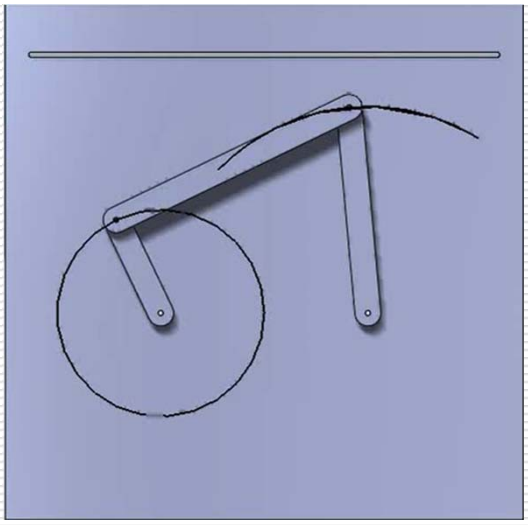
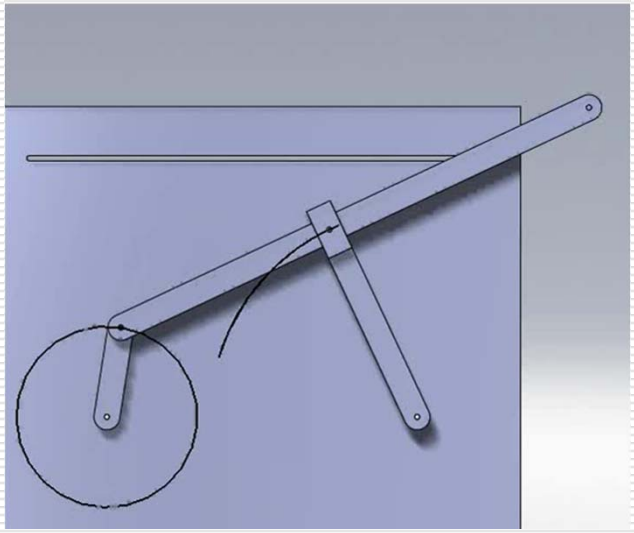
Mechanism Synthesis Rules

- Linkage Transformation Rules
- 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.

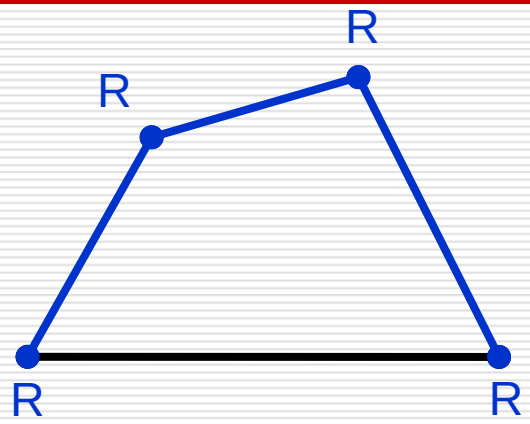


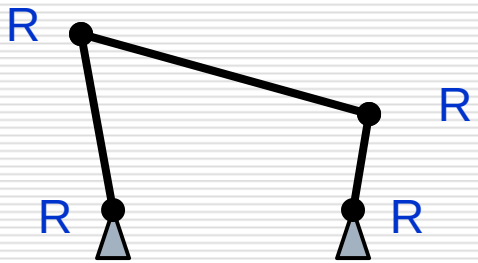


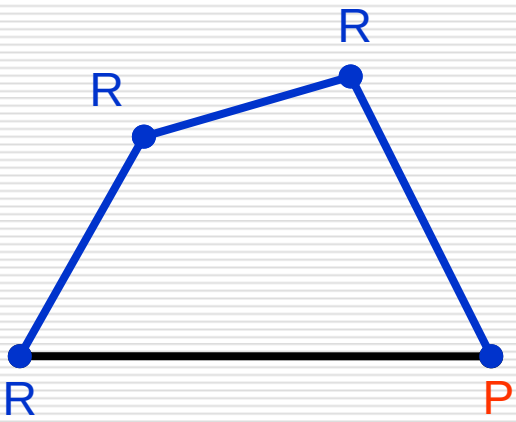
LINKAGE TRANSFORMATION
RULE 1: COROLLARIES

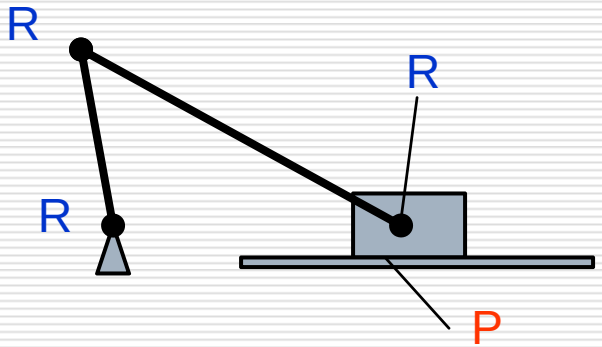
- A maximum of two revolute pairs may be replaced by two prism pairs in a given loop of a given loop of a linkage.
- The axes of substituted prism pairs must intersect one another.
- The axis of the prism pair must be either in the plane of the linkage or in a plane parallel to the plane of the linkage.

Substituting Prism Pairs in Place of Revolute Pairs

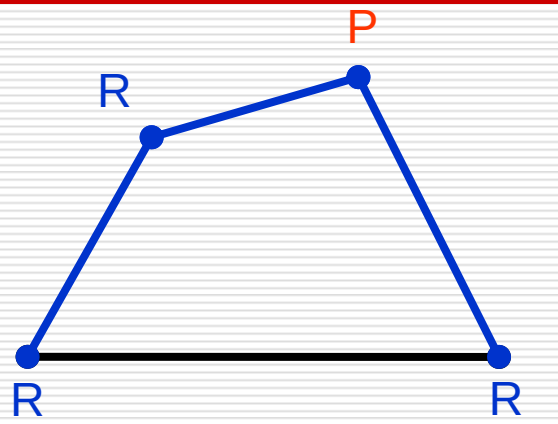


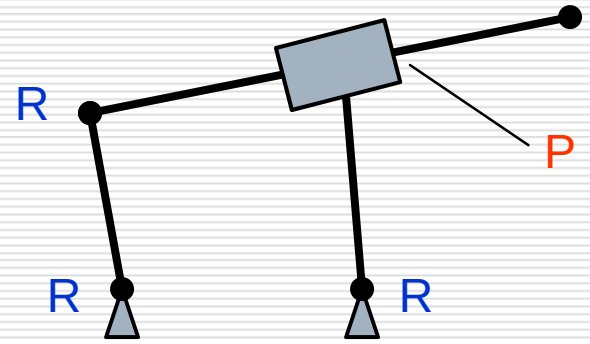


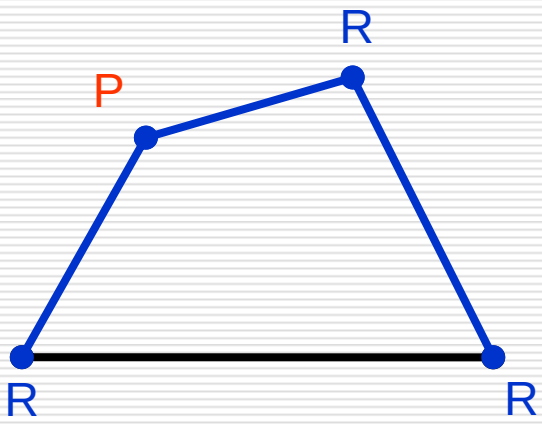


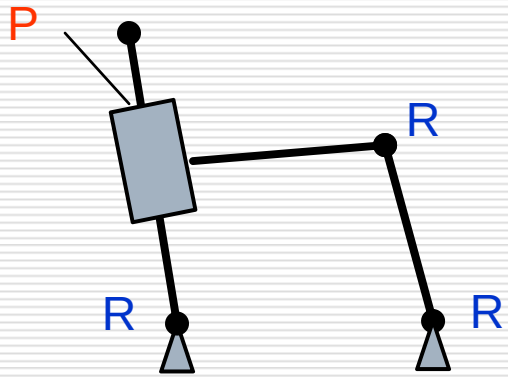


Any Revolute Pair can be Replaced by Prism Pairs

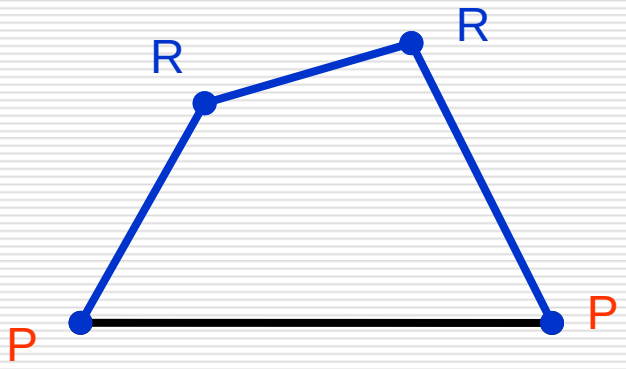


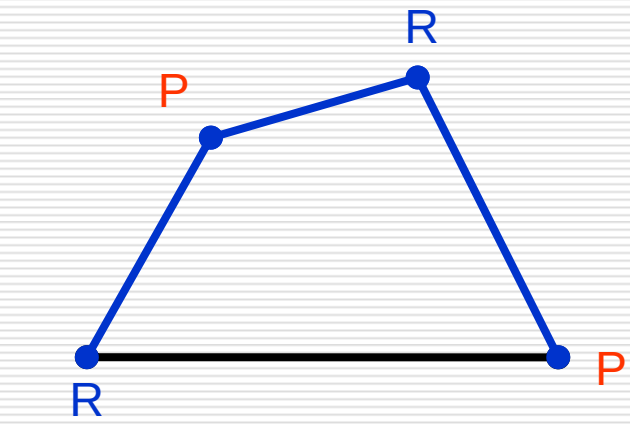


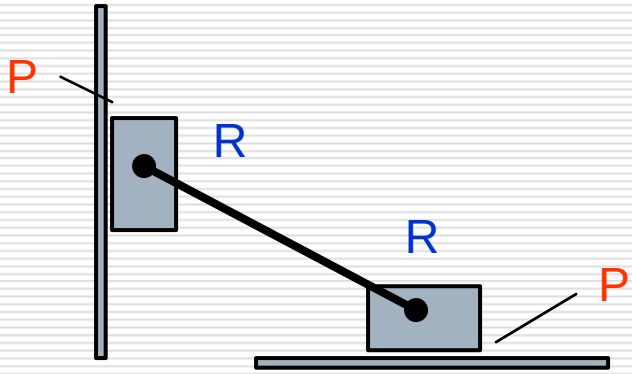


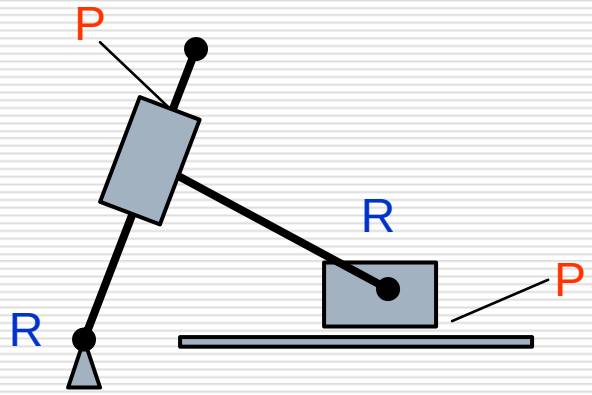


Substituting a Maximum of 2 Prism Pairs in Place of Revolute Pairs

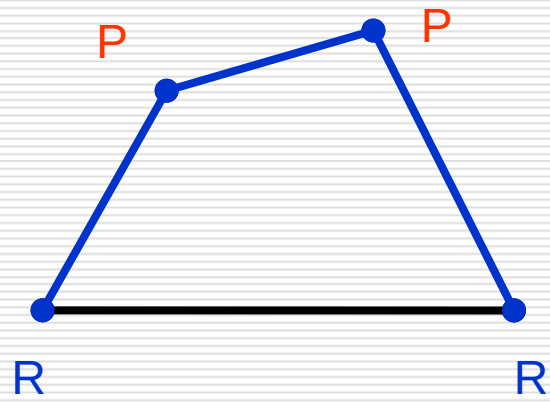


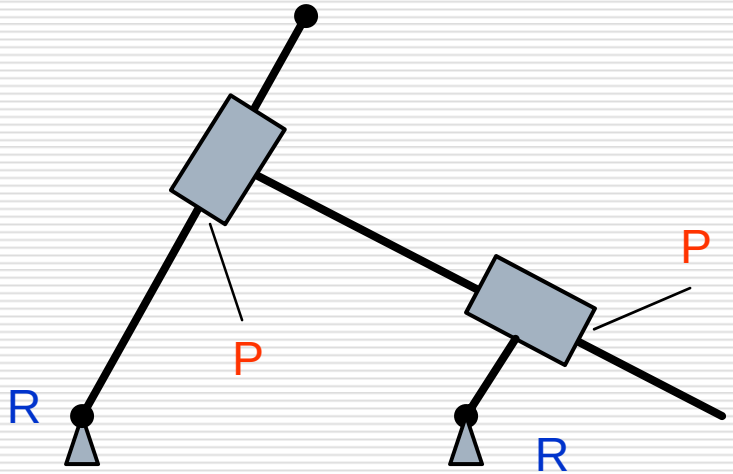






Any 2 Revolute Pairs can be Replaced by 2 Prism Pairs

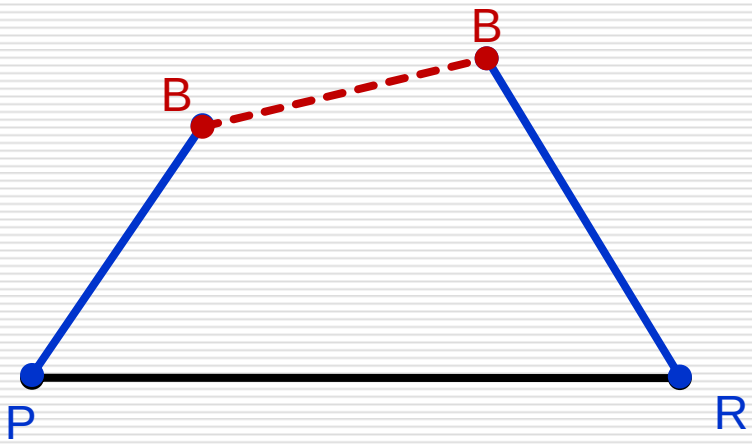


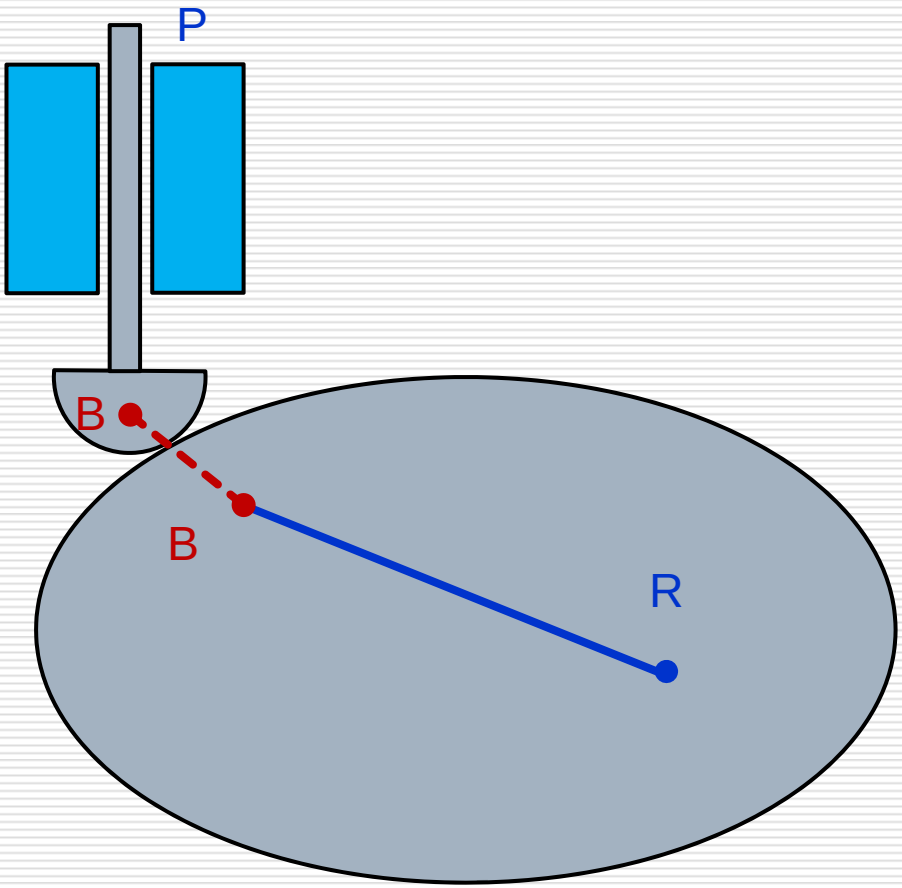


4 Bar Isomers Can Be Transformed To Other Mechanism

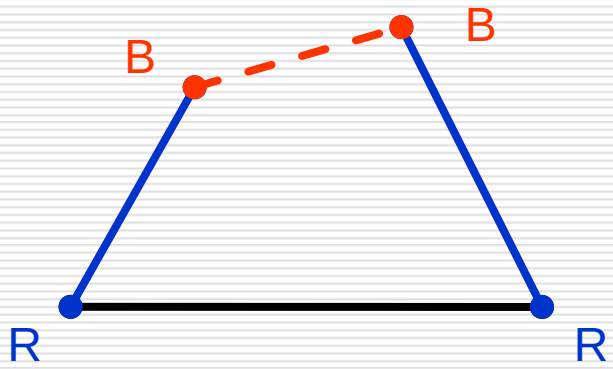
- Cam Pairs
  - R-R-B-B
  - R-P-B-B
- Gear Pairs
  - R-R-B-B

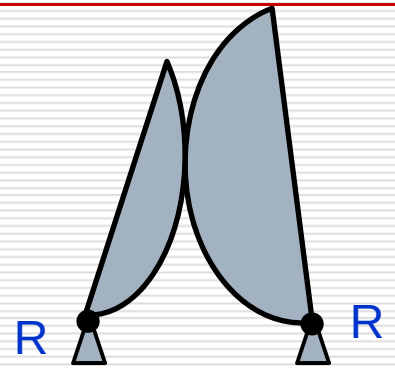
Cam Pairs (B-B) can be Substituted in Place of Revolute Pairs

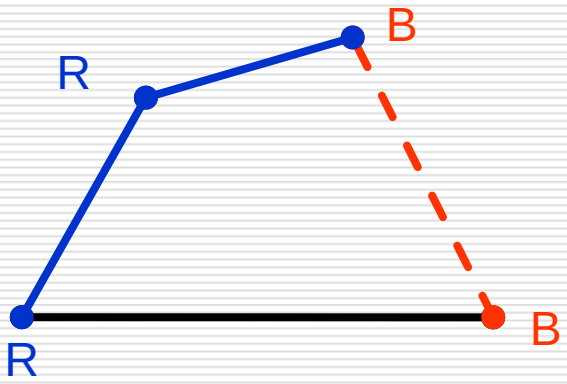


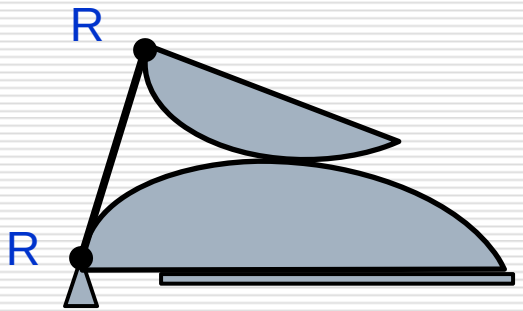


Substituting Cam Pairs in Place of Revolute Pairs

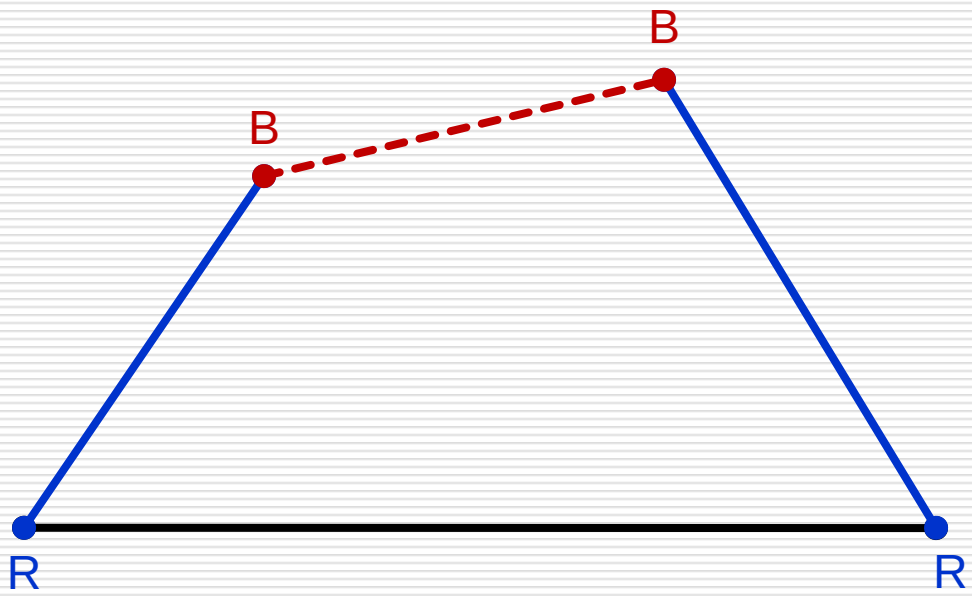


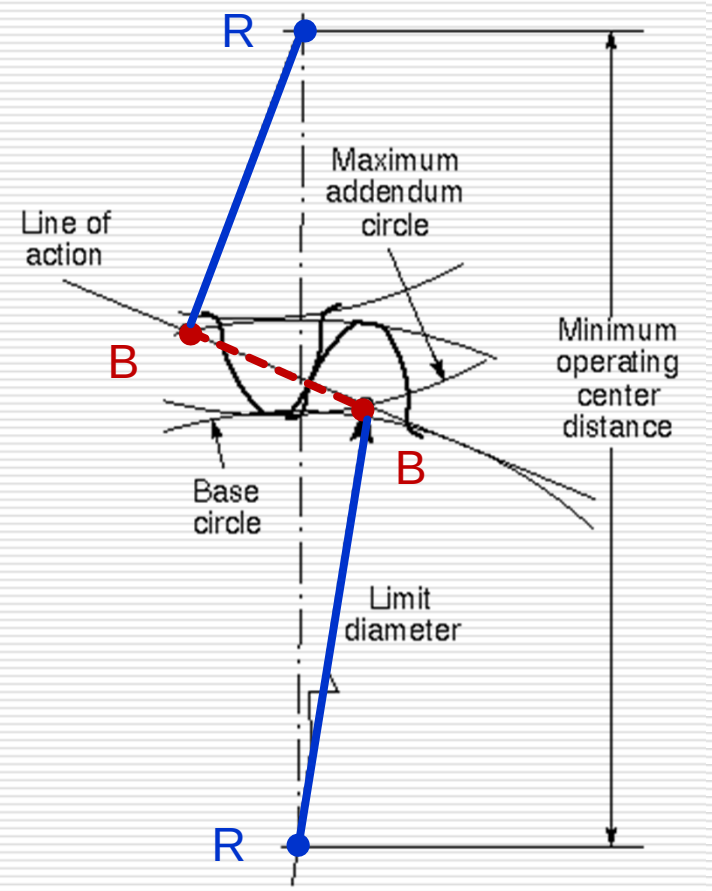






Gear Simulation





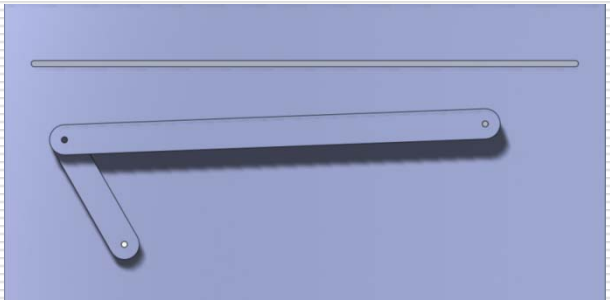
LINKAGE TRANSFORMATION

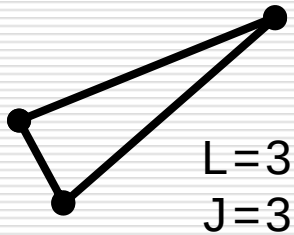
RULE 2

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

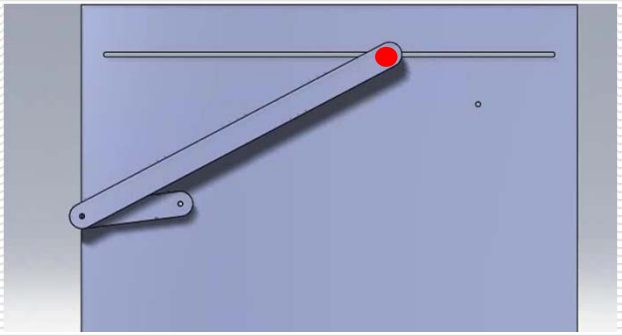
M=0

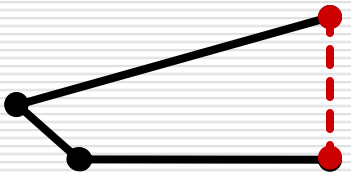




L=3
J=3

M=1



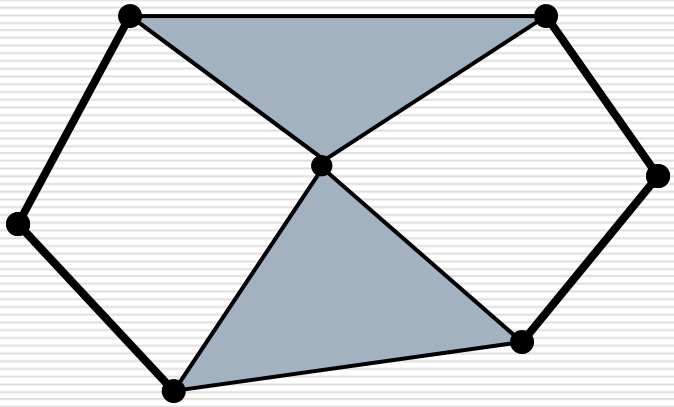


L=4
J=4

Rules for Transforming Linkages With Higher Order Elements

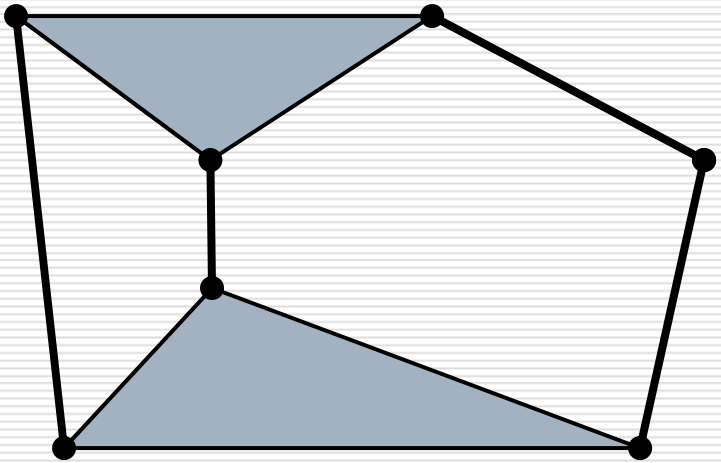
M	L	B	T	Q	P	Designation
+1	6	4	2	0	0	II

Watt's Linkage



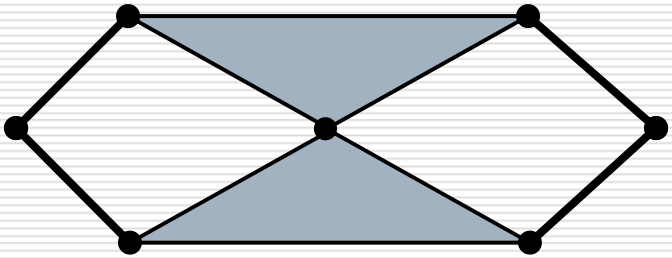
1

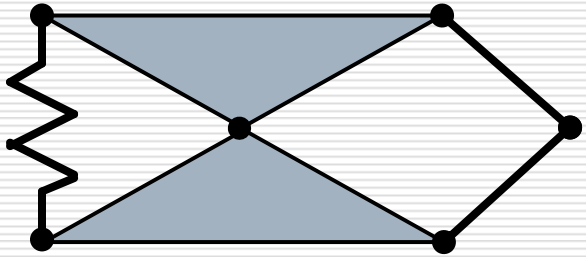
Stephenson's Linkage

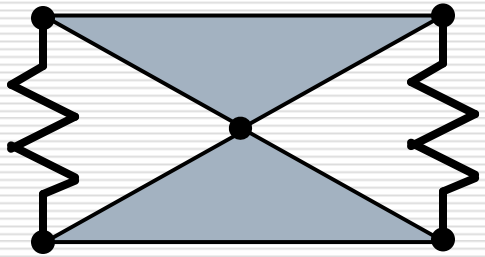


2

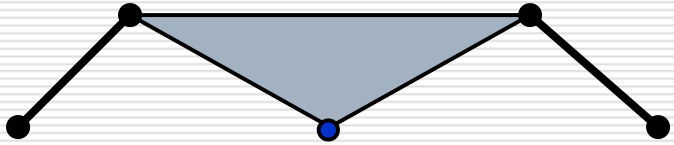
Substituting a Spring in Place of a Revolute Pair and Two Binary Links

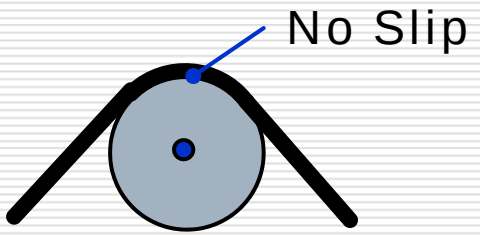


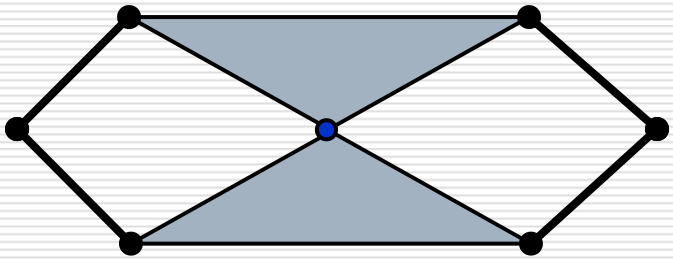


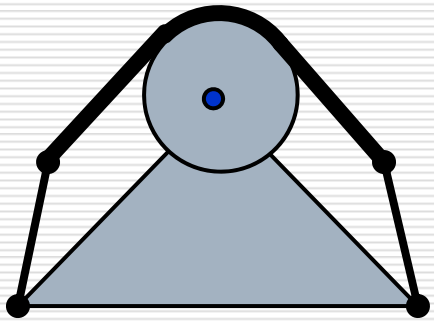


Belt and Pulley Combinations in Place of Revolute Pairs, Two Binary Links, and a Ternary Link





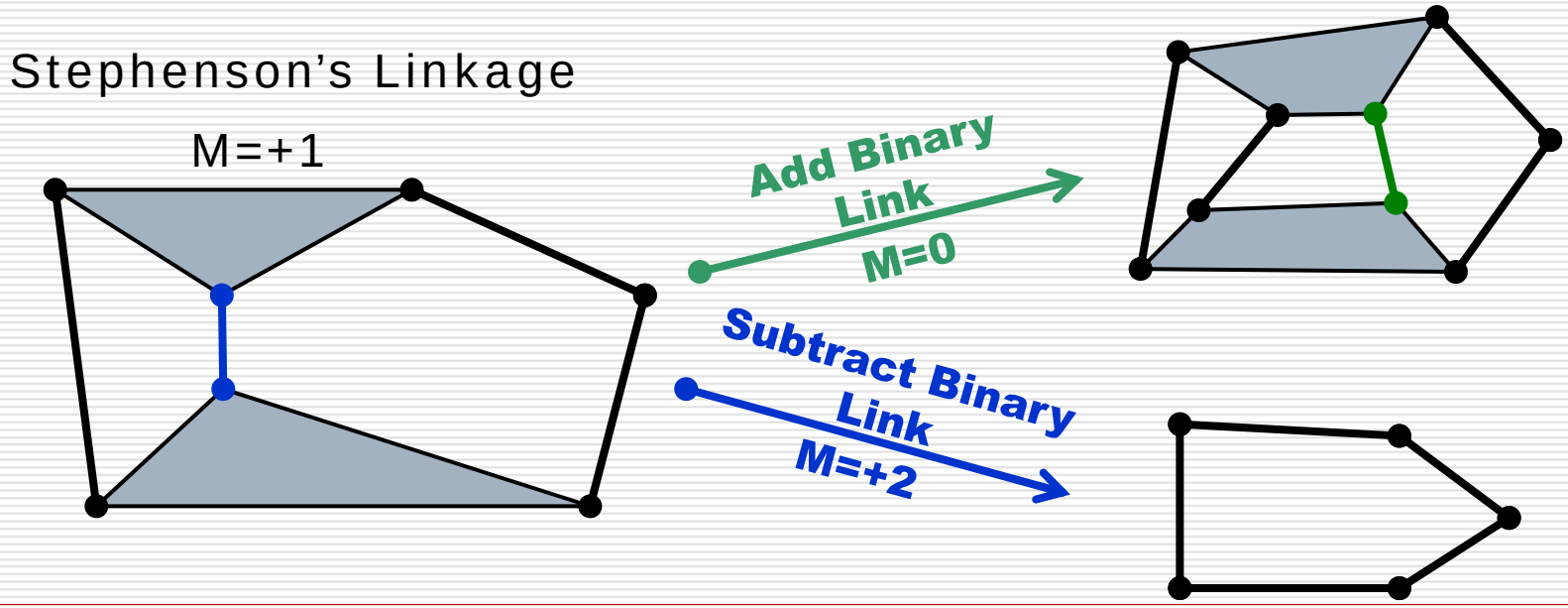




LINKAGE TRANSFORMATION
RULE 3

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)

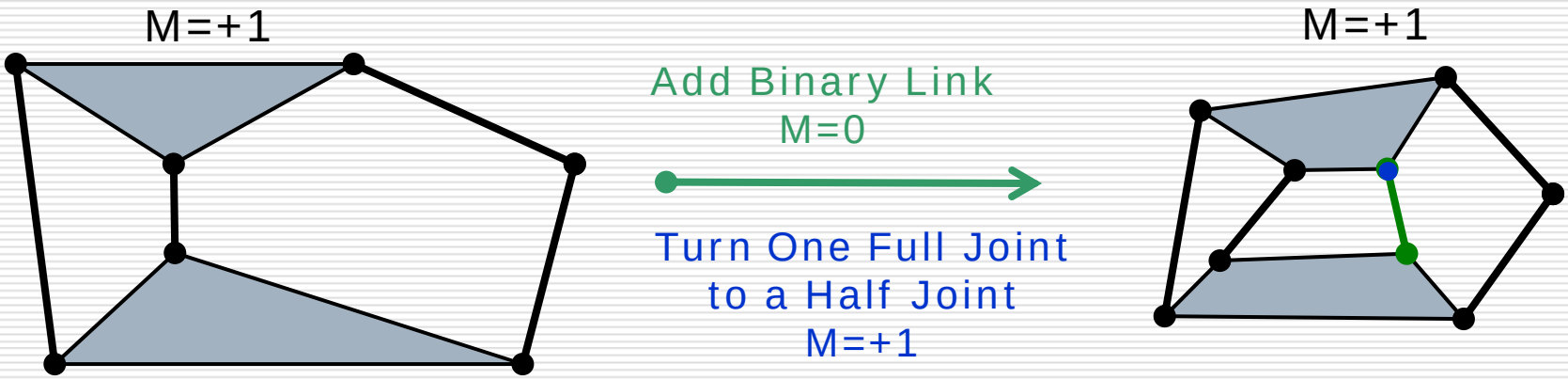
a. This rule adds one link and two joint to the system



LINKAGE TRANSFORMATION
RULE 4

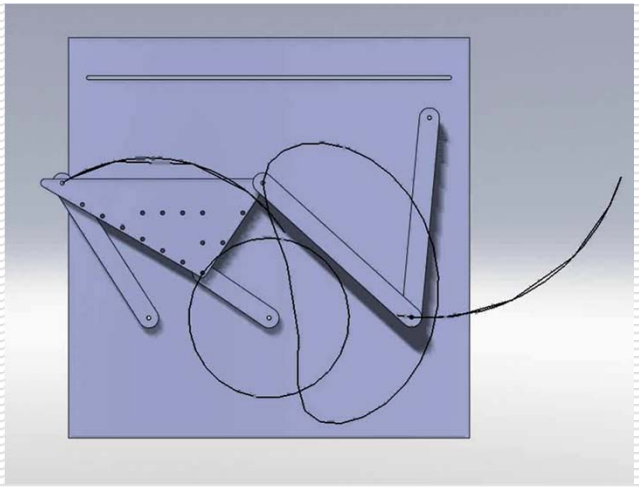
The Combination of rules 2 and 3 (Addition) above will keep the original DOF unchanged

Stephenson's Linkage



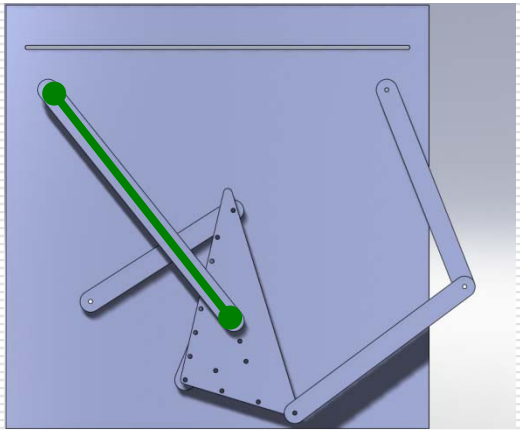
Simulation of Rule 4

Stephenson's Linkage
M=+1

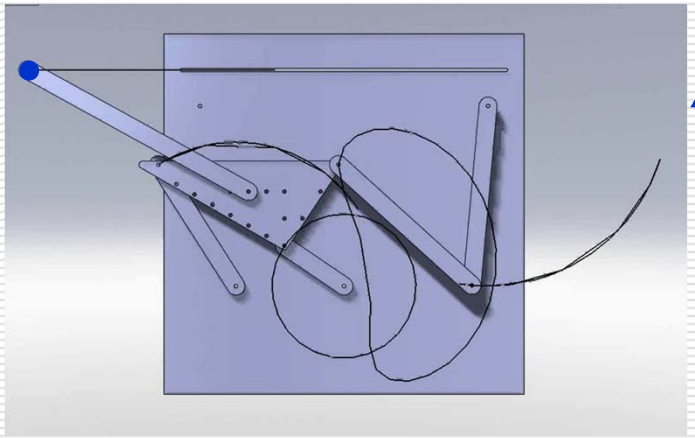


Add Binary Link
-1 DoF

M=0



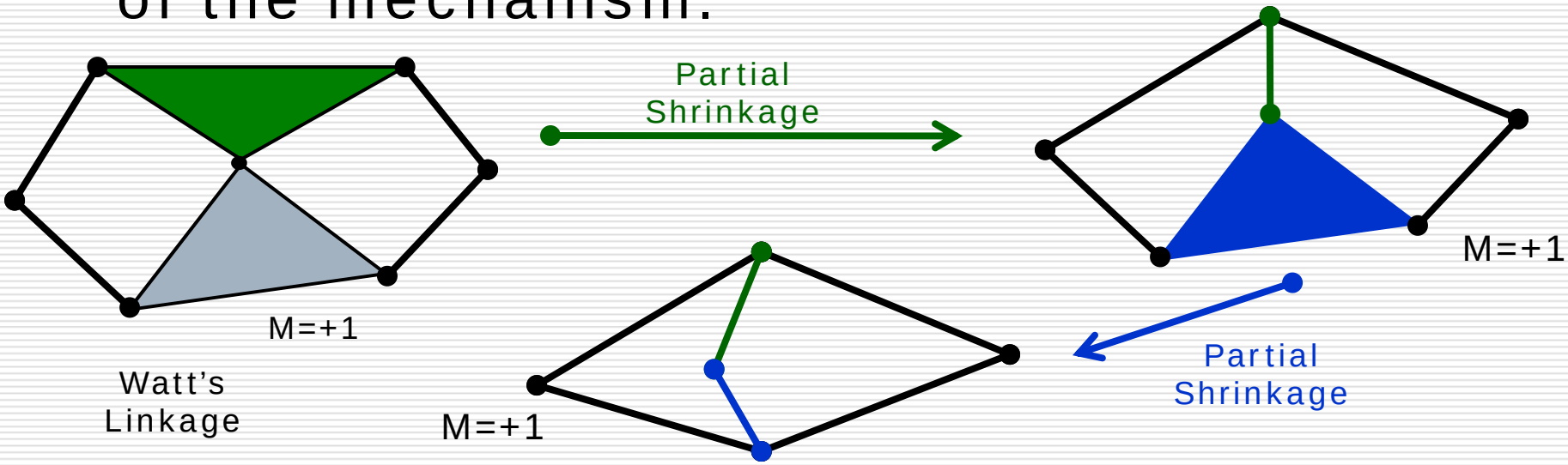
Turn One Full Joint
to a Half Joint
+1 DoF



M=+1

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.