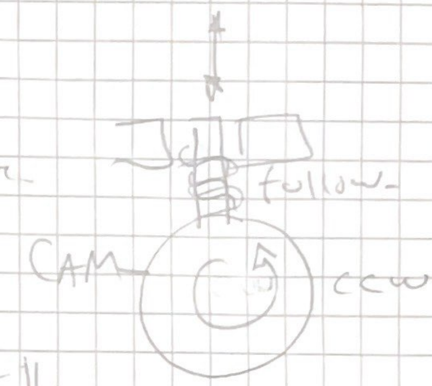
Kinematics of Mechanical System

- ① Synthesis of Mechanisms
- ② Analysis of mechanisms
  - Position
  - velocity
  - acceleration

. Compass: drawing tools. Amazon

S = displacement = follower Displacement.



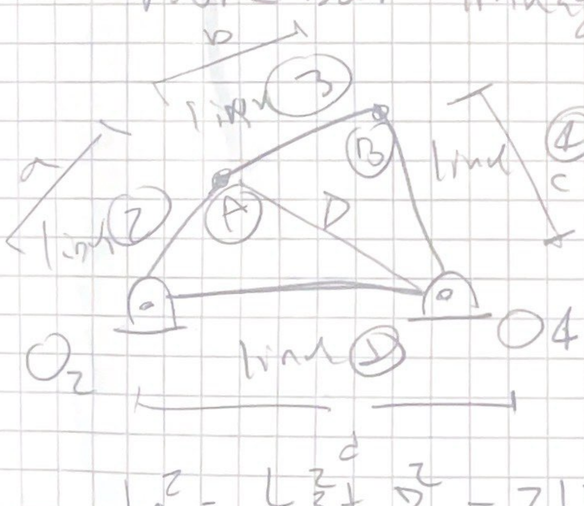
follow over cam

crank - Shaft = motor

link de rotacion

linkage

Four - bar linkage



Joints = O_2, O_4, A, B

links = ①, ②, ③, ④.

$$L_4^2 = L_3^2 + D^2 - 2 L D \cos\theta$$

$$\cos\theta = \frac{L_4^2 - (L_3^2 + D^2)}{2 L_3 D}$$

Ley Cos | Estudiar.

Ley Sen.

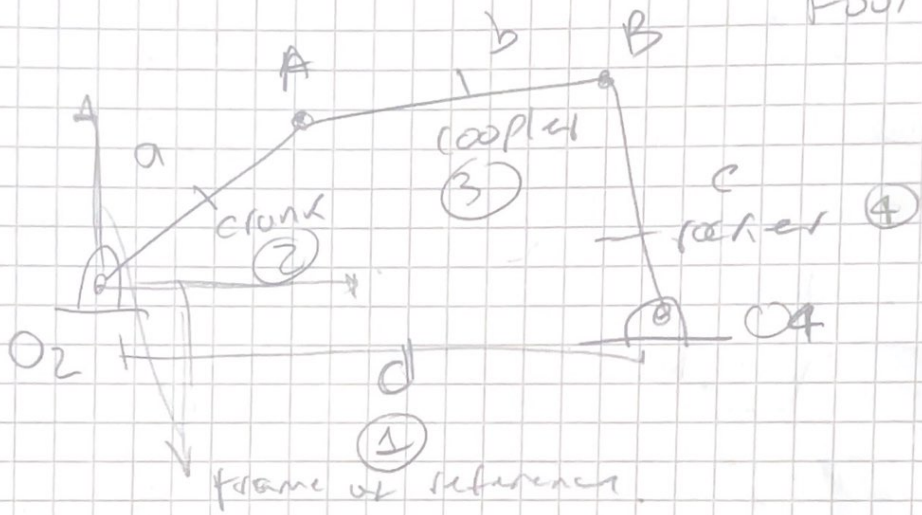
$$\sin^2\theta + \cos^2\theta = 1$$

$$\sin^2\theta = 1 - \cos^2\theta$$

$$\sin = \sqrt{1 - \cos^2\theta}$$

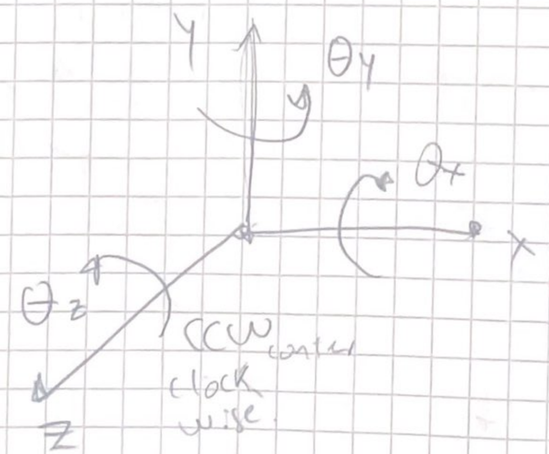
Four_bar linka

2D



todos los puntos fijos representan el enlace 1

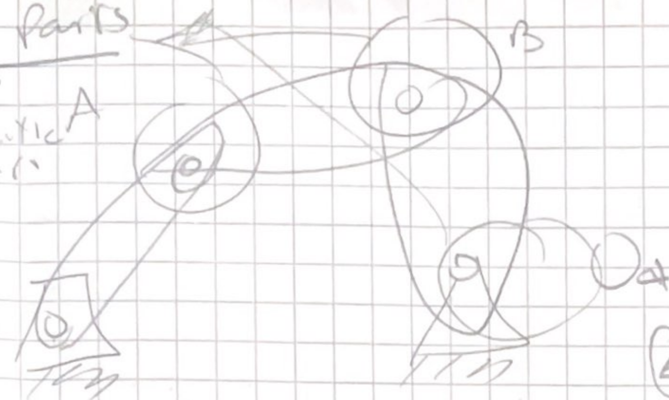
3D



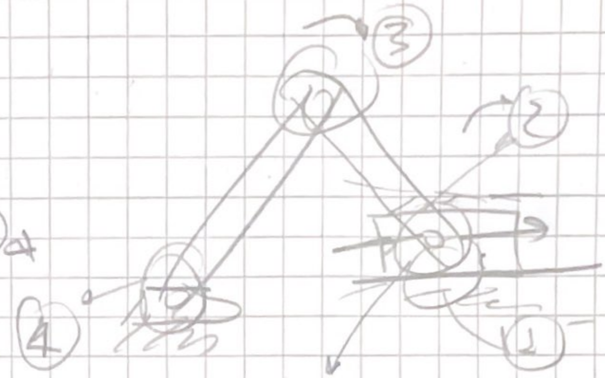
- Join
- links
- Angles

low pairs

kinematic pair



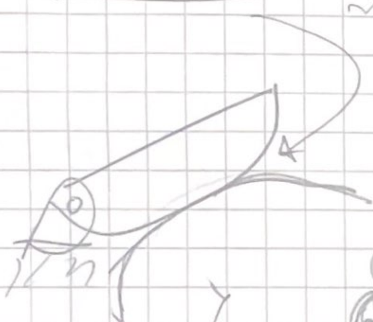
fixed support



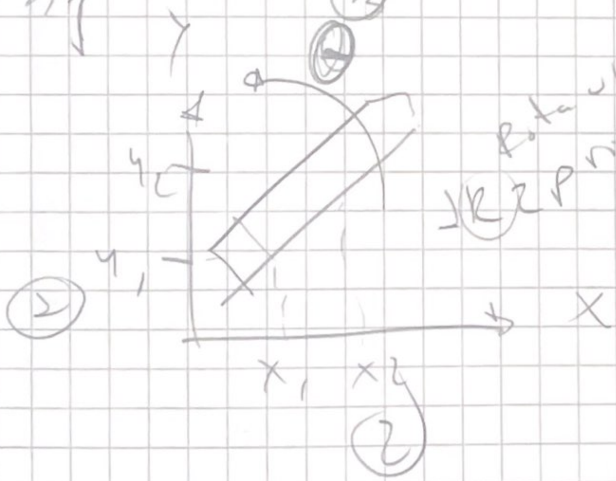
low pairs

(kinematic pair

High pair : given transmit movements



high pair



Rotation prismatic

1R 2P

- Grashof condition.

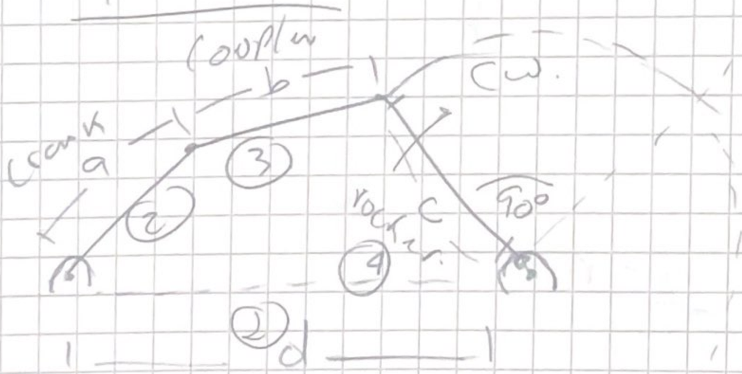
- dar una vuelta completa si se cumple la cond el crank

Suma longitudes de los link más corto más longer link $\leq P + Q$

$$S + L \leq P + Q$$

Synthesis

Plane layout

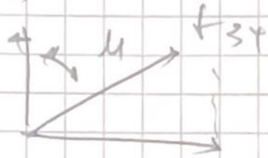


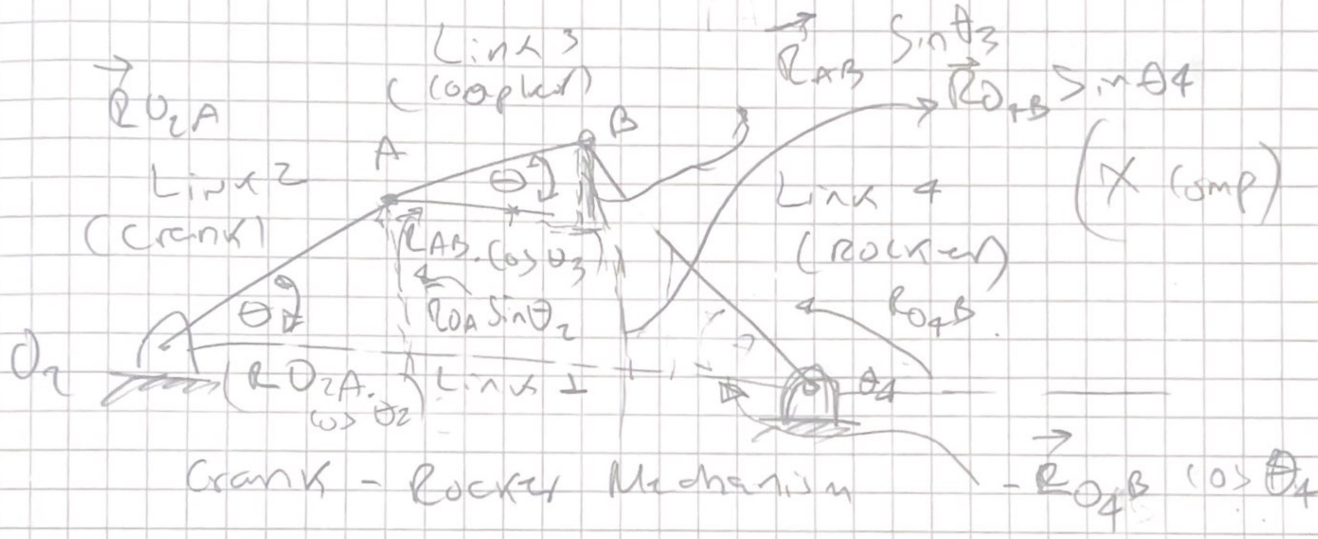
- Synthesis   Known: c, 90° cw.
rocker link length

- unknown: a, b, and d

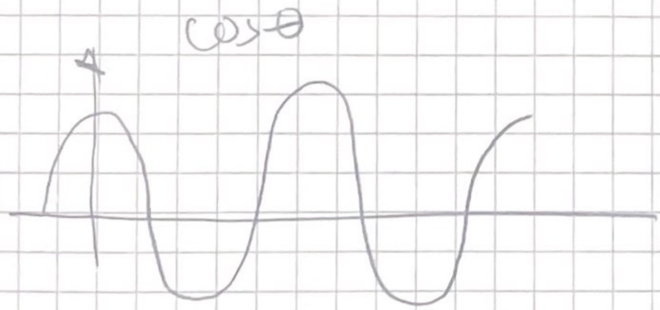
$f_{actual} = f_{34} \cos(\mu)$

$f_{34} = \sqrt{f_r^2 + f_t^2}$

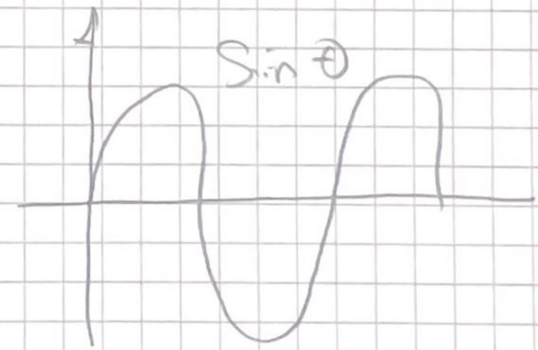




Crank - Rocker Mechanism



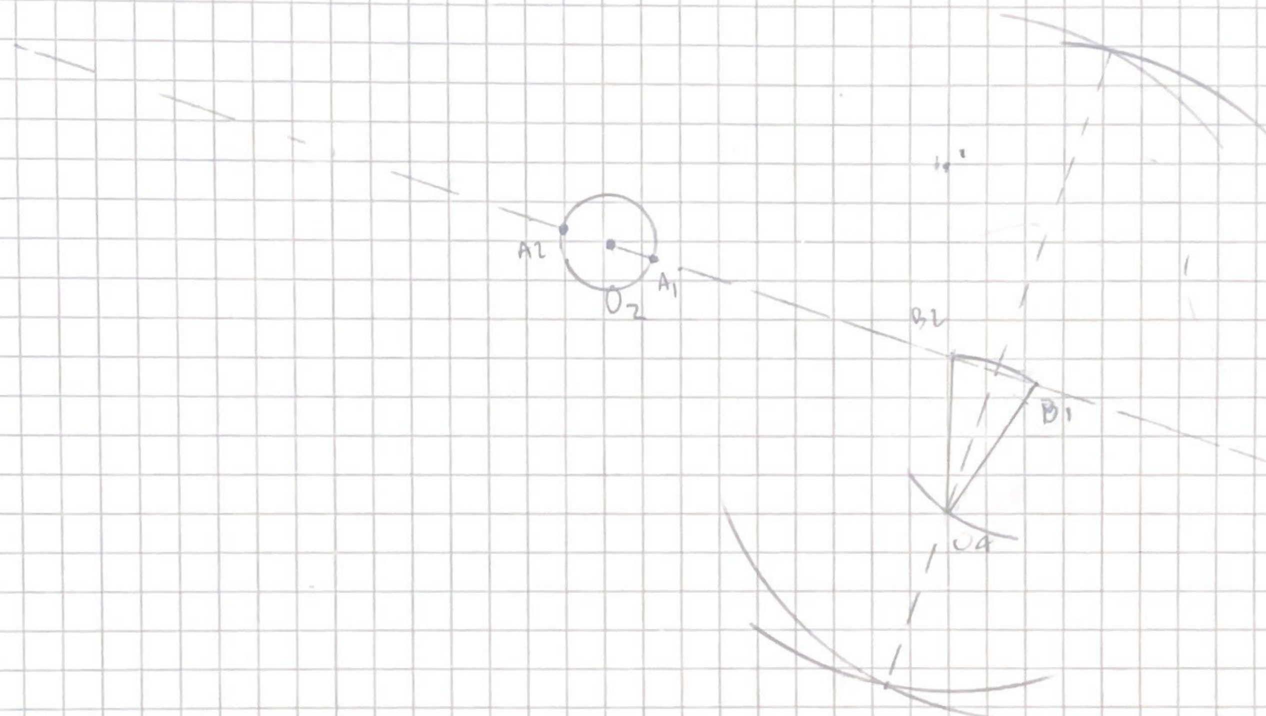
X - Component



Y - Component.

X Comp → f function → f(x, y)

Y Comp → g function → g(x, y)



Grasshof Condition.

S+L < P+Q

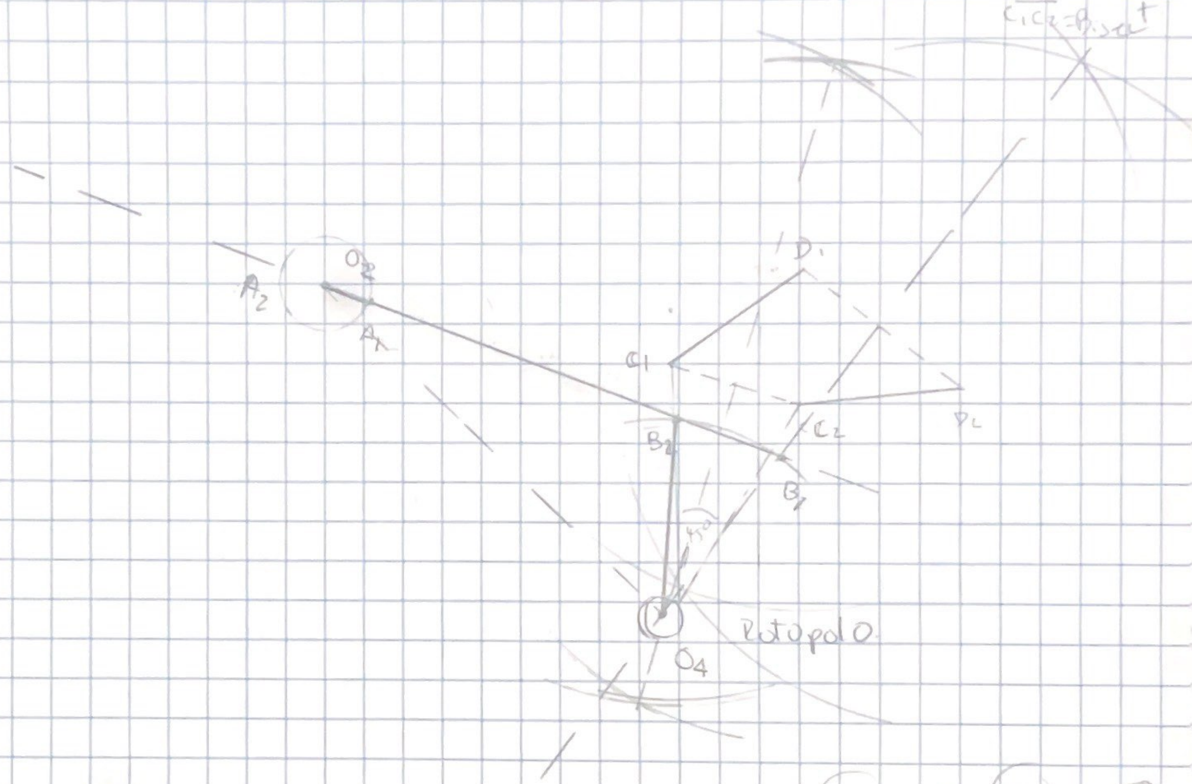
62 mm < 73mm

Q Rocker ($\overline{O_4B_1}$) = 20 mm

P Coupler ($\overline{A_1B_1}$) = 53 mm

(S) Crank ($\overline{O_2A_1}$) = 6mm.

(L) Link 1 (O_2A_4) = 56 mm



$84 \leq 130 = Q$

$(76+6) \leq (59+71)$

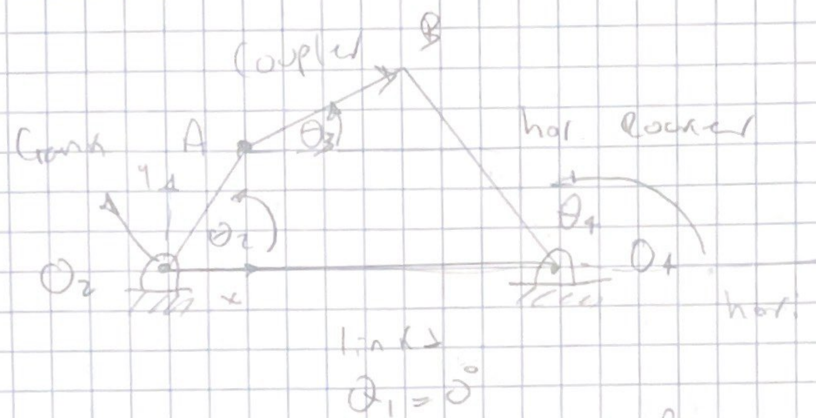
P Q Rocker: 59 mm

coupler: 71 mm

S crank: 6 mm

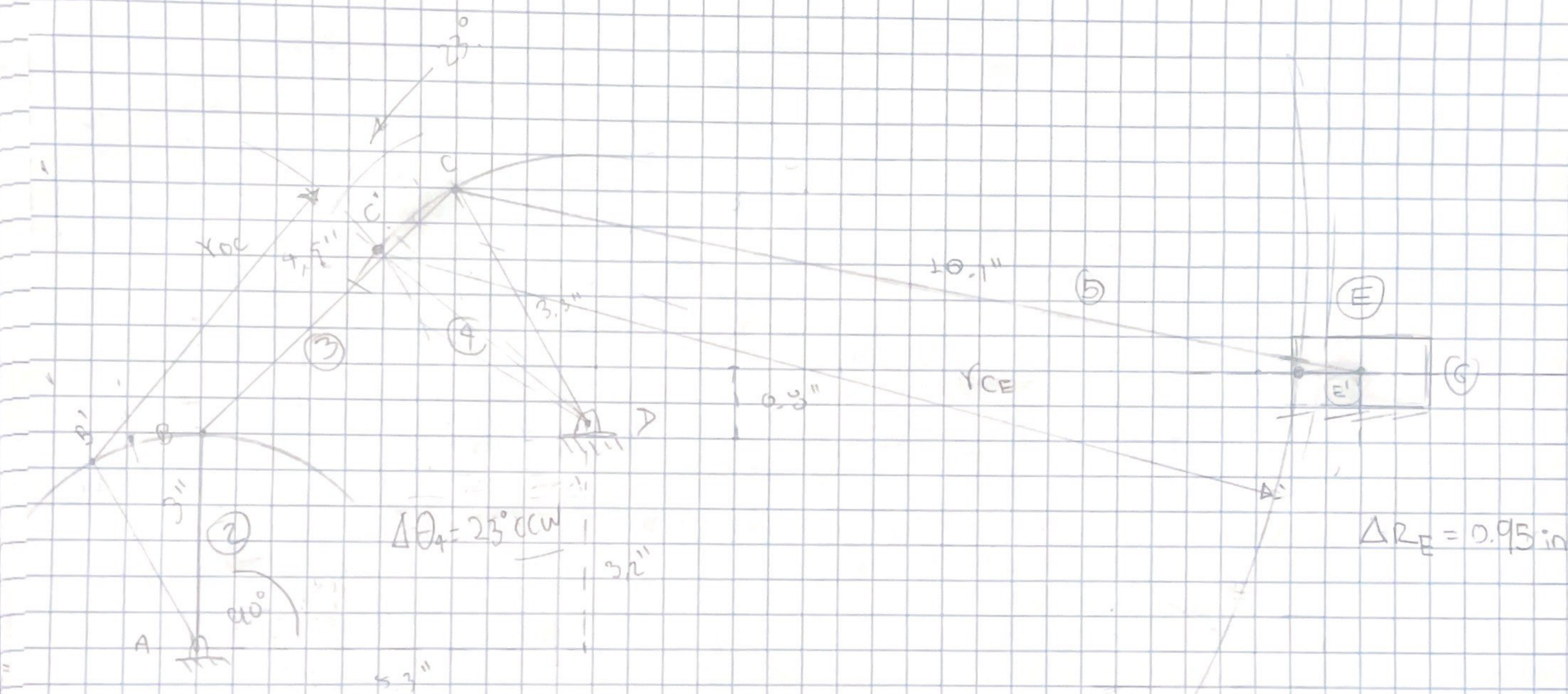
L $L_1 = 76$ mm

Antonio Perez



- Displacement of a point
- Position vector
- $\vec{R}_{B/A} = \vec{R}_B - \vec{R}_A$ +
- Closure loop.

R = position
V = velocity
a = acceleration

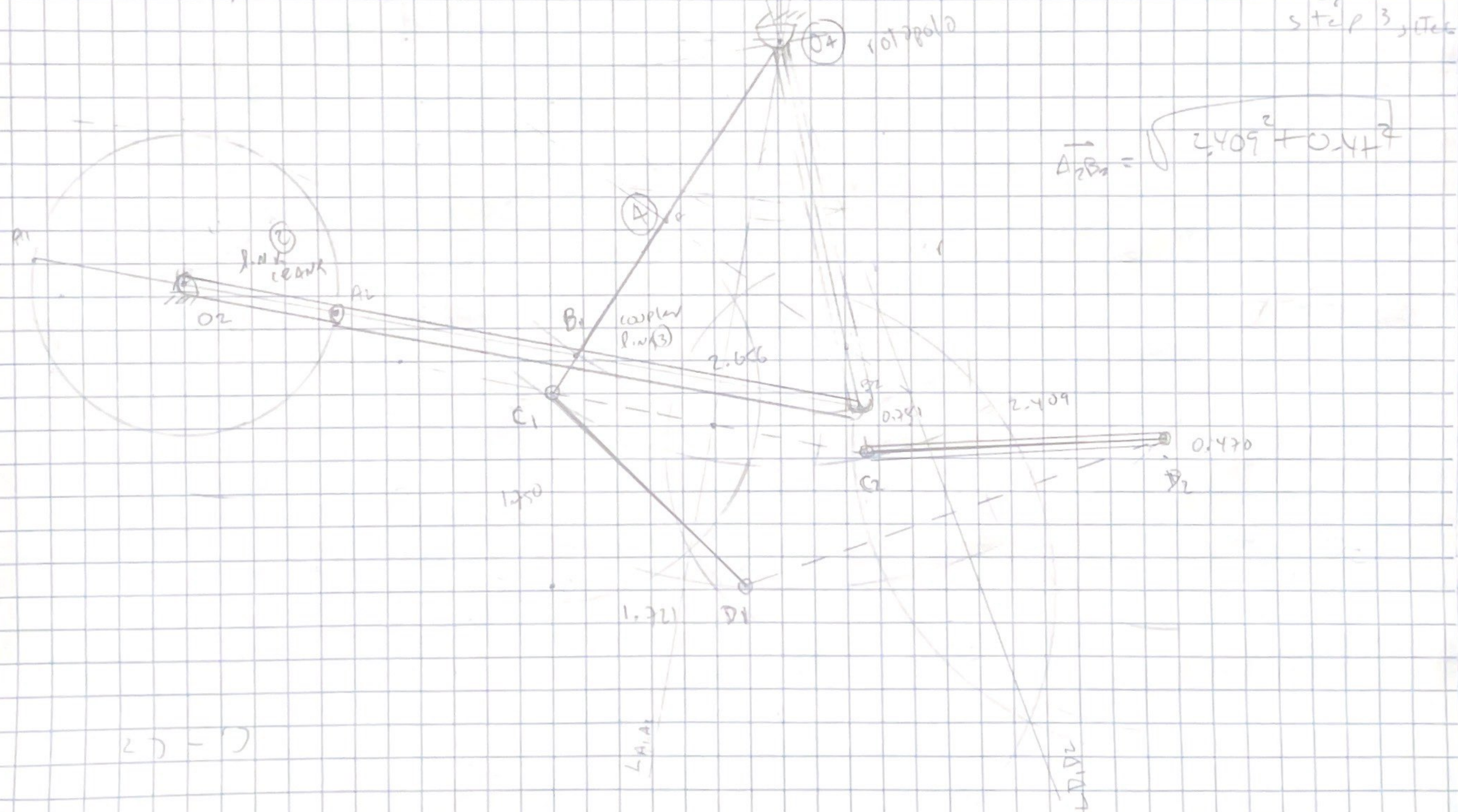

A
B
B'
C
C'
D
E
E'
G
3"
4.5"
3.5"
10.1"
0.3"
3.2"
r_DC
r_CE
ΔΘ4 = 23° CCW
ΔR_E = 0.95 in

Link Coupler : 4.1 inches
Link Crank 1.2 inch
link Rocker 2.409 inch
link 1 5 inch
2 S
5 + 1.2 = 6.2
4.1 + 2.409 = 6.5 } Rotate

middle #2
part 2

Step 1
Step 2
Step 3, etc.

$\overrightarrow{A_2B_2} = \sqrt{2.409^2 + 0.47^2}$



2 D - D

→ J C 3 1
J C 1 3

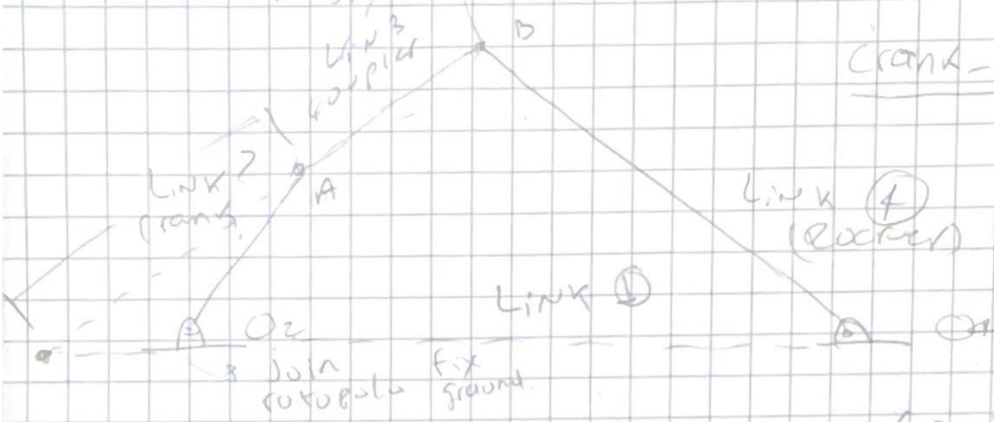
Newton Raphson Posición y Velocidad.

Circulo otomov

· Método Gráfico analítico

· Centro instantáneo de Rotación (Gráfico)

Crank_Rocker Mechanism



≠ rotopar o puede ser ... join

$n = 4$, (LINKs)

$$C\_IC = \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = \frac{\cancel{4}^{2} \times 3}{\cancel{2}} = 6$$

Instantáneo
Posiciones
longitudes
Posición
Velocidad
aceleración

• Ejercicio. Modulo 4. Velocity analysis

Crank (a) = 3.0 m

Coupler (b) = 8.0 m

Rocker (c) = 6.0 m

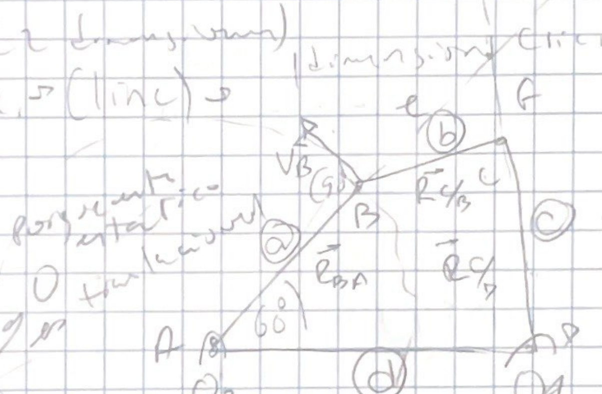
$\omega_2 = 10.5$ rad/s

$\theta_2 = 60°$ crank

Distancia entre grounds (d) = 7.0 m

Creo parametric
· medidas
· Right
· sketch (2 dimensional)
· centerline → (line) →

(dimension) (line)



$c = 6000\,mm = 6\,m$

$e = 29524.70\,mm$

$f = 23650.13\,mm$

equation 4.2, 4.3

magnitud absoluta

velocidad vectorial

$|\vec{V}_B| = \cancel{\vec{V}_A} + \vec{W}_2 \times \vec{R}_{B/A}$ → vector posicion de B con respecto de A → R significa posicion

10.5 rad/s, 3000 mm

es como decir el Radio por Vel. ∡

Siempre perpendicular al Radio

$|\vec{V}_B| = 10.5\,rad/s \cdot \cancel{3000\,mm} \cdot \frac{1\,m}{\cancel{1000\,mm}} = 30.15\,m/s$

$|\vec{V}_B| = 30.15\,m/s$

$|\vec{V}_B| = e\,W_3 \therefore W_3 = \frac{|\vec{V}_B|}{e} = \frac{30.15\,m/s}{29524.70\,\cancel{mm} \cdot \frac{1\,m}{1000\,\cancel{mm}}}$

$W_3 = \frac{30.15\,m/s}{29.5247\,m} = 1.02113\ \frac{rad}{s}$

$W_4 = \frac{f}{c} \cdot W_3 \longrightarrow \frac{23.650\,\cancel{m}}{6\,\cancel{m}} \cdot 1.0211\frac{rad}{s} = 4.027\ \frac{rad}{s}$

- Position Analysis.
- Velocity analysis

$\theta_2 \measuredangle = 60^\circ$ $\theta_3 \measuredangle = ?$

$a = 3$ mt
$b = 8$ mts
$c = 6$ mts
$d = 7$ mts

$\theta_4 \measuredangle = ?$

- Metodo Newton Raphson
- Guess values: Para iniciar las iteraciones
  └ iteración 1
- Para correr el software en matlab (Live script)
  para activarlo doble click
  ; Para que no muestre el computado
- Nueva función

posiciones angulares: 22.8120
71.7975

el método va a calcular a partir de la iteración inicial

No es la solución correcta

θ_3	θ_4
10	60
22.81°	71.79°

el método converge a

Instant centers (Si) gráfico y matlab

Velocity analysis (No)
→ Numérica Newton Raphson

Acceleracion Polygon:

1.1 ① Analysis of position:
1.2 ② Analysis of Velocity:
1.3 ③ Analysis of Acceleration:

- Se continua despues del diseño
- Se requiere la longitud de los linkas
- R_{AO_2} vector de posicion de A respecto O_2

① Longitud de los linkas (synthesis or design)
- Links → Types
- Joints → Types
- Grashof Condition (ea tela o no rota) (transmission angle)
- Grados de libertad → a traves de una formula modify Kuhsback

o movilidad

DOFs or Mobility

$M = 3L - 2J - 3G$

$M = 3(L-1) - 2J_{LP} - J_{HP}$

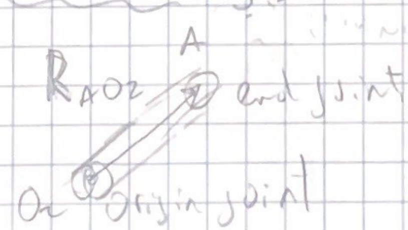
1.1 ② Metodos

1.2
- Metodo Grafico (Graphical approach)
- Analitico. → Newton Raphson (NR) → Mathematical Model

hasta aca Parcial ①

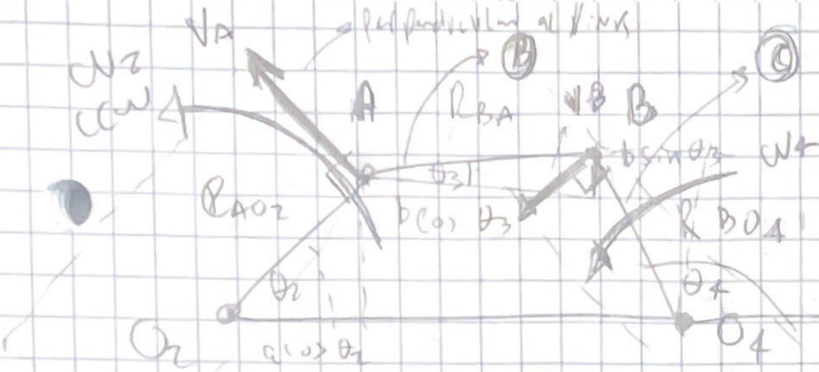
1.3 Aceleracion

① $\vec{R}$ Posicion
② $\vec{V}$ Velocidad
③ $\vec{A}$ Aceleracion



- El rotopolo es solo del Rocker

Motion generation



① $\vec{R} = \theta_3\, \theta_4$ (unknown)

② $\vec{V}_A = \vec{V}_{O_2} + \vec{\omega}_2 \times \vec{R}_{AO_2}$ (B)

$\vec{V}_A = \vec{\omega}_2 \times \vec{R}_{AO_2}$

③ $\vec{V}_B = \vec{V}_{O_4} + \vec{\omega}_4 \times \vec{R}_{BO_4}$

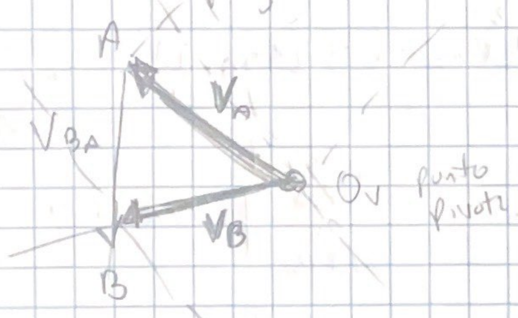
$\vec{V}_B = \vec{\omega}_4 \times |\vec{R}_{BO_4}|$

$\vec{V}_B = \vec{\omega}_4 \times$ (C)

- θ_3 = es desconocido } Posiciones Angular
- θ_4 = es desconocido. } Posición Angular
- Nota: Las longitudes son conocidas gracias a la posición y el análisis de síntesis de diseño

Posición

- $R_{AO_2} + R_{BA} - R_{BO_4} - R_{O_4O_2} = 0$ (loop closure equation)
  Derivando esta fórmula tenemos la velocidad
- Para obtener el polígono de aceleraciones



- Sale siempre del (CRANK punto pivote) O_2
- Depende si va CW o CCW
  a tener en cuenta los símbolos.

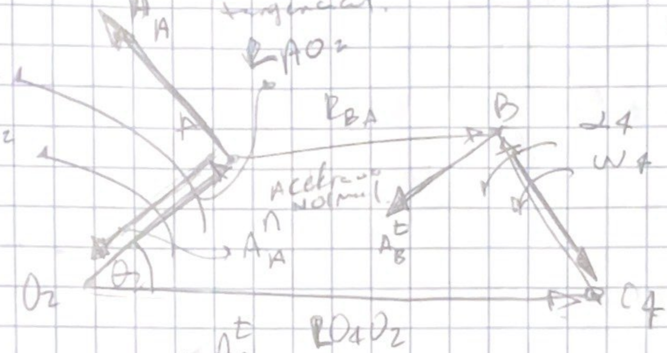
Velocidad

$V_A + V_{BA} - V_B = 0$

Velocity Polygon

Aca empieza la aceleración.

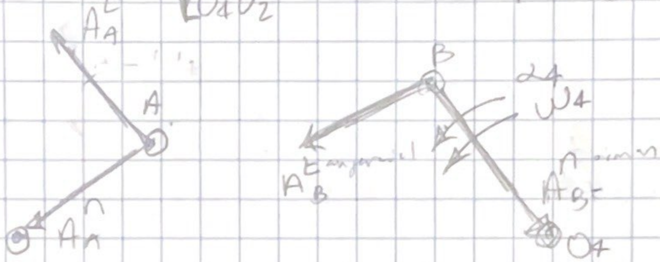
CCW



• Aceleración tangencial, misma dirección de α_2

• Aceleración Normal es siempre contraria al vector $\breve{R}_{AO_2}$

Aceleración



$$A_A^n + A_A^t + A_{BA}^n + A_{BA}^t - A_B^n - A_B^t = 0$$

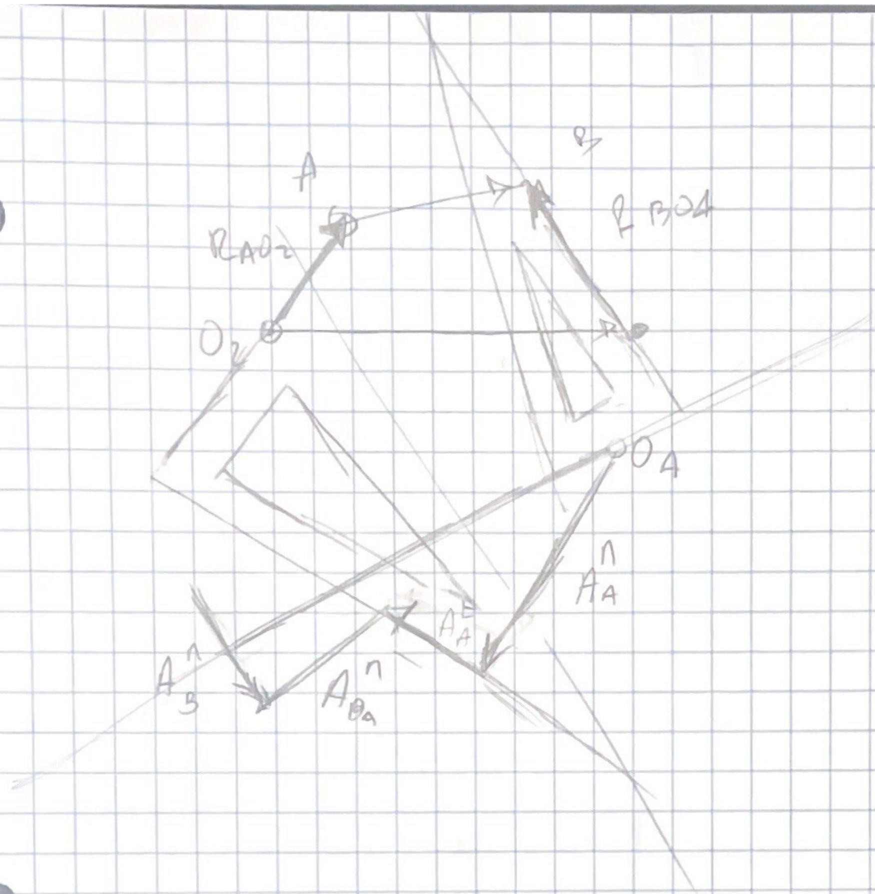
$$-\omega_2^2 R_{AO_2} + \alpha_2 \breve{R}_{AO_2} - \omega_3^2 R_{BA} + \alpha_3 \breve{R}_{BA} - \left(-\omega_4^2 R_{BO_4}\right) - \alpha_4 \breve{R}_{BO_4} = 0$$

$$\underbrace{-\omega_2^2 R_{AO_2} + \alpha_2 \breve{R}_{AO_2} - \omega_3^2 R_{BA} - \left(-\omega_4^2 R_{BO_4}\right)}_{\text{KNOW}} + \underbrace{\alpha_3 \breve{R}_{BA} - \alpha_4 \breve{R}_{BO_4}}_{\text{UNKNOW.}} = 0$$

$\omega_2, \omega_3, \omega_4, \alpha_2$, $A_A^n, A_A^t, A_{BA}^n, A_B^n$ } KNOW.

A_{BA}^t, A_B^t } UNKNOW.

α_3, α_4 } UNKNOW



A
B
R_{AO_2}
R_{BO_4}
O_2
O_4
A^n_A
A^t_A
A^n_B
A^n_{BA}