Four Bar Linkage

By:-
Mohit Jain
Amool Gupta

Four Bar Linkages

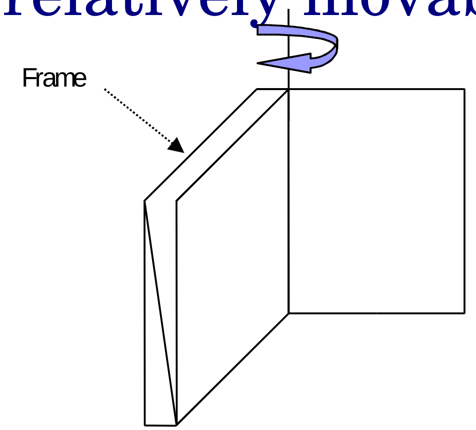
- Concept Analysis
- Demo
- Work Flow
- Experiments and Instructions

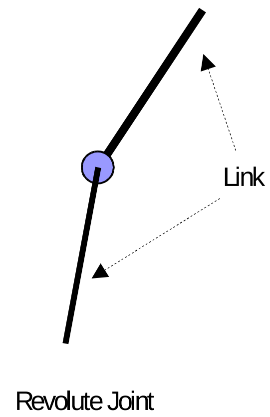
Concept Analysis

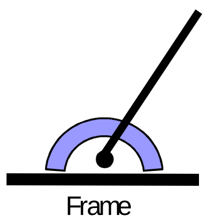
- Pairs
- Links
- Linkage
- Four link Mechanism

Pairs

Definition :- A pair is a joint between the surfaces of two rigid bodies that keeps them in contact and relatively movable







Example :-

Door joint to the frame with hinges makes revolute joint (pin joint), allowing the door to be turned around its axis. Either both of the links connected can move or one of the connected links can move.

Classification of Pairs on the basis of <u>Contact Between Bodies</u>

Lower Pairs

<u>Surface Contact Pairs</u>

Revolute Pairs

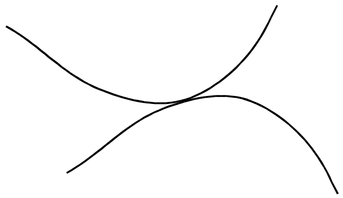
Prismatic Pairs

Example Prismatic Pairs

Relative motion between drawer and its frame

Higher Pairs

Point/Curve/Line Contact Pairs



Links

Definition:- A link is defined as a rigid body having two or more pairing elements which connect it to other bodies for the purpose of transmitting force or motion.

Fixed Link:- In every machine, at least one link either occupies a fixed position relative to the earth or carries the machine as a whole along with it during motion. This link is the *frame* of the machine and is called the fixed link**.**

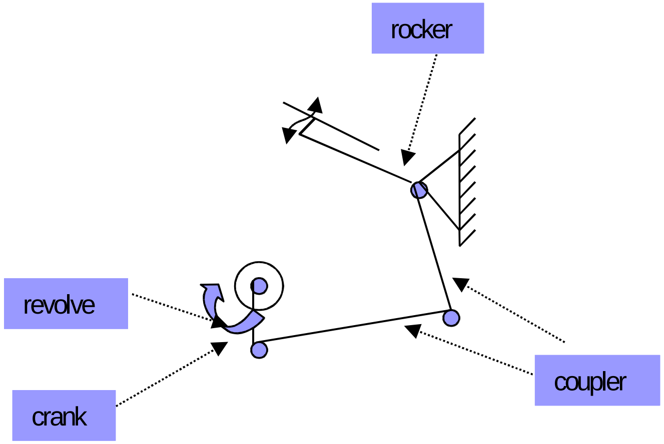
Kinematic Chain :- The combination of links and pairs without a fixed link is not a mechanism but a kinematic chain.

Linkages

Definition:- A mechanism composed of rigid bodies and lower pairs is called linkages.

Function:- Main Function of link Mechanism is to produce rotating, oscilating and reciprocating motion from rotation of crank and vice versa. Link mechanism can be used to convert.

1. Continuous rotation into continuous rotation.
2. Continuous rotation into oscillation or reciprocation (or the reverse).
3. Oscillation into oscillation, or reciprocation into reciprocation.



Kinematics of Linkages Mechanism

Function Generator:- relative Motion between links connected to frame

Path Generator:- path of tracer point

Motion Generator:- the motion of the coupler linkages

Four Link Mechanism

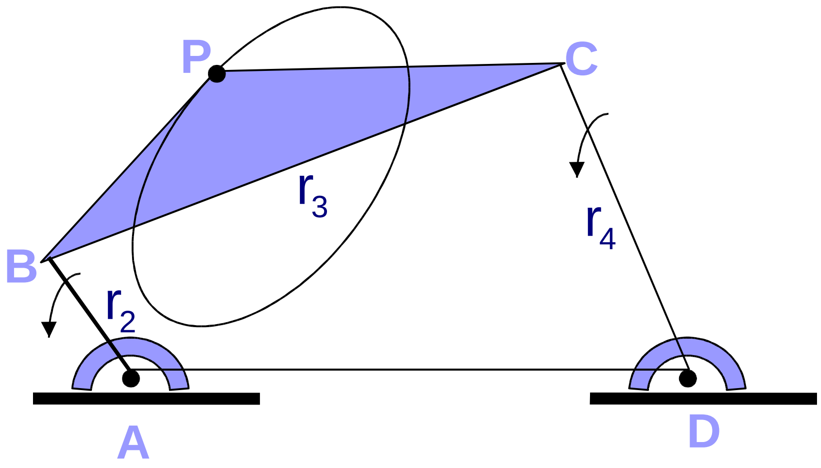
- Best example of constrained linkages
- A variety of useful mechanisms can be formed from a four-link mechanism through slight variations, such as changing the character of the pairs, proportions of links and many complex link mechanism can be formed from combination of two or more such four link mechanism

Main types of Four Link mechanism (rest fall under these)

- Four Bar Linkages
  - Double Crank Mechanism
  - Double Rocker Mechanism
  - Crank Rocker Mechanism
- Slider Crank Mechanism

Four Bar Linkage

- Is the simplest of all closed loop linkage
- Have 3 three moving link, 1 fixed link and 4 pin joints
- There is only one constraint on the linkage , which defines a definite motion



COUPLER :- Link opp. to frame *{can be said which transmit force from input to output}*

Side Link :- Links which are hinged to frame are called Side links {side links are said to be in relative motion with each other}

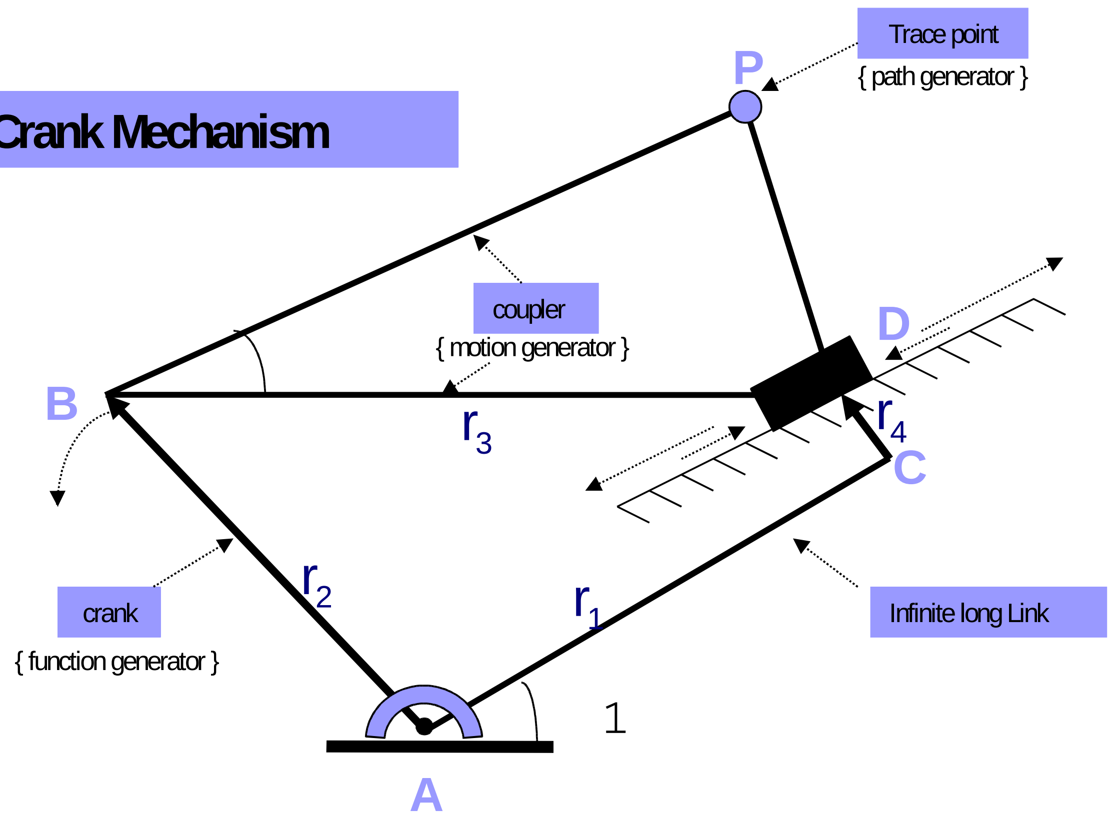
Revolve:- A link which is free to rotate through 360 degree with respect to other link (not necessarily frame)

Change Point :- instant at which all the links of 4BL are aligned

Crank: A side link which revolves relative to the frame is called a crank.

Rocker: Any link which does not revolve is called a rocker.

Slider Crank Mechanism



$$R_1 + R_4 = R_3 + R_4$$

$$s + l \Leftarrow p + q$$

Slider Position Analysis

We have equation

$s+l <= p+q$

$R1 + R4 = R2 + R3$ [where $R = re^{i\theta}$]

$r_1e^{i\theta_1} + r_4e^{i\theta_4} = r_2e^{i\theta_2} + r_3e^{i\theta_3}$

$r_1e^{i\theta_1} - r_3e^{i\theta_3} = r_2e^{i\theta_2} - r_4e^{i\theta_4}$

we put $a = r2 \cos \theta_4 - r4 \cos \theta_4$

$b = r2 \cos \theta_4 - r_4 \cos \theta 4$

$r_1e^{i\theta_1} - r_3e^{i\theta_3} = a + ib$

Multiplying by $e^{-i\theta_1}$

$r_1 - r_3\, e^{i(\theta_3 - \theta_1)} = ae^{-i\theta_1} + ibe^{-i\theta_1}$

$r_1 - r_3 \cos(\theta_3 - \theta 1) - ir_3 \sin(\theta_3 - \theta 1) = a \cos \theta 1 - ia \sin \theta 1 + ib [\cos \theta_1 - i\sin \theta_1]$

$r_1 - r_3 \cos(\theta_3 - \theta 1) - ir_3 \sin(\theta_3 - \theta 1) = a \cos \theta 1 + b \sin \theta 1 - i[a \sin \theta 1 - b \cos \theta 1]$

by equating real and imaginary parts on both side of above equation we get

$r_1 - r_3 \cos(\theta_3 - \theta 1) = a \cos \theta 1 + b \sin \theta 1$ and

$r_3 \sin(\theta_3 - \theta 1) = a \sin \theta 1 - b \cos \theta 1$

by re arranging terms we get

$\theta_3 = \theta_1 + \sin^{-1}[a/r_3 \sin \theta 1 - b/r_3 \cos\theta 1]$ and

$r_1 = [a + r3 \cos\theta 3] / \cos\theta 1$

Position of slider $= R_1 + R_4$

$= r_1e^{i\theta_1} + r_4e^{i\theta_4}$

$\theta_4 = \theta_1 + 90^o$

$r_1e^{i\theta_1} + r_4e^{i(\theta_1 + 90^o)}$

Value of r_1

$r_1 = [a + r3 \cos\Theta3] / \cos\Theta1$

$a = r2 \cos \Theta4 - r4 \cos \Theta4$

$\Theta_3 = \Theta_1 + \sin^{-1}[a/r_3 \sin \Theta1 - b/r_3 \cos\Theta1]$

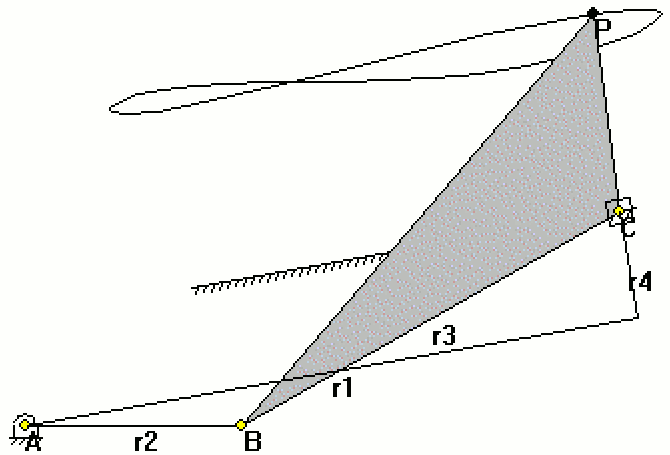
$b = r_2 \cos \Theta_4 - r_4 \cos \Theta4$

Coupler Analysis

$\Theta_5 = \Theta_3 + \beta$

$P_x = r_2 \cos \Theta_2 + r_2 \cos (\Theta_3 + \beta)$

$P_y = r_2 \sin \Theta_2 + r_2 \sin (\Theta_3 + \beta)$


P
C
r4
r3
r1
A
r2
B