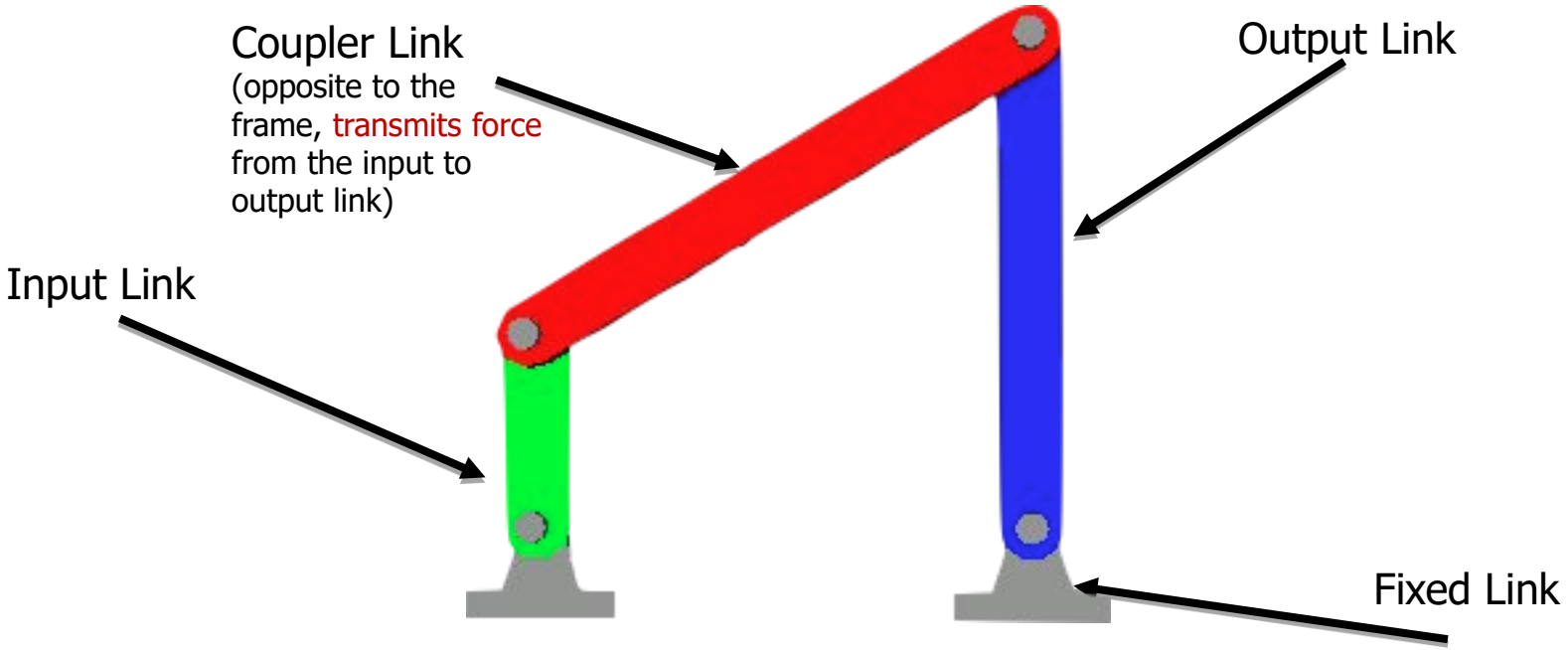
Lesson 3

Grashof's Law for a Planar Four-Bar Linkage

Grashof's Law .. for a Planar Four-Bar Linkage ...

What is a Planar Four-Bar Linkage?

- 4 link mechanism is the simplest of all closed loop mechanisms.
- A four bar linkage comprises four bar-shaped links (.. Have 3 moving links; 1 fixed link; and 4 pin joints).
- The four bar chain has four turning pairs (.. this is simplest type of kinematic chain/linkage in which four rigid links are connected by four pin joints).

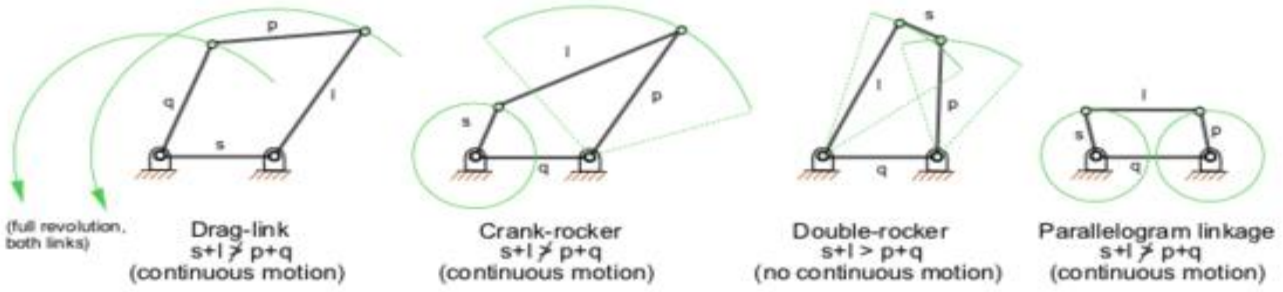


Grashof's Law .. for a Planar Four-Bar Linkage ...

Terminology ...

- Crank: A link which can make complete revolution is known as crank.
- Rocker: Any link which does not revolve is called a rocker.
- Frame: The fixed link is known as frame.
- Coupler/connecting rod: The opposite link of frame is known as connecting rod.

- Crank-rocker mechanism: In a four bar linkage, if the shorter side link revolves and the other one rocks (i.e., oscillates), it is called a crank-rocker mechanism.
- Double-crank mechanism: In a four bar linkage, if both of the side links revolve, it is called a double-crank mechanism.
- Double-rocker mechanism: In a four bar linkage, if both of the side links rock, it is called a double-rocker mechanism.



Grashof's Law .. for a Planar Four-Bar Linkage ...

- Grashof's Law states that for a planar four-bar linkage system, the sum of the shortest and longest link lengths cannot be greater than the sum of the remaining two link lengths if there is to be a continuous relative rotation between two members.

- Mathematically,

  Suppose

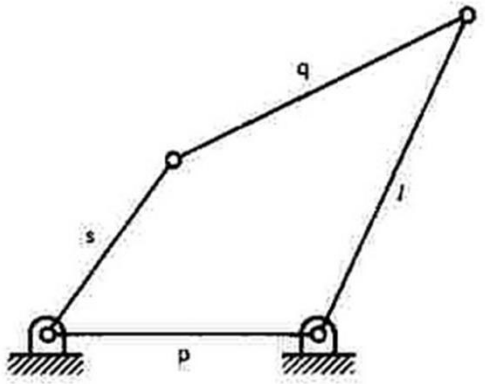
  s= length of the shortest link

  l = length of the longest link

  p & q = lengths of other links

  $s + l \leq p + q$

  -> if there is to be a continuous motion



Note: if $s + l > p + q$, then no continuous relative motion is possible; i.e., if the above inequality is NOT satisfied, no link will make a complete revolution relative to another.

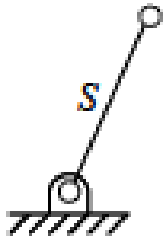
Grashof's Law .. for a Planar Four-Bar Linkage ...

Grashof's Law and a Four-Bar-Linkage ...

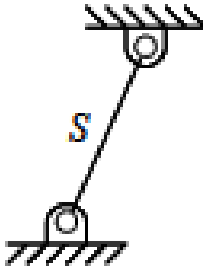
- Consider a four-bar-linkage. Denote the smallest link by s , the longest link by l and the other two links by p and q . If

$$s + l \leq p + q,$$

- then depending whether link s is connected to the ground by one end, two ends, or no end is connected, the mechanism can be one of the following types:



Crank-Rocker



Crank-Crank

Rocker-Rocker

Grashof's Law .. for a Planar Four-Bar Linkage ...

- Function: The main function of mechanism is to produce rotating, oscillating, and reciprocating motion from rotation of crank and vice versa.

- Kinematics of linkage mechanisms:
  - Function generator: relative motion between links connected to frame
  - Path generator: path of tracer point
  - Motion generator: motion of the coupler linkage

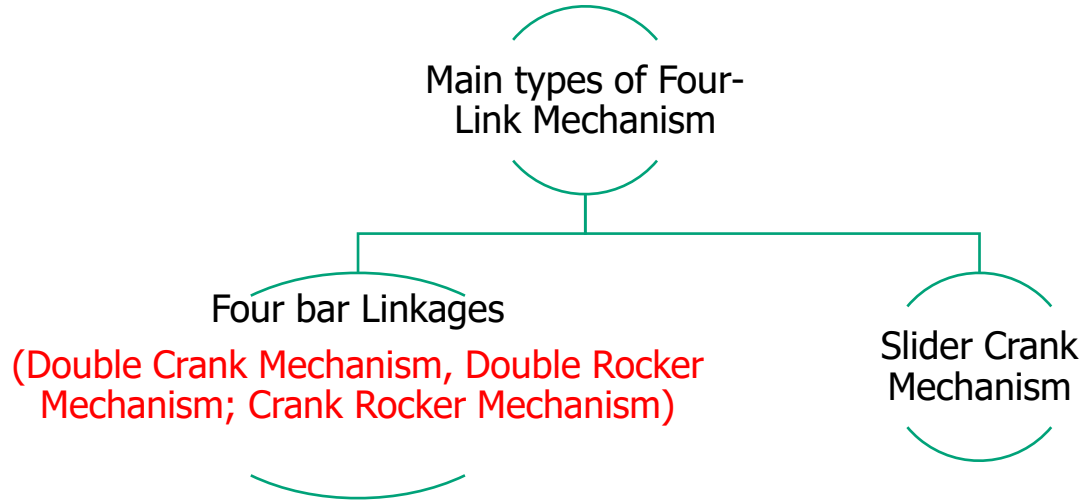
- Links can be used to convert:
  - Continuous rotation into another rotation motion
  - Continuous rotation into oscillation or reciprocation (or vice versa)
  - Continuous rotation into oscillation, or reciprocation into reciprocation

Reciprocating motion is a repetitive up-and-down or back-and-forth linear motion. Found e.g. in reciprocating engines and pumps.

Oscillating motion is swinging from side to side, like a pendulum in a clock..

Grashof's Law .. for a Planar Four-Bar Linkage ...

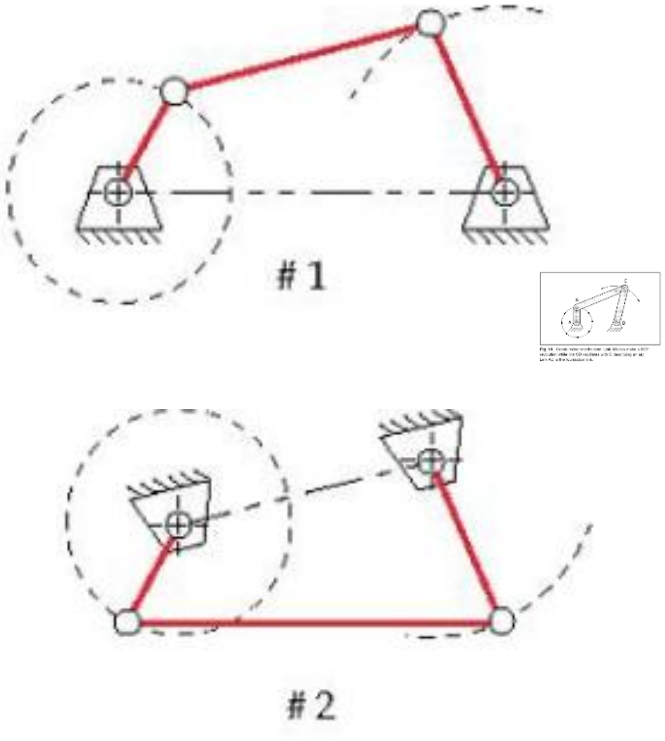
- A variety of mechanisms can be found/created from a four link mechanism through slight variations such as:
  - Changing the character of a pair, e.g., from rotation to sliding, etc.
  - Proportion/size, e.g., length of the link.
  - Many complex mechanisms can be formed from combination of two or more such four link mechanisms



Grashof's Law .. for a Planar Four-Bar Linkage ...

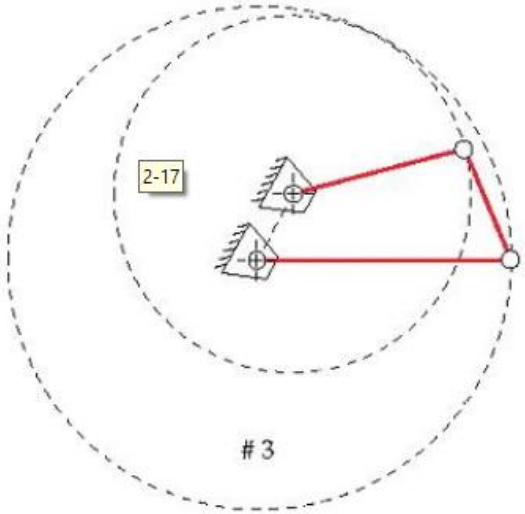
Grashof's Law and a Four-Bar-Linkage ...

- A crank-rocker mechanism



(... the shortest link can make a 360° revolution while the output link oscillates)

- A double crank (i.e., crank-crank) mechanism

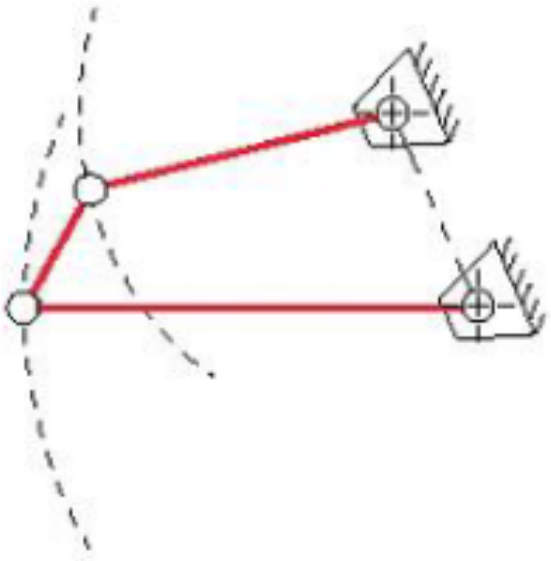


(... the shortest link is the frame - both input and output links can rotate through 360°).

Grashof's Law .. for a Planar Four-Bar Linkage ...

Grashof's Law and a Four-Bar-Linkage ...

- A rocker-rocker (double rocker) mechanism



(... the shortest link can make a 360° revolution but the pivoting links can only oscillate)

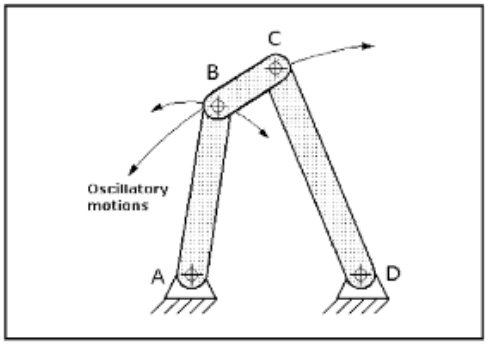
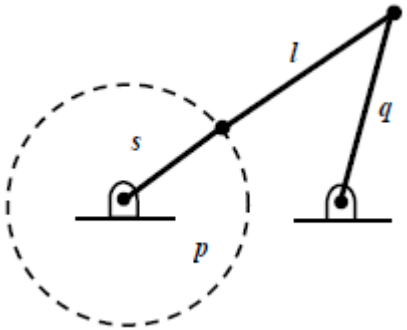


Fig. 11 Double-rocker mechanism: Short link BC can make a 360° revolution, but pivoting links AB and CD can only oscillate, describing arcs.

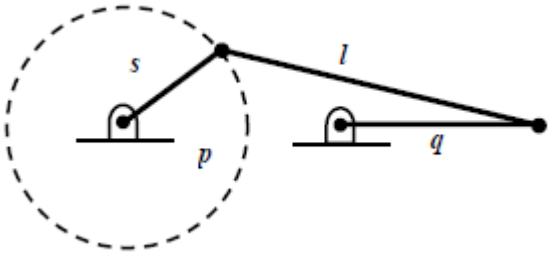
Grashof's Law .. for a Planar Four-Bar Linkage ...

Significance of Grashof's Law....

- Grashof's law is a very important consideration when designing a mechanism driven by a motor.
- Grashof's criteria is used to determine whether or not at least one of the links can rotate 360°. (... in mechanisms driven by motors, helps to ensure that the input crank can make a complete revolution.)

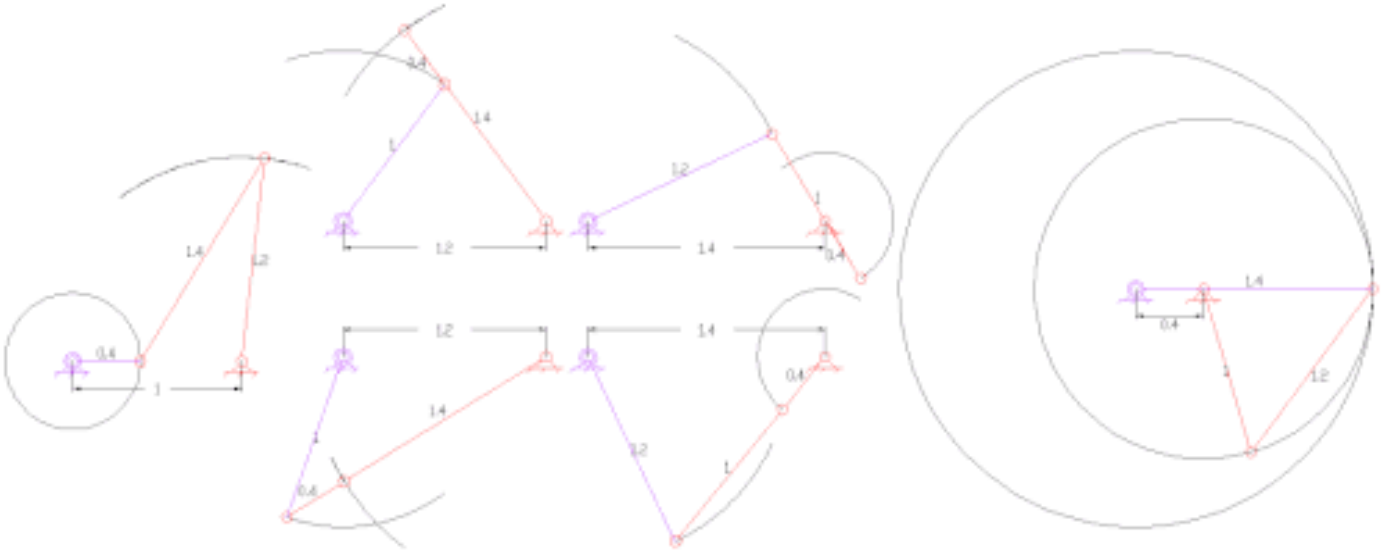


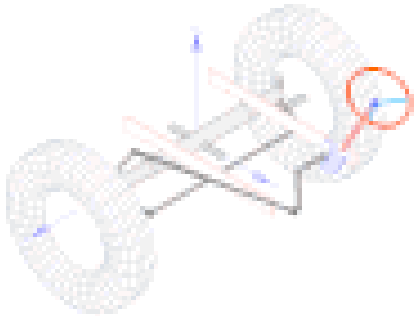
Grashof's mechanism (the Grashof condition is satisfied, s + l < p + q, and the shortest link can rotate 360°.)



Non-Grashof's mechanism (as the short link is moved around, the fact that s + l > p + q means that the short link cannot complete its revolution).

Grashof's Law .. for a Planar Four-Bar Linkage ...





Summary

End...