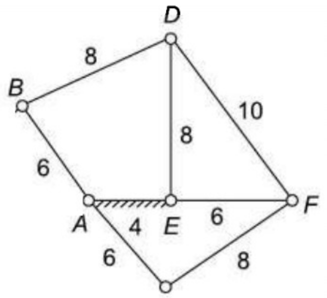
From given arrangement of links identify which of the following is mechanism

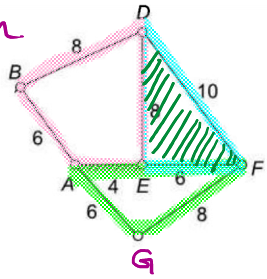


AEDB — 4 bar mechanism.

AEFG — 4 bar mechanism

EDF → Not a mechanism.

↳ It can be assumed as a single link.



Mechanism AEDB

$L_{min} = 4 \quad L_{max} = 8 \quad P = 8 \quad Q = 6$

$L_{min} + L_{max} < P + Q \rightarrow 4 + 8 < 8 + 6 \longrightarrow$ class – I. (crank-crank)

Mechanism AEFG — $L_{min} = 4 \quad L_{max} = 8 \quad P = 6 \quad Q = 6$

$L_{min} + L_{max} = P + Q \Rightarrow 4 + 8 = 6 + 6 \longrightarrow$ class – III (crank-crank)

02. A planar closed kinematic chain is formed with rigid links $\boxed{PQ = 2.0\text{ m}}$ → L_{min}, $\boxed{QR = 3.0\text{ m}}$ → L_{max}, RS = 2.5 m and SP = 2.7 m with all revolute joints. The link to be fixed to obtain a double rocker (rocker-rocker) mechanism is (GATE-13)

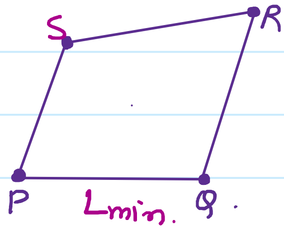
(a) $\boxed{PQ}$ → L_{min}. (b) QR
(c) $\boxed{RS}$ (d) SP

QR, SP → Crank–Rocker Mechanism.

RS → Rocker – Rocker (Link opposite to L_{min} is fixed)

PQ → Crank – crank. Mechanism. (L_{min} is fixed)

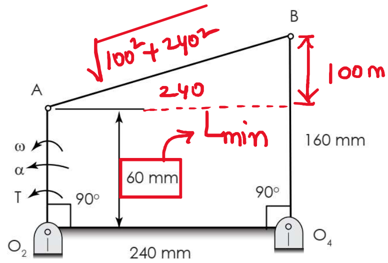
Link adjacent to L_{min} is fixed.



$L_{max} + L_{min} < P + Q$

$3 + 2 < 2.5 + 2.7 \longrightarrow$ class. I.

An instantaneous configuration of a four bar mechanism, whose plane is horizontal, is shown in the fig below.



$L_{min} = 60\text{ mm}$.

$L_{max} = 260\text{ mm}$.

$P = 240\text{ mm}. \quad Q = 160\text{ mm}$.

At this instant, the angular velocity and angular acceleration of link O_2A are $\omega = 8$ rad/s and $\alpha = 0$, respectively, and the driving torque (τ) is zero. The link O_2A is balanced so that its center of mass falls at O_2 (GATE-05)

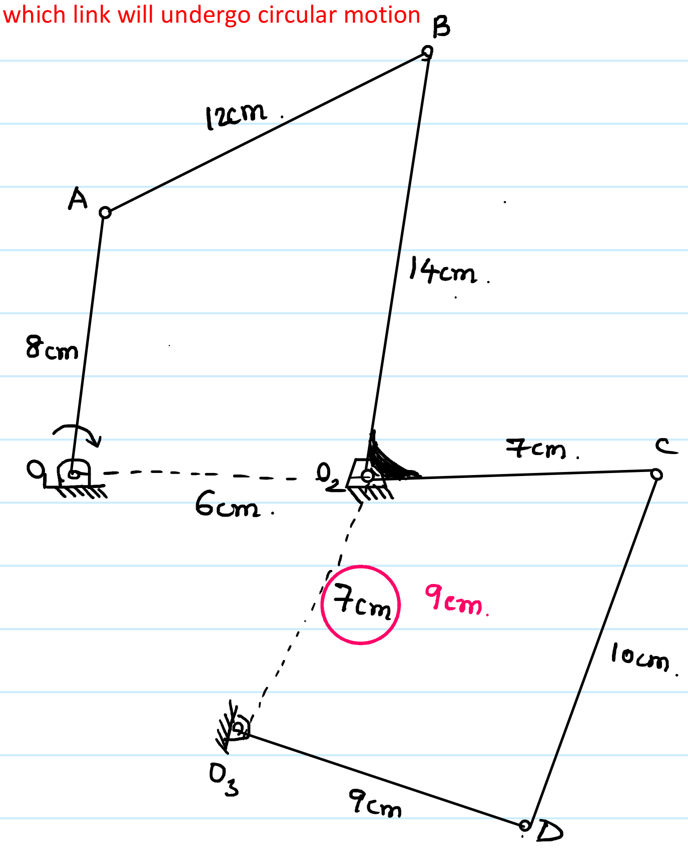
$L_{max} + L_{min} < P + Q$

$60 + 260 < 240 + 160 \longrightarrow$ class – I.

42. Which kind of 4-bar mechanism is O_2ABO_4?
(a) Double-crank mechanism
(b) Crank-rocker mechanism
(c) Double-rocker mechanism
(d) Parallelogram mechanism

Link adjacent to L_{min} is fixed. so it is Crank – Rocker Mechanism.

Identify which link will undergo circular motion



$BO_2C \longrightarrow$ compound link/ L-shape link.

$O_1ABO_2 \rightarrow$ Mechanism.

$L_{min} = 6\,cm$, $L_{max} = 14\,cm$

$P = 8\,cm$ $\quad Q = 12\,cm$.

$L_{min} + L_{max} = P + Q$

$\underbrace{6 + 14 = 12 + 8}$

class – III linkage.

L_{min} is fixed so O_1A and O_2B will be cranks.

O_2CDO_3 – Mechanism.

$L_{min} = 7\,cm$ $\quad L_{max} = 10\,cm$. $\quad P = 7\,cm$ $\quad Q = 9\,cm$.

$L_{min} + L_{max} > P + Q$

$7 + 10 > 7 + 9 \longrightarrow$ class – II linkage.

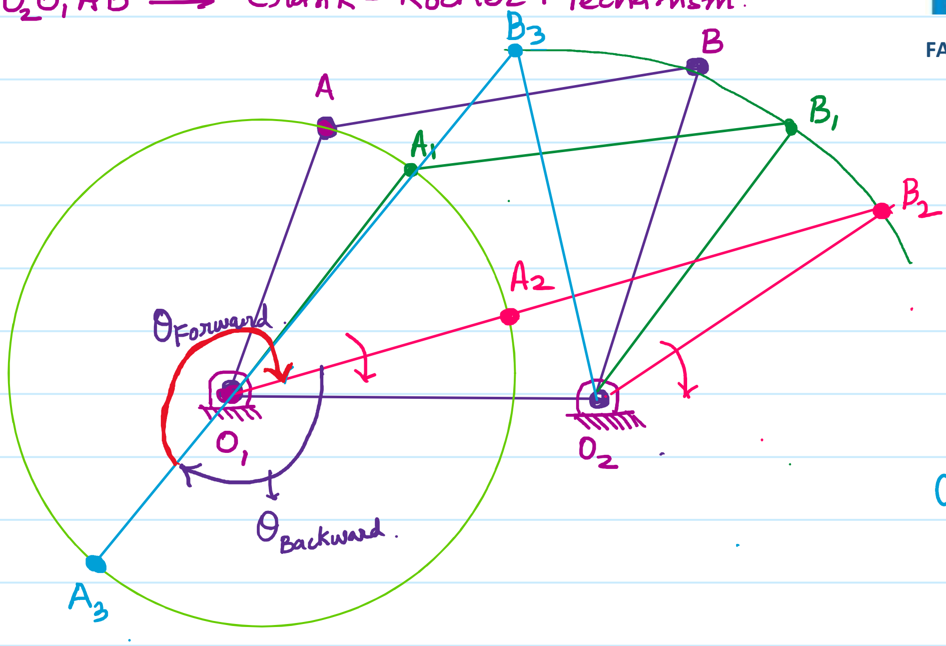
Link O_2C must be crank it cannot be rocker because BO_2C is a single link and Locus of B and C must be same.

$7 + 10 < 9 + 9 \longrightarrow$ class – I linkage.

Crank – Rocker mechanism.

link O_1A and BO_2C will complete circular motion

$O_2O_1AB \longrightarrow$ Crank-Rocker Mechanism.

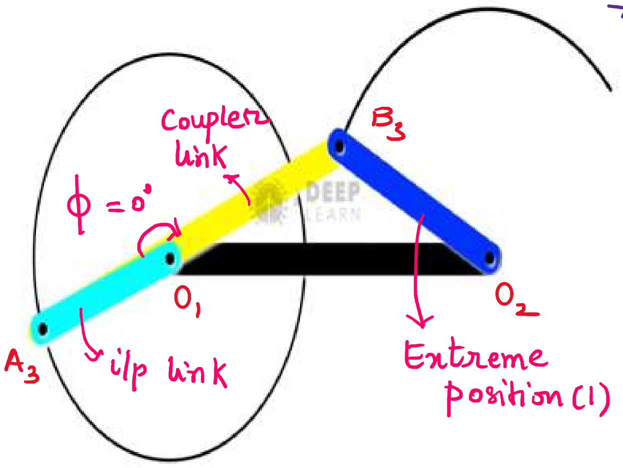


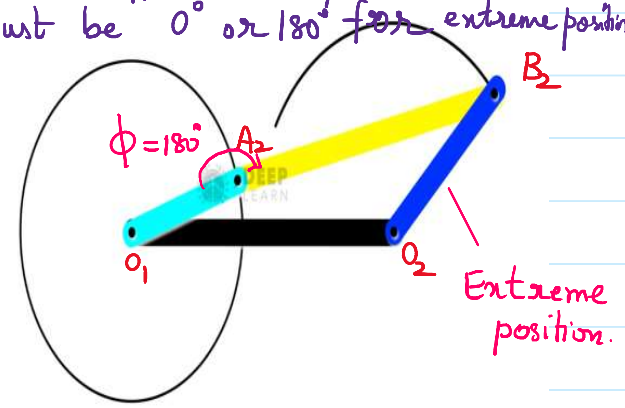
$O_1A_2B_2O_2$ – Extreme position.

$O_2A_3B_3O_2$ — Extreme position.

If crank O_1A moves from O_1A_3 to O_1A_2 the Rocker O_2B moves from point B_3 to B_2

Angle b/w i/p and coupler link. must be 0° or 180° for extreme position





$\theta_{Forward} > \theta_{Backward} \longrightarrow$ Quick Return. Mechanism.

$$\frac{\theta_{cutting}}{\theta_{Return}} > 1$$

Position Analysis of 4-bar mechanism:

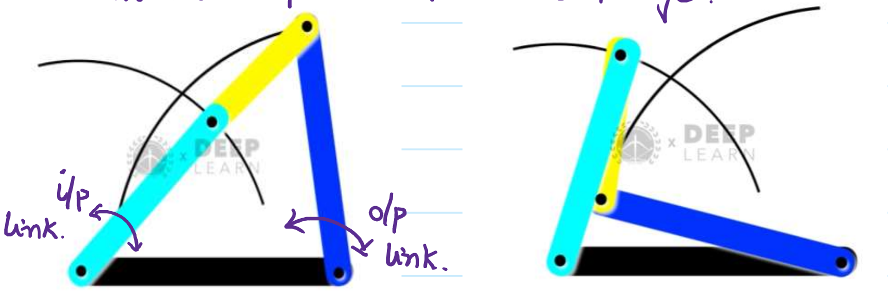
1. Extreme positions of rocker in a Crank-Rocker mechanism of Class – I linkage

2. It is given by the angle between input and coupler of a 4-bar mechanism.

3. In a four bar mechanism of (C-R of class – I) whenever the angle between the input and coupler is 0 or 180 degree the rocker will be at its extreme position.

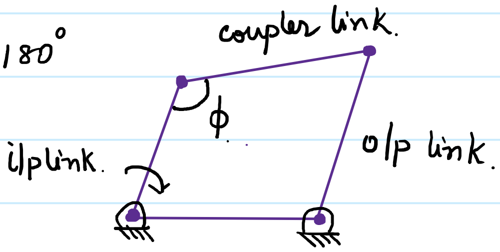
4. At the extreme position the angular velocity of rocker will be zero and angular retardation will be maximum.

Extreme position of o/p link in Rocker-Rocker mechanism of class-I linkage.



Pressure Angle - It is angle subtended between the input link and coupler link

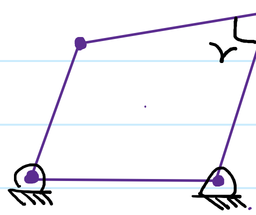
$\phi = 0^\circ$ or 180°



ϕ – Pressure Angle.

Transmission Angle - It is the angle subtended between the output link and the coupler link.

γ – Transmission Angle.

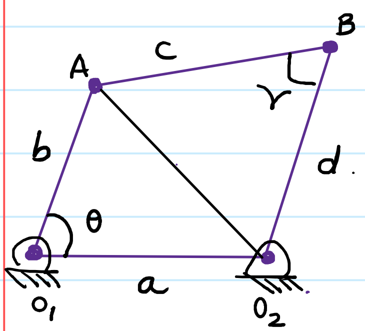


★ It is a important performance parameter because it signifies about the Possibility of relative motion getting transmitted.

★ Smaller values of transmission angle must be avoided because under The presence of friction forces the mechanism has the tendency to get Locked at the smaller values of transmission angle.

$$\boxed{35/40 \leq \gamma \leq 135/140}$$

θ – i/p Angle.



In Δ^{le} O_2O_1A

$$AO_2^2 = O_1A^2 + O_1O_2^2 - 2 \cdot O_1A \cdot O_1O_2 \cdot \cos\angle O_2O_1A$$

$$AO_2^2 = a^2 + b^2 - 2ab\cos\theta \longrightarrow (1)$$

In Δ^{le} ABO_2

$$AO_2^2 = AB^2 + BO_2^2 - 2 \cdot AB \cdot BO_2 \cos\angle ABO_2$$

$$AO_2^2 = c^2 + d^2 - 2dc\cos\gamma \longrightarrow (2)$$

(1) = (2)

$$a^2+b^2-2ab\cos\theta = c^2+d^2-2dc\cos\gamma$$

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$$\cos\gamma = \frac{c^2+d^2-a^2-b^2+2ab\cos\theta}{2dc}$$

$$\gamma = f(\underbrace{a, b, c, d}_{\text{constants}}, \theta) \longrightarrow \text{variable.}$$

$$\gamma = f(\theta)$$

For γ = Max or Min. $\frac{d\gamma}{d\theta} = 0$

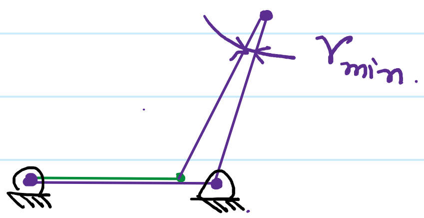
$$-\sin\gamma \cdot \frac{d\gamma}{d\theta} = \frac{0+0-0-0+2ab(-\sin\theta)}{2dc}$$

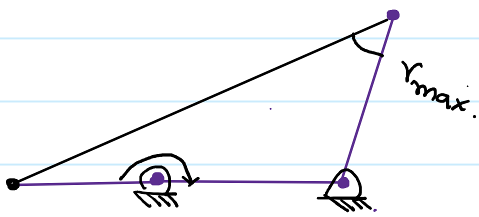
$$\frac{d\gamma}{d\theta} = \frac{ab\sin\theta}{cd\sin\gamma} \qquad \frac{d\gamma}{d\theta} = 0 \qquad \sin\theta = 0, 180 \quad \sin\gamma = \infty \text{ (Not possible)}$$

$$\sin\theta = 0 \Rightarrow \theta = 0^\circ, 180^\circ$$

θ – Angle b/w input and fixed link.

$\theta = 0^\circ$





$\theta = 180$

- Maximum and Minimum values of transmission angle is dependent on the position of input link w.r.t fixed link.
- Extreme positions of output link (rocker) in crank rocker mechanism is dependent on the angle between input link and coupler link (pressure angle).

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Mechanical Advantage -

It is the performance parameter which measures the effectiveness of mechanism.

$$M.A. = \frac{\text{Load}}{\text{Effort}} > 1$$

$$M.A. = \frac{\text{Torque @ o/p}}{\text{Torque @ i/p}} > 1$$

$$M.A. = \frac{\sin\gamma}{\sin\phi}$$ [In terms of Transmission and Pressure Angle]

$M.A. \propto \sin\gamma$ — As $\gamma\uparrow$ $\sin\gamma\uparrow$ $M.A.\uparrow$

$M.A. \propto \frac{1}{\sin\phi}$ — As $\phi\downarrow$ $\sin\phi\downarrow$ $M.A.\uparrow$

Efficiency

$$\eta = \frac{\text{Power @ o/p}}{\text{Power @ i/p}} = \underbrace{\boxed{\frac{T_{o/p}}{T_{i/p}}}}_{M.A.} \cdot \underbrace{\boxed{\frac{\omega_{o/p}}{\omega_{i/p}}}}_{\text{Velocity Ratio (V.R)}}$$

$$\eta = M.A \times (V.R)$$

Conservation of Energy $\eta = 100\%$

$$M.A. = \frac{1}{V.R.}$$

$$\boxed{V.R. = \frac{\omega_{o/p}}{\omega_{i/p}}}$$

$$\boxed{M.A. = \frac{\omega_{i/p}}{\omega_{o/p}}}$$

Also written as

$$\boxed{V.R. = \frac{D_{o/p}}{D_{i/p}} = \text{const}}$$

★ Velocity Ratio is a performance parameter for those mechanisms in which relative motion is transferred without transformation (ex - Gear and Pinion , Belt and Pulley & Chain and Sprocket).

★ In the above mentioned mechanism relative motion is transferred at constant ratio.

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- Mechanical advantage is performance parameter for those mechanisms In which relative motion is transferred with transformation (ex- crank Slider mechanism).
- The value of Mechanical advantage is dependent on pressure angle and Transmission angle , they vary based on the change in the configuration of Mechanism.
- Mechanical advantage is variable during the motion transmission.

→ At the extreme position of o/p link. (Rocker) the value of

$$\boxed{\phi = 0^\circ \text{ or } 180^\circ} \rightarrow \text{Toggle Position.}$$

$$M.A. = \infty$$

$$M.A. = \frac{T_{o/p}}{T_{i/p}}$$

[Very small amount of Torque is required at input in order overcome very large value of Torque at the o/p].

As $M.A. \rightarrow 0$ the mechanism is likely to get locked.

$$\boxed{M.A. > 1.}$$

$$\eta = M.A. \times \boxed{V.R} \quad (V.R. < 1)$$

$$\eta \leq 100\%$$

$M.A. > 1 \qquad V.R. > 1.$

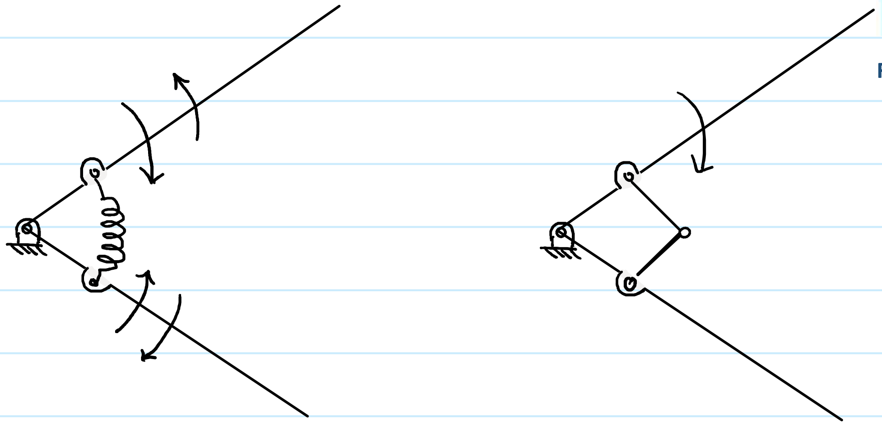
$$\eta = \frac{M.A.}{V.R.}$$

$M.A. \propto \sin\gamma$

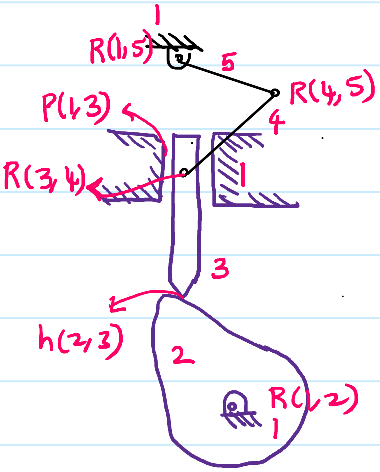
Observation:

- M.A = ∞ means a very small input torque is required to overcome a very large output torque.
- For a 4-bar mechanism M.A will be variable as pressure angle and transmission angle changes continuously.
- In a mechanism corresponding to large value of transmission angle mechanical advantage will be large.
- Velocity ratio is the performance parameter mainly for those mechanism which do not transform the type of relative motion.

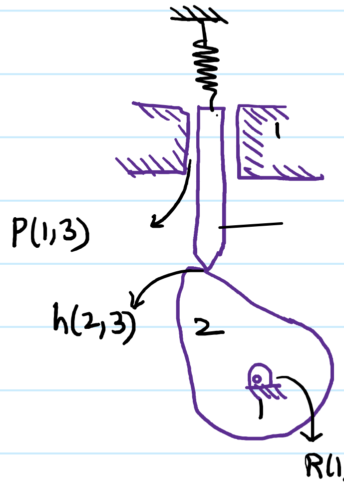
Equivalence of Links



Spring $\equiv$ 2 links. (Binary links)



N = 5
j = 5
h = 1



N = 3
j = 2
h = 1

$$DOF = 3(N-1) - 2j - h$$
$$= 3(5-1) - 2(5) - 1$$
$$= 12 - 10 - 1 = 1$$

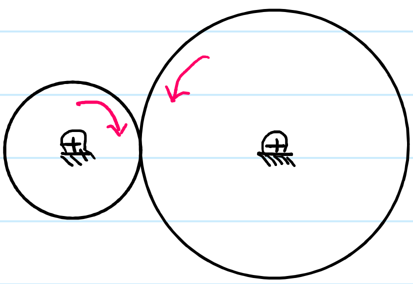
$$DOF = 3(3-1) - 2(2) - 1$$
$$= 6 - 4 - 1$$
$$= 1$$

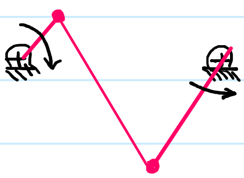
Spring is a mechanical element used for restoring force or energy.

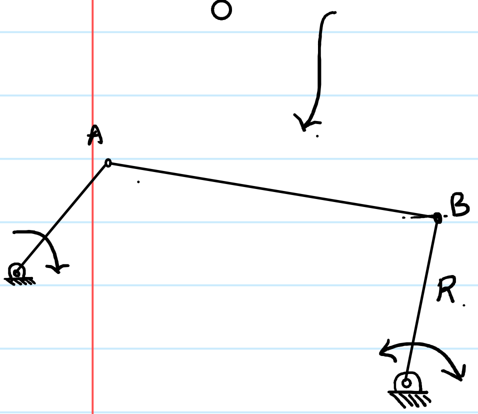
Equivalence of Higher pair and Lower Pair

1 Higher pair $\equiv$ 2 lower pair

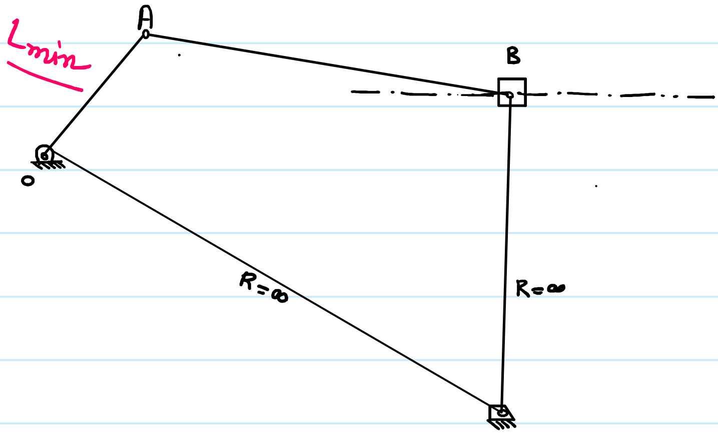
1 Higher Pair $\equiv$ 1 Binary link.



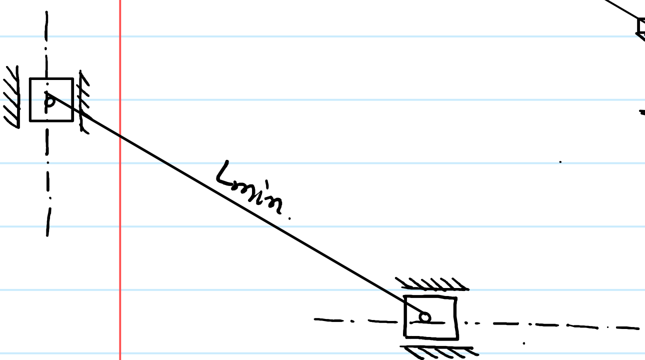


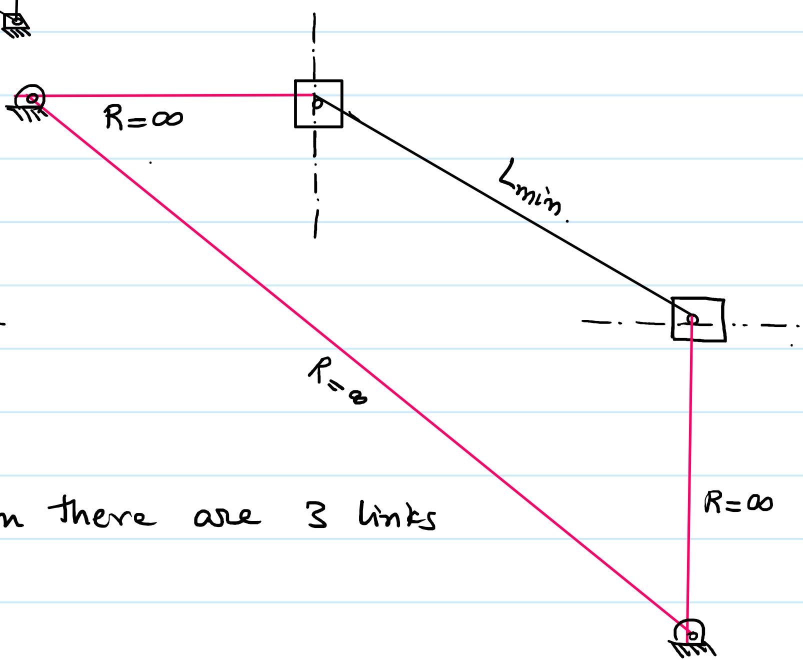


As $R \rightarrow \infty$ Locus of point B will become a st. line.

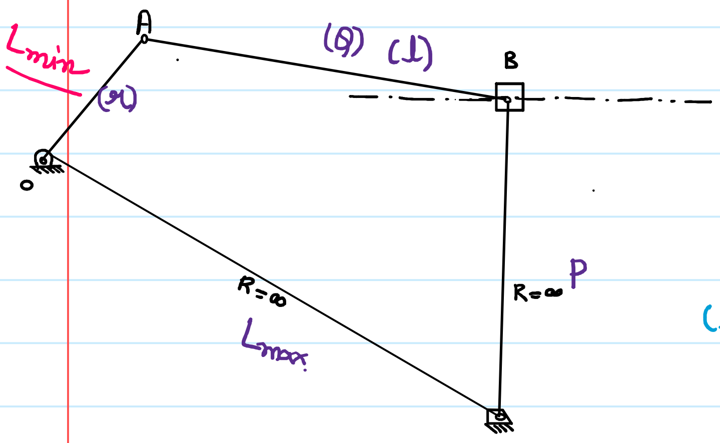


In crank slider there are 2 links of infinite lenght which it is converted to 4 bar mechanism.

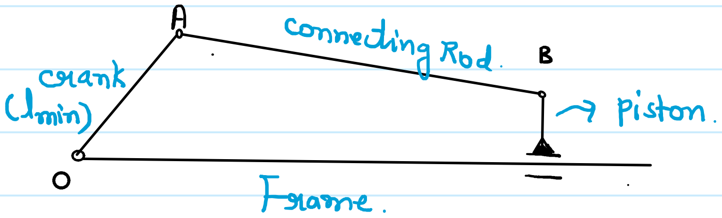




In double slider mechanism there are 3 links of infinite lenght.



Crank slider chain.



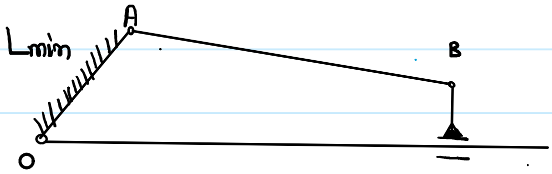
No. of inversions = No. of different links = 4.

According Grashof's law $L_{min} + L_{max} < P + Q$.

$\Rightarrow r + \infty \leq \infty + l$.

Inversion – I. Fixed link — Lmin.

→ Inversion – crank – crank mechanism.



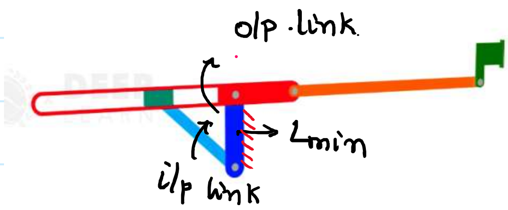
I/p & o/p link — o/wr motion.

Application 1. Radial Engine / Wrankel engine.

2. Whitworth Mechanism.

Radial Engine.

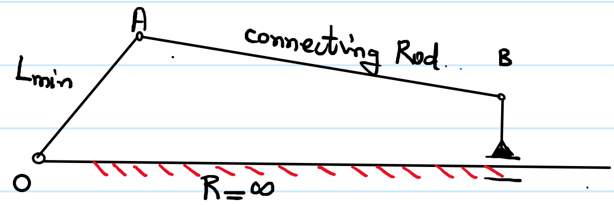
Whitworth Mechanism.



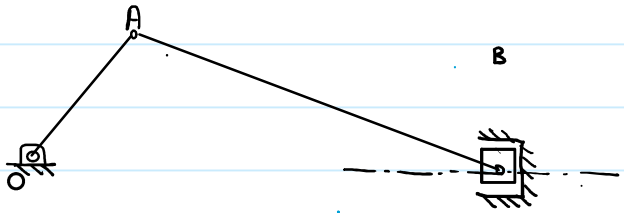
Inversion – II . case (A)

Fixed link – link adjacent to Lmin.
(Link of infinite lenght)

Inversion – crank – Rocker Mechanism



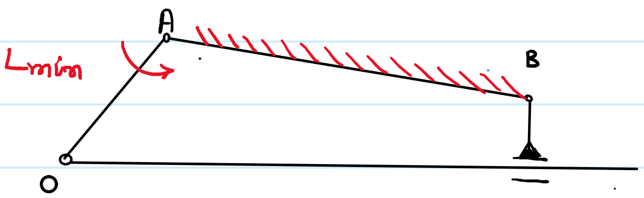
Application – I C Engine, Air-compressor, offset crank slider mechanism



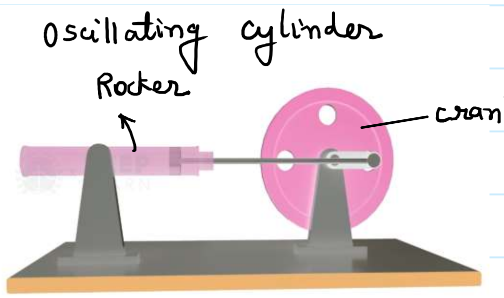
case (B)

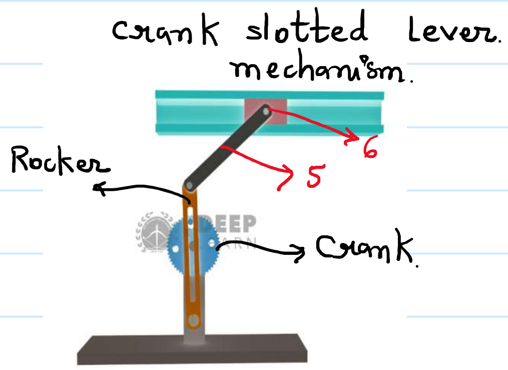
Fixed Link – Link adjacent to Lmin / connecting Rod / Link 3 /
Link of finite lenght.

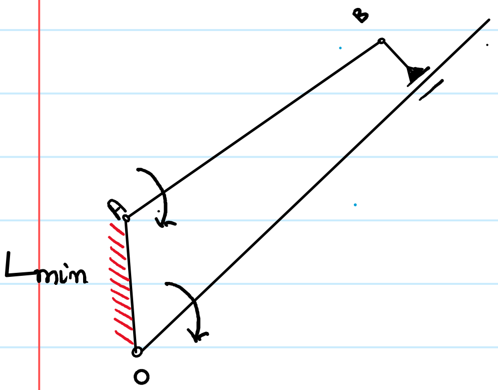
Inversion – crank – Rocker mechanism.



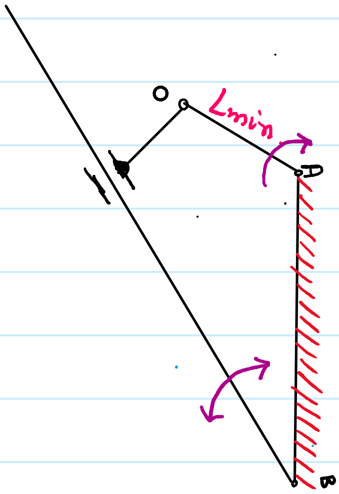
Application – 1. Crank slotted lever mechanism.
2. Oscillating cylinder.







Whitworth Mechanism.



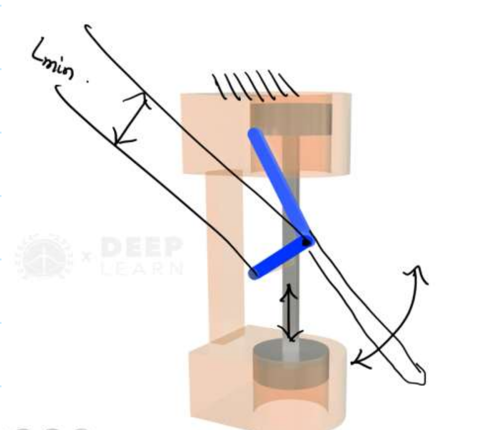
Crank slotted lever mechanism.

Inversion - III

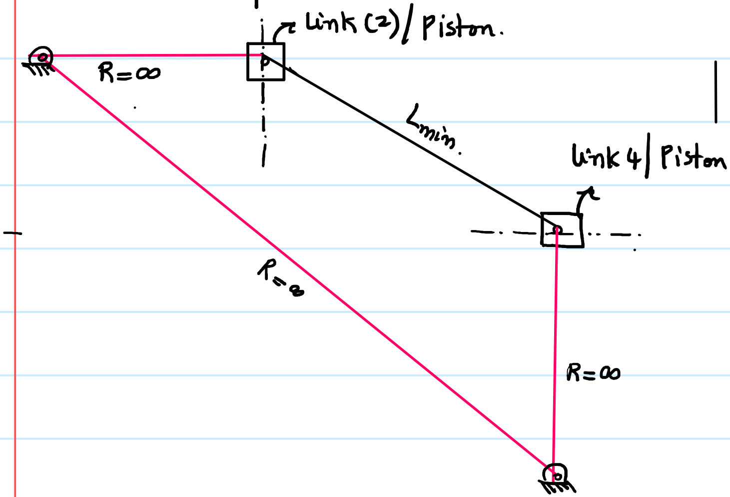
Fixed link - link opposite to Lmin / Link 4 / Link of infinite lenght / Piston Rod.

Inversion - Rocker - Rocker Mechanism

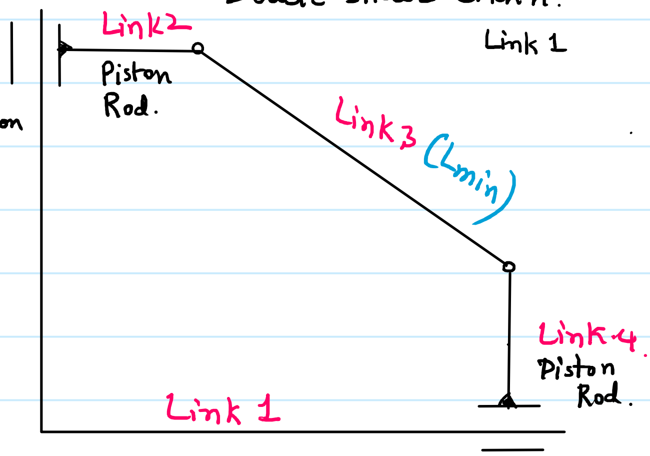
Application - Hand pump / Pendulum Pump.



Inversions of Double slider mechanism.



Double slider chain.



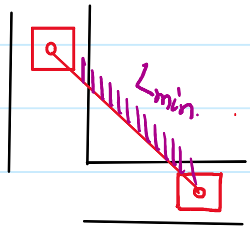
No. of different links = No. of inversions = 3.

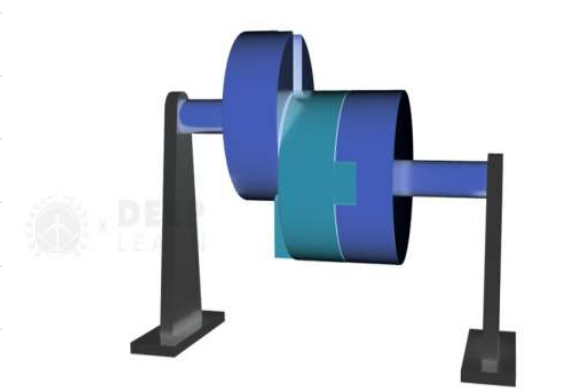
Inversion – I.

Fixed link. – L_{min}.

Inversion – Double crank Mechanism.

Application – Oldham Coupling





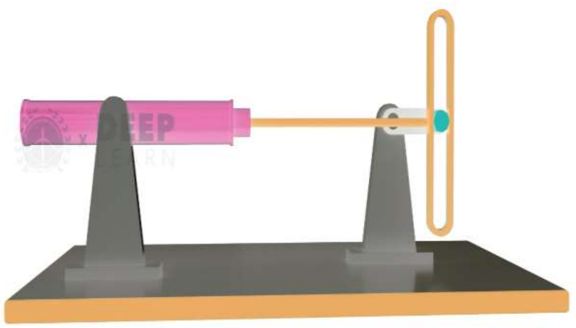
Inversion – II.

Fixed link – Link adjacent to L_{min} / Piston Rod / Piston.

Inversion – Crank – Rocker mechanism.

Application – Scotch Yoke Mechanism.

↳ This mechanism is used for generating sine and cosine functions.

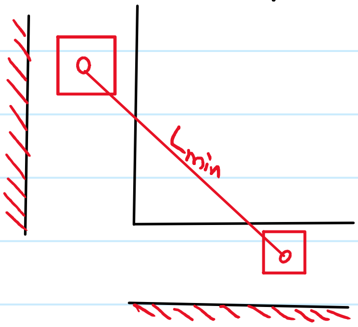


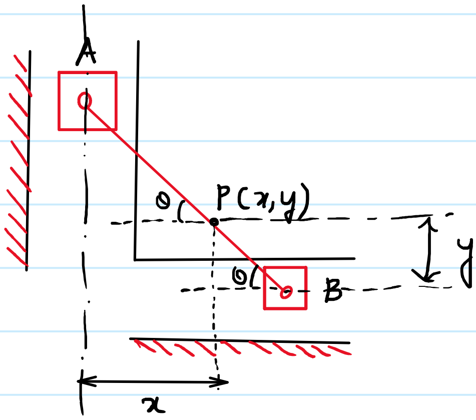
Inversion – III.

Fixed link — Link opposite to Lmin

Inversion – Rocker – Rocker mechanism.

Application – Elliptical trammel.





$$x = AP\cos\theta$$

$$y = BP\sin\theta.$$

$$\left(\frac{x}{AP}\right)^2 + \left(\frac{y}{BP}\right)^2 = 1$$

Locus of point P is ellipse.

AP – lenght of semi major axis.

BP – lenght of semi minor axis.

If $AP = BP$ [P is a mid point]

Locus of midpoint is circle.

$$x^2 + y^2 = AP^2$$

Analysis of Quick Return Mechanism

The mechanism in which return stroke is completed in the shortest
Possible time is called Quick return Mechanism

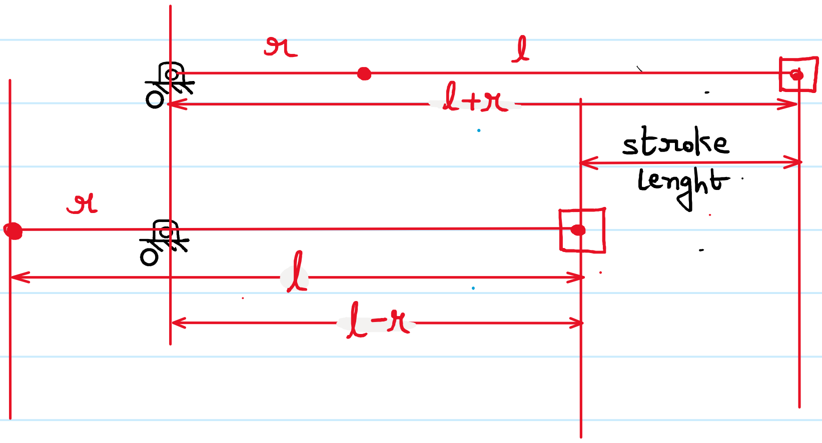
Types of Quick Return Mechanism

1. **Offset Crank slider Mechanism**
2. **Whitworth Mechanism**
3. **Crank Slotted lever Mechanism**

Parameters

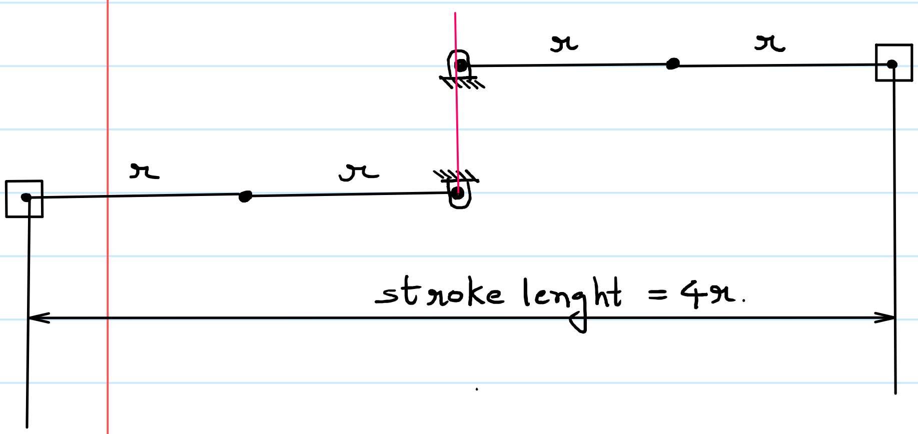
1. Stroke Length - It the distance between the extreme positions of cutting tool.
2. Quick Return Ratio - It is ratio of time required for cutting stroke to time required for return stroke.
It is ratio of angular displacement of input link responsible for cutting stroke to angular displacement of input link responsible for return stroke.

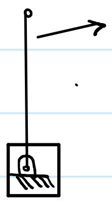
$$Q.R.R. = \frac{\theta_{cutting}}{\theta_{Return}} > 1 \qquad Q.R.R. = \frac{\theta_{Return}}{\theta_{cutting}} < 1$$



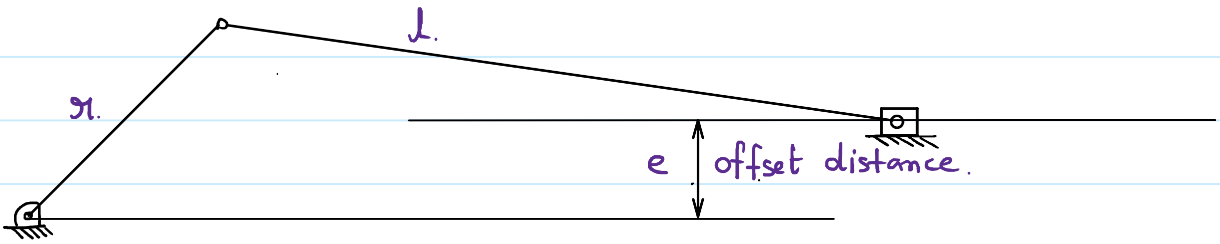
stroke lenght $= 2r$.

If $l = r$ then stroke lenght





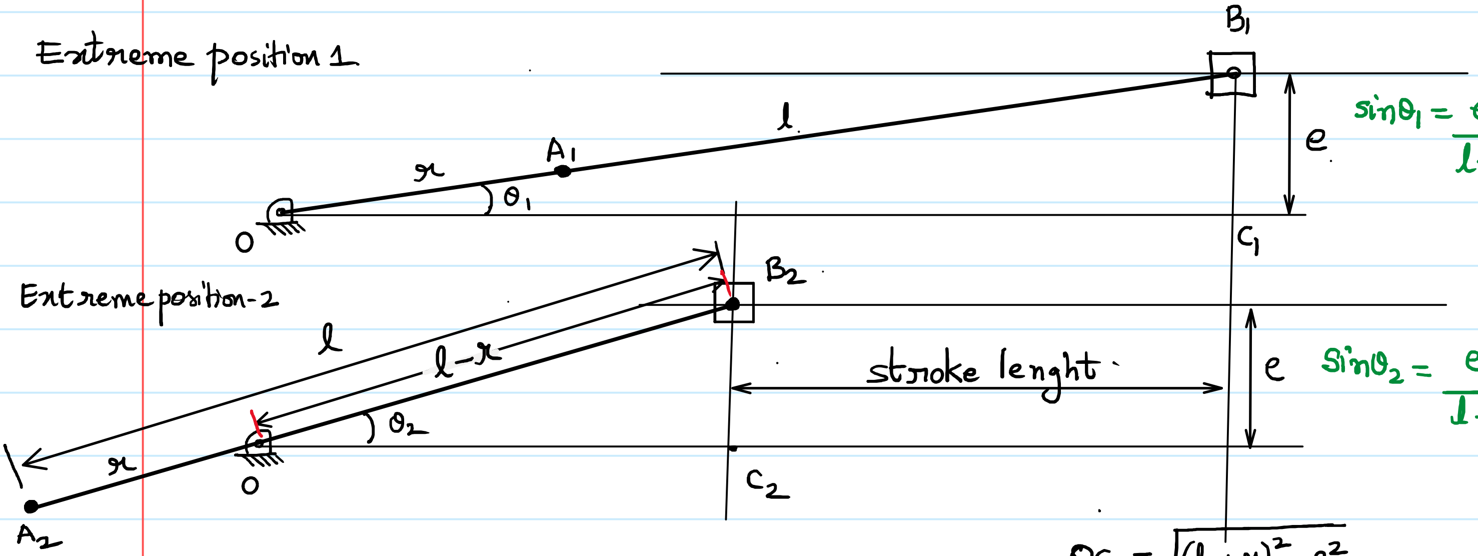
$\gamma = 0$
Mechanism is getting locked.
$M.A. = 0$



r – crank lenght · l – lenght of connecting rod.

e – offset distance.

Extreme position 1



$\sin\theta_1 = \dfrac{e}{l+r}$

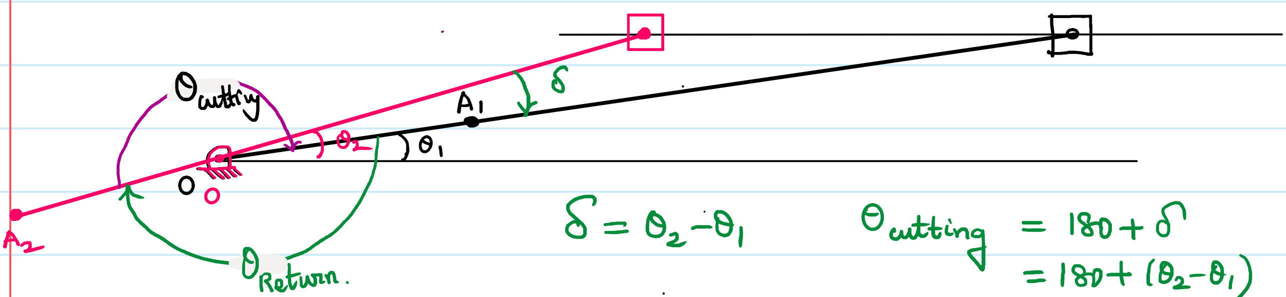
$\sin\theta_2 = \dfrac{e}{l-r}$

$OC_1 = \sqrt{(l+r)^2 - e^2}$

$OC_2 = \sqrt{(l-r)^2 - e^2}$

stroke lenght $= OC_1 - OC_2 = C_1C_2$

stroke lenght $= \left[\sqrt{(l+r)^2 - e^2}\right] - \left[\sqrt{(l-r)^2 - e^2}\right]$



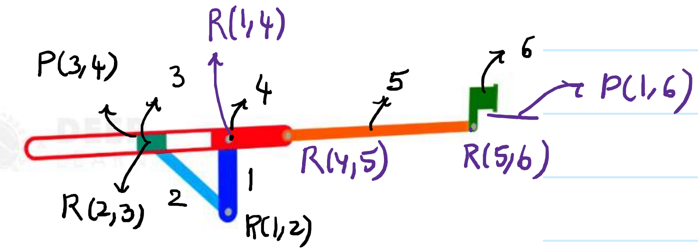
$\delta = \theta_2 - \theta_1$

$\theta_{cutting} = 180 + \delta$
$= 180 + (\theta_2 - \theta_1)$

$\theta_{Return} = 180 - \delta$
$= 180 - (\theta_2 - \theta_1)$

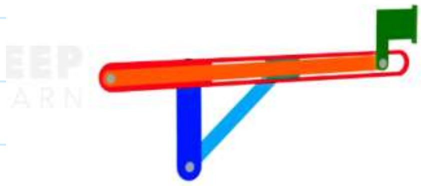
$Q.R.R. = \dfrac{\theta_{cutting}}{\theta_{Return}} = \dfrac{180 + (\theta_2 - \theta_1)}{180 - (\theta_2 - \theta_1)}$

6 link mechanism. 5 Revolute & 2 Prismatic Joints.

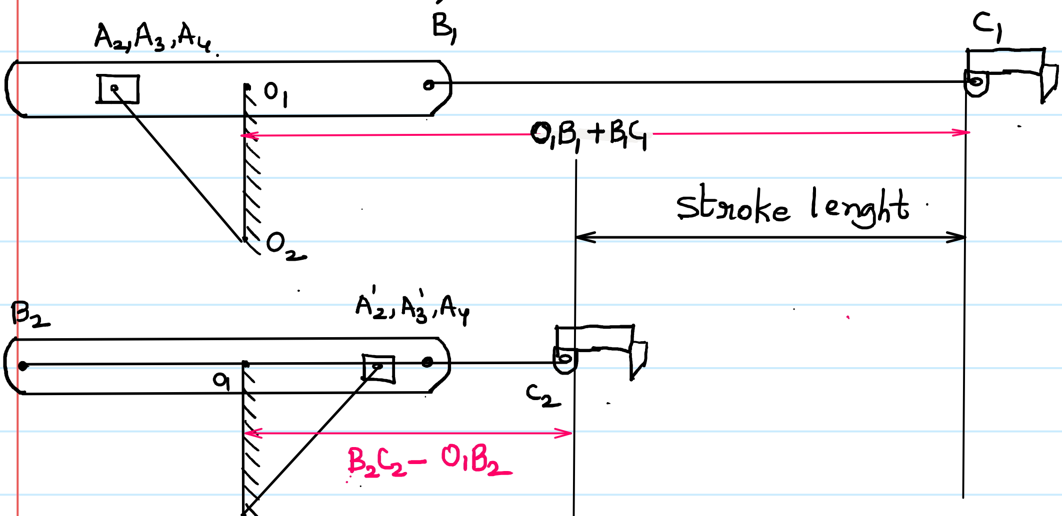


Extreme Position 1

Extreme position.

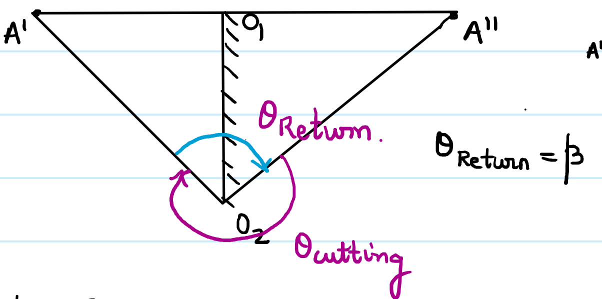


A_2, A_3, A_4 are points on link 2 (crank), link 3 (slider) link 4. (slotted bar)

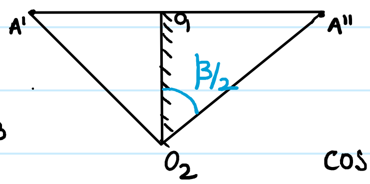


$B_1C_1 = B_2C_2$
$O_1B_1 = O_1B_2$

stroke lenght $= (O_1B_1 + B_1C_1) - (B_2C_2 - O_1B_2)$
$= 2 \times O_1B_1$



$\theta_{Return} = \beta$



In $\Delta O_1O_2A''$

$$\cos \beta/2 = \frac{O_1O_2}{O_2A''}$$

$$\cos \beta/2 = \frac{\text{lenght of fixed link } /(L_{min})}{\text{lenght of crank.}}$$

Quick Return Ratio $= \dfrac{\theta_{cutting}}{\theta_{Return}} = \dfrac{360 - \beta}{\beta}.$

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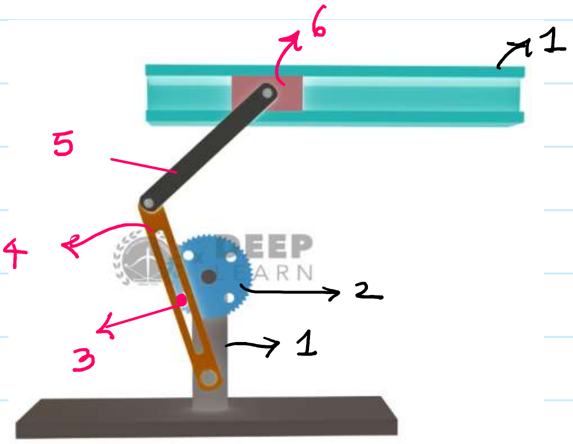
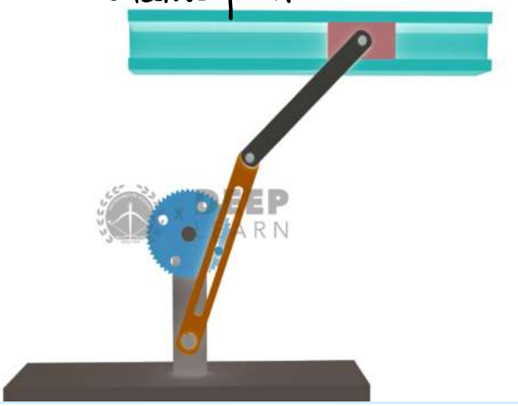
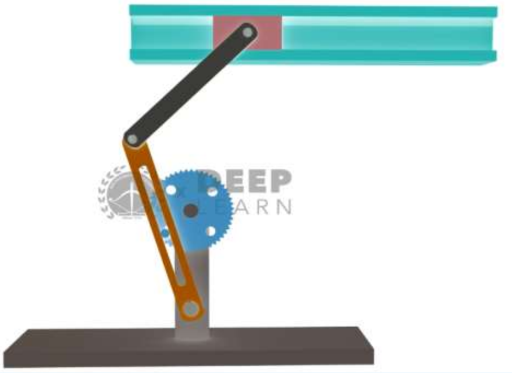


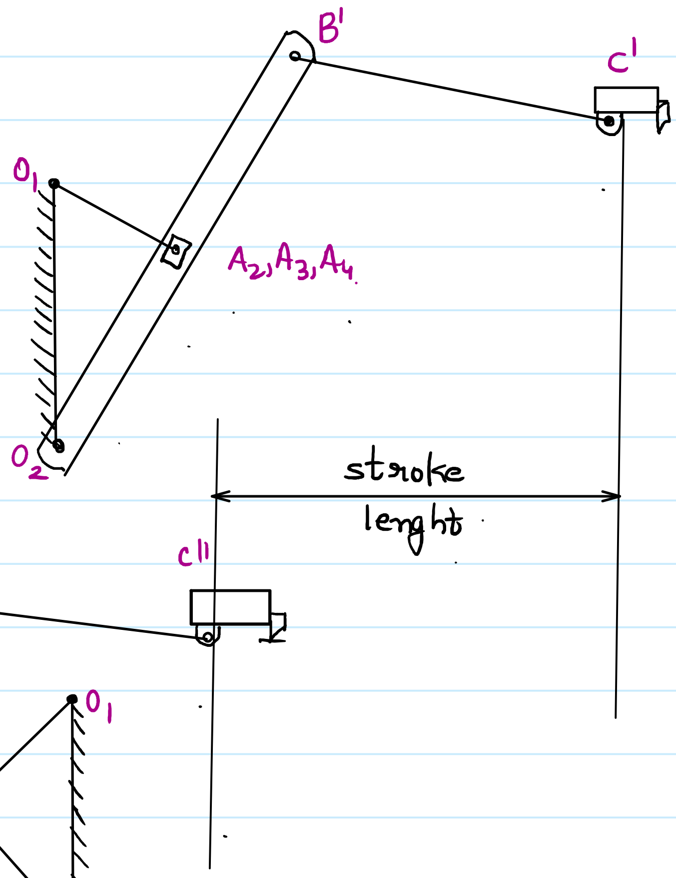
6 links mechanism.
5 revolute and 2 Prismatic joints.

Extreme position 1



Extreme Position.





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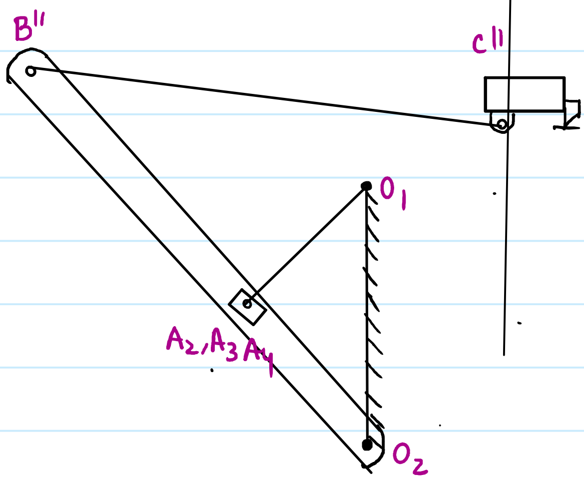

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