Chapter 4

Introduction

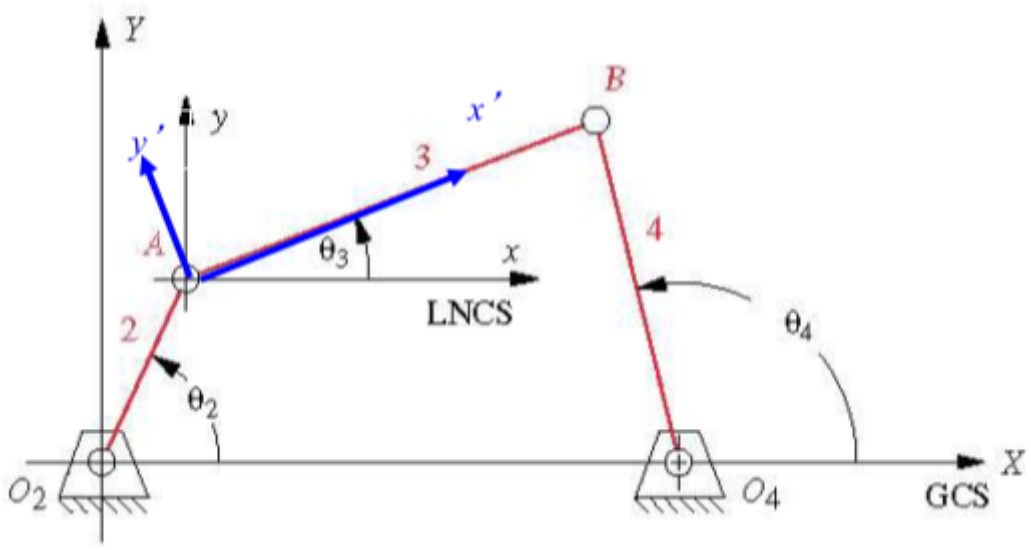
A principle goal of **kinematics analysis** is to determine the **acceleration** of all the moving parts in the assembly

And the **stress** in materials must be kept well under its operating conditions

To calculate the **stress**, the first thing we need to know is the **accelerations**

In order to calculate the **accelerations**, we must find the **positions** of all the links or elements in the mechanism.

4.1 Coordinate Systems



- GCS: Global Coordinate System (X, Y)

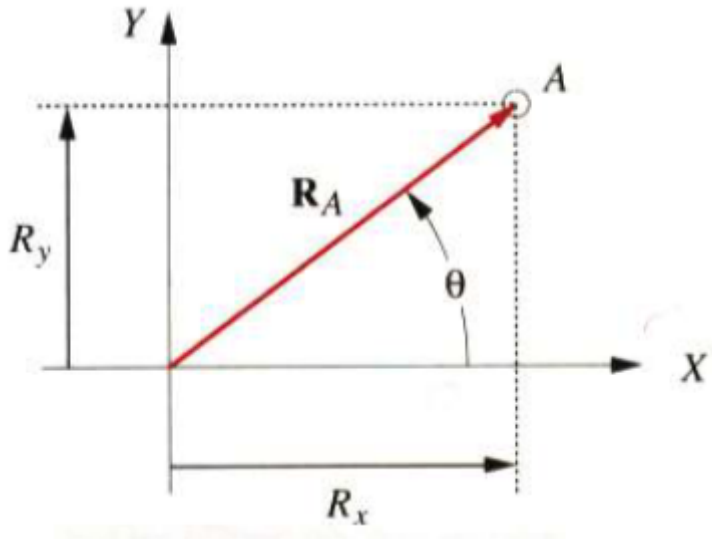
- LNCS: Local Non-Rotating Coordinate System (x, y)
- LRCS: Local Rotating Coordinate System (x', y')

All angles will be measured according to the right-hand rule.

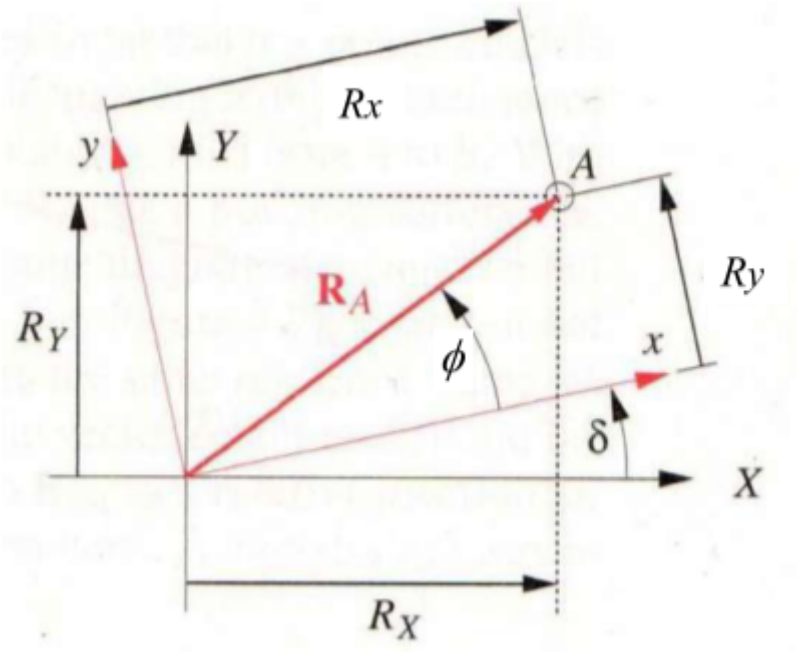
4.2 Position and Displacement

Position

- GCS



  - Polar form: $|R_A|\angle\theta$
  - Cartesian form: R_x,R_y
- LRCS

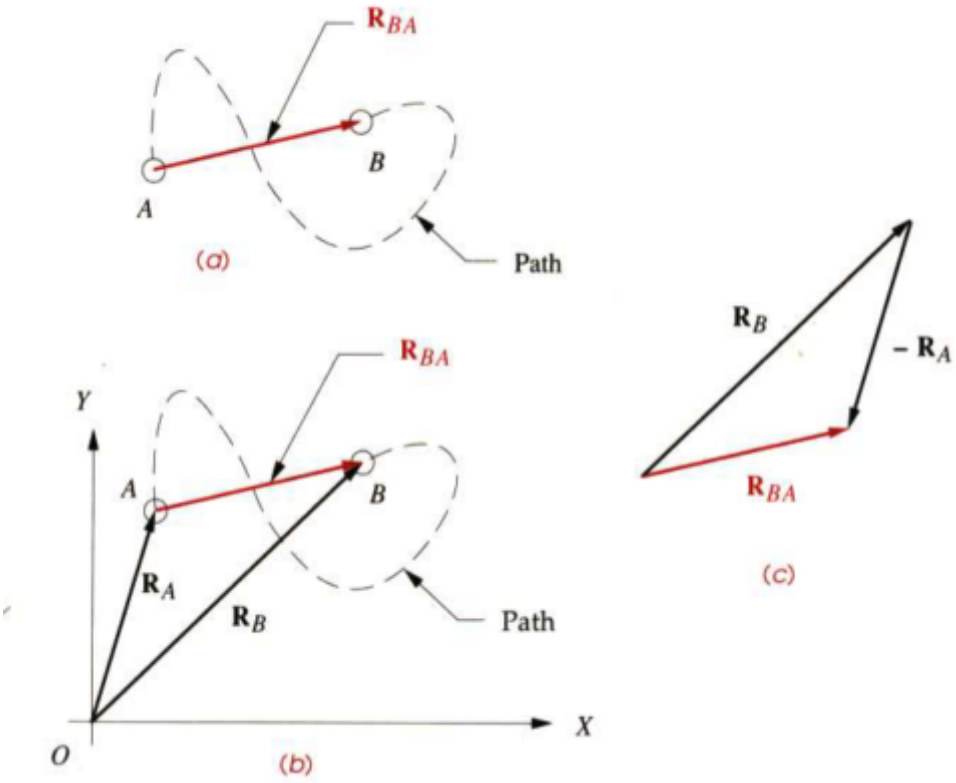


  - Polar form: $|R_A|\angle\phi$
  - Cartesian form: R_x, R_y

where $R_A = \sqrt{R_x^2 + R_y^2}$ and $\theta = \arctan\left(\frac{R_y}{R_x}\right)$

Displacement

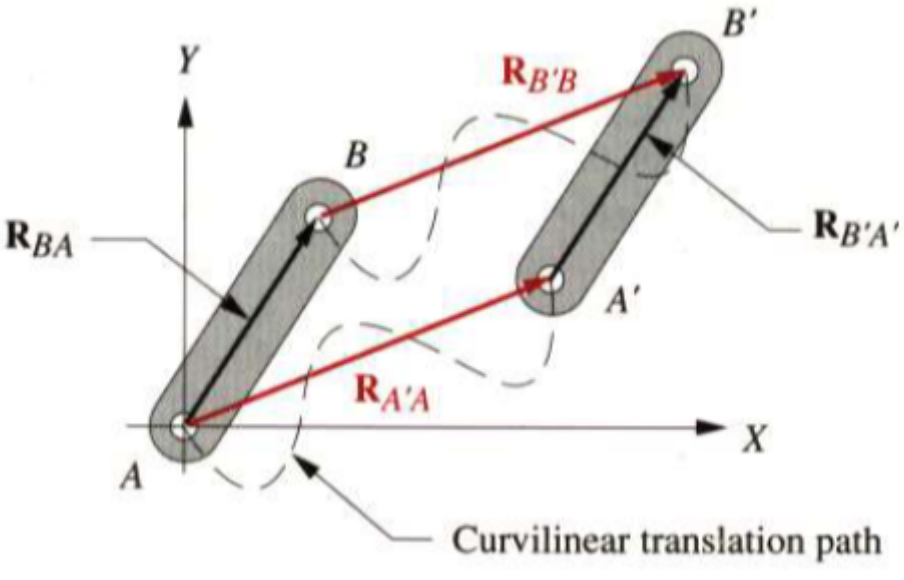
$$R_{AB} = R_B - R_A$$



4.3 Basic Motion

Translation

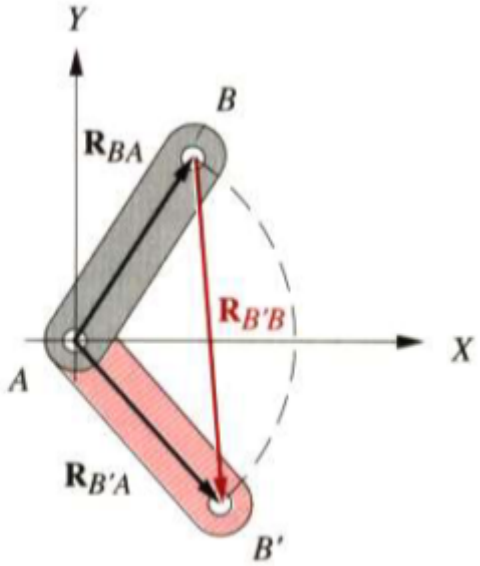
All points on the body have the same displacement



Rotation

Different points in the body undergo different displacements and thus is a displacement difference between any two points chosen

$$R_{B'B} = R_{B'A} - R_{BA}$$



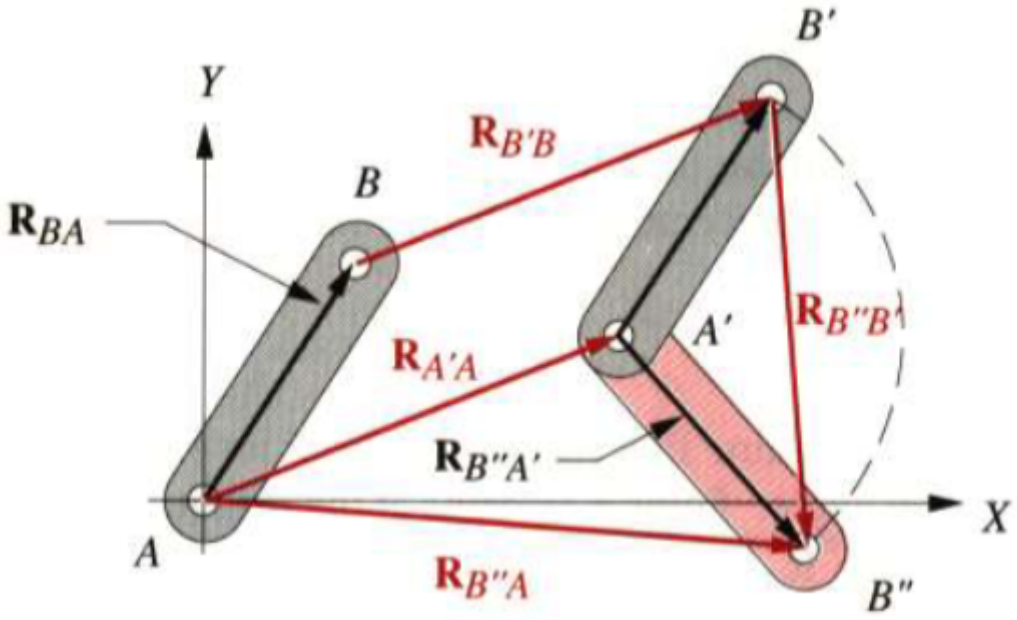
(c)

Complex Motion

the complex motion combined of translation and rotation

$$R_{B''B} = R_{B'B} + R_{B''B'}$$

$$R_{A''A} = R_{A'A} + R_{A''A'}$$

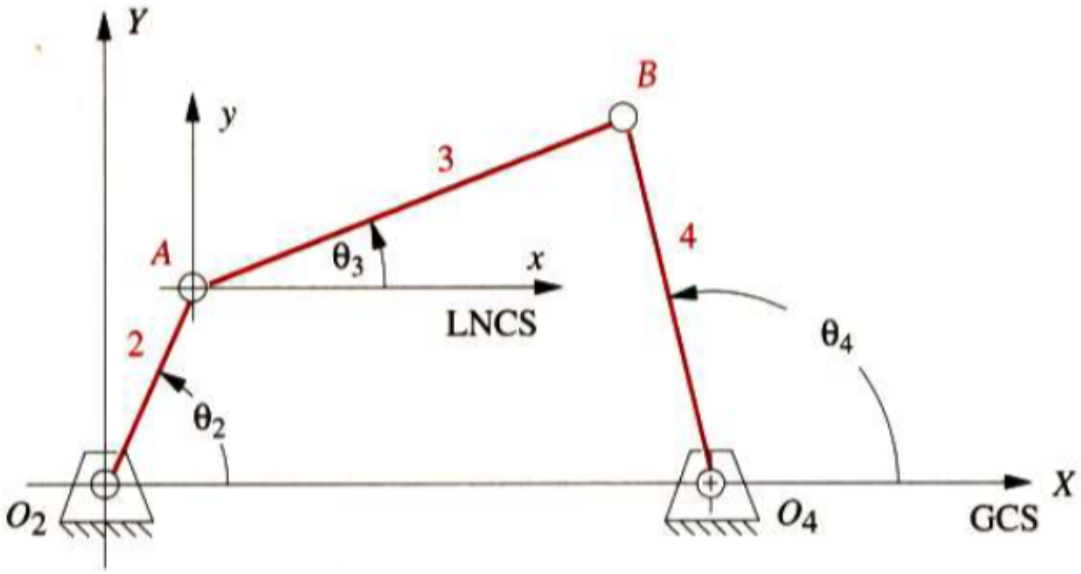


4.4 Graphical Position Analysis of Linkages

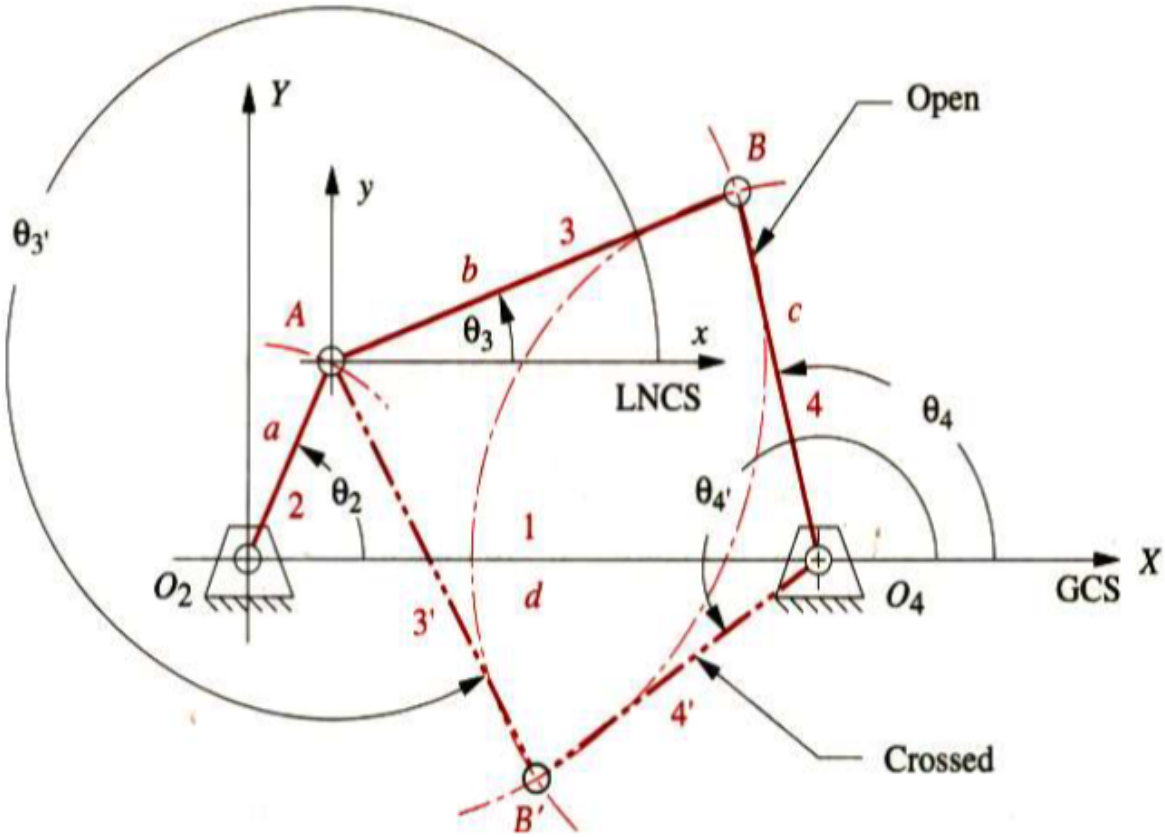
the main idea of this part is using the graphical method to find the possible positions of given linkages and the input degress

Example 1

Graphically find all the possible θ_3

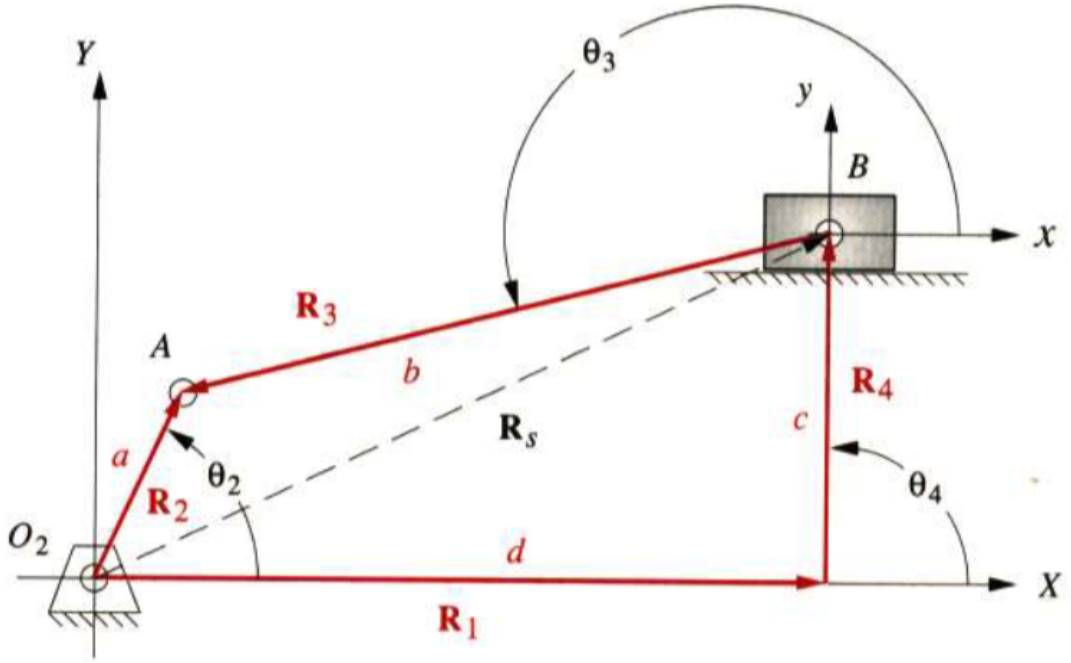


1. 根据给定θ_2和O_2A长度画得杆件
2. 以A为圆心，AB长度为半径做圆
3. 以O_4为圆心，O_4B长度为半径做圆
4. 两圆相交位置即为B的可能位置，量取角度

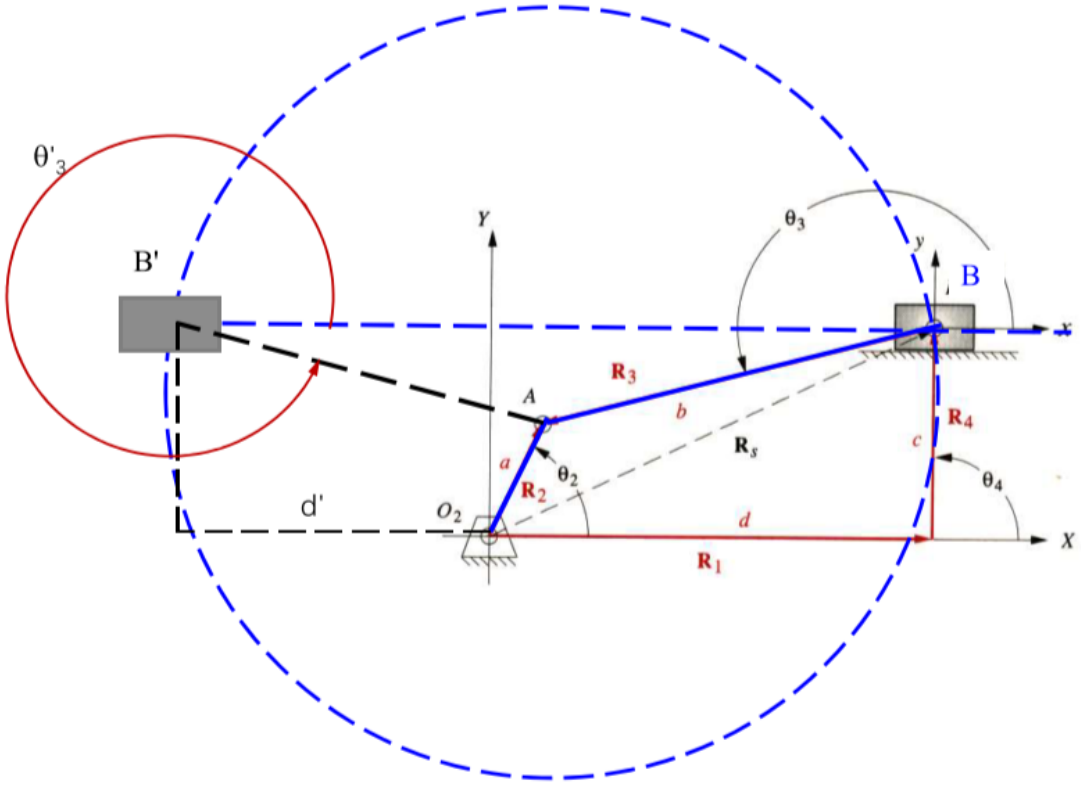


Example 2

Graphically find all the possible θ_3

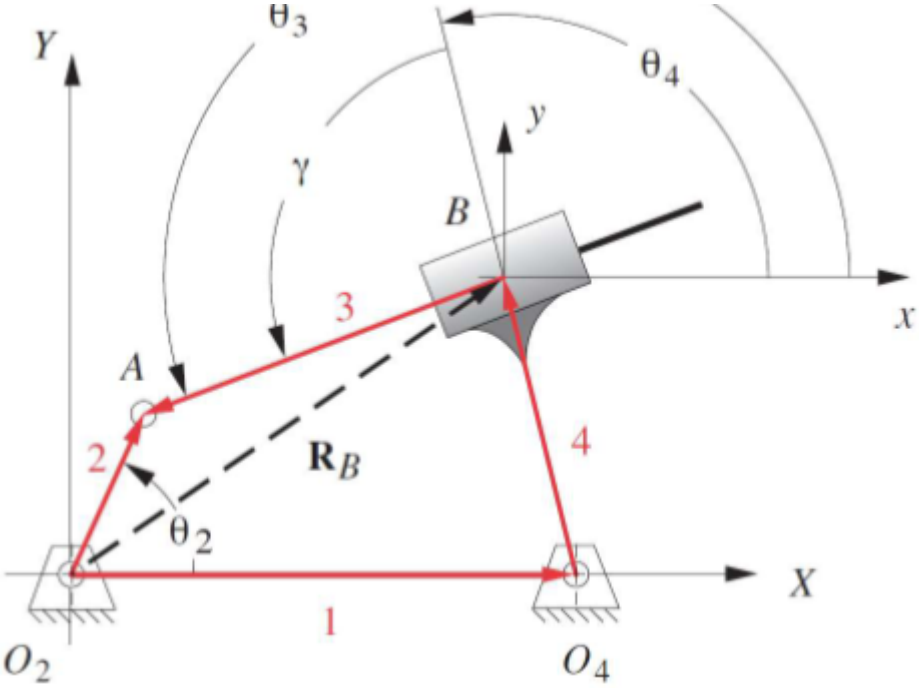


1. 根据给定θ_2和O_2A长度画得杆件
2. 以A为圆心，AB长度为半径做圆
3. 圆交B所在水平线上两点即为B的不同位置，两区角度和长度



Example 3

Graphically find both open and crossed solutions for angles θ_3 and θ_4 and vector R_B

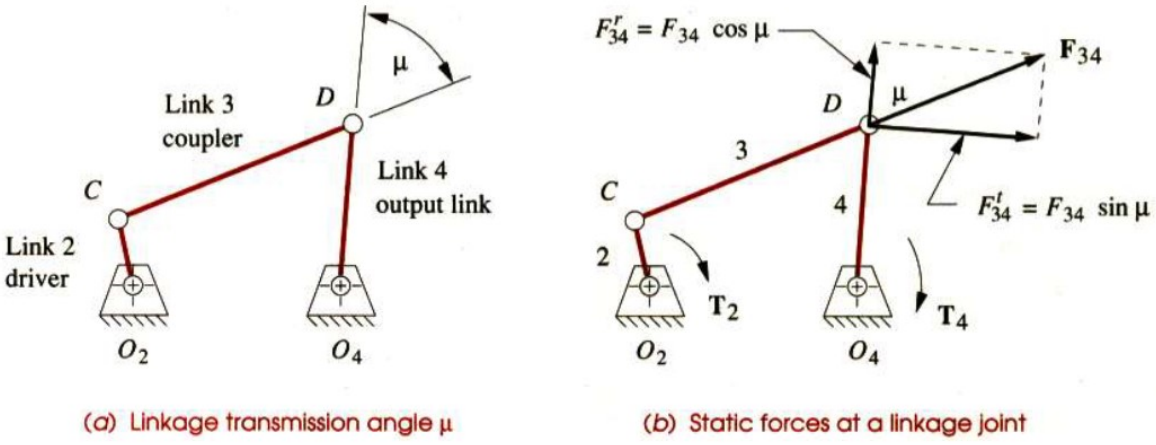


1. 根据给定θ_2和O_2A长度画得杆件
2. 以O_4为圆心，O_4B长度为半径做圆
3. 过点A做圆的两条切线，两个交点即为B的两个位置

4.5 to 4.9 Algebra Method to Solve Position Method

skipped ~~(Boring)~~

4.10 Transmission Angle



$$\theta_{trans} = |\theta_3 - \theta_4|$$

if $\theta_{trans} > \frac{\pi}{2}$, $\theta_{trans} = \pi - \theta_{trans}$

the extreme transmission angle

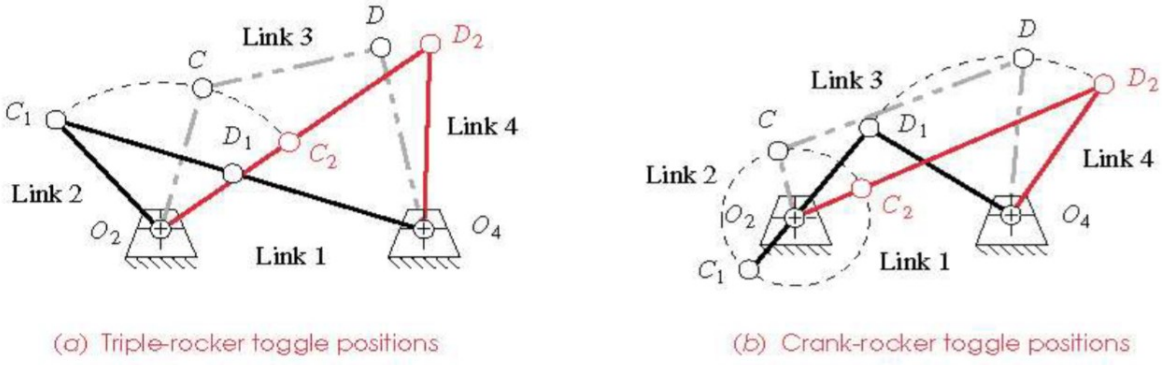
$$\mu_1 = \arccos \frac{b^2 + c^2 - (d+a)^2}{2bc}$$

$$\mu_2 = \arccos \frac{b^2 + c^2 - (d-a)^2}{2bc}$$

for toggle position

$$\mu = \arccos \frac{(a+b)^2 + c^2 - d^2}{2c(a+b)}$$

4.11 Toggle Positions



(a) Triple-rocker toggle positions

(b) Crank-rocker toggle positions

$$\theta_{2toggle} = \arccos\left[\frac{a^2 + d^2 - b^2 - c^2}{2ad} \pm \frac{bc}{ad}\right] \qquad 0 \leq \theta_{2toggle} \leq \pi$$