epicyclic gear mechanism of two satellite gears.
Zf/Zs = 2
Zf: tooth number of stationary grey gear.
Zs: tooth number of green gear.
Tooth number of yellow gear is arbitrary.
Points on the green gear crank trace ellipses in general.
Semi-major axis = Rb + Rg
Semi-minor axis = Rb - Rg
Rb: center distance of the grey and green gears
Rg: distance from the point tracing the line to axis of the green gear
The red is an absolutely straight line because Rb = Rg



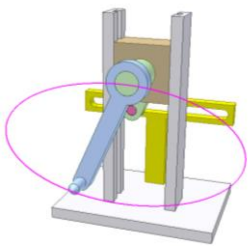
Drawing ellipse mechanism 9



http://youtu.be/WDcfFQXtMo4

Grey gear of Z1 teeth is stationary. The blue frame is pivoted to the grey gear.
Pink gear of Z2 teeth has key sliding joint with the green shaft to which is fixed green gear of Z3 teeth.
Yellow vertical shaft to which is fixed yellow gear of Z4 teeth has yellow tracer.
Tooth numbers are chosen so that 1 rev. of the blue frame corresponds 2 rev. of the yellow shaft. (here: Z1 = Z2 = 20; Z3 = 32; Z4 = 16)
When the blue frame turns, the point of the yellow tracer will trace an ellipse (in green).
Semi minor axis = A - R
Semi major axis = A + R
A: center distance of the grey and yellow gears (adjusted by moving brown slider).
R: distance from the point of the yellow tracer to yellow shaft axis (adjustable).

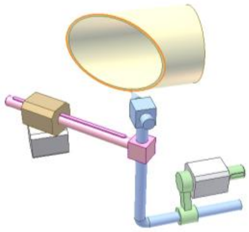
Drawing ellipse mechanism 10



https://youtu.be/8FX81b5i7uc

Input: green shaft to which blue crank is fixed.
The blue crank traces an ellipse (in pink).
Angle between green and blue cranks A = 0 deg. (in this video) or 180 deg.
For case A = 0 deg. the ellipse semi-axes are B and (B-G).
For case A = 180 deg. the ellipse semi-axes are B and (B+G)
B: radius of the blue crank.
G: radius of the green crank.
Disadvantage: the input shaft bearing is not stationary.

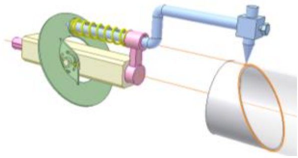
Mechanism for drawing intersection of cylinder and plane 1



https://youtu.be/V9tQcq-FBkg

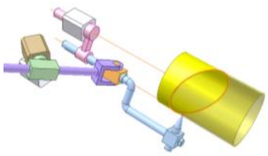
Input: green crank.
Point of blue bar draws intersection (orange ellipse) of yellow cylinder and a plane. The plane is parallel to the one that contains two axes (vertical and horizontal) of pink slider.
Cylinder axis and rotary axis of the green crank are parallel.
Radius of the green crank and radius of the yellow cylinder are equal.
Adjust tilt angle of the brown bearing to get various intersections.

Mechanism for drawing intersection of cylinder and plane 2
https://youtu.be/egCSIUkkS9o



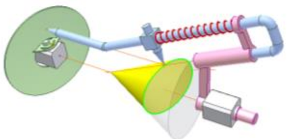
Input: pink crank.
Right point of blue slider draws intersection (orange ellipse) of grey cylinder and a plane. The plane is parallel to the face of the green disk, tilt angle of which is adjustable for various intersections.
Yellow spring forces blue slider toward the disk, maintains the contact between left point of the blue slider and the disk.
If the left point is of a sphere, its radius should be as small as possible to reduce error of the intersection.
Cylinder axis and rotary axis of the pink crank are in line.
The right point of the blue bar lays on sliding axis of the blue slider.

Mechanism for drawing intersection of cylinder and plane 3
https://youtu.be/HxfhFikNBaY



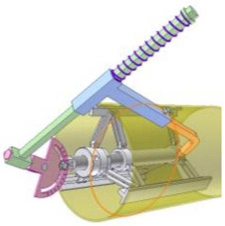
Input: pink crank.
Point of blue slider draws intersection (orange ellipse) of yellow cylinder and a plane. The plane is parallel to the one that is created by the longitudinal axis of violet slider during motion.
Cylinder axis and rotary axis of the pink crank are in line.
Point of the blue slider lays on sliding axis of the latter.
Adjust tilt angle of the brown bearing to get various intersections.

Mechanism for drawing intersection of cone and plane 1
https://youtu.be/H0jiYtGkNiE



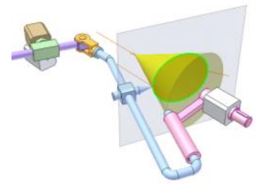
Input: pink crank.
Middle point of blue slider draws intersection (green ellipse) of yellow cone and a plane. The plane is parallel to the face of the green disk, tight angle of which is adjustable.
Red spring forces the blue slider toward the disk, maintains the contact between left point of the blue slider and the disk.
If the left point is of a sphere, its radius should be as small as possible to reduce error of the intersection.
Axis of the cone and rotary axis of the pink crank are in line.
Line that connects two points of the blue slider is parallel to rotary axis of the pink crank.
Adjust tilt angle of the green disk to get various intersections.

Instrument for marking intersection of plane and cylinder
https://youtu.be/cAHJQFKDg_U



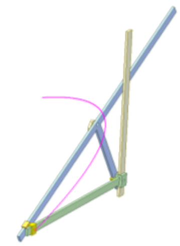
The grey device inside yellow cylinder is for centering instrument.
See:
https://youtu.be/XDHO9JHlPzI
Turn green bar to draw the intersection of an inclined plane and the cylinder (orange ellipse).
The inclined angle is adjustable thanks to pink dial.

Mechanism for drawing intersection of cone and plane 2
https://youtu.be/-G_Pnv725Ak



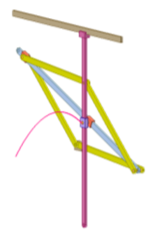
Input: pink crank.
Middle point of blue slider draws intersection (green ellipse) of yellow cone and a plane. The plane is created by axis of sliding joint of green link when it turns.
Axis of the cone and rotary axis of the pink crank are in line.
Axis of revolute joint between the blue slider and orange part contains middle point of the blue slider and is parallel to rotary axis of the pink crank.
Adjust tilt angle of the brown bearing to get various intersections.

Drawing Parabola Mechanism 1
http://www.youtube.com/watch?v=BdiGhqDBWpU



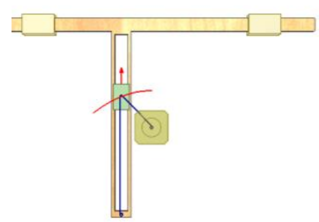
Equation of traced parabola: y.y = b.x
b: distance between the fixed revolution joint center of the T-bar (blue) O and the centerline of the fixed bar (popcorn).
Axis Oy is vertical. Axis Ox is horizontal.

Conic section drawing mechanism 2
http://www.youtube.com/watch?v=JRynHxNjjhM



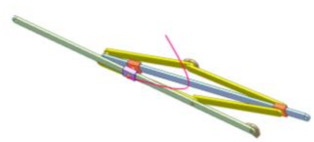
Drawing parabolas
The four yellow bars create a rhombus.

Cable mechanism for drawing parabola
http://youtu.be/BsBRUoL2XKE



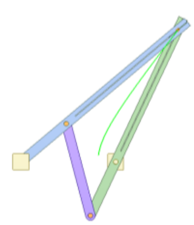
The tow wraps on the pivot of small diameter of green slider. It is possible that the tow passes through a hole of the pivot. One tow end is fixed to a immobile point, the other end is fixed to a point of the orange bar. Move the bar while keeping the tow strained, the center of slider pivot traces an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



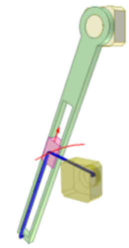
Drawing hyperbolas
The four yellow bars create a rhombus.

Inverse Parallelogram Mechanism 5
http://www.youtube.com/watch?v=i5uj88NBq_s

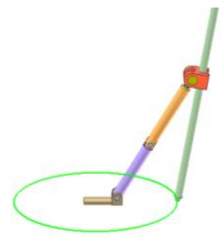


The intersection point of the cranks traces a hyperbola.

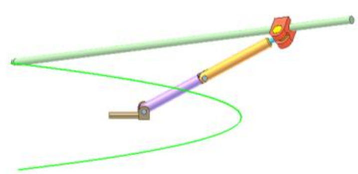
Cable mechanism for drawing hyperbola
http://youtu.be/72bwAtzubiY
The tow wraps on the pivot of small diameter of pink slider. It is possible that the tow passes through a hole of the pivot. One tow end is fixed to a immobile point, the other end is fixed to a point of the green bar. Turn the bar while 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).



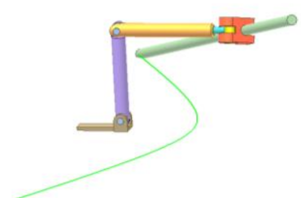
Conic section compass 1
http://www.youtube.com/watch?v=EMTJHircC-A
Drawing ellipses according to US Patent 5870830.
To adjust angles α and θ for each ellipse.
- α angle between the orange axis and the plane of paper
- θ: angle between the orange axis and the green arm
The green arm rotates around the orange axis to create a cone.
Its intersection curve with the plane of paper is an ellipse.



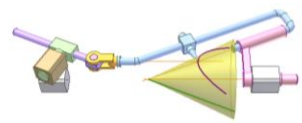
Conic section compass 2
http://www.youtube.com/watch?v=Mfi9SgAyrK4
Drawing parabolas according to US Patent 5870830.
To adjust angles α and θ for each parabola.
- α angle between the orange axis and the plane of paper.
- θ: angle between the orange axis and the green arm.
α is equal to θ for parabola 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.

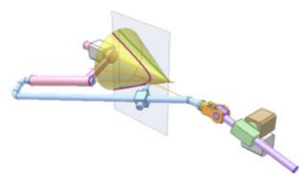


Mechanism for drawing intersection of cone and plane 3
https://youtu.be/LwCfxIX1pms



Input: pink crank.
Middle point of blue slider draws intersection (violet parabola) of yellow cone and a plane. The plane is parallel to the green generatrix of the cone.
The plane is created by axis of sliding joint of green link when it turns.
Axis of the cone and rotary axis of the pink crank are in line.
Axis of revolute joint between the blue slider and orange part contains middle point of the blue slider and is parallel to rotary axis of the pink crank.

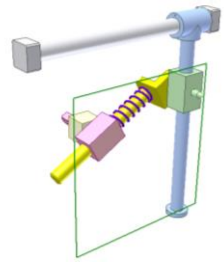
Mechanism for drawing intersection of cone and plane 4
https://youtu.be/6RmK5WZty_M



Input: pink crank.
Middle point of blue slider draws intersection (violet hyperbola) of yellow cone and a plane. The plane is parallel to two green generatrices of the cone.
The plane is created by axis of sliding joint of green link when it turns.
Axis of the cone and rotary axis of the pink crank are in line.
Axis of revolute joint between the blue slider and orange part contains middle point of the blue slider and is parallel to rotary axis of the pink crank.
Rotary axes of the pink crank and the green shaft should be skew to ease the motion.

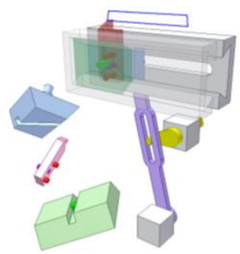
17.3. Other planar curves

Linkage for drafting a parallelogram
http://youtu.be/Hbq9J_HJsTo



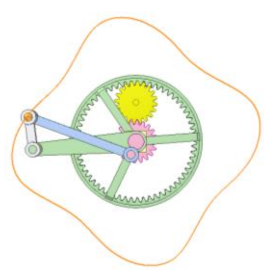
Input: pink coulisse.
End point of green slider traces a parallelogram (in green)
Length of horizontal side = length of grey runway – length of blue slider
Length of vertical side = length of blue runway – length of green slider
Parallelogram angle = angle between grey runway and blue runway (90 deg. for this case).
Rotary axis of the pink coulisse is at intersection of the parallelogram diagonals.
The mechanism has two DoFs. Violet spring always forces blue slider or green slider towards the ends of grey runway or blue runway.

Three slider mechanism
https://youtu.be/qtGZFapSnp8



A point on red slider draws a trapezoid of small height.
Blue slider moves in rear runway.
Green slider moves in front runway.
Two red pins of the pink slider move in groove of the green slider.
Violet pin of the pink slider moves in 45 deg. oblique groove of the blue slider.
Green pin fixed to the green slider restricts motion of the pink slider in vertical direction when it contacts with the two red pins.
Input: yellow crank gives the blue slider reciprocating linear motion via a coulisse mechanism (violet lever of two slots).
When the blue slider goes to the right, first it pushes up the pink slider (due to its 45 deg. oblique groove) then moves the green slider to the right. The green slider can not move first because of its large inertia and its large friction with the runway.
When the blue slider goes to the left, first it pushes down the pink slider (due to its 45 deg. oblique groove) then moves the green slider to the left.

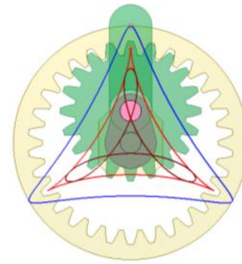
Gear and linkage for drafting a square 1
http://youtu.be/-VkcLhWsE-I



Input: pink crank-gear of Z1 teeth.
Green crank-gear has Z3 teeth, Z3 = 3.Z1.
With appropriate lengths of the 4-bar linkage the orange pin traces a curve nearly square.
Better mechanisms for drafting squares:
http://youtu.be/ft9gmtesYUE
http://youtu.be/Hbq9J_HJsTo

Loci in Epicyclic gearing A1

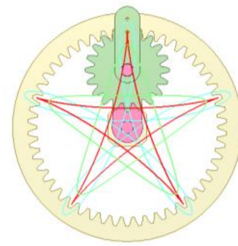
http://youtu.be/usF8GCmD7xM



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

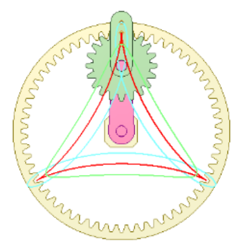
http://youtu.be/M4Sp2e6_BRw



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

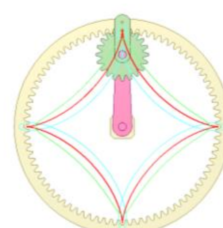
http://youtu.be/U8vf3DEmWS0



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.

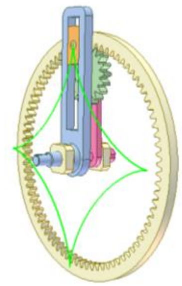
Loci in Epicyclic gearing A4

http://youtu.be/hGu6yUYF8mc

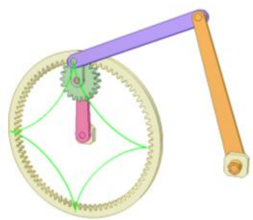


R: pitch diameter of the fixed sun gear
r: pitch diameter of the planetary gear
k = R/r = 4
Loci of various points on the planetary gear are shown.
The red locus is for a point on the pitch circle of the planetary gear.
It is a special hypocycloid: astroid. The two other loci are hypotrochoid.
1 cycle of the mechanism corresponds 1 revolution of the input crank.

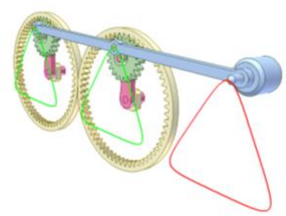
Loci in Epicyclic gearing A4c
http://youtu.be/4QYQy2akPY0
R: pitch diameter of the fixed sun gear
r: pitch diameter of the planetary gear
k = R/r = 4
A point on pitch circle of the planetary gear traces a special hypocycloid: astroid (green)
The blue slotted crank has 4 dwells in a revolution.



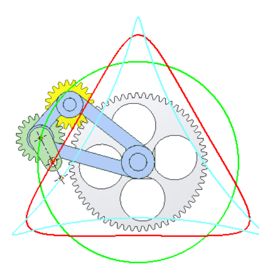
Loci in Epicyclic gearing A4r
http://youtu.be/xfwYbT46mKo
R: pitch diameter of the fixed sun gear
r: pitch diameter of the planetary gear
k = R/r = 4
A point on pitch circle of the planetary gear traces a special hypocycloid: astroid (green)
The orange crank rocks with a dwell at its rightest position.



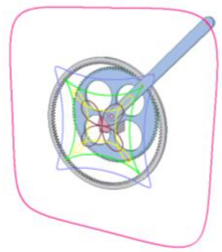
Loci in Epicyclic gearing A3b
http://youtu.be/BdXXi4fgli0
Two identical hypocycloid mechanisms guide the point of the blue bar along the triangularly shaped path.
Distance between the bar holes is equal to distance between the two fixed bearings of the pink cranks.
R: pitch diameter of the fixed sun 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.



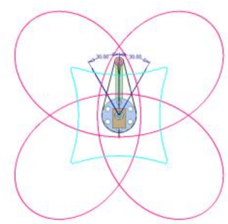
Loci in epicyclic gearing BB6
https://youtu.be/jDr2_BTUNRY
Input: blue crank.
It is an external epicyclic gear mechanism of two satellite gears.
Zf/Zs = 3
Zf: tooth number of stationary grey gear.
Zs: tooth number of green gear.
Tooth number of yellow gear is arbitrary.
Points on the green gear crank trace various lines.
The red is an equilateral triangle of rounded vertices.
This mechanism is a replacement for the mechanism showed at
http://youtu.be/U8vf3DEmWS0
when the gear of internal teeth is not preferable.



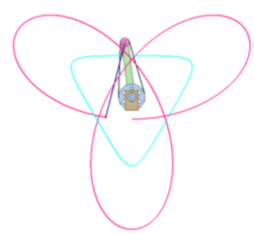
Loci in Epicyclic gearing A0
https://youtu.be/Wygr39gMr7s
R: pitch diameter of the fixed sun gear
r: pitch diameter of the planetary gear
R/r = a/b
a/b is an irreducible fraction
Here a/b = 4/3
Loci of various points on the planetary gear are shown.
The green curve is for a point on the pitch circle of the planetary gear. It is a hypocycloid. The other loci are hypotrochoid.
The red curve is a polygon of a sides with rounded corners.
Here a = 4. Radius of the point that traces the red square is Rc = 2.78r.
1 working cycle of the mechanism corresponds b revolutions of the input crank. Here b = 3.



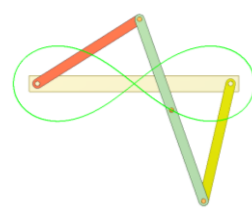
Belt satellite mechanism 1
http://www.youtube.com/watch?v=QNIhGtqKn_M
Diameter ratio between the fixed large pulley and the small one is 4.
If the green crank oscillates 60 degrees between the two blue lines, the small pulley makes a 180 degree oscillation.
It is similar to the case of a gear satellite with sun internal gear.



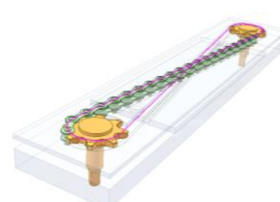
Belt satellite mechanism 3
http://www.youtube.com/watch?v=_d0cYQsQJP4
Diameter ratio between the fixed large pulley and the small one is 3.
The blue locus has three approximately straight parts.
It is similar to the case of a gear satellite with sun internal gear.

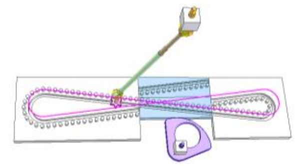


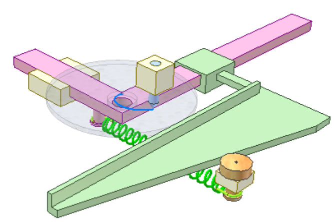
Inverse Parallelogram Mechanism 6
http://www.youtube.com/watch?v=rjxnoQz4xDs
The middle point of the coupler link traces a figure-eight shaped curve, a lemniscate.

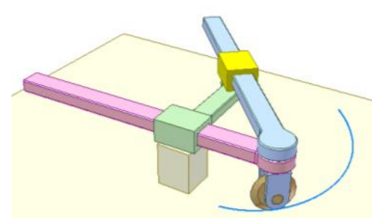


Drawing eight-shaped line 1
https://youtu.be/N893HWEX-Hg
It is a solution for an YouTuber request: tracing an eight-shaped line with constant velocity.
Two sprockets are both driving and of opposite rotary directions.
One among the transmission ways for them is
http://youtu.be/k0-Gd4PYR_o
Relative angular position between two sprockets can not be arbitrary to ensure that the chain can be in mesh with both sprockets at needed time.
A point on axis of revolute joint of any link draws the required line (in pink).

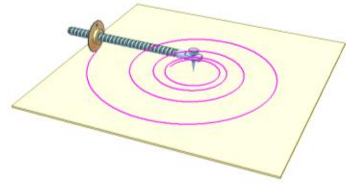


Drawing eight-shaped line 2
https://youtu.be/spgT6mJ_QEk

It is a solution for an YouTuber request: tracing an eight-shaped line with constant velocity.
Pin rack consists of grey stationary part and blue moving part. Its pin number: Zr.
Input: orange shaft that is connected to pink pinion of Zp teeth via a double Cardan universal joint. Its velocity: Vp.
A point on the pinion axis draws the required line (in pink).
One working period corresponds N revolutions of the pinion.
N = Zr / Zp
Motion of the blue part is controlled by violet cam that rotates at velocity Vc.
Vc = Vp / N
Device for preventing the pinion from axial displacement is not shown.
Spring device to force the blue part towards the cam is not shown.
Device for motion transmission from the input shaft to the cam is not shown.
There is considerable necessary backlash because the pinion has to engage with the rack on both sides of the rack.
For more about the double Cardan universal joint see:
https://youtu.be/aQrnXWo4DxE
For measures for copying the line to other place see:
https://youtu.be/fG48K40OWJ8

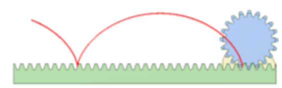
Instrument for drafting Archimedean spiral 1
http://youtu.be/P0IJzglFj5w

When green wedge moves, the blue pen traces on glass disk an Archimedean spiral.
The disk rotates due to the friction with the wedge (using rack-gear drive here is better)
Separation distance of traced Archimedean spiral t = πD.tan(α)
D: outer diameter of the disk.
α: wedge angle.

Instrument for drafting Archimedean spiral 2
http://youtu.be/Xdqeg_Hmu1g

When green crank turns, orange roller traces on ground an Archimedean spiral. It is said in a book. However I do not know how to prove this. It is a dynamic problem, not purely kinematic.
Friction between the roller and the ground must be adequate to prevent the roller moving along its rotary axis.
In case no friction contact between the roller and the ground, the mechanism has two degrees of freedom.

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.

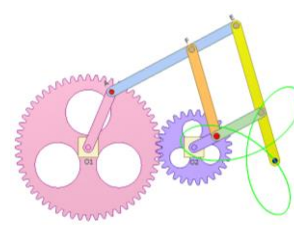


Rack pinion mechanism 2
http://www.youtube.com/watch?v=RN-6AH52V8U
A point on the rolling circle of the pinion traces a cycloid.

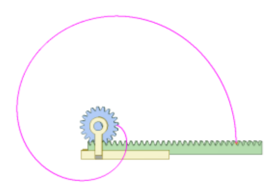


Chain drive 4D
http://youtu.be/eby46_llQnU
A chain drive rolls on the ground.
Loci of various points on a link (the pink one) are shown. The red line is for the link's pin center. The curve portions of the line are cycloids.

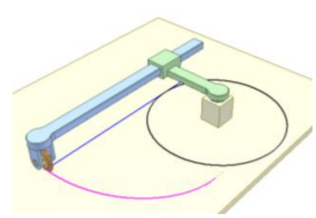
Pantograph for drawing cycloid curves
https://youtu.be/jOEqU57FQWU
Blue, orange, green and yellow bars create a pantograph.
Two red pins and blue one are in line.
The blue pin traces a curve of cycloid family (in green) subject to radii of pink and violet cranks, gear transmission ratio (2 for this video).



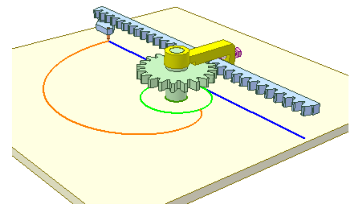
Rack pinion mechanism 3
http://www.youtube.com/watch?v=t_GxDXfQ0GA
A point on the rolling line of the rack traces an involute.



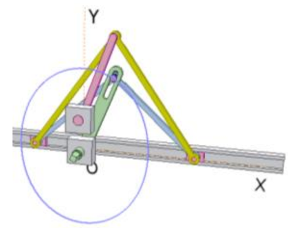
Instrument for drafting involute of a circle 1
http://youtu.be/qGTi7ahahTs
When green crank turns, orange roller traces on ground an involute (in pink) of a circle (in black).
Friction between the roller and the ground must be adequate to prevent the roller moving along its rotary axis. So the blue line fixed to the blue bar rolls without slipping on the black circle and its end traces the involute.



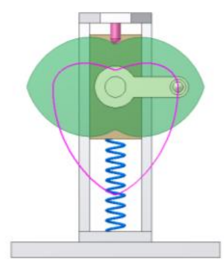
Instrument for drafting involute of a circle 2
http://youtu.be/X8RvgKauFzM
Blue rack has prismatic joint with yellow crank.
When the crank turns, orange pin traces on ground an involute (in orange) of a circle (in green).
Blue line fixed to the blue rack rolls without slipping on the circle and its end traces the involute.



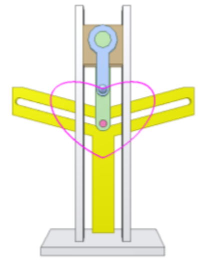
Cassini oval
https://youtu.be/NEDkUs6zGEE
Input: green crank.
Violet pin traces a Cassini oval.
Its equation:
(y^2+x^2)^2-2c^2(y^2-x^2) = d^4-c^4
d^4 = 4(a^2-b^2)c^2
a: length of yellow bars
b: length of blue bars
c: distance from rotary axis of pink rocker to center line of grey runway.



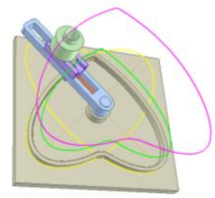
Mechanism for drawing heart shape 1
https://youtu.be/Yu37sMYfadc
Input: green shaft to which a cam and a crank are fixed.
The crank traces a heart-shaped curve (in pink).
Angular position between the Archimedean cam and crank must be as shown in the video (0 deg.) or 90 deg.
The cam profile consists of 4 sections. Each one is an Archimedean spiral of equation in polar coordinate system:
$\rho = a + (B/360)\varphi$
a: smallest radius of the profile
B: spiral parameter
φ: rotation angle of the cam
If the profile is a concentric circle, the crank traces a circle.
Its equation:
$x = R\cos(\varphi)$
$y = R\sin(\varphi)$
R: the crank radius.
However the cam moves the bearing and affects the y value so equation of the heart curve in polar coordinate system is
$x = R\cos(\varphi)$
$y = R\sin(\varphi) +/- (B/360)\varphi$
For more details about the mathematical basis of this mechanism see Method 1 in:
http://www.geocities.jp/nyjp07/index_heart_E.html
Disadvantage: the input shaft bearing is not stationary.
The mechanism can be used for cake decoration.



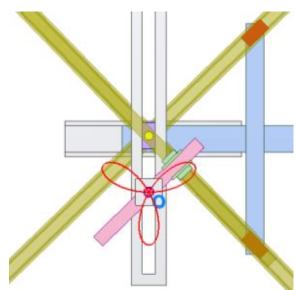
Mechanism for drawing heart shape 2
https://youtu.be/xS5NfAB3rxA
Input: green shaft to which blue crank is fixed.
The blue crank traces a heart-shaped curve (in pink).
Angle between green and blue cranks A = 0 deg.
This is a development of the mechanism shown at:
https://youtu.be/8FX81b5i7uc
The original ellipse is deformed along the vertical axis due to the yellow cam of V-shaped slot.
Disadvantage: the input shaft bearing is not stationary.
The mechanism can be used for cake decoration.



Mechanism for drawing heart shape 3
https://youtu.be/uT7gkK6F5N0
Input: blue crank.
A pin on violet slider moves along heart-shaped profile of a stationary cam under orange spring force.
The pin center traces a heart-shaped curve (in green).
Point of the green part adjustable fixed to the violet slider traces a heart-shaped curve (in pink) that is the equidistant curve of the green heart-shaped one.
The heart-shaped profile of the cam is created from two ellipses (in yellow).
For more about heart-shaped profiles refer to
http://www.mathematische-basteleien.de/heart.htm
The mechanism can be used for cake decoration.

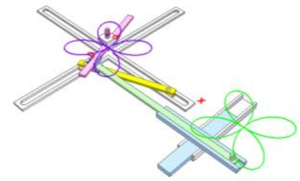


Mechanism to draw three-petalled rose
https://youtu.be/kDXZs_IcwlU
Input: pink crank.
Output: green slider. Its center D draws three-petalled rose (in red). Its equation in polar coordinate system OX:
OD = a*sin(3φ)
φ: angle DOX
a: vertical distance between O and the center of the lower revolution joint of the blue part.
Center distance of two revolution joints of the blue bar = 4a. The joints are symmetric over the horizontal bar of the blue part.
The violet slider has revolution joint with the yellow part.
In one revolution of the pink crank the rose is drawn two times.
For reproducing the same rose at other place refer to the way shown at
https://www.youtube.com/watch?v=cJZaNy9qA3A



Mechanism to draw four-petalled rose

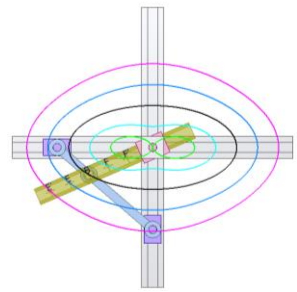
https://youtu.be/cJZaNy9qA3A



Input: pink shaft.
Output: violet slider. Its center draws four-petalled rose (in violet).
Its equation in polar coordinate system OX:
OD = (a/2)*sin(2φ)
φ: angle DOX
a: length of the yellow bar
Green and blue parts are for drawing green four-petalled rose, a reproduction of the violet one.

Equidistant curves to an ellipse 1a

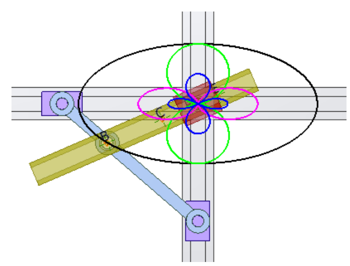
https://youtu.be/fAgVRTKiG6U



Point B on blue bar of an ellipse mechanism traces an ellipse (in black). Four other curves are traced by the points on the yellow bar that has revolution joint with the blue bar at B and prismatic joint with the pink part.
They are considered as the result of the black ellipse deformation with constant distance along the direction toward the ellipse center.
They are equidistant or parallel curves with respect to the black ellipse.
Input: the pink part. One working cycle corresponds two input revolutions
This method of forming curves is used in designing and manufacturing of profiles, non-circular wheels, cams etc.

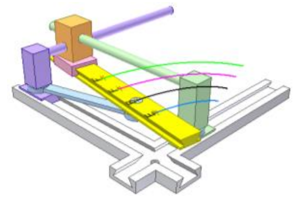
Equidistant curves to an ellipse 1b

https://youtu.be/dHh-cVZcYiQ



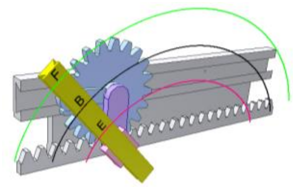
Point B on blue bar of an ellipse mechanism traces an ellipse (in black). Three other curves are traced by the points on the yellow bar that has revolution joint with the blue bar at B and prismatic joint with the red part.
They are considered as the result of the black ellipse deformation with constant distance along the direction toward the ellipse center.
They are equidistant or parallel curves with respect to the black ellipse.
Input: the red part. One working cycle corresponds two input revolutions.
In this video:
BC = a; BE = b; BD = (a+b)/2
a: length of semi-minor axis of the black ellipse.
b: length of semi-major axis of the black ellipse.
Points C, D and E trace eight-shaped curves.

Equidistant curves to an ellipse 2
https://youtu.be/rX4G9p09sJY



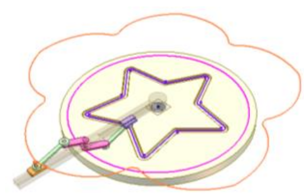
Point B on blue bar of an ellipse mechanism traces an ellipse (in black). Three other curves are traced by the points on the yellow bar that has revolution joint with the blue bar at B and prismatic joint with the pink part.
They are considered as the result of the black ellipse deformation with constant distance along the normals to the black ellipse.
They are equidistant or parallel curves with respect to the black ellipse.
This method of forming curves is used in designing and manufacturing of profiles, non-circular wheels, cams etc.

Equidistant curves to a cycloid
https://youtu.be/S4oKVYZyc5Q



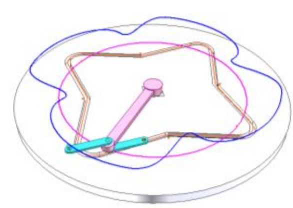
Violet slider moves along horizontal runway.
Blue gear pivoted on the violet slider rolls on grey rack.
Pink rotary runway has a revolution joint with the crank of the violet slider. The joint center is always on rolling line of the rack.
Yellow bar slides along the pink runway and has a revolution joint with the blue gear at B.
Distance from B to rotary axis of the blue gear is R (gear rolling radius).
Point B traces an cycloid (in black).
Point E and F trace red and green curves.
They are considered as the result of the black cycloid deformation with constant distance along the direction toward the instantaneous center of the gear rotation.
This method of forming curves is used in designing and manufacturing of profiles, non-circular wheels, cams etc.

Symmetry over a circle
https://youtu.be/KP394x5n0NA



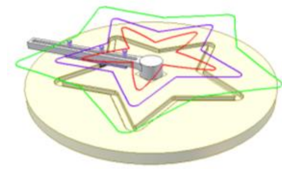
Orange curve is the symmetric one of the violet curve over pink circle. A double slider crank mechanism ensures that distances from violet and orange curves to the pink circle along its radial direction are always equal.
It can be used in cake decorations.

Symmetry over a point moving on a circle
https://youtu.be/6tAronouPto

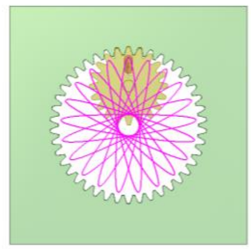


Blue curve is the symmetric one of the orange curve over a point that moves on the pink circle.
Crank radii of the blue double crank are equal.
It can be used in cake decorations.

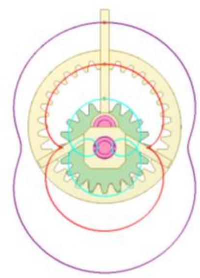
Curve enlarging and reducing 1
https://youtu.be/owLo-gXPJnA
Violet part slides in dovetail slot of white crank.
When the crank rotates points of the violet slider trace curves.
Violet curve and center curve of the groove on the yellow cam are identical.
Red and green curves can be considered as created from violet curve.
Distance between two curves along the white crank is constant.
It can be used in cake decorations.



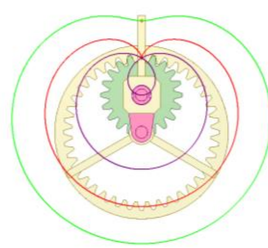
Loci in Epicyclic gearing A2.1
http://youtu.be/VMG5039DKoo
Drawing toy Spirograph.
This video shows how the pink pencil traces a 21 wing hypotrochoid.
Tooth number of green gear: 42.
Tooth number of yellow gear: 20.



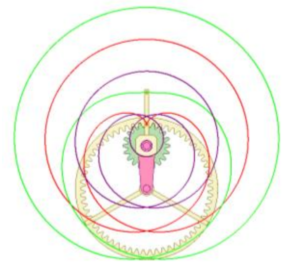
Loci in Epicyclic gearing B1
http://youtu.be/lkwYaPxSUgw
r: pitch diameter of the fixed sun gear with external teeth.
R: pitch diameter of the planetary gear with internal teeth
k = R/r = 1.5
Loci of various points on the planetary gear are shown.
The red is for a point on the pitch circle of the planetary gear.
1 cycle of the mechanism corresponds 3 revolutions of the input crank.



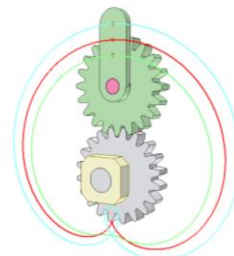
Loci in Epicyclic gearing B2
http://youtu.be/QzP8eA1h91g
r: pitch diameter of the fixed sun gear with external teeth.
R: pitch diameter of the planetary gear with internal teeth
k = R/r = 2
Loci of various points on the planetary gear are shown.
The red is for a point on the pitch circle of the planetary gear.
1 cycle of the mechanism corresponds 2 revolutions of the input crank.



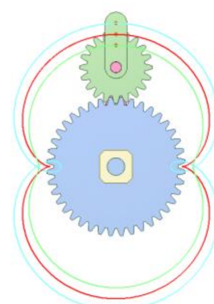
Loci in Epicyclic gearing B3
http://youtu.be/tzisrqQ8lls
r: pitch diameter of the fixed sun gear with external teeth.
R: pitch diameter of the planetary gear with internal teeth
k = R/r = 3
Loci of various points on the planetary gear are shown.
The red is for a point on the pitch circle of the planetary gear.
1 cycle of the mechanism corresponds 3 revolutions of the input crank.



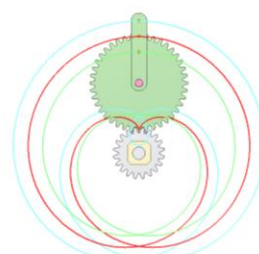
Loci in epicyclic gearing E1
http://youtu.be/rWe0P63_GjI
r: pitch diameter of the fixed sun gear.
R: pitch diameter of the planetary gear.
k = R/r = 1
Loci of various points on the planetary gear are shown.
The red is for a point on the pitch circle of the planetary gear.
1 cycle of the mechanism corresponds 1 revolution of the pink input crank.



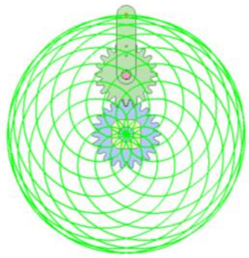
Loci in epicyclic gearing E2
http://youtu.be/ljMCYyT84mY
R: pitch diameter of the fixed sun gear.
r: pitch diameter of the planetary gear.
k = R/r = 2
Loci of various points on the planetary gear are shown.
The red is for a point on the pitch circle of the planetary gear.
1 cycle of the mechanism corresponds 1 revolution of the pink input crank.



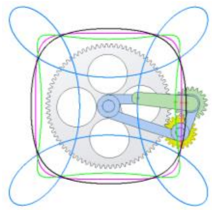
Loci in epicyclic gearing E2b
http://youtu.be/sjJLXzc-vlk
R: pitch diameter of the fixed sun gear.
r: pitch diameter of the planetary gear.
k = R/r = 0.5
Loci of various points on the planetary gear are shown.
The red is for a point on the pitch circle of the planetary gear.
1 cycle of the mechanism corresponds 2 revolutions of the pink input crank.



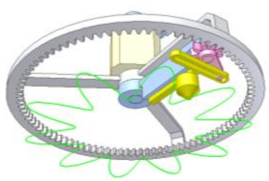
Loci in epicyclic gearing E1.1
http://youtu.be/jq4DZkcoR-A
R: pitch diameter of the fixed sun gear.
r: pitch diameter of the planetary gear.
k = R/r = 1.1
The red curve is locus of point on the pitch circle of the green planetary gear.
1 cycle of the mechanism corresponds 10 revolutions of the pink input crank.



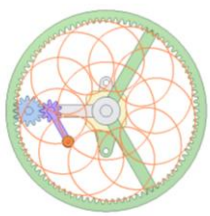
Loci in epicyclic gearing BB4
https://youtu.be/XDZAvCDoMhg
Input: blue crank.
It is an external epicyclic gear mechanism of two satellite gears.
Zf/Zs = 4
Zf: tooth number of stationary grey gear.
Zs: tooth number of green gear.
Tooth number of yellow gear is arbitrary.
Points on the green gear crank trace various lines.



Cake decorating machine 1
https://youtu.be/pTtov_mi9N4
Input: blue carrier.
It is a combination of satellite gear drive and sine mechanism.
A pastry bag attached to yellow slider pipes green star on a cake (not shown).
Height of the star petal = two times of the pink crank radius.
Number of the star petals N = Zg/Zp
Zg: tooth number of grey gear.
Zp: tooth number of pink gear.

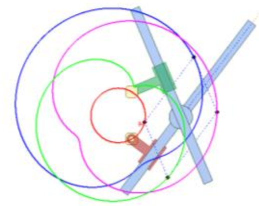


Cake decorating machine 2
https://youtu.be/KSibMCQV8vo
Input: grey carrier and green gear.
The grey carrier rotates continuously. When completing 1 revolution it makes more 1 revolution together with the green gear. The mechanism shown in:
http://youtu.be/CZhhw9hGUms
is connected to the two inputs to perform such motion.



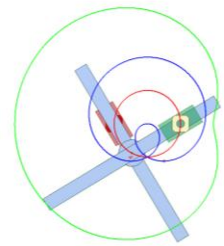
An orange pastry bag attached to violet crank pipes orange line on a cake (not shown). The line consitsts of a cycloid and a circle.

Oldham mechanism 1



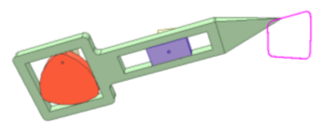
http://www.youtube.com/watch?v=Zb2wx3yaCeE
It is the generalized case of Oldham mechanism
Loci of various points on the X-shaped bar are shown.
Point A traces a circle two times during 1 revolution of the cranks.

Oldham mechanism 2



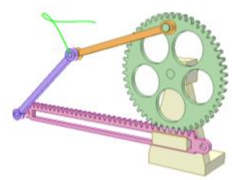
http://www.youtube.com/watch?v=TBYJwi4BTsM
It is the standard case of Oldham mechanism
Loci of various points on the X-shaped bar are shown.
Remark: Point A traces a circle (in red) two times during 1 revolution of the cranks. Center of the circle is located in the middle of line segment connecting the two rotation joints.

Drawing trapezium with Reuleaux triangle



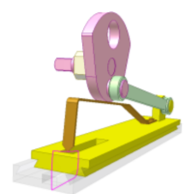
http://www.youtube.com/watch?v=HEiAhhQwNQ0
The cam profile is a Reuleaux triangle with rounded vertices.
The mechanism is used for moving film in cameras.

Rack and linkage mechanism 1



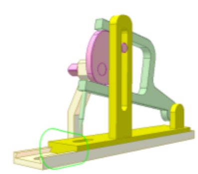
http://youtu.be/67GjJMQaWgM
The green input gear oscillates.
The orange and violet bars have complicated motions.

Cam and crank slider mechanism 1



http://youtu.be/TRbIgSk2ydI
The output flat spring tip traces a trapezium for moving film in cameras.

Cam and sine mechanism 1

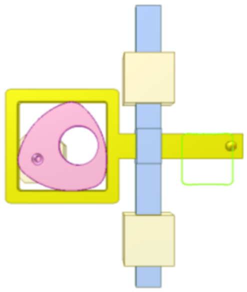


http://youtu.be/o0bvLlWQYhk
The tip of the green follower traces a green curve for moving film in cameras.

Cam of two followers 2

http://youtu.be/58OOKUT9nNY

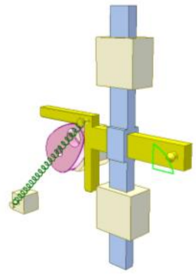
Input: pink cam (Reuleaux triangle) (cam of constant width).
The blue follower linearly reciprocates with dwells at both stroke ends.
The yellow follower has planar motion. Each point on it traces a square (in green). The square side = R2 – R1
R1, R2 are radii of the Reuleaux triangle.



Cam of two followers 3

http://youtu.be/ubVPb-KMsz0

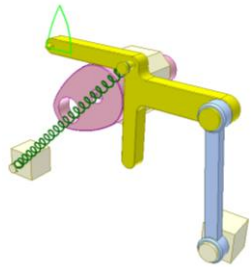
Input: pink cam causing two motions of blue and yellow followers.
The blue follower linearly reciprocates with dwell at its highest position.
The yellow follower has planar motion. Green closed curve is locus of a point on it. There are two straight portions because the cam profile contains a circular sector.
Spring maintains the cam contact with the yellow follower.



Cam of two followers 4

http://youtu.be/kyY9mVDxboM

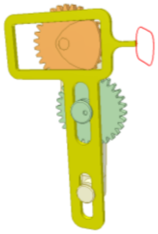
Input: pink cam causing two motions of blue and yellow followers.
The blue follower oscillates with dwell at its leftest position.
The yellow follower has planar motion. Green closed curve is locus of a point on it.
Spring maintains the cam contact with the yellow follower.



Cam and gear mechanism 7

http://youtu.be/HbeuoAhQ3kE

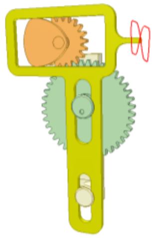
The yellow follower contacts with the orange cam fixed on the orange gear, eccentric portion of the green gear and the fixed lower pin. The cam is of constant width shape. A point of the frame follower traces the red curve that is used for moving film in cameras. Transmission ratio of the gear drive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



Cam and gear mechanism 8

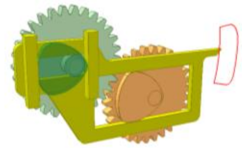
http://youtu.be/Mv6IA8nlogs

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

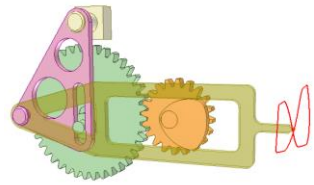
http://youtu.be/8IiGR-OqX1Q



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

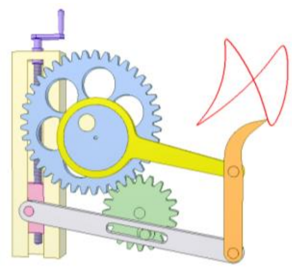
http://youtu.be/dDITwo4j4SA



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.

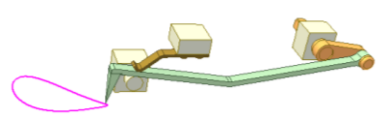
Blue and green gears have eccentrics.

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

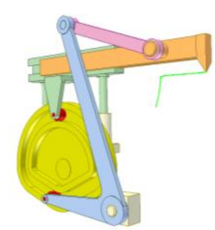
http://youtu.be/DQB1pY3It08



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

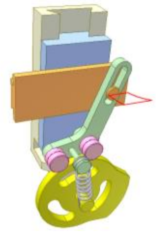
http://youtu.be/eOg1P04m8tM



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

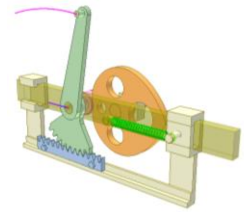
http://youtu.be/JAtnB_WAhOE



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.

Cam and gear mechanism 1

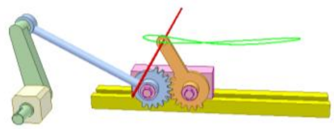
http://youtu.be/nGqN-2ckst8



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

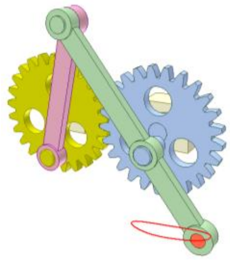
http://youtu.be/wql18kbXN1c



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

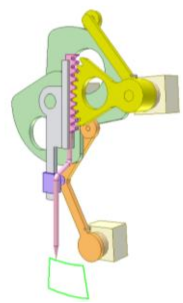
http://youtu.be/9JErtHWgtk4



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.

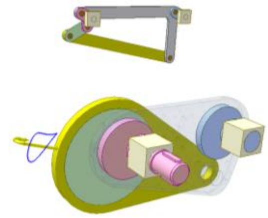
Double cam and gear rack mechanism

https://youtu.be/KVXVY27Bh08



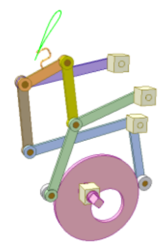
Input: green double cam
Output: pink awl, the point of which traces green closed line.
Change cam profiles for various shapes of the line.
Grey bar, violet slider and orange lever create a coulisse mechanism.
Pink rack is not always perpendicular to the line connecting cam and gear centers so some tooth gap of the rack-gear drive is needed.
The mechanism is applied in shoe making machines.

Linkage for complicated trajectory 1
https://youtu.be/P-zSCsfliDk
Five bar mechanism gives knitting needle a complicated trajectory.
The mechanism looks enigmatic because of large revolute joints, purpose of which is to ensure full rotation of the pink input shaft.
Upper figure is kinematic diagram of this mechanism.

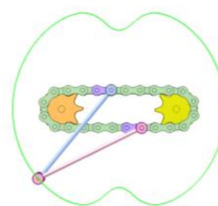


Cam and bar mechanism for complicated trajectory 1
https://youtu.be/5cseSVc0Wr8
Input: pink shaft.
Double cam and bars give knitting needle a complicated trajectory.
Grey rollers are forced toward cam by springs (not shown).

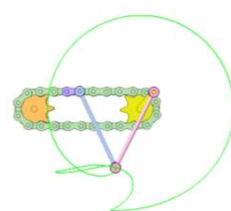
Cam and bar mechanism for complicated trajectory 2
https://youtu.be/fjREhx7D8hU
Input: pink shaft.
Cam and bars give knitting needle a complicated trajectory.
Grey rollers are forced toward cam by springs (not shown).



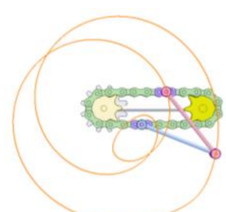
Chain drive 3E
http://youtu.be/rCyWwj-QU54
Two sprockets are identical.
Locus of center of the revolution joint between blue and pink bars is complicated.



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.

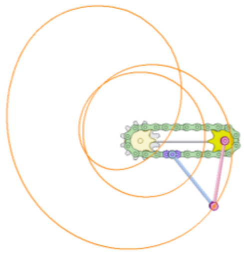


Chain drive 5D
http://www.youtube.com/watch?v=KDUgrrAbn6Q
Satellite chain drive.
The popcorn sprocket is fixed.
The popcorn and yellow sprockets have the same tooth number.
The grey crank and gear is driving.
Locus of center of the revolution joint between blue and pink bars is complicated.



Chain drive 5E

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



Satellite chain drive.

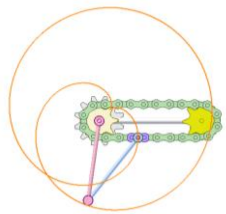
The popcorn sprocket is fixed. The popcorn and yellow sprockets have the same tooth number. The pink bar has a revolution joint with the yellow sprocket at its center.

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

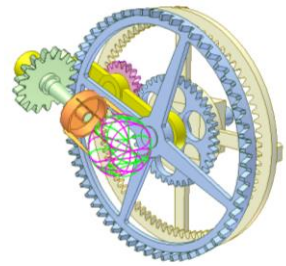


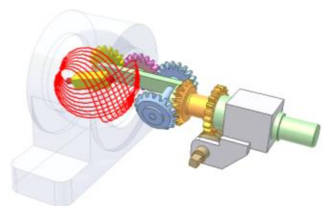
Satellite chain drive.

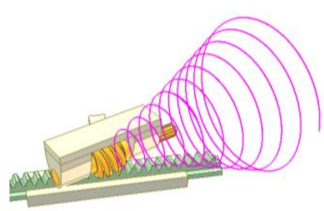
The popcorn sprocket is fixed. The popcorn and yellow sprockets have the same tooth number. The pink bar has a revolution joint with the popcorn sprocket at its center. The grey crank and gear is driving.

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

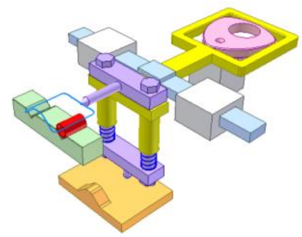
17.4. Spatial curves

Planetary spur and face gear drive 1
http://youtu.be/p1fBJH4Fz20

Input: blue shaft with spur gear (40 teeth) and face gear (60 teeth).
Yellow carrier rotates idly on the blue shaft.
Pink gear (20 teeth) rotates idly on pivot of the yellow carrier.
Green gear (16 teeth) with orange tool rotates idly in bearing of the yellow carrier.
Popcorn internal gear (80 teeth) is stationary.
In 3 revolutions of the input, the yellow carrier makes 1 rev. and the tool makes 7.5 rev. around its own rotary axis. A point of the orange tool traces curve laid on a sphere.
It is said that this mechanism is applied to an apple-paring machine.

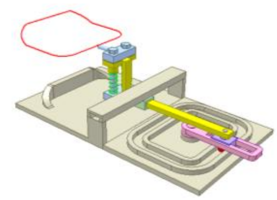
Study of satellite spur and bevel gear mechanism 1
http://youtu.be/xtB1qzva1gM

Inputs: green center crank and brown worm.
Three spur gears are of the same tooth number.
Two bevel gears are of the same tooth number.
The orange spur and bevel gears are fixed together.
Axes of the red bar, the yellow and green shafts are concurrent.
Red spatial curve is traced by the red bar point.
The curve lies on a sphere.
The mechanism can be applied for burnishing internal spherical surfaces.
Using the red bar as a cutter is impposible because the angle between the cutter edge and the red curve changes considerably during motion.
If the brown worm is kept immobile, the red bar point traces a spatial figure-eight shaped curve (spherical lemniscate).

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 deg., left hand
Rack: Helix angle B2 = 0 deg.
Angle between worm axle and rack moving direction is L = 30 deg.

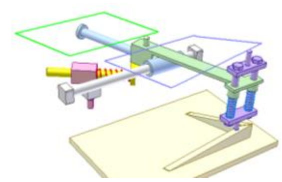
3D trajectory creation 1
https://youtu.be/wpn0KLPlo0o
Input: pink shaft of Reuleaux triangle.
Output: violet horizontal pin. In the view from above its trajectory is a square. Orange cam makes the pin move in vertical plane while it moves along one side of the said square.
The video shows an application of this mechanism: displacing the red bush.



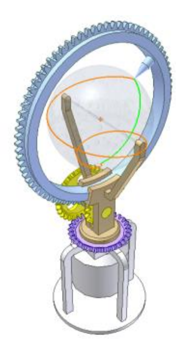
3D trajectory creation 2
https://youtu.be/046t-KP1ffw
Input: pink shaft.
A point of blue follower traces a 3D curve (in red), plan projection of which is a rectangle.
Change profiles of the beige cams to get other curve shapes.



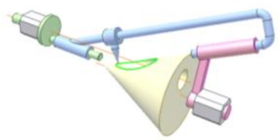
3D trajectory creation 3
https://youtu.be/FL3PwNuzxXw
It is a development of the mechanism shown at:
http://youtu.be/Hbq9J_HJsTo
Input: pink shaft.
A point of green part traces a 2D parallelogram (in green).
A point of violet follower traces a 3D curve (in blue), plan projection of which is the said parallelogram.



Drawing a spherical helix
https://youtu.be/bx6Pn9XReg8
Input: brown shaft.
Blue gear has revolute joint with the brown shaft and is driven via planetary bevel gear drive and spur gear one.
Glass sphere is fixed to the brown shaft.
A point on the blue gear:
- traces on the glass sphere a green circle.
- traces in the space the orange line, a spherical helix.

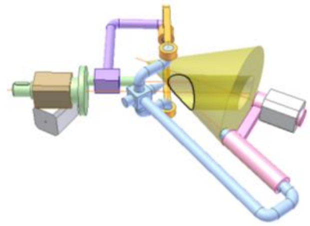


Mechanism for drawing intersection of cone and cylinder 1
https://youtu.be/BDUMUlwKY9M



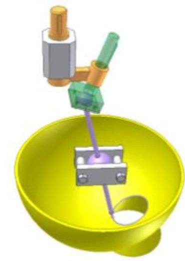
Input: green crank.
Point of blue slider draws intersection (in green) of cylinder and cone of the yellow work. The cylinder and cone axes are parallel.
Rotary axis of the green crank and axis of the work cylinder are in line.
Rotary axis of pink crank and axis of the work cone are in line.
Angle between axes of two joints of the pink crank = 0.5 A.
A: opening angle of the yellow cone.

Mechanism for drawing intersection of cone and cylinder 2
https://youtu.be/kbq0qb4vVYs



Input: green crank.
Point of blue slider draws intersection (in black) of cylinder and cone of the yellow work. The cylinder and cone axes are in a plane and intersected at an angle B (30 deg.) adjustable by turning brown bearing.
Rotary axis of the green crank and axis of the work cylinder are in line.
Rotary axis of pink crank and axis of the work cone are in line.
Angle between axes of two joints of the pink crank = 0.5 A.
A: opening angle of the yellow cone.
The green crank and the blue slider are connected together through an universal joint (violet and orange links).

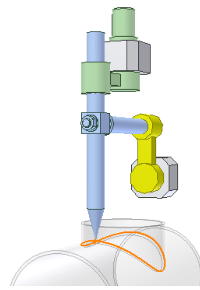
Mechanism for drawing intersection of sphere and cone 1
https://youtu.be/NTUd5aKKVm8



Input: orange crank.
Lower point of violet bar draws intersection (violet curve) of yellow hemisphere and cone (inner surfaces).
Hemisphere diameter: D1 = 100. Cone opening angle A = 40 deg. Their offset: E = 25
Distance between two spherical joints of violet bar: 0.5 D1.
Distance between lower point and lower spherical joint of violet bar: 0.5 D1.
Center of yellow hemisphere and center of lower spherical joint of violet bar are coincident.
Rotary axis of orange crank lays in plane created by center of lower spherical joint of violet bar and axis of yellow cone. Distance of rotary axis of orange crank and axis of yellow cone: 2 E.
Angle of rotary axis of orange crank and axis of green slider: 0.5 A.

Mechanism for drawing intersection of two cylinders

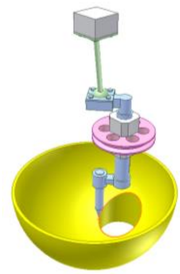
https://youtu.be/zTNFiVohvNc



Input: green crank.
Orange curve is intersection of two glass cylinders.
Their diameters: D1 = 40 and D2 = 30. Their offset: E = 3
Axes of cylinder D1 and bearing of yellow crank are parallel in vertical plane. Their distance: V
Axes of cylinder D2 and of bearing of green crank are in line.
Axes of bearing of yellow crank and bearing of green crank are skew. Their distance: E.
Distance between the point of blue vertical bar and axis of cylindrical joint between blue horizontal bar and yellow crank: V.

Mechanism for drawing intersection of sphere and cylinder 1

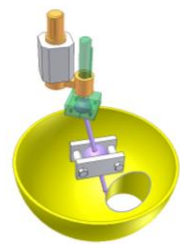
https://youtu.be/t9X2cbK2zEA



Input: pink pulley.
Orange curve is intersection of yellow hemisphere and cylinder (inner surfaces).
Hemisphere diameter: D1 = 100. Cylinder diameter D2 = 30. Their offset: E = 25
Length of green bar of two spherical joints: 0.5 D1.
Axis of cylinder D2 and rotary axis of blue crank are in line.
Vertical axis of the hemisphere and vertical axis of the upper spherical joint (fixed) are in line.
Distance between center of the upper spherical joint and center of yellow hemisphere is L.
Distance between the point of blue bar and center of its spherical joint is L.
Distance from the point of blue bar to its rotary axis is 0,5 D2.
Distance from center of spherical joint of blue bar to its rotary axis is 0,5 D2.

Mechanism for drawing intersection of sphere and cylinder 2

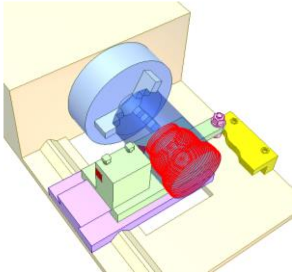
https://youtu.be/TF3exkI6uo4



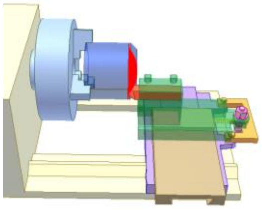
Input: orange crank.
Lower point of violet bar draws intersection (violet curve) of yellow hemisphere and cylinder (inner surfaces).
Hemisphere diameter: D1 = 100. Cylinder diameter D2 = 30. Their offset: E = 25
Distance between two spherical joints of violet bar: 0.5 D1.
Distance between lower point and lower spherical joint of violet bar: 0.5 D1.
Center of yellow hemisphere and center of lower spherical joint of violet bar are coincident.
Rotary axis of orange crank lays in plane created by center of lower spherical joint of violet bar and axis of yellow cylinder.
Distance of rotary axis of orange crank and axis of yellow cylinder: 2 E.
Axis distance between two revolute joints of orange crank: 0.5 D2

18. Mechanisms for copying

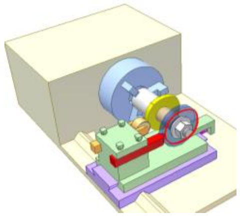
Copying device on lathe 1
http://youtu.be/kR-dbUTMNuU
The violet carriage is power-fed along the axis of rotation of the blue workpiece. The green slider carrying pink roller is forced by a spring (between violet and green sliders, not shown) towards the yellow template.
The tool traces a curve that corresponds to the template profile.



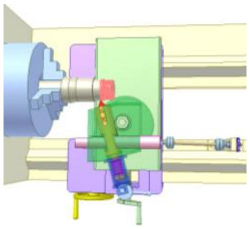
Copying device on lathe 2
http://youtu.be/DOd6PZm0iQY
The brown cross slide is power-fed square to the axis of rotation of the blue workpiece. The green upper slide carrying pink roller is forced by yellow spring towards the orange template.
The tool traces a curve that corresponds to the template profile.



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.

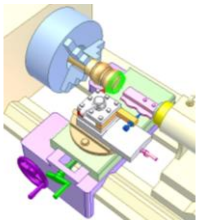


Copying device on lathe 4
http://youtu.be/_Av-t9bY1wg
The violet carriage is power-fed along the axis of rotation of the workpiece. The orange tool spindle carrying a red tool and a red tracer can slide in the green post that is fixed to the cross slide of the lathe.
The tracer is forced toward the pink 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

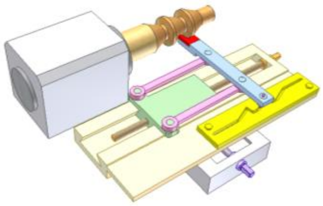
http://youtu.be/3kEpkg9RdwE



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.

Copying device for soft workpieces

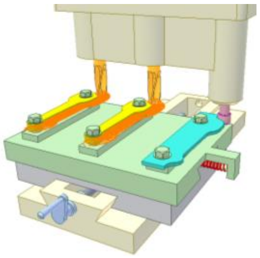
http://youtu.be/k7p2FzFgi5s



Red tool bit is fixed to an end of blue bar and pink tracer to the other end. Pink tracer moves in groove of yellow cam template. Blue tool bar, two pink bars create a parallelogram mechanism that eases the tool bar motion when the pressure angle in the cam is big (compared to cam sliding follower). Tool bar moves along the axis of rotation of orange workpiece thanks to green slider and orange screw.
Use violet screw of the lower runway to withdraw tool bit from workpiece a little in return stroke.
Attention: profile of the workpiece is a little different from the one of the template because the tool bit has three cutting edges (not a point).

Copying device on vertical milling machine 1

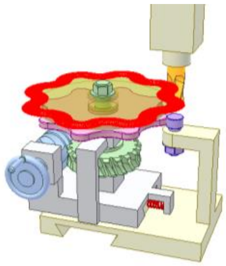
http://youtu.be/4xFMKC-NgBE



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

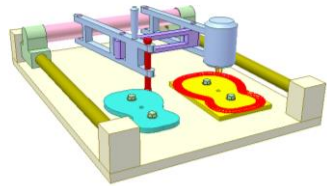
http://youtu.be/lLognO-dzOE



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

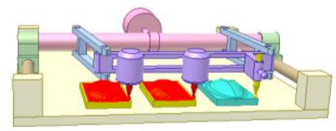
http://youtu.be/WJeliwU6OzU



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

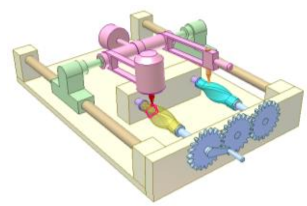
http://youtu.be/TzBM9iJa5mM



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

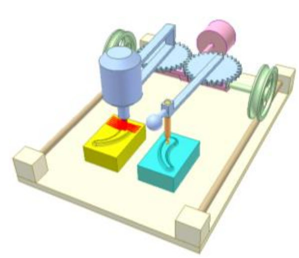
http://youtu.be/dxN5TNR_4WY



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=dskTOlmPJ0o

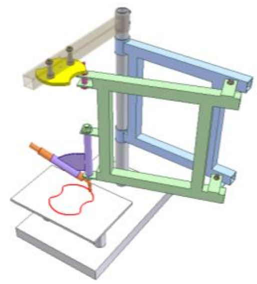
Wood 3D copy milling machine 3

http://youtu.be/x4zuhNgtR5I

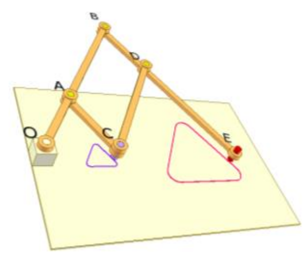


Pink tube can pivot on axle of green wheels that can roll along two brown rods.
The pink tube carries a drive of two identical gears. Motor with red spherical milling cutter is on one gear, orange stylus is on the other.
Move (by hand) the stylus on upper surface of cyan model, the cutter creates on 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).

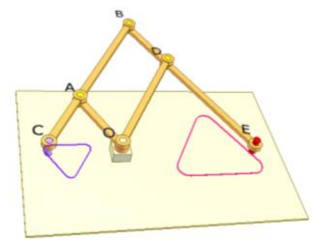
Plasma tracer
https://youtu.be/vkNi64cOqK4
The operator moves pink tracer along stationary yellow sample and orange torch cuts out the product of the sample shape.
Blue frame has revolution joints with the base and with the green frame.
The tip of the torch must be set to be always on the pink tracer axis.
The animation was made based on video:
http://www.rottenleonard.com/Plasma-Tracer.html



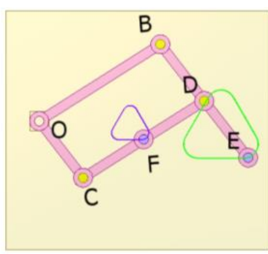
Bar pantograph 1
http://youtu.be/9H5hSLaRPTQ
ABCD: parallelogram.
OCE: straight line
O: immobile
OE/OC = BE/BD = k = constant
Figures traced by pen E and pen C are similar. Scale factor is k.



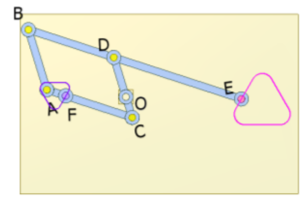
Bar pantograph 2
http://youtu.be/p8SDBkLV4mg
OABD: parallelogram.
COE: straight line
O: immobile
OE/OC = DE/BD = k = constant
Figures traced by pen E and pen C are similar but upside down each other when O is between C and E. Scale factor is k.



Bar pantograph 3
http://youtu.be/-Y8IyDkJpL0
OBCD: parallelogram.
OFE: straight line
O: immobile
OE/OF = BE/BD = k = constant
Point O or F do not necessarily coincide with an vertex of the parallelogram.
Figures traced by pen E and pen C are similar. Scale factor is k.

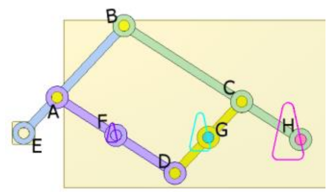


Bar pantograph 4
http://youtu.be/kjlwFXx2GI4
ABDC: parallelogram.
FOE: straight line
O: immobile
OE/OF =OD/OC = k = constant
Point O or F do not necessarily coincide with an vertex of the parallelogram.

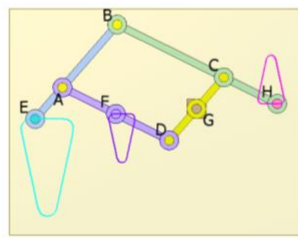


Figures traced by E and F are similar but upside down each other when O is between F and E. Scale factor is k.

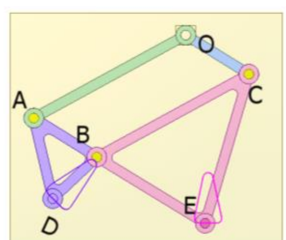
Bar pantograph 5a
http://youtu.be/oAhVbY0CBAk
ABDC: parallelogram.
EFGH: straight line
E: immobile
Point E, F, G and H do not necessarily coincide with vertices of the parallelogram.
Figures traced by pens F, G and H are similar.



Bar pantograph 5b
http://youtu.be/N0grDs9phHg
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.

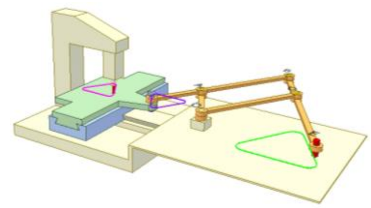


Bar pantograph 6
http://youtu.be/pGTyCtDIqBU
OABC: parallelogram.
Triangles ADB and CBE are similar.
Triangles DAO, DBE and OCE are similar.
Triangles ODE and ABD are similar.
O: immobile
Figures traced by pen E and pen D are similar but figure D is turned an angle DAB in comparison with figure E.
Scale factor is k = AD/AB = CB/CE = constant.



Bar pantograph 7a

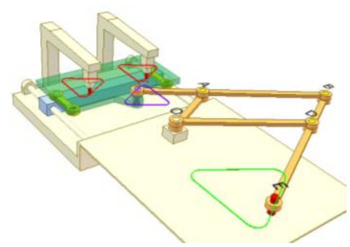
http://youtu.be/ZHWPj2dmMA8



ABCD: parallelogram
OCE: straight line
O: immobile
OE/OC = BE/BD = k = 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

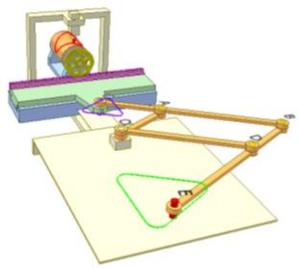
http://youtu.be/E2t-rz36CcM



ABCD: parallelogram
OCE: straight line. O: immobile
OE/OC = BE/BD = k = 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

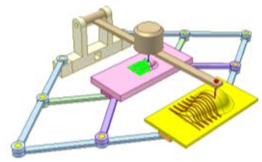
http://youtu.be/3h3NMbycOkk



ABOD: parallelogram
OCE: straight line. O: immobile
OE/OC = BE/BD = k = 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.

Bar pantograph 9

https://youtu.be/3hy452y4CcI



This 3D copying mechanism is based on "Reproducing a planar trajectory 3a" shown in

https://youtu.be/hOXci0HZcwU

Brown bar pivots in the vertical plan.

Red tracer of the brown bar moves on yellow sample and blue spherical milling cutter creates 3D surface on the pink work.

Length of blue bars: a + b. Here b = a

Length of green bars: a

Length of violet bars: b

Reducing copy ratio: i = a/(a+b) = 1/2

Length of orange bar: x

Length of pink bar: y

Distance between two fixed pivots of the blue bars: z

Condition to get orange and pink bars translate: (y-x)/(z-x) = b/(a+b)

Length of brown bar: e + f

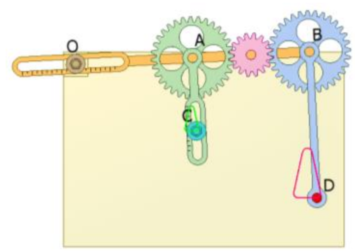
Condition to get right reducing copy ratio i in vertical direction:

e/(e+f) = a/(a+b) = 1/2

Because the tracer does not move exactly vertically so there is some error for the created surface.

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 = constant

O: immobile

Figures traced by pen E and pen C are similar. Scale factor is k.

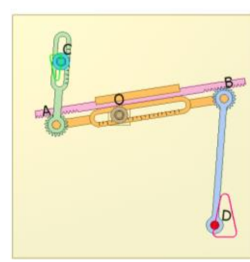
Adjust OA and AC to get various values of k.

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 = constant

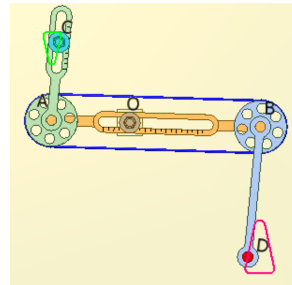
Figures traced by pen D and pen C are similar but upside down each other. Scale factor is k.

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

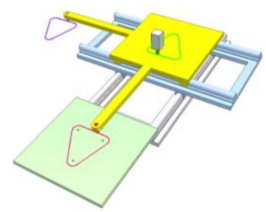
http://youtu.be/_5G4Qb3VeUA



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 = 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.

Reproducing a planar trajectory 1

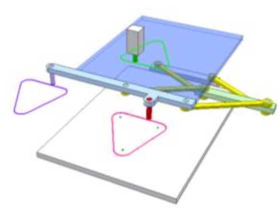
https://youtu.be/fG48K40OWJ8



Red planar trajectory traced by a red point on green table can be transferred to other place thanks to a system of two prismatic joints. The yellow table and blue slider move perpendicularly to each other. The yellow table planarly translates. Each point on it reproduces the red trajectory (violet curve) thus the multiplying is possible.
A stationary point traces on the yellow table a curve that is the red trajectory flipped two times around longitudinal and traversal axes of the mechanism (or turned 180 deg. in its plane).

Reproducing a planar trajectory 2

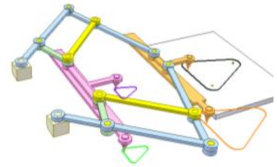
https://youtu.be/F8QoiwChTxg



Red planar trajectory traced by a red point on grey table can be transferred to other place thanks to a system of two parallelogram mechanisms. The blue table planarly translates. Each point on it reproduces the red trajectory (violet curve) thus the multiplying is possible.
A stationary point traces on the blue table a curve that is the red trajectory flipped two times around longitudinal and traversal axes of the mechanism (or turned 180 deg. in its plane).

Reproducing a planar trajectory 3a

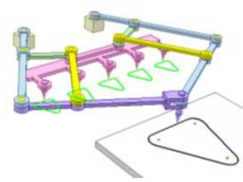
https://youtu.be/hOXci0HZcwU



Black planar trajectory traced by the middle point of orange bar can be transferred to other place thanks to a system of two pantograph mechanisms.
Orange and pink bars that connect the two pantographs translate.
Each point of the orange bar reproduces the black trajectory (orange curve) thus the multiplying is possible.
Each point of the pink bar gives reducing copies of the black trajectory (green and violet curve).
Length of blue bars: a + b. Here b = 2a
Length of green bars: a
Length of yellow bars: b
Reducing copy ratio: i = a/(a+b). Here i = 1/3
Length of orange bar: x
Length of pink bar: y
Distance between two fixed pivots of the blue bars: z
Condition to get orange and pink bars translate: (y-x)/(z-x) = b/(a+b)

Reproducing a planar trajectory 3b

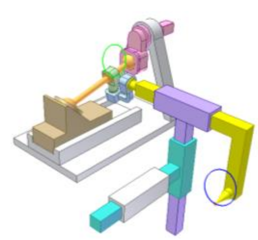
https://youtu.be/DwqNQbo07Sk



Black planar trajectory traced by the violet point can be copied with reducing ratio to other place thanks to a system of two pantograph mechanisms. They are connected together through violet pin and pink bar.
Each point of the pink bar gives reducing copies of the black trajectory (green curves).
Length of blue and violet bars: a + b. Here b = 2a
Length of green bars: a
Length of yellow bars: b
Reducing copy ratio: i = a/(a+b) = 1/3
Length of pink bar: y
Distance between two fixed pivots of the blue bars: z
Condition to get pink bar translate: y/z = b/(a+b)

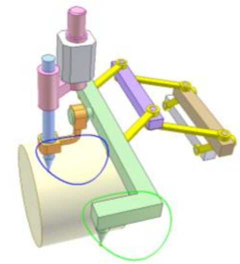
Reproducing a spatial trajectory 1

https://youtu.be/pSUHspv_BFc



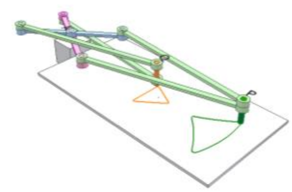
Green spatial trajectory traced by a point on orange conrod of a spatial mechanism can be transferred to other place thanks to a spherical joint and three sliders (yellow, violet and cyan) moving perpendicularly to each other. Yellow slider spatially translates.
Each point on it reproduces the orange trajectory (blue curve) thus the multiplying is possible.
Here spherical joint between the orange conrod and blue part is replaced with Hook joints. See “Spherical joint of large turning angle 2a”: https://youtu.be/XupyXgd30h8

Reproducing a spatial trajectory 2
https://youtu.be/W7Y5_L0EBdo



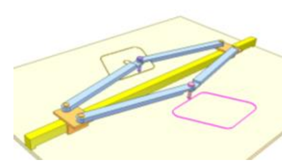
Blue spatial trajectory traced by a point on blue slider can be transferred to other place thanks to a orange joint and three parallelogram mechanisms (green, violet, brown conrods and yellow bars). The green conrod spatially translates. Each point on it reproduces the blue trajectory (green curve) thus the multiplying is possible.
In general the orange joint between the blue slider and the green conrod must be spherical. Center of the spherical joint coincides with the point that traces the blue trajectory. But in this special case no problem if the blue slider and the green conrod are fixed together by the orange part.

Linkage for tracing inverse figures
https://youtu.be/1Ov7a7R5fO8



Lengths of pink and blue bars: b/2 + b/2 = b
Lengths of green bars: a
The linkage maintains always:
Points A, P and Q are in line.
AP.AQ = (a.a – b.b) = constant
P and Q trace figures (in orange and green) that are inverse to each other.
If Q moves following a circle, P traces a circle.

Instrument for tracing a symmetric curve 1
http://youtu.be/rpWT0MskXhA

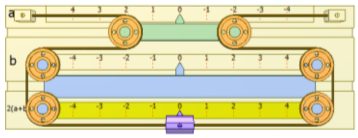


Blue links have the same length.
Move violet tracer along a given curve (a rhombus in this case), pink pen traces pink curve that is symmetric to the given curve about the centerline of the yellow runway.

19. Mechanisms for math operations

Cable adding mechanism

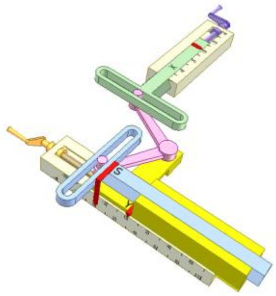
http://youtu.be/56mtxOTCezM



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

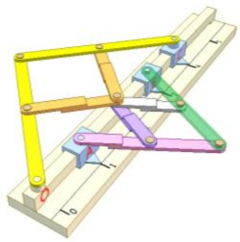
http://youtu.be/e_zW20jO48I



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 deg. Angle between sliding directions of the green and blue sliders is B = 90 deg. This ensures that the displacements of the green slider and the blue one are equal when the yellow slider is immobile.

Linkage adding mechanism 2

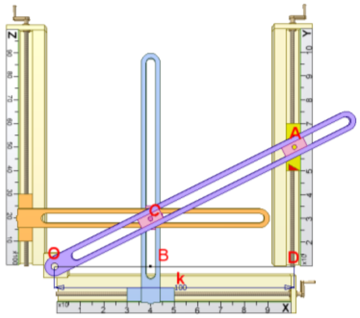
http://youtu.be/C_OQr_8aelU



Combination of two pantograph mechanisms.
Yellow and orange bars create a rhombus.
Center distances from middle hole to end holes of yellow bar are equal.
Pink, violet, grey and green bars create a rhombus.
Center distances from middle hole to end holes of pink or green bar are equal.
The mechanism ensures: OA + OB = OC
Move slider A to enter value X
Move slider B to enter value Y
Slider C shows S = X + Y
The video shows the operation 1 + 3 = 4 and the return to initial position.

Linkage multiplication mechanism 1

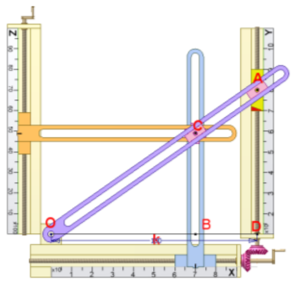
http://youtu.be/U262eypJ7ik



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 congurent 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
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

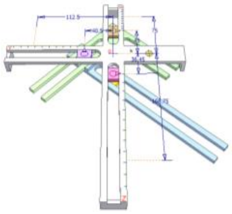
http://youtu.be/mUGOtdwxvYI



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 congurent 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*k)
For the X and Y scale, 1 mm corresponds 1 unit.
For the Z scale, 1 mm corresponds 100 units.

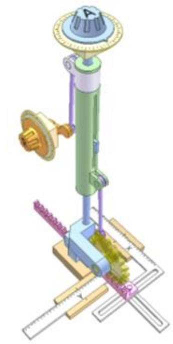
Square and cube linkage

https://youtu.be/6u5mN6Y2NZw



Move brown slider to enter positive number x to be squared or cubed.
Violet slider shows y = (x^2)/k
Pink slider shows z = (x^3)/(k^2)
The red letter O is origin of the Cartesian coordinate system.
k: distance between O and center of orange slider (k = 50 in this video).
The video shows:
When x = 45; y = (45^2)/50 = 40.5; z = (45^3)/(50^2) = 36.45
When x = 75; y = (75^2)/50 = 112.5; z = (75^3)/(50^2) = 168.75

Converting polar coordinates to Cartesian coordinates

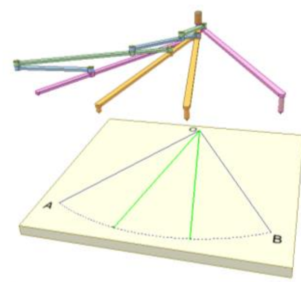


http://youtu.be/uBMnVAMafgI

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.cos(DA)
The Y scale shows increment along the Y axis: DY = DR.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

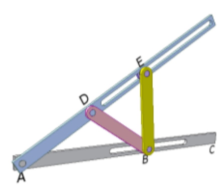
http://youtu.be/sxwMGcshJI8



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: Ai = i.A1
i = 1 to 3
i.e.: A2 = 2.A1 ; A3 = 3.A1

Linkage for double and triple angles 1

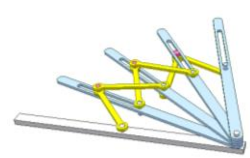
https://youtu.be/T11ws1_tZWs



This linkage ensures following angle relations at any position of blue bar:
Angle EDB = 2*Angle DAB
Angle EBC = 3*Angle DAB

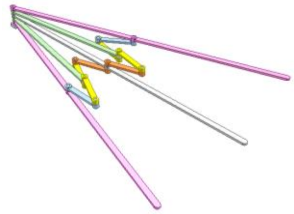
Linkage for equal angles 1

https://youtu.be/uTQVi7zskGU

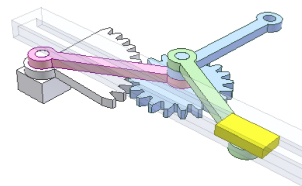


This linkage ensures that angles between two any adjacent long bars are always equal to each other during motion.
It can be used for the compass for angle trisection shown in https://youtu.be/sxwMGcshJI8

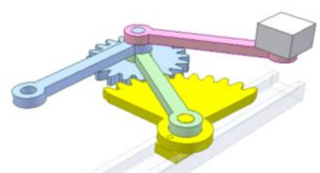
Bar mechanism of bisector 1
https://youtu.be/9a3oxnXpOf8
The grey bar is the bisector of angle between two pink bars at any their position.
Length of blue bars: a
Length of yellow and orange bars: a + a
Length of green bars: 4a
Distance between revolution joints of pink and grey bars: 4a
Green bar is not bisector of adjoining pink and grey bars.
It is a particular case of
http://youtu.be/gY0oJDQ-uVU



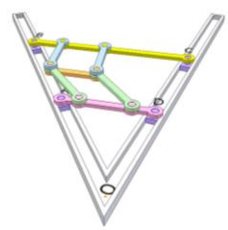
Bar gear mechanism of bisector 1a
https://youtu.be/ZBpjnkjSDNw
If pink bar is set to be the bisector of angle created by green and blue bars at a position of the pink bar, it remains the bisector of the said angle at any other position of the mechanism.
Zg = 2.Zb
Zg: complete tooth number of grey gear.
Zb: tooth number of blue gear.



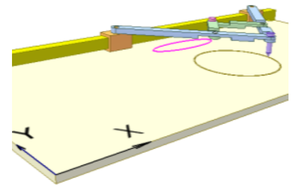
Bar gear mechanism of bisector 1b
https://youtu.be/LDsmjUn_bvQ
If green bar is set to be the bisector of angle created by pink and blue bars at a position of the pink bar, it remains the bisector of the said angle at any other position of the mechanism.
Zg = 2.Zb
Zg: complete tooth number of yellow gear.
Zb: tooth number of blue gear.



Mechanism of proportional line segments
https://youtu.be/DMMZmRdq_o0
Two green bars create a parallelogram.
Two blue bars create a parallelogram.
So pink and yellow bars are always parallel.
Mechanism ensures:
OA/OB = OD/OC = k = AD/BC = constant
In this video k = 1/2
Point B (or C) moves twice faster than point A (or D).

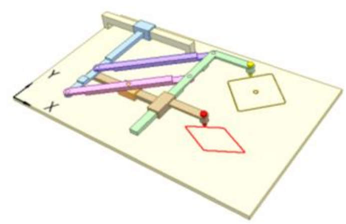


Instrument for directional scaling 1
http://youtu.be/HHfAlO4CQS8



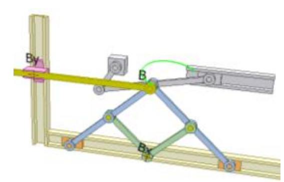
Affinograph.
Blue links have the same length.
Green links have the same length.
Blue and green links create a rhombus.
Move violet tracer along a given curve (a circle in this case), pink pen traces pink curve (an ellipse in this case). It is the given curve scaled only in Y direction.
Y-scale factor: ky = B / (B – 2G)
B: length of the blue link
G: length of the green link
X-scale factor: kx = 1

Instrument for directional scaling 2
http://youtu.be/yBvjB9tYCew



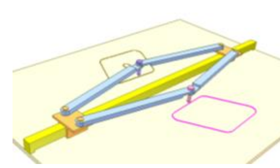
Affinograph.
Blue, green, violet and pink links create a parallelogram.
Green, brown and pink links create a right triangle.
Move yellow tracer along a given curve (a square in this case), red pen traces red curve (a rhombus in this case). It is the given curve scaled only in Y direction.
Y-scale factor: ky = P1/P2
P1: distance between end revolution joints of the pink link.
P2: distance between middle revolution joint of the pink link and end revolution joint of the blue link.
X-scale factor: kx = 1

Projection of a moving point on a line
https://youtu.be/RUAi_XvhpDE



Projections Bx and By of a point B moving along any curve (in green) on horizontal and vertical axes can be obtained thanks to a pantograph (for horizontal axis in this mechanism) or two slider mechanism (for vertical axis in this mechanism).
Length of blue bars: a + a.
Length of green bars: a.
The green curve is created by a slider crank mechanism (in grey).

Instrument for tracing a symmetric curve 1
http://youtu.be/rpWT0MskXhA

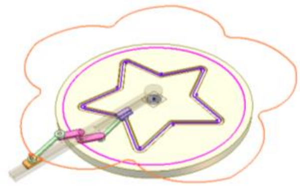


Blue links have the same length.
Move violet tracer along a given curve (a rhombus in this case), pink pen traces pink curve that is symmetric to the given curve about the centerline of the yellow runway.

Symmetry over a circle

https://youtu.be/KP394x5n0NA

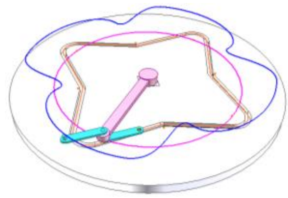
Orange curve is the symmetric one of the violet curve over pink circle. A double slider crank mechanism ensures that distances from violet and orange curves to the pink circle along its radial direction are always equal.
It can be used in cake decorations.



Symmetry over a point moving on a circle

https://youtu.be/6tAronouPto

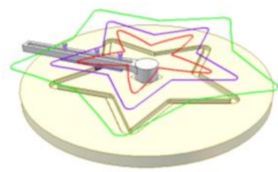
Blue curve is the symmetric one of the orange curve over a point that moves on the pink circle.
Crank radii of the blue double crank are equal.
It can be used in cake decorations.



Curve enlarging and reducing 1

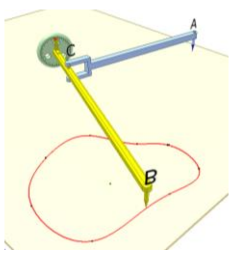
https://youtu.be/owLo-gXPJnA

Violet part slides in dovetail slot of white crank.
When the crank rotates, points of the violet part trace curves.
Violet curve and center curve of the groove on the yellow cam are identical.
Red and green curves can be considered as created from violet curve.
Distance between two curves along the white crank is constant.
It can be used in cake decorations.



Polar planimeter 1

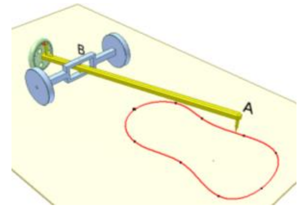
http://youtu.be/kdxPEZnv-U0



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.R.(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: intergration 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

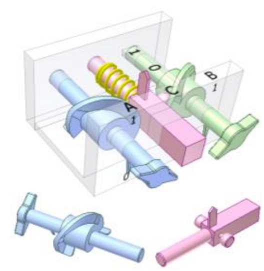
http://youtu.be/qThV6gTaYMI



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.R.(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.

Mechanical OR logic gate

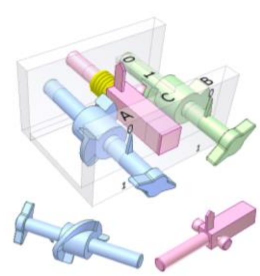
https://youtu.be/_UrNLrBwcuQ



Input: blue and green shafts A, B
Output: pink slider C
Yellow spring forces the slider towards the shaft helical cams.
The video shows four logic states alternately:
1. A = 0; B = 0; C = 0
2. A = 1; B = 0; C = 1
3. A = 0; B = 1; C = 1
4. A = 1; B = 1; C = 1

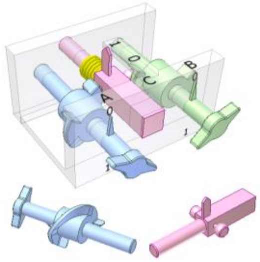
Mechanical AND logic gate

https://youtu.be/Ue9yaG5F4iQ

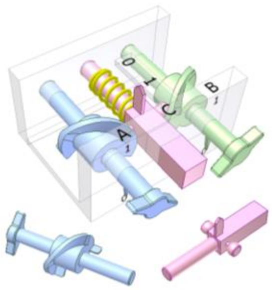


Input: blue and green shafts A, B
Output: pink slider C
Yellow spring forces the slider towards the shaft helical cams.
The video shows four logic states alternately:
1. A = 0; B = 0; C = 0
2. A = 1; B = 0; C = 0
3. A = 0; B = 1; C = 0
4. A = 1; B = 1; C = 1

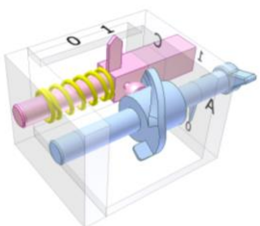
Mechanical NAND logic gate
https://youtu.be/hX_d6MkRTJM
Input: blue and green shafts A, B
Output: pink slider C
Yellow spring forces the slider towards the shaft helical cams.
The video shows four logic states alternately:
1. A = 0; B = 0; C = 1
2. A = 1; B = 0; C = 1
3. A = 0; B = 1; C = 1
4. A = 1; B = 1; C = 0



Mechanical NOR logic gate
https://youtu.be/KVkogDxPndA
Input: blue and green shafts A, B
Output: pink slider C
Yellow spring forces the slider towards the shaft helical cams.
The video shows four logic states alternately:
1. A = 0; B = 0; C = 1
2. A = 1; B = 0; C = 0
3. A = 0; B = 1; C = 0
4. A = 1; B = 1; C = 0



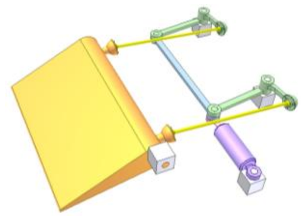
Mechanical NOT logic gate
https://youtu.be/8fBk6GfnHVA
Input: blue shaft A
Output: pink slider C
Yellow spring forces the slider towards the shaft helical cam.
The video shows two logic states alternately:
1. A = 0; C = 1
2. A = 1; C = 0



20. Mechanisms for object position control

Mechanism for spoiler control

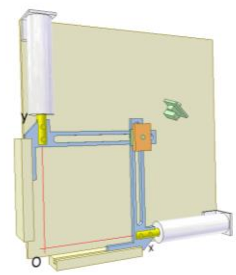
https://youtu.be/HkWqFFrAZu8



Input: violet cylinder, piston of which moves blue conrod of a parallelogram mechanism of two green crank.
Output: orange spoiler that rocks thanks to two yellow conrods of spherical joints at their ends.

Planar motion control 1a

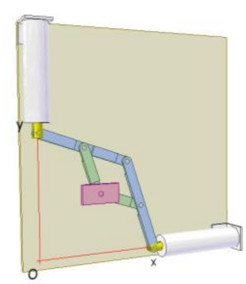
http://youtu.be/tZj6O5biJ0M



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

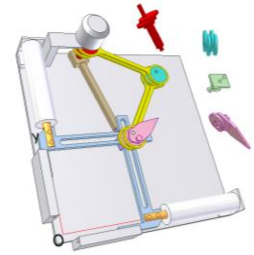
http://youtu.be/7OX351jGXeM



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 α = 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

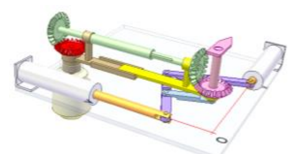
http://youtu.be/cMA1BmS-Ptk



Pink object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.
Two white actuators deals 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 doest 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

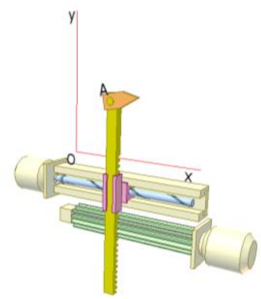
http://youtu.be/GMVuvjjDMPs



Pink object has 3 degrees of freedom in its planar motion: two linear and one angular displacements.
Two white actuators deals 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 doest 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

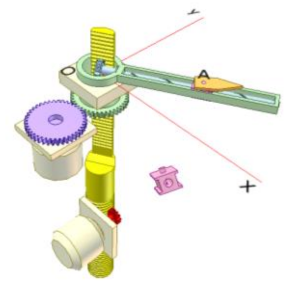
http://youtu.be/c49hIov2C2I



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.

$x = r. \cos\varphi$

$y = r.\sin\varphi$

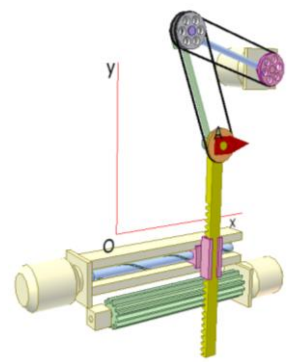
The video shows how the mechanism moves the object to get distance r and then angle φ.
Lower motor controls r value.
Upper motor controls φ value.
There is a helical joint between pink slider and blue shaft.
Round rack on lower half of the yellow shaft allows independent operation of the motors.
Angular 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

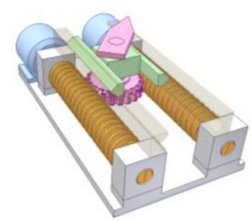
http://youtu.be/6jpgp8GXdgc



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.

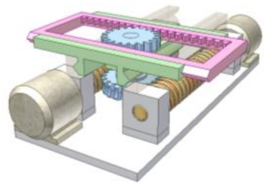
Controlling linear and rotary motions of an object 1

https://youtu.be/gU0wqocH7tQ



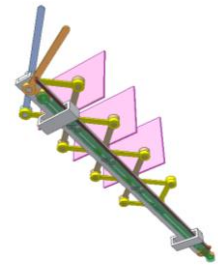
Linear motion of pink object along longitudinal axis and its rotary motion around vertical axis are controlled by two grounded blue motors. Two worms are identical.
When the motors rotate in the same direction at the same velocity, the object moves linearly only.
When the motors rotate in different directions at the same velocity the object rotates only.
Linear displacement $L = S.(n1 + n2)/2$
Angular displacement in degrees: $A = 180. k.(n1 – n2)/Z$
S: lead of the worms of k starts
n1, n2: worms revolutions. They are of same sign (+ or -) if the worms rotate in the same direction and vice versa.
Z: tooth number of the pink gear.
Advantage: self-locking feature. So after getting desired position of the pink object there is no need to supply the motors further with the electricity.

Controlling 2 linear motions of an object 1



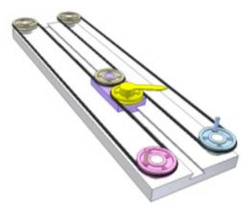
https://youtu.be/roD6pfjI8cA
The motion of pink frame along two perpendicular horizontal axes is controlled by two grounded brown motors. This mechanism is developed from the one shown at:
https://youtu.be/gU0wqocH7tQ
When the motors rotate in the same direction, the frame moves along longitudinal axis.
When the motors rotate in different directions, the frame moves along traversal axis.

Controlling 2 DoF of a series of objects



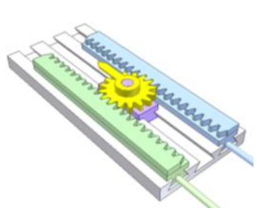
https://youtu.be/Wb_ymWviVKI
Blue crank controls linear motions of pink plates via a scissor mechanism.
Orange crank controls their 90 deg. rotation via a parallelogram mechanism. The rotation can be performed at any position of the plates.
Each plate has a pin that moves in long groove of green bar.
Long brown rod helps the parallelogram mechanism overcome dead positions.
It can be used for louver or deployable curtain wall (for indoor light control).

Controlling linear and rotary motions of an object 2



https://youtu.be/pe19F4LaWog
Linear motion of yellow object along longitudinal axis and its rotary motion around vertical axis are controlled by two grounded cranks (in blue and pink). Six pulleys are identical. They are connected together by a closed cable.
Instead of pulleys and cable a chain drive of six sprockets is possible.
When only one crank rotate, the object performs two motions: rotation and translation.
When two cranks rotate in the same direction at the same velocity, the object moves linearly only.
When two cranks rotate in different directions at the same velocity, the object rotates only.

Controlling linear and rotary motions of an object 3

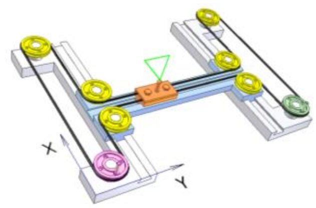


https://youtu.be/LxqMH_2DcBI
Linear motion of yellow object along longitudinal axis and its rotary motion around vertical axis are controlled by two racks (in blue and green).
When two racks move in the same direction at the same velocity, the object moves linearly only.
When two racks move in opposite directions at the same velocity, the object rotates only.
Each rack is connected to a cylinder (not shown).

Controlling linear and rotary motions of an object 4
https://youtu.be/KBRDFzGqd6k

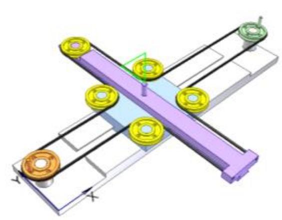
Linear motion of violet object along longitudinal axis and its rotary motion around vertical axis are controlled by two chain drives. Their driving sprockets are in pink and green.
When two driving sprockets rotate in the same direction at the same velocity, the object rotates only.
When two driving sprockets rotate in opposite directions at the same velocity, the object moves linearly only.

Controlling two linear motions of an object 1a
https://youtu.be/IkM2K7CsiHo



This is called as Hbot mechanism.
Hbot = H-shaped robot.
Linear motions of orange object along X and Y axes are controlled by pink and green driving pulleys.
The black timing belt is fixed to the object.
When pink and green pulleys rotate in opposite directions at the same velocity, the object moves along X axis.
When pink and green pulleys rotate in the same direction at the same velocity, the object moves along Y axis.
The green line is trajectory of a point on the object.
The mechanism can be used for 3D printers.
When the pink pulley turns P deg. clockwise (the green one is immobile) the orange object displacements are:
Along X axis: ΔXp = - Pi.D.P/720
Along Y axis: ΔYp = - Pi.D.P/360
When the green pulley turns G deg. clockwise (the pink one is immobile) the orange object displacements are:
Along X axis: ΔXg = Pi.D.G/720
Along Y axis: ΔYg = - Pi.D.G/360
Pi = 3.1416
D: pulley diameter.
Programming driving pulley motion to get desired trajectory of the orange object is not easy.

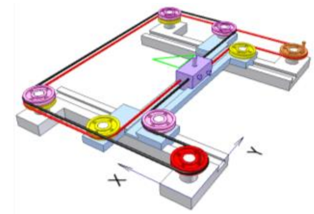
Controlling two linear motions of an object 1b
https://youtu.be/_nzxGOKhHSY



Linear motions of violet slider along X and Y axes are controlled by orange and green driving pulleys.
The black timing belt is fixed to the violet slider.
When orange and green pulleys rotate in opposite directions at the same velocity, the slider moves along Y axis.
When orange and green pulleys rotate in the same direction at the same velocity, the slider moves along X axis.
When only one driving pulley rotates, the violet slider moves obliquely.
The green line is trajectory of a point on the slider.
The mechanism can be used for 3D printers.
Disadvantage: the violet slider mass is large.

Controlling two linear motions of an object 3

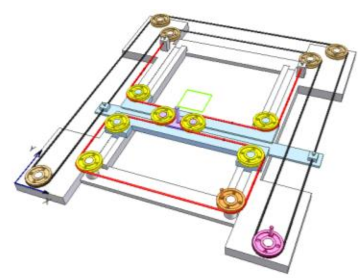
https://youtu.be/fW7jzLN-__w



This is called as CoreXY mechanism.
Linear motions of violet object along X and Y axes are controlled by red and orange driving pulleys.
The black timing belt is fixed to the violet object. It connects the red driving pulley with pink pulleys.
The red timing belt is fixed to the violet object. It connects the orange driving pulley with yellow pulleys.
When red and orange pulleys rotate in opposite directions at the same velocity, the object moves along X axis.
When red and orange pulleys rotate in the same direction at the same velocity, the object moves along Y axis.
When only one driving pulley rotates, the violet object moves obliquely.
The green line is trajectory of a point on the object.
The mechanism can be used for 3D printers.

Controlling two linear motions of an object 2

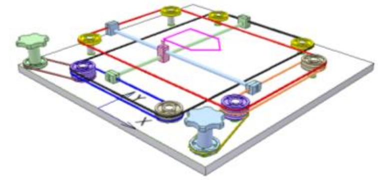
https://youtu.be/XJ23Id2GE8w



Linear motions of violet object along X and Y axes are controlled by pink and orange driving pulleys.
The black timing belt is fixed to blue slider at two points. It connects the pink driving pulley with brown pulleys.
The red timing belt is fixed to the base at two points. It connects the orange driving pulley with yellow pulleys.
The orange pulley controls motion of the object along X axis.
The pink pulley controls motion of the object along Y axis.
The green line is trajectory of a point on the object.
The mechanism can be used for 3D printers.

Controlling two linear motions of an object 4

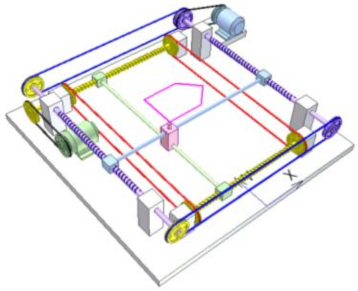
https://youtu.be/hOXxcvLxli8



It is the mechanism in "Etch A Sketch", a drawing toy.
Two ends of the green rail are fixed to black and blue belts.
Two ends of the blue rail are fixed to red and orange belts.
Pink stylus has prismatic joints with the green and blue rails.
Violet pulleys have 3 belt grooves.
Brown pulleys have 2 belt grooves.
Turn the green knob to move the green rail along X axis (via brown, blue and black belts).
Turn the blue knob to move the blue rail along Y axis (via yellow, orange and red belts).
The pink line is trajectory of the pink stylus.

Controlling two linear motions of an object 5

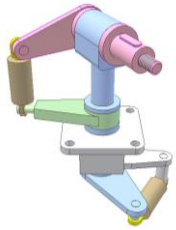
https://youtu.be/1Gv2FKfgvBo



Green motor moves the green rail along X axis (via belt and yellow screw-nut drives).
Blue motor moves the blue rail along Y axis (via belt and violet screw-nut drives).
Pink stylus has prismatic joints with the green and blue rails.
The pink line is trajectory of the stylus.
The mechanism can be used for 3D printers.

2 DoF spherical connection control 1

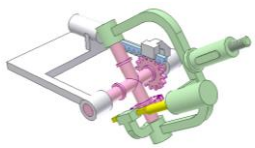
https://youtu.be/BwMVrxxZPt8



This mechanism is a replacement for spherical joint with a pin (2 degrees of freedom).
Input: two brown actuators.
Output: pink shaft of 2 degrees of freedom (rotations).
Disadvantage: only one actuator is base grounded.
The mechanism is applied for manipulators.

2 DoF spherical connection control 2

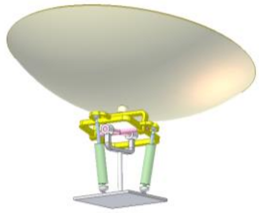
https://youtu.be/p5gInBFmQc0



This mechanism is a replacement for spherical joint with a pin (2 degrees of freedom).
Input: two actuators, grey and green.
Output: green shaft of 2 degrees of freedom (rotations).
Disadvantage: only one actuator is base grounded.
The mechanism is applied for manipulators.

2 DoF spherical connection control 3

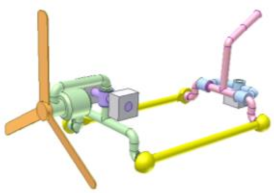
https://youtu.be/Ja4k5iIYK-g



This mechanism is a replacement for spherical joint with a pin (2 degrees of freedom).
Yellow output frame has 2 degrees of freedom (rotations).
When the yellow frame is horizontal, centers of spherical joints between blue pistons and the yellow frame must lay on axis of pink cross shaft to get motion independence of two pistons.
Advantage: two actuators (green cylinders) are base-grounded.
The mechanism can be applied for moving antennas.

2 DoF spherical connection control 4

https://youtu.be/oEOzNIbI5zQ

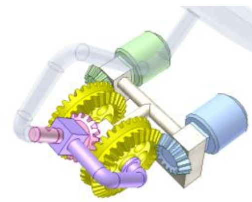


The left 2 DoF spherical joint is controlled from a distance thanks to pink lever of the right 2 DoF spherical joint and two yellow conrods of sphericals joints at their ends.

2 DoF spherical connection control 5
https://youtu.be/WYhf-KRjzhQ

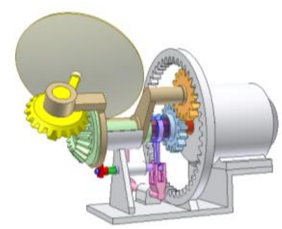
Blue and orange parts are connected by a spherical joint with a pin (in red). It can be replaced with a Hook joint to get larger rotary angles.
Blue and green parts are connected by a planar joint.
Inputs: orange and green parts.
Output: blue part of 2 degrees of freedom (rotations).
Advantage: motors (not shown) are base grounded.
The combination of input velocities or turning angles gives various output motions or positions.

2 DoF spherical connection control 6
https://youtu.be/EvALwzHBlUQ



Violet frame pivots around grey base.
Pink gear to which an antenna is fixed, pivots around the violet frame.
Inputs: green and blue gears.
Output: pink gear.
Three small gears are of the same tooth number.
Four yellow gears are identical.
The video shows alternately:
1. When green and blue gears rotate in the same direction and with the same speed, the violet frame is immobile, the pink gear pivots around its own axis.
2. When green and blue gears rotate in opposite directions and with the same speed, the violet frame pivots on its revolute joint with the base, the pink gear does not pivot around its owns axis.
Thus the pink gear has 2 degrees of freedom (rotations).
Advantage: motors are base grounded.
The combination of input velocities or turning angles gives various output motions or positions.

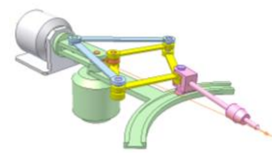
2 DoF spherical connection control 7
https://youtu.be/TKoZp0MiN8w



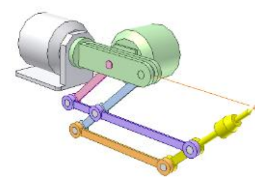
Yellow antenna can turn around two perpendicular axes. Only one motor (in grey) drives it. The mechanism is controlled by pink lever and violet sliding shifter.
The video shows:
1. Clutch (in blue transparent) moves to the right to connect transmission between red motor shaft and blue gear. The clutch has key sliding joint with the motor shaft.
2. Motor starts, red shaft rotates. Brown carrier gets motion through gear satellite drive (blue, orange and grey gears) and the antenna turns around longitudinal axis.
Green gear is not kept immobile so its turns together with yellow gear.
3. Motor stops when the antenna reaches needed position.
4. The clutch moves to the left to connect transmission between the motor shaft and green gear and to brake the brown carrier (red brake pad and green spring).
5. Motor starts, red shaft rotates. The antenna turns around traversal axis thanks to bevel gear drive.
6. Motor stops when the antenna reaches needed position.
7. The clutch moves to neutral position.
Advantage: motor is base grounded.
Disadvantage: the antenna can not turn around two axes at the same time.

Controlling rotation around a point 1a
https://youtu.be/Xf_Vik8cCHw
Inputs: green shaft driven by grey motor and yellow shaft driven by green motor.
Cylindrical bar fixed to blue gear moves around a point at various angles. The bar point moves on a sphere.
This mechanism is used for moving the welding head.

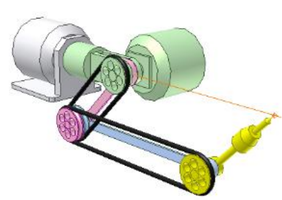
Controlling rotation around a point 1b
https://youtu.be/R-6Uo_zjnaQ
Inputs: green shaft driven by grey motor and orange crank driven by green motor.
Blue and yellow bars create a variant of Peaucelier linkage. See:
https://youtu.be/1VzRxG1Bg04
Pink bar moves around a point at various angles.
This mechanism is used for moving the welding head.



Controlling rotation around a point 1c
https://youtu.be/tXuFyE5kcII
Inputs: green shaft driven by grey motor and pink crank driven by green motor.
It is a combination of two parallelogram mechanisms.
Yellow bar moves around a point at various angles.
This mechanism is used for moving the welding head.

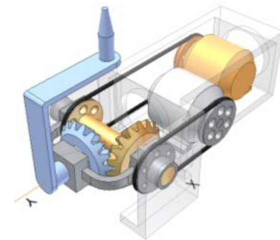


Controlling rotation around a point 1d
https://youtu.be/PH3NogbMGmM
Inputs: green shaft driven by grey motor and pink crank driven by green motor.
Pulleys of each timing belt (or chain) drive are of equal diameter.
Pink pulley is fixed to pink bar.
Blue pulley is fixed to blue bar.
Yellow bar moves around a point at various angles.
This mechanism is used for moving the welding head.



Controlling 2 rotations of an object 5

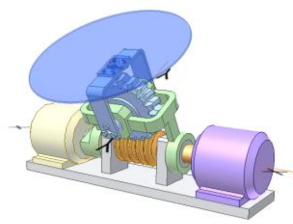
https://youtu.be/EmdYFiPCO2A



The rotations of blue object of a bevel gear (around two perpendicular axes XX and YY) are controlled by two grounded motors.
Grey motor makes grey frame rotate around axis XX thus controls the object rotation around axis XX.
Orange motor makes orange gear shaft rotate around axis XX thus controls the object rotation around axis YY.
Motion of the grey motor also affects the object rotation around axis YY. First part of the video shows this phenomenon.
To keep the object do not rotate around axis YY while adjusting the object position around axis XX, the orange motor must rotate together with the grey one. Second part of the video shows this correction.
Motion of the orange motor does not affect the object rotation around axis XX (see third part of the video).

Controlling 2 rotations of an object 6

https://youtu.be/ztrsc_MPFWQ



The rotations of blue antenna of a worm gear (around two perpendicular axes XX and YY) are controlled by two grounded motors.
Yellow motor makes green frame rotate around axis XX thus controls the object rotation around axis XX.
Violet motor makes orange worm shaft rotate around axis XX thus controls the object rotation around axis YY.
Motion of the yellow motor also makes the object turn around axis YY a small value that is not easy to be realized. First part of the video shows this phenomenon.
To keep the object do not turn around axis YY while adjusting the object position around axis XX, the violet motor must rotate together with the yellow one (with different speed subject to transmission ratio of the worm drive). Second part of the video shows this correction.
Motion of the violet motor does not affect the object rotation around axis XX (see third part of the video).

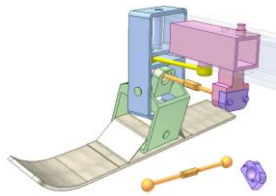
Controlling 2 rotations of an object 7

https://youtu.be/BC4EhwPEa1w

The rotations of blue gun around two intersecting vertical and horizontal axes are controlled by grounded brown motor and violet linear actuators.
Brown motor makes pink shaft and the gun rotate around vertical axis.
Violet linear actuators make yellow bush of inner circular groove move up down thus control the gun rotation around horizontal axis (via sine mechanism).

Control of Cardan joint 1

https://youtu.be/ELc28X25ZUM



Green output frame is connected to the base (in glass) via a Cardano joint. Output motion is controlled by linearly moving pink slider.

The green output frame can rotate around vertical axis thanks to yellow conrod and around horizontal axis thanks to orange conrod.

Relation between rotation angles of blue and green frames depends on ratio Rb/Rg.

Rb: center distance of two vertical revolute joints of the blue frame.

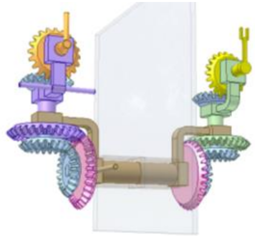
Rg: center distance of revolute and spherical joints of the green frame.

The mechanism can be applied for ice boat of four skis. The ski (in brown) is fixed to green frame. The skis are tilted when the boat turns.

This mechanism was made on request of Jason Brown, a student from Concordia University in Montreal, Canada.

Remote control of three rotations

https://youtu.be/qfOsJi5Gmgg



The rotations of yellow object around 3 axes perpendicular to each other are controlled from a distance by turning in turn orange, violet and brown levers.

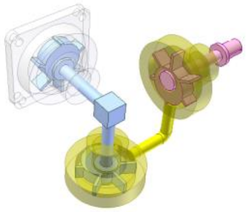
Small gears have the same tooth number.

So do the large gears.

To avoid incidental rotations there must be enough braking friction forces in the revolution joints between orange gear and violet bracket, violet bracket and brown bracket, brown bracket and the base.

Spherical connection control 1

https://youtu.be/xKKQVEb0pk4



This is “Spherical connection of large turning angle 2a” equiped with drives.

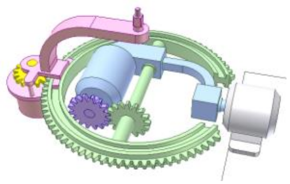
Transparent parts represent hydraulic motors.

Disadvantage: only one motor is base grounded.

The mechanism is applied for manipulators.

Spherical connection control 2

https://youtu.be/BgOkUOfRlvs



This is “Spherical connection of large turning angle 2a” equiped with drives.

Joint center is the intersecting point of three rotary axes (blue, green and pink parts).

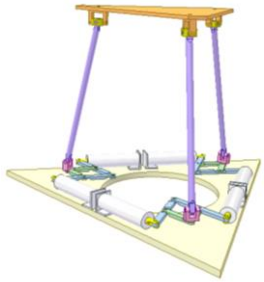
The video shows the motion caused by grey, blue and pink motors alternately.

Disadvantage: only one motor is base grounded.

The mechanism is applied for manipulators.

Spatial motion control 1

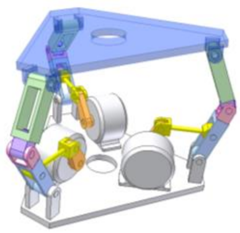
http://youtu.be/iNa6y4aXG3g



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.

Canfield joint 1

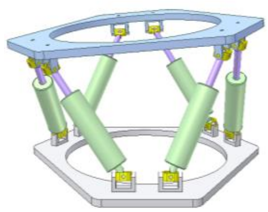
https://youtu.be/g3CmLAj1YzY



It was invented by Dr. Stephen Canfield and is used for spacecraft thrusters and solar panels.
Grey motor controls blue platform via orange crank, yellow conrod, blue arm, pink and violet hinge, green arm. All the joints are revolute.
Orange crank, yellow conrod and blue arm create a parallelogram mechanism.
The platform can be directed toward a point moving in the upper hemisplere by programming motions of three orange cranks mounted on the motors.

Stewart platform

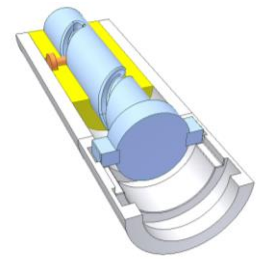
https://youtu.be/A0JeDvGCkXc



Six cylinders are connected to grey base and blue platform by Cardan joints. Joints between the cylinders and their pistons are cylindrical (not prizmatic). Six degrees of freedom of the platform are controlled by programming relative positions between pistons and cylinders.
The kinematic calculation is very complicated:
http://www.techfak.uni-bielefeld.de/~fszufnar/publications/Szufnarowski2013.pdf
Stewart platforms have applications in flight simulators, machine tool technology, crane technology, underwater research, air-to-sea rescue, satellite dish positioning, telescopes and orthopedic surgery.

Controlling rotation and translation of an object

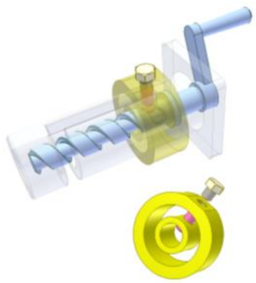
https://youtu.be/s7rny2aIwlw



Input: yellow slider that has linear reciprocating motion.
Output: blue part that moves forwards, turns 180 deg., moves backwards and turns back 180 deg.
Orange pin fixed to the slider moves along helical groove of the blue part. This helical joint can be replaced with a screw-nut drive (the yellow part: nut; the blue part: screw).
The friction preventing the blue part from rotation must be set larger than the friction preventing the yellow part from translation to ensure that the blue part rotates only when it can not translate.
Grey outer pipe and the yellow slider are cut off haft for easy understanding.
This video was made based on the following video:
https://www.youtube.com/watch?v=N70Vy7hgDTk
The mechanism is aimed at moving needle in a medical instrument.

Nut of two motions

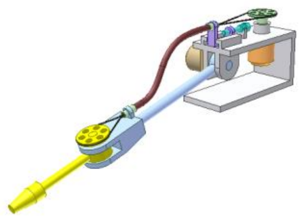
https://youtu.be/uYUSwiRqH1Q



Turn blue screw counterclockwise to move yellow nut linearly and then to turn it.
Turn back to return it to initial position.
Pink pin moves along helical groove of the screw and along L-shaped slot of the base (in glass).
See its application in tea rolling machine:
https://youtu.be/7AExAoGK1lc

Bowden mechanism for robot control 1

https://youtu.be/mcANMG9A-MA



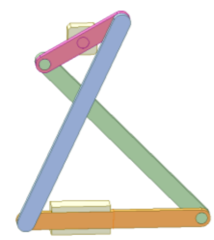
In this video the Bowden mechanism is used for motion transmission to a shaft, position of which is variable in relation with the base. It is for 2 DoF robot.
Both motors are grounded.
Brown motor controls blue arm rotation.
Orange motor controls yellow arm rotation via a Bowden mechanism that consists of green and yellow pulleys, black cable and brown flexible tube.
Ways to avoid cable sliding on the pulleys:
- Tension screw as shown in this video (cyan screw).
- Spring placed between the base and violet slider.
- Fixing the cable to the pulleys at a point, if the pulley rotation is small.
- Wrapping the cable more than one revolution around the pulleys if the pulley rotation is small.

Transmission ratio can differ from 1 if the pulley diameters are different.
For a robot of more DoF, several similar Bowden mechanisms can be used. Advantage: they operate independently from each other.

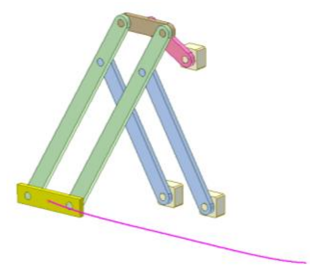
21. Mechanisms having self-controlled direction link

21.1. Mechanisms having linearly translating link

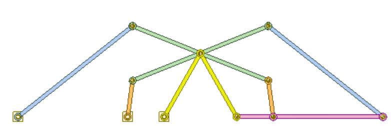
Tchebicheff's four-bar linkage 3B
http://www.youtube.com/watch?v=xPVcL0fMBCk
Length of the crank: a = 30 mm
Length of the two connecting rods: 2.6a = 78 mm
Length of the translating bar: 2a = 60 mm
The mechanism can work if the crank oscillates +/- 30 degrees around the horizontal direction and gap between 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.



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

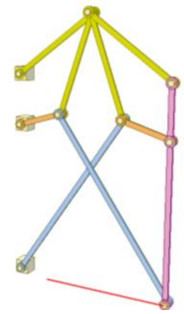
Length of pink bar of 3 joints: 0.25a + 0.75a

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

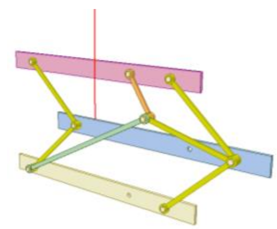
A modification of Peaucellier linkage proposed in 1877 by A. B. Kempe, London.

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

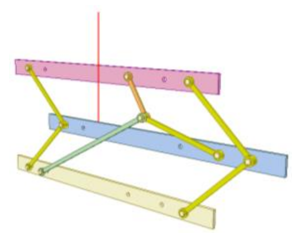
A modification of “Kite and spear-head mechanism 5a” proposed in 1877 by A. B. Kempe, London.

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.



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”.

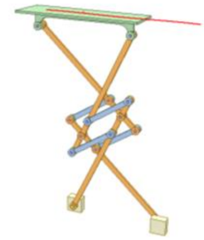
Revolution joint centers of the yellow (or blue) V-shaped arm create a isosceles right triangle.

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.

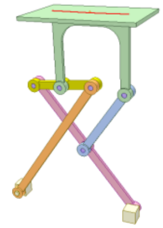
The green table moves along an absolutely straight line.

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

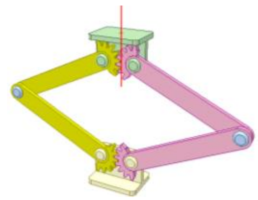
Tchebicheff stool 1
http://youtu.be/k0XrKv1B7h0
This is a development of “Tchebicheff's four-bar linkage 3”.
Bars of identical colour are of equal length.
Axle distance between the revolution joints of the green seat, axle distance between the ground revolution joints are equal.
The green seat has horizotal motion (not strictly rectilinear).



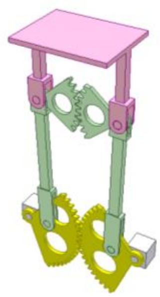
Tchebicheff stool 2
http://youtu.be/gV0xl_lbdDs
This is a development of “Tchebicheff's four-bar linkage 3”.
Axle distance between the revolution joints of the green seat, axle distance between the ground revolution joints are equal.
The green seat has horizotal motion (not strictly rectilinear).



Gear and linkage mechanism 3a
http://youtu.be/3FNWwFqunNU
Combination of linkage and gear drive. The green part translates along an absolutely straight line.

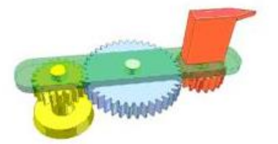


Gear and linkage mechanism 3
https://youtu.be/cSg8g83QanU
Linear motion without prizmatic joint.
Input: one among two yellow gears.
Green gear is fixed to green bar.
The yellow gears have the same tooth number.
The green gears have the same tooth number.
Pink table translates along an absolutely straight line (vertical).

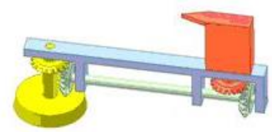


21.2. Mechanisms having direction unchanged link

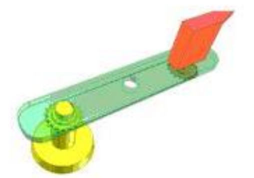
Keeping direction unchanged during rotation 1
http://www.youtube.com/watch?v=jMCBm9bG4EY
The direction of the red object is unchanged.
Using spur gears.
The end gears have the same number of teeth.
The number of intermediate gears must be odd.



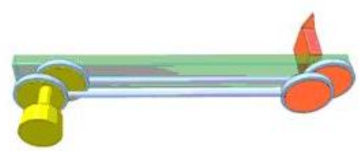
Keeping direction unchanged during rotation 2
http://www.youtube.com/watch?v=5Oa_7k1GMi0
The direction of the red object is unchanged.
Using bevel gears.
The gears have the same number of teeth.



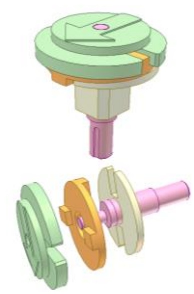
Keeping direction unchanged during rotation 3
http://www.youtube.com/watch?v=BkZswBBbvD8
The direction of the red object is unchanged.
Using chain (or tooth belt) drive.
The sprockets have the same number of teeth.



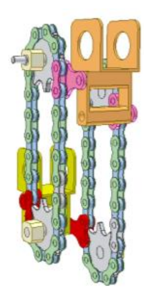
Keeping direction unchanged during rotation 4
http://www.youtube.com/watch?v=N8jE8gLbHR4
The direction of the red object is unchanged.
Using parallelogram mechanism.
Overcoming dead point by adding second parallelogram mechanism



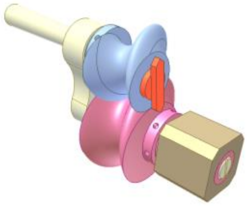
Keeping direction unchanged during rotation 5
http://youtu.be/-XsHSvDqG8s
The green disk receives motion from a pink eccentric shaft. Due to a Oldham mechanism that consists of three disks, the orientation of the green disk does not change during motion.



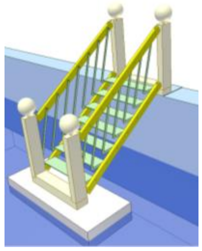
Keeping direction unchanged during rotation 6
http://youtu.be/D1lPLELEBuA
Two chain drives are arranged with a large non-coaxiality A.
The yellow link connects two drives by two red chain pivot links. Center distance between two revolution joints of the yellow link is equal to A.
The direction of the 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.



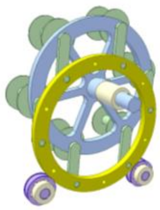
Pin coupling 6
http://www.youtube.com/watch?v=zfXDfoOAnrY
A planetary mechanism from Pin Coupling 5.
http://www.youtube.com/watch?v=QfiJSTRDASs
The direction of the red bar attached to the blue shaft is unchanged during the motion.



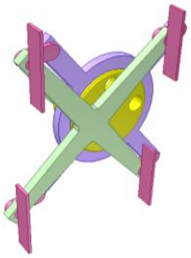
Application of parallelogram mechanism 6
http://www.youtube.com/watch?v=PJQEkv4UESw
Self-adjusting step ladder for wharfs. The steps remain horizontal whatever the water level rises or falls.



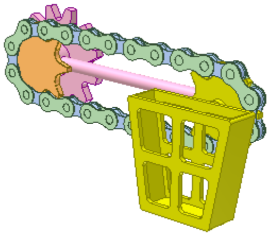
Application of parallelogram mechanism 7
http://www.youtube.com/watch?v=nn_v_DlZ6tY
Cable winding machine.
The bobbins rotate about the machine main shaft axle but not their own ones.



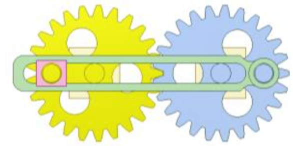
Application of parallelogram mechanism 8
http://www.youtube.com/watch?v=hWNt1ZhnSnk
Vertical blade paddle wheel.
The blades are kept always upright giving the most propulsion effectiveness.



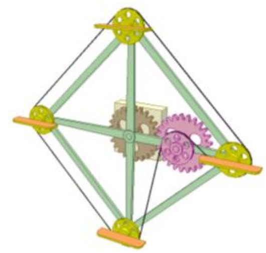
Chain drive 5A
http://youtu.be/DI6DdKPXctY
The orange sprocket is fixed. The orange and yellow sprockets have the same tooth number. The pink crank and gear is driving. The yellow basket, which is fixed with the yellow sprocket, stays vertically during rotation.



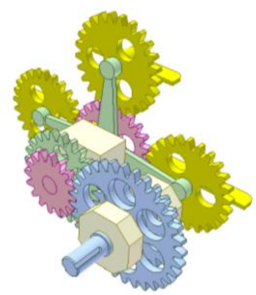
Gear and linkage mechanism 8a
https://www.youtube.com/watch?v=iGYtz_uVKTY
The green bar has unchanged direction during rotation.
The gears have the same tooth number and the same distance of their pins to their rotation axes.
Assembly requirement: there is mechanism position where pin axes and gear rotation 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=wTG1Ai2S9I8



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.



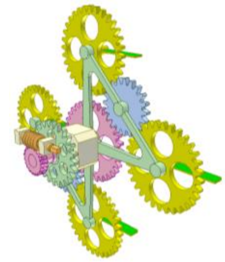
Keeping direction unchanged during rotation 8
http://youtu.be/W5tLTJraf84
Pink gear, four yellow satellite gears and green carrier create a differential planetary drive.
Four yellow satellite gears and the big pink gear have same tooth number.
Input is the blue shaft having two gears.
Receiving rotation 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/g8HKd938yp0
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

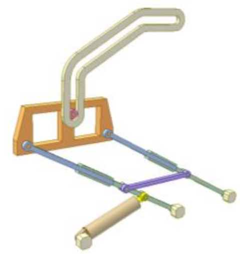
http://youtu.be/APdnbZl20S0



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/g8HKd938yp0
but uses less gears.

Keeping direction unchanged during motion 10

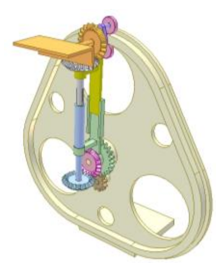
http://youtu.be/xAYL_MtkEgM



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 11

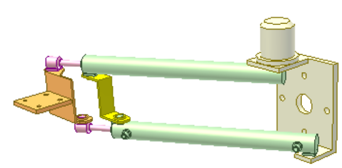
http://youtu.be/iIYesahDn38



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 12

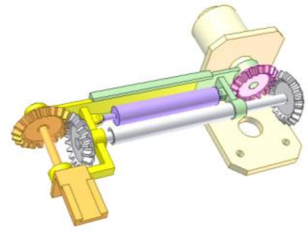
http://youtu.be/4xGNB2jlcVk



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 13

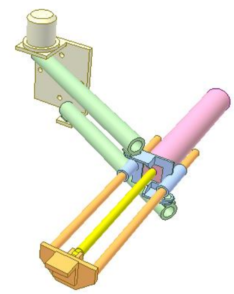
http://youtu.be/485OGPdp13g



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 14

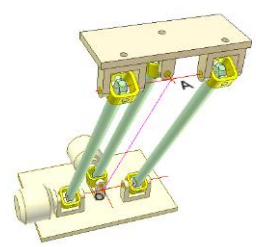
http://youtu.be/g2Foisj9re0



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 15

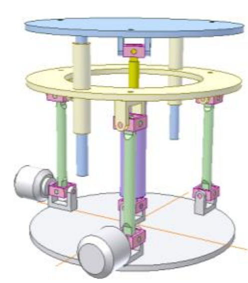
http://youtu.be/iQ5TkU04Xdc



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 differ from 90 deg.

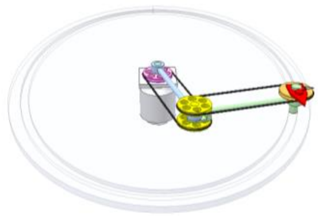
Keeping direction unchanged during motion 16

http://youtu.be/4smmgMNyrvc



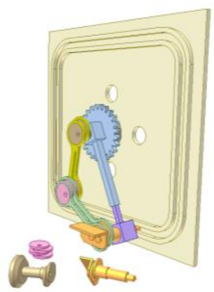
Blue upper table is kept always horizontal when moving in 3D space.
Motion of the popcorn disk is controlled by two base-mounted motors.
Motion of the blue table along sliding joint on the popcorn disk is controlled by violet actuator.
Disadvantages:
The actuator is not base-mounted.
The calculation of trajectory of a point on the blue table can not be based on spherical coordinate system.

Keeping direction unchanged during motion 17
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 puleys 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.

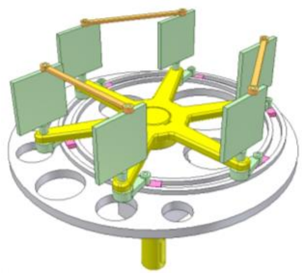


Keeping direction unchanged during motion 18
http://youtu.be/6NayQfZpSWY
Pink and yellow plates perform planar motion without rotation thanks to gear drives. Tooth numbers of 5 gears are equal. Grey gear is immobile. Four others gears idly rotate on their bearings.
Change of glass fixed cam profile gives various trajectories (a hexagon in this video) of the pink plate.

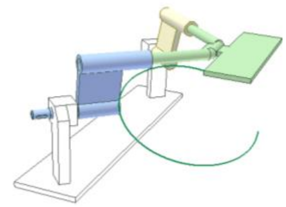
Keeping direction unchanged during motion 19
http://youtu.be/M3qFSlEA1Rg
Orange plate performs planar motion without rotation. Its upper surface is kept always horizontal thanks to a double parallelogram mechanism driven by blue gear. Each of brown and orange shafts has 2 eccentrics for overcoming dead 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 rotation 20
http://youtu.be/P-BaJiRCg68
Grey cam of eccentric circular goove is immobile.
Its eccentricity and length of green cranks are equal.
Radius of center circle of the cam groove and radius of yellow crank are equal.
When yellow shaft rotates, the direction of the green cranks is unchanged during rotation.
In fact it is a combination of 6 parallelogram mechanisms.
Orange conrods help in overcoming unstable positions when the green and yellow cranks are in line.
Turn cam to adjust the direction.

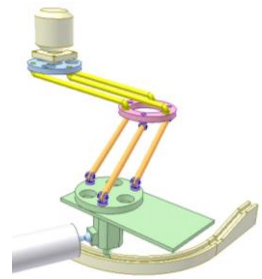


Keeping direction unchanged during rotation 21
https://youtu.be/fNuWRsr17mY



It is an application of Hobson's joint so it can be called as Hobson's platform.
Input: blue crank.
Green plate moves along an ellipse and is kept always horizontal.
The mechanism has unstable positions when the planes created by axes of two joints of each crank are vertical.

Keeping direction unchanged during spatial motion 1
http://youtu.be/Cu8oJTe8zrk

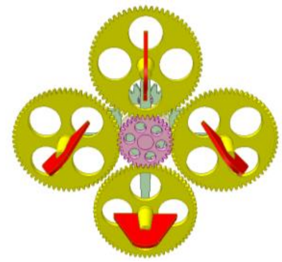


The green disk lower end moves along a 3D curve. When blue disk is immobile, green plate (fixed to green disk) performs spatial motion without rotation around all three coordinate axes thanks to yellow planar and orange spatial parallelogram mechanisms.
The grey cylinder is connected to the base via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

21.3. Other mechanisms

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.

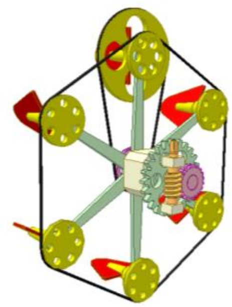
Input: green carrier rotating regularly.

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.

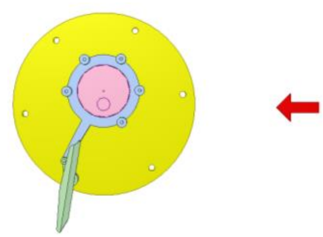
Input: green carrier rotating regularly.

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/7pN7hFZuIUw



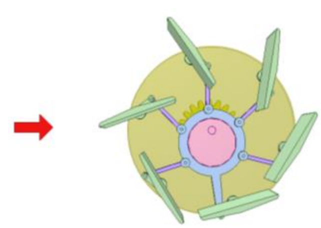
Plan view. It is a 4-bar linkage consisting of two cranks (blue bar, yellow disk) and a connecting rod (green sail). Blue bar rotates on the eccentric of a pink fixed shaft.

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.

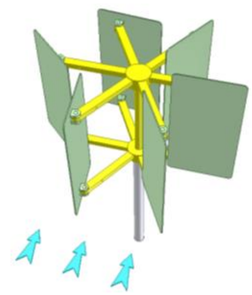
The mechanism can be applied for simple water turbines (no need of flow guide).

This mechanism is developed from “Wind-mill 1a”:

http://youtu.be/7pN7hFZuIUw

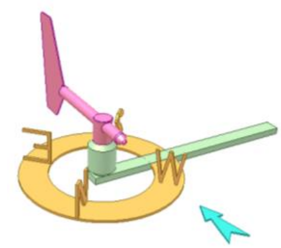
by adding more sails.

Wind mill 2
https://youtu.be/zheuqW77FWs



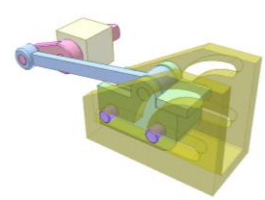
The sails are so pivoted as to present their edges in returning toward the wind, but to present their faces to the action of the wind when they are on other side. The arrows show the wind direction.
The sails are automatically flipped under the wind action.
This mechanism is numbered as 486 in the book "507 mechanical movements", 1868.
Mass center of each sail must lay on its rotary axis by adding counter weight to eliminate the influence of centrifugal forces.

Wind vane
https://youtu.be/dEkImjFX234



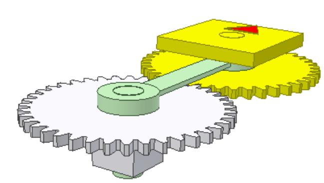
Wind vanes are designed to rotate freely on the vertical axis so they can respond to small changes in wind direction (shown by blue arrow). The weight on either side of the vertical axis is equal, but the surface area is much larger on one side. That side will catch the wind if the pointer is not pointing directly in line with the wind. The vane tends to get stable equilibrium so the pointer always points the direction from which the wind blows.
The letters indicate the points of the compass.
Disadvantage: when no wind it still shows the recent wind direction. So an anemometer should be added. See:
http://www.whenwasitinvented.org/when-was-anemometer-invented/
In modern designs wind vanes can send the wind direction to a data logger using a potentiometer; as the vane rotates, the resistance of a potentiometer changes.

Turnable slider
https://youtu.be/6c5ow2ped3Y



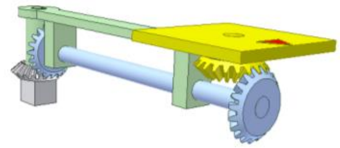
Input: pink crank.
The green slider reciprocates and turns 90 deg. at its right stroke end.
Slider crank mechanism is converted into four-bar linkage and vice versa in one working cycle.

Planetary rotation 1
https://youtu.be/gUGJZED-7FY

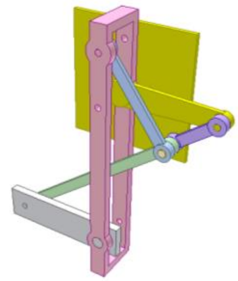


Input: green crank.
Output: yellow square, velocity of which is double of the input one.
The video shows that 90 deg. input oscillation gives 180 deg. output oscillation.
The square is fixed to yellow gear.
The same fuction can be got by replacing the spur gear drive with any drive of transmission ratio of -1, for example, crossed belt drive.

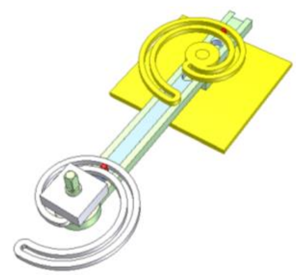
Planetary rotation 2
https://youtu.be/9T1HfRjnoYc
Input: green crank.
Output: yellow square, velocity of which is double of the input one.
The video shows that 90 deg. input oscillation gives 180 deg. output oscillation.
The square is fixed to yellow gear.
It is used when the green crank is long.



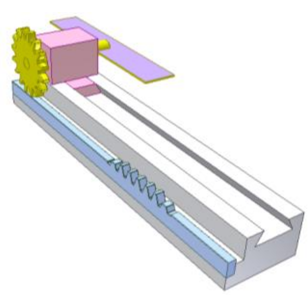
Planetary rotation 3
https://youtu.be/eEfZKlC8AAM
Input: pink crank.
Output: yellow square, velocity of which is double of the input one.
The video shows that 90 deg. input oscillation gives 180 deg. output oscillation.
The mechanism has the same function of mechanisms shown at:
https://youtu.be/gUGJZED-7FY
https://youtu.be/9T1HfRjnoYc
but consists only of bars and revolution joints (no gears).
The square is fixed to yellow crank.
It is developed from the mechanism shown at:
http://youtu.be/dqDHfOBE8EQ
where the part dimensions can be got.



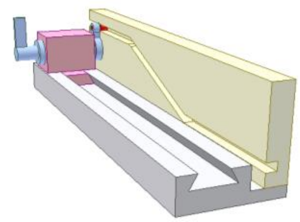
Planetary rotation 4
https://youtu.be/MmJCbsQHS6k
Input: green crank.
Output: yellow square, velocity of which is double of the input one.
The video shows that 90 deg. input oscillation gives 180 deg. output oscillation.
The wheels have Archimedean grooves of the same radial distance between successive turnings and of opposite spiral directions. Distance between two red pins of blue slider is equal to the one between two revolution joints of the green crank. The square is fixed to the yellow wheel.
It is developed from the mechanism shown at:
https://youtu.be/aNLLu7VUKVk



Gear-rack drive for linear motion and interrupted 180 deg. turn
https://youtu.be/i5VoNWBuC7s
Input: pink slider linearly reciprocating.
Output: yellow shaft.
When the shaft moves to the right, it rotates 180 deg. at the end of its stroke thanks to the gear-rack drive.
When moving to the left at first the shaft rotates 180 deg. then moves to the initial position without rotation.
The flat portions of the rack prevent the shaft from rotation.
Tops of two end teeth of the rack are cut off for easy meshing start.

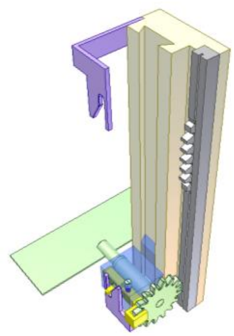


Linear reciprocation with one way interrupted 180 deg. rotation 1



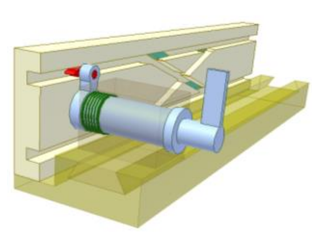
https://youtu.be/twMg0D5i3JM
Input: pink slider linearly reciprocating.
Output: blue shaft.
When the shaft moves to the right, it rotates 180 deg. at the center of its stroke thanks to the cam mechanism.
When it moves to the left it rotates 180 deg. at the center of its stroke in the same direction.
So in one double stroke the output rotates totally 360 deg.
To ease the output rotation the cam slanting angle must not large (20 deg. in this video).

Linear reciprocation with one way interrupted 180 deg. rotation 1



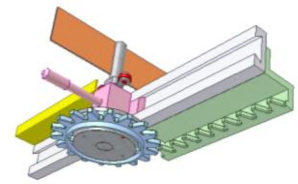
https://youtu.be/KosONar7WzA
Input: blue slider linearly reciprocating.
Output: green shaft.
When the slider moves up, at upper end of its stroke the shaft rotates 180 deg. thanks to gear-rack drive and then the shaft moves to the right by interaction of the pin on yellow shifter and violet upper cam.
When the slider moves down, the shaft does not rotate at all because the gear and the rack are not in merge. At lower end of the slider stroke the shaft moves to the left by interaction of the pin on yellow shifter and violet lower cam.
Red spring pin is for positioning the yellow shifter and the shaft.
This mechanism isí developed from the mechanism shown at:
https://youtu.be/i5VoNWBuC7s

Linear reciprocation with one way interrupted 180 deg. rotation 2



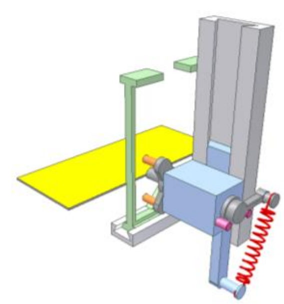
https://youtu.be/47GoltUb3pw
Input: glass slider linearly reciprocating.
Output: blue shaft.
When the shaft moves to the right, it rotates 180 deg. at the center of its stroke thanks to the cam mechanism.
When it moves to the left it does not rotate at all.
So in one double stroke the output rotates only 180 deg.
Key factors: shape of the red pin and variable depth of the cam grooves (the cyan portions are slant)
Green spring always forces the blue shaft towards the yellow cam.

Linear reciprocation with one way interrupted 180 deg. rotation 3
https://youtu.be/2yWE15zedxE



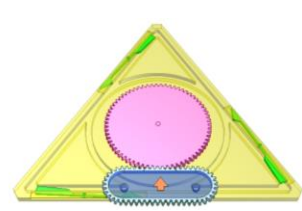
Input: pink slider linearly reciprocating.
Output: grey shaft.
When the shaft moves to the right, it rotates 180 deg. at the end of its stroke thanks to the gear-rack drive.
When it moves to the left it does not rotate at all because of the ratchet mechanism of red pawl (one way overrunning clutch, http://youtu.be/bAL_nWjuhOI)
The grey arm of two red rollers and the yellow runway ensure that after one double stroke the shaft rotates exactly 180 deg.
Disadvantage: possible jam when the blue gear starts to mesh with the rack so their teeth should be rounded as much as possible.

Linear reciprocation with one way interrupted 180 deg. rotation 4
https://youtu.be/xSbUKu9sFi0



Input: blue slider linearly reciprocating.
Output: grey shaft.
When the shaft moves up, it rotates 180 deg. at the upper end of its stroke thanks to orange pins, green movable stopper and red spring.
When moving down the shaft does not rotate at all.
At the lower end of the shaft stroke the orange pins move the stopper horizontally to prepare the stopper for the back 180 deg. rotation of the shaft.
The device for positioning the green stopper (for example spring pin) is not shown.
The orange pins can turn the shaft a little more than 90 deg. only but the red spring helps to get 180 deg. rotation.
Pink pins ensure that the shaft turns 180 deg exactly.

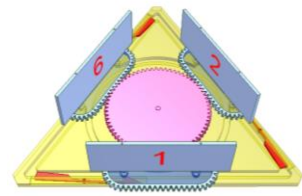
Oval gear 3a
http://youtu.be/jedbQnuuiy0



An input pink gear, rotating around fixed axis, engages with blue gear of oval shape. The latter has two pins that slide in grooves of the base. In one cycle of motion the blue gear performs two revolutions around rotary axis of the pink gear and changes its direction twice.
Green arms that always turn clockwise due to springs (not shown) in coordination with the front pin of the blue gear allow the front pin follow the straight grooves and direct the rear pin follow the circular groove.

Oval gear 3b

http://youtu.be/9kjUcsqieRg



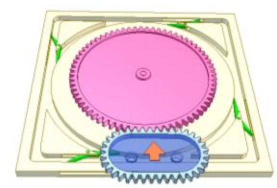
An input pink gear, rotating around fixed axis, engages with blue gears of oval shape. The latter have two pins that slide in grooves of the base. In one cycle of motion the blue gears performs two revolutions around rotary axis of the pink gear and changes its direction twice.

Red arms that always turn clockwise due to springs (not shown) in coordination with the front pin of the blue gear allow the front pin follow the straight grooves and direct the rear pin follow the circular groove.

On each side of the triangular base numbers 1, 2, …, 6 appear one after another.

Oval gear 3c

http://youtu.be/dPif6o4yf18

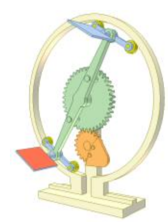


An input pink gear, rotating around fixed axis, engages with blue gear of oval shape. The latter has two pins that slide in grooves of the base. In one cycle of motion the blue gear performs four times of straight motion and four times of rotation alternately.

Green arms that always turn anticlockwise due to springs (not shown) in coordination with the front pin of the blue gear direct the front pin follow the straight grooves and the rear pin follow the circular groove.

Cam and gear mechanism 2

http://youtu.be/-zOdLhISU1M



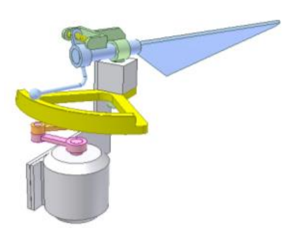
Input is the green gear to which a long arm is fixed.

Two short arms (each carries two rollers) are connected to both ends of the long arm by revolution joints. Due to the orange gear cam and a slot in the base, the short arms change their directions after every revolution of the long arm.

Trasmission ratio of the gear drive is 2.

Oar of 2 DoF 1

https://youtu.be/kMuxyhFrPYU



Blue oar moves with different oblique angles A.

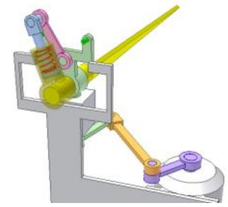
A = 45 deg. when going forward.

A = 0 deg. when going backward.

A is changed at the ends of the oar stroke thanks to the interaction of blue ball and yellow face cam. Yellow springs tend to press the ball on upper surface of the cam.

Grey motor makes the oar turn around vertical axis via 4-bar mechanism.

Oar of 2 DoF 2



https://youtu.be/gSd6uFLe7zw

Yellow oar moves with different oblique angles A.

A = 45 deg. when going forward.

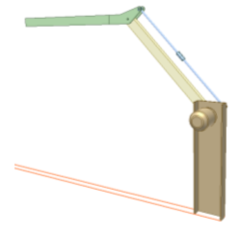
A = 0 deg. when going backward.

A is changed at the ends of the oar stroke thanks to spring toggle mechanism shown at:

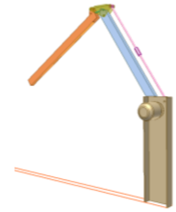
http://youtu.be/u4oW1ZiiRGA

Grey motor makes the oar turn around vertical axis via 4-bar mechanism.

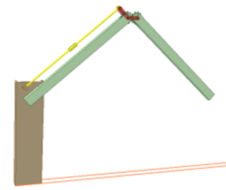
22. Mechanisms for folding, contracting or stretching



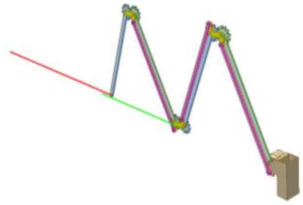
Folding barrier 1
http://www.youtube.com/watch?v=bq0iiqCSTFg
An application of parallelogram mechanism.
Folding barrier is used for height limited place.



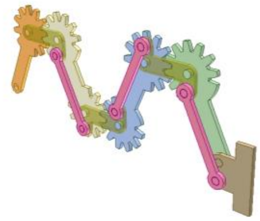
Folding barrier 2
http://www.youtube.com/watch?v=LF8kSTCZIxw
A combination of parallelogram mechanism and 4-bar linkage.
Folding barrier is used for height limited place.



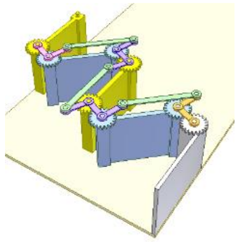
Folding barrier 3
https://www.youtube.com/watch?v=j3RNoijvcD4
A combination of a parallelogram mechanism and gears.
The gears are fixed to the bars.
Folding barrier is used for height limited place.



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 1
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.

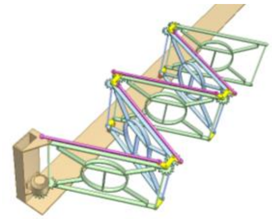


Stretch and contraction mechanism 2
https://youtu.be/L_ScRCOM2y0
A combination of parallelogram mechanisms and gears.
Input: orange angular lever. Its cylinder is not shown.
By similar connecting of bars the stretch can be very long.
At contraction position the mechanism does not occupy any portion of the passage.

Penta-folding gate

http://www.youtube.com/watch?v=6jSwpmr4k5I

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



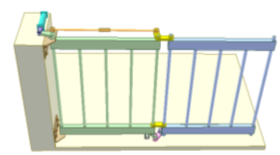
Bi-folding gate 1

http://youtu.be/LG2-y4iVDB4

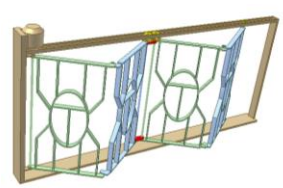
Orange conrod, green and upper yellow cranks create a parallelogram mechanism.
R1: pitch radius of green gear
R2: pitch radius of blue gear
i = R1 / R2 = 40 / 19. This ratio is needed to meet requirement when green gate rotates α = 58 deg., blue gate rotates 90 deg. in relation with the green gate.
i changes when α has different values. i = 1 if α = 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=LF8kSTCZIxw

Bi-folding gate 2

https://youtu.be/ysdMIuJH5tI



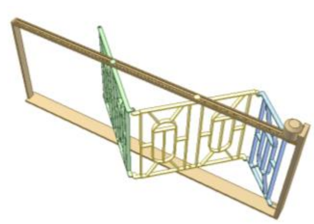
Orange conrod, green and upper yellow cranks create a parallelogram mechanism. There is a 4-bar linkage of the pink conrod that connect green and blue panels. See another solution:
https://www.youtube.com/watch?v=yeL_tcLv1do



Tetra-folding gate

http://www.youtube.com/watch?v=II88l0AP6-Q

A combination of slider-crank mechanisms and gears.
The gears are fixed with the two center gate panels.



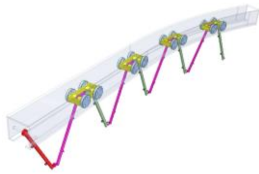
Tri-folding gate

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

A combination of slider-crank mechanisms.

Festooning cable system

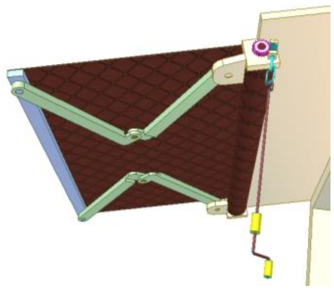
https://youtu.be/RFt0SUmiYoA



Pink lever and green lever on each car are connected together via gear sectors.
Pink lever and green lever on adjacent cars are connected together by a spherical joint.
So the cars can move along curved runway and distances between two adjacent cars are always equal.
The power cable (in zigzag shape) is attached to the small rings on red, pink and green levers.

Contractible eave

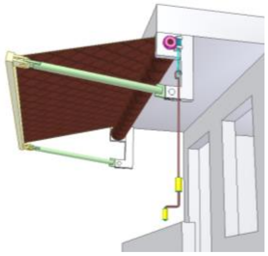
http://www.youtube.com/watch?v=YmcJmXpR7XM



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.

Movable eave for balcony

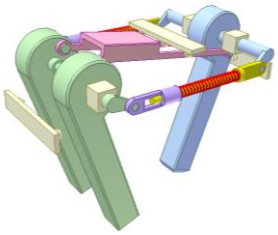
https://youtu.be/_ETc-dLC18s



Turn the brown detachable crank to roll or unroll the roof through a worm drive thus uncover or cover the balcony.
The gravity maintains the roof tension.
No relative motion between yellow bar and two green bars. The revolution joints between them are for easy assembling only.

Folding plug 1

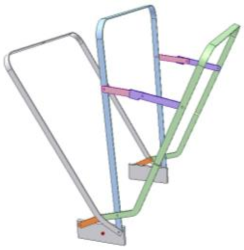
https://youtu.be/21ULLBnoWu8



Two green and one blue prongs (rockers) are connected by pink double bar (conrod) to create a 4-bar linkage.
They are also connected by two spring - bar assemblies, the purpose of which is keeping the prongs firmly at closing or opening positions.
Three popcorn bars play role of stoppers for the prongs.
The plug base and cover are not shown.

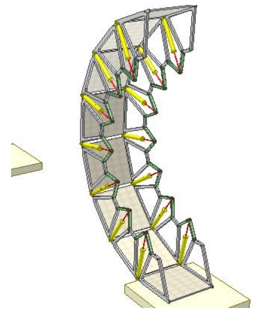
Folding hood frame for a cyclo

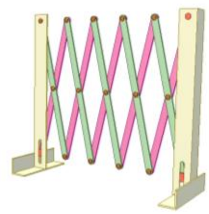
https://youtu.be/-G95Mv38rPc



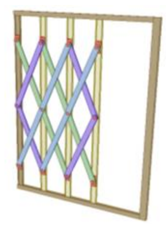
It consists of four-bar linkage (orange, blue and green bars) and a bar lock (pink and violet bars).
The lock keeps the frame firmly at its open position against any outside force applied to the green and blue bars.
To open the frame first pull the green bar, then push up the lock.
To fold the frame first push down the lock then push the green bar.

Rolling bridge
https://youtu.be/2yNamCnxdw4
It is an animation of the Paddington bridge, London.
The bridge consists of 8 spans of isosceles trapezoid shape.
A revolution joint (A) connects two adjacent spans.
Besides they are connected by two green conrods which are linked together by a revolution joint (B).
Yellow cylinder and red piston connect A and B.
7 pairs of hydraulic cylinders moving at the same speed roll and straighten the bridge.
At curled up pisition the brigde looks like a sculpture of octagonal shape on one side of the bank.

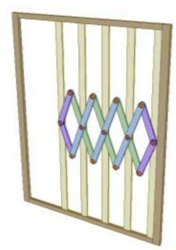




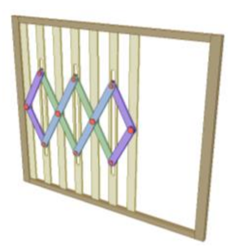
Folding scissor fence
http://www.youtube.com/watch?v=Do1DwSqkZoM
Combination of slider crank mechanism and parallelogram mechanism.



Folding scissor gate 1
http://www.youtube.com/watch?v=opSblgV2pSE
A combination of slider crank mechanisms and parallelogram mechanisms.



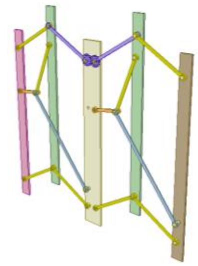
Folding scissor gate 2
http://www.youtube.com/watch?v=GvjFwcl9rro
A combination of slider crank mechanisms and parallelogram mechanisms.



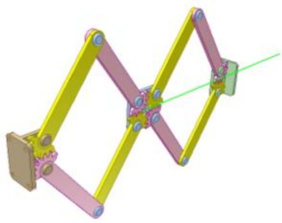
Folding scissor gate 3
http://www.youtube.com/watch?v=tb4H7Tr_W1s
A combination of slider crank mechanisms and parallelogram mechanisms.

Folding scissor gate 4
http://www.youtube.com/watch?v=_GApddnCKz4
A combination of slider crank mechanisms and parallelogram mechanisms.

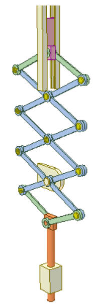
Kite mechanism 5c
http://youtu.be/AD_0MACi44M
A way to connect two (or more) “Kite and spear-head mechanism 5b” by adding gear drive (in violet). Thus very long rectilinear motion of the end bar (in pink) can be obtained. This mechanism may be applied for retractable gates.



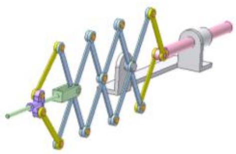
Gear and linkage mechanism 3b
http://youtu.be/jFVh3nKOVf8
Combination of linkage and gear drive. It shows the way to connect two (or more) mechanisms of “Gear and linkage mechanism 3a”. The green part translates along an absolutely straight line.



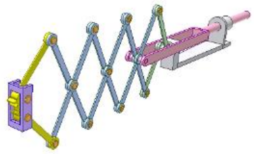
Lazy tong 1
http://youtu.be/Zm-4kJLdRcM
Input: pink slider.
Output: orange link.
Small longitudinal force on the input causes large one on the output (around 3 times in this case). The input and output move in opposite directions.
The mechanism finds application in lazy tong riveter:
https://www.youtube.com/watch?v=7D7ECCps0h4



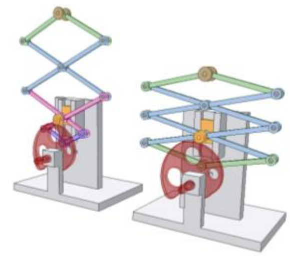
Lazy tong 2
http://youtu.be/UniRkbt0LOY
Input: pink slider.
Output: violet link.
Short input motion gives a long output one (around 3 times in this video). The input and output move in opposite directions.
The green link is for keeping the violet link direction unchanged.



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.

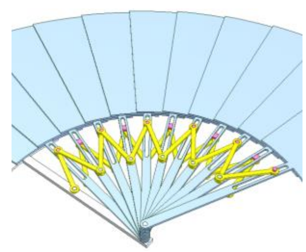


Scissor mechanism 2
https://youtu.be/luW-YqVl5nA
Compare two scissor mechanisms
The right one is an ordinary scissor mechanism of three identical large rhombi.
The left one is a special scissor mechanism of two large rhombi and one small rhombus.

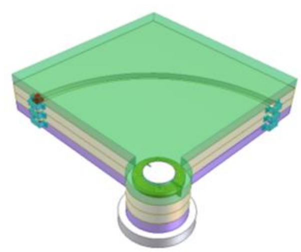


Length of violet bars: a
Length of pink bars: a + 2a
Length of blue bars: 2a + 2a
Length of green bars: 2a
Red identical cams give orange sliders the same displacement S.
- Left mechanism: displacement of the brown roller L1:
L1 = S + 2.n.S
n: number of large rhombi created by the bars.
Here n = 2, so L1 = 5.S
- Right mechanism: displacement of the brown roller L2:
L2 = n.S
Here n = 3, so L1 = 3.S
L1 is larger than L2

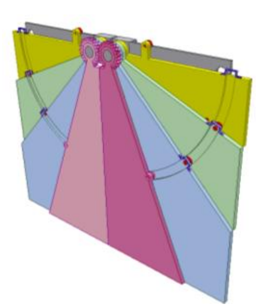
Deploying a circle 1
https://youtu.be/KTIXd9ptIgs



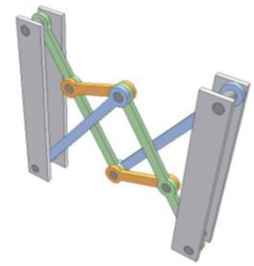
Deploying a square 1
https://youtu.be/0G_rI8Aau7M
The square of four sectors is deployed thanks to the interaction of red pins and cyan U-shaped parts.
In hubs of movable sectors there are coil springs that tend to turn the sectors counterclockwise.
It can be used for deploying solar panels.



Deploying a rectangle 1
https://youtu.be/X_7VxnyygYE
The rectangle is devided into two groups of four sectors.
The interaction of red or pink pins and violet U-shaped parts helps to deploy the rectangle.
Input: one among two pink gears.
It can be used for deploying a partition.

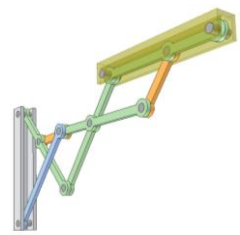


Eight-bar linkage for translation along straight line



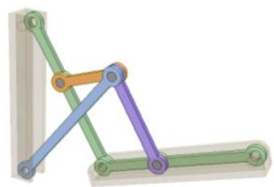
https://youtu.be/joJUV5Cbr4w
Input: one of the bars pivoted on the base.
Length of the grey base bar and end bar: a
Length of blue bar: a
Length of green bars: 0.4a + 0.6a
Length of orange bars: 0.4a
Output: the grey end bar that translates along an approximately straight line (is kept always parallel to the base).
The gravity tends to keep the mechanism at stretching position.
See a real mechanism:
https://www.youtube.com/watch?v=E19ht39x7hY

Eight-bar linkage for stretch and 90 deg turn



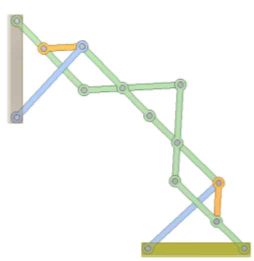
https://youtu.be/gh0xOluJOgY
Input: one of the bars pivoted on the base.
Length of the grey base bar and yellow end bar: a
Length of blue bar: a
Length of green bars: 0.4a + 0.6a
Length of orange bars: 0.4a
Output: the yellow end bar that moves out and gets horizontal position.
The gravity tends to keep the mechanism at folding position.

Six-bar linkage for stretch and turn



https://youtu.be/q8tVdjMo22E
Input: one of the bars pivoted on the base.
Length of the grey base bar and end bar: a
Length of blue bar: a
Length of green bars: 0.4a + 0.6a
Length of orange bars: 0.4a
Length of violet bar: 0.6a
Output: the yellow end bar that moves out and gets horizontal position.
The gravity tends to keep the mechanism at stretching position.

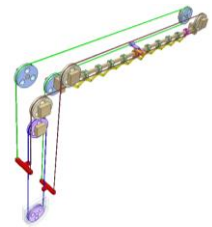
Twelve-bar linkage for stretch and turn



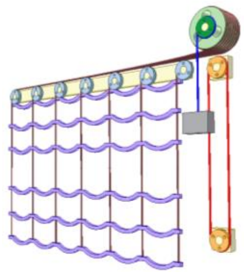
https://youtu.be/RyO447EkxfI
Input: one of the bars pivoted on the grey base.
Length of the grey base bar and the yellow end bar: a
Length of blue bar: a
Length of green bars: 0.4a + 0.6a
Length of orange bars: 0.4a
Output: the yellow end bar that moves out and gets horizontal position.
The gravity tends to keep the mechanism at stretching position.

Cable mechanism for controlling window curtains 1
https://youtu.be/H6Un9TCUDxk
Pull one or another of cable vertical branches to close or open the curtains that are represented by yellow short bars.
The pulley box (in glass) weight creates the cable tension.

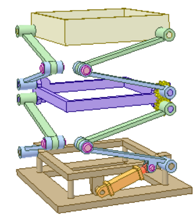
Cable mechanism for controlling stage curtains 1
https://youtu.be/DzQp_RqS5GU
Pull one or another of violet cable branches to close or open the curtains that are represented by yellow short bars.
The pulley box (in glass) weight creates the cable tension.
The ends of green and brown cables are fixed to the red bars, which are fixed to the blue cable
The video was made based on following picture:
https://www.peroni.com/lang_UK/_imgschede/TravellerCurtain_01aa.jpg



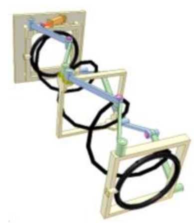
Cable mechanism for controlling stage curtains 2
https://youtu.be/DImZ9vU9Sp4
Pull one or another of red cable branches to lift or lower the curtain that are represented by violet waved bars.
The lower end of each brown cable is fixed to lower side of the curtain. The upper end of each brown cable is fixed to multi-groove pulley. The brown cables pass through button-holes of the curtain.
The lower end of blue cable is fixed to the grey contra-weight.
The upper end of blue cable is fixed to the small green pulley.
The contra-weight is fixed to the red cable.
The video was made based on following picture:
https://www.peroni.com/lang_ES/_imgschede/VenetianCurtain_02aa.jpg



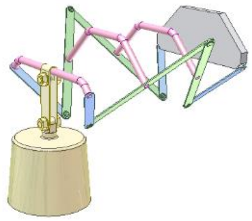
Sarrus linkage 3
http://youtu.be/FlNFaiCQIAk
A way to connect two (or more) Sarrus linkages by adding gear drive (in yellow). Thus very long up-down rectilinear motion of the top floor can be obtained by just small displacement of a piston (in orange).



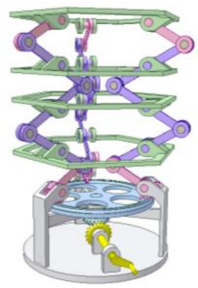
Retractable device for fluid supply
http://youtu.be/B3khF2lBUyU
“Sarrus linkage 3” in combination with helical hose.



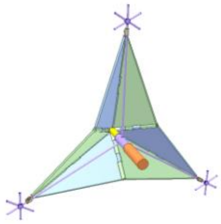
Sarrus linkage 4
https://youtu.be/AWvQ6-pfwFA
It is an application of Sarrus mechanism for a wall lamp.
The mechanism contains only revolution joints.
Yellow lamp moves along a straight line.
For original Sarrus mechanism see:
http://youtu.be/pQBJcgJe6t0



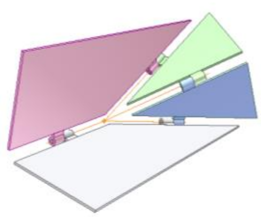
Sarrus linkage 5
https://youtu.be/butGEnekwYA
Green frames moves along a vertical straight line.
Self-locking Archimedean gear drive is used for turning three pink gear-cranks at the same time.
The mechanism can be applied for platforms or folding antennas.
For original Sarrus mechanism see:
http://youtu.be/CPYbD1GUS1A



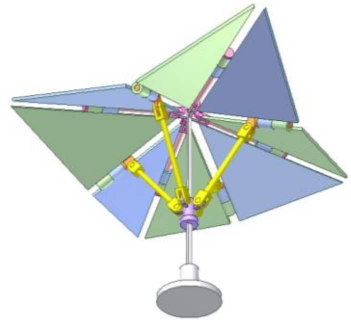
Deployable curtain wall
https://youtu.be/6UIjbLG-nD4
It was made based on the deployable curtain wall for indoor light control, Al Bahr Towers, Abu Dhabi, UAE.
http://i.imgur.com/5PtvZmV.gifv
The video shows only an unit of the wall.
The units are assembled on violet stationary frame. Yellow center slider, outside beige slider and pink rod create an ellipse mechanism.
The yellow center slider has 3 revolution joints with 3 pink rods.
Triangular plates have revolution joints with the pink rods and between themselves.
Orange cylinder moves the yellow center slider to deploy the unit.



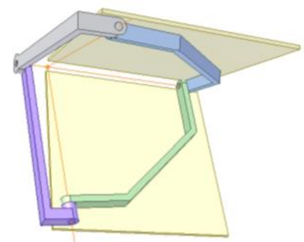
Folding a rectangle 1
https://youtu.be/UNPU7ECOtVA
The rectangle is divided into 4 parts.
Input: the pink part.
The 4 parts are connecting together by revolute joints, axes of which are concurrent. In fact, it is a spherical 4-bar linkage.
The mechanism has an unstable position when all parts are in a plane.
The mechanism is inspired by paper folding art.
The video was made base on
https://youtu.be/oLuO_-CPJXk



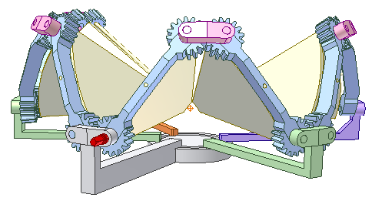
Folding a square 1
https://youtu.be/RoRK2kN9Mlk
The square is divided into 8 sectors.
Input: violet slider.
Two adjoining sectors are connected together by a revolute joint. Yellow conrods connect the violet slider with orange hinge pins by revolute joints. Pink hinge pins are connected to the grey post by revolute joints
The mechanism has an unstable position when all sectors are in a plane.



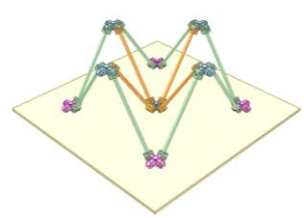
Folding a rectangle 2
https://youtu.be/bKgAcnW8R0s
Input: blue bar.
It is a spherical 4-bar linkage.
Angle A between two axes of revolute joints of the blue (and green) bar is 85 deg.
The simulation shows that if A = 90 deg., the mechanism can't work.



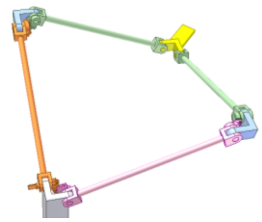
Folding a circle 1
https://youtu.be/IOVuCLSCcIU
Input: red shaft fixed to one of the blue bars.
The circle is divided into 8 sectors.
It is a spherical mechanism. Axes of all revolute joints are concurrent. Bevel gear drives make all blue bars turn the same angle.
It can be used for deploying solar panels.



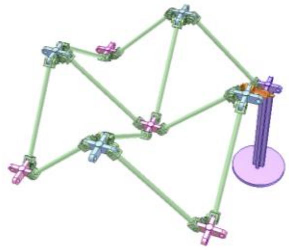
Folding a square frame 1
https://youtu.be/65gqlGk-5Tc
The center cross is stationary.
Input: one among the orange bars.
Four pink crosses slide on the ground surface.
The frame can be enlarged by connecting more bars and crosses.
See a real mechanism:
https://www.youtube.com/watch?v=ayk9PBwpwmM



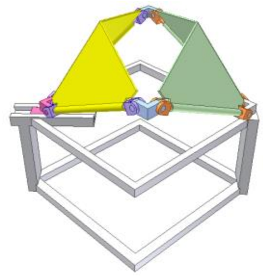
Folding a square frame 2a
https://youtu.be/miI1MH8cTvQ
Input: orange bar.
Orange and pink bars are connected together by bevel gears.
Orange and green bars are connected together by bevel gears.
Pink and green bars are connected together by bevel gears.
Yellow part moves in the horizontal plan.
This mechanism can be used for manipulators.



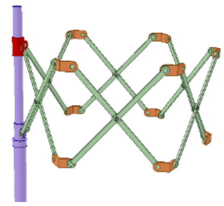
Folding a square frame 2b
https://youtu.be/tVkDVS-mGOw
Input: orange bar.
It is developed from “Folding a square frame 1a”:
https://youtu.be/miI1MH8cTvQ
by adding more parts.



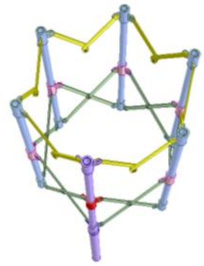
Folding a square 2
https://youtu.be/V6_sy5B5r5A
Input: one among the orange bars.
Joints between triangular panels and orange or violet bars are cylindrical.
Joints between two yellow (or green) triangular panels are revolute.
It is an attempt to create a movable roof.



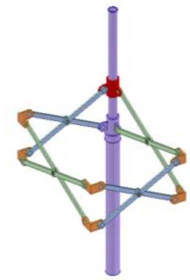
Folding a hexagon frame 1a
https://youtu.be/jwzcOYU6XKQ
It is an application of scissor mechanisms.
It can be called as the cylindrical scissor mechanism



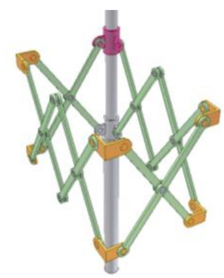
Folding a hexagon frame 1b
https://youtu.be/JPV3Qqulob8
It is an embodiment of mechanism shown at:
https://youtu.be/jwzcOYU6XKQ
Input: red slider.
Adding cylindrical joints of the pink parts with the blue rods as well as the yellow bars does not change motion rule of the whole mechanism.
See a real mechanism:
https://www.youtube.com/watch?v=APSsrPbh_X4



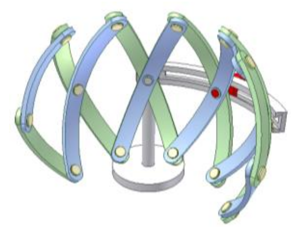
Folding a rectangular frame 1
https://youtu.be/wXx4iZ1eZBs
It is an application of scissor mechanisms.



Folding a rectangular frame 2
https://youtu.be/VRHqUxAPCD0
It is an application of scissor mechanisms.
Length ratio of the rectangle two sides is around ½.



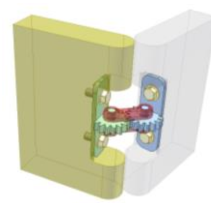
Spherical scissor mechanism 1a
https://youtu.be/GjqqTo3NjdY
Input: red circular slider.



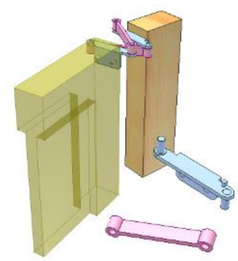
23. Mechanisms for opening and closing

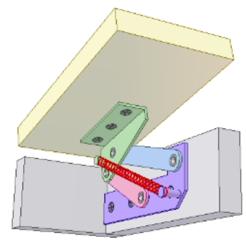
The simplest hinge
https://youtu.be/qJKEnWo4r9Y
Position of the door can be adjusted thanks to the threads of the pink rings and the blue pins.

Hinge enabling 360 degree rotation 1
http://www.youtube.com/watch?v=pl8tq3Z76is
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.



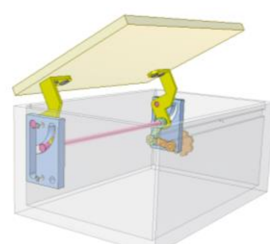
Hinge enabling 360 deg. rotation 2
http://youtu.be/gItkHi0Rink
Ordinary hinges can not rotate 360 degrees because of thickness of moving and grounded parts. The proposed design does not have such limitation.
An anti-parallelogram mechanism is used here.
Lengths of blue and pink parts are 80 and 95 respectively.
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/9t6a7uvkrwi5b8q/360dHinge2STEP.zip



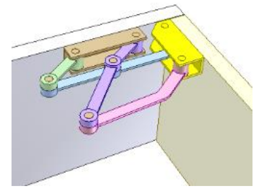


Bench seat hinge 1
https://youtu.be/eA4mC4Cf2MM
It is an application of 4 bar linkage.
End open positions of the seat is kept firmly thanks to the red spring.

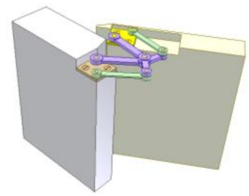
Concealed hinges 1
https://youtu.be/kh252HOZrqc
These concealed hinges allow raising and turning the lid to open.
The opening force may be applied to the orange crank or to the lid directly.



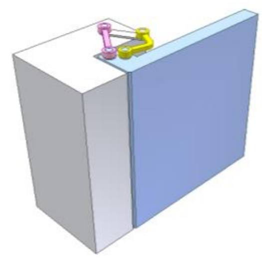
180 deg concealed hinge
https://youtu.be/6bMMZq0X29E
This 6 bar mechanism enables the hinge to rotate 180 deg..
At close position the hinge is not seen from outside.
Green, blue and violet bars create a parallelogram.
It is used for car doors.



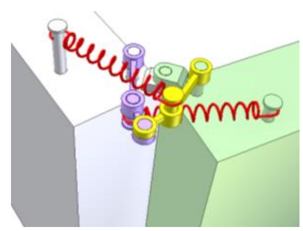
90 deg concealed hinge
https://youtu.be/lE-HTMKPDjQ
It is 6 bar mechanism of two parallelograms enables the hinge to rotate 90 deg..
At close position the hinge is not seen from outside.



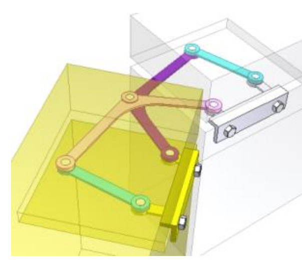
Door 1
https://youtu.be/gYrI_t0-U3A
Pink, yellow rockers and blue conrod (door panel) create a 4-bar linkage.



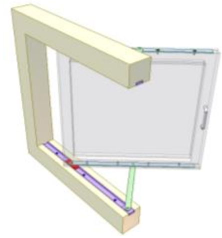
Door 4
https://youtu.be/1TmTI4IxiAs
Violet, green (door panel) rockers and yellow conrod create a 4-bar linkage.
Red springs make the door always closed if no external force.
Advantage: Torques caused by springs applied on the door panel is not too large at door open positions.



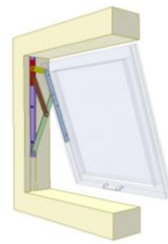
Door 6
https://youtu.be/Bi4rNqL2VCI
It is a 6-bar mechanism consisting of two blue identical bars, two identical V-bars and two white/yellow symmetric bars.
The yellow panel turns 180 deg. around a virtual moving vertical axis.
It is called the hidden hinge because it is not seen when closing.



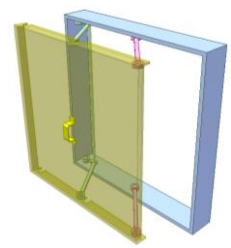
Window friction hinge 1
https://youtu.be/p9Vf0iJaF1s
The sash is attached to blue conrod of a slider crank mechanism. Push/pull the sash to open/close the window.
Red slider has friction shoes (not shown) that are pressed towards violet runway thus holds the sash at a desired position against undesired movement by wind or the like.
An advantage of this hinge: the outside of the sash is accessible from the inside for purposes of cleaning.



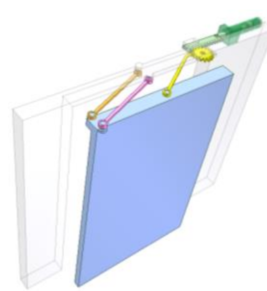
Window friction hinge 2
https://youtu.be/7ylZISiVbXA
The sash is attached to blue conrod of a 6-bar mechanism. Push/pull the sash to open/close the window.
Red slider has friction shoes (not shown) that are pressed towards violet runway thus holds the sash at a desired position against undesired movement by wind, weight or the like.



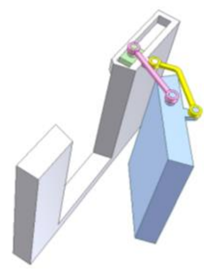
Door 2a
https://youtu.be/8gg9g0fgx94
Pink, green rockers and yellow conrod (door panel) create parallelogram mechanism that reduces space needed for door opening.



Door 2b
https://youtu.be/pTMZ2fbvz-w
Pink, orange, yellow rockers and blue conrod (door panel) create parallelogram mechanisms that reduce space needed for door opening.
This design can be applied for vehicle doors.

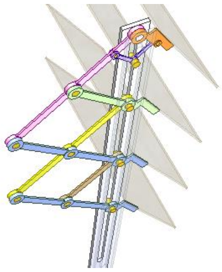


Door 3
https://youtu.be/oNzxy69P8Bs
Pink and yellow rockers, blue conrod (door panel) create a 4-bar linkage. Green slider-pivot can move so the mechanism has two degrees of freedom. By giving two input motions (yellow link and green slider in this video) the blue door panel can be opened to both sides in spite of its wedge section.



Slat window 1

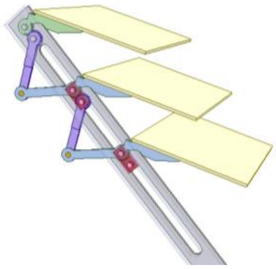
https://youtu.be/ZCRxmJUbJqM



Four slats turn and move up to open.
It is an application of the scissor mechanism.
The counterbalance device is not shown.
Driving force may be applied to any movable part.
It can be used for the cabinet window shown at:
https://www.youtube.com/watch?v=LWUU_CYgjbE

Slat window 2

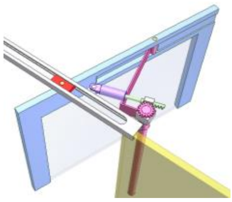
https://youtu.be/qT1CvAewZzs



Three slats turn and move up to open.
It is an application of the slider-crank mechanism in combination with gear drives.
The counterbalance device is not shown.
Driving force may be applied to any movable part.
It can be used for the cabinet window shown at:
https://www.youtube.com/watch?v=LWUU_CYgjbE

Bus door 1

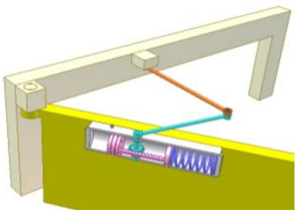
https://youtu.be/6jZc1bNglak



Pink crank, red slider and blue bus door (in role of a conrod) creates a slider-crank mechanism. Violet cylinder controls door opening.
Door motion occupies very small room for both inside and outside space of the bus.

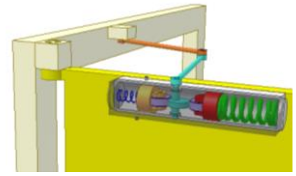
Door closer 1

http://youtu.be/vBDlDc9MmI4



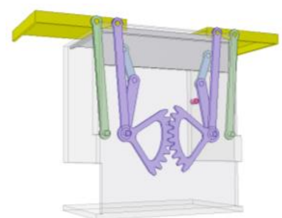
The cyan arm is connected to cyan gear that engages with pink rack-piston. At one end of the rack-piston is violet spring that accumulates energy during door opening and releases it during closing.
The spaces around the rack-piston contain oil. There are oil ways connecting the oil spaces including adjustment valves that regulate opening and closing speeds.
As the door swings closed, connecting link (in orange) comes into toogle 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



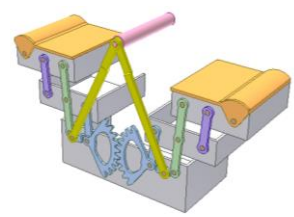
The cyan arm is connected to a cam (eccentric circle profile) that contacts with rollers of two pistons. The red piston has green spring that accumulates energy during door opening (the spring length is reduced) and releases it during closing. The orange piston has a blue spring that ensures its permanent 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 toogle 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.

Extendable table
https://youtu.be/IBwslMs6DkY



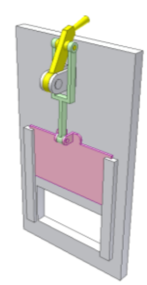
Pull aside one of two yellow side panels to double table surface area. The middle panel has prismatic joint with the base. Pink stopper prevents the middle panel from falling down at its upper position.
Weakness: there are two longitudinal slots between the three panels.
It can be used for hiding an object under the table after displaying.

Tool box 1
https://youtu.be/WsgnkpT1Kpg



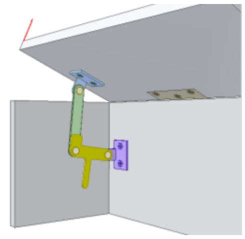
Push down the pink grip to open the box.
Thanks to blue gear sectors the pink grip is always in longitudinal symmetrical plane of the box and the compartments move to opposite directions synchronously.
If no blue gear sectors, the compartments of each side can move independently with the ones of the other side.
Orange covers can be opened thanks to revolution joints.
For simplicity the tool box is cut off a half.

Up-down window
https://youtu.be/YxzauOhqTkU

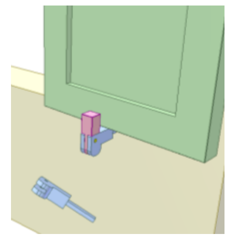


It is an application of slider crank mechanism.
The gravity ensures that the pink window is kept firmly at its open and closed positions.

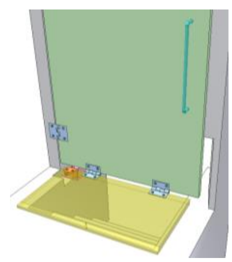
Bench seat strut 1
https://youtu.be/ozczEpcOtvo
It is an application of 4 bar linkage.
Raise the seat (red arrow) and turn the yellow lever clockwise (black arrow) to lock the seat at open position. The seat weight pushes the yellow lever toward the back board.
Turn the yellow lever counterclockwise (black arrow) to close the seat.



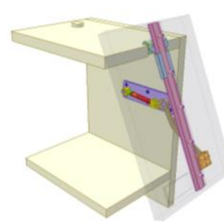
Window stopper
https://youtu.be/AnbnIvLnplw
Pink stopper can be set to two positions: up or down.
When it is down, green window can be opened 180 deg. Then the stopper is set to up position to hold window there. The window can not overcome it because the pink stopper acts as a lever around yellow pivot.
Set the stopper to down position to close the window.



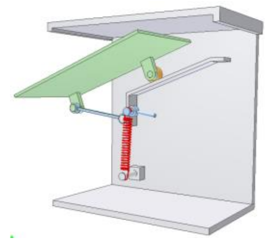
Door and stairs cover
https://youtu.be/oPsgOePdKU8
This mechanism enables to open green door and raise yellow cover at the same time.
Motion of the cover is controlled by pink cam and orange follower.
Attention: Axes of vetical and horizontal hinges are skew (not intersecting).
This mechanism was made on request of a YouTube viewer from Arab Saudi for his new house.



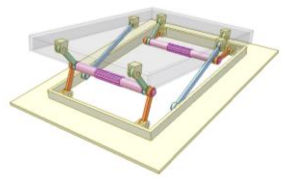
Cabinet door
https://youtu.be/JQQEYlvM2GY
Pull glass door to open or close.
The door slides on its hinge to reduce occupation space at open position.
Red spring holds the door steadily at its opening or closing position.
It can be applied for garage doors.
See real mechanism:
https://www.youtube.com/watch?v=mzEpVIMyrxs&index=9&list=PLRvMm7pRoiKjx7VT9Ds4WIip5MkXv5n7S
See a mechanism of the similar function:
https://youtu.be/f6OKy6Nr_4o



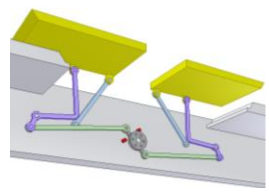
Door 5
https://youtu.be/f6OKy6Nr_4o
Blue crank, green conrod (door panel) and orange roller create crank slider mechanism (to some extent, because the roller can be replaced with a slider).
Lower fixed end of red spring is set at position so as to keep the green door panel firmly at its closed or open positions (to create anticlockwise moment on the blue crank at closed position and vice versa).



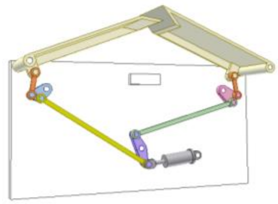
Car roof window
http://youtu.be/Url8JhauPYA
This mechanism (group of 4 bars and 6 revolution joints + two cranks) has 2 degrees of freedom.
Use two pink grips to open the window to the desired direction.
Measure to create friction in the joints is needed for holding the window at adjusted position.



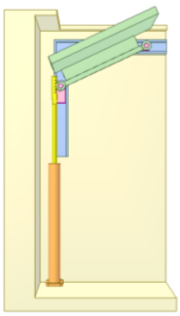
Ceiling window 1
https://youtu.be/N395Mxotd2M
Yellow panels, violet and blue rockers create parallelogram mechanisms. Grey crank fixed to a load chain-wheel moves the panels synchronically. The gravity and two red stoppers keep the panels firmly at their end positions.



Ceiling window 2
https://youtu.be/vfUhv4d3Woo
The mechanism ensures:
- At beginning of open process the right panel turns faster than the left one.
- At beginning of close process the left panel turns faster than the right one.

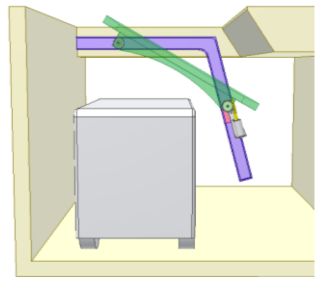


Cover for basement entrance 1a
http://youtu.be/KHyIXFYPtfA
Green cover is a connecting rod of an ellipse mechanism of two pink sliders. Driving force from fixed cylinder is applied to the connecting rod via a pinion rack drive (instead of to pink lower slider) ensures smooth motion of the mechanism even 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

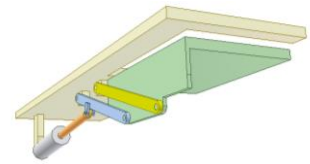
http://youtu.be/iRH5lwF-1VE



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

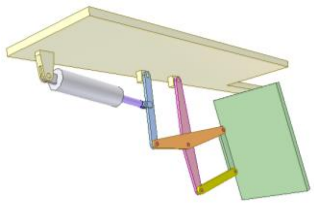
http://youtu.be/MeeW9S2qojE



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

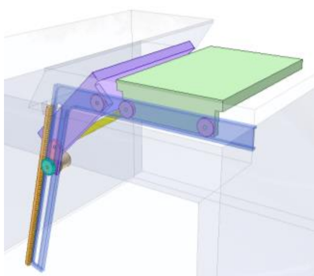
http://youtu.be/VN9ERN1UK1s



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.

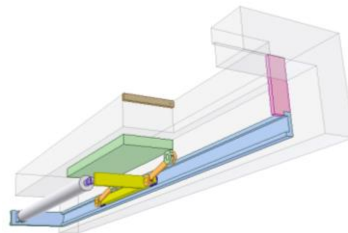
Cover for basement entrance 1c

http://youtu.be/Wnkzo14aA3o



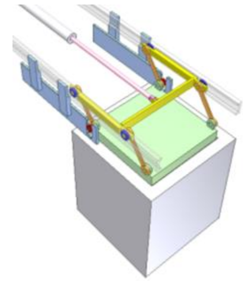
The cover is divided into green and violet halves in order to reduce its occupied space in moving or to ease the manufacture.
The green half has two pink rollers rolling in blue runway.
The violet half has a pink roller rolling and a pink slider sliding in the runway.
Yellow conrod has revolute joints 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/rfnXYbCxlQg
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.

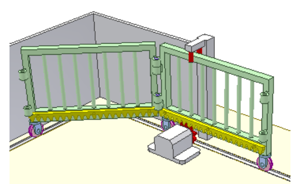


Gap between the floor and the cover is minimum.
The cover occupies small space during motion.
Center of mass of the cover moves up only a little so the mechanism is good in term of saving energy.
The mechanism is cut off half for easy understanding.
The mechanism of two opposite moving covers is possible.

Cover for furnace 1
http://youtu.be/bKSJOITl9kE
Yellow frame reciprocates linearly under action of a cylinder.
Parallelogram mechanism of orange rockers keeps green cover always horizontal in motion.
The cover moves up thanks blue cams and red rollers, goes down due to the gravity.

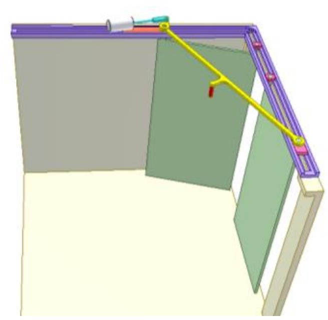


Slide folding gate
https://youtu.be/21eDdRSMuA0
Red pinion of grey motor can engage with two yellow racks and push the gate of two panels.
See a real gate of 4 panels:
https://www.youtube.com/watch?v=AN8C7m8cYY4



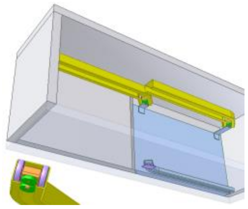
Using lengths of chain instead of the racks is possible. Then the pinion axis is vertical.

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.

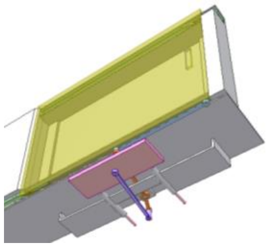


In case of power interruption:
- Move red grip of the conrod to open the door.
- The door can not be opened from outside.
- At completely closed or opened positions of the door, force applied to the panels can not move them.
This mechanism can be applied for up & down garage doors.

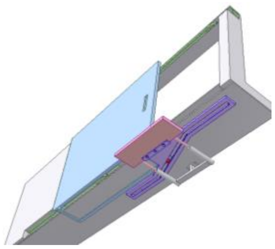
Flush sliding door
https://youtu.be/6IniHdigpmc
Violet rollers bear the weight of blue door.
Green rollers are for guiding.
The door is connected to the upper sliders via revolute joints.
The 45 deg. corners at the rail ends make the door flush with the wall.
Blue lower rail fixed to the door and violet pin fixed to the ground and moving in the slot of the lower rail keeps the door from swinging.
This video was made on request of a YouTube viewer.
Related sources:
https://www.youtube.com/watch?v=4RxCRMNvhQ0
http://www.sugatsune.com/instructions/mfuinst0115.pdf



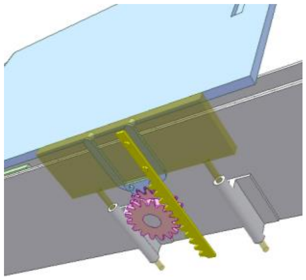
Car sliding door 1
https://youtu.be/4FlzoGsCQ1Y
This ensures synchronic motions of yellow door and pink step.
When the door opens, the step moves out and vice versa.
The mechanism consists of two slider crank mechanisms of a common crank (in orange).



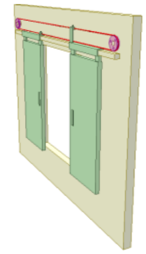
Car sliding door 2
https://youtu.be/lonlZH7myA0
This ensures synchronic motions of blue door and pink step.
When the door opens, the step moves out and vice versa.
Violet translating cam is fixed to the pink step.
Red pin of the door moves in the cam slot and moves the step.
Anti-dust measure for the cam is needed.



Car sliding door 3
https://youtu.be/oDW_ckSf8s4
This ensures synchronic motions of blue door and yellow step.
When the door opens, the step moves out and vice versa.
Yellow rack is fixed to the yellow step.
Blue rack is fixed to the blue door.
Both can be in mesh with the pink gear.
Disadvantage: Measure for positioning the step at its two end positions is needed.
Anti-dust measure for the gears is needed.

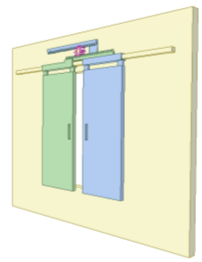


Synchronously sliding windows 1
http://youtu.be/3yodKPhoTsM
Left pannel is fixed to lower cable branch.
Right pannel is fixed to upper cable branch.
Cable tension device is not shown.

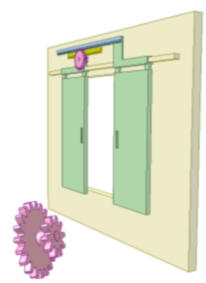


Synchronously sliding windows 2
http://youtu.be/-8WbMU12oyk
Threads at two sides of blue screw are of opposite hand. Each orange pannel has red pin that moves in helical groove of the screw.
When one panel is driving, the screw is driven but at same time it is driving for the other panel, so reasonable helix angle of the screw is 45 deg.
Use ball screw to ease the motion.

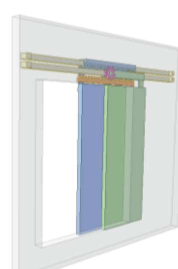
Synchronously sliding windows 3
http://youtu.be/QHr38WRYuyg
A pinion and two racks enable window synchronous sliding.



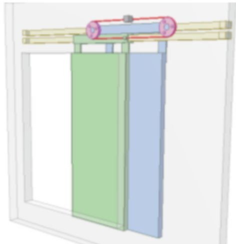
Synchronously sliding windows 4
http://youtu.be/PiHCcPcSsEE
Yellow rack is stationary and engages with pink small pinion of a block of two ones.
Tooth number of large pinion is twice that of the small one.
This mechanism is not good solution for synchronously sliding windows however it can be applied for other cases where the gears are driving (actuator must be on the left panel).
► In case two pinions are of equal tooth numbers:
- If the pinion block or left panel are driving, only the left panel moves, the right one is immobile.
- If right panel is driving, both panels are stuck.



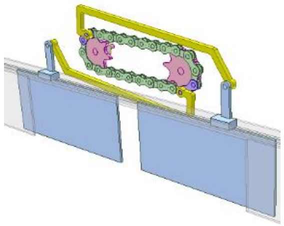
Telescopic sliding windows 1
http://youtu.be/kBeLWPvoimU
Orange rack is fixed to the wall.
Pink pinion rotates on a pivot of the green panel.
Blue rack is fixed to blue panel.
The blue panel moves twice faster than the green one.
The video shows back view of the window.
Disadvantage: The two panels are not on the same level.



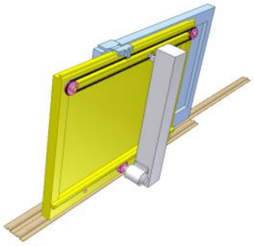
Telescopic sliding windows 2
http://youtu.be/OuZ9xsp0-LU
Two pink pulleys rotate on pivots of the blue panel.
Green pannel is fixed to lower cable branch.
Upper cable branch is fixed to the wall.
The green panel moves twice faster than the blue one.
Cable tension device is not shown.
The video shows back view of the window.
Disadvantage: The two panels are not on the same level.



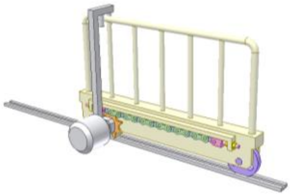
Lift door 1
https://youtu.be/AGXlEqppz1Y
Stroke length of each door panel = A + D.
A: center distance of chain drive.
D: pitch diameter of sprockets
The chain drive can be replaced with timing belt one.



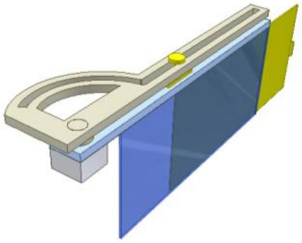
Telescopic sliding gate
http://www.youtube.com/watch?v=ASAxH51ify8
A roller cable mechanism is used.
A point on lower part of the cable is fixed with the grounded post.
A point on upper part of the cable is fixed with the blue panel 2 that moves twice faster than the yellow panel 1.



Chain drive 1D
http://youtu.be/D70s_01VTGo
Using chain rack instead of ordinary one reduces production costs.

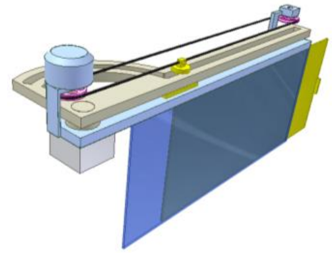


Turning and telescopic sliding door 1a
https://youtu.be/OeniilmaG-s
Push yellow panel to open, pull it to close the door.
The yellow panel is fixed to yellow slider that moves along blue straight runway, to which blue transparent panel is fixed. The runway is pivoted on the wall.
The yellow slider has a pin that moves along the slot of stationary brown plate. The curve portion of the slot is an Archimedean one.
When the pin enters the curve portion, both panels start their 90 deg. turning.



Turning and telescopic sliding door 1b

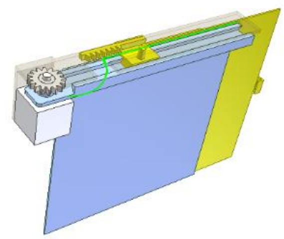
https://youtu.be/OXc_GsdP9k4



It is a motorized embodiment of
"Turning and telescopic sliding door 1a"
https://youtu.be/OeniilmaG-s
Yellow slider is fixed to the black belt of two pink pulleys. Input: blue motor giving the slider linear reciprocating motion.
The yellow panel is fixed to yellow slider that moves along blue straight runway, to which blue transparent panel is fixed. The runway is pivoted on the wall.
The yellow slider has a pin that moves along the slot of stationary brown plate. The curve portion of the slot is an Archimedean one.
When the pin enters the curve portion, both panels start their 90 deg. turning.

Turning and telescopic sliding door 2a

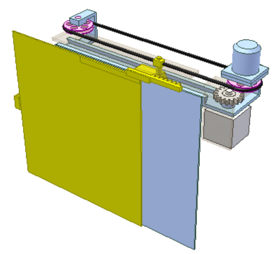
https://youtu.be/Wrn0brP2Z_A



Push yellow panel to open, pull it to close the door.
The yellow panel is fixed to yellow slider that moves along blue runway.
The yellow slider has a pin that moves along a slot of stationary plate (in transparent brown).
At left end of the yellow panel stroke the interaction between yellow rack and the stationary grey gear makes the blue runway, to which blue panel is fixed, turn 90 deg.
Green line is the trajectory of the yellow pin center.
For easy motion of the mechanism make the gear as large as possible.

Turning and telescopic sliding door 2b

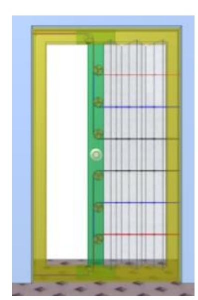
https://youtu.be/LVJ5Ob-JyGI



It is a motorized embodiment of
"Turning and telescopic sliding door 2a"
https://youtu.be/Wrn0brP2Z_A
Yellow slider is fixed to the black belt of two pink pulleys. Input: blue motor giving the slider linear reciprocating motion.
The yellow panel is fixed to yellow slider that moves along blue runway. The yellow slider has a pin that moves along a slot of stationary plate (in transparent brown).
At left end of the yellow panel stroke the interaction between yellow rack and the stationary grey gear makes the blue runway, to which blue panel is fixed, turn 90 deg.
For easy motion of the mechanism make the gear as large as possible.

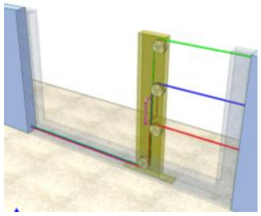
Wire door

https://youtu.be/BbljXYQvlJE

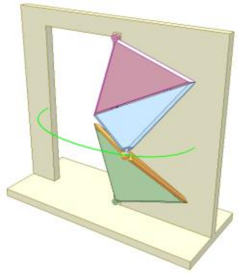


It is used for anti-insect door.
The zigzag net is made of plastic.
There are six wires in red, blue and black. The ends of each wire are fixed to yellow stationary frame. The wires are for guiding and supporting the zigzag net.
In case without the net and the wires diameter is large, it can be used as a normal door.

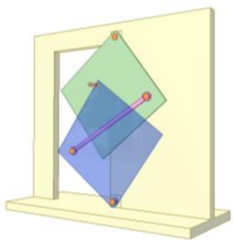
Wire door for fences
https://youtu.be/_TxLCK7GWyY
There are three wires in red, blue and green. The ends of each wire are fixed to glass stationary frame.



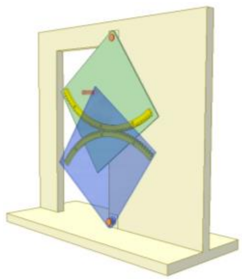
Torggler door 1
http://youtu.be/ipx3HfH76F8
The mechanism consists of 4 links (triangular panels) and 5 joints.
Blue and orange panels are connected together by a spherical joint.
Four remaining joints are revolute.
When the door is completely open or closed (death positions), force applied to the pink or green panels can not move the door. So do the gravity, thus the door is kept rather stable at open or closed positions.
No problem for forces applied to the blue or orange panels.
Center of the sperical joint traces half of an ellise (green curve) so the door occupies less space than ordinary doors in moving.
Disadvantages:
- At closed position the panels lay outside the wall thickness.
- Not suitable for partly opening.
It looks like an art work more than an useful door.
The door is named after its designer, Klemens Torggler, an Austrian artist.
Mechanisms of square, pentagon and hexagon panels have been animated but they do not show practice applications.



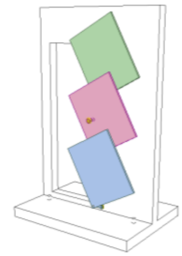
Torggler door 2
http://youtu.be/AvLZwzHtHKo
An application of 4 bar linkage.
Friction in revolute joints must be large enough, otherwise the mechanism will move from open or closed positions due to the gravity.
Adding positioning devices is another solution.
Disadvantage: The two panels are not on the same level.



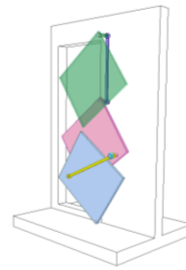
Torggler door 3
http://youtu.be/B7y1979IRgk
An application of gear drive.
Friction in revolute joints must be large enough, otherwise the mechanism will move from open or closed positions due to the gravity.
Adding positioning devices is another solution.
Disadvantage: The two panels are not on the same level.



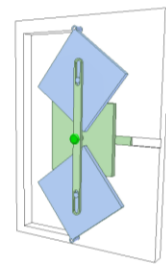
Torggler door of three leaves 1
https://youtu.be/mZSSRooaKP0
It is for the door of height/width ratio of 3/1.
Three leaves are connected together by a double parallelogram mechanism. It needs some free space above the door.



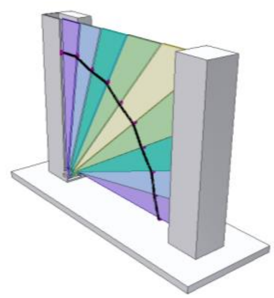
Torggler door of three leaves 2
https://youtu.be/OHKay3Jqygk
It is for the door of height/width ratio of 3/1.
Green, pink leaves and violet conrod create a parallelogram mechanism.
Blue, pink leaves and yellow conrod create a four-bar linkage.



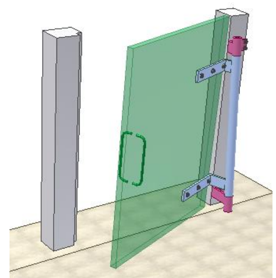
Torggler door of three leaves 3
https://youtu.be/L5tork2p_BI
It is for the door of height/width ratio of 3/1.
Weakness: prismatic joint between the green leaf and the wall is needed.



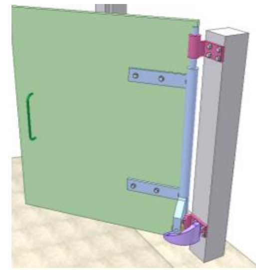
Gate of hand fan style
https://youtu.be/K1ayFZqs0ZU
The gate consists of several sectors.
Raise the lowest sector (in violet) to open the gate. The pin (in pink) fixed to the lower sector moves the upper adjacent sector to open position. The measure to keep all sectors at the open position is not shown. It may be a hook for example.
The gate is closed thanks the gravity. The chains (represented by black lines) that pivot on two adjacent pink pins hold the sectors at the close position.
See the gate in real life:
https://dantricdn.com/2017/anh-dong-hai-huoc-8-1489341515727.gif



Gate to open inward uphill 1
https://youtu.be/UHOIfmHJaxI
The gate hinge axis is perpendicular to the ground uphill surface, thus the panel does not collide with the ground.
The gravity tends to close the gate, if the open angle is less than 90 deg.
See a real gate:
https://www.youtube.com/watch?v=11D54zdl1JI



Gate to open inward uphill 2

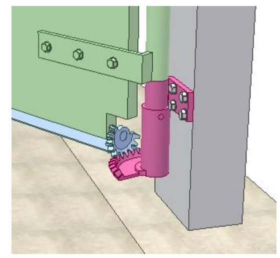


https://youtu.be/J8Lf3N9v3NQ

Thanks to violet face cam the gate panel is raised when open, thus it does not collide with the uphill ground.

This mechanism is suitable for case when the gate is not too wide and the ground is not too uphill (for easy raising the gate panel).

Gate to open inward uphill 3



https://youtu.be/P32pBR-HRa0

The gate panel includes a lower portion (in blue) that is folded when open thanks to a bevel gear drive. Thus, the panel does not collide with the uphill ground.

Transmission ratio of the bevel gear drive is 2.

For more uphill ground the height of the lower portion is larger.

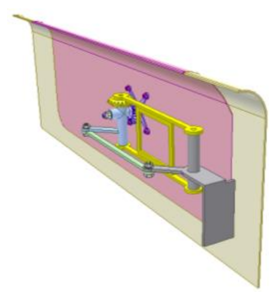
For larger opening angle (more than 90 deg.) use teeth-uncompleted bevel gear drive shown at:

https://youtu.be/0JMF5Op6984

See an embodiment of this mechanism where the bevel gear drive is replaced with a cable drive:

https://www.youtube.com/watch?v=UKh6v30d7hI

Scissor (Lambo) car door



https://youtu.be/FCPElvdzgmc

A parallelogram mechanism (yellow and green rockers, blue conrod) makes the pink door panel (fixed to violet bevel gear) always parallel to the car longitudinal vertical plane.

Yellow bevel gear is fixed to yellow rocker.

The violet bevel gear rotates on a bearing fixed to the blue conrod.

Here the two gears have the same tooth number.

The door has two motions at the same time:

- rotation around a stationary vertical axis.
- rotation around a moving horizontal axis.

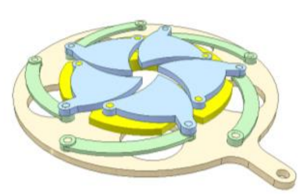
Thus, the door is vertical at open position to ease entry/exit.

The chamfer at upper front corner of the panel is needed to avoid its collision with the car body during open/close process.

See a real door:

https://www.youtube.com/watch?v=zE1R-IeKoOg

Diaphragm shutter 1



http://youtu.be/_P1ghKADv78

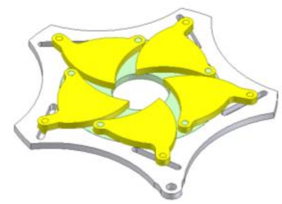
Turn outer disk to open or close the aperture of a camera.

The outter disk, yellow conrod and blue blade create a 4-bar mechanism.

Diaphragm shutter 2

http://youtu.be/msWygarinBs

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

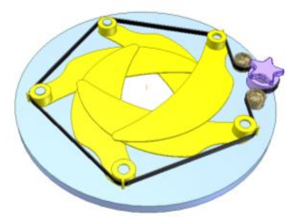
http://youtu.be/VUoVnl9PjPU

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/lW5Wbic1D64

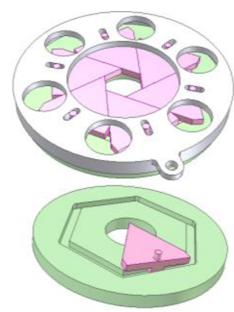
Turn violet knod to open or close the aperture.
Belt drive forces all yellow blades to rotate synchronuosly.
It is possible to replace belt drive with a gear one (internal gear ring and 5 pinions).
The mechanism can be used for windows:
https://www.youtube.com/watch?v=-qlgsCU2NJo



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



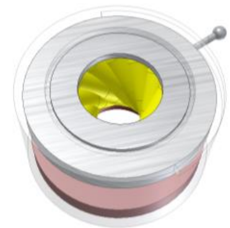
Diaphragm shutter 5b

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.

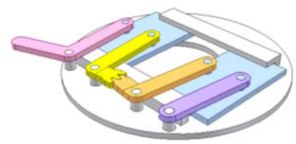
In practice the yellow bars are replaced with a flexible tube.

The mechanism finds application in valves for handling powder or granule materials. See:

https://www.youtube.com/watch?v=A-4V_V4Hi0g

Diaphram shutter 7

https://youtu.be/kytt7QD7mbs



Input: pink arm.

There are two parallelogram mechanisms connected together by a gear drive. A rectangular slit is created during opening or closing the blue diaphrams that don’t move linearly.

24. Hydraulic and pneumatic mechanisms

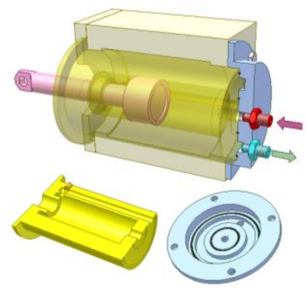
Swinging cylinder

http://youtu.be/Hlg3ZeaeoGU

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

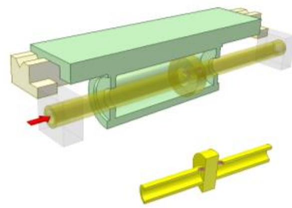
http://youtu.be/ytR2ku1wBgA



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.

Hydraulic cylinder with fixed piston

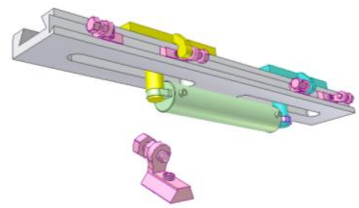
https://www.youtube.com/watch?v=yX_rCTcAPi4



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.

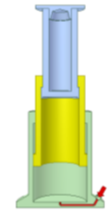
Floating cylinder 1

https://youtu.be/B7BGs7T-7Ys

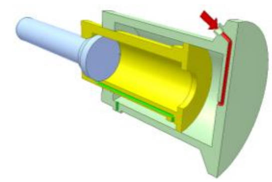


Green cylinder is pivoted on yellow slider.
Violet piston is pivoted on cyan slider.
When the cylinder stretches, the sliders get their farthest positions to each other when contact with the pink outside stopper.
When the cylinder contracts, the sliders get their nearest positions to each other when contact with the pink inside stoppers.
Two stoppers on the left are for setting length and position of the yellow slider stroke.
Two stoppers on the right are for setting length and position of the cyan slider stroke.
Applications of floating cylinders:
https://youtu.be/vSEGVGXqV7A
http://youtu.be/U9fi2DJrIZY
http://youtu.be/fzz7-g6Qr1o

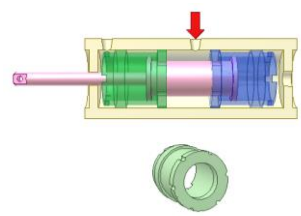
Hydraulic telescopic cylinder 1
http://youtu.be/icaqvfAtccY
Red arrow shows pressure flow.
It is single acting cylinder.
The gravity brings pistons to their lowest positions.



Hydraulic telescopic cylinder 2
https://youtu.be/GsZfb3vtof4
Red and green arrows show pressure flows that control both forward and backward strokes of blue piston.
It is double acting cylinder.

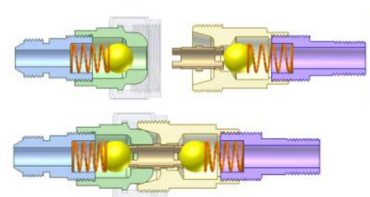


Hydraulic cylinder with three piston positions
http://youtu.be/sPD62mJ_ViM



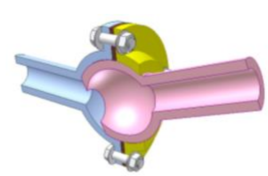
By alternately conducting pressure fluid into cylinder through its three holes the pink piston can reach one of its three stable positions: center, left and right.
Green and blue floating pistons are identical.
The arrows show flows of pressure fluid.
When pressure fluid enter through the medium hole, 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.

Pipe connection 1
http://youtu.be/Nn4P3z589B4

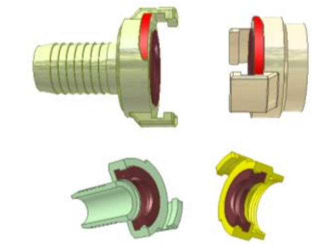


In disconnected state the fluid can not flow out due to the contact of yellow balls with green and popcorn parts under spring forces.
In connected state brown part pushes the balls, thus prevent the above mentioned contact and the fluid flows through holes on the brown part.
Most parts are cut off half for easy understanding.

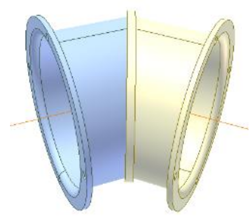
Pipe movable connection 1
http://youtu.be/DwrlPPTBrPA
Spherical joint, arranged for tubing.
The brown gasket is for sealing.



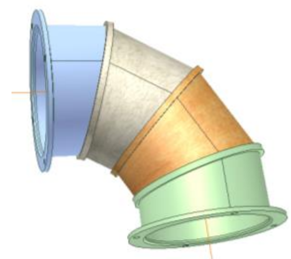
Geka connector
https://youtu.be/D6X7TcXXYRA
Push and twist the connector ends to connect water hoses.
The red circular wedges force them together.
Brown elastic washers ensure the connection tightness.



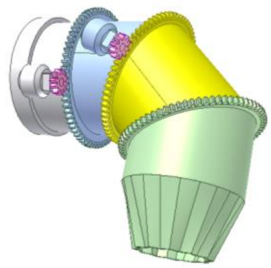
Round adjustable duct elbow 1
https://youtu.be/VYl7mGtac1o
The duct elbow consists of two parts.
Angle between oblique face and longitudinal axis of each part is B.
Angle A between axes of two parts is adjustable.
Turn the right part 180 deg. to get max A = 2B.
The more angle B is, the more duct shape differs from cylinder shape.
So the elbow with more parts (3, 4, …) is recommended to reduce B.
At two connection planes (not parallel) the duct sections are round. The duct is created by connecting (lofting) those sections. So the duct middle sections are of complicated shape.



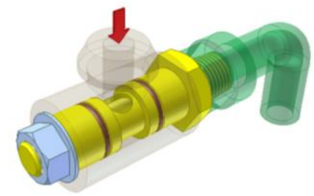
Round adjustable duct elbow 2
https://youtu.be/se65u1xmmiQ
The duct elbow consists of four parts.
Angle between oblique face and longitudinal axis of each part is B = 15 deg.
Angle A between axes of two end parts is adjustable.
Turn the brown part 180 deg. to get A of 30 deg.
Then turn orange part 180 deg. to get A of 60 deg.
Then turn green part 180 deg. to get max A of 90 deg.
In general: max A = k.2.B
Where k is number of movable parts.



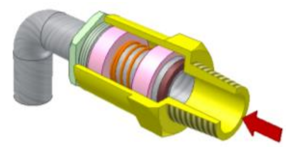
F-35 Swivel Nozzle
https://youtu.be/Po--2PoHGI8
Three motors control gas flow direction.
It is an application of the mechanism shown at:
https://youtu.be/se65u1xmmiQ



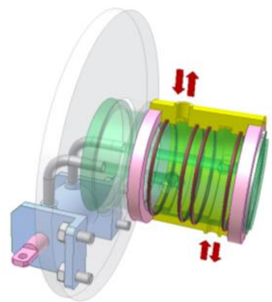
Rotary connector for fluid 1
https://youtu.be/H-ucbzaXg0I
Brown transparent part is stationary and connected to fluid source (red arrow). The fluid is transmitted to rotary part (in green) via circular groove and cross hole on yellow part.
Brown seals are for preventing fluid leakage.



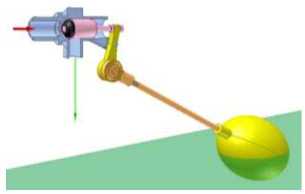
Rotary connector for fluid 2
https://youtu.be/CVvECYK8bPA
Yellow part is stationary and connected to fluid source (red arrow).
The fluid is transmitted to rotary part (in grey).
Pink parts represent ball bearings.
Brown seal is for preventing fluid leakage.



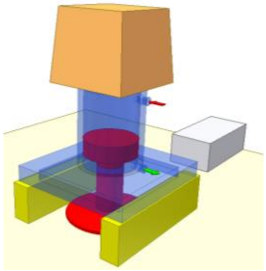
Rotary connector for fluid 3
https://youtu.be/YMHKGJY4-Zc
Yellow part is stationary and connected to fluid source (red arrow).
The fluid is transmitted to blue rotary cylinder via inner circular grooves of the yellow part, cross and longitudinal holes of green shaft and grey hoses.
Pink parts represent ball bearings.
Brown seal is for preventing fluid leakage.
This working principle can be seen in electric slip rings:
http://www.uea-inc.com/products/slip-rings



Water tank automatic valve
https://youtu.be/TTad0HzrQt8
Blue valve body is fixed to the tank. It is cut off haft for easy understanding.
Red arrow represents the water supply.
Green arrow shows water flow controlled by the valve.
Angle between yellow arm and orange lever is adjustable to set the highest water level in the tank when the black cone completely closes the valve.

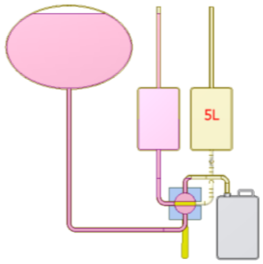


Hydraulic lift 1
https://www.youtube.com/watch?v=ITnEJLjQsAk
This is a way to lift an object (in orange) to large height using cylinder of small stroke by alternately conducting pressure fluid into upper and lower spaces of the piston.
Yellow cushions support blue cylinder.
Grey cushions support red piston.
Arrows show fluid flows. Red arrow is for pressure flow.



Liquid dispenser 1

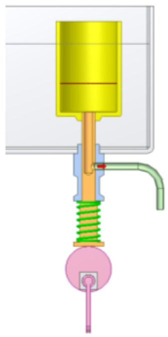
http://youtu.be/4fbcr1ISroU



Liquid from the ovan 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 oscilation of liquid level in the oval tank and the inside diameter (should be minimum) of the air pipes of the meter containers.

Liquid dispenser 2

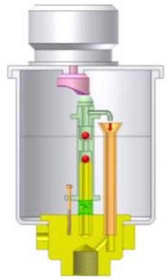
http://youtu.be/4E1AnCBeeQ4



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 dispencer of large liquid amount see “Liquid dispenser 1”:
http://youtu.be/4fbcr1ISroU

Liquid dispenser 3

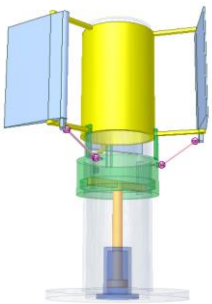
http://youtu.be/m_8wjkpjYLY



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.

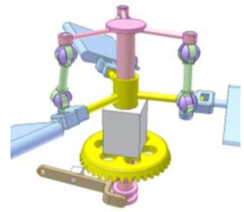
Blade angle adjustment for VWT

https://youtu.be/X9D6VrphBv4



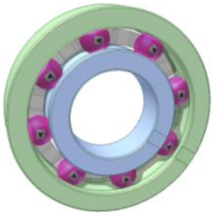
Blue blades are mounted on yellow rotor of a vertical wind turbine (VWT) by revolute joints.
Green slider has prismatic joint with the rotor.
Pink conrods of two spherical joints connect the slider and the blades.
Orange piston, which can move up down only, has planar joint with the slider.
Blue cylinder moves piston and the slider up down to set angular positions of the blades in relation with the rotor.

Pitch adjustment for air propeller 1
https://youtu.be/Dd628Oxq4RA
Điều chỉnh góc cánh quạt. Các cánh xanh lắp lên ổ cánh quạy màu vàng bằng khớp quay và nối với trục trượt màu hồng qua khớp Hook kép. Quay đòn nâu quanh chốt cố định để chỉnh góc cánh quạt.



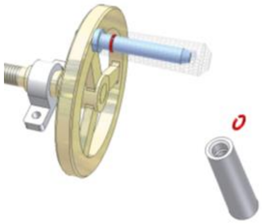
25. Study of mechanisms

25.1. Mechanical joints

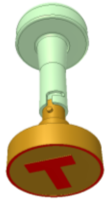


Ball bearing simulation 1
http://www.youtube.com/watch?v=hxUXX0tYMHM
Outer race stationary

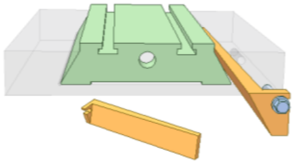
Ball bearing simulation 2
http://www.youtube.com/watch?v=hxUXX0tYMHM
Inner race stationary



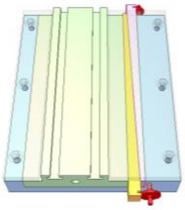
Axial stopper for a grip
https://youtu.be/49XXMZdadC0
The video shows:
A. The assembling process for red spring snap ring.
B. How the glass grip works.
In A: the grip pushes the ring to place it in the circular groove of the blue shaft. The ring is expanded during being pushed. It is compressed when the grip moves futher to set the ring in the circular groove of the grip.
In B: when the operator rotates the wheel, the grip translates circularly. The ring prevents the grip from being removed by a small force.



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.

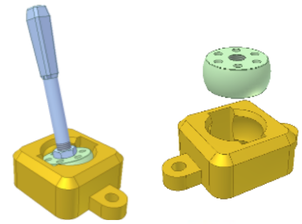


Wedge mechanism 17
http://youtu.be/_I3PPttljC8
The gap between the green slider and the runway is adjusted by moving the orange wedge. The slopes on the wedge and on the runway are equal.



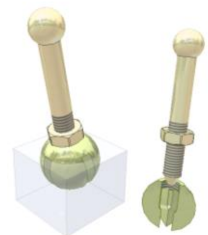
Wedge mechanism 28
http://youtu.be/rM8FcOcZ9M8
The gap between the green slider and the runway is adjusted by moving the orange and pink wedges. The slopes on the wedges are equal.

Sphere joint having unsplit outer part 1
http://youtu.be/gWzPxNvG0Dw
Length of rectangular slot on the yellow outer part must be larger than the diameter of green sphere.



Sphere joint having unsplit outer part 2
http://youtu.be/KfGUpfkucNM
The ball has cylindrical portion diameter of which is slightly smaller than diameter of the socket surface hole. Assembling position: axis of the said cylindrical portion is perpendicular to the upper surface of the socket. The ball can not come out of the socket for other positions.

Sphere joint having unsplit outer part 3
http://youtu.be/4xufc30z-xo
The ball has two slots to form 4 wings that are deformed to reduce ball diameter when pushing the ball into spherical hole of the socket.
Cone end of the screw is in mesh with cone hole of the ball to prevent the said deformation after assembling thus the ball can not come out of the socket.



Spherical connection of large turning angle 1
https://youtu.be/95bZU6ylEzw
Turning angle of ordinary spherical joints can not exceed 180 deg.
This joint doesn't have such limitation. In fact it is a Hook joint.
Blue sphere has two circular dovetail grooves that are perpendicular to each other. The sphere is divided into two for assembling pink and yellow parts.

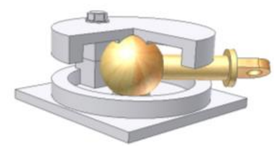
Spherical connection of large turning angle 2a
https://youtu.be/XupyXgd30h8
Turning angle of ordinary spherical joints can not exceed 180 deg.
Mechanism of three revolute joints on the right doesn't have such limitation. In fact it is a Hook joint.

2 DoF spherical connection of large turning angle 1
https://youtu.be/iK253Ww_MwU
Mechanism on the left is a spherical joint with a pin (2 degrees of freedom). Its turning angle can not exceed 180 deg.
Mechanism on the right doesn't have such limitation. In fact it is a Hook joint.

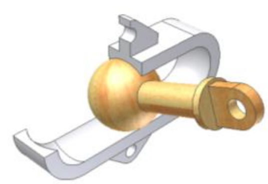
Pin spherical joint 1
https://youtu.be/kztZu3uTyvM
The sphere has 2 degrees of freedom: rotation around its longitudinal axis and rotation around a horizontal axis.
The pin-groove contact restricts the third rotation of a simple spherical joint.

Pin spherical joint 2
https://youtu.be/K0dFf9714L8
The sphere has 2 degrees of freedom: rotation around its longitudinal axis and rotation around a horizontal axis. The sphere is kept by two cone holes on green base and pink cover.
The pin-groove contact restricts the third rotation of a simple spherical joint.
The large circular hole on the pink cover is for inserting the sphere when assembling.
The cover is one fourth cut off for easy understanding.

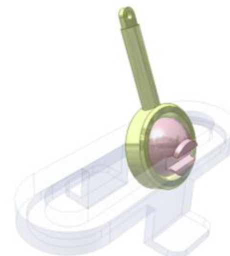
Pin spherical joint 3
https://youtu.be/MX6HHcQ2dX0
Orange shaft of spherical end has 2 degrees of freedom: rotation around its longitudinal axis and rotation around vertical axis.
The pin-groove contact restricts the third rotation of a simple spherical joint.
The grey cover is one fourth cut off for easy understanding.



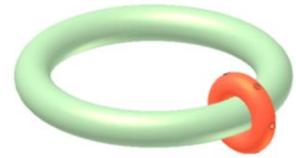
4 DoF joint
https://youtu.be/2lrOl8ilOw0
Orange shaft of spherical end has 4 degrees of freedom: 3 rotations and 1 linear translation.
The outter part is one fourth cut off for easy understanding.



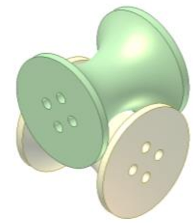
4 DoF connection
https://youtu.be/vde8SWF5Fmg
The connection consists of 3 links (2 movable).
Green shaft has 3 DoF spherical joint with pink sphere.
The latter has prizmatic joint with the glass base.



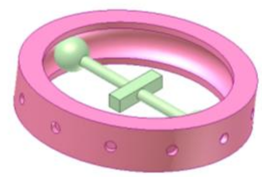
Mechanical torus joint 1
http://youtu.be/uCEPAw4jxCA
The joint allows two degrees of freedom (rotations) of relative movement.



Mechanical torus joint 2
http://youtu.be/mHkdwnrhsPU
The joint allows two degrees of freedom (rotations) of relative movement.

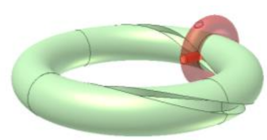


Mechanical torus joint 3
http://youtu.be/BbsGHSC1i5c
The joint allows two degrees of freedom (rotations) of relative movement.



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.

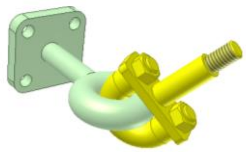
Helix torus joint 1b
http://youtu.be/CvsviKzNoqs
There are a helix groove of two rev. (n = 2) on the big torus. The small torus makes 2 rev. around its axis during 1 rev. around the big torus axis.



Helix torus joint 1c
http://youtu.be/6vWSl5JYUoI
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.

Mechanical torus joint 4

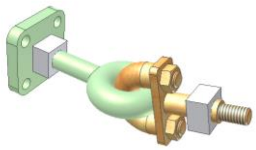
https://youtu.be/6yrlo0dxIOw



The joint allows two degrees of freedom (rotations).
It is not a spherical joint. A point of the yellow part doesn't move on a sphere.

Mechanical torus joint 5

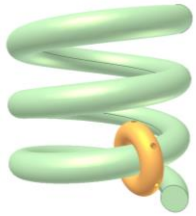
https://youtu.be/_GgPSNcFF2w



The joint between green and orange parts allows two degrees of freedom (rotations).
It can transmit rotary motion between two intersecting shafts.
It is not a constant velocity joint.

Helix torus joint 2

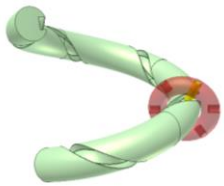
http://youtu.be/6s-giKB1TBE



The orange torus can turns 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

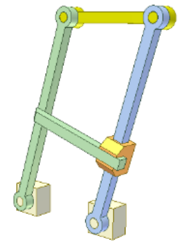


The red torus carrying a pin has two interdependent helical motions around its own axis and around axis of the green spring-shaped part. The pin slides in a helical groove of the green spring-shaped part.

25.2. Planar mechanisms

Equivalency of parallelogram and Oldham mechanisms

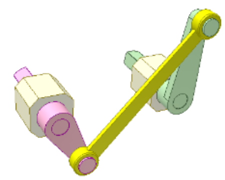
http://youtu.be/wi0NyZNd7I4



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

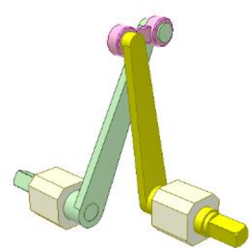
http://youtu.be/ADofvwxYImA



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

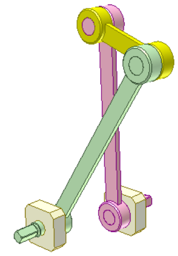
http://youtu.be/Y5lMzmEPOX0



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

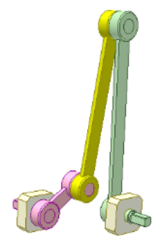
http://youtu.be/BOJSJvOUyAE



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

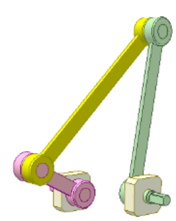
http://youtu.be/nP_tGreHHEY



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/Aqg7tl4jfe8

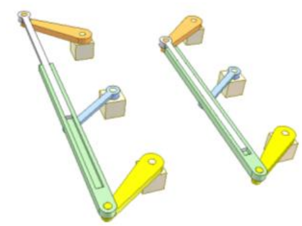


A special case of the 4-bar linkage.
Input: pink crank.
Output: green crank rotating irregularly.
The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the input. It happens because:
1. The sum of the lengths of the two opposite links is equal to the sum of the lengths of the 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

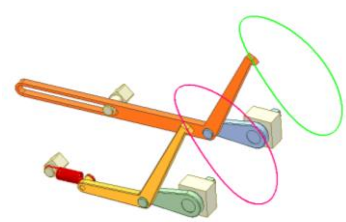
A special case of the 4-bar linkage.
Input: pink conrod.
Output: oscillating cranks.
The unusualness: a working cycle of the mechanism corresponds 2 revolutions of the input. Oscillating angle of the yellow crank is larger than 180 deg., a thing that is hard to get by using an ordinary 4-bar linkage. 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



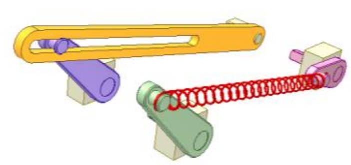
Two mechanisms are identical.
Lengths of three cranks are equal.
Yellow, green and blue links create a parallelogram.
Input: yellow cranks. Output: orange cranks.
Besides the dead positions (when the cranks and the bars are in line) the mechanisms have unstable positions when the cranks are perpendicular 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/XVoarCYMlVc



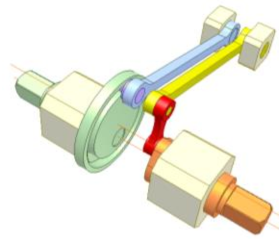
The behind is a coulisse mechanism. The front one is the same but the prismatic joint is replaced by a pull spring.
Tips of the orange levers trace similar curves.
However different loads applied to the orange lever of the spring mechanism may alter curve shape.

Spring linkage mechanism 2
http://youtu.be/wVKjmL3iOQo

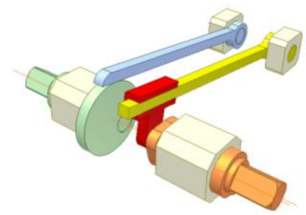


The behind is a coulisse mechanism. The front one is the same but the prismatic joint is replaced by a pull spring.
The orange lever and the pink crank oscillate with similar motion rules.
However loads applied to the pink crank of the spring mechanism may alter its motion rule.

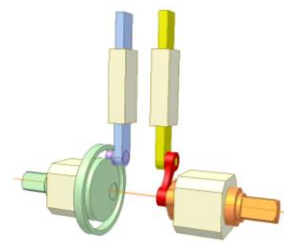
Equivalency of circular cam and linkage mechanisms 1
https://www.youtube.com/watch?v=AO_h10UqLIQ
Eccentricity of the green circular cam = length of the orange crank
Radius of cam pitch circle = length of the red conrod.
The blue follower and the yellow rocker have the same motion.



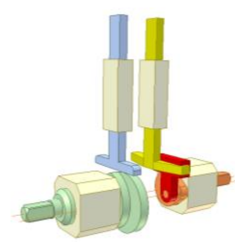
Equivalency of circular cam and linkage mechanisms 3
https://www.youtube.com/watch?v=4DyP4Vo6cVU
Eccentricity of the green circular cam = length of the orange crank
Radius of cam circle = length of the red conrod.
The blue follower and the yellow slider have the same motion.



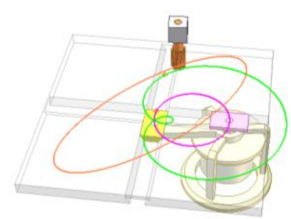
Equivalency of circular cam and linkage mechanisms 2
http://youtu.be/DQB1pY3It08
Eccentricity of the green circular cam = length of the orange crank
Radius of cam pitch circle = length of the red conrod.
The blue follower and the yellow slider have the same motion.



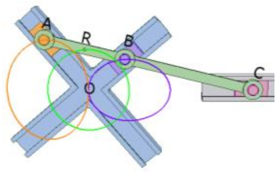
Equivalency of circular cam and linkage mechanisms 4
http://youtu.be/DQB1pY3It08
Eccentricity of the green circular cam = length of the orange crank
Radius of cam circle = length of the red conrod.
The blue follower and the yellow slider have the same motion.



Study of planar ellipse mechanism 1
http://youtu.be/M3hlMN--gAg
Ellipse mechanism consists of a conrod and two sliders (in pink and yellow) connected together by revolution joints. The slider moves in straight grooves of a glass table. The table is movable and the conrod is stationary.
Input is the pink slider rotating continuously.
Pink and green curves are loci of points of the table in relation with the ground.
Orange curve is locus of a grounded point in relation with the table.

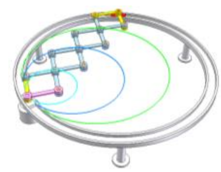


Ellipse mechanism 3a
https://youtu.be/cu1JslGWgCk



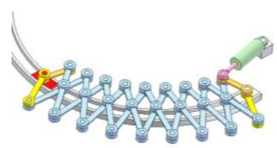
Input: blue shaft of two 90 deg. runways.
Output: pink slider linearly reciprocating. Its stroke length: AB
It moves as if it belongs to a slider-crank mechanism of crank OR (RA = RB) and conrod RC.
Orange ellipse, green circle and violet ellipse are loci of points A, R and B respectively.
The loci are drawn 2 times in one revolution of the input.
One revolution of the input corresponds with two strokes of the pink slider.
This mechanism is numbered as 348 in the book “507 mechanical movements”, 1868.

Scissor mechanism 1a
https://youtu.be/KzYeW75-6Ww



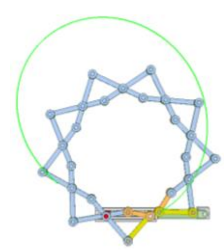
Input: pink crank driven by grey motor.
Output: red slider moving along a circular runway.
Blue circles are loci of middle pin centers.
Thanks to scissor mechanism there is no need to place the motor at the runway center.

Scissor mechanism 1b
https://youtu.be/R8JjJLC5diU



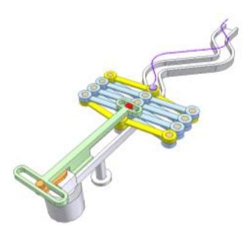
Input: orange crank driven by green cylinder.
Output: red slider moving along a circular runway.
Small displacement of pink piston makes the red slider move long way.
Centers of the scissor middle joints almost follow the ruwnay thanks to asymmetric links.
However the red slider can not move more than half of the runway circle.

Scissor mechanism 1d
https://youtu.be/IutSwph1VXk



Scissor mechanism of asymmetric bars.
Input: red slider driven by green cylinder.
Small displacement of pink piston makes the mechanism almost closed.

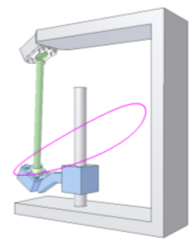
Scissor mechanism 1c
https://youtu.be/Xq7C_xGCkQQ



Input: orange crank driven by grey motor.
Output: red slider moving along a zigzag runway.
This mechanism can be used for copying a curve.

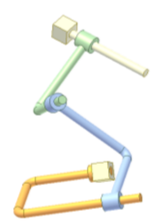
25.3. Spatial mechanisms

Spatial mechanism of two links
https://youtu.be/XXxEd3twlpA
Input: rotary motion of blue slider-crank.
Output: reciprocating linear motion of the blue slider-crank.
Pink curve is the trajectory of center of spherical joint between the two links. It is the intersection of a spherical surface (its radius = length of green bar) and a cylindrical one (its radius = radius of the blue crank).
With some modifications it can be used for presses:
http://www.youtube.com/watch?v=613_NYKz68I
https://youtu.be/kkpg8go09yU



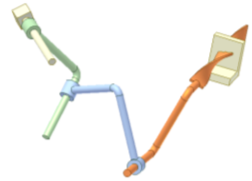
Space 4-bar mechanism 10
http://youtu.be/q433oAXwHuU
Bennett 4R mechanism
It is Bennett 4R mechanism (not spherical 4R mechanism)
4R: 4 revolute joints. It does not meet Kutzbach criterion.
The conditions that the mechanism must satisfy to be able to move:
1. The opposite sides of the mechanism (i.e. 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:
sinA/a = sinB/b
For the blue and yellow (fixed) link: a = 17.599, A= 15 deg.
For the orange and green link: b= 34, A= 30 deg.

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



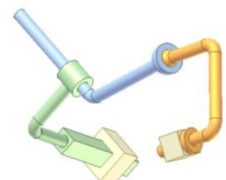
Space 4-bar mechanism 2
http://youtu.be/nK66IwNJG78
P-C-C-C mechanism. Input: the orange link. Output: the green link.
P-C-C-C: Joint symbols from input to output joint.
P: prism
C: cylinder

Space 4-bar mechanism 3
http://youtu.be/aUlLcT74mXM
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

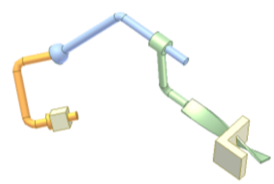


Space 4-bar mechanism 4
http://youtu.be/xZcAUtW8XVc
R-S-C-R mechanism. Input: the orange link. Output: the green link.
R-S-C-R: Joint symbols from input to output joint.
R: revolute
S: sphere
C: cylinder

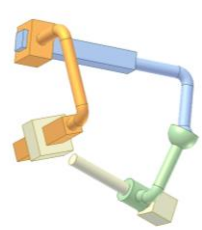
Space 4-bar mechanism 5
http://youtu.be/nJyS6zxSsMo
R-S-C-P mechanism. Input: the orange link. Output: the green link.
R-S-C-P: Joint symbols from input to output joint.
R: revolute
S: sphere
C: cylinder
P: prism



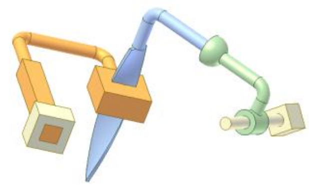
Space 4-bar mechanism 6
http://youtu.be/Gg8Q6nUZc1c
R-S-C-H mechanism. Input: the orange link. Output: the green link.
R-S-C-H: Joint symbols from input to output joint.
R: revolute
S: sphere
C: cylinder
H: helix



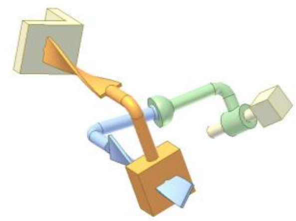
Space 4-bar mechanism 7
http://youtu.be/H_5D9wsdPM4
P-P-S-C mechanism. Input: the orange link. Output: the green link.
P-P-S-C: Joint symbols from input to output joint.
P: prism
S: sphere
C: cylinder



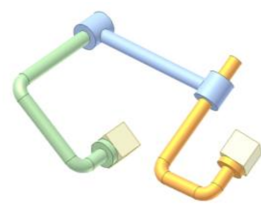
Space 4-bar mechanism 8
http://youtu.be/4k5WcYcqoQg
R-H-C-H mechanism. Input: the orange link. Output: the green link.
R-H-C-H: Joint symbols from input to output joint.
R: revolute
H: helix
C: cylinder



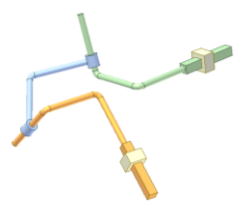
Space 4-bar mechanism 9
http://youtu.be/aiAdhly2Guo
H-H-S-C mechanism. Input: the orange link. Output: the green link.
H-H-S-C: Joint symbols from input to output joint.
H: helix
S: sphere
C: cylinder



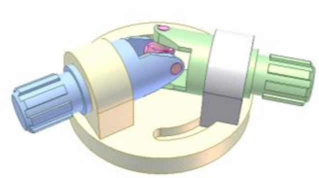
Space 4-bar mechanism 12
http://youtu.be/m0xG_u63WH0
R-C-C-R mechanism
R-C-C-R: Joint symbols from input to output joint.
R: revolute
C: cylinder
It does not meet Kutzbach criterion.



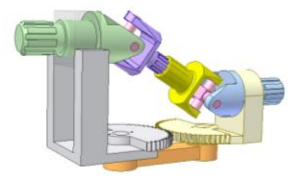
Space 4-bar mechanism 13
http://youtu.be/ccvYpANAWPE
P-C-C-P mechanism
P-C-C-P: Joint symbols from input to output joint.
P: prism
C: cylinder
It does not meet Kutzbach criterion.



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..

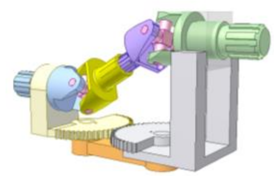


Study of double cardan universal joint 1a
http://youtu.be/gBoJT_Pl-RA



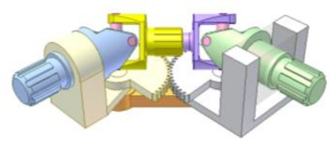
Double Cardan drives allow to adjust relative linear positions between the input and output shafts even during rotary transmission. The output velocity is always equal to the input one (constant velocity joint) because their shafts are kept parallel each other.
The pin axles on the intermediate half shafts (in yellow and in violet) must be parallel each other.

Study of double cardan universal joint 1b
http://youtu.be/4CYnLyTsYOA



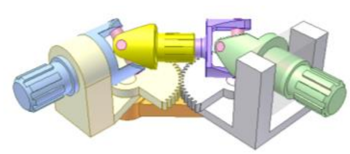
This is wrong case of a double Cardan joint: the pin axles on the intermediate half shafts (in yellow and in violet) are perpendicular each other.
The joint loses the feature of velocity constant when the input and output shafts are not in a straight line although they are kept parallel each other.
So pay attention to assembling the intermadiate shaft.

Study of double Cardan universal joint 2a
http://youtu.be/cydmR0lX2t8



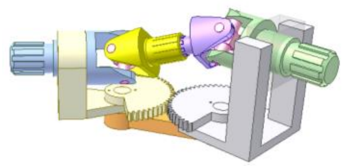
Double Cardan joints allow to adjust angle A between input and output shafts even during rotary transmission. This case shows +/- 90 deg regulation and proves that double Cardan joints are of constant velocity.
Due to the gear planetary drive of two gear sectors and orange crank, angle between input (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/IttUsogU4AQ



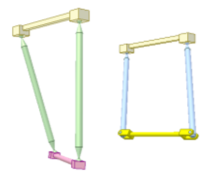
This is wrong case of a double Cardan joint: the pin axles on the yellow-violet intermediate shaft are perpendicular each other.
Although due to the gear planetary drive of two gear sectors and orange crank, angle between input (or output) shaft and the yellow intermediate shaft is always equal to A/2 (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 deg.).
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/uP6IyI5OqtY

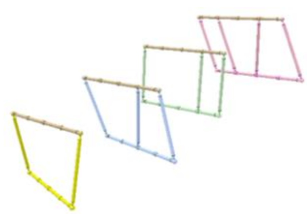


There are two spatial parallelogram mechanisms (lengths of opposite links are equal).
For the left one of 4 spherical joints the opposite links may be not parallel during motion.
For the right one of 2 spherical and 2 revolute joints the opposite links are always parallel. Direction of longitudinal axis of the yellow conrod is kept unchanged during motion.

Study of spatial parallelogram mechanism 1b
http://youtu.be/DgVxKULp6zE

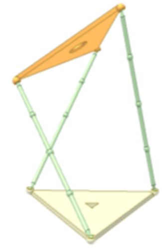
Blue and green rockers, yellow conrod and the base create a parallelogram.
The two rockers are connected to the base by universal joints of 2 degrees of freedom.
The yellow conrod is connected to the green rocker by a revolute joint and to the blue rocker by a spherical joint.
The mechanism has two degrees of freedom (by computer testing) so two actuators are needed for controling 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

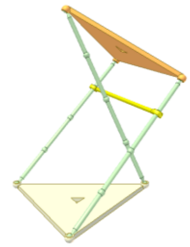


Long bars are identical.
Short bars are identical.
Brown bars are fixed.
All joints are spherical.
The video shows 4 mechanisms during motion.
1. The yellow one in general can not always gives a parallelogram.
2. The blue one in general can not always gives a parallelogram.
3. The green one always gives a variable parallelogram (distance between two long bars is variable).
4. The pink one of one DoF always gives a stable, invariable parallelogram.

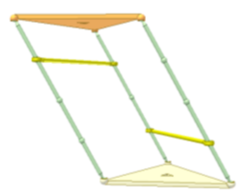
Study of spatial parallelogram mechanism 2a
http://youtu.be/qnFIFyQqdm0
Lower and upper regular triangle plates are identical.
Green vertical bars are identical.
All joints are spherical.
When the upper plate moves, it may not be parallel to the lower plate.
Computer testing shows that the mechanism has 3 degrees of freedom (DoF) excluding passive DoF (rotation of each bar around the line joining its two joints).



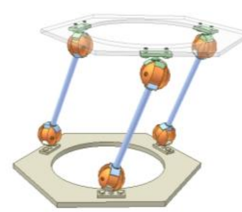
Study of spatial parallelogram mechanism 2b
http://youtu.be/R38F202W0eY
Lower and upper plates are identical.
Green vertical bars are identical.
All joints are spherical.
Distance between two joints of the plates and of yellow horizontal bar are equal.
In general lower and upper plates are kept parallel but there is the case shown in this video.



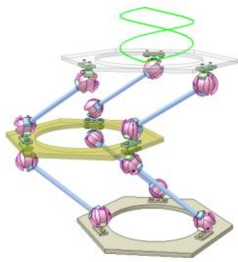
Study of spatial parallelogram mechanism 2c
http://youtu.be/tttYnzX1t74
Lower and upper plates are identical.
Green vertical bars are identical.
All joints are spherical.
Distance between two joints of the plates and of yellow horizontal bars are equal.
Lower and upper plates are always parallel.
Computer 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)..



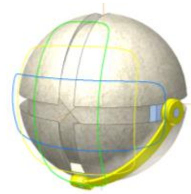
Spatial parallelogram mechanism 1
https://youtu.be/Cc70nsa3Oug
It is an application of double Cardano joints.
The joint is shown at:
https://youtu.be/95bZU6ylEzw
The direction of upper disk is kept unchanged and its surface is kept always horizontal.
Each point of the disk moves on a spherical surface.
See a similar mechanism where the upper disk can be controlled by grounded motors:
http://youtu.be/iQ5TkU04Xdc



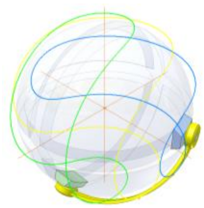
Double spatial parallelogram mechanism 1
https://youtu.be/OdCJRpMf_78
It is developed from the mechanism shown at
https://youtu.be/Cc70nsa3Oug
The upper disk can move in any direction. Its direction is kept unchanged and its surface is kept always horizontal. Green line Is the trajectory of the upper disk center in this animation.
If the upper disk is driving, the middle disk moves in 3 directions unstably. In this animation one is restricted.



Study of ellipse mechanism on a sphere 1
http://youtu.be/D7Vu3OqEztE
Ellipse mechanism consists of a conrod and two sliders.
The sliders moves in two 90 deg. crossed grooves.
The conrod is driving link. Angle between its revolution joints is 75 deg.
Two sliders oscillate around the same groove intersection.
The closed curves are loci of various points on the conrod.
In case on a planar ellipse mechanism they are ellipses.



Study of ellipse mechanism on a sphere 2
http://youtu.be/_8M_R3_YzsY
Ellipse mechanism consists of a conrod and two sliders.
The sliders moves in two 90 deg. crossed grooves.
The conrod is driving link. Angle between its revolution joints is 100 deg.
The closed curves are loci of various points on the conrod.
Two sliders oscillate around different groove intersections.



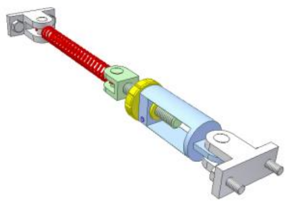
Study of ellipse mechanism on a sphere 3
http://youtu.be/eTE8UDZ-W80
Ellipse mechanism consists of a conrod and two sliders.
The sliders moves in two 90 deg. crossed grooves.
The conrod is driving link. Angle between its revolution joints is 200 deg.
The closed curves are loci of various points on the conrod.
Two sliders oscillate around different groove intersections.

Study of ellipse mechanism on a sphere 4
http://youtu.be/MKlwhTOJzYc
This is an application of ellipse mechanism on a sphere and can be seen as a kinetic art sculpture.
Input is the green slider rotating regularly.
Output: the sphere rotating around its center point, not center axis.
The conrod is stationary. Angle between its revolution joints is 120 deg.
The sliders moves in two 90 deg. crossed grooves.
The sphere can be of other material: glass, plastic, stone, wood.

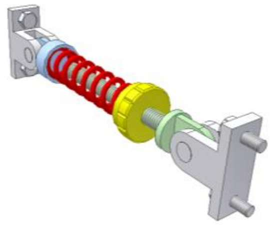
Study of four leg chair
https://youtu.be/AUnPILFOiYI
A revolution joint of two front legs ensures the permanent contact of four legs with an uneven floor. It happens only in case the vertical load (represented by red arrow) is applied inside the green triangle. Otherwise only three legs are in contact with the floor.

25.4. Springs

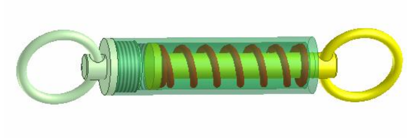
Adjusting force of a tension spring 1
https://youtu.be/aDkSlFBwsSM
Turn yellow nut to increase or reduce tension force applied to axle pins of grey parts.



Adjusting force of a compression spring 1
https://youtu.be/ZbpacL9NOdM
Turn yellow nut to increase or reduce compression force applied to axle pins of grey parts.

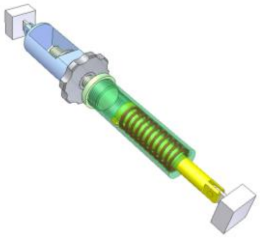


Using compression spring to bear tension 1
http://youtu.be/KU4JKCrpjGw
Reason: the hooks of a extension spring are difficult for production and easy to be broken in operation.

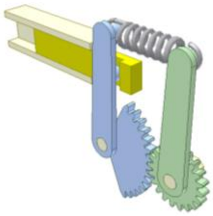


Using compression spring to bear tension 2
http://youtu.be/7QWoF76HuXs
Reason: the hooks of a extension spring are difficult for production and easy to be broken in operation.

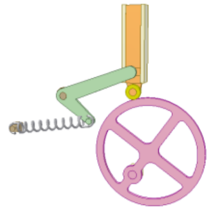
Using compression spring to bear tension 3
https://youtu.be/HbW7QeQUkWc
Turn grey nut to increase or reduce tension force applied to the ends of blue and yellow parts.



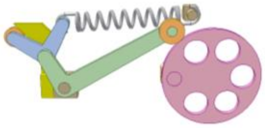
Spring increased tension
http://youtu.be/m_XVJT-4T4o
Increased tension for the same movement is gained by providing a movable spring mount and gearing it to the other movable lever.



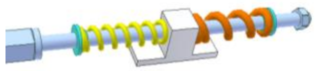
Constant tension from spring 1
http://youtu.be/YzvwrYgNOH0
The spring force applied along the orange slider is nearly constant because when the spring length is increased, the action radius of spring force around the pivot of green lever is reduced.



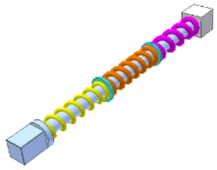
Constant tension from spring 2
http://youtu.be/W8R-BN6WXXg
Spring constant tension for large movement of the green lever is gained by providing a movable spring mount on the blue lever that is controlled by the yellow stationary cam.



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/qaHBqI6ycaE
Two springs at both sides of a piston play anti-shock role well.