

INTRODUCTION TO MECHANISM SYNTHESIS

- **Mechanics Place in Science**
- **Mechanisms and Structures**
- **Number Synthesis**

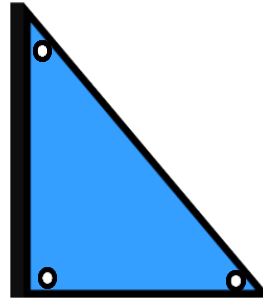
A Link Is A Rigid Body Having Two or More Nodes



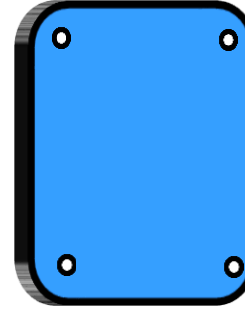
Unary



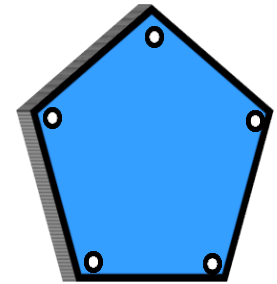
Binary



Ternary



Quaternary



Pentagonal

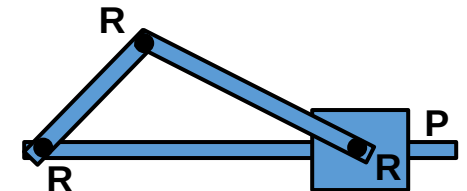
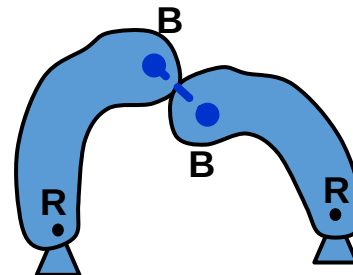
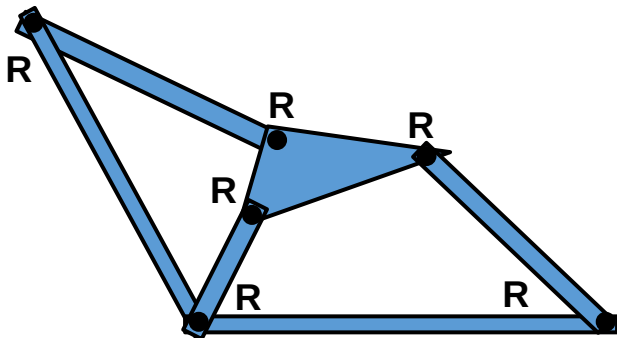
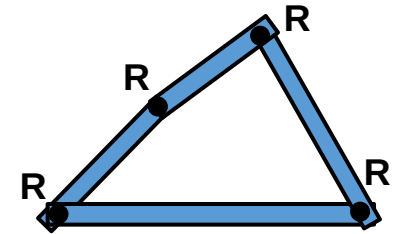
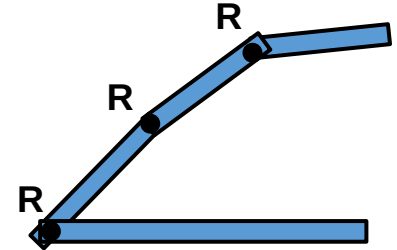
Nodes/Pairing Elements: Points at which links can be attached. The order of the link is determined by the attachments used.

Joints/Kinematic Pairs: Allows relative motion between links.

Joint Classes: a kinematic pair is of the j^{th} class if it diminishes the relative motion of linked bodies by j Degrees of Freedom (DoF)

Kinematic Chains are Formed by Connecting Links with Pairs

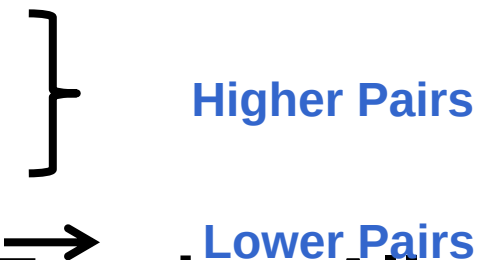
- **Open Kinematic Chain:** A chain with one or more open loops.
- **Closed Kinematic Chain:** A chain that forms one or more closed loops.
- **Simple-Closed Chain:** Chain consisting of entirely binary links and is closed.
- **Compound Closed Chain:** Chain including other than binary links that is closed.
- **Mechanism:** A kinematic chain with one link grounded.



RBB

RBB

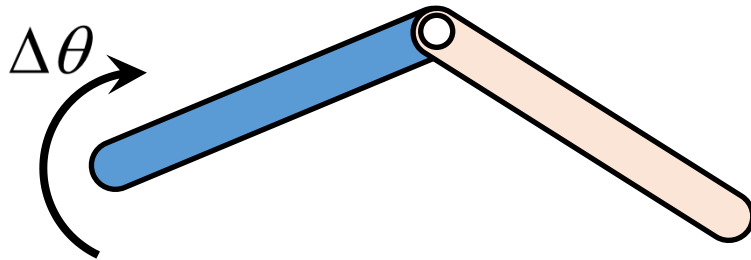
Joint Classification, Kinematic Pairs

- **Type of contact between elements**
 - Line
 - Point
 - Surface

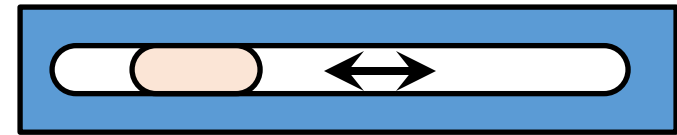
Higher Pairs

Lower Pairs
- **Degrees of Freedom Allowed**
- **Type of Physical Closure**
 - Force
 - Form
- **Number of Links Joined (Order)**

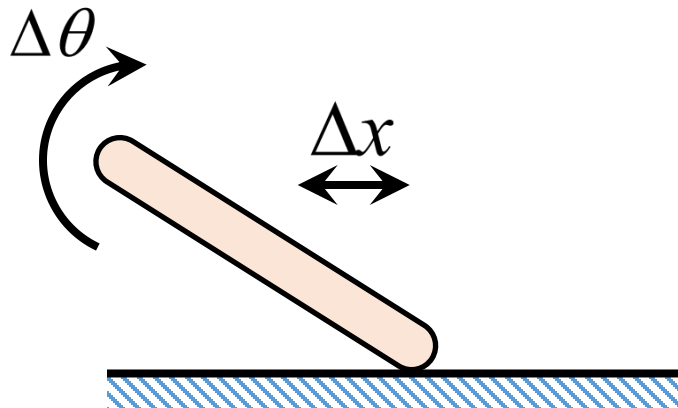
Joint Closure Classified as Lower Pairs and Higher Pairs



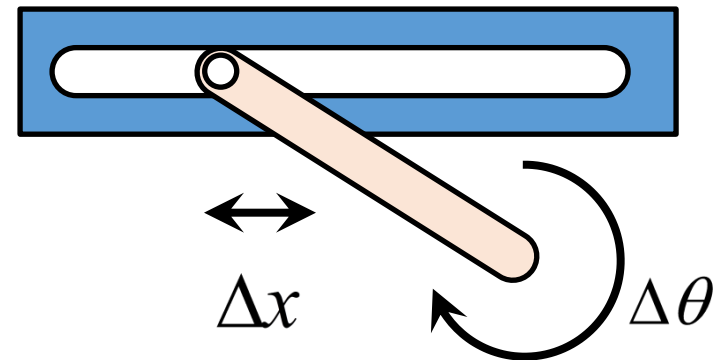
Form Closed, Rotating FULL Pin Joint



Form Closed, Translating FULL Slider Joint



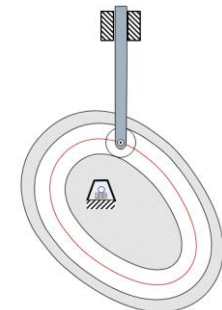
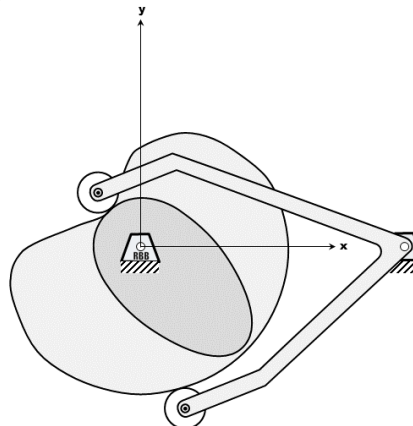
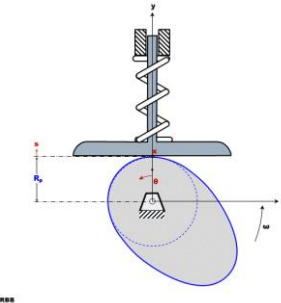
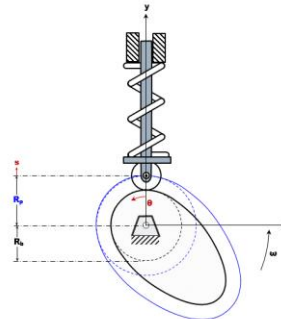
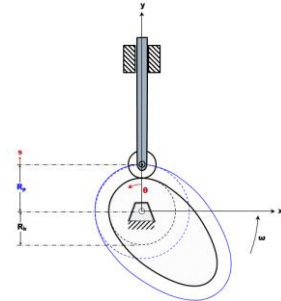
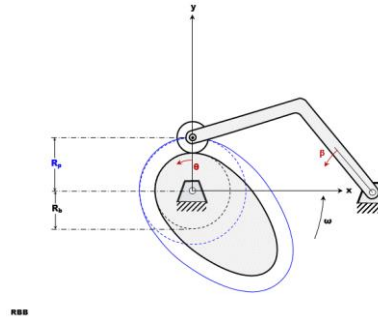
Force Closed,
Link against a plane HALF Joint



Form Closed,
Pin in Slot HALF Joint

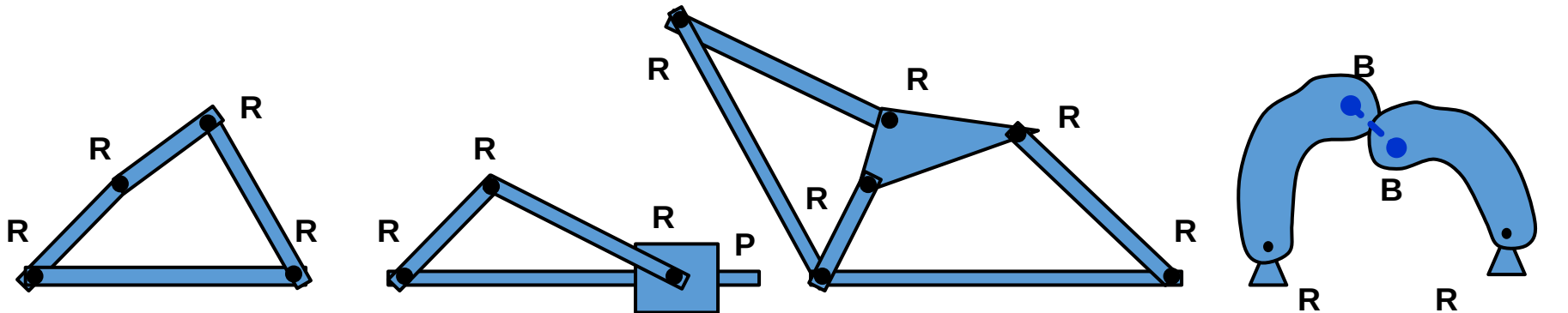
For All CAMs The Follower Must Be Constrained

- Gravity constraint
- Spring constraint
- Positive mechanical constraint
 - Conjugate
 - Geometric Form Closed



Degrees of Freedom or Mobility

- The number of inputs needed in order to create a predictable output
- The number of independent coordinates required to define its position

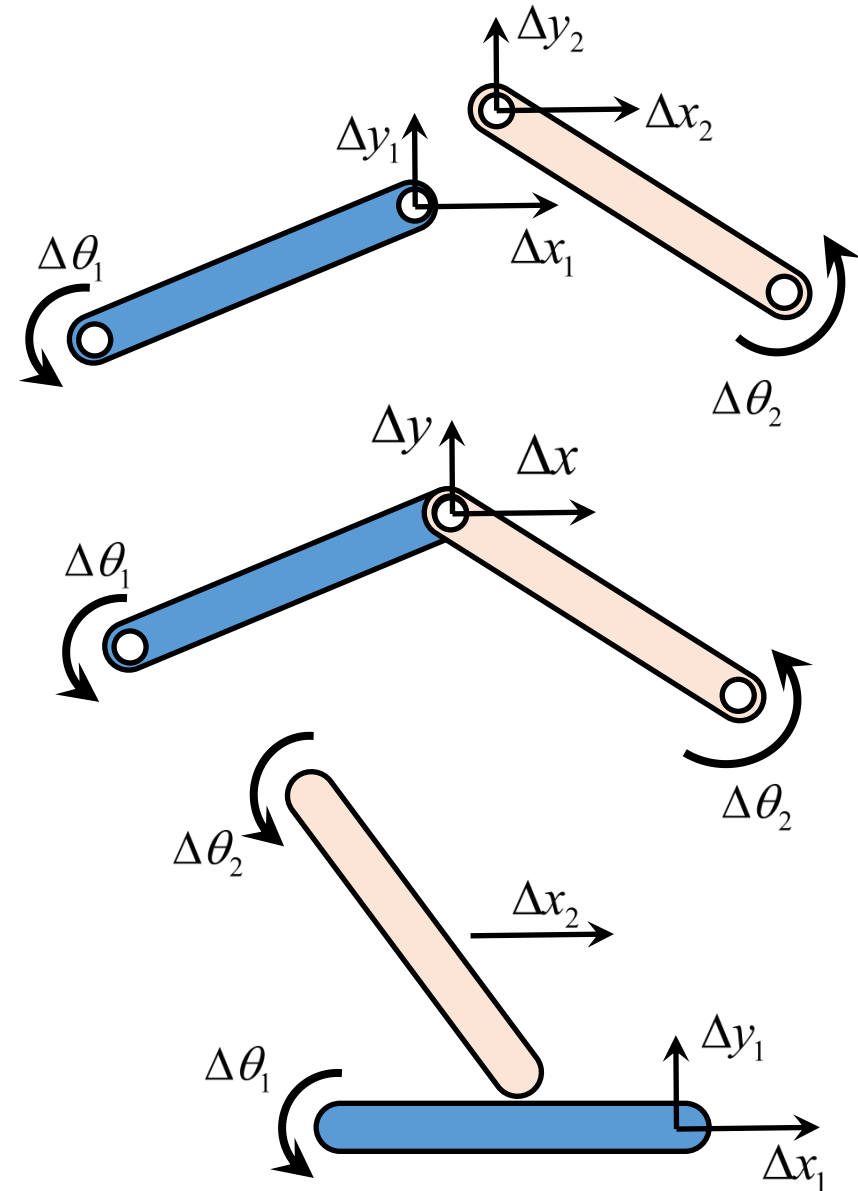


RBB

RBB

Planar Mechanisms

- Each link has 3 DoF when moving relative to a *fixed link*
- n link planar mechanism (*one link is considered FIXED*) has $3(n-1)$ degrees of freedom before joints are connected
- Connecting a revolute pair
 - 1 DoF $\rightarrow$ 2 constraints
 - 2 DoF $\rightarrow$ 1 constraint
- Mobility of Mechanism
 - Constraints of all joints minus total DoF of unconnected links



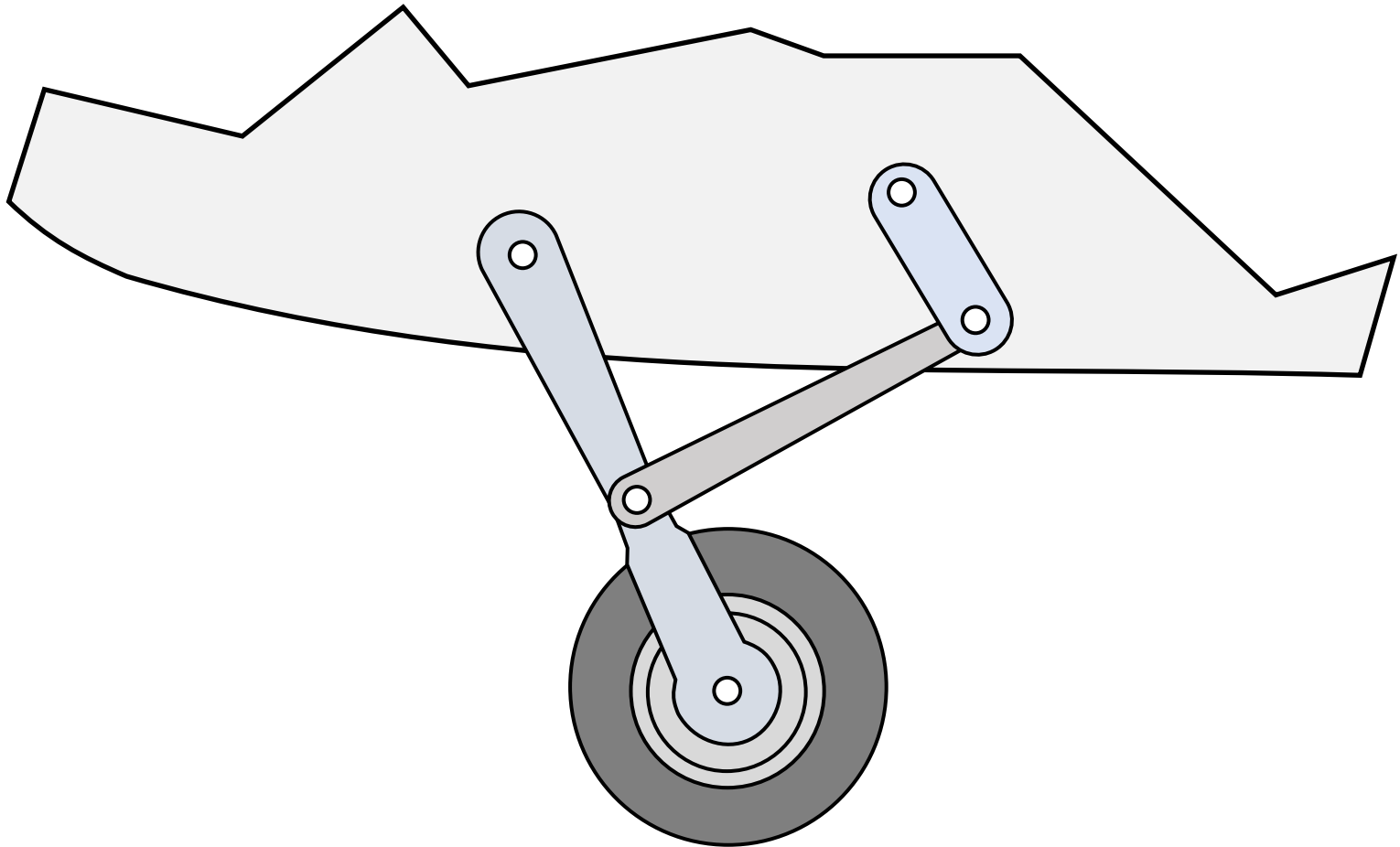
Mobility Calculation

- **L**- number of links
- **M**- mobility of planar n-link mechanism
- **j₁**- number of 1 DoF pairs
- **j₂**- number of 2 DoF pairs

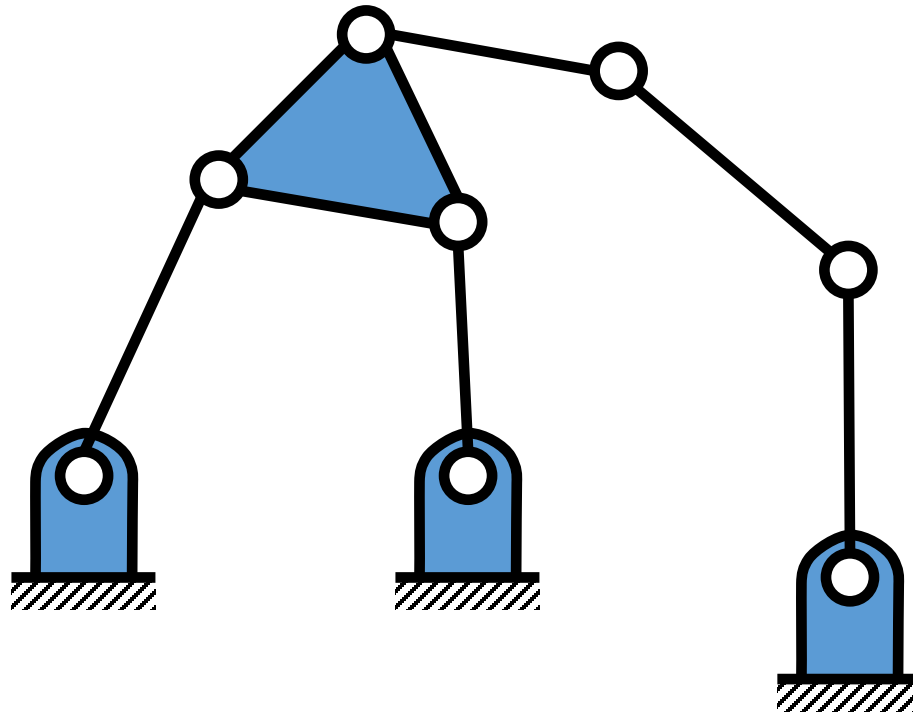
- **Kutzbach Criterion**
 - $M = 3 \cdot (L - 1) - 2 \cdot j_1 - j_2$

- **Grübler Criterion**
 - $M = 3 \cdot (L - 1) - 2 \cdot j_1$

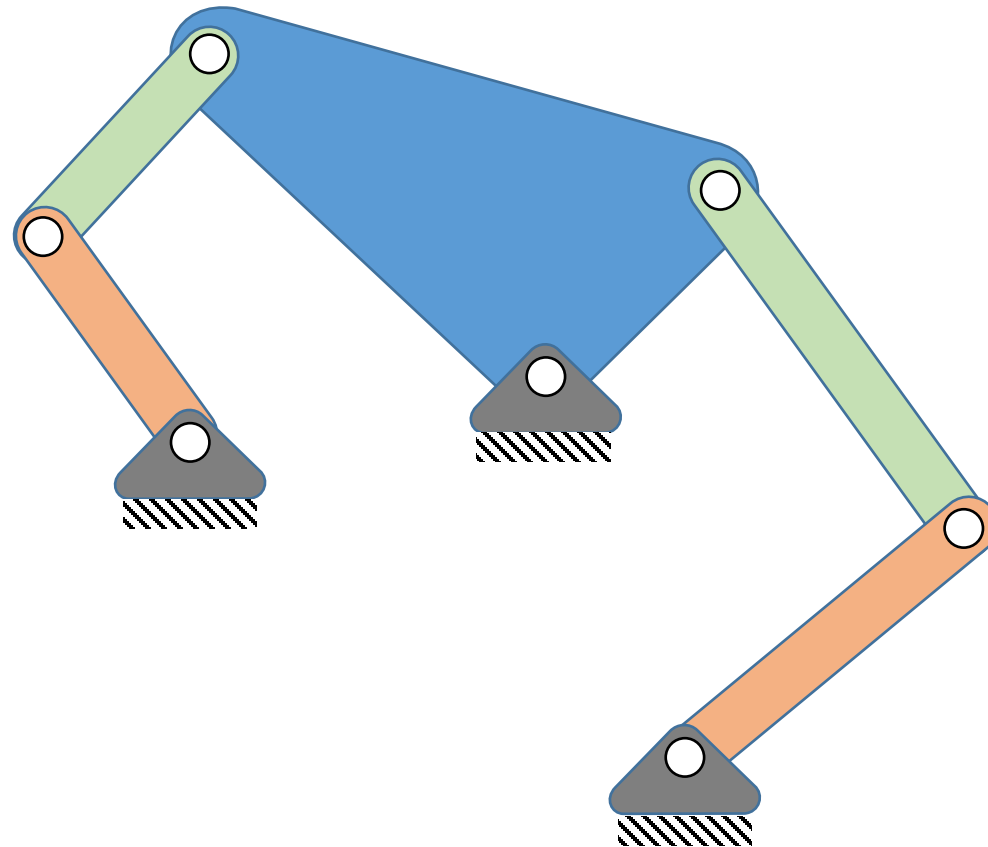
Example 1



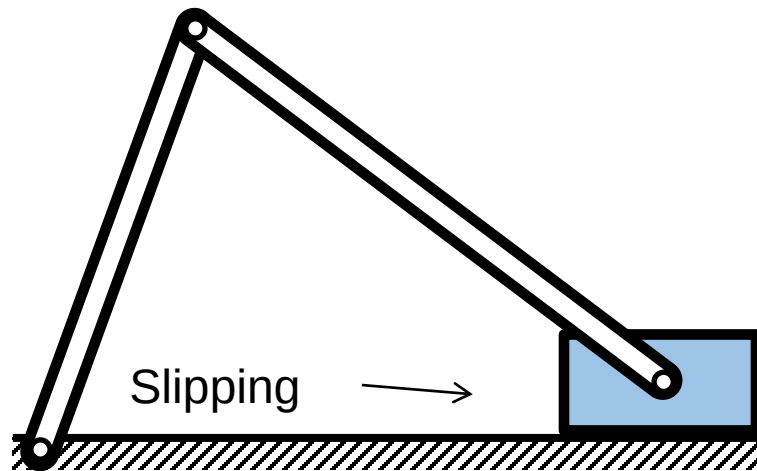
Example 2



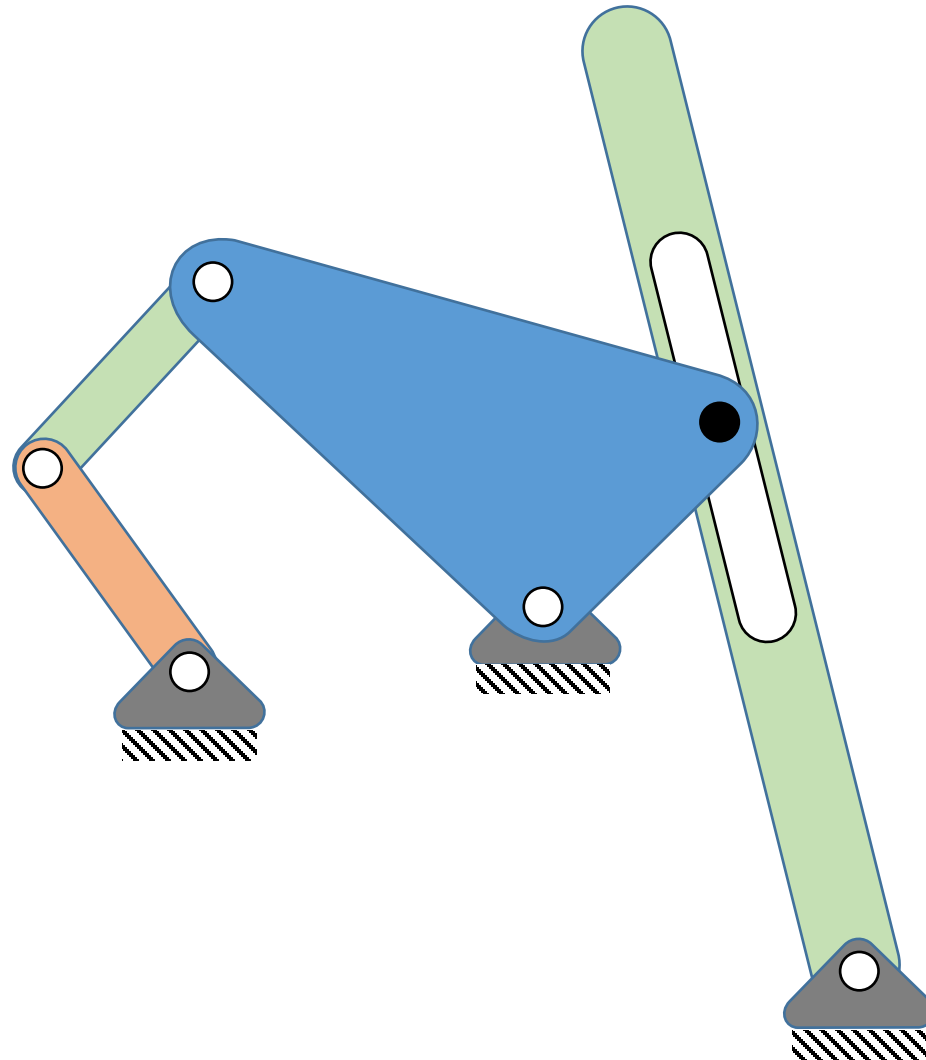
Example 3



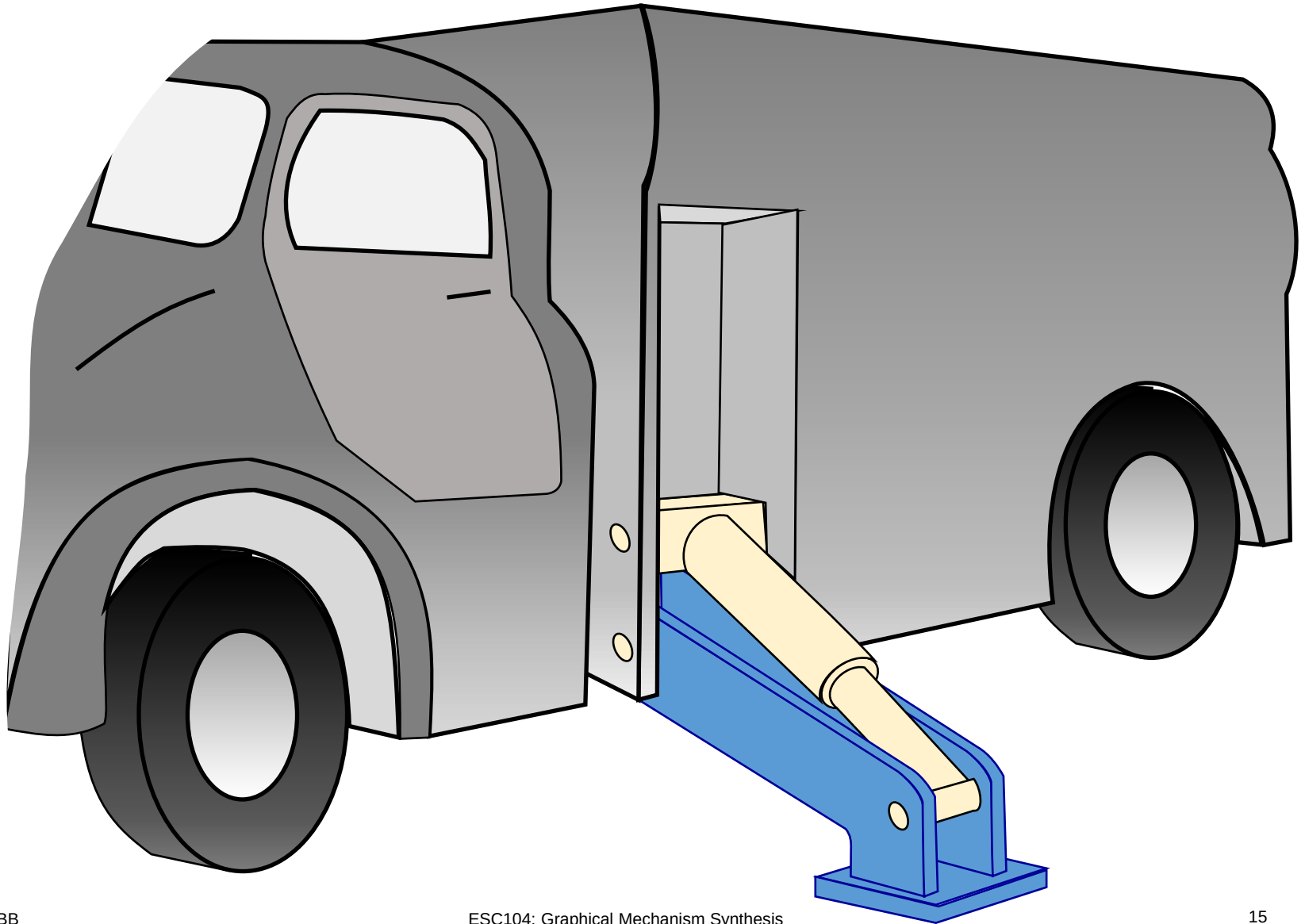
Example 4



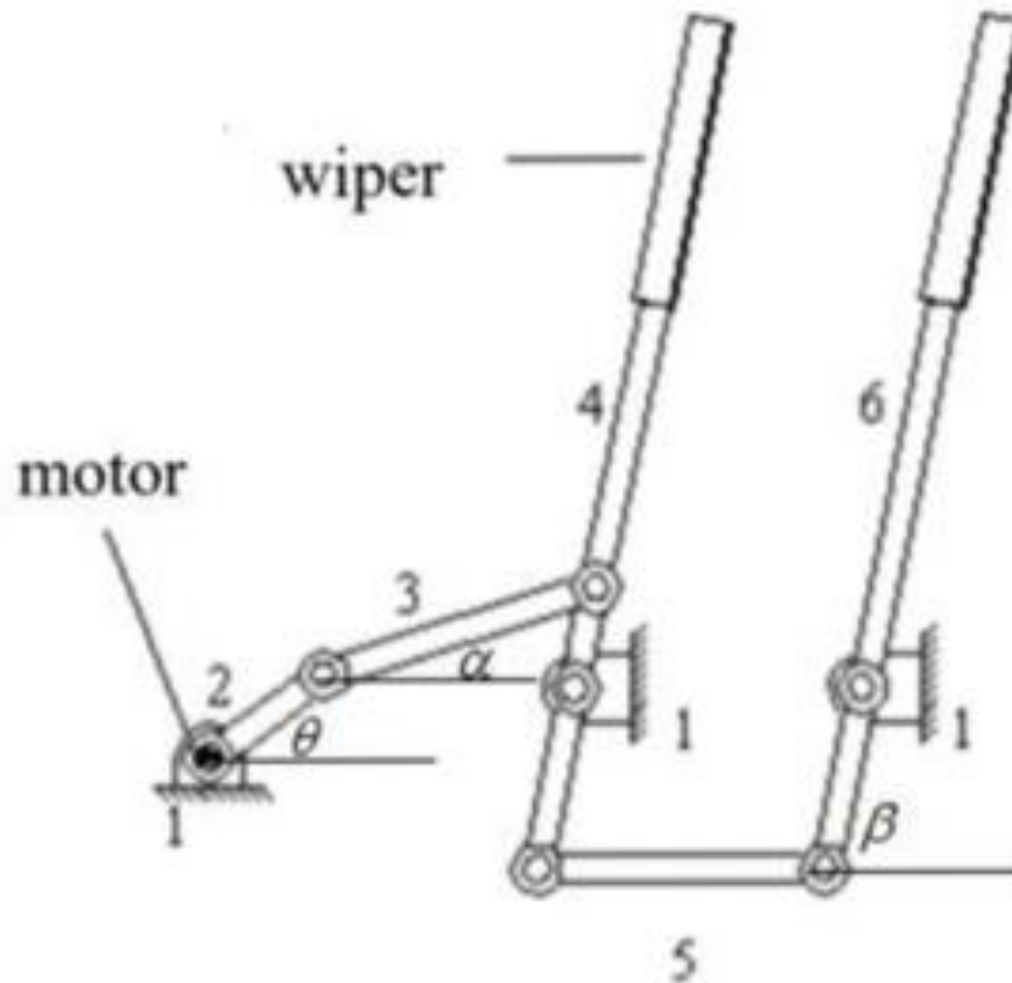
Example 5



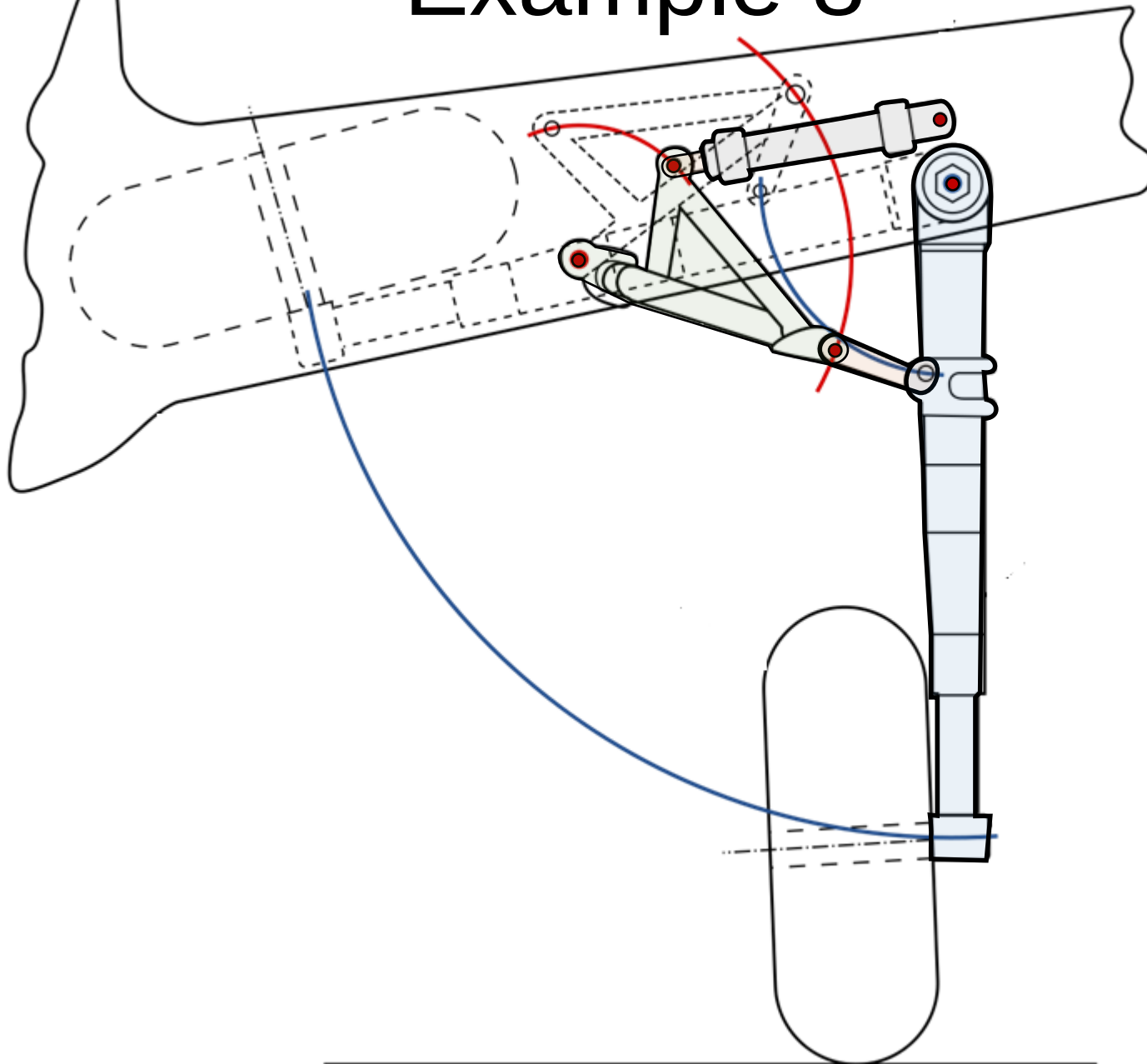
Example 6



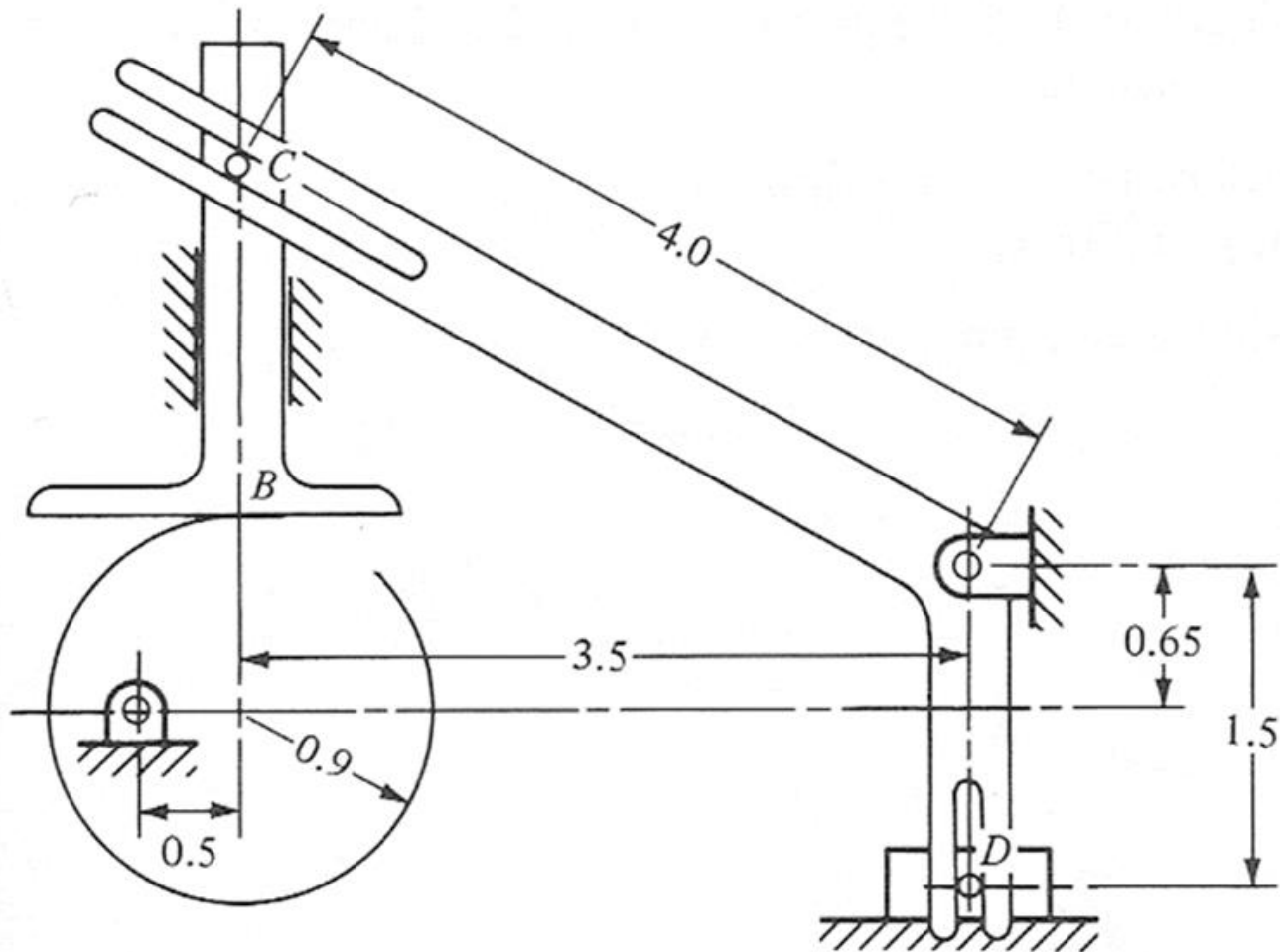
Example 7



Example 8

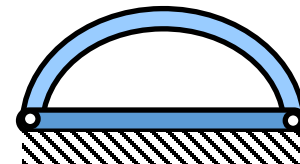
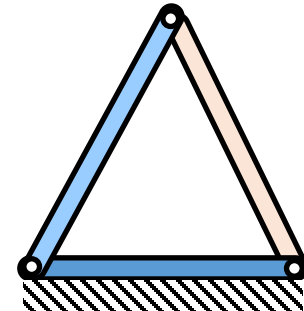
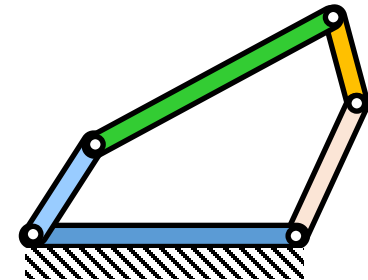
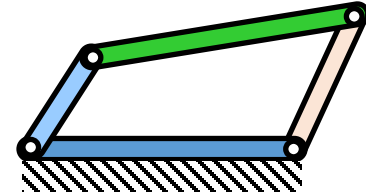


Example 9



Mobility Criterion: Kutzbach or Gruebler

- $M=1$
 - Mechanism can be driven by a single input direction
- $M=2$
 - Two separate input motions are necessary to produce constrained motion for the mechanism
 - Differential Mechanism
- $M=0$
 - Motion is impossible and the mechanism is a structure
 - Exact Constraint
- $M=-1$
 - Redundant constraint
 - Pre-Load



Example: Calculate the Mobility

