Grubler's criterion for plane mechanisms

- A little consideration will show that a plane mechanism with a *movability of 1* and only single degree of freedom joints i.e. full joints can not have odd number of links. Substituting *n* = 1 and *h* = 0 in Kutzbach's equation, we have

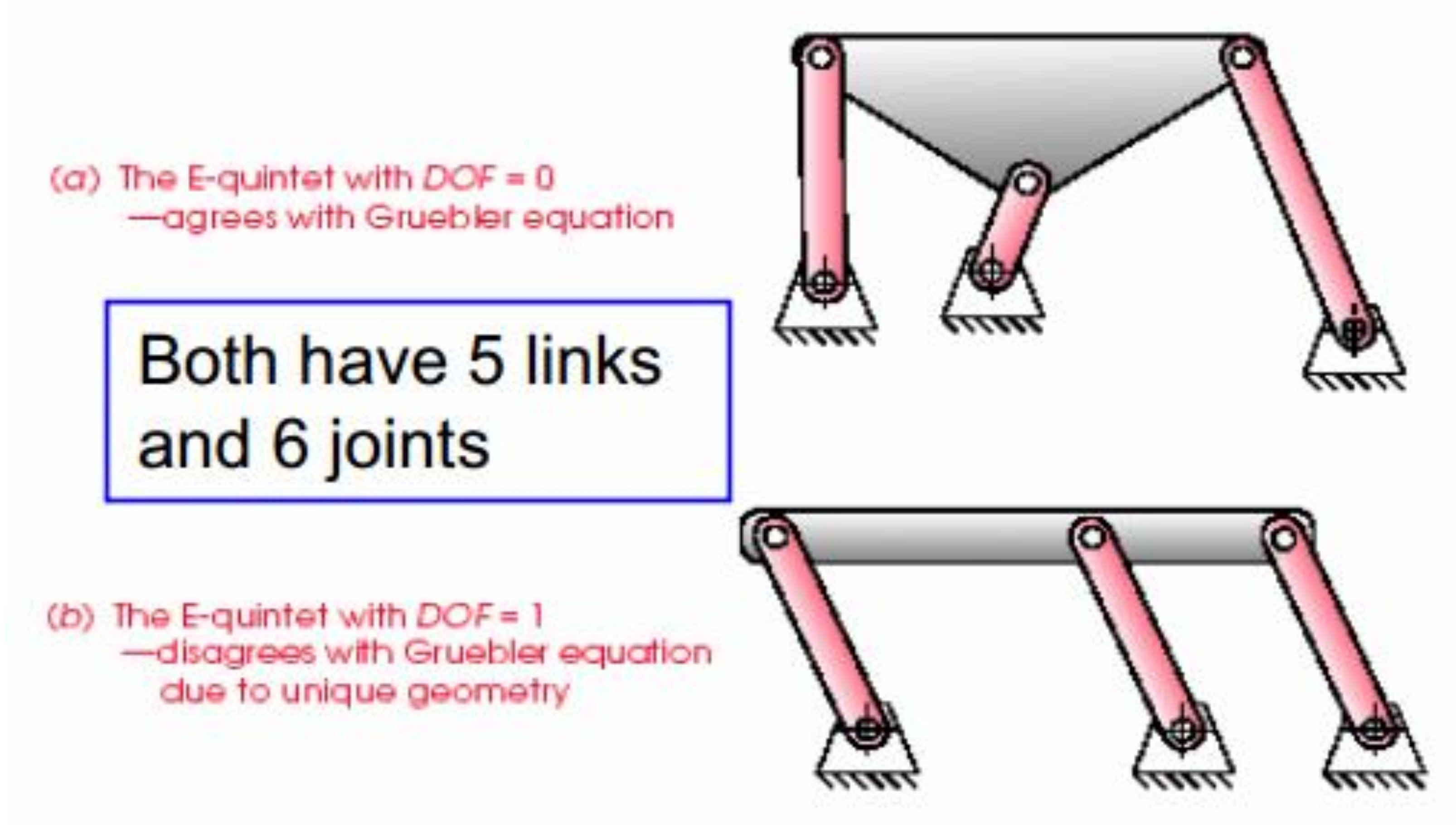
$$1 = 3\,(l - 1) - 2\,j \quad \text{or} \quad 3l - 2j - 4 = 0$$

- This equation is known as *the Grubler's criterion for plane mechanisms with constrained motion*.

- The simplest possible mechanisms of this type are a four bar mechanism and a slider-crank mechanism in which 1= 4 and j= 4.

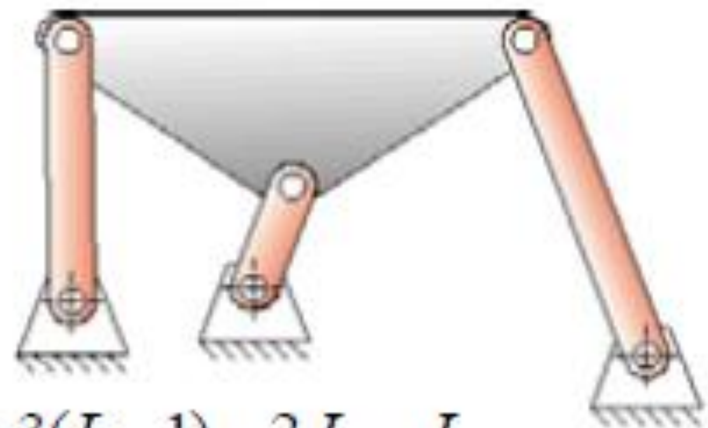
Degree of Freedom Paradoxes

- Gruebler's equation does not account for link geometry, in rare instance it can lead to misleading result

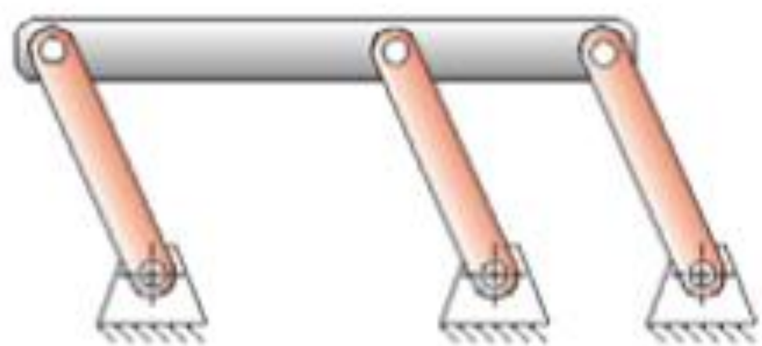


Degree of Freedom Paradoxes (contd.)

The "E-quintet" is an example in which *If three binary links happen to have equal length*, the joints of a middle link do not constrain the mechanism any more than the outer links. The equation predicts DOF = 0, but the mechanism has DOF = 1.



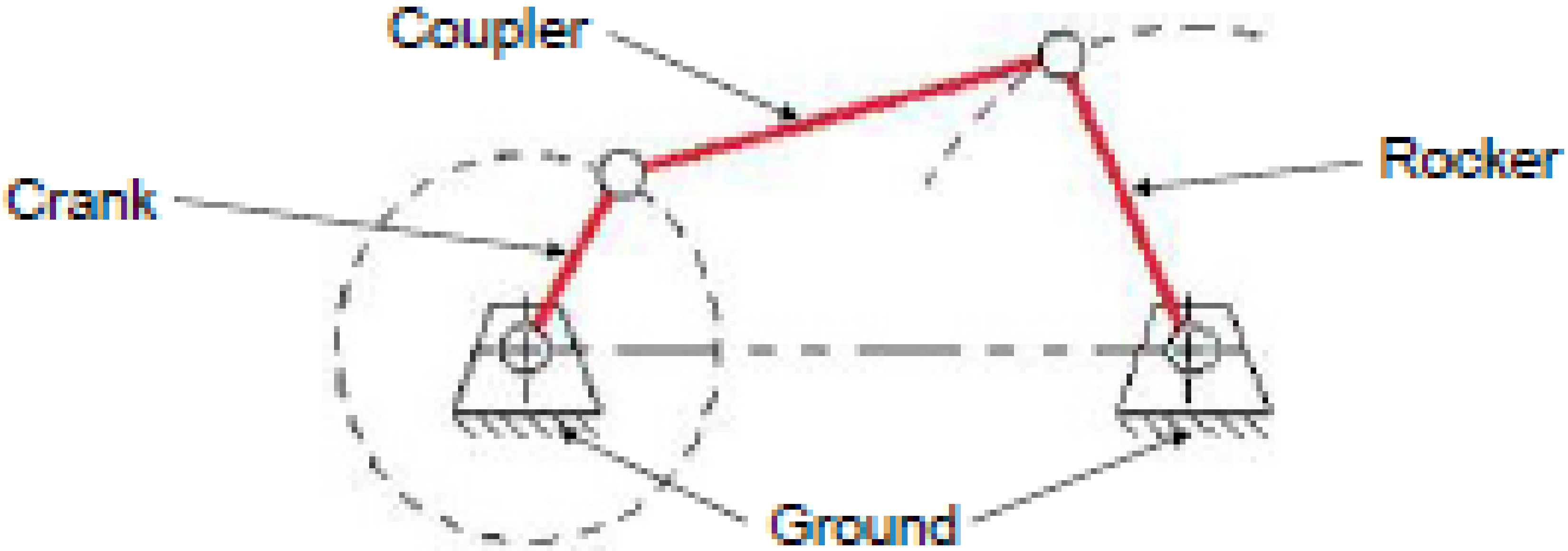
$$M = 3(L-1) - 2J_1 - J_2$$



Link Classification

- Ground or fixed Link: fixed w.r.t. reference frame
- Input [Driving] Link : Link where by motion and force are imparted to a mechanism
- Output [Driven] Link : Link from which required motion and forces are obtained

Link Classification



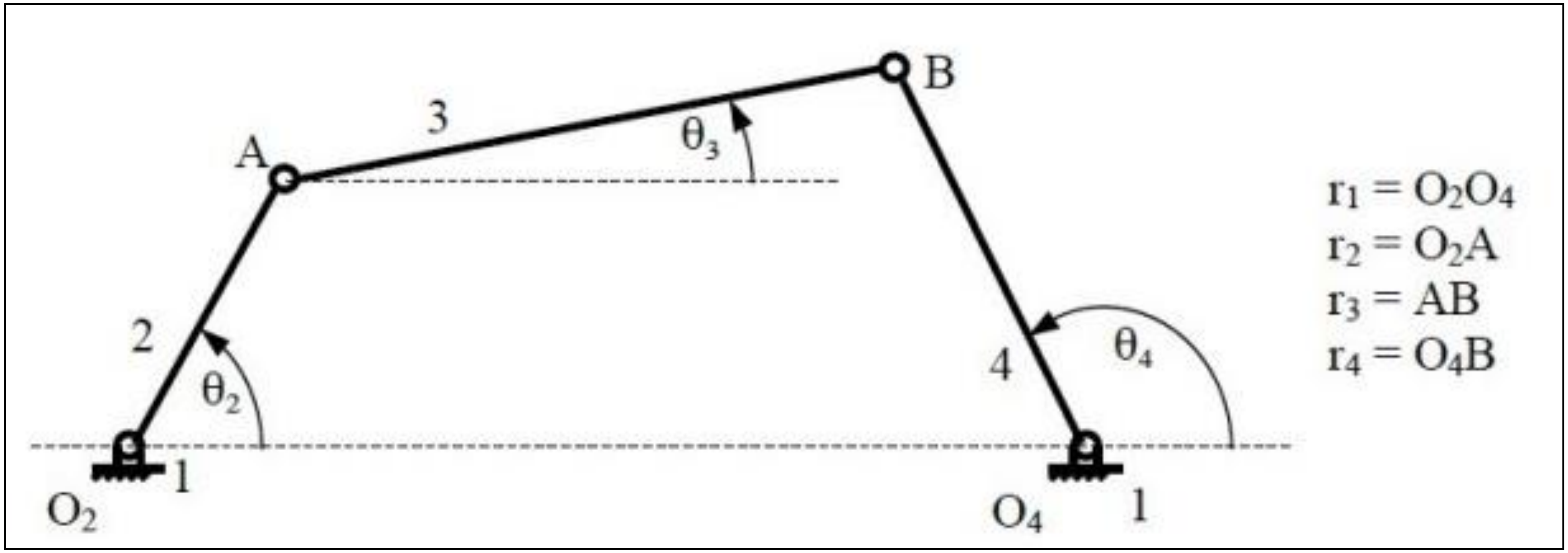
Link Classification (contd.)

- **Crank Link**: pivoted to ground, makes complete revolutions; i.e. Link that rotates completely about a fixed axis
- **Rocker Link**: pivoted to ground, has oscillatory (back & forth) motion
- **Coupler Link**: aka connecting rod, is not directly connected to the fixed link or frame, it in effect connects inputs & outputs

Four Bar Mechanism

- Four bar mechanism consists of four rigid links connected in a loop by four one degree of freedom joints.
- A joint may be either a *revolute*, that is a hinged joint, denoted by R, or a prismatic, as sliding joint, denoted by P.

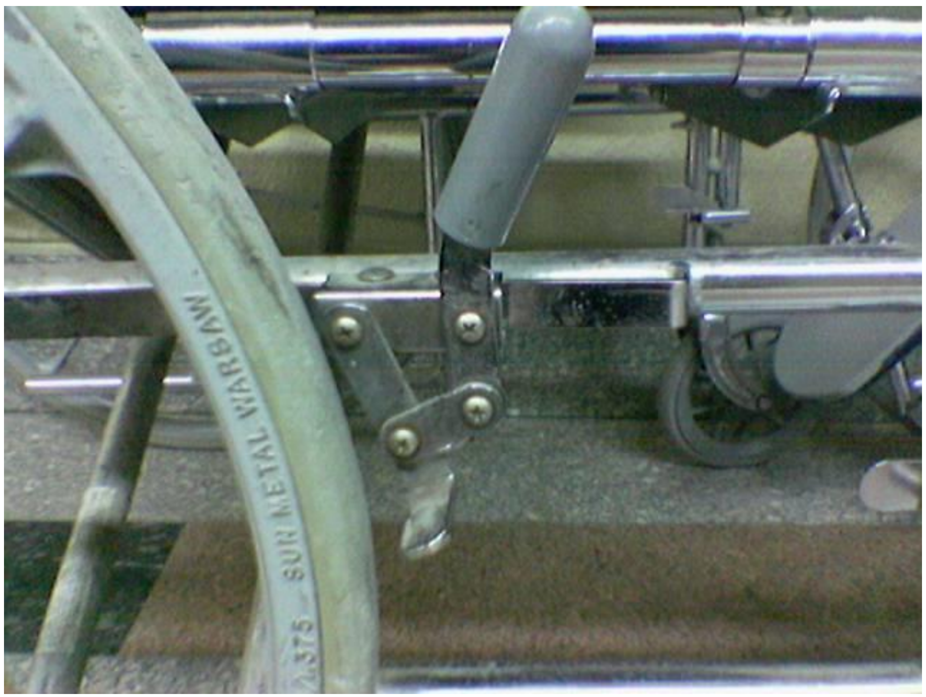
Four Bar Mechanism (contd.)



A link that makes complete revolution is called crank (r_2), the link opposite to the fixed link is the coupler (r_3) and forth link (r_4) is a rocker if oscillates or another crank if rotates.

Four Bar Mechanism (contd.)

Brake of a Wheelchair



Folding sofa

Four Bar Mechanism (contd.)

Backhoe Excavator

Mechanism Classification

- **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*.