Mechanism Synthesis Rules

- Linkage Transformation Rules Summary
- Grashof's Law
- Inversion

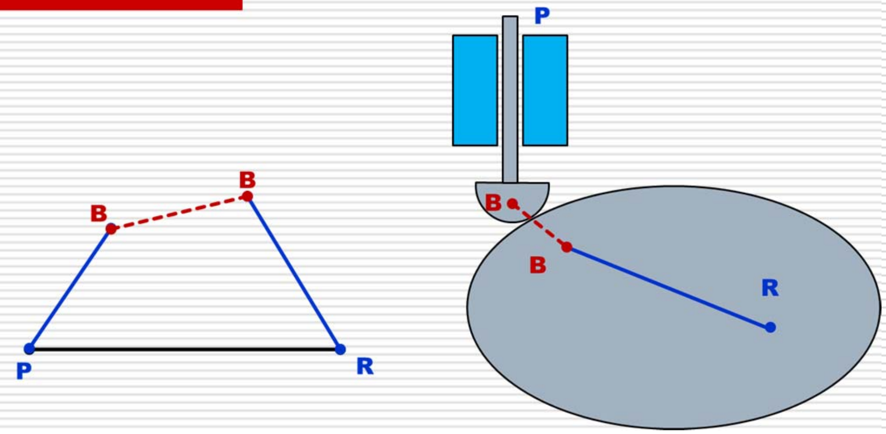
LINKAGE TRANSFORMATION
RULE 1

Revolute joints in any loop can be replaced by prismatic joints with no change in DOF of the mechanism, provided that at least two revolute joints remain in the loop.

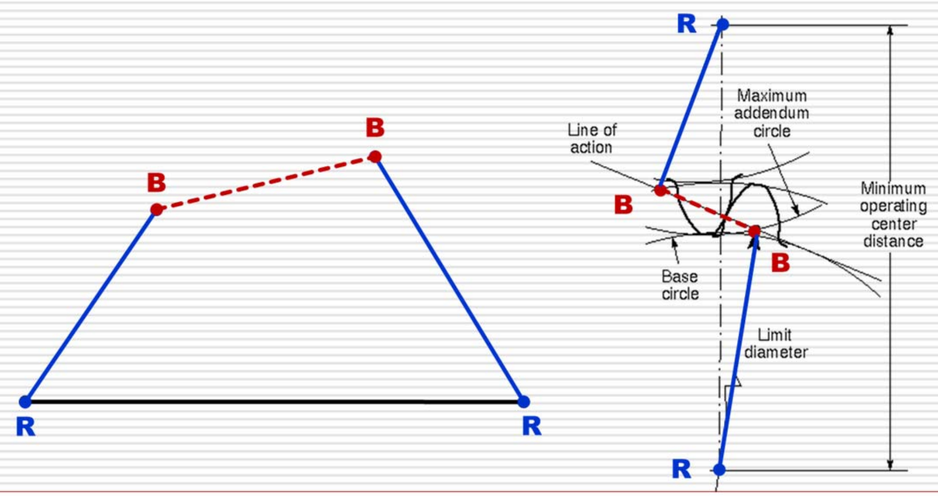
- A maximum of two revolute pairs may be replaced by two prism pairs in a given loop of a given loop of a linkage.
- The axes of substituted prism pairs must intersect one another.
- The axis of the prism pair must be either in the plane of the linkage or in a plane parallel to the plane of the linkage.

4 Bar Isomers Can Be Transformed To Other Mechanism

- Cam Pairs
  - R-R-B-B
  - R-P-B-B



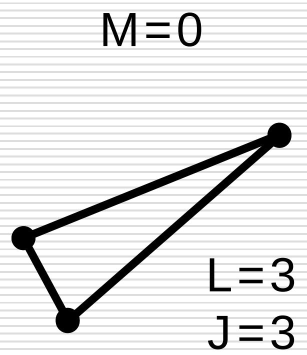
- Gear Pairs
  - R-R-B-B

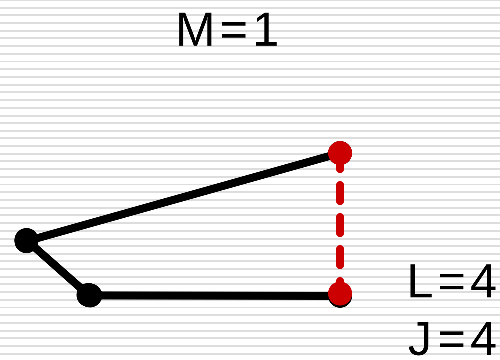


LINKAGE TRANSFORMATION RULE 2

Any full joint can be replaced by a half joint, but this will INCREASE the DOF by one.

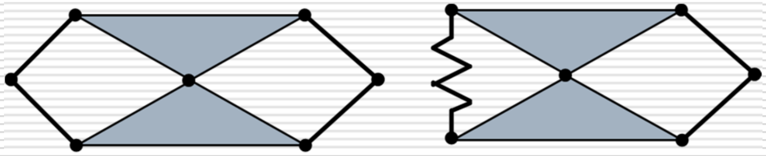
a. A half joint adds an imaginary link and one joint to the system



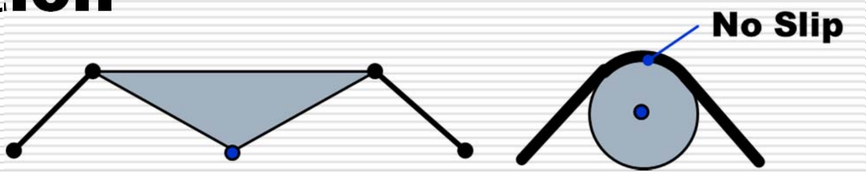


Type Transformations for Higher Order Isomers

- Springs
  - Revolute Pair
  - Two Binary Links



- Belt and Pulley Combination
  - Revolute Pairs
  - Two Binary Links
  - Ternary Link

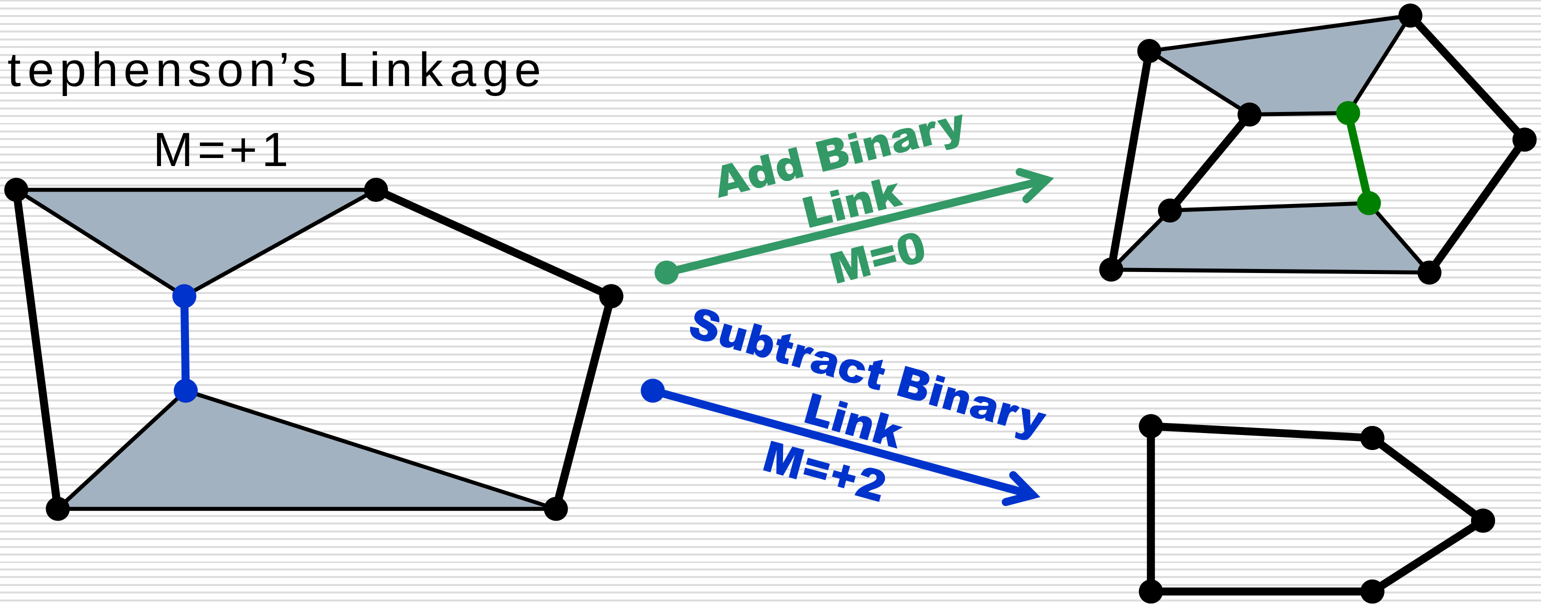


LINKAGE TRANSFORMATION
RULE 3

Addition of a link will Reduce the DOF by one,
Removal of a link will Increase the DOF by one
(the DoF distribution Principle must be maintained)

a. This rule adds one link and two joint to the system

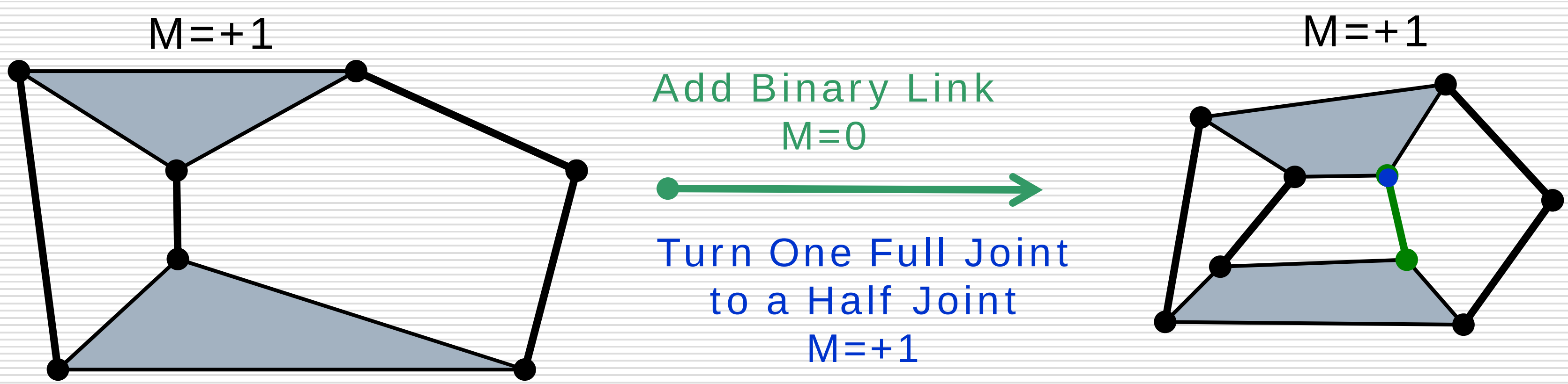
Stephenson's Linkage



LINKAGE TRANSFORMATION RULE 4

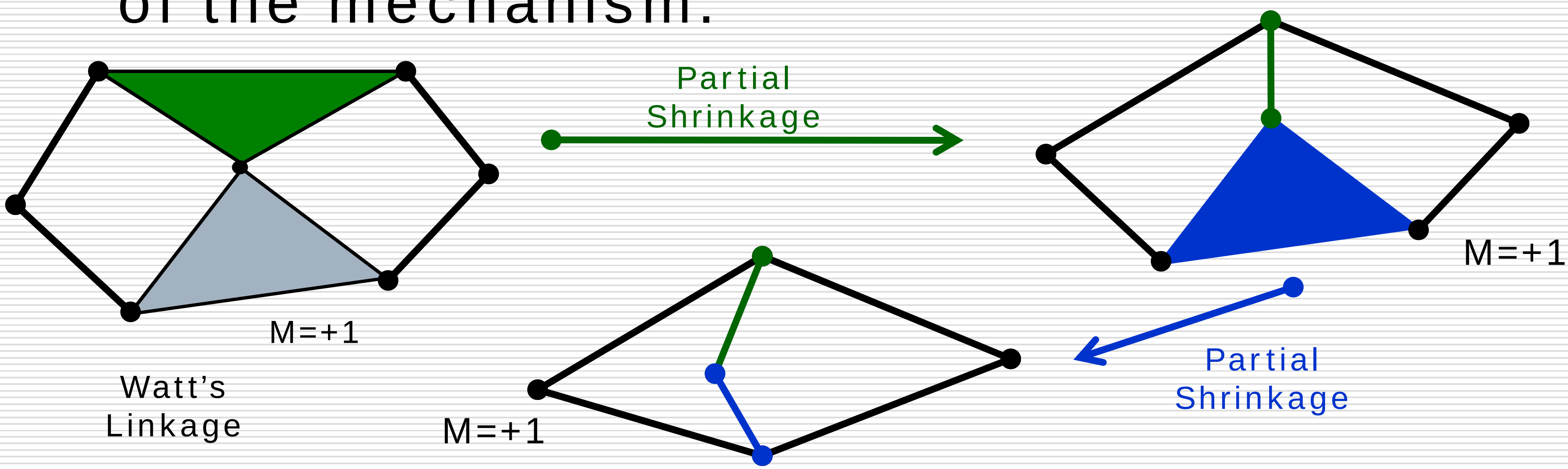
The Combination of rules 2 and 3 (Addition) above will keep the original DOF unchanged

Stephenson's Linkage



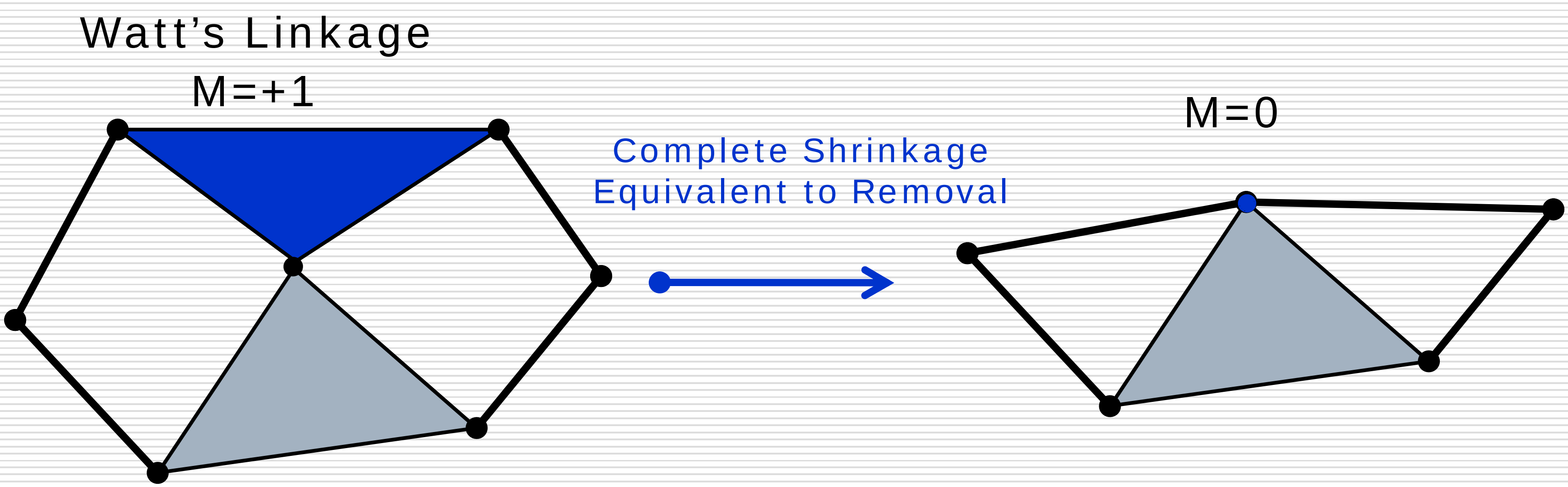
LINKAGE TRANSFORMATION
RULE 5

Any ternary or higher-order link can be partially “shrunk” to a lower-order link by coalescing nodes. This will create a multiple joint but will not change the DOF of the mechanism.



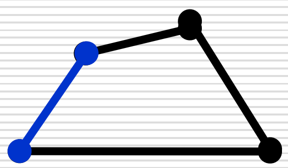
LINKAGE TRANSFORMATION
RULE 6

Complete shrinkage of a higher-order link is equivalent to its removal. A multiple joint will be created, and the DOF will be reduced.



Grashof's Law

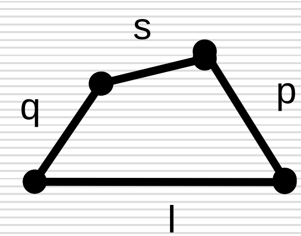
- In motor driven mechanisms it is important to ensure that the input crank can make a complete revolution
- For a planar four bar linkage, the sum of the shortest and longest link lengths can not be greater than the sum of the remaining two link lengths if there is to be continuous relative rotation between two members.

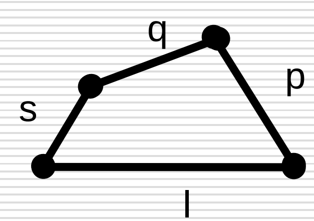


Grashof's Law

- l – is the length of the longest link
- s – is the length of the shortest link
- p,q – lengths of the other two links

$$s + l \le p + q$$

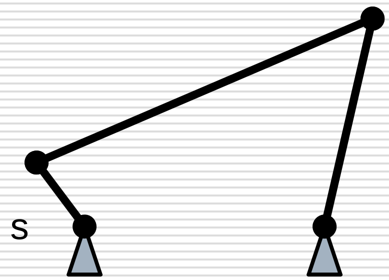


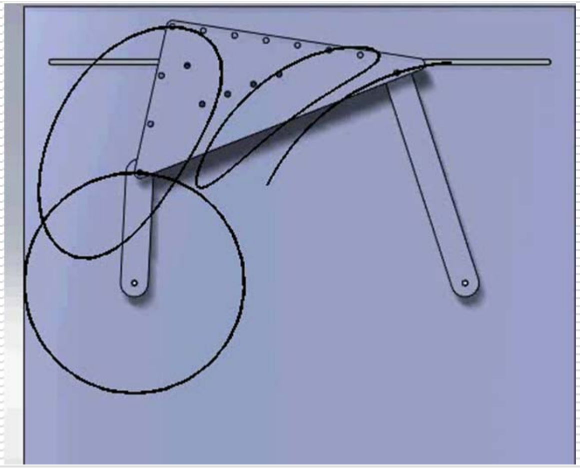


- Does not specify link order
- Does not specify which link is fixed

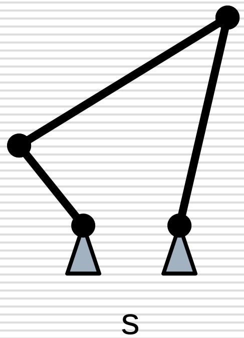
Examples of Grashof Mechanisms

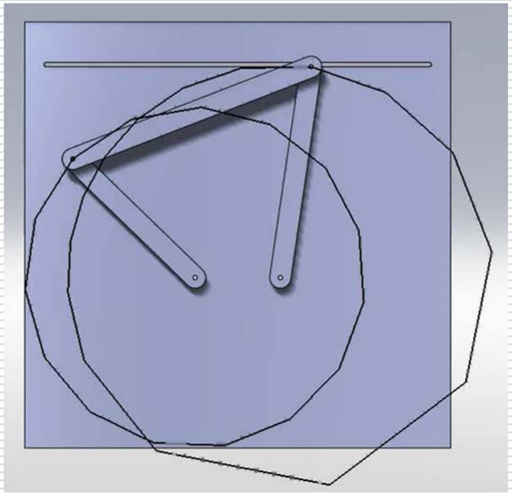
- Crank Rocker,
  s+l < p+q
  2+6<4+5
  s-Drive





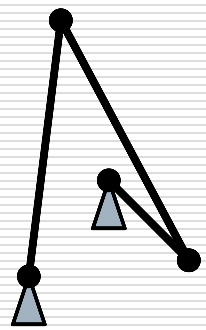
- Double Crank,
  s+l < p+q
  2+6<4+5
  s-Ground



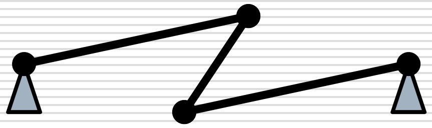


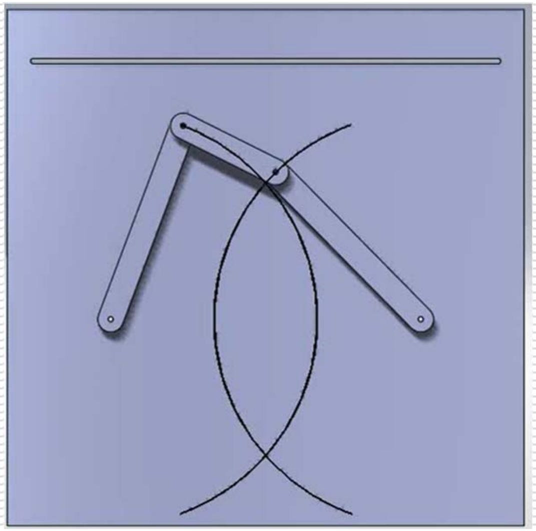
Examples of Grashof Mechanisms

- Non-Grashof Rocker-Rocker (Triple Rocker), $s+l > p+q$



- Double Rocker, $s+l = p+q$
  $2+6=4+4$

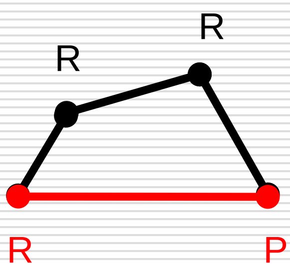


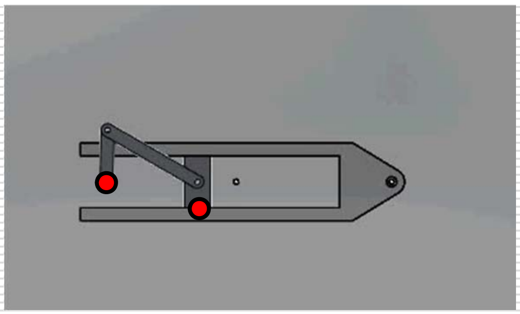


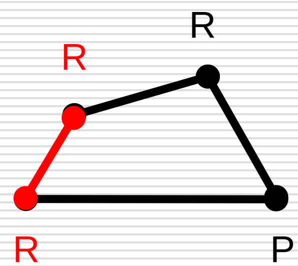
Kinematic Inversion

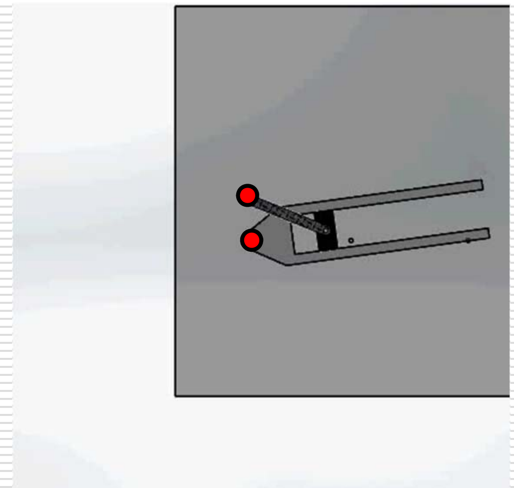
- Until frame link has been chosen
  - Kinematic chain
- When different links are chosen as the frame link
  - RELATIVE motion between links is not altered
  - ABSOLUTE motion measured with respect to the frame is drastically changed

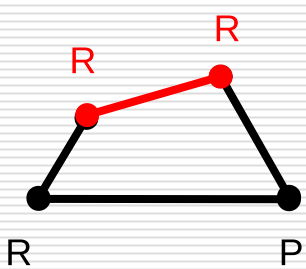
Kinematic Inversion

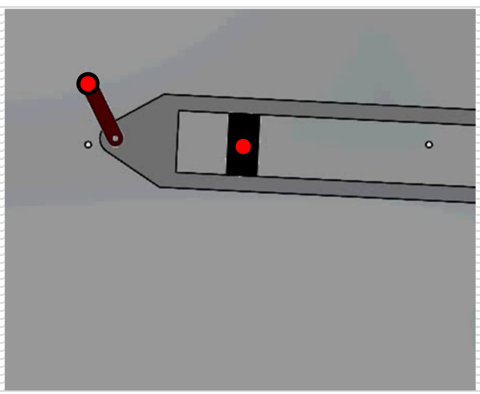


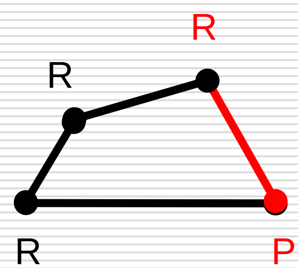


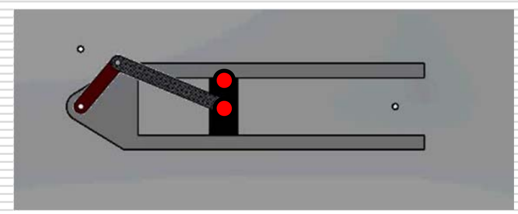






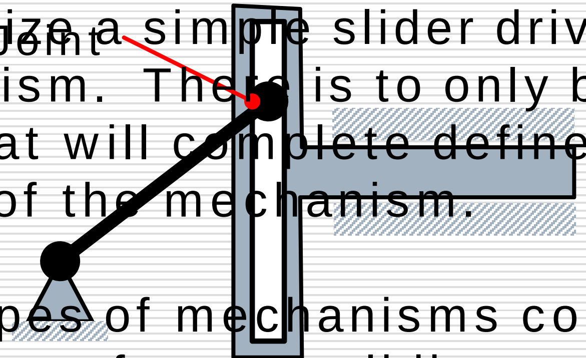




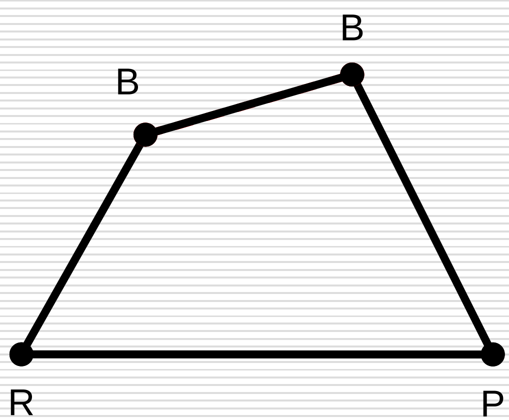


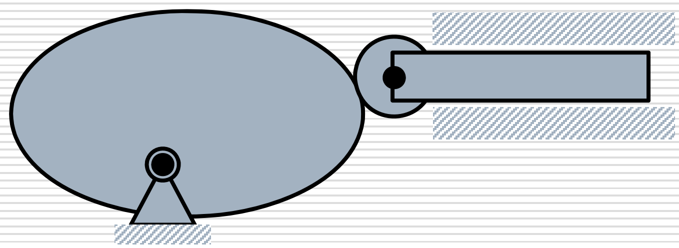
Example 1: M=+1

Synthesize a simple slider drive mechanism. There is to only be a single drive that will complete define the motion of the mechanism.



What types of mechanisms could be used if the type of output sliding motion is well defined?

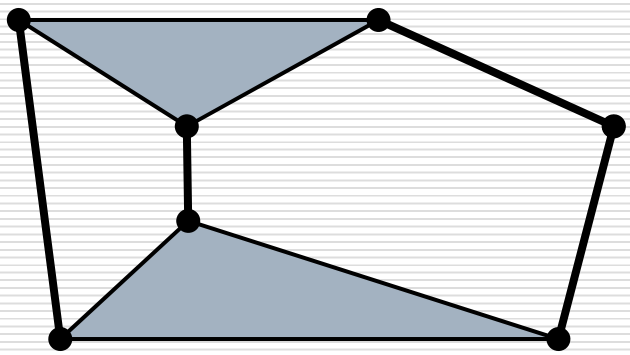


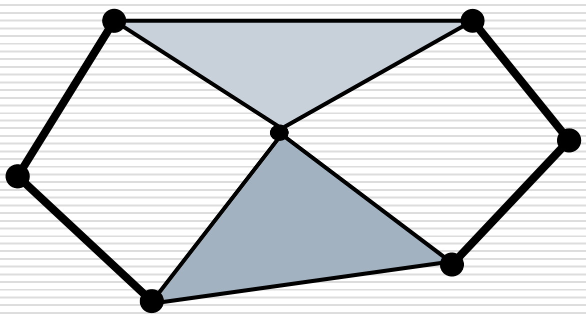


Example 1: M=+1, L=6

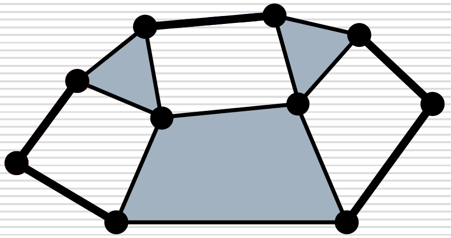
Synthesize a simple slider drive mechanism. There is to only be a single drive that will complete define the motion of the mechanism.

What types of mechanisms could be used if the type of output sliding motion is well defined?



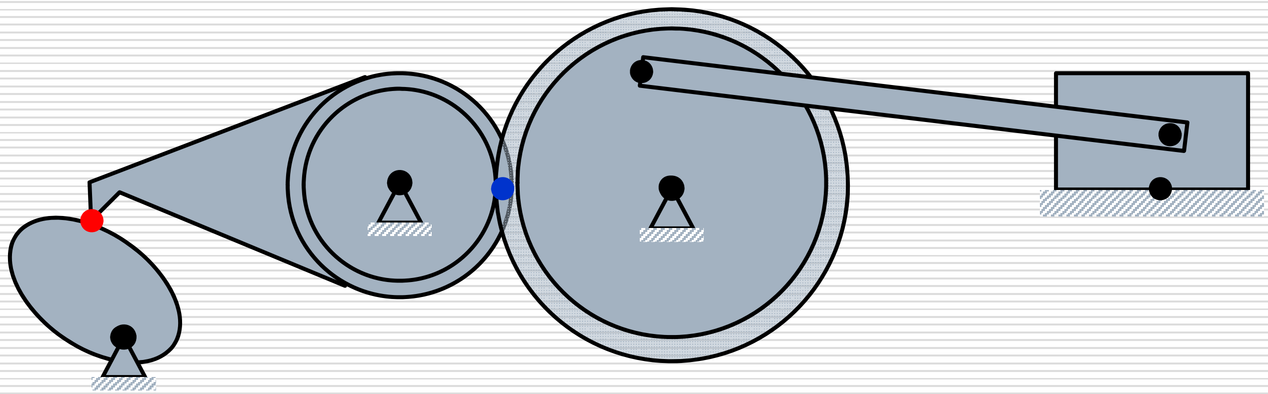


Example 1: M=+1, L=8



Synthesize a simple slider drive mechanism. There is to only be a single drive that will complete define the motion of the mechanism.

What types of mechanisms could be used if the type of output sliding motion is well defined?



Example 2:

Synthesize the simplest possible drive mechanism for oscillating two widely separated agitator shafts.