II year

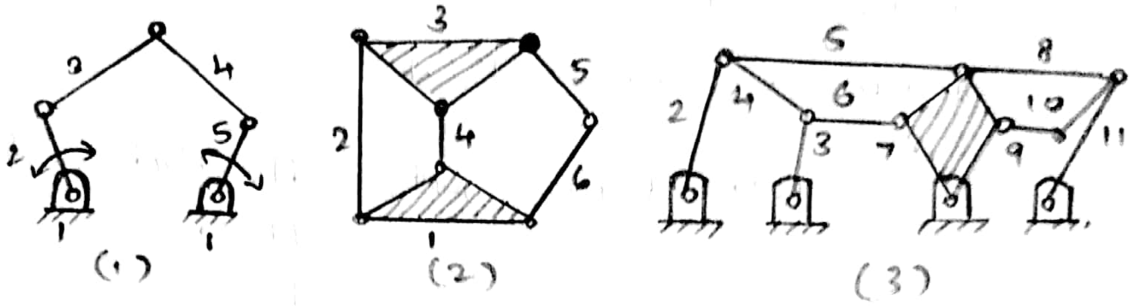
KOM - ME8492

UNIT - 1 Basics of Mechanism

①

(1) Find the degree of Freedom for the Mechanisms shown in Fig 1.

[April/May 2017]



To find degree of Freedom:

Kutzback criterion for Planar Mechanism is given by

For Mechanism (1):

Number of links, $n = 5$

Number of binary joints, $j = 5$

Number of lower pair, $l = j = 7$

Number of higher pairs, $h = 0$

$DOF = 3(5-1) - 2(5) = 2$

For Mechanism (2):

Number of links, $n = 6$

Number of binary joints, $j = 7$

Number of lower pair, $l = j = 7$

Number of higher pairs, $h = 0$

$DOF = 3(6-1) - 2(7) = 1.$

For Mechanism(3):

Number of links, $n = 11$

Number of binary joints = 7

Number of ternary joints = 4.

Equivalent number of binary joints, $j = 7 + 2$ (Number of ternary joints)

$= 7 + 2(4)$

$= 15$

Number of lower pairs, $l = j = 15$

Number of higher pairs, $h = 0$

$DOF = 3(11-1) - 2(15) = 0.$

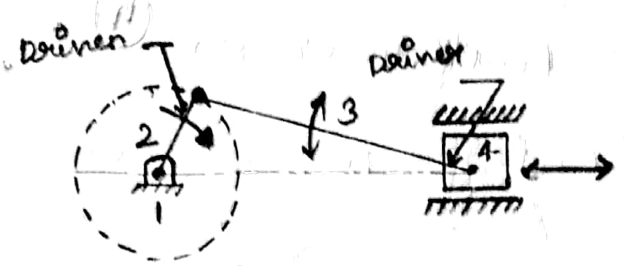
(2) What is a kinematic inversion? Discuss any three applications of inversions of slider-crank mechanism with suitable sketches. (A/M-2015)

Reciprocating Engine and Reciprocating compressor. 1st inversion

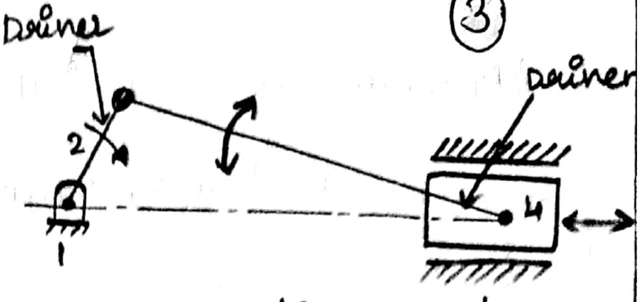
1. In both reciprocating engine and reciprocating compressor, the link (ie frame) is fixed.

2. In reciprocating engine (ie in IC engine / steam engine), the link 4 (i.e the slider) is the driver and the link 2 (ie. crank) becomes the driven, as shown in fig 1.44 (a).

3. In reciprocating compressor / reciprocating pump, the link 2 (ie the crank) is the driver and the link 4 (ie slider) becomes the driven, as shown in fig 1.44 (b).



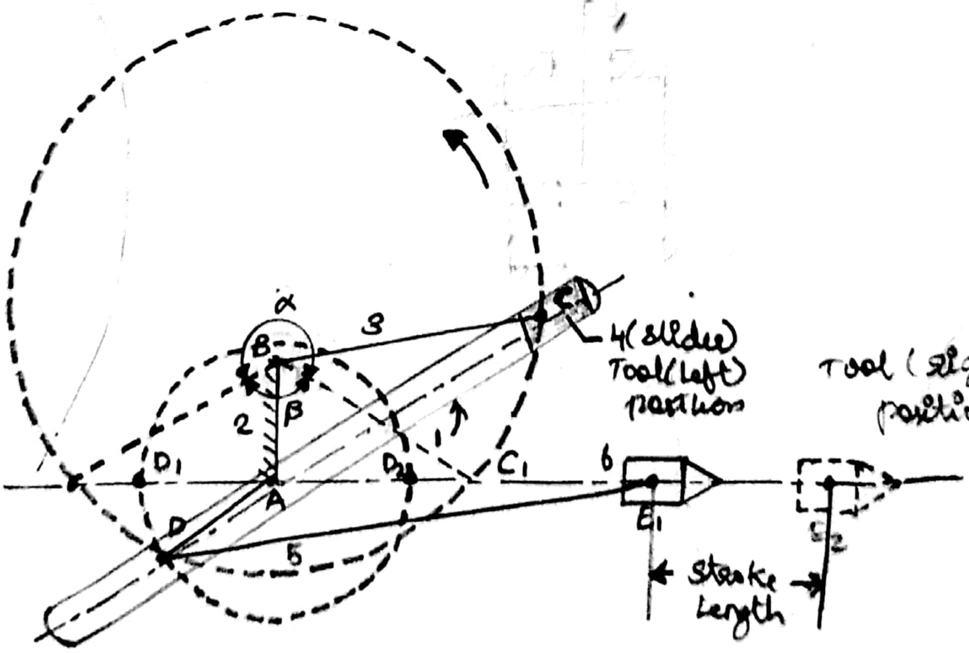
a) Reciprocating Engine



b) Reciprocating compressor

Whitworth Quick-Return Mechanism: 2nd inversion

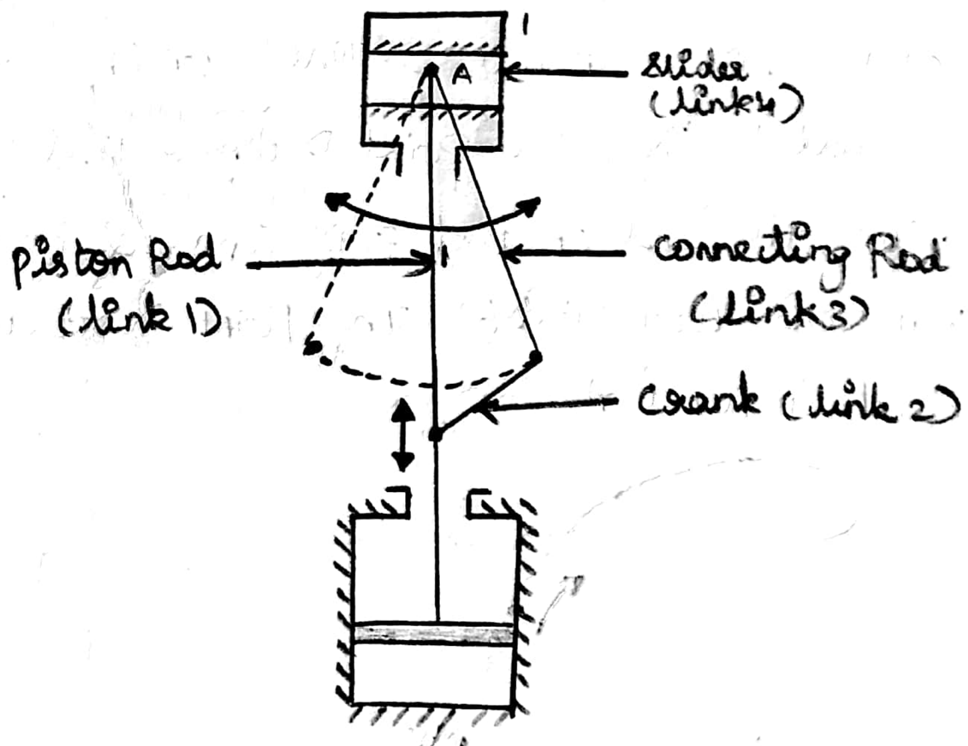
In this Mechanism, link 2 (ie Crank) is fixed, link 3 rotates, link 4 reciprocates and link 1 oscillates as shown in Fig 1.46. The link 3 along with its slider (link 4) rotates in a circle about B. By doing so, the link 1 rotates about A along with the slider which reciprocates on link 1. On the other end of the link 1, there is a point D where link 5 is connected. The other end of link 5 is connected to the return ram and tool (link 6). The point D rotates in a circle about point A.



Pendulum Pump (or, Bull Engine) Fourth Inversion

1. This mechanism is used to supply feed water to boilers.

2. This Mechanism is obtained by fixing the link A (i.e cylinder), as shown in Fig. 1.52. In this case, when link 2 (Crank) rotates, link 3 (Connecting rod) oscillates like a Pendulum about a pin pivoted to the fixed link 4 at end A and link 1 reciprocates. This reciprocating motion of link 1 can be used for a pump.



(3) Inversion of Double slider crank chain N/D.2017

write in detail with neat sketch any three inversion of double slider crank chain. (Nov, Dec-2017)

The double slider crank chain provides Three different inversion.

First inversion:-

$x = AC\cos\theta$

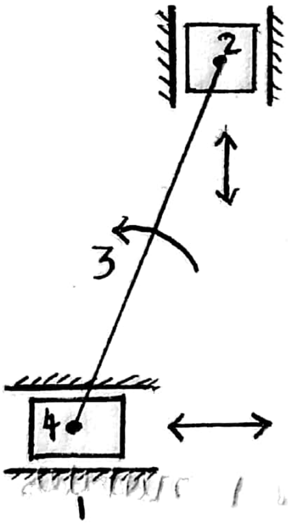
(or)

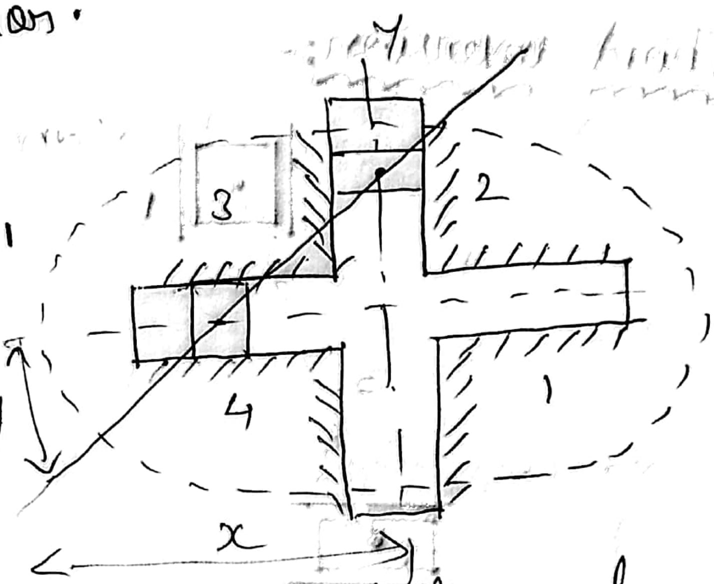
$\frac{x}{AC} = \cos\theta$

$y = BC\sin\theta$

$\sin\theta = y/BC$

$\frac{x^2}{AC^2} + \frac{y^2}{BC^2} = 1$





elliptical trammel.

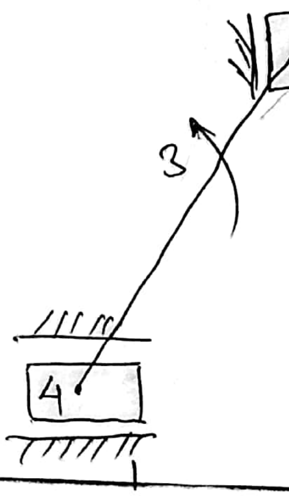
link 1 is fixed; link 3 rotates; links 2 and 4 reciprocate.

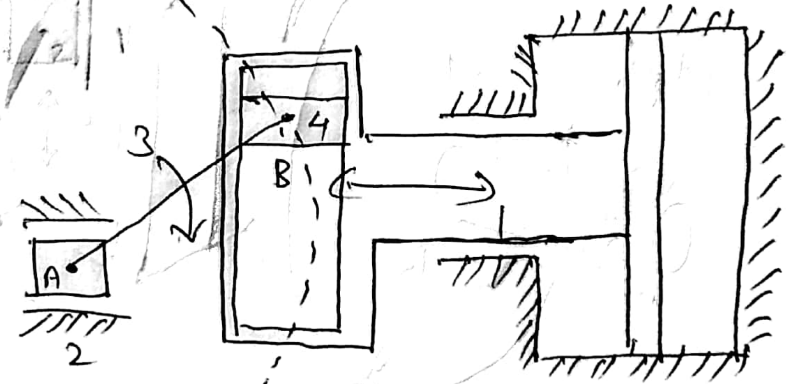
Practical application

Elliptical Trammel.

Second inversion:-

Scotch Yoke.



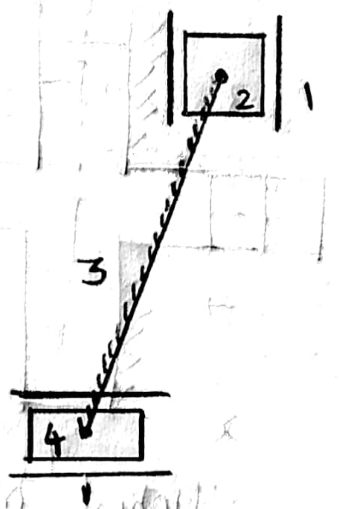


link 4 (or link 2) is fixed; link 3 rotates; link 2 (or link 4) reciprocates.

Practical Application:-

Scotch yoke mechanism.

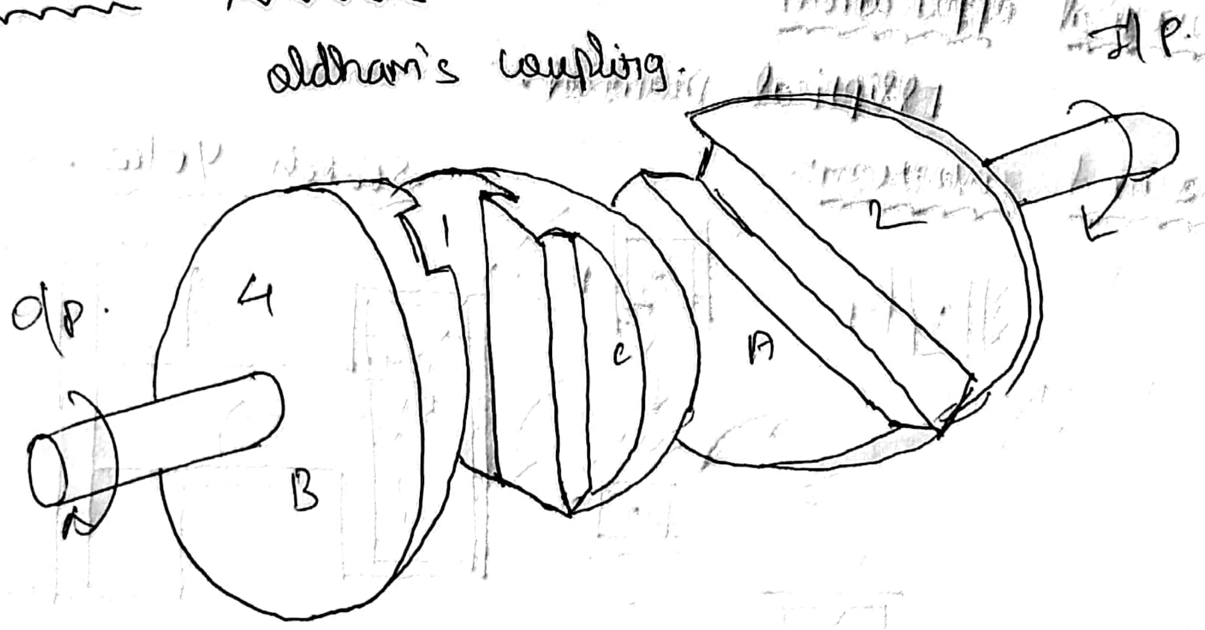
Third inversion:-



link 3 is fixed; link 1 rotates; link 2 and 4 reciprocate.

Practical application:-

oldham's coupling.



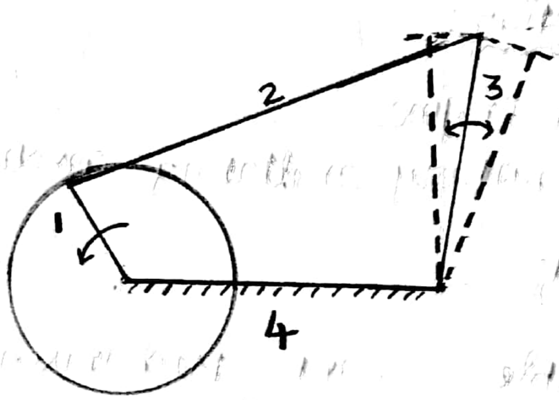
(4) Describe with neat sketch, the mechanisms obtained by inversion of four bar chain. (NOV, DEC-2017)

Inversion of Four bar chain:-

From a four bar chain four different inversions can be obtained by fixing its four links one at a time in turn.

First inversion:-

Crank - rocker mechanism



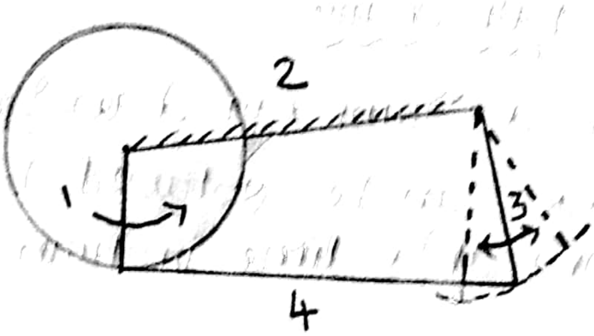
Link 4 is fixed ; link 1 rotates ; link 2 and 3 oscillates.

Practical applications

* Beam engine
* All rotary oscillating converters

Second inversion:-

Crank - rocker mechanism



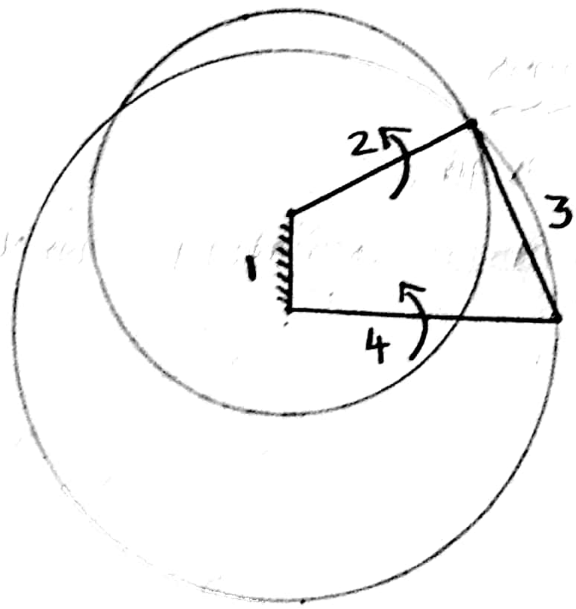
link 2 is fixed ; link 1 rotates ; link 3 and 4 oscillates

Practical application:-

* Beam Engine
* All rotary oscillating converters

Third inversion:-

Double crank Mechanism



Scanned by CamScanner

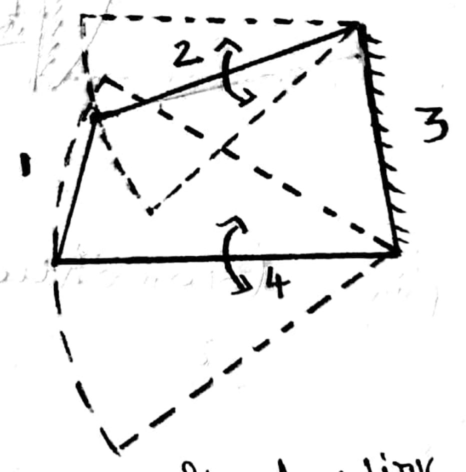
Link 1 is fixed; link 2 and 4 rotate; link 3 oscillates.

Practical application:-

* Coupled wheels of a locomotive
* All rotary - rotary converters.

Fourth inversion:-

Double rocker mechanism



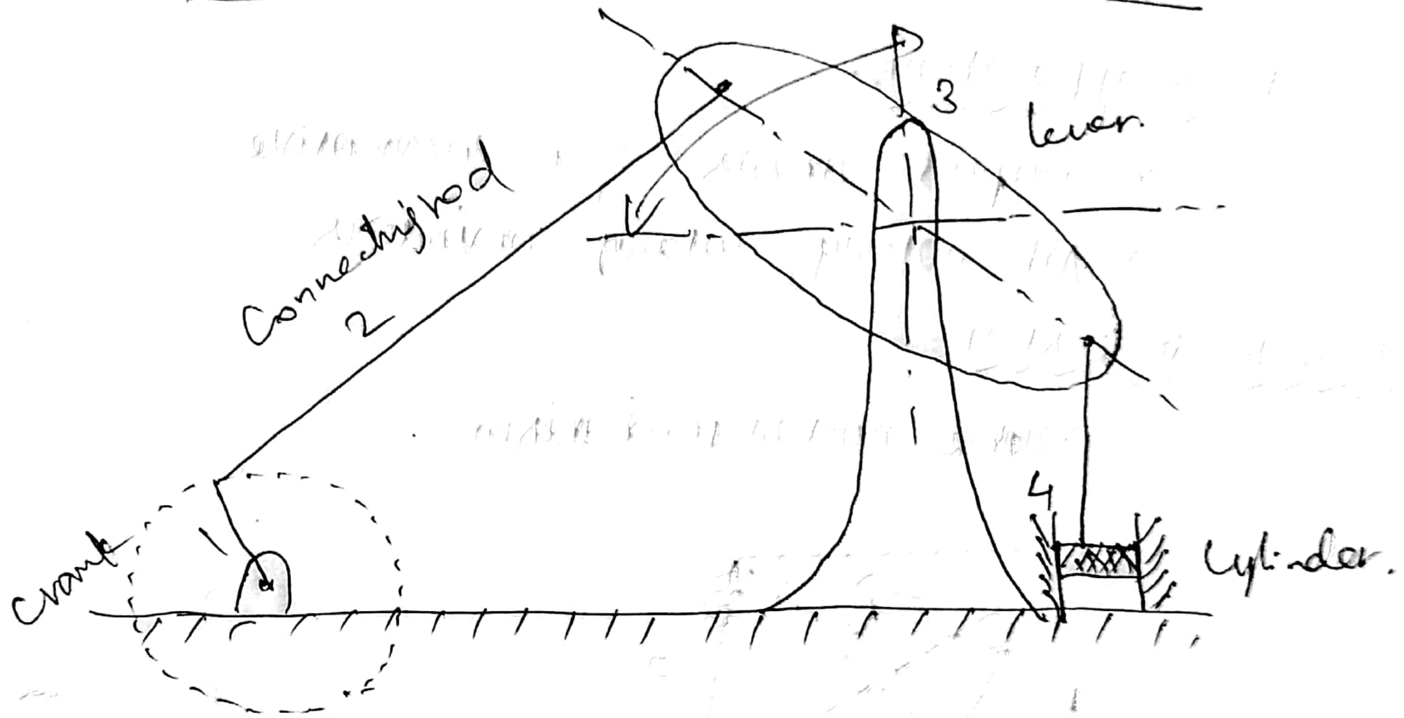
Link 3 is fixed; link 2 and 4 oscillate

Practical application:-

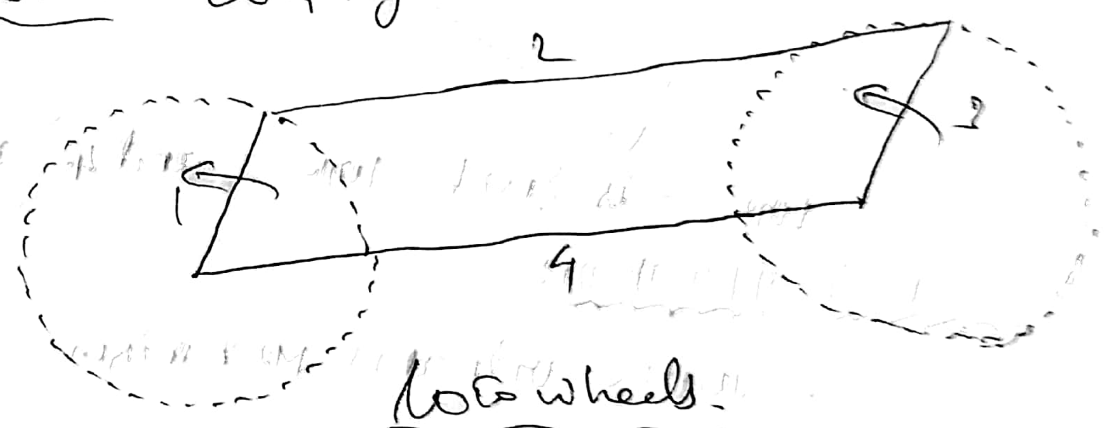
* watt's indicator mechanism
* Pantograph
* Ackermann steering

fourbar inversion. Application

1st & 2nd inversion. Beam engine.

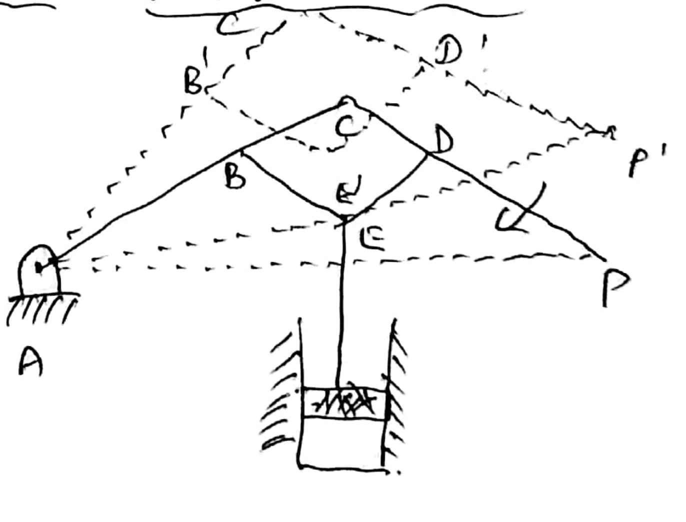


3rd inversion Coupling locomotive

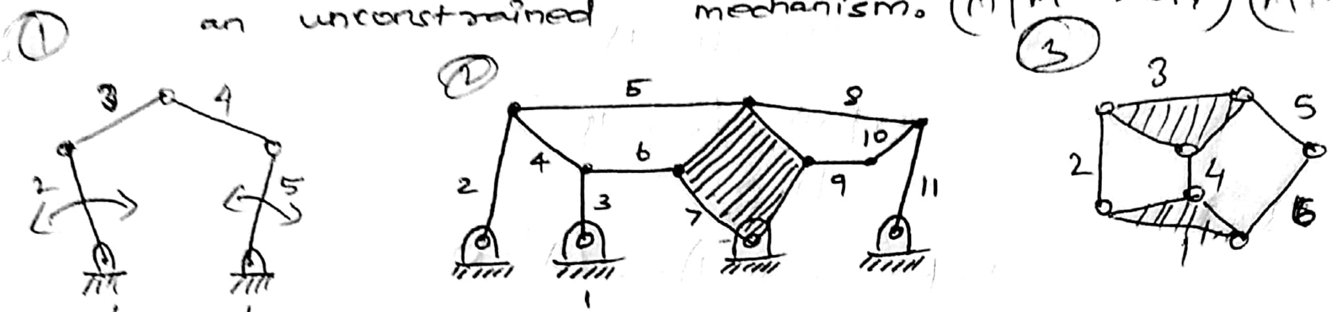


Loco wheels.

4th inversion watt's Indicator



(5) i) State and brief the kutzbach criterion for planar mechanism and using this criterion, determine the arrangement shown in Figure. as a structure or a constrained mechanism or an unconstrained mechanism. (A/M. 2017) (A/M-2018)



(6) Define transmission angle of a four-bar mechanism and explain its significance. Also, neatly sketch a crank-rocker mechanism in its minimum and maximum transmission angle position. (A/May. 2017)

(5) Ans: Kutzback criterion for planar mechanism.

(i) $DOF = 3(n-1) - 2l - h$.

No of links $n = 5$

binary joints $= j = 5$.

lower pair $l = j = 5$

higher pair $h = 0$

$DOF = 3(5-1) - 2(5) = 2$.

2) No of links $n = 6$

binary joints $j = 7$

lower pair $l = j = 7$

$h = 0$

$DOF = 3(6-1) - 2(7) = 1$

3) No of link $n = 11$

binary joint $= 7$

ternary $= 4$

joint $= 7 + 2$ (no of ternary)

$= 7 + 2 \times 4 = 15$

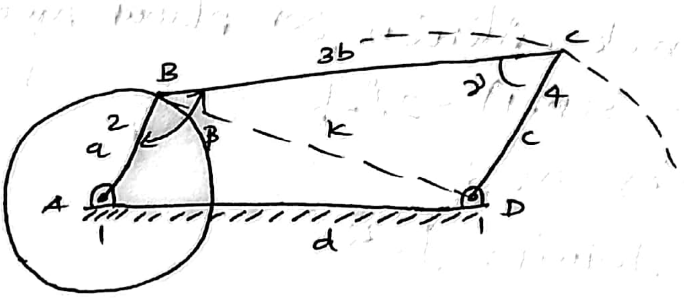
lower pair $l = j = 15$

$h = 0$

$DOF = 3(11-1) - 2(15) = 0$

(ii)

(6) Consider a four-bar mechanism shown in figure. In this link AB is the driver link, link BC is the coupler link, link CD is the driven link and link DA is the frame. (A/M) - 2018



<u>Transmission angle:</u> (γ)

The angle between the coupler link & the driven link is known as transmission angle. It is denoted by 'γ'.

<u>Equation for mechanical advantage:</u>

let, θ = Crank angle

γ = transmission angle

β = Angle between the coupler link and the driven link

a, b, c and d = Length of links AB, BC, CD and DA respectively.

(iii) The equation for mechanical advantage:

$$MA = \frac{T_{CD}}{T_{AB}} = \frac{\omega_{AB}}{\omega_{CD}} = \frac{c \sin \gamma}{a \sin \beta}$$

* Mechanical advantage of the four-bar mechanism is directly proportional to the sine of angle between γ between the coupler and the follower.

* The mechanical advantage of the four-bar mechanism is inversely proportional to the sine of angle β between the coupler and driver.

* As the linkage moves, the mechanical advantage is continuously changing (value of both angle γ and β keep changing as linkage moves).

Effect of transmission angle on Mechanical Advantage

(i) As the value of transmission angle γ becomes small, the mechanical advantage decreases and even a small amount of friction will cause the mechanism to lock or jam.

(ii) Because of the above reason four-bar mechanism should not be used in the region where the transmission angle γ is less than 45°.

(iii) The transmission angle γ is minimum when the crank is position AB_2.

(iv) The transmission angle γ is maximum when the crank is position AB_3.

Applications:

Such as toggle positions are used in clamping mechanism, stone crushing mechanism, presses, etc. to produce very high mechanical advantage.

(7) (i) Define kinematic inversion and neatly sketch an elliptic trammel. i.e. one of the inversion of a double - slider crank chain. Also, prove or disprove that all the the points on the revoluing link of the elliptic trammel will trace ellipses only.

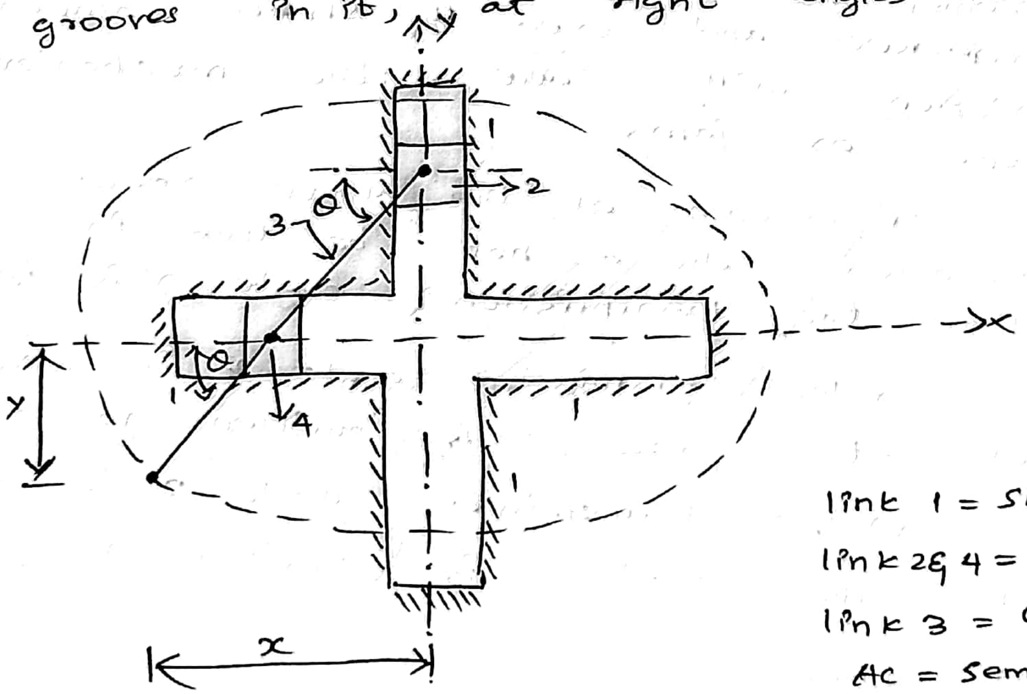
(8) Sketch and brief peaucellier exact straight line mechanism.

(7) Ans:

Elliptical trammel:

Elliptical trammel is an instrument used for drawing ellipses.

This inversion is obtained by fixing the link 1 as shown in figure. The link 1 or the fixed plate has two straight grooves in it, at right angles to each other.



link 1 = Slotted plate
link 2 & 4 = Sliders
link 3 = Crank
AC = semi - major axis
BC = semi - minor axis

When the link 2 and 4 slide along their respective grooves, the end C of the extension BC of the link AB, trace an ellipse such that AC and BC are the semi major and let AC makes an angle θ as shown in figure

$$x = AC \cos\theta \text{ (or) } \frac{x}{AC} = \cos\theta$$

$$y = BC \sin\theta \text{ (or) } \frac{y}{BC} = \sin\theta$$

Squaring and adding we get,

$$\frac{x^2}{AC^2} + \frac{y^2}{BC^2} = \cos^2\theta + \sin^2\theta = 1$$

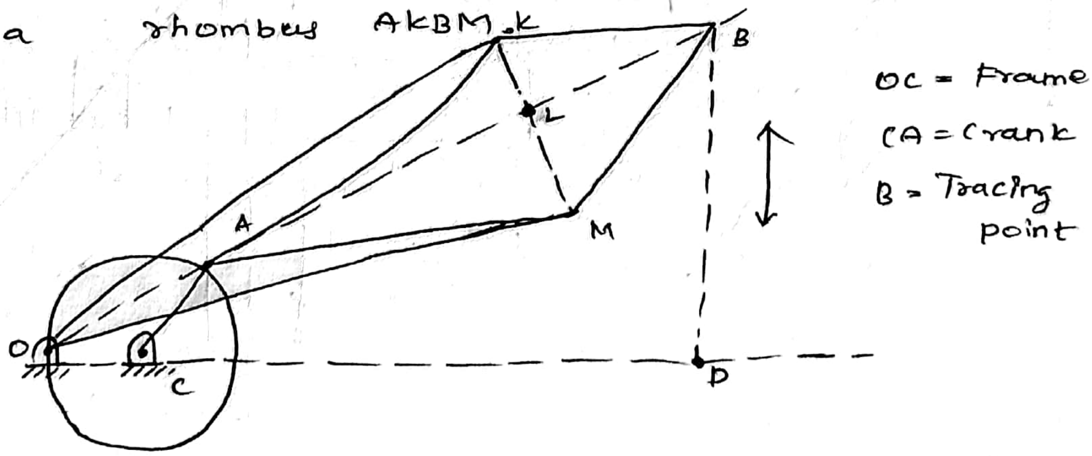
which is the equation of an ellipse.

The above expression proves that AC is the semi-major axis of the ellipse and BC is the semi-minor axis of the ellipse.

(8) Peaucellier Mechanism:

The peaucellier mechanism is an exact straight line generating mechanism, satisfying the above condition.

The configuration of the peaucellier mechanism is shown in fig. It is an eight-link mechanism. It consists of isosceles four-bar chain OKBM. Additional link AK and AM from a rhombus AKBM.



The relative dimensions of the various links are:

Frame link OC = Crank link CA

OK = OM
AK = KB
BM = MA

When the crank CA rotates about C, the tracing point B will move a straight path BD perpendicular to OC produce.

$$OA \times AB = \text{constant}$$

from the right angled traiangles OLK and BLK

$$OK^2 = OL^2 + LK^2 \quad \text{——— (1)}$$

$$BK^2 = BL^2 + LK^2 \quad \text{——— (2)}$$

Substracting equation (1) from (2)

$$OK^2 - BK^2 = (OL + AL)(OL - AL) \quad \text{——— (3)}$$

But, it can be noted that

$$OL + LB = OB \text{ and } OL - AL = OA \quad \text{——— (4)}$$

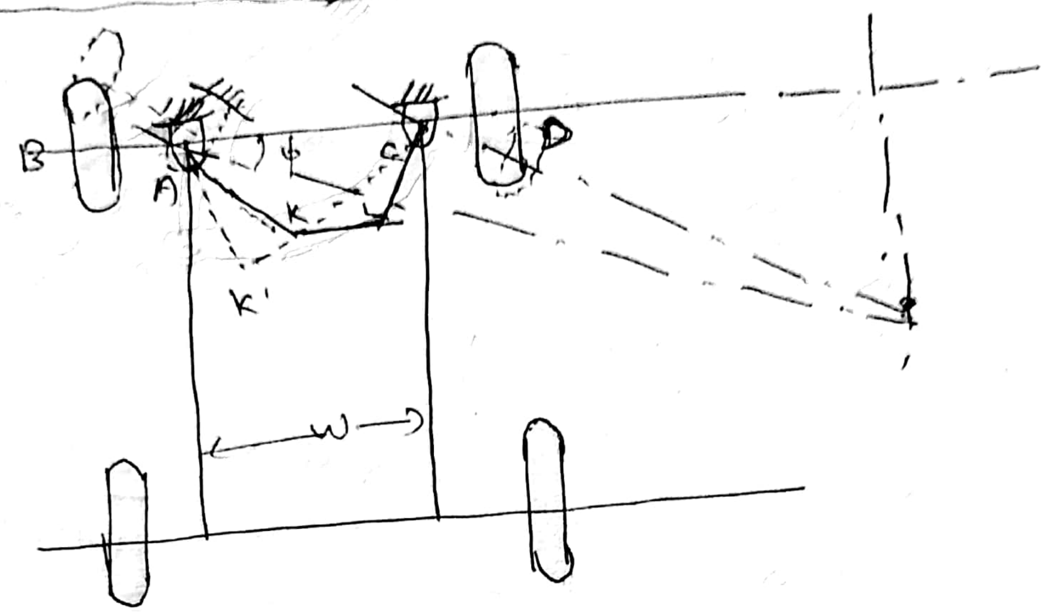
Now, equation (3) becomes,

$$OK^2 + BK^2 = \text{constant}$$

$$OA \times OB = \text{constant}$$

Since, the peaucellier mechanism satisfies the required condition discussed in the previous section, therefore the tracing point B moves along a straight line perpendicular to OC produced.

(9) • Ackermann steering mechanism.



when moving straight $\theta = 0°$

turning right $\theta = 24°$

left = $\theta = 24°$

$$\cot\phi - \cot\theta = \frac{AQ - QC}{IQ} = \frac{AC}{IQ}$$

to find α value

Projection of LL' on AC = proj of KK' on AC

$$CL\left[\sin(\alpha+\theta) \sin\alpha\right] = AK\left[\sin\alpha - \sin(\alpha-\phi)\right]$$

as AK = CL

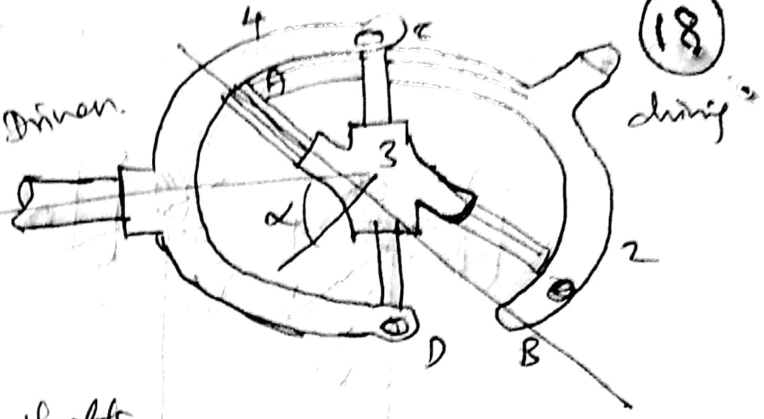
$$\sin\alpha\cos\theta + \cos\alpha\sin\theta - \sin\alpha = \sin\alpha - (\sin\alpha\cos\phi - \cos\alpha\sin\phi)$$

$$\sin\alpha(\cos\theta + \cos\phi - 2) = \cos\alpha(\sin\phi - \sin\theta)$$

$$\tan\alpha = \frac{\sin\phi - \sin\theta}{(\cos\theta + \cos\phi - 2)}$$

(18)

(10) Hooks' law.



Speed ratio $\frac{N_1}{N_2} = \frac{\omega_1}{\omega_2}$

$$= \frac{1-\cos^2\theta \sin^2\alpha}{\cos\alpha}$$

α - angle of incline driven shaft

θ - angle of turned driving shaft

$$\frac{\omega_2}{\omega_1} = \frac{\cos\alpha}{1-\cos^2\theta\sin^2\alpha}$$

$$\omega_1 = \omega_2 \frac{(1-\cos^2\theta\sin^2\alpha)}{\cos\alpha}$$

for equal speed. $\omega_1 = \omega_2$

$$\cos\alpha = 1-\cos^2\theta\sin^2\alpha$$

(or)

$$\cos^2\theta . \sin^2\alpha = 1-\cos\alpha$$

so.

$$\cos^2\theta = \frac{1-\cos\alpha}{\sin^2\alpha} \quad \text{—①}$$

we know that.

$$\sin^2\theta = 1-\cos^2\theta$$

$$= 1 - \frac{1-\cos\alpha}{\sin^2\alpha}$$

$$= 1 - \frac{1-\cos\alpha}{1-\cos^2\alpha}$$

$$= 1 - \frac{1-\cos\alpha}{(1+\cos\alpha)(1-\cos\alpha)}$$

$$= 1 - \frac{1}{1+\cos\alpha} = \frac{\cos\alpha}{1+\cos\alpha}$$

$$\sin^2\theta = \frac{\cos\alpha}{1+\cos\alpha} \quad \text{—②}$$

2/1

$$\frac{\sin^2\theta}{\cos^2\theta} = \frac{\cos\alpha}{1+\cos\alpha} \times \frac{\sin^2\alpha}{1-\cos\alpha}$$

$$\tan^2\theta = \cos\alpha$$

$$\tan\theta = \pm\sqrt{\cos\alpha}.$$

(30)