

Degrees of Freedom: Examples

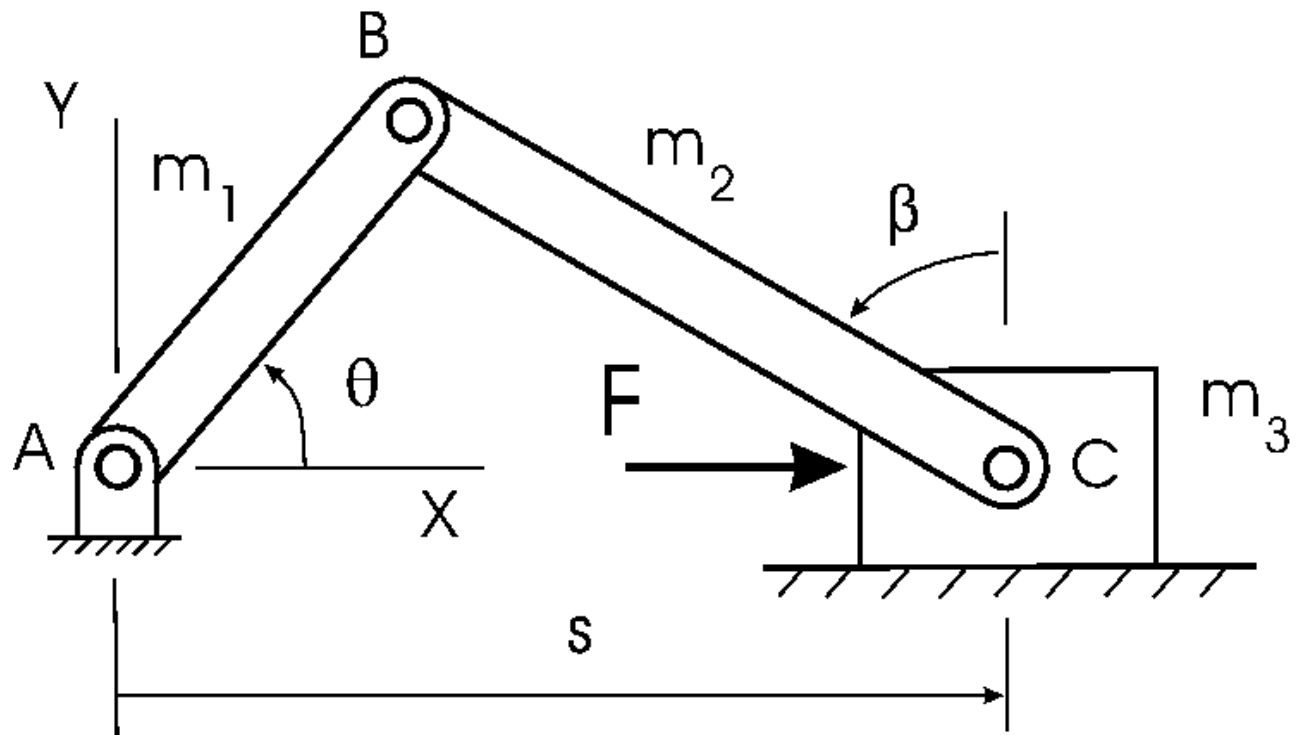
Prof. John McPhee
Systems Design Engineering
University of Waterloo, Canada

Degrees of Freedom:

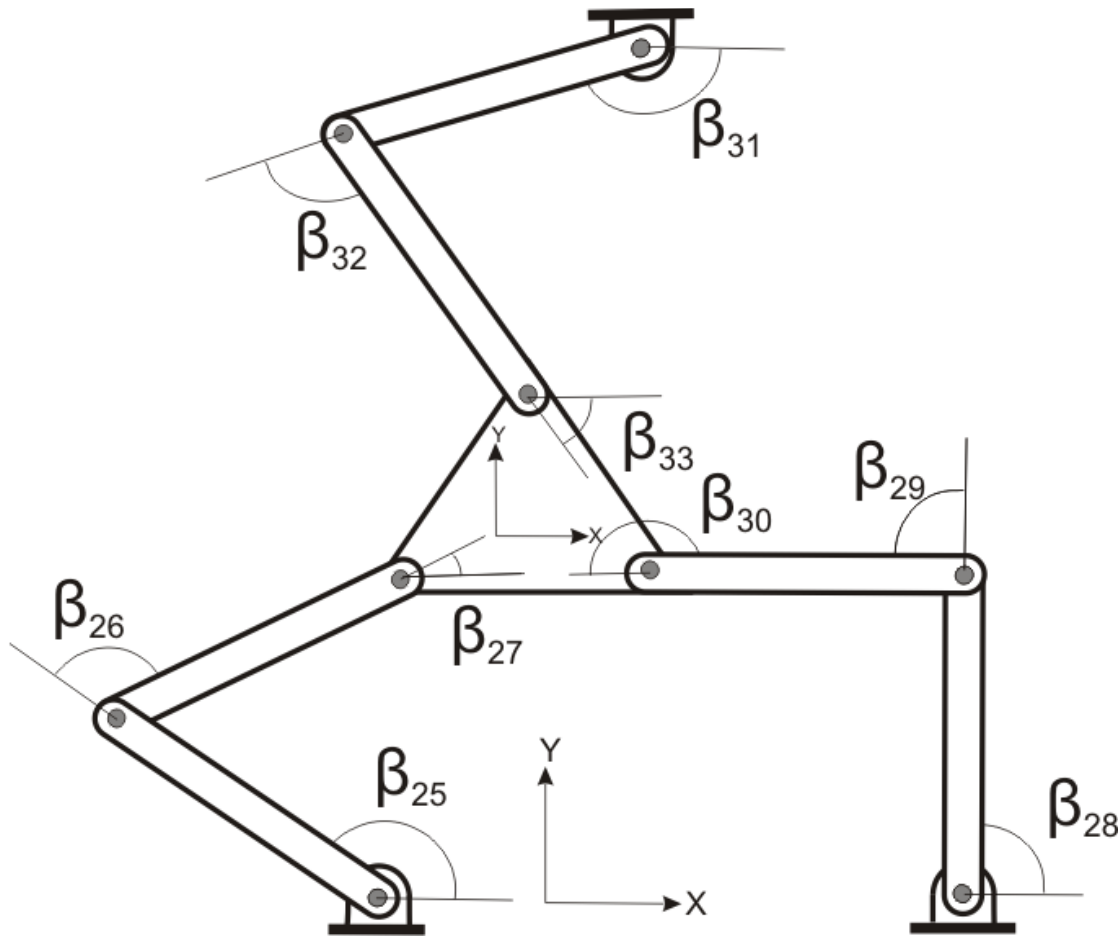
$$f = n - m$$

- n = number of coordinates
- m = number of independent constraint equations that relate the coordinates
- Grubler's equation is a special case for 2D pin-connected linkages:

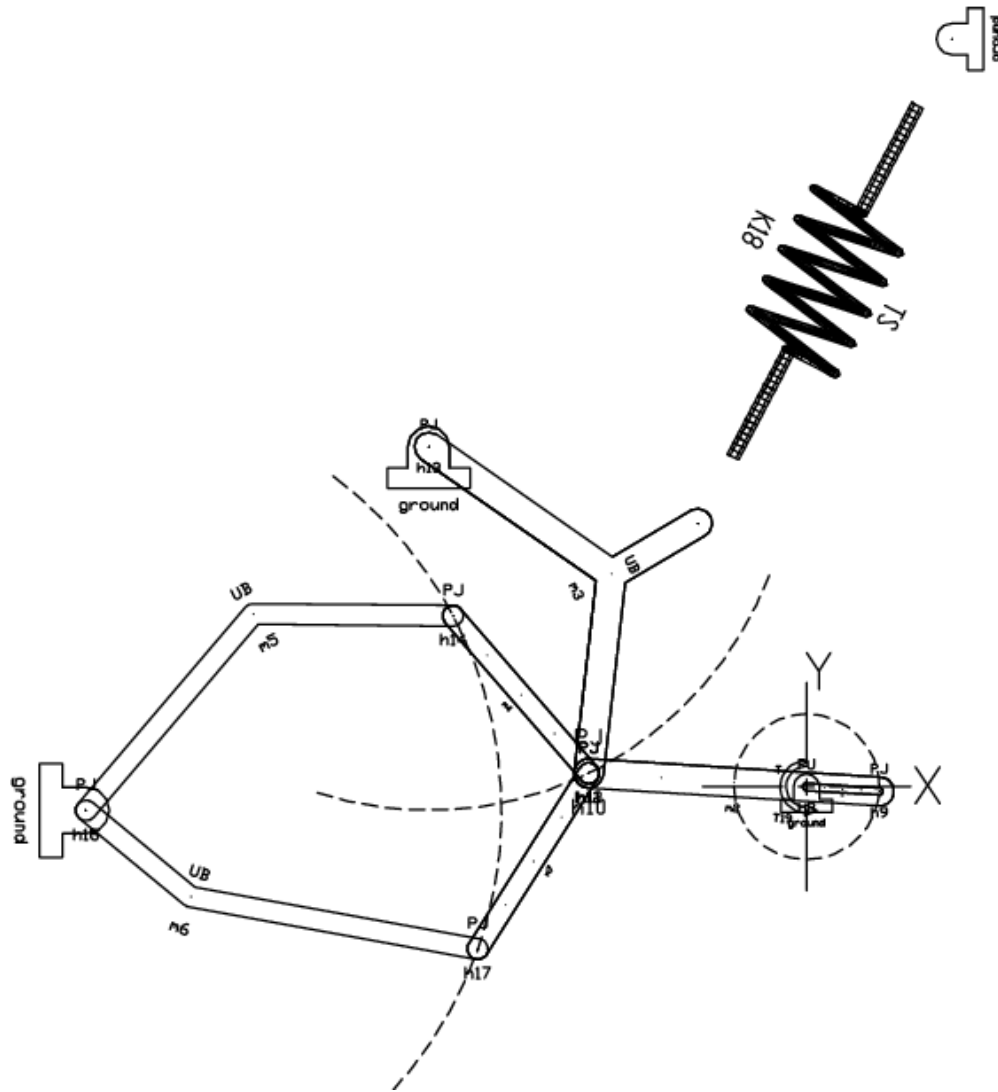
$$f = 3n_{bodies} - 2n_{joints}$$



Planar slider-crank mechanism ($f=1$)

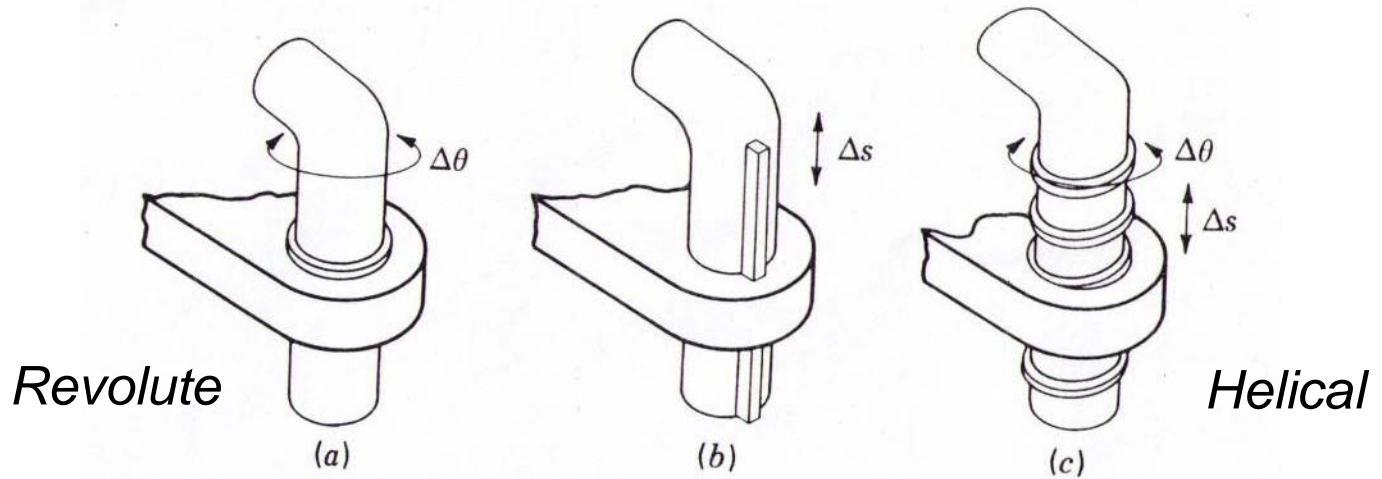


2D planar parallel robot ($f=3$)

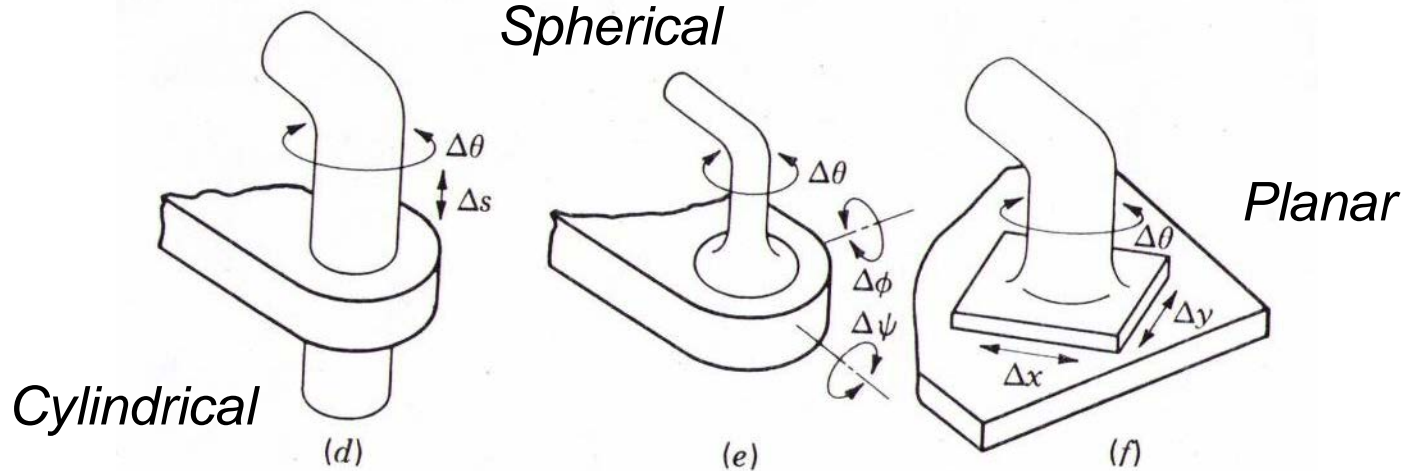


7-link “squeezer” mechanism ($f=1$)

Prismatic

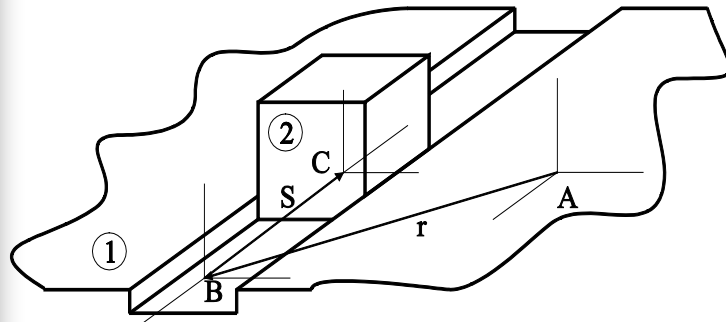


Spherical

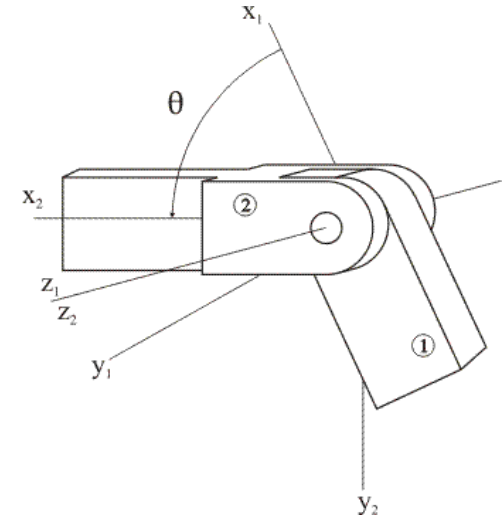


3D lower kinematic pairs

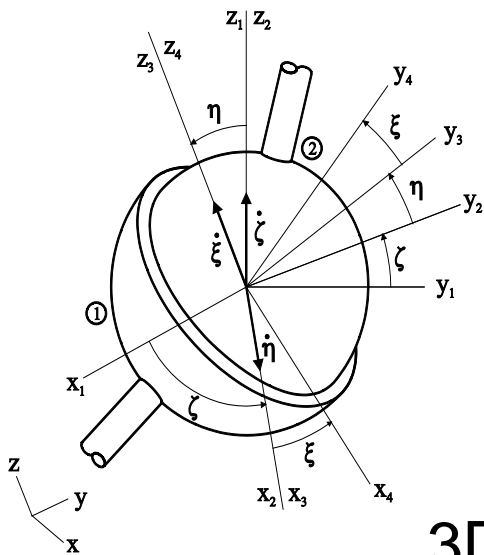
Prismatic joint ($m=5$)



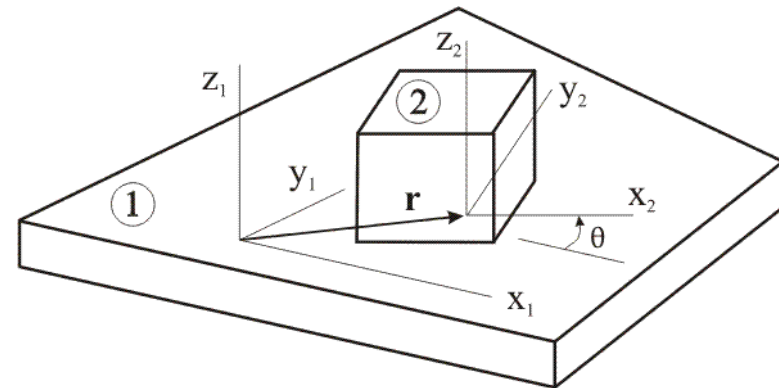
Revolute joint ($m=5$)



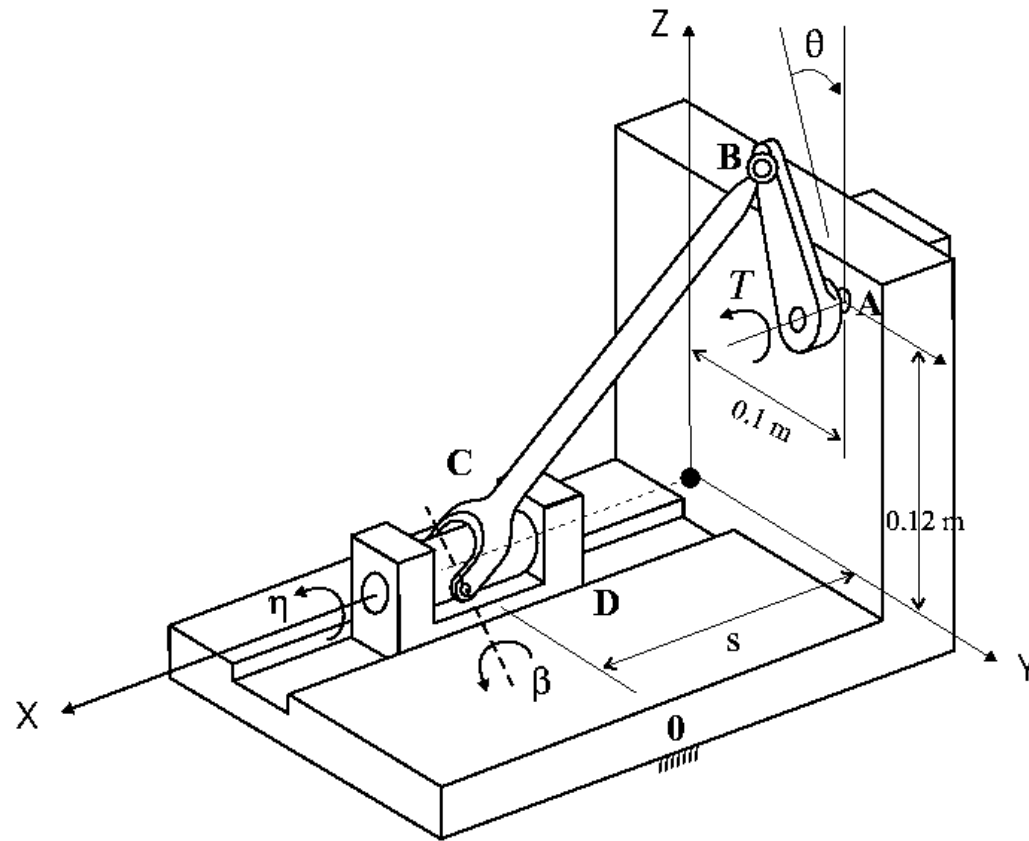
Spherical joint ($m=3$)



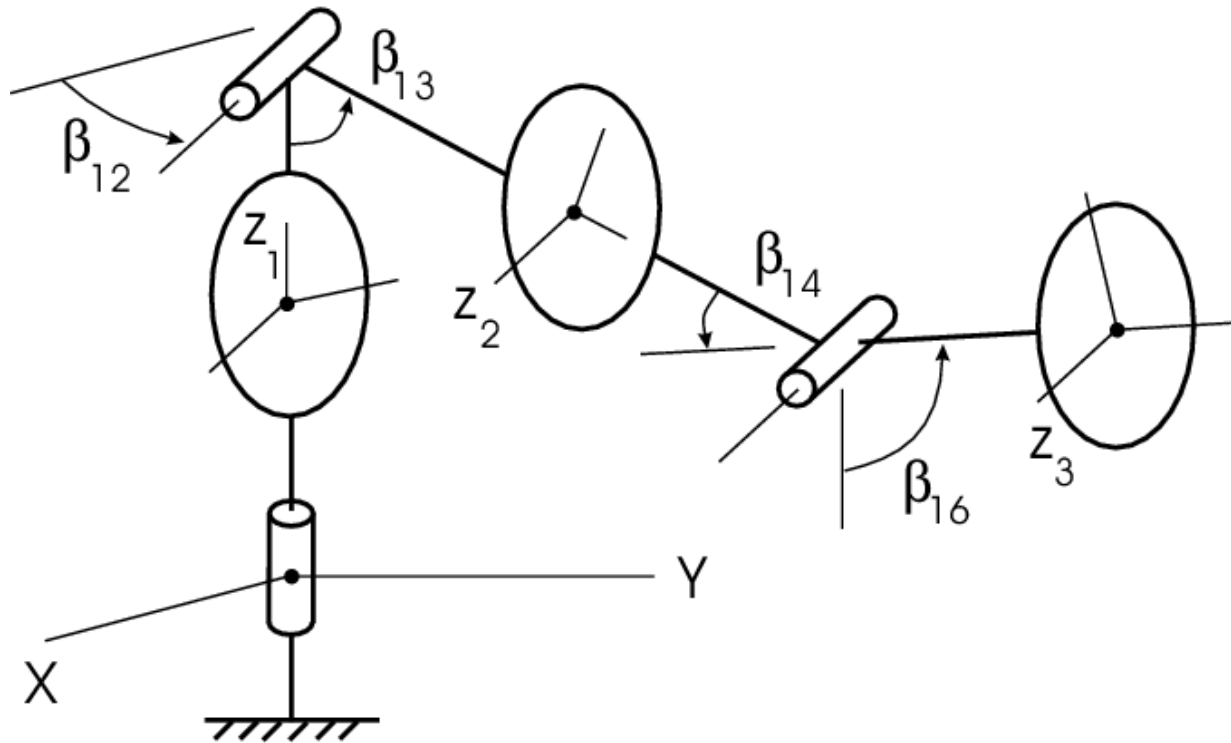
Planar joint ($m=3$)



3D lower kinematic pairs



Spatial slider-crank mechanism ($f=1$)

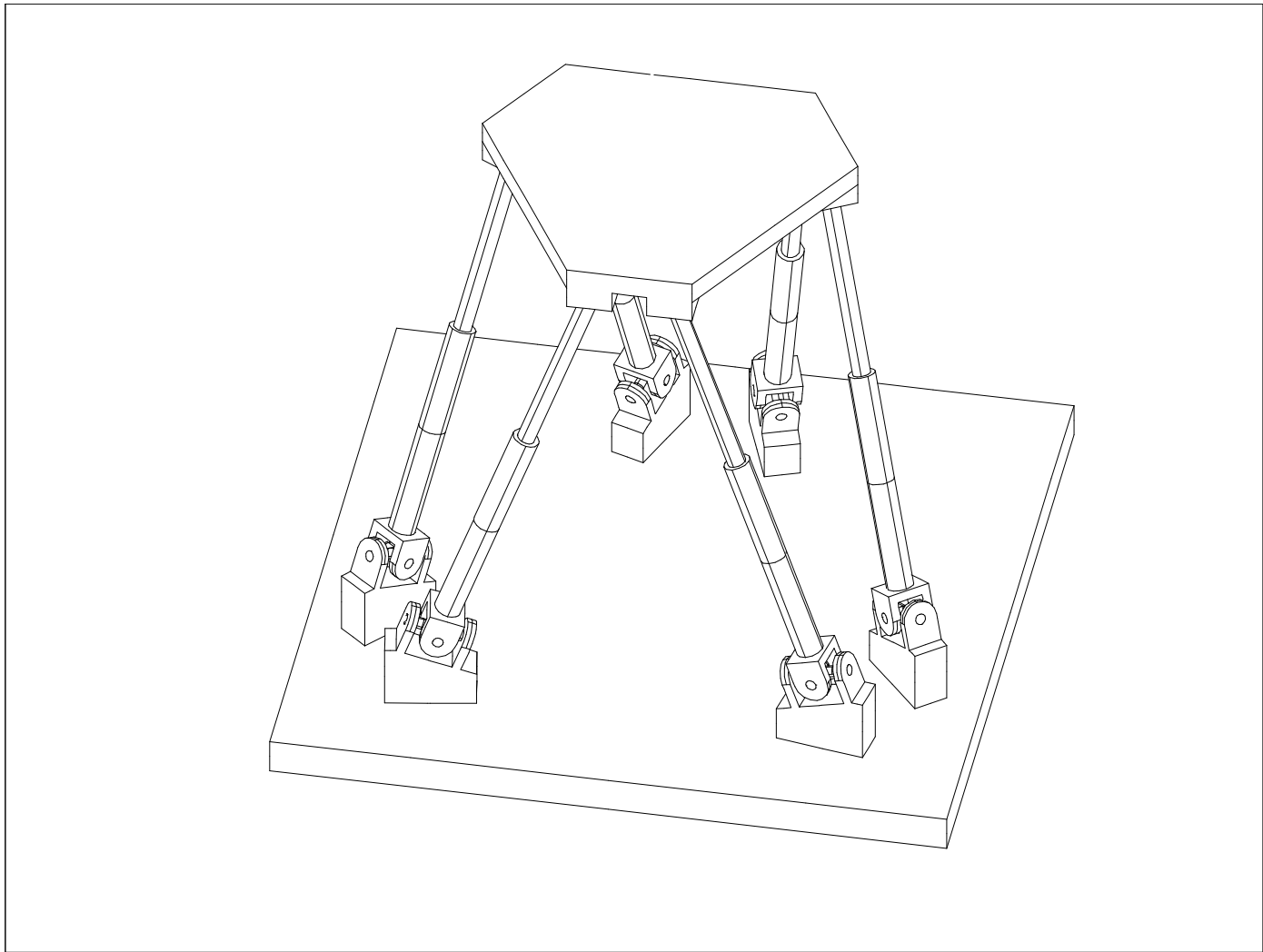


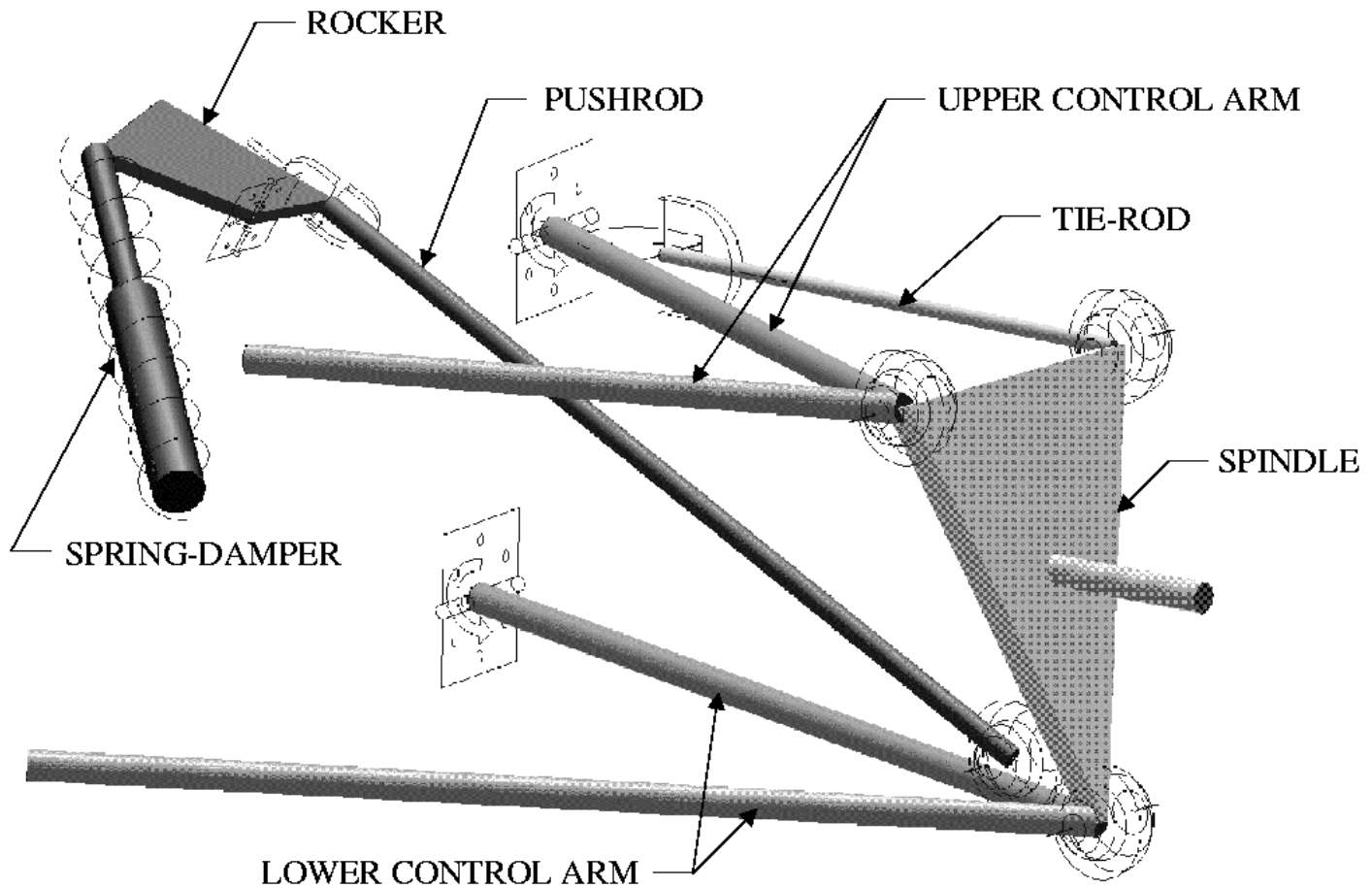
3-link serial robot ($f=3$)



SPDM ($f=15$)

- Gough-Stewart PKM (Wang+Gosselin,2000):





Double wishbone suspension ($f=1$)