기구설계학 Lec1 (20210831)

- 좋은 기계란? (Good Machine)

High quality

- High performance.
- multi-function.
- High efficiency
- Low price

Easy to make

parts, material, machine tool, assembly, cost,

Easy to use

↳ operation, tuning, inspection, repair, cleaning.
less breakdown/malfunction. noise, size

Easy to throw away / dispose of

capability of recycling.
environmentally friendly
sustainability.

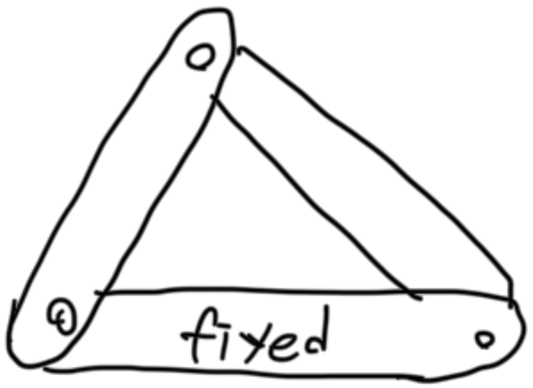
Machine : A device to transform/transfer physical quantities and to be useful for people.

Input → $\boxed{\text{Mechanism}}$ → Output.

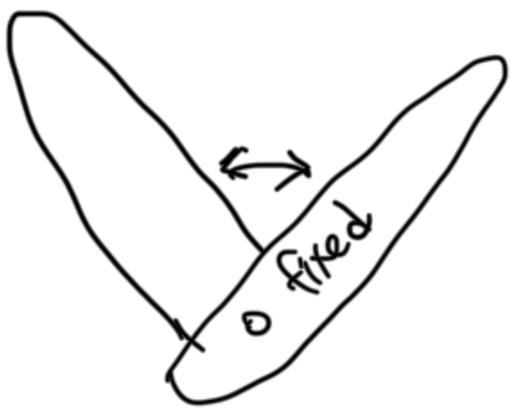
Mechanism : device that has the purpose of transferring motion / force from the input to output.

Linkage : Σ link, bar, rigid connected by joints to form open/closed chains/loops.

Kinematic chains, with at least one link fixed, become $\boxed{\text{mechanisms}}$ or $\boxed{\text{structures}}$ depending on mobility (# of mobile links ≥ 2)

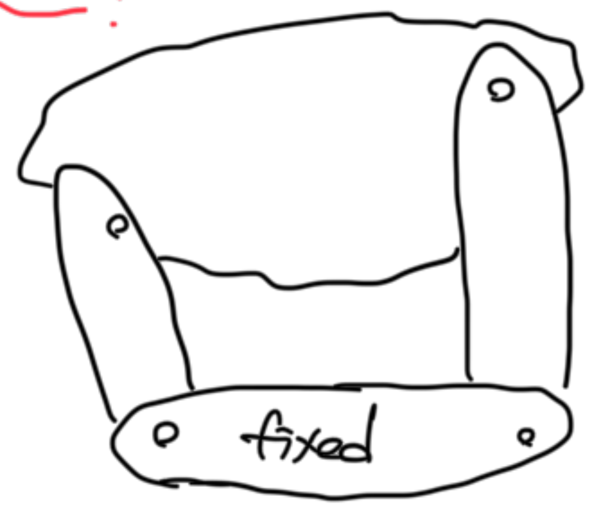


no mobility ⇒ structure



no mobility (number of mobile links < 2)

⇒ 둘다 아님! (정의에 따라 다를수도?)



⇒ mechanism.

(closed chain)

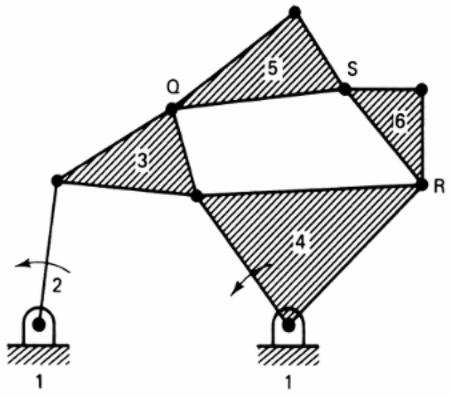
Machine = Σ Mechanism.

* 고정 link 에 따라 link 사이의 상대운동은 불변

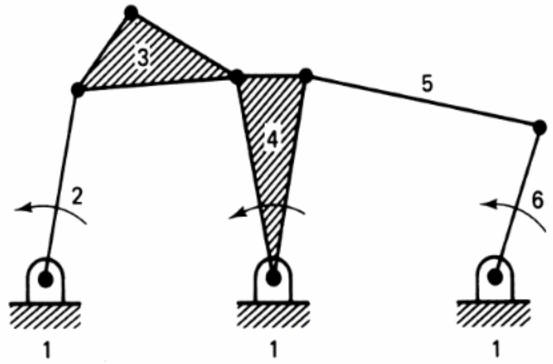
<Plane Motion> : 2D plate 위에서만 운동. = translation + rotation.

Lower pairs : full 접촉 joint : Surface Contact pairs.

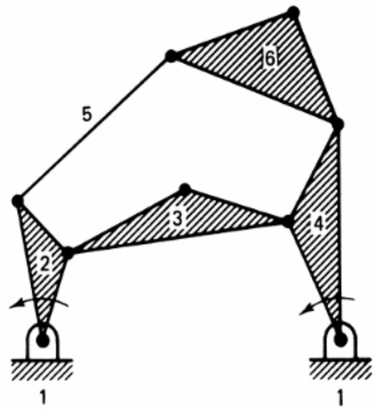
Higher pairs (joints) : have line/point contact. e.g) cam, ball, roller bearings, gear



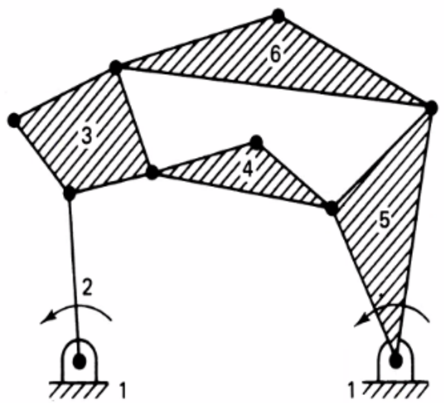
Watt I six-bar linkage.



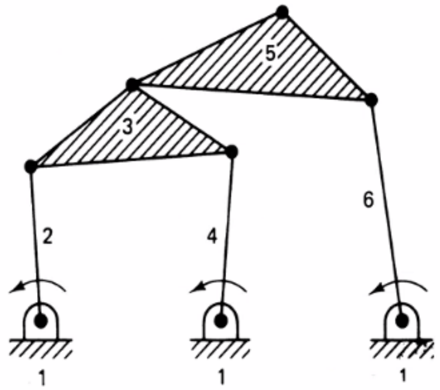
Watt II six-bar linkage



Stephenson I six-bar linkage

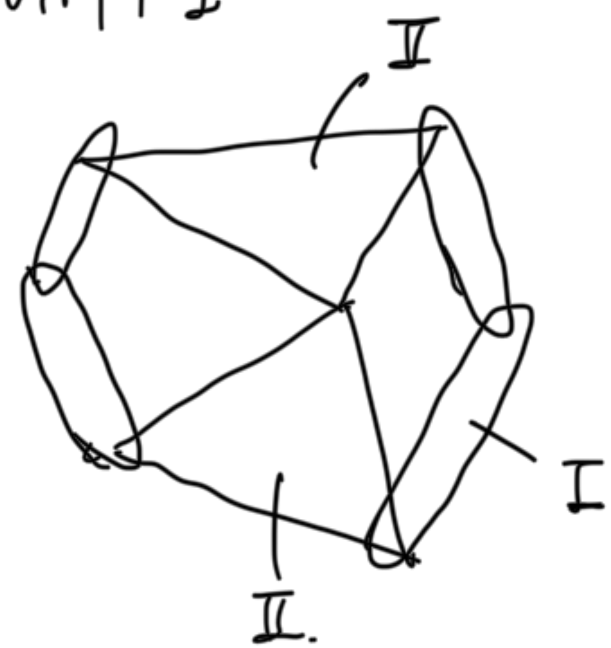


Stephenson II six-bar linkage

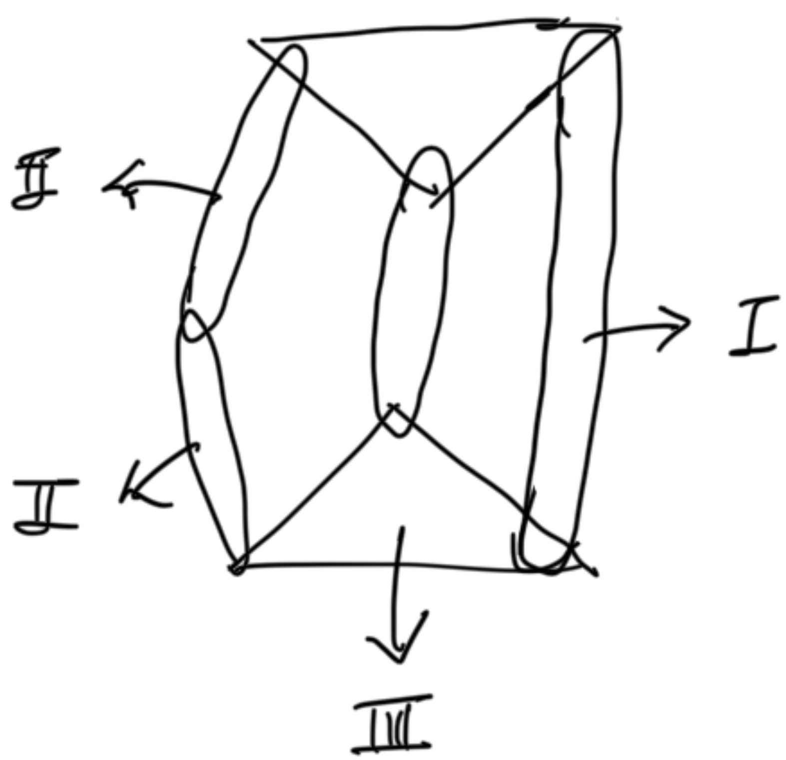


Watt : Tenary link 서로 직결.   고정에 따라 I ~ III 이 결정.

WATT I

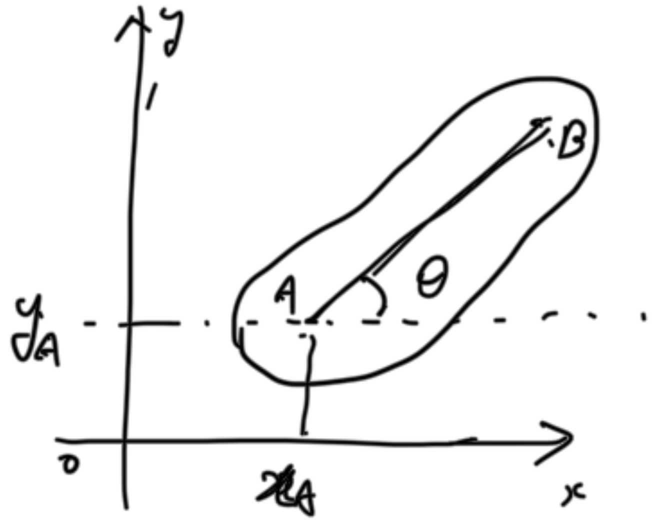


STEPHENSON.



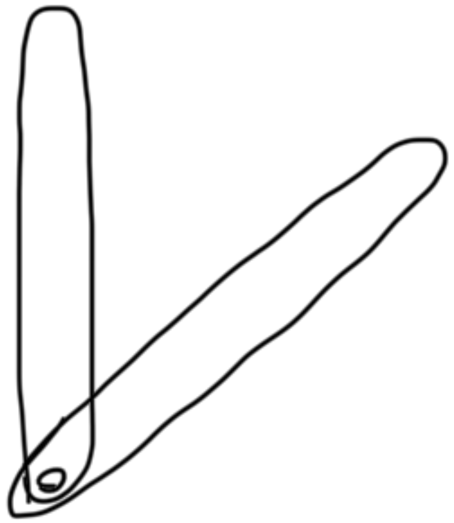
Degrees of Freedom : Number of independent inputs required to determine the position of all links of the mechanism with respect to ground.

$\underbrace{x, y, \theta}_{3\,DOF} \longrightarrow \boxed{\text{link}} \longrightarrow$ position

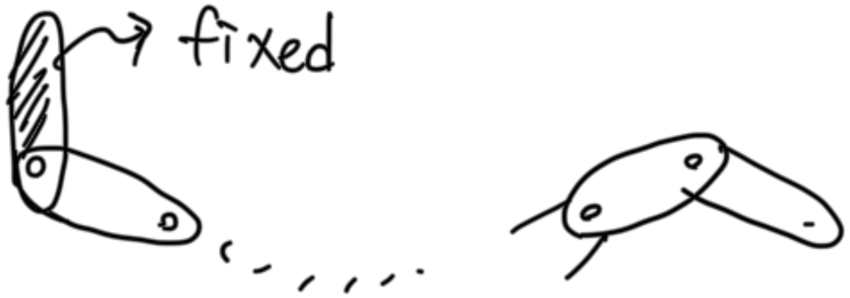


$\Rightarrow \boxed{3DOF}$

Gruebler's Equation



$\Rightarrow$

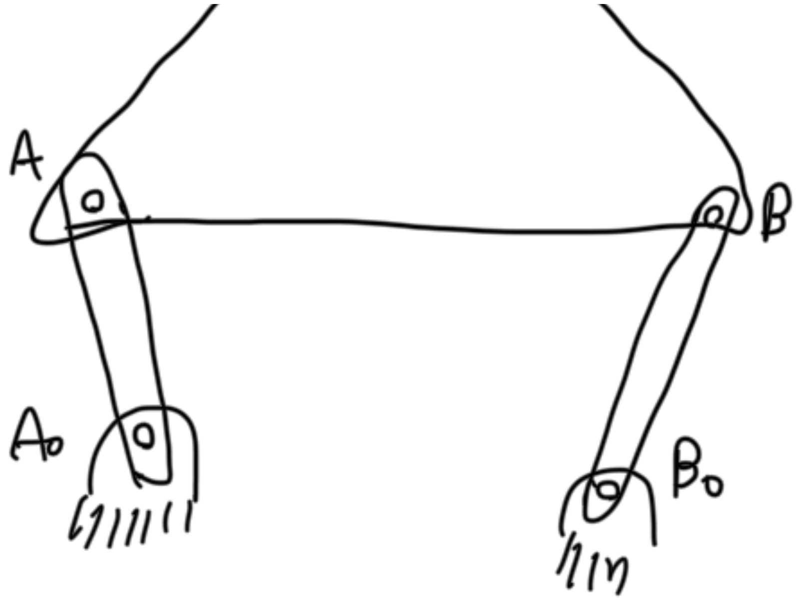


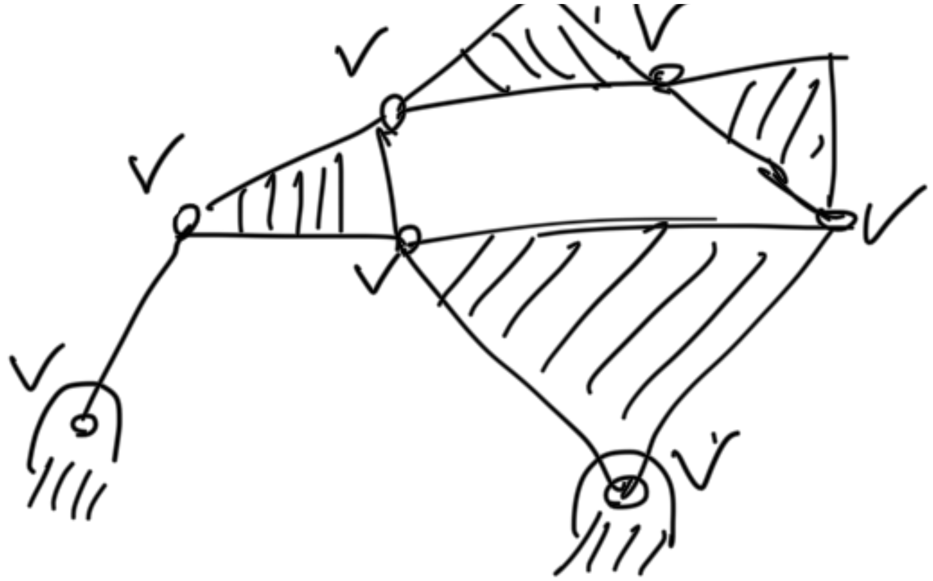
n link, f pinjoints
One link fixed on ground

$$\boxed{DOF : F = 3(n-1) - 2f_1 \quad (\text{Gruebler's Eq})}$$

4 DOF $= 3 \cdot 2 - 2 \cdot 1 = 4$ * pinjoint = lower link

E.g.)





$F = 3 \cdot 3 - 2 \cdot 4 = 1$ (Gruebler)

A_0 fixed → If A fixed → B should be fixed

→ 1 DOF (Intuition)

$F = 3 \cdot 5 - 2 \cdot 7 = 1$ (Gruebler)

* Also can be done intuitively.

Has to be $F=3$

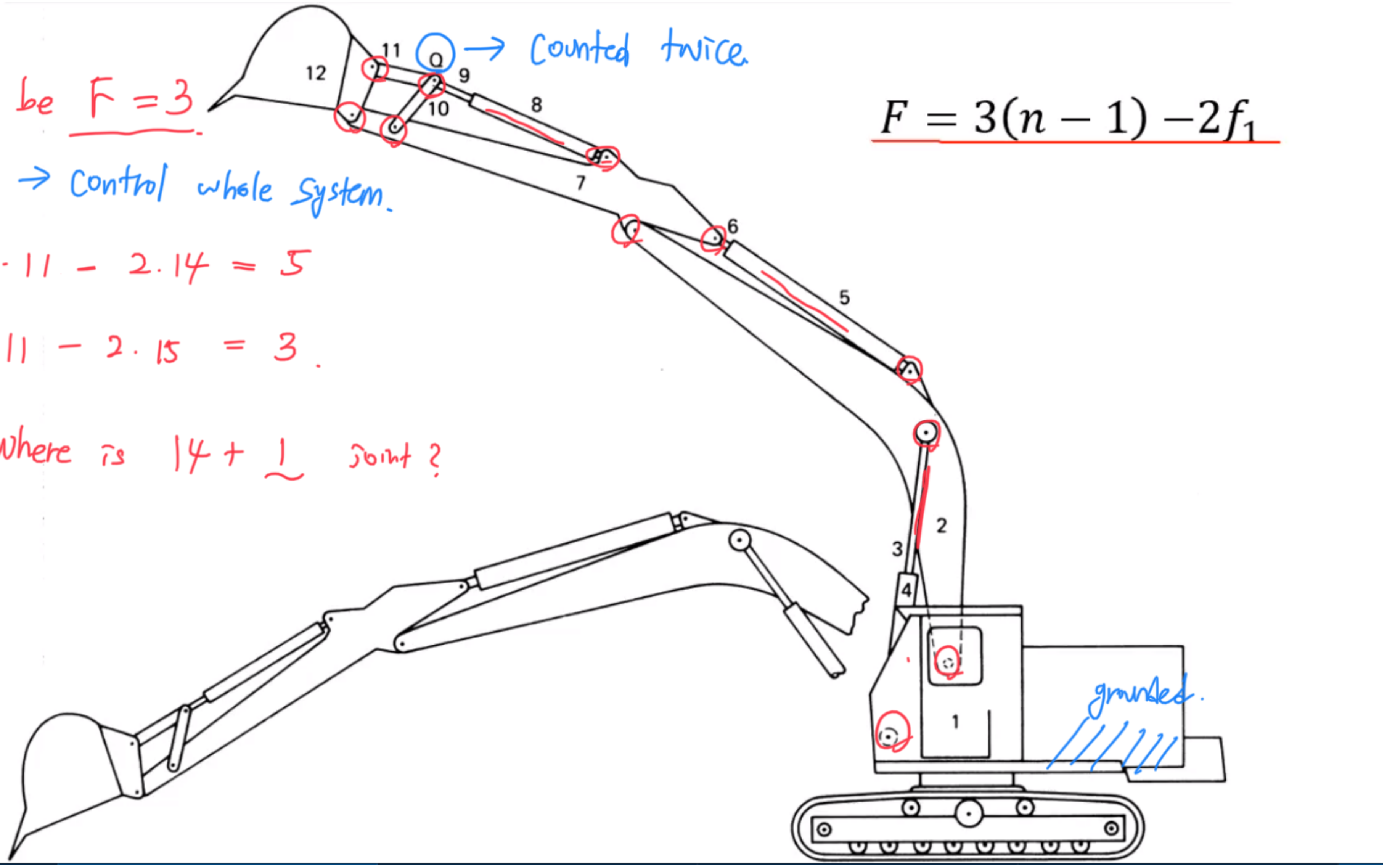
∵ 3, 5, 8 → control whole system.

$3\cdot 11 - 2\cdot 14 = 5$

$3\cdot 11 - 2\cdot 15 = 3$.

Q) Where is 14 + 1 joint?

$$F = 3(n-1) - 2f_1$$

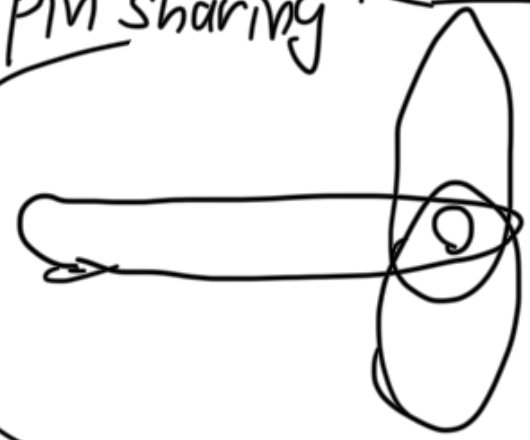


① 7~12 ⇒ $3\cdot5 - 2\cdot7$ ("7" fixed)

② 2,5,6,7 ⇒ $3\cdot3 - 2\cdot4 = 1$ ("2" fixed)

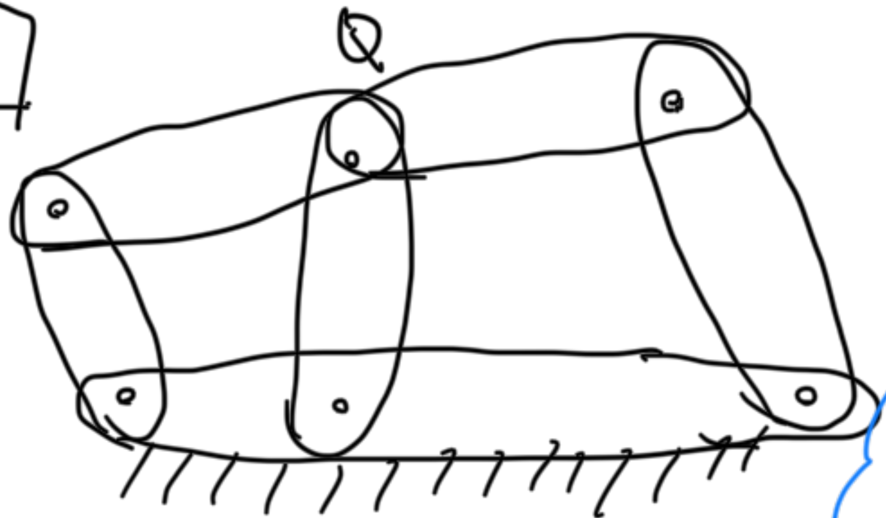
③ 1~4 ⇒ $3\cdot3 - 2\cdot4 = 1$ ("1" fixed)

★ Pin sharing



$3+\underline{(3-2)}+\underline{(3-2)} = 5$

$\boxed{7\sim12}$



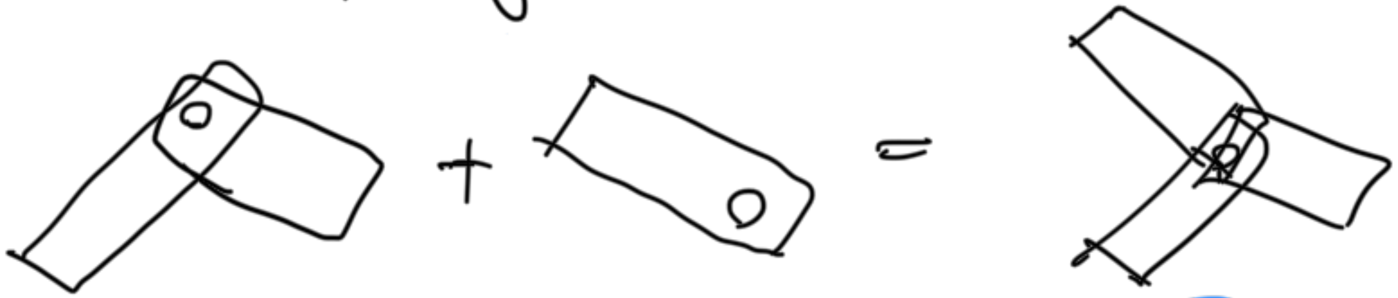
2 link ⇒ 1 pinjoint.

$F = 3\cdot5 - 2\cdot6$ (X)

$F = 3\cdot5 - 2\cdot7$ (O)

★ pinjoint shared by links more than <u>two</u> should be thought twice.

⇒

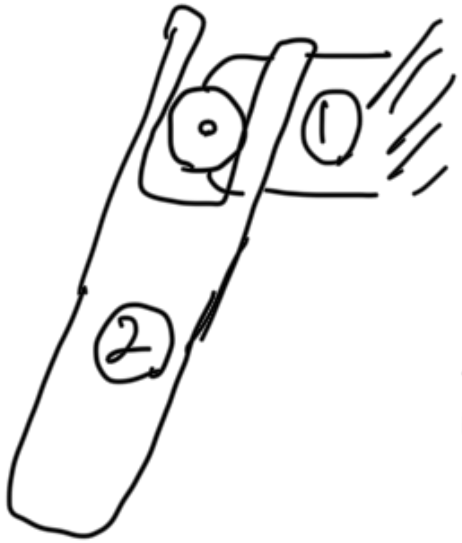


pinjoint & slide $= f_1$

∴ Gruebler's Equation (modified) : $F = 3\underbrace{(n-1)}_{\text{links}} - \underbrace{2f_1}_{\text{lower pair}} - \underbrace{f_2}_{\text{higher pair}}$.

E.g.)

g)



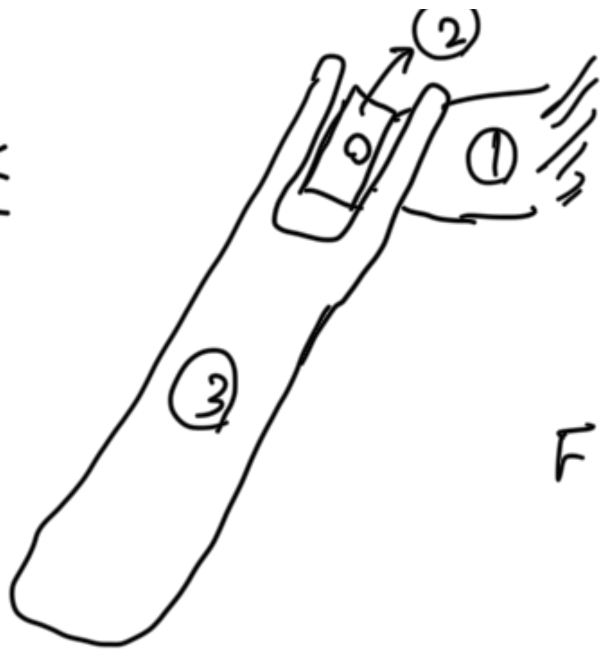
$n = 2$

$f_1 = 0$

$f_2 = 1$

$F = 3(2-1) - 1 = \underline{2}$

$\equiv$



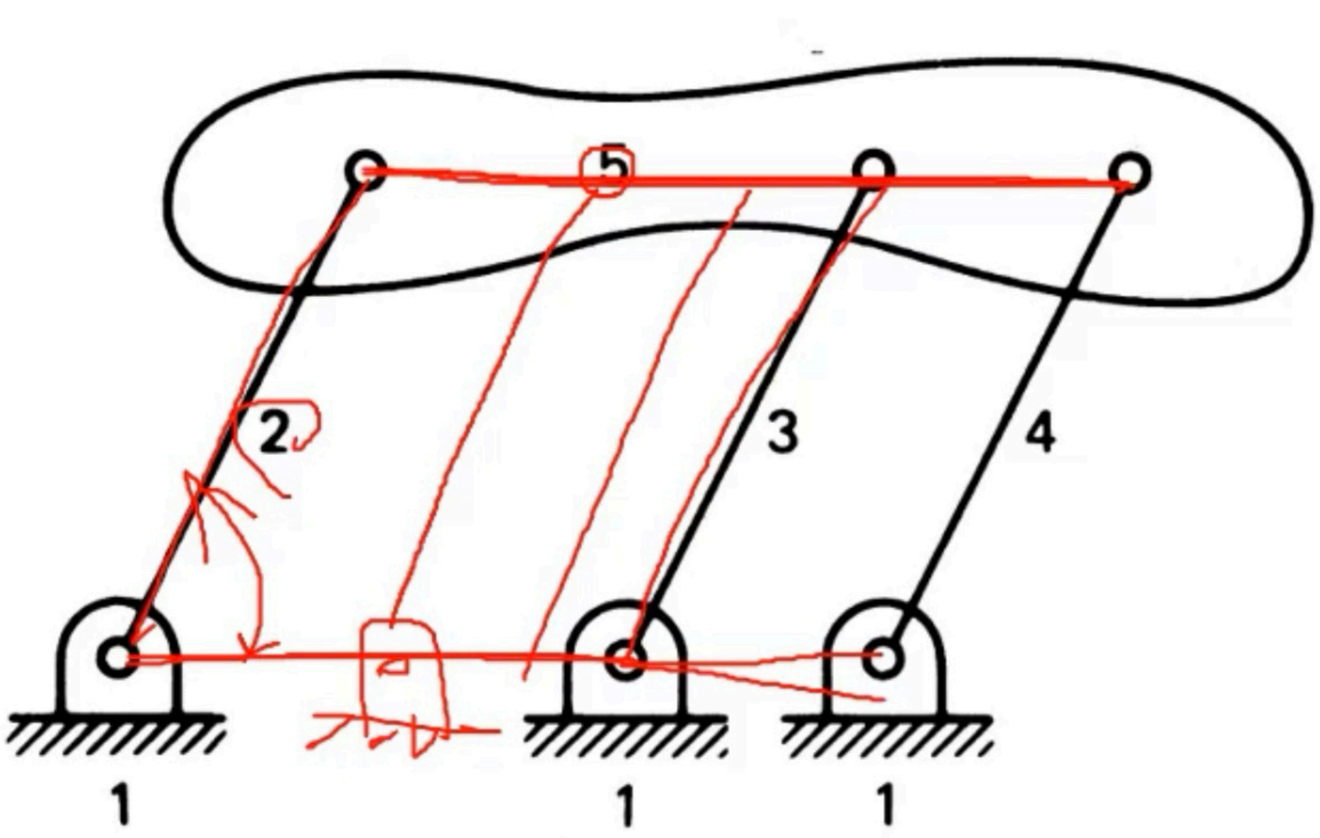
$n = 3$

$f_1 = 2$

$f_2 = 0$

$F = 3\cdot(3-1) - 2\cdot 2 = \underline{2}.$

Overconstrained linkage

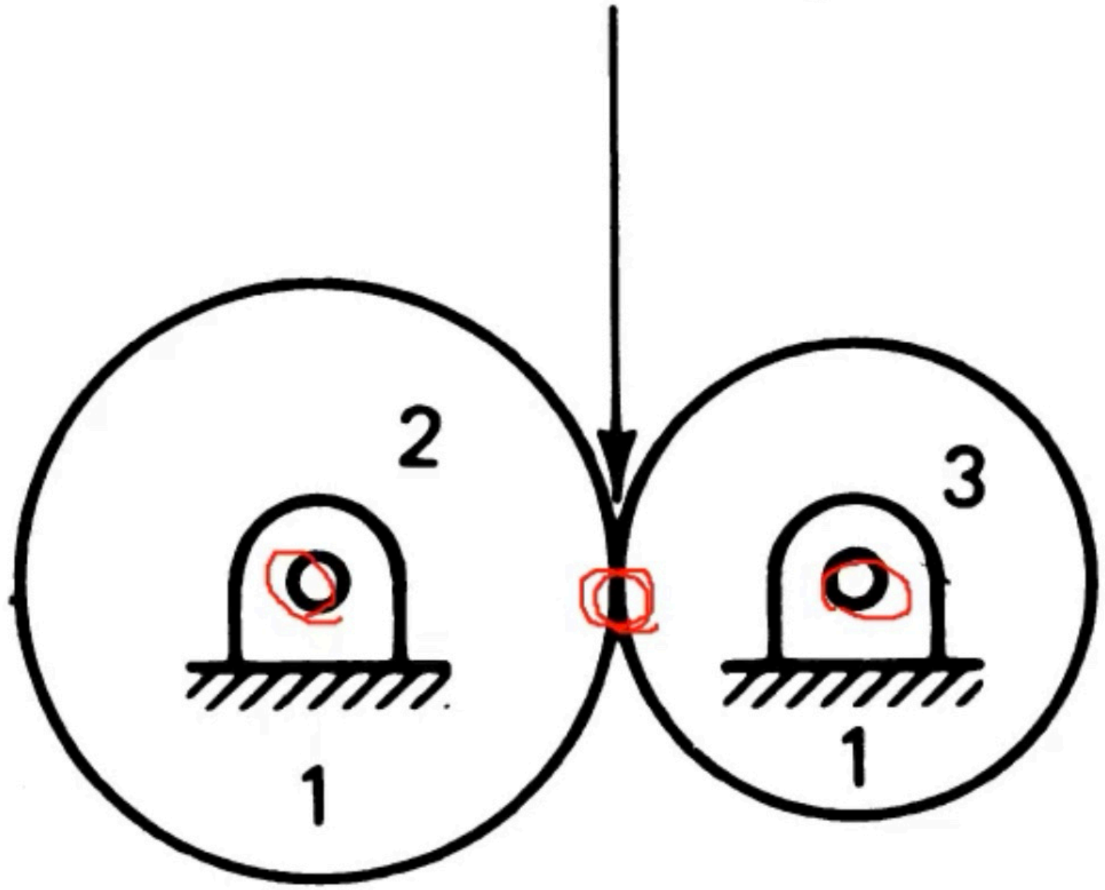


$F=3x(5-1)-2x6=0$

-1

F=1 when all parallel to each other.

Pure Rolling



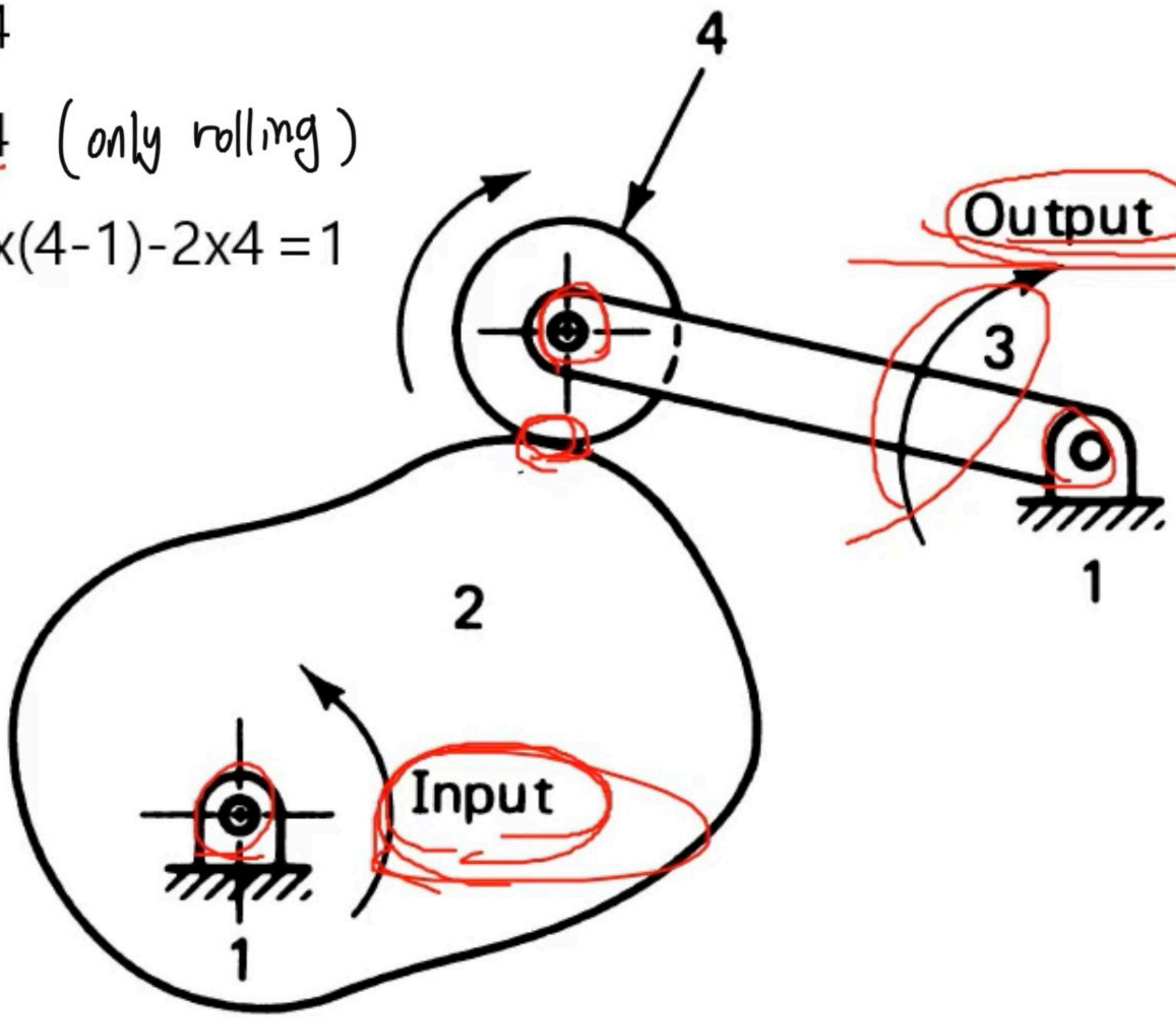
$F=3x(3-1)-2x3=0$

Passive or redundant degree of freedom

$n = 4$

$f_1 = 4$ (only rolling)

F=3x(4-1)-2x4 =1



$n = 4$

$f_1 = 3$

$f_2 = 1$ (allows sliding + rolling)

F=3x(4-1)-2x3-1 =2

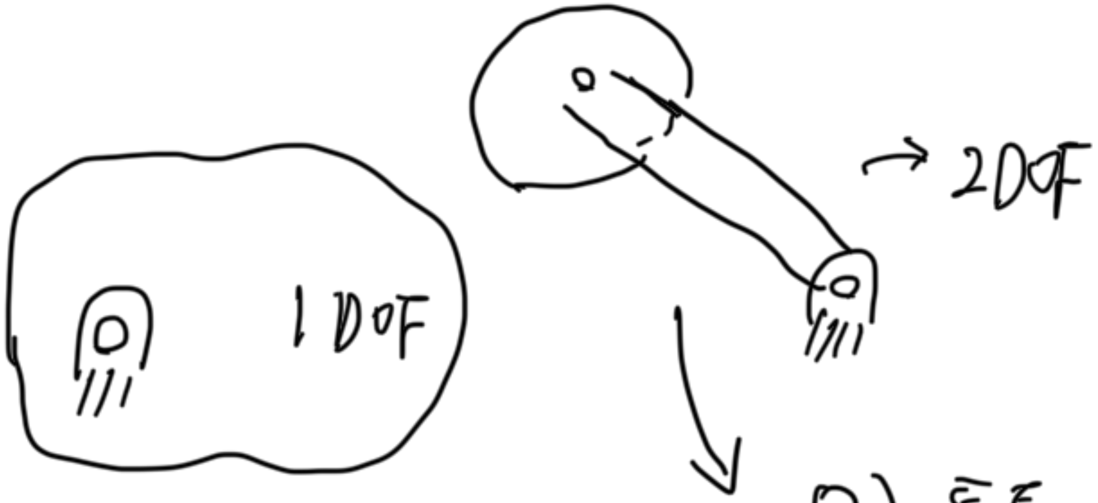
$n = 3$ (③ & ④ fixed together)

$f_1 = 2$

$f_2 = 1$ (only sliding)

F=3x(3-1)-2x2-1 =1

Q) what is DOF for whole system ?



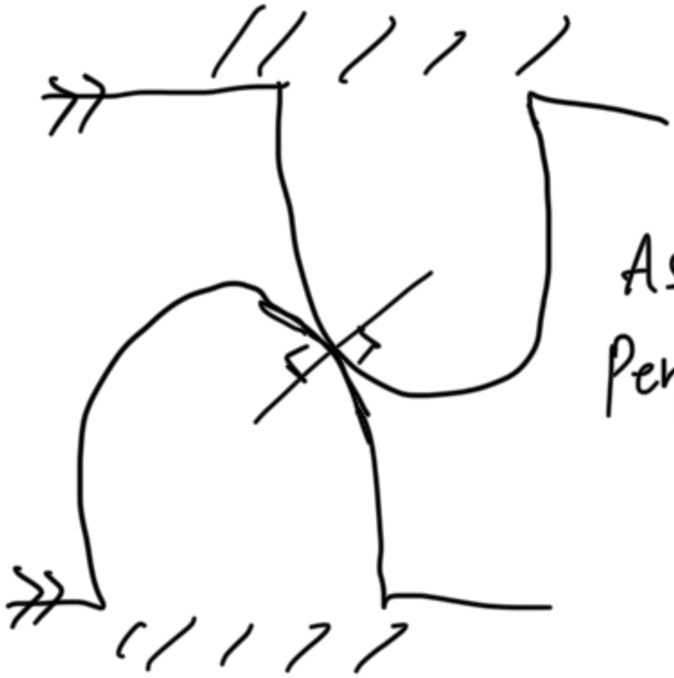
비접촉 : $n = 4$, $f_i = 3$ $\Rightarrow$ $F = 3$

접촉(no slide) : $n = 4$, $f_i = 4$ $\Rightarrow$ $F = 1$

Q) 통통 튀면 어떻게 함?

DOF determination & kinematic diagram drawing are First Step in both kinematic analysis & synthesis processes.

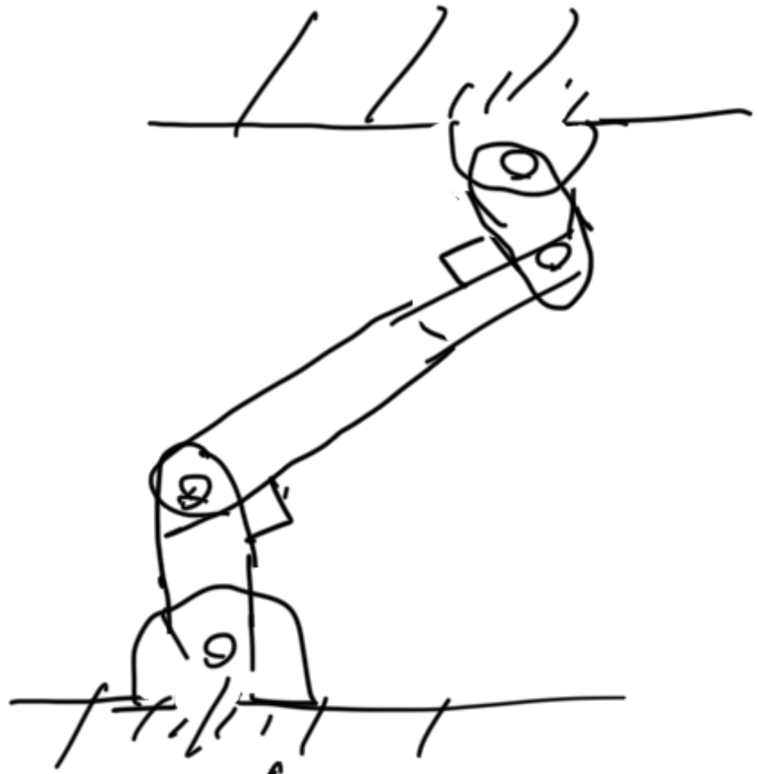
Higher Pair : DOF 1개 줄어 / Lower Pair : DOF 2개 줄어.



Assume Perpendicular.

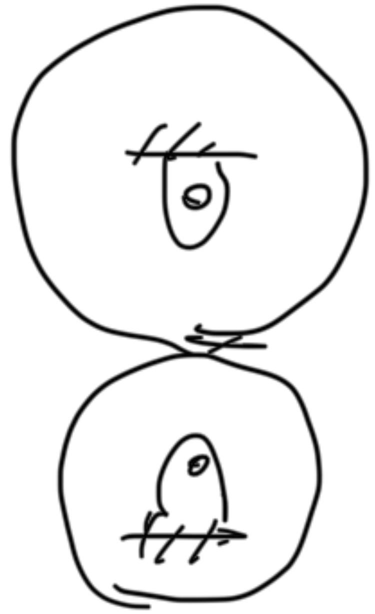
$$3 \cdot (2-1) - 1 = 2$$

$\neq$

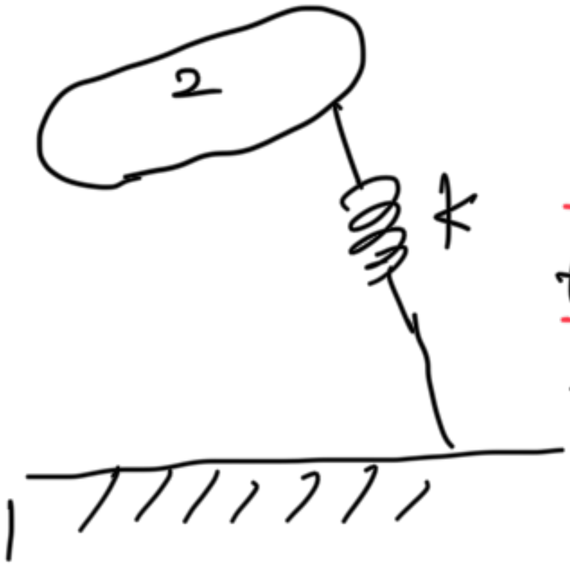


$$3 \cdot (4-1) - 2 \cdot 4 = 1.$$

$\equiv$



$$3 \cdot (3-1) - 2 \cdot 2 - 1 \cdot 1 = 1$$



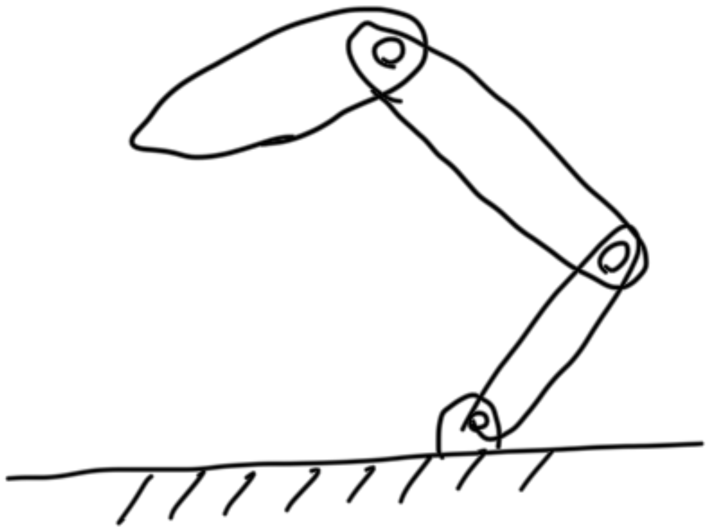
$n = 2$

$f_1 = 0$

$f_2 = 0$

$F = 3.$

$\equiv$



$n = 4$

$f_1 = 3$

$f_2 = 0$

$F = 3.$

* spring does not affect # of DOFs (only force exertion).

① Why 4-bar linkage is simplest closed-loop.

$F = 3(n-1) - 2f_1 - f_2$, $f_2 = 0$ assuming,

$\Rightarrow F = 3(n-1) - 2f_1$, for $F=1$ purpose, $3n = \underbrace{2f_1 + 4}_{\text{짝수}} \Rightarrow n = \text{even \#}$

To be closed loop, $n \geq 3 \Rightarrow n = 4 \Rightarrow$ $\boxed{\text{4 bar linkage is simplest closed loop.}}$

② How to figure out linkage components

B : binary

T : Ternary

⋮

$n = B + T + Q + P + H + \cdots$

$2f_1 = 2B + 3T + 4Q + \cdots$

Using $F = 3(n-1) - 2f_1$, $\Rightarrow n - (F+3) = T + 2Q + 3P + 4H + \cdots$

Thus, if $F=1$, and $n=4$, (4-bar linkage), only binary link possible.

if $F=1$ and $n=6$, (6 〃), $T=2$. $B=4$

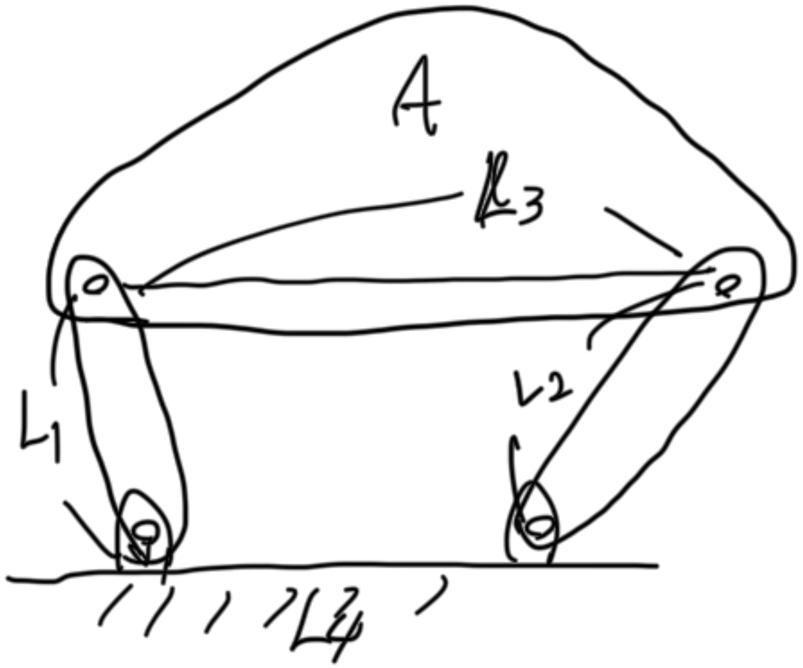
$\alpha = 1$, $B = 5$ $\Rightarrow$ 불가능!

$\boxed{\text{HW 1}}$ 1-2, 16, 36.

Chapter 1

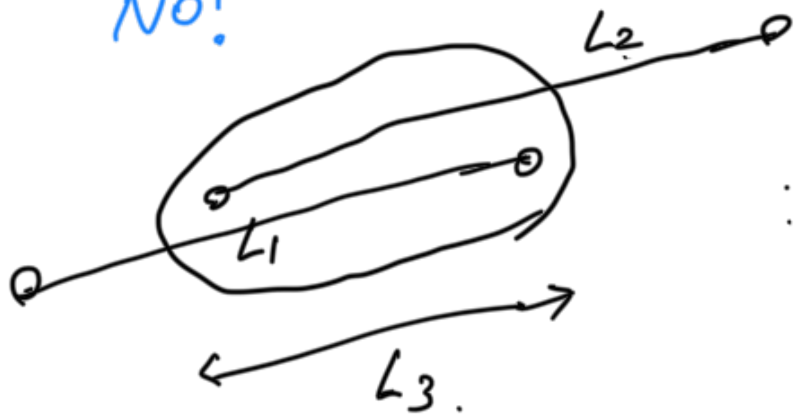
기구설계학 LEC 5 (20210909)

Q) Can "A" rotate ?



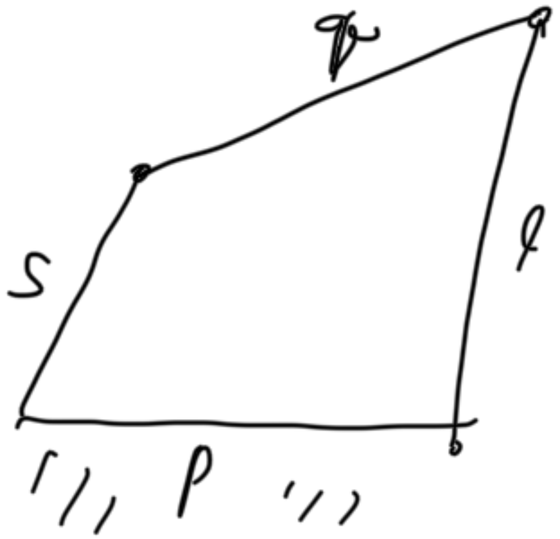
My idea : If $|L_1 - L_2| = L_3$ → rotate!

(∵) No!



$L_1 < L_3, L_4 < L_2$?

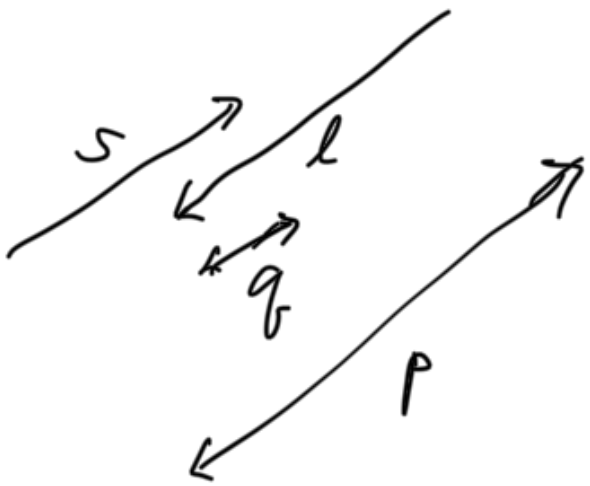
∴ Boundary Condition.



$\boxed{\text{Grashof criteria : } s + l < p + q}$

$s + l - q < p$

pf)

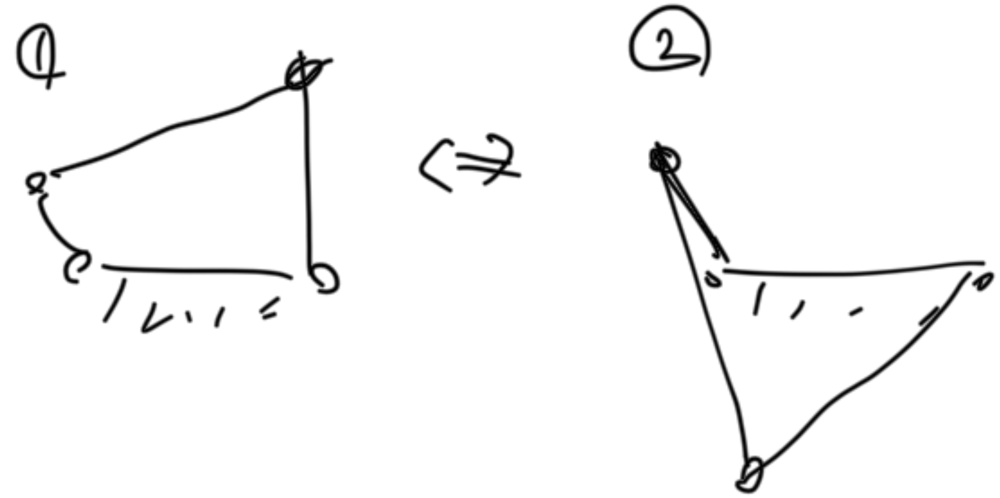


⇒ Kinematic inversion

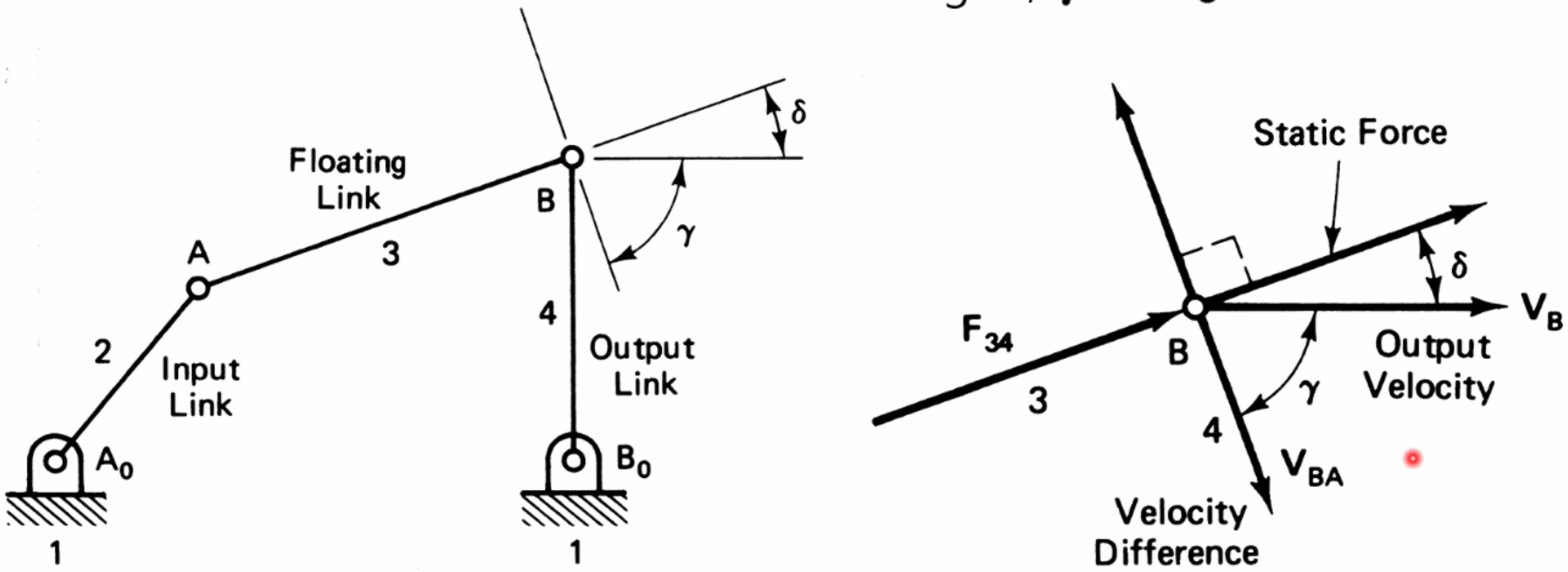
Geometric inversion

고정 link 바꾸기

특정 linkage 에 대해
여러 가능성

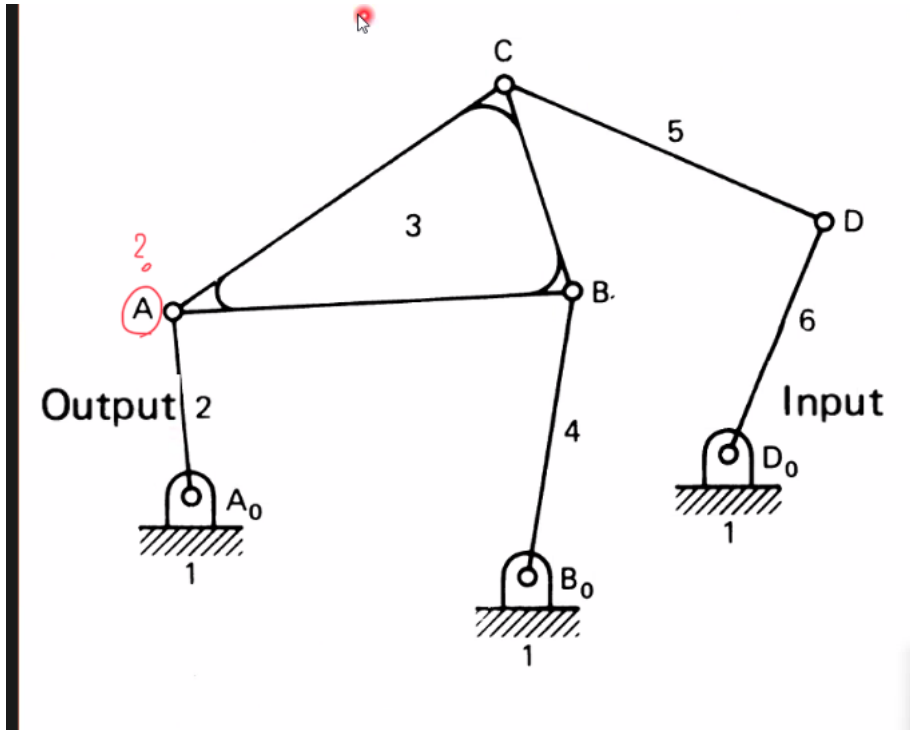


Transmission and deviation angles, $\boldsymbol{\gamma}$ and $\boldsymbol{\delta}$



//
A 에 대한 B의 상대속도 방향

γ has to be close to 0 for force transfer

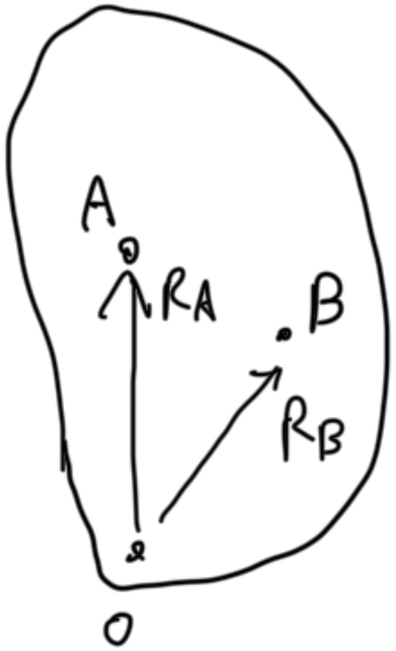


How ? (Input $\rightarrow$ output)

기구설계학 LEC 6 (20210916)

	Same point	Different point
Same link 같은 링크에 있는.	*Case 1* Trivial	*Case 2* Difference motion
Different links 다른 링크에 있는	*Case 3* Relative motion	*Case 4* Manageable through a series of case 2 and case 3 steps

Link 는 얼마든지 확장 가능.

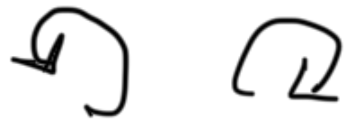


$$\vec{V_A} = \frac{d}{dt}\{\vec{R_A}\} = \frac{d}{dt}\{R_A e^{j w t}\} = j w \vec{R_A}$$

$$\vec{V_{BA}} = \vec{V_B} - \vec{V_A} = j w (\vec{R_B} - \vec{R_A}) = j w \vec{R_{BA}}$$

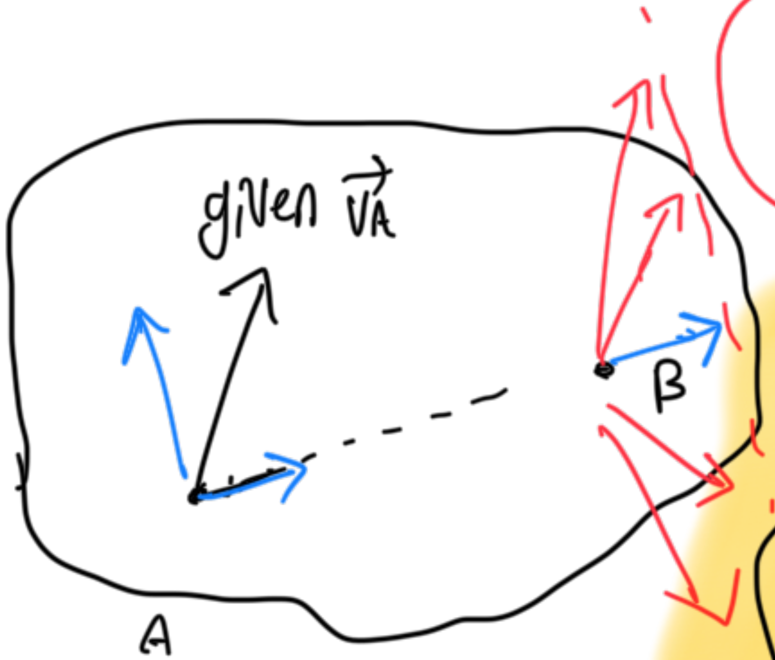
$$\Rightarrow \quad w = \frac{\vec{V_{BA}}}{j \vec{R_{BA}}} \quad \Rightarrow \quad |w| = \frac{\|\vec{V_{BA}}\|}{\|\vec{R_{BA}}\|}$$

Note : $w > 0$ = counter clockwise



R_{BA} (A 가 기준!)

B의 속도는 → 만 가능!

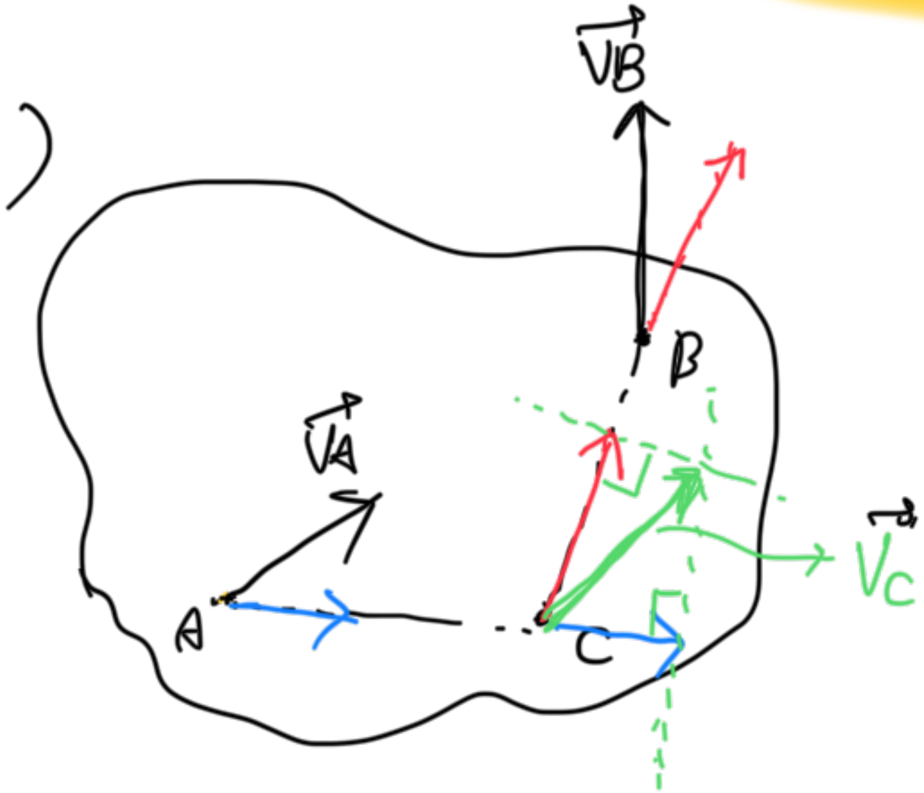


Note : $\overline{AB}$ 위 방향 속도 성분이 동일해야함 (∵ Rigid Body).

why ? → $w = \dfrac{\vec{V_{BA}}}{j \vec{R_{BA}}} \in \mathbb{R}$

Thus $\vec{V_{BA}} \perp \vec{R_{BA}}$ has to be satisfied this, $\vec{V}_{BA} \perp \vec{r}_{BA}$ has to be satisfied.)

E.g.)



Note: In textbook, $\omega_2 = -600$ rpm : clockwise. $= \left\{ \begin{array}{l} \curvearrowright \omega_2 \\ \omega_2 = 600 \text{ rpm} \end{array} \right\}$

$\nearrow$: arrow indicates purely direction!

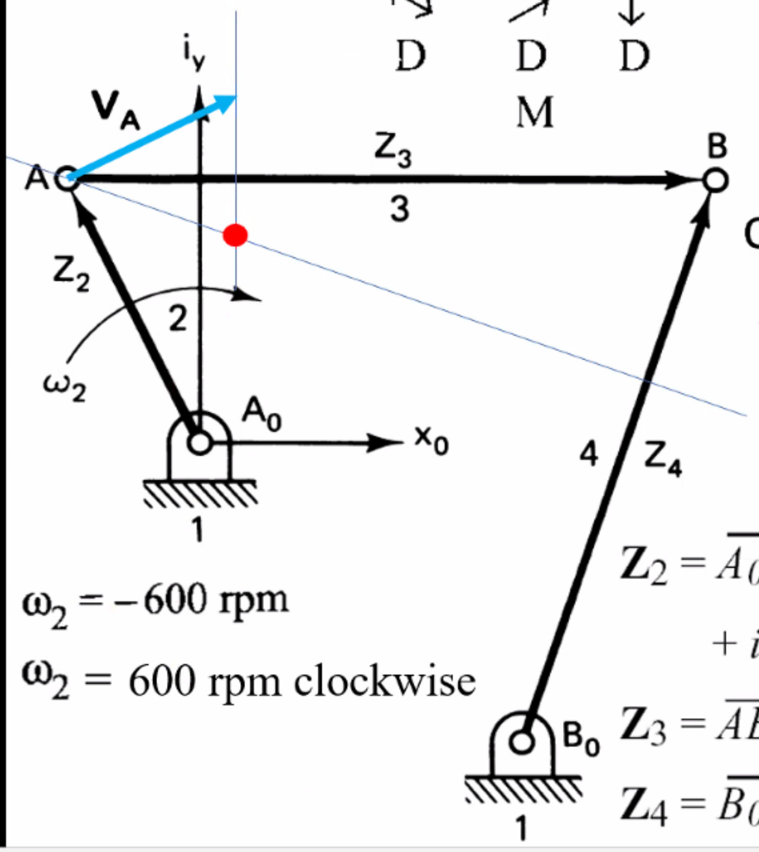
$$\mathbf{V}_A = i(\overrightarrow{A_0A})\,(\omega_2) = i(2.5)e^{i(118.72°)}(-62.8) = (157)e^{i(28.72°)}\ \text{cm/sec} \nearrow$$

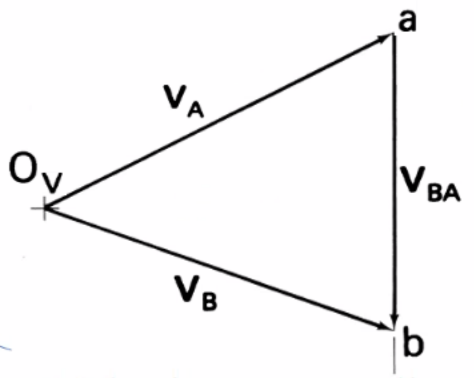
$$\mathbf{V}_B = \mathbf{V}_A + \mathbf{V}_{BA}$$

$$\begin{array}{ccc} \leftrightarrow & \nearrow & \updownarrow \\ \text{D} & \text{D} & \text{D} \\ & \text{M} & \end{array}$$

$$\mathbf{V}_B = (147)e^{i(-17.7°)}\ \text{cm/sec} \searrow$$

$$\mathbf{V}_{BA} = (120)e^{i(-87.99°)}\ \text{cm/sec} \downarrow$$





Velocity-vector diagram

$$|\omega_2| = \frac{157\ \text{cm/sec}}{2.5\ \text{cm}} = 62.8\ \text{rad/sec}$$

$$|\omega_3| = \frac{120\ \text{cm/sec}}{5.5\ \text{cm}} = 21.8\ \text{rad/sec}$$

$$|\omega_4| = \frac{147\ \text{cm/sec}}{5.0\ \text{cm}} = 29.4\ \text{rad/sec}$$

$$\omega_3 = \frac{\mathbf{V}_{BA}}{i\mathbf{Z}_3} = -21.8\ \text{rad/sec}$$

$$\omega_4 = \frac{\mathbf{V}_{B}}{i\mathbf{Z}_4} = -29.4\ \text{rad/sec}$$

-21.8 rad/sec (cw)

$$\omega_2 = -600\ \text{rpm}$$

$$\omega_2 = 600\ \text{rpm clockwise}$$

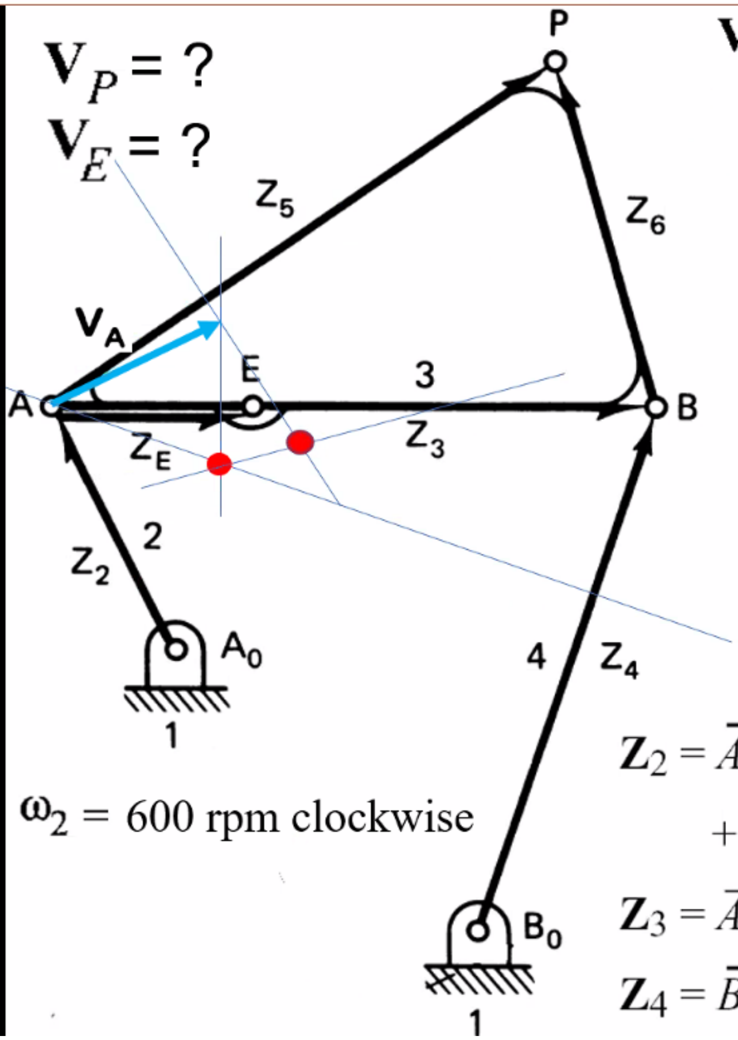
$$\mathbf{Z}_2 = \overrightarrow{A_0A} = 2.5\ \text{cm}\ e^{i(118.72°)} = -1.20 + i2.19$$

$$\mathbf{Z}_3 = \overrightarrow{AB} = 5.5\text{cm}\ e^{i(2.01°)} = 5.50 + i0.20$$

$$\mathbf{Z}_4 = \overrightarrow{B_0B} = 5.0\ \text{cm}\ e^{i(72.30°)} = 1.52 + i4.76$$

$\mathbf{V}_P = ?$

$\mathbf{V}_E = ?$



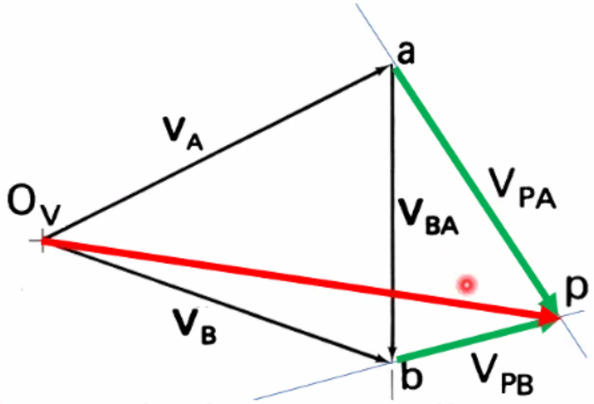
ω_2 = 600 rpm clockwise

$$\mathbf{V}_P = \mathbf{V}_A + \mathbf{V}_{PA}$$
$\nearrow$ D M, $\nwarrow\!\!\searrow$ D

$$\mathbf{V}_B = \mathbf{V}_A + \mathbf{V}_{BA}$$
$\nwarrow\!\!\searrow$ D, $\nearrow$ D M, $\updownarrow$ D

$$\mathbf{V}_P = \mathbf{V}_B + \mathbf{V}_{PB}$$
$\searrow$ D M, $\leftrightarrow$ D

$$\mathbf{V}_A + \mathbf{V}_{PA} = \mathbf{V}_B + \mathbf{V}_{PB}$$
$\nearrow$ D M, $\nwarrow\!\!\searrow$ D, $\searrow$ D M, $\leftrightarrow$ D



Velocity-vector diagram

$$\mathbf{Z}_2 = \overrightarrow{A_0A} = 2.5\text{ cm } e^{i(118.72^\circ)} = -1.20 + i2.19$$

$$\mathbf{Z}_3 = \overrightarrow{AB} = 5.5\text{cm } e^{i(2.01^\circ)} = 5.50 + i0.20$$

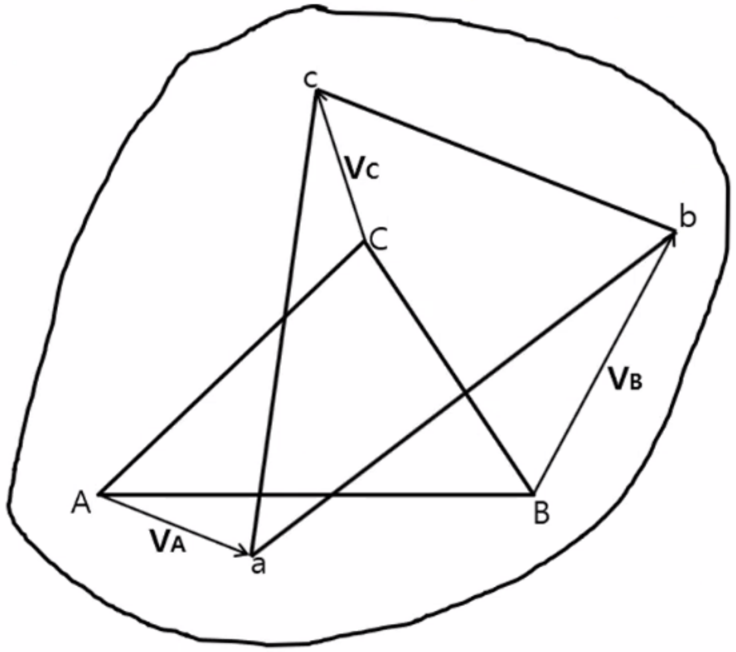
$$\mathbf{Z}_4 = \overrightarrow{B_0B} = 5.0\text{ cm } e^{i(72.30^\circ)} = 1.52 + i4.76$$

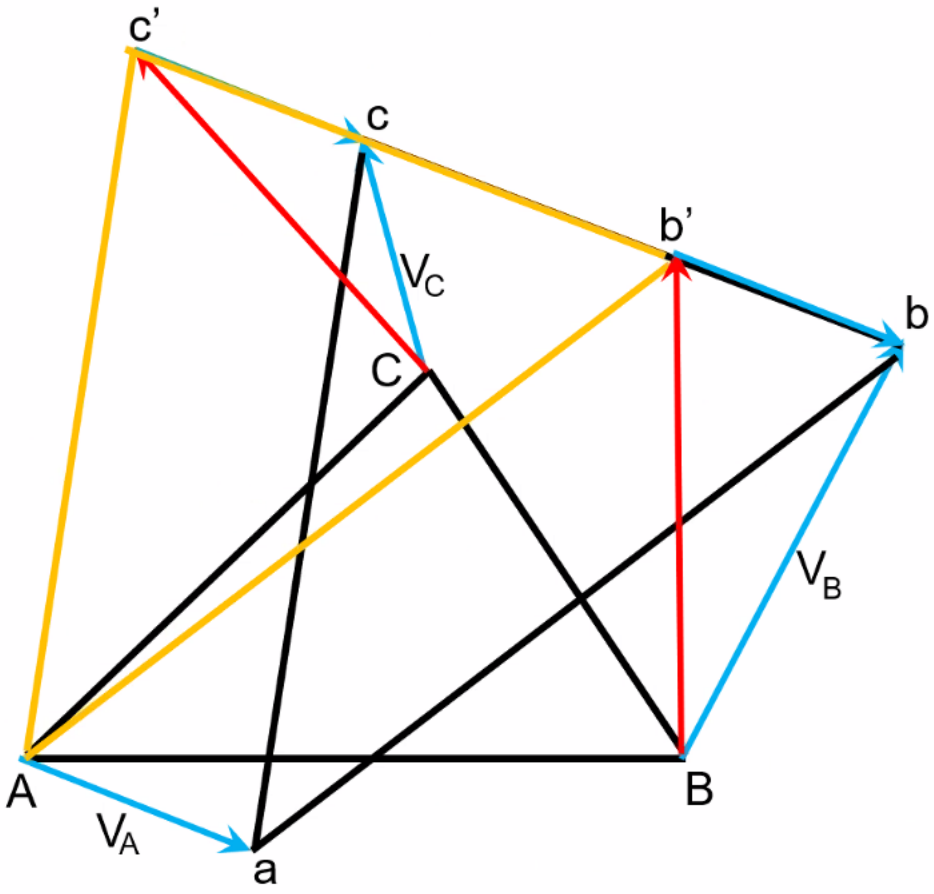
$\triangle ABC \backsim \triangle abc$

$\triangle Ab'c' = \triangle abc$

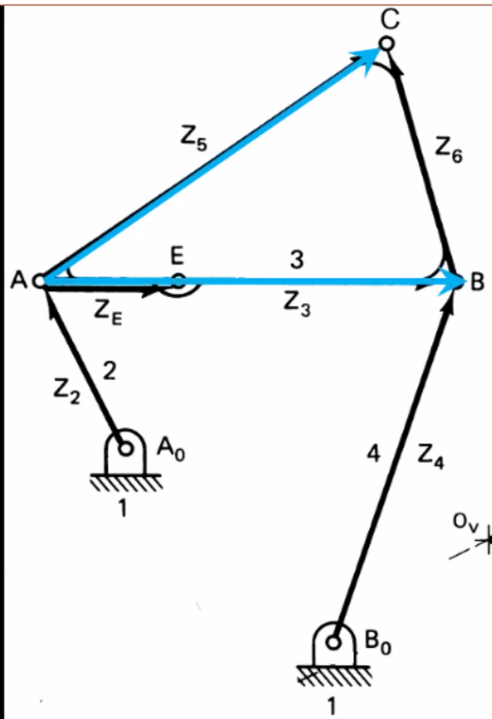
$\triangle ABb' \backsim \triangle ACc'$

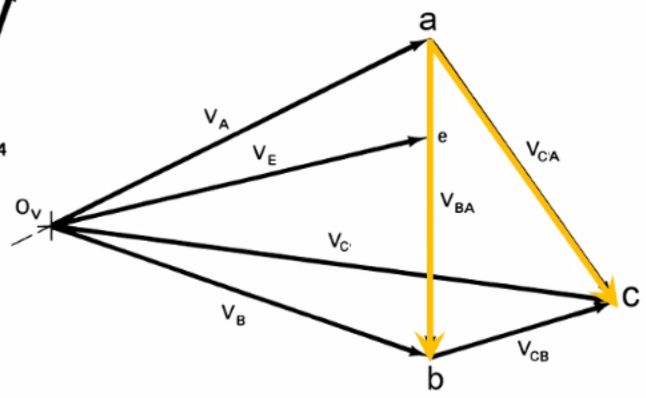
$\triangle ABC \backsim \triangle Ab'c'$

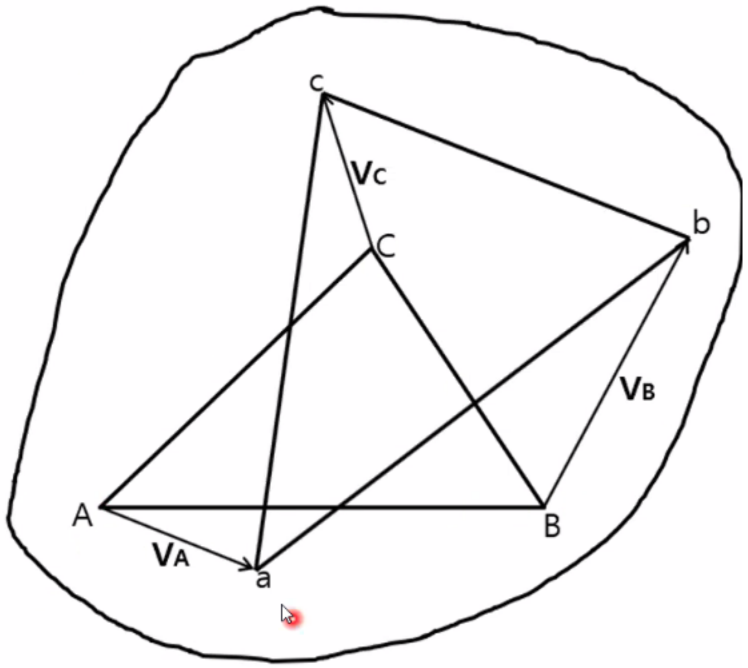




$\triangle ABC \backsim \triangle abc$







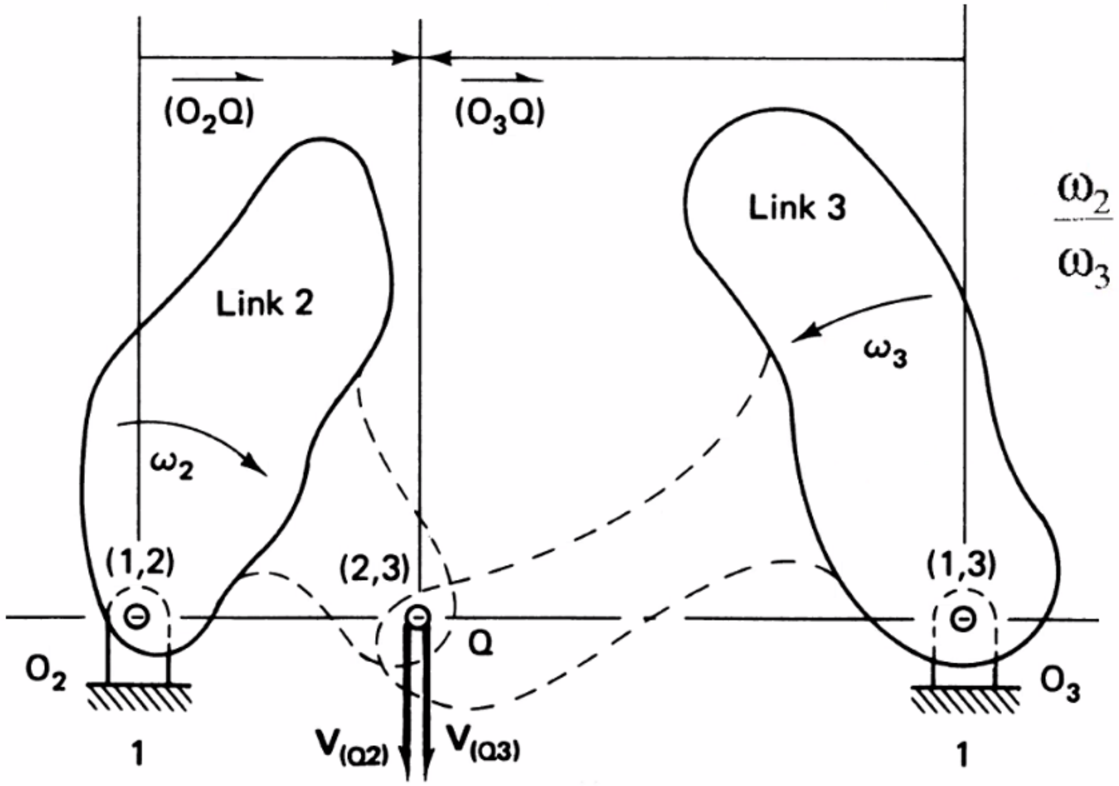
$$Z_C = Z_A + C(Z_B - Z_A) \qquad \dot{Z}_C = \dot{Z}_A + C(\dot{Z}_B - \dot{Z}_A)$$

$$C = \frac{Z_C - Z_A}{Z_B - Z_A} = \frac{\dot{Z}_C - \dot{Z}_A}{\dot{Z}_B - \dot{Z}_A} = \frac{Z_C - Z_A + k(\dot{Z}_C - \dot{Z}_A)}{Z_B - Z_A + k(\dot{Z}_B - \dot{Z}_A)} = \frac{Z_C + k\dot{Z}_C - (Z_A + k\dot{Z}_A)}{Z_B + k\dot{Z}_B - (Z_A + k\dot{Z}_A)}$$

기구설계학 LEC 8 (20210930)

PowerPoint 슬라이드 쇼 - [MA 210930 - 실시간 zoom.pptx] - PowerPoint

$$\mathbf{V}_{(Q2)} = i\omega_2(\overline{O_2Q}) = i\omega_2(\overrightarrow{1,2-2,3}) \qquad \mathbf{V}_{(Q3)} = i\omega_3(\overline{O_3Q}) = i\omega_3(\overrightarrow{1,3-2,3})$$



$$\mathbf{V}_{(Q2)} = \mathbf{V}_{(Q3)}$$

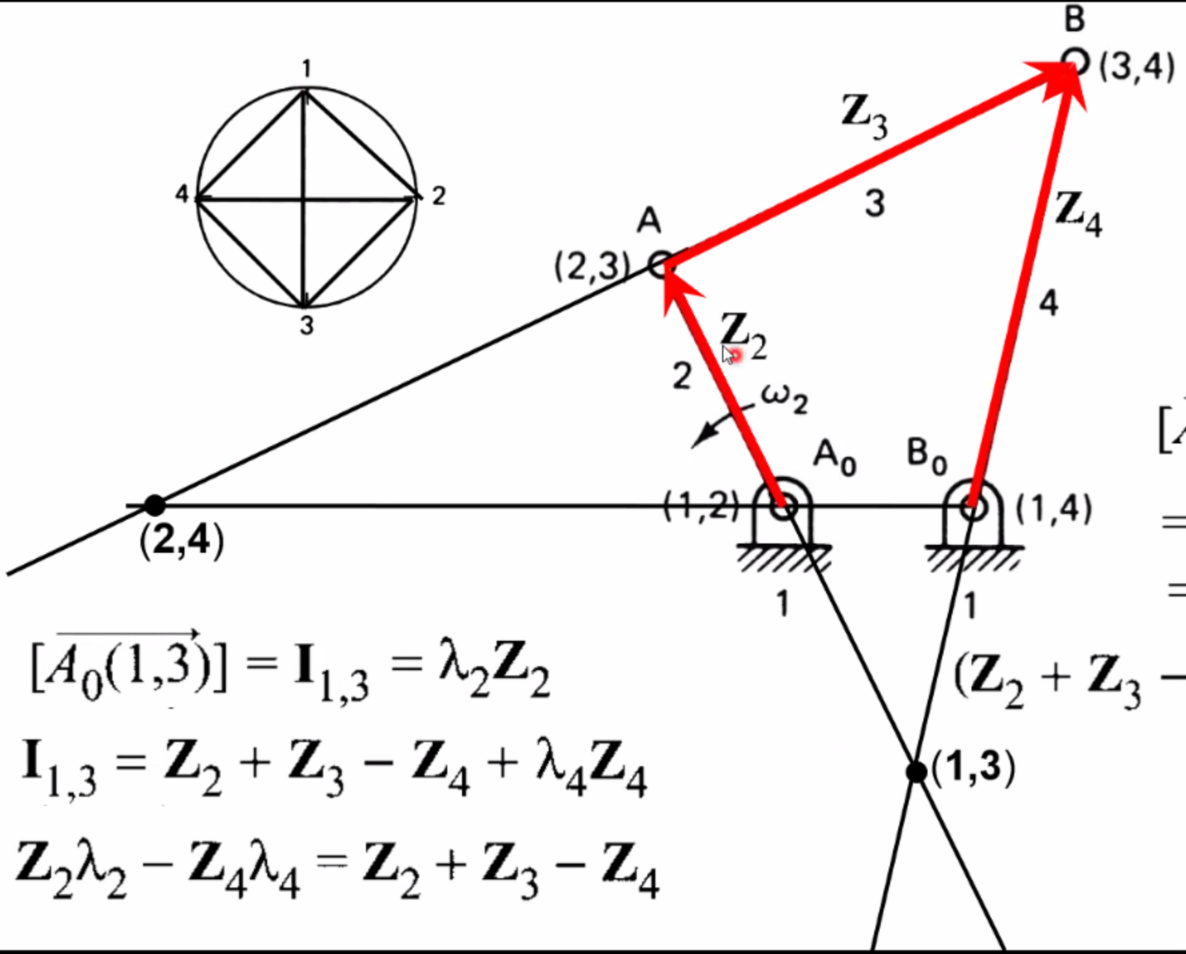
$$\frac{\omega_2}{\omega_3} = \frac{(\overrightarrow{O_3Q})}{(\overrightarrow{O_2Q})} = \frac{(\overrightarrow{1,3-2,3})}{(\overrightarrow{1,2-2,3})}$$

→ Simple proof.

Arthur G. Erdman
George N. Sandor
Sridhar Kota
Mechanism Design: Analysis and Synthesis, Volume I, 4th Ed.

슬라이드 11/65

PowerPoint 슬라이드 쇼 - [MA 210930 - 실시간 zoom.pptx] - PowerPoint

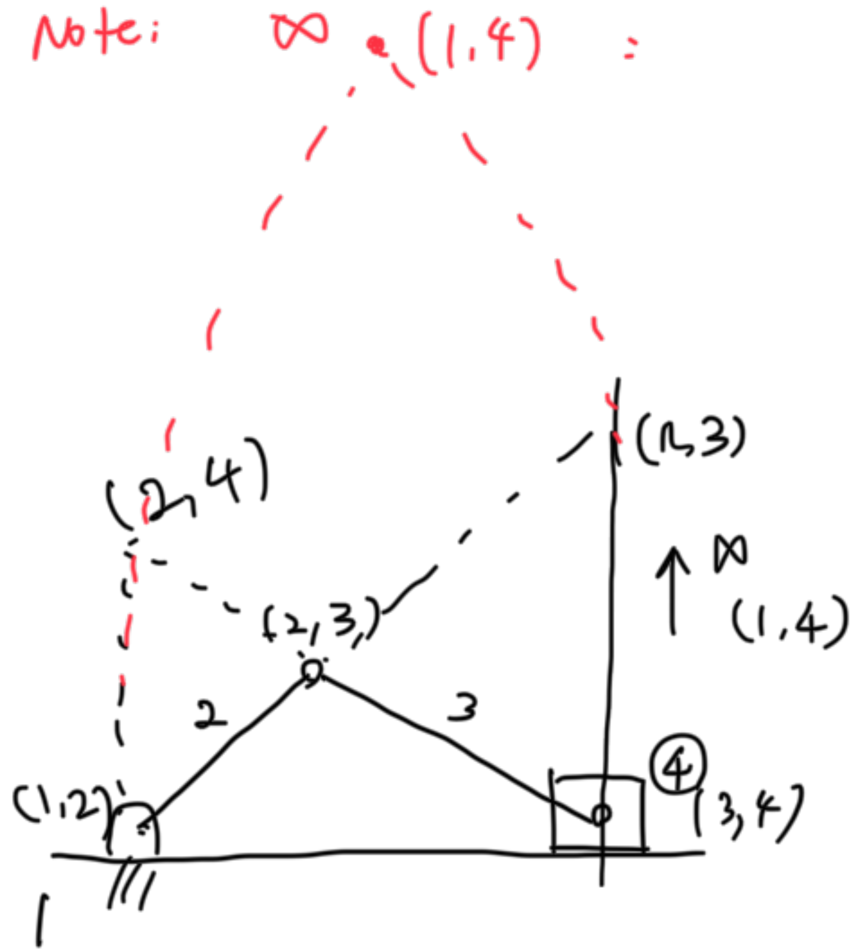


$$[\overrightarrow{A_0(2,4)}] = \mathbf{I}_{2,4}$$
$$= \lambda_1(\mathbf{Z}_2 + \mathbf{Z}_3 - \mathbf{Z}_4)$$
$$= \mathbf{Z}_2 + \lambda_3\mathbf{Z}_3$$
$$(\mathbf{Z}_2 + \mathbf{Z}_3 - \mathbf{Z}_4)\lambda_1 - \mathbf{Z}_3\lambda_3 = \mathbf{Z}_2$$

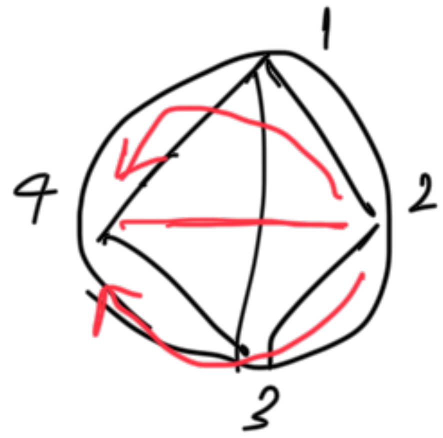
$$[\overrightarrow{A_0(1,3)}] = \mathbf{I}_{1,3} = \lambda_2\mathbf{Z}_2$$
$$\mathbf{I}_{1,3} = \mathbf{Z}_2 + \mathbf{Z}_3 - \mathbf{Z}_4 + \lambda_4\mathbf{Z}_4$$
$$\mathbf{Z}_2\lambda_2 - \mathbf{Z}_4\lambda_4 = \mathbf{Z}_2 + \mathbf{Z}_3 - \mathbf{Z}_4$$

슬라이드 15/65

Note:



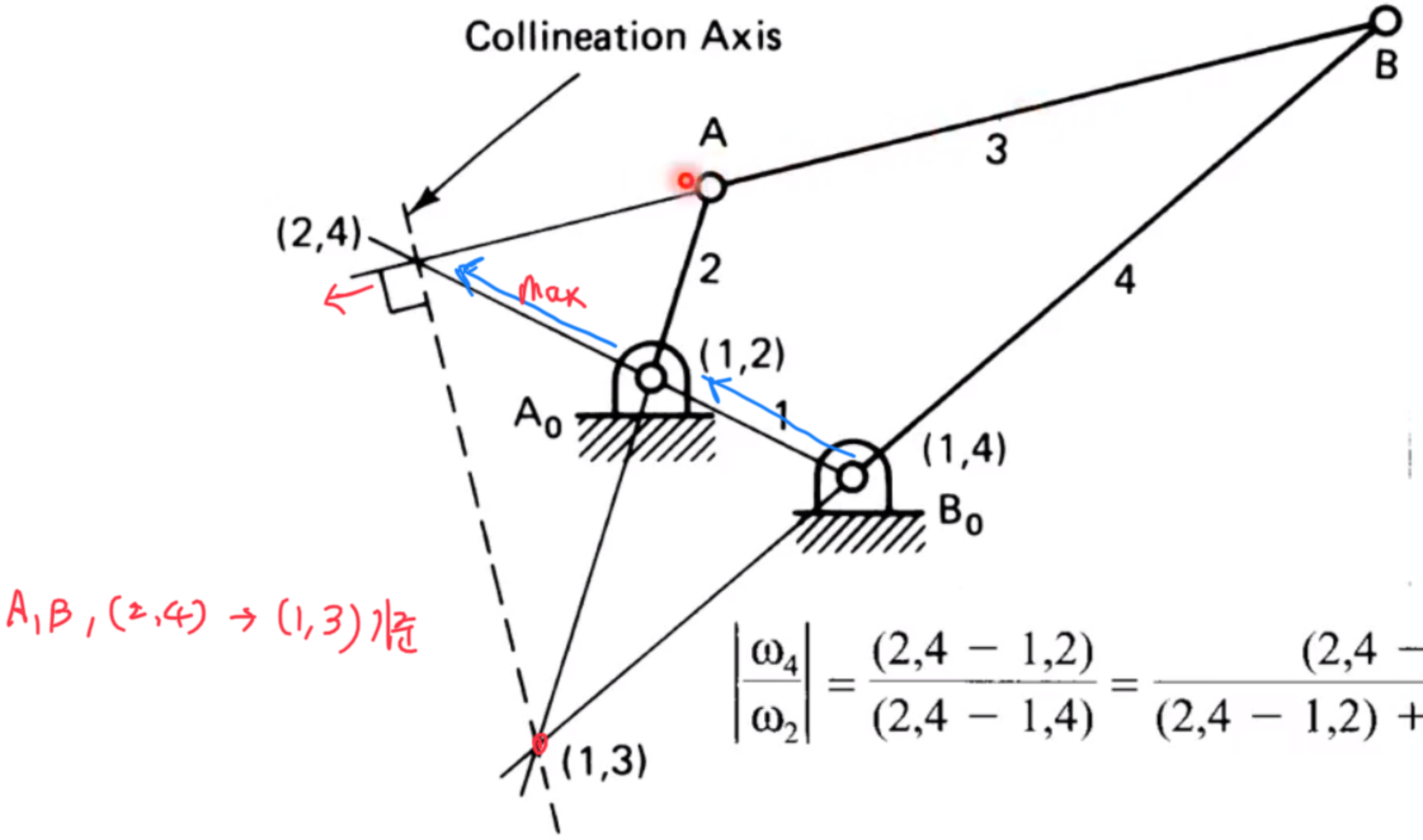
멀리서 보면 ≈ 근사(approximation)



(2,4) 에 대한 설명. By kennedy theorem, (2,4) and (2,3) (3,4) (2,1) (1,4) are on a straight line (일직선 위)

기구설계학 Lec 9 (20211005)

HW 3-3, 12, 29, 62 "

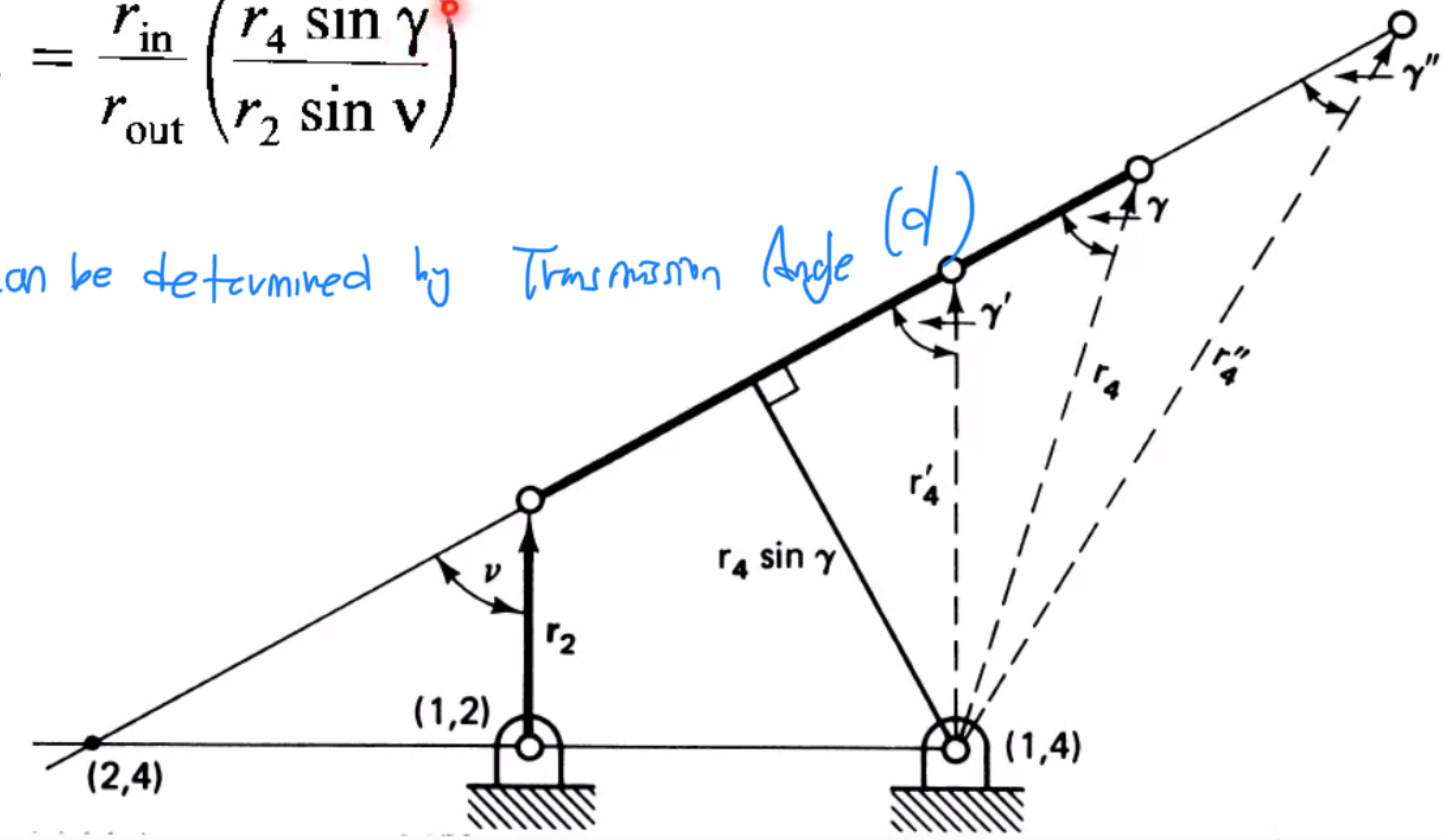


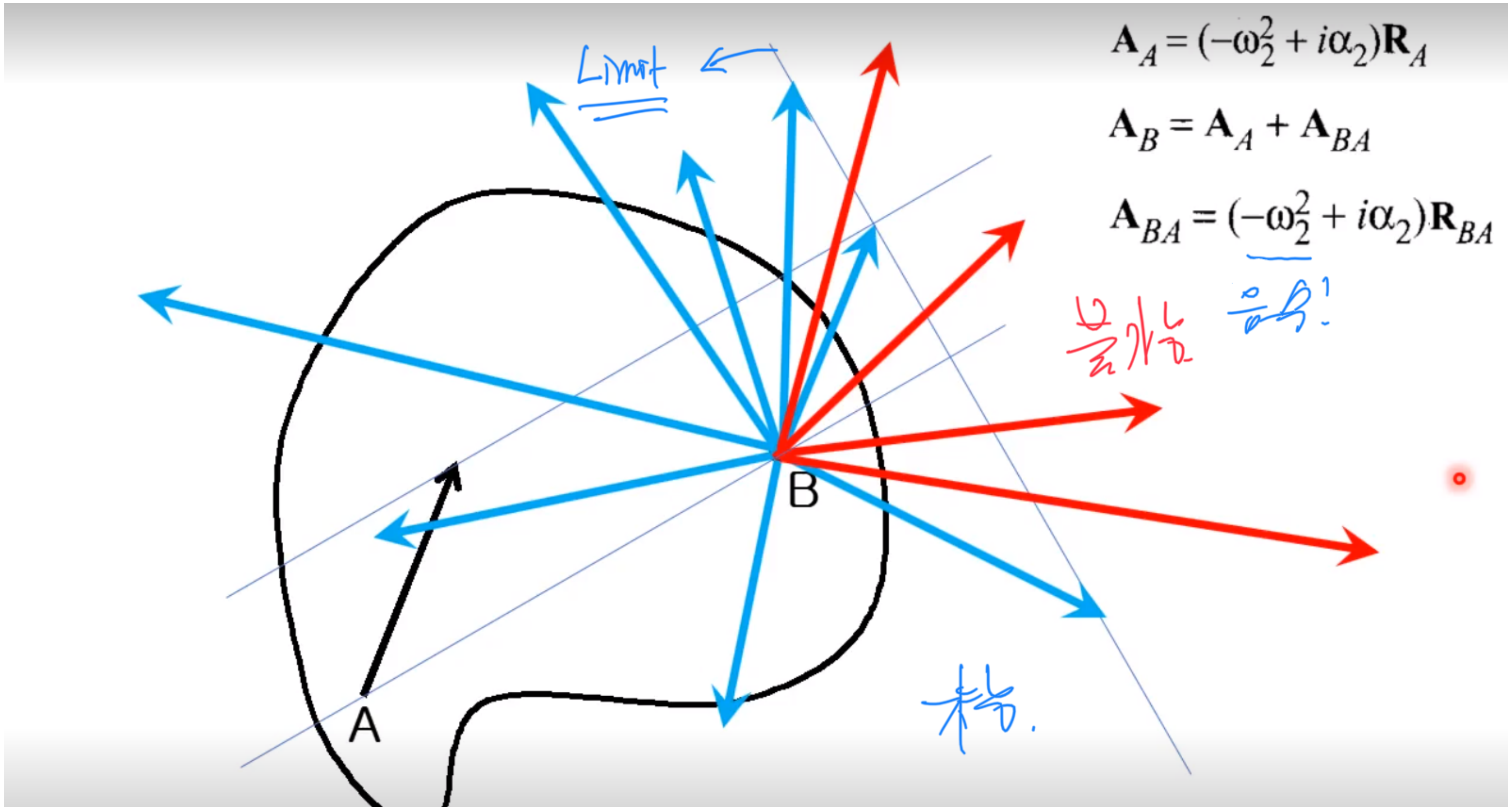
$$\left|\frac{\omega_4}{\omega_2}\right| = \frac{(2,4 - 1,2)}{(2,4 - 1,4)} = \frac{(2,4 - 1,2)}{(2,4 - 1,2) + (1,2 - 1,4)}$$

Figure 3.80 Freudenstein's theorem: At extreme of ω_4/ω_2 the collineation axis is perpendicular to coupler 3.

$$\text{M.A.} = \frac{r_{in}}{r_{out}}\left(\frac{r_4 \sin\gamma}{r_2 \sin\nu}\right)$$

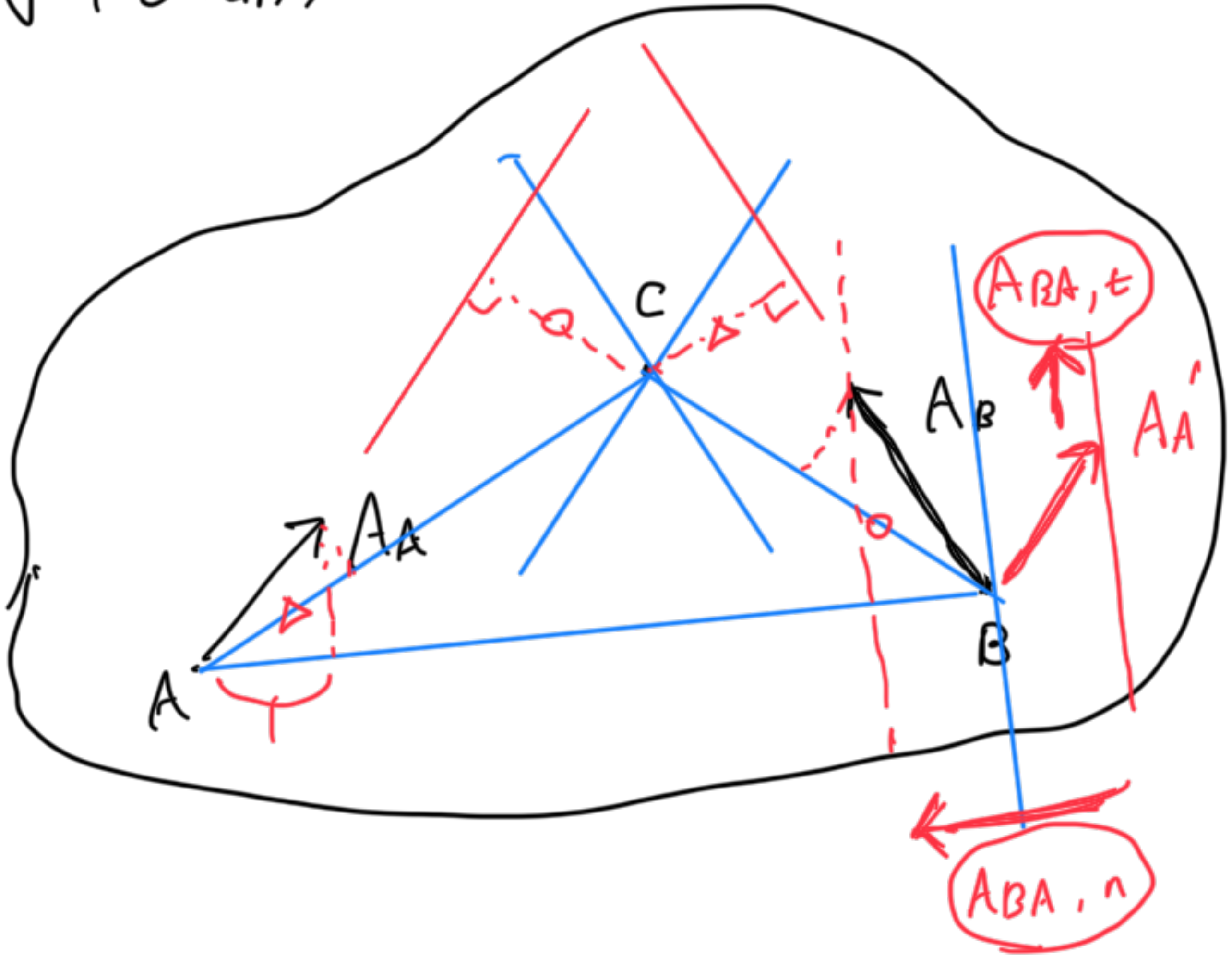
Can be determined by Transmission Angle (γ)

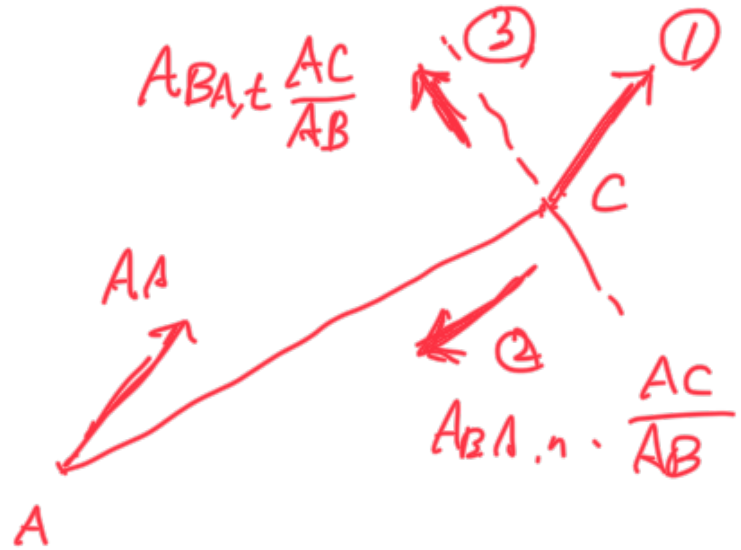




가속도 제한 Acceleration Limitations

<My theorem> : A_C.





$\vec{1}+\vec{2}+\vec{3} = \vec{A_C}$

$\triangle ABC \backsim \triangle abc$ (Goal)

$\triangle Ab'c' = \triangle abc$ (평행이동)

$\triangle ABb' \backsim \triangle ACc'$

AB → $-\omega^2 + j\alpha$

AC →

$\triangle ABC \backsim \triangle Ab'c'$

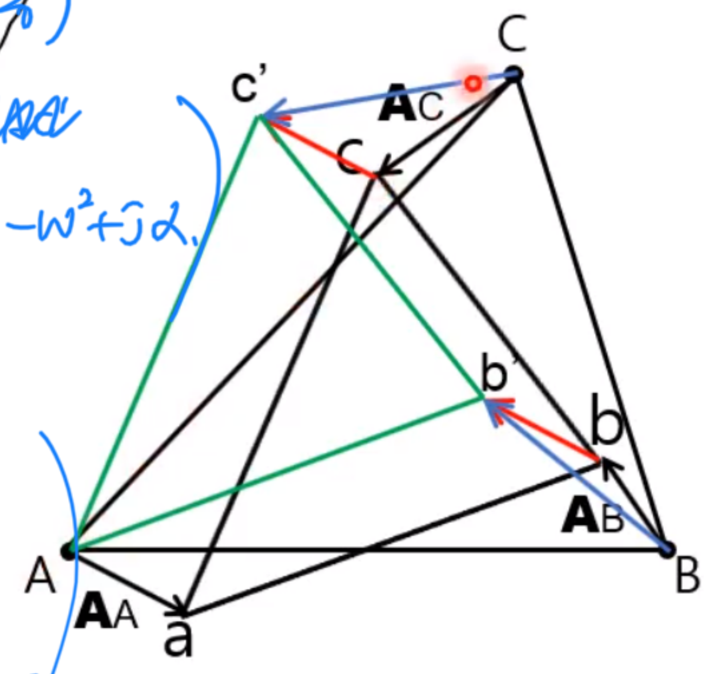
∵ AB : Ab'

AC : Ac'

$\angle c'Ab' = \angle CAB$

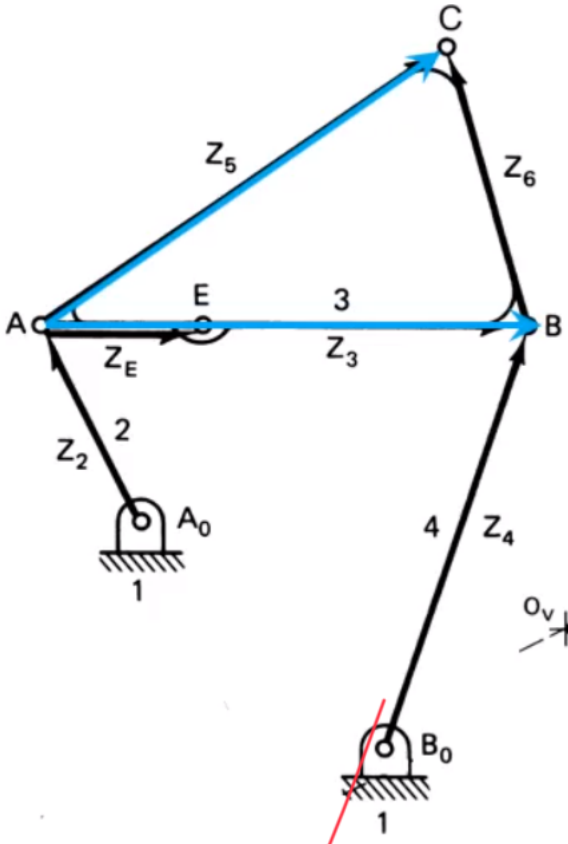
⇒ $\triangle ABC \backsim \triangle abc$

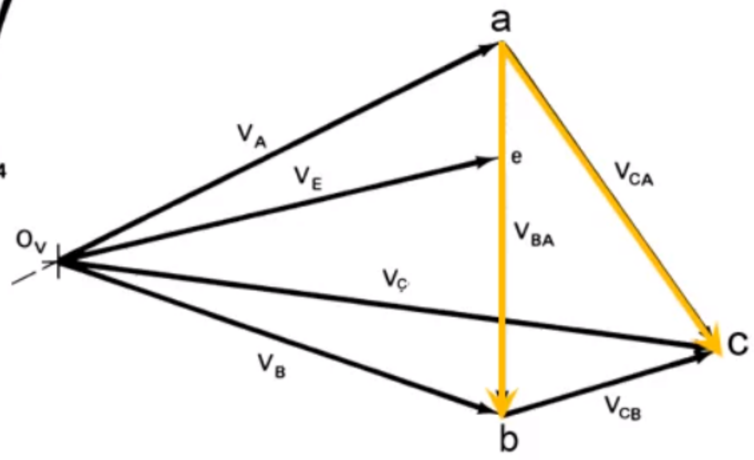
$$\mathbf{A}_{BA} = (-\omega_2^2 + i\alpha_2)\mathbf{R}_{BA}$$

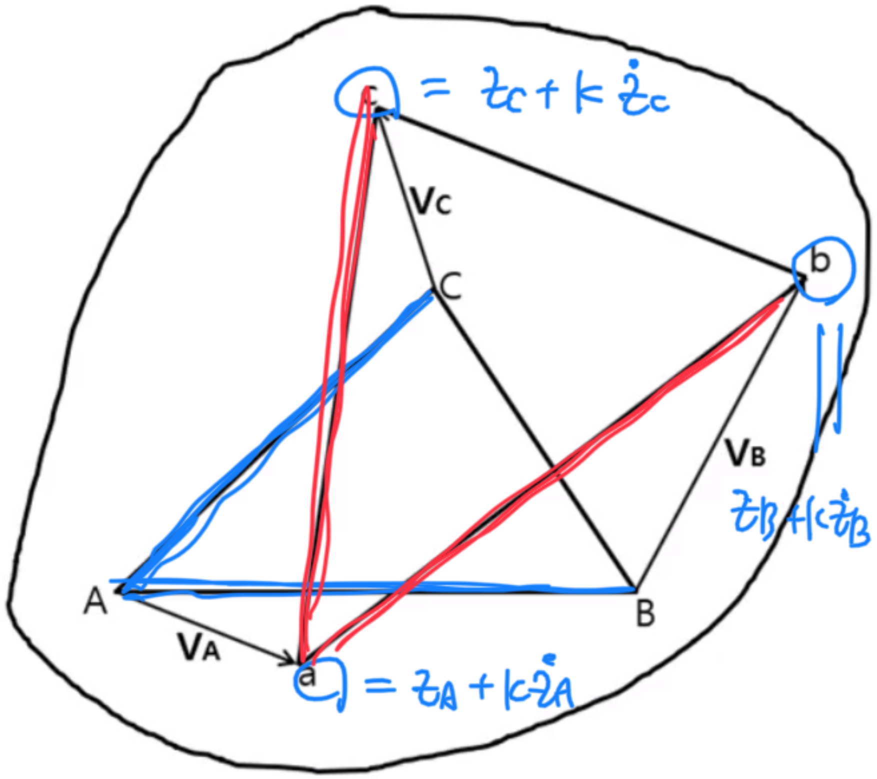


$$\mathbf{A}_{CA} = (-\omega_j^2 + i\alpha_j)\mathbf{R}_{CA}$$

$$\triangle ABC \backsim \triangle abc$$







$$Z_C = Z_A + C(Z_B - Z_A) \qquad \dot{Z}_C = \dot{Z}_A + C(\dot{Z}_B - \dot{Z}_A)$$

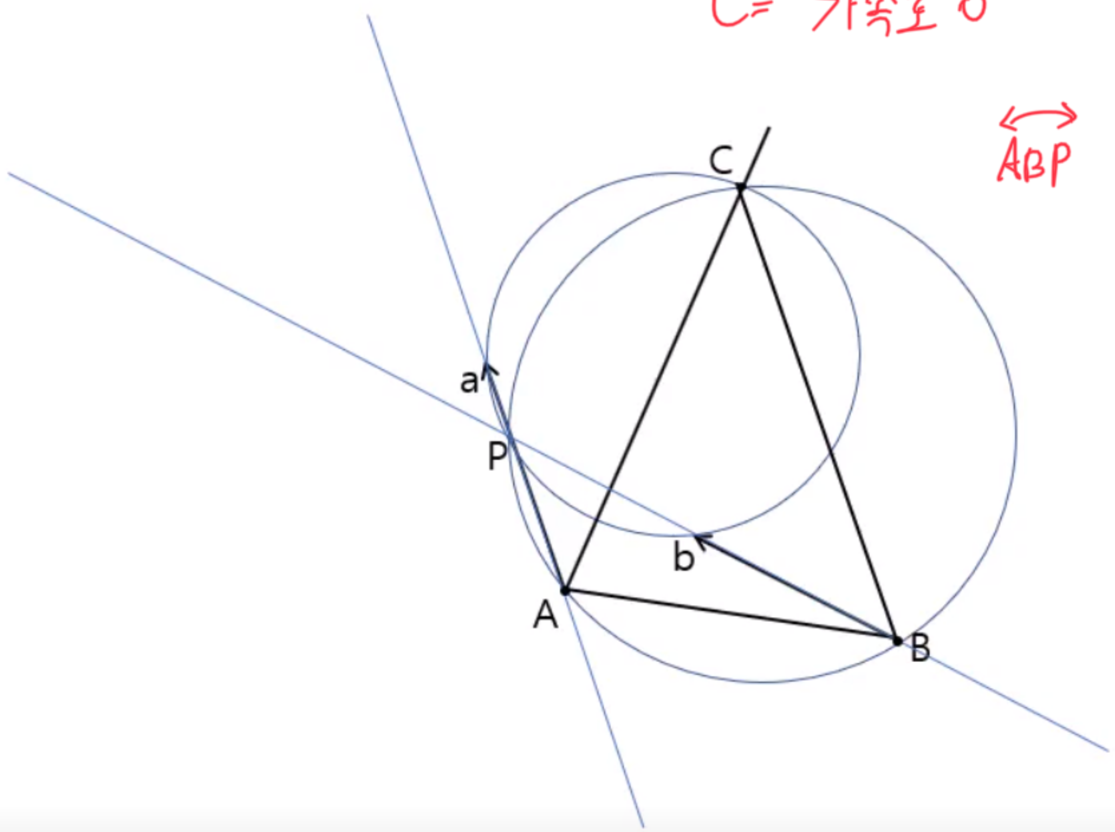
$$C = \frac{Z_C - Z_A}{Z_B - Z_A} = \frac{\dot{Z}_C - \dot{Z}_A}{\dot{Z}_B - \dot{Z}_A} = \frac{Z_C - Z_A + k(\dot{Z}_C - \dot{Z}_A)}{Z_B - Z_A + k(\dot{Z}_B - \dot{Z}_A)} = \frac{Z_C + k\dot{Z}_C - (Z_A + k\dot{Z}_A)}{Z_B + k\dot{Z}_B - (Z_A + k\dot{Z}_A)}$$

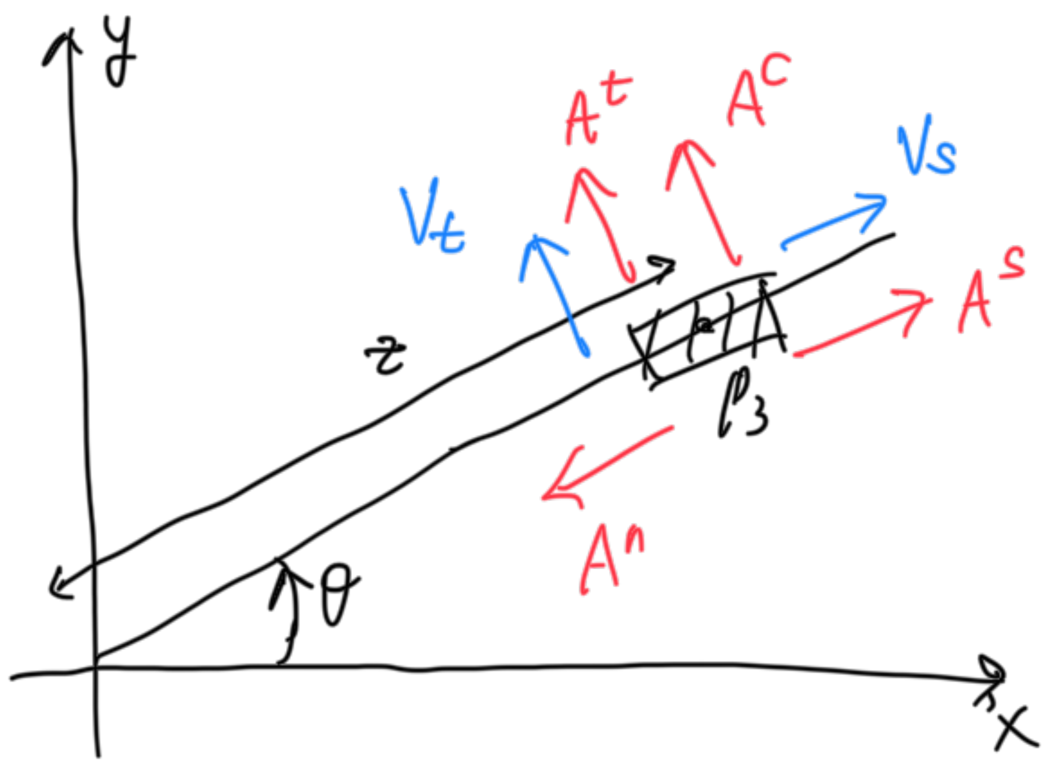
$$\Rightarrow \dot{z}_C = \dot{z}_A + c(\dot{z}_B - \dot{z}_A) \Rightarrow \ddot{z}_C = \ddot{z}_A + c(\ddot{z}_B - \ddot{z}_A)$$

$$\Rightarrow \frac{z_C + k\ddot{z}_C - (z_A + k\ddot{z}_A)}{z_B + k\ddot{z}_B - (z_A + k\ddot{z}_A)}$$ same as velocity case.

C= 가속도 0

$\overleftrightarrow{ABP}$ $\overleftrightarrow{abP}$ $\to C$





$\vec{z} = \underbrace{z \; e^{j\theta}}_{\text{scalars}}$ $\quad V = dz/dt \quad \omega = d\theta/dt$

$\boxed{\text{Position}}$: $ze^{j\theta}$

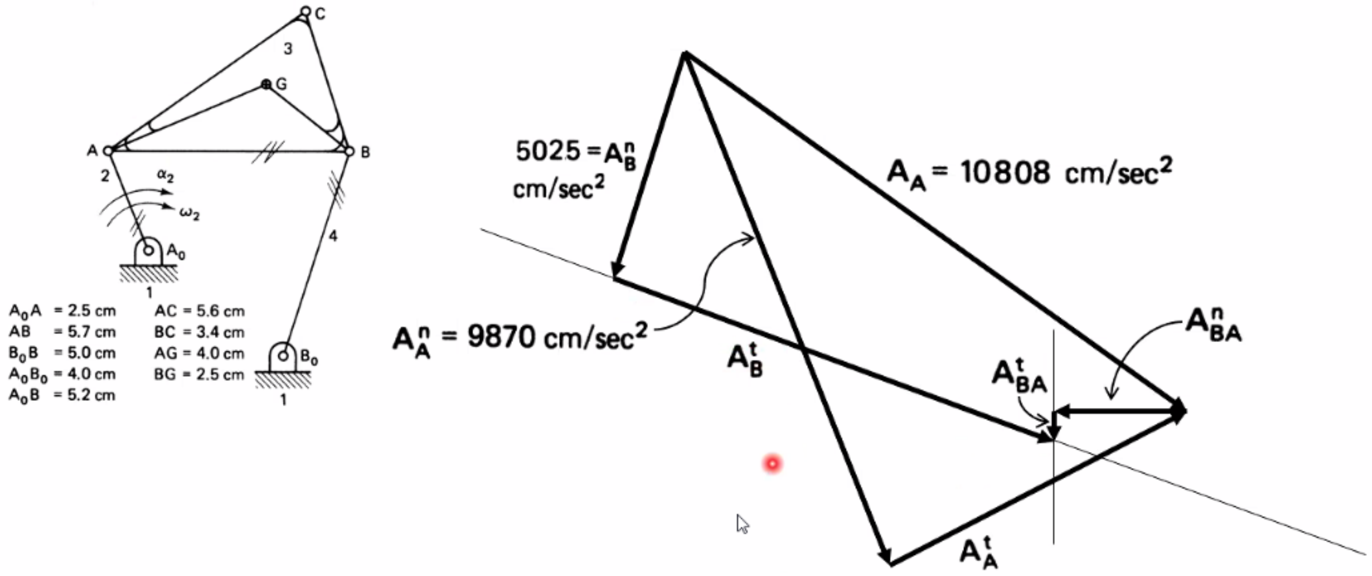
$\boxed{\text{Velocity}}$: $ve^{j\theta} + z\omega j e^{j\theta}$

$\boxed{\text{Acceleration}}$: $\underbrace{ae^{j\theta}}_{\text{sliding}} + \underbrace{v\omega j e^{j\theta} + v\omega j e^{j\theta}}_{\text{corriolis}} + \underbrace{z\alpha j e^{j\theta}}_{\text{tangential}} - \underbrace{z\omega^2 e^{j\theta}}_{\text{Centripetal}}$

Centripetal (구심가속도)

Centripetal : real pushing to center

Centrifugal : fake (pushes away from).



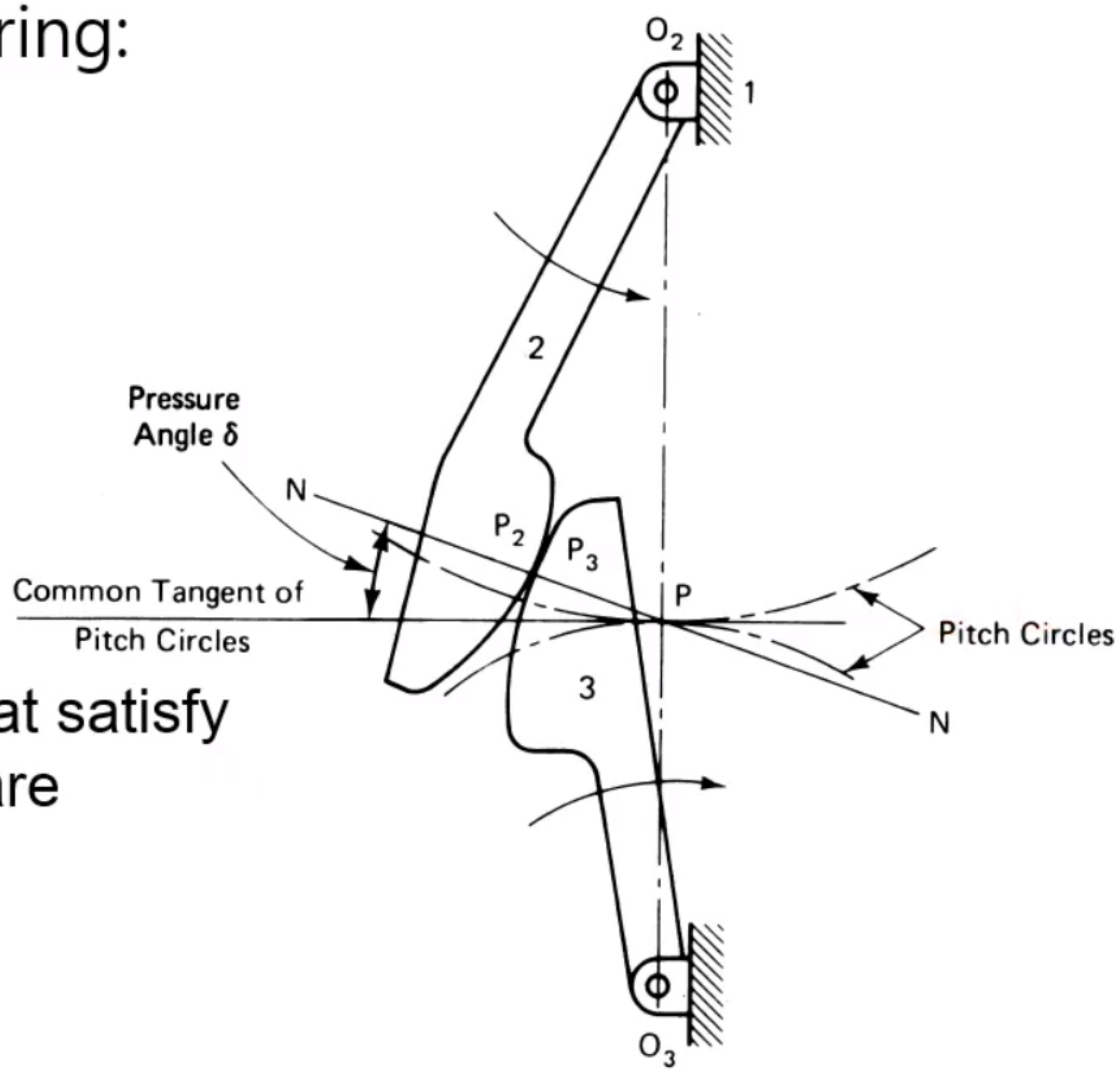
$$\mathbf{A}_A = \mathbf{A}_A^n + \mathbf{A}_A^t \,, \qquad \text{where } |\mathbf{A}_A^n| = (A_0A)\omega_2^2 \,, \qquad |\mathbf{A}_A^t| = (A_0A)\alpha_2$$

$\mathbf{A}_B^n$	$+\,\mathbf{A}_B^t$	$=$	$\mathbf{A}_A^n$	$+$	$\mathbf{A}_A^t$	$+$	$\mathbf{A}_{BA}^n$	$+\,\mathbf{A}_{BA}^t$
D $\swarrow$	D $\nwarrow\!\searrow$		D $\searrow$		D $\nearrow$		D $\leftarrow$	D $\updownarrow$
M			M		M		M	
$[(B_0B)\omega_4^2]$			$[(A_0A)\omega_2^2]$		$[(A_0A)\alpha_2)]$		$[(BA)\omega_3^2)]$	

The fundamental law of gearing:

For constant velocity ratio, the common normal of contacting tooth flanks must always pass through the *pitch point* P.

$$\frac{|\omega_2|}{|\omega_3|} = \frac{O_3P}{O_2P}$$

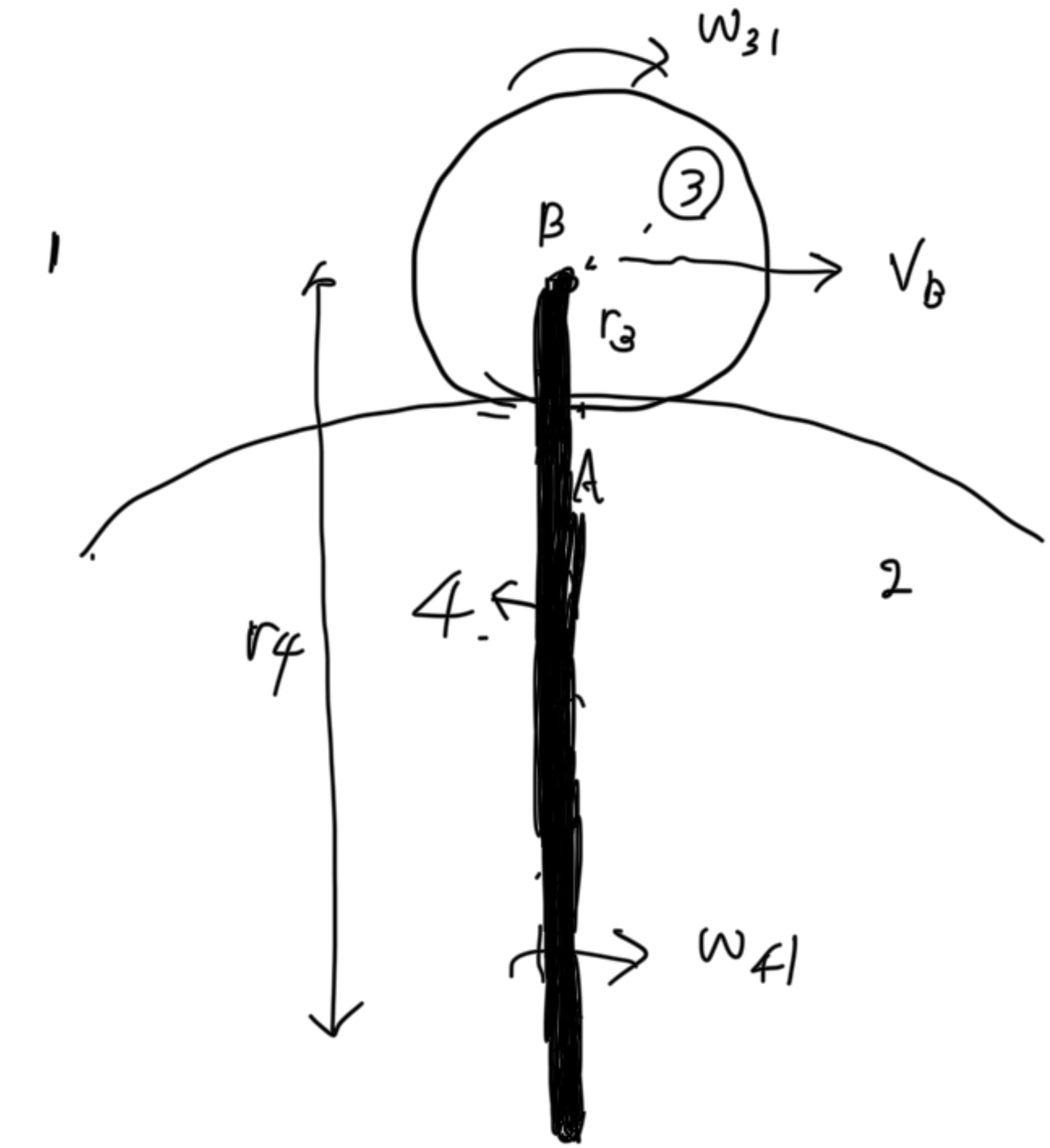


Any two mating tooth profiles that satisfy the fundamental law of gearing are called ***conjugate profiles*** and the condition is called ***conjugacy***.

cycloidal profile

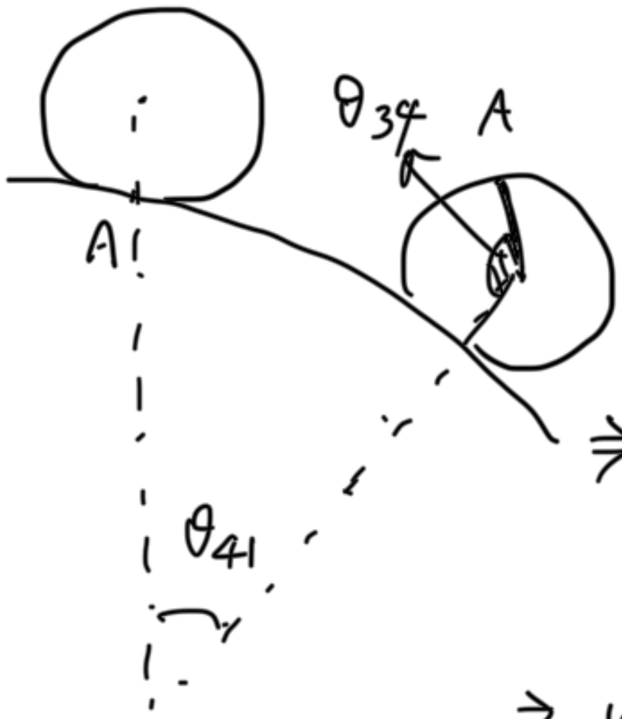
P_2P_3 (Perpendicular)

<Formula Method>



$$r_3\,\omega_{31} = r_4\,\omega_{41} = \|\vec{V_B}\|.$$

$$\Rightarrow \underbrace{\omega_{31} = \frac{r_4}{r_3}\,\omega_{41}}\quad ①$$



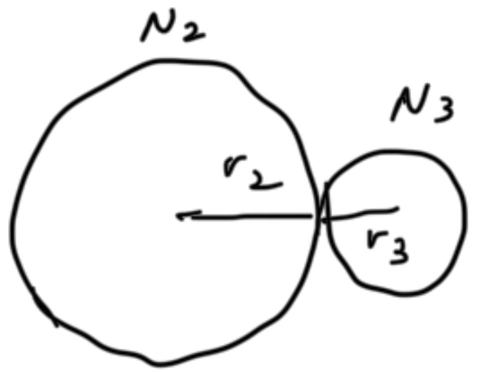
$$\theta_{34}\cdot r_3 = \theta_{41}(r_4 - r_3)$$

$$\Rightarrow \underline{\omega_{34} r_3 = \omega_{41}(r_4 - r_3)}$$

$$\Rightarrow \omega_{34} = \left(\frac{r_4}{r_3} - 1\right)\omega_{41}$$

$$\Rightarrow \underline{\omega_{34} = \left(\frac{r_2 + \cancel{r_3}}{\cancel{r_3}} \cancel{-1}\right)\omega_{41}}\quad ②$$

Since



$$\frac{N_3}{N_2} = \frac{r_3}{r_2} \Rightarrow \underline{\omega_{34} = \frac{N_2}{N_3}\,\omega_{41}}$$

or,

$$\omega_{34} = \underline{\frac{r_4}{r_3}\,\omega_{41}} - \omega_{41} \Rightarrow \boxed{\omega_{31} = \omega_{41} + \omega_{34}}$$

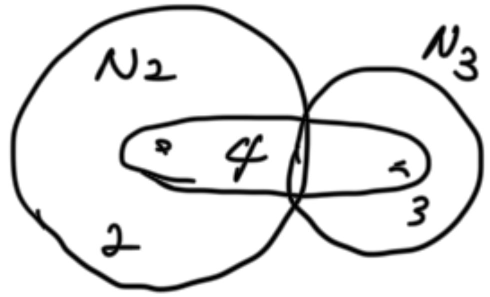
$= \omega_{31}$

✓ Relative

✓ Relative angular velocity. (Addition)

$\omega_{21} = \omega_{41} + \omega_{24}$ Similarly, $\omega_{34} = \omega_{31} - \omega_{41}$

$\omega_{24} = \omega_{21} - \omega_{41}$



ω_{ij} : j 번 gear is fixed. E.g. $\dfrac{\omega_{34}}{\omega_{24}} = -\dfrac{N_2}{N_3}$.

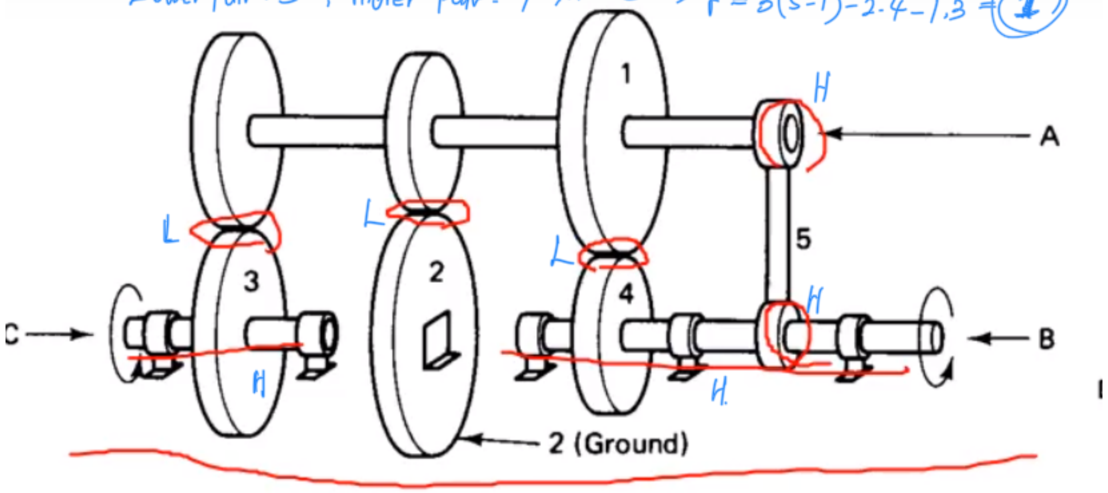
$$\Rightarrow \frac{|\omega_{LA}|}{|\omega_{FA}|} = \left|\frac{\omega_L - \omega_A}{\omega_F - \omega_A}\right| = \frac{\text{Product of \# of teeth on driver gears}}{\text{Product of \# of teeth on driven gears}}$$

$\boxed{\text{부호}}$ (sign)

→ 외접기어 (−) 내접기어 (+)

(ω_A : Arm, ω_L : Last gear, ω_F : First gear)

Lower Pair : 3 , Higher Pair : 4 , n = 5 ⇒ F = 3(5−1)−2·4−1·3 = 1



FORMULA METHOD

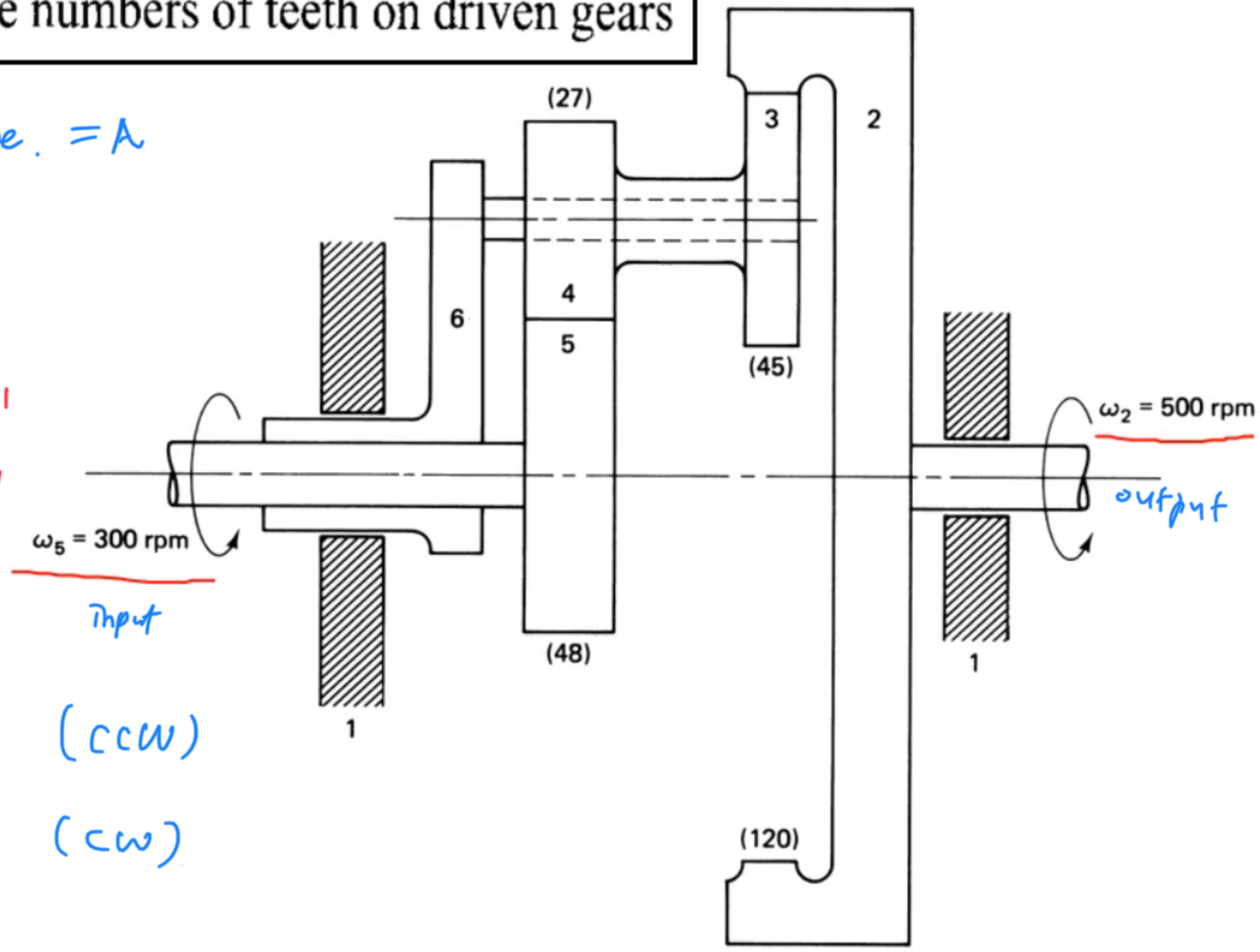
$$\left|\frac{\omega_{LA}}{\omega_{FA}}\right| = \left|\frac{\omega_L - \omega_A}{\omega_F - \omega_A}\right| = \frac{\text{product of the numbers of teeth on driver gears}}{\text{product of the numbers of teeth on driven gears}}$$

6 is the arm part of this machine. = A

$$\left|\frac{\omega_{26}}{\omega_{56}}\right| = \frac{\omega_2 - \omega_6}{\omega_5 - \omega_6} = -\frac{N_5 \cdot N_3}{N_4 N_2}$$

4,5 → 외접 (−)'

2,3 → 내접 (+)'



\+ → Counter Clock Wise (CCW)

− → Clock Wise (CW)

N : 6

Higher Pair :

Lower Pair :

FORMULA METHOD

$$\left|\frac{\omega_{LA}}{\omega_{FA}}\right| = \left|\frac{\omega_L - \omega_A}{\omega_F - \omega_A}\right| = \frac{\text{product of the numbers of teeth on driver gears}}{\text{product of the numbers of teeth on driven gears}}$$

$$\frac{\omega_{26}}{\omega_{56}} = \frac{\omega_2 - \omega_6}{\omega_5 - \omega_6} = -\frac{N_3 N_5}{N_2 N_4}$$

$$= -\frac{(45)(48)}{(120)(27)} = -\frac{2}{3}$$

$$\frac{\omega_{26}}{\omega_{76}} = \frac{\omega_2 - \omega_6}{\omega_7 - \omega_6} = \frac{N_3 N_7}{N_2 N_4}$$

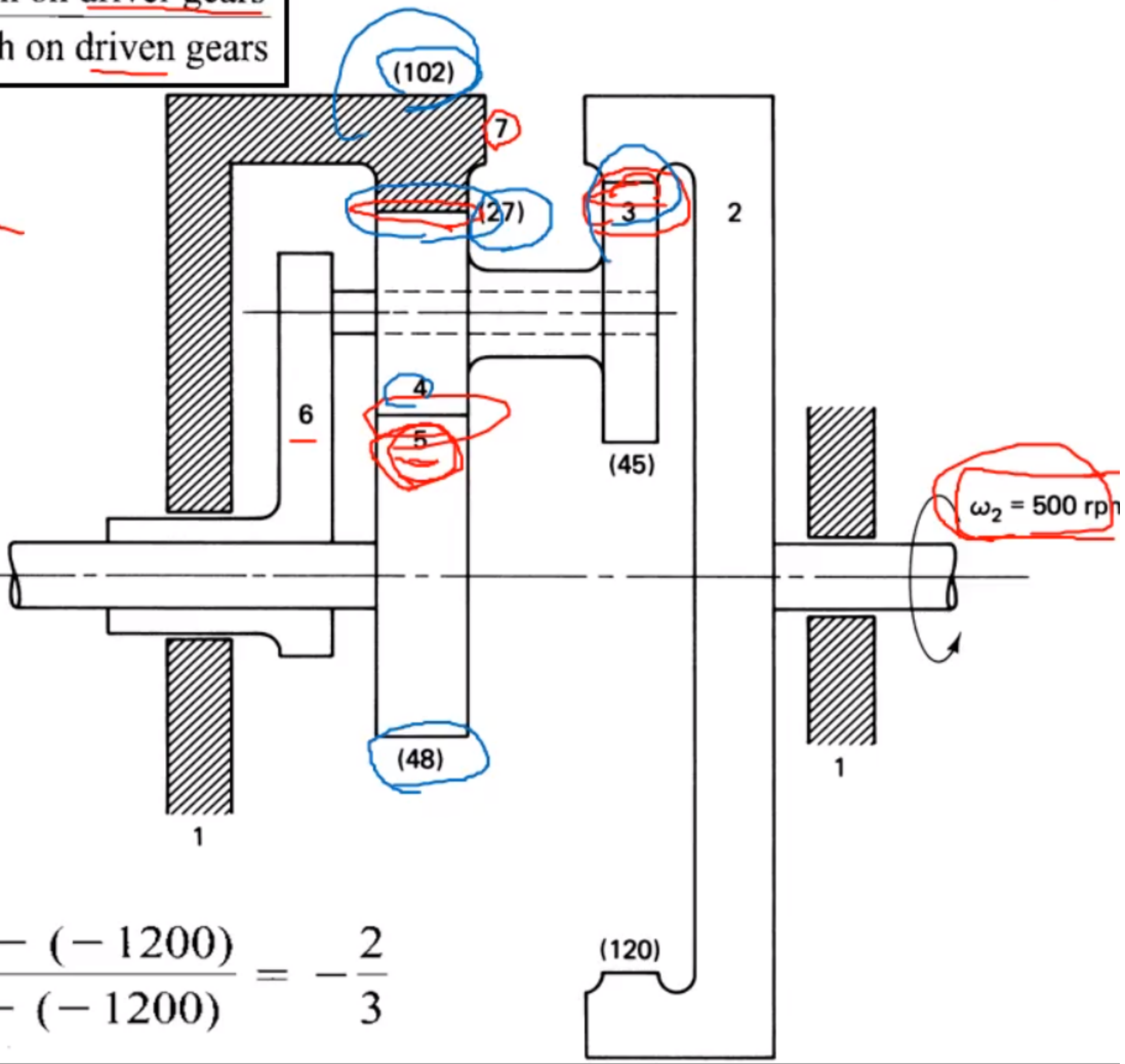
$$N_7 = N_5 + 2N_4 = 102$$

Why ?

$$\frac{500 - \omega_6}{0 - \omega_6} = \frac{(45)(102)}{(120)(27)}$$

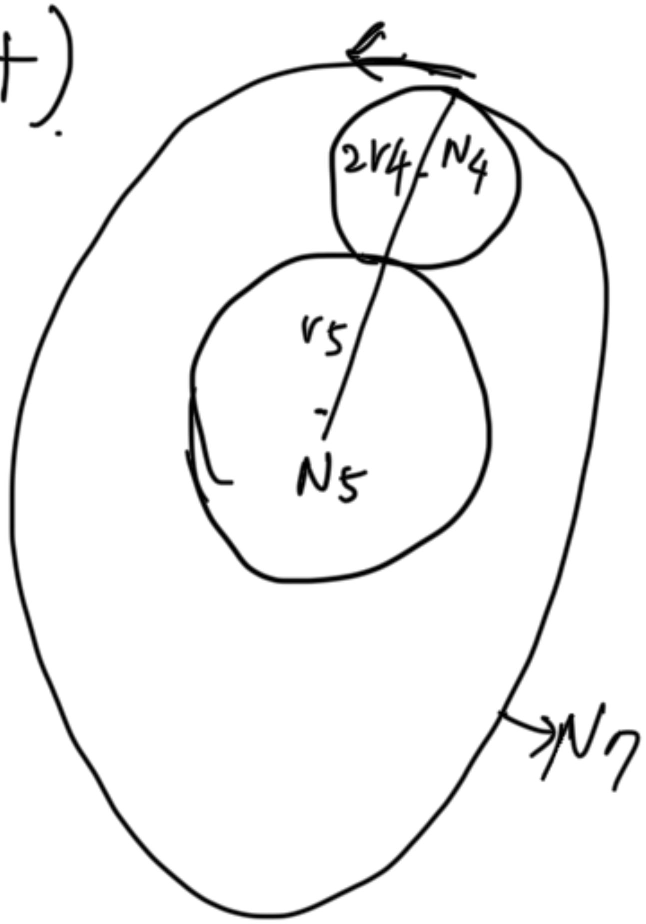
$$\omega_6 = \omega_6 \frac{(45)(102)}{(120)(27)} + 500$$

$$\omega_6 = -1200 \text{ rpm}$$



$$\frac{500 - (-1200)}{\omega_5 - (-1200)} = -\frac{2}{3}$$

+)

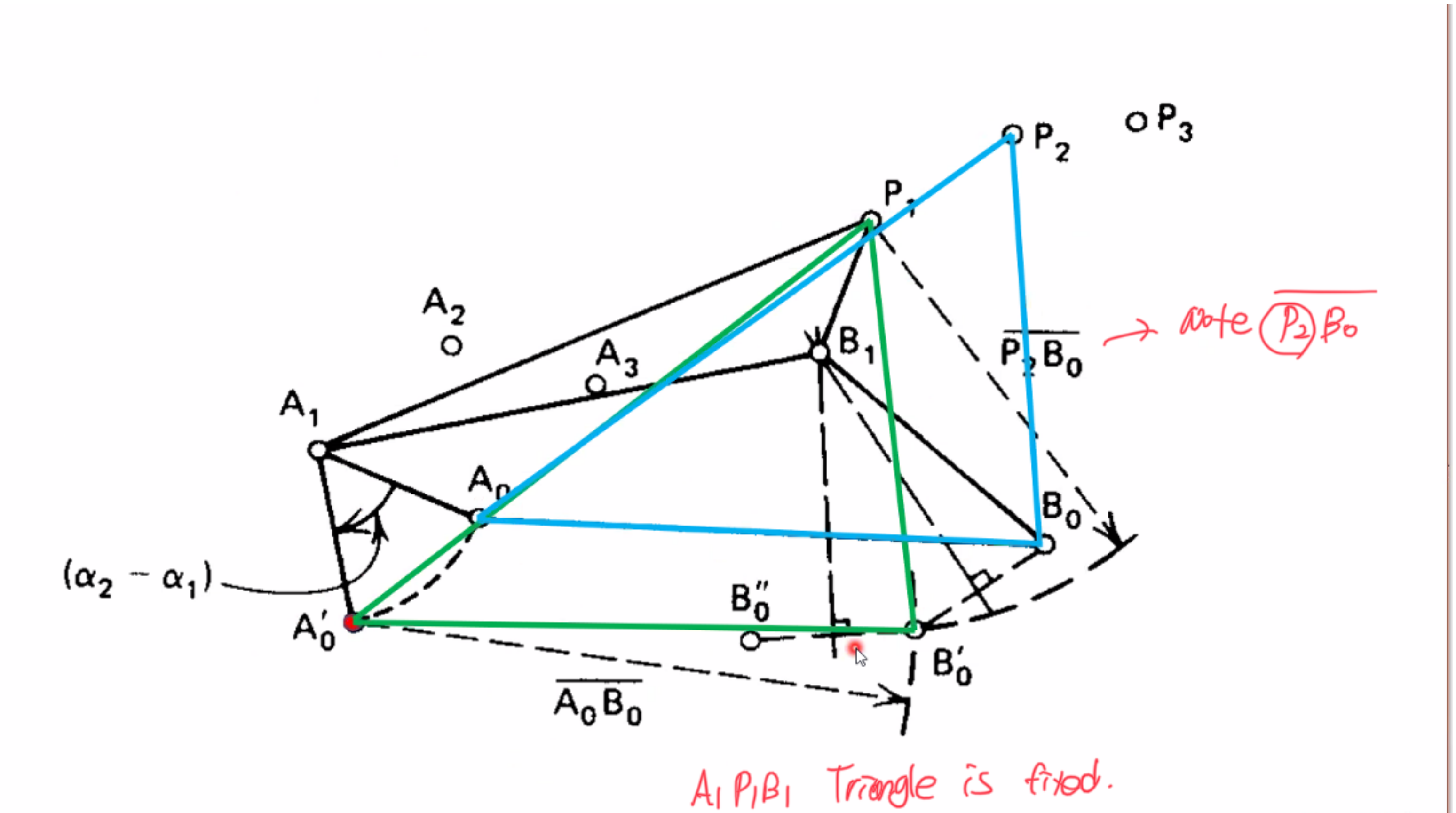


$r_5 + 2r_4 = r_7$

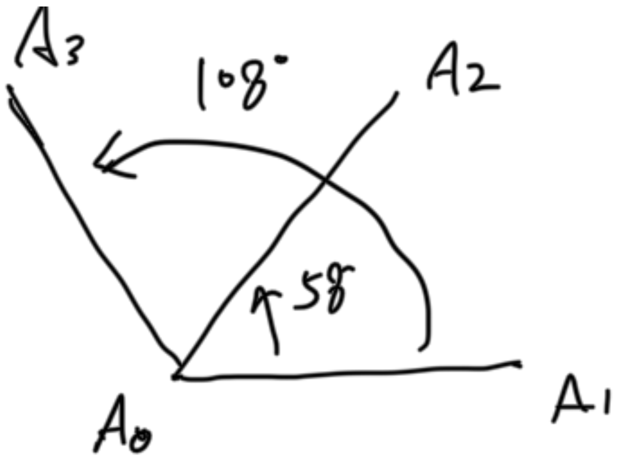
$N_5 + 2N_4 = N_7 = 102$

$48 + 2 \cdot 27$

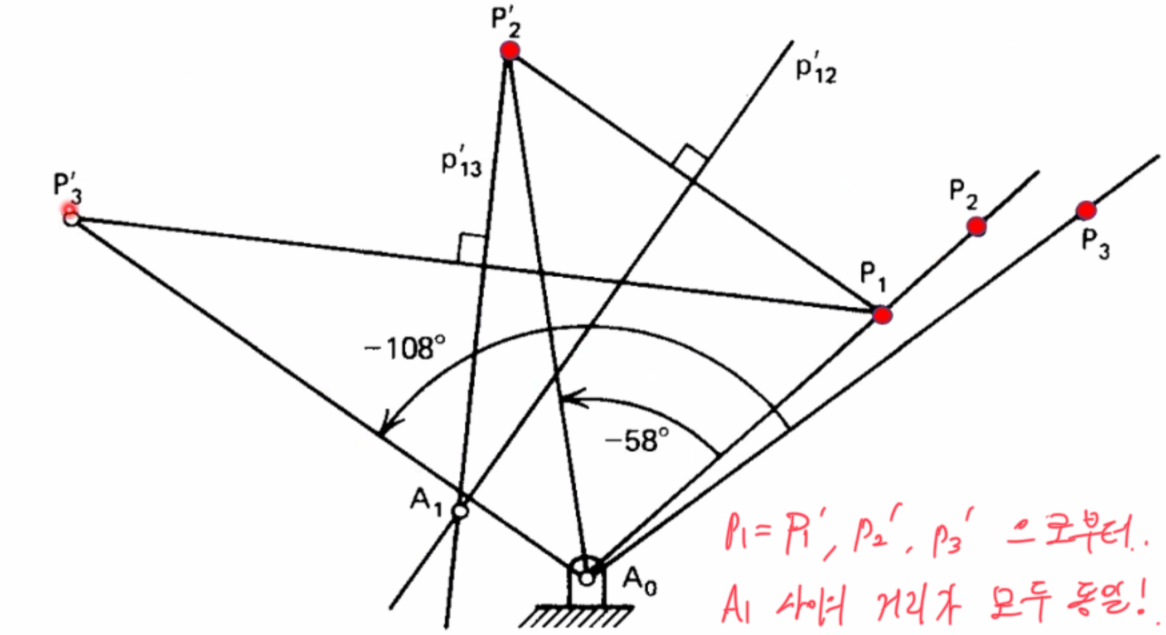
기구설계학 (20211130)



Let



is given and Corresponding P_1, P_2, P_3 given.



$P_1 = P_1'$, P_2', P_3' 으로부터.
A_1 사이 거리가 모두 동일!
※ Kinematic Inversion!

PowerPoint 슬라이드 쇼 - [ch8-211130-실시간 zoom.pptx] - PowerPoint

GRAPHICAL SYNTHESIS FOR PATH GENERATION (WITHOUT PRESCRIBED TIMING): FOUR POSITIONS

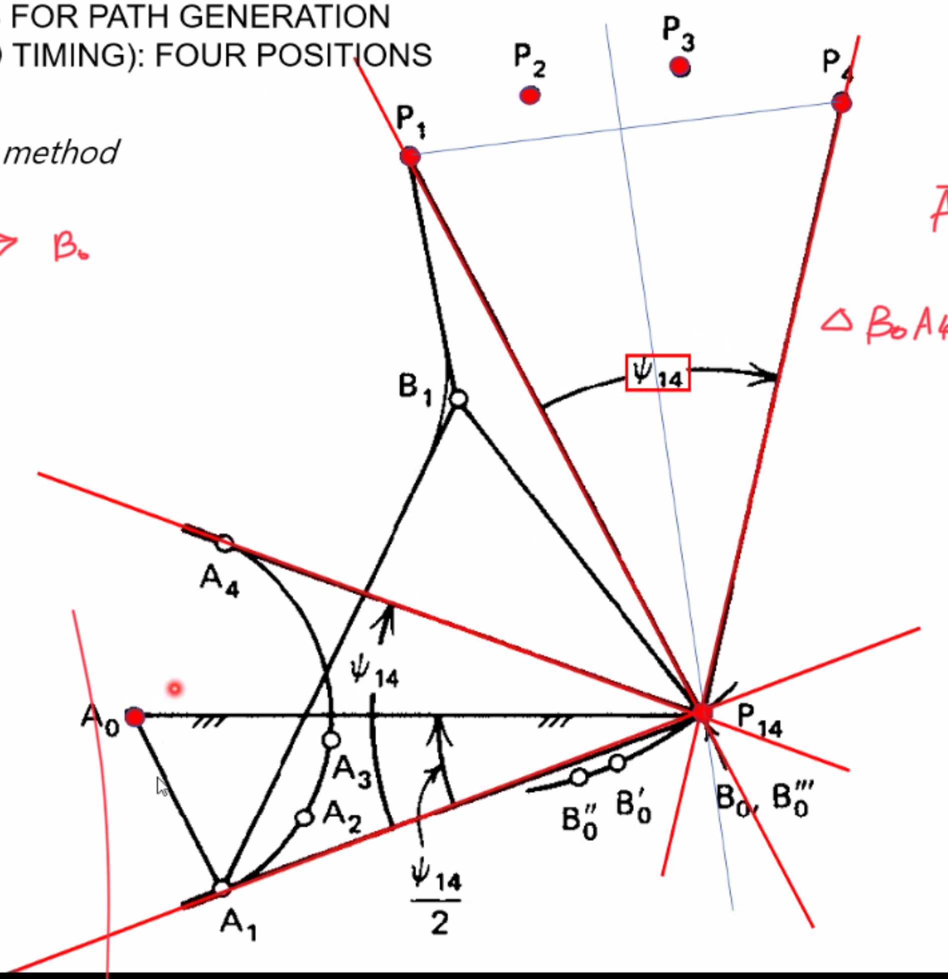
point-position reduction method

① P_1P_4 수직이등분 → B_0

② ψ_{14} 동일,

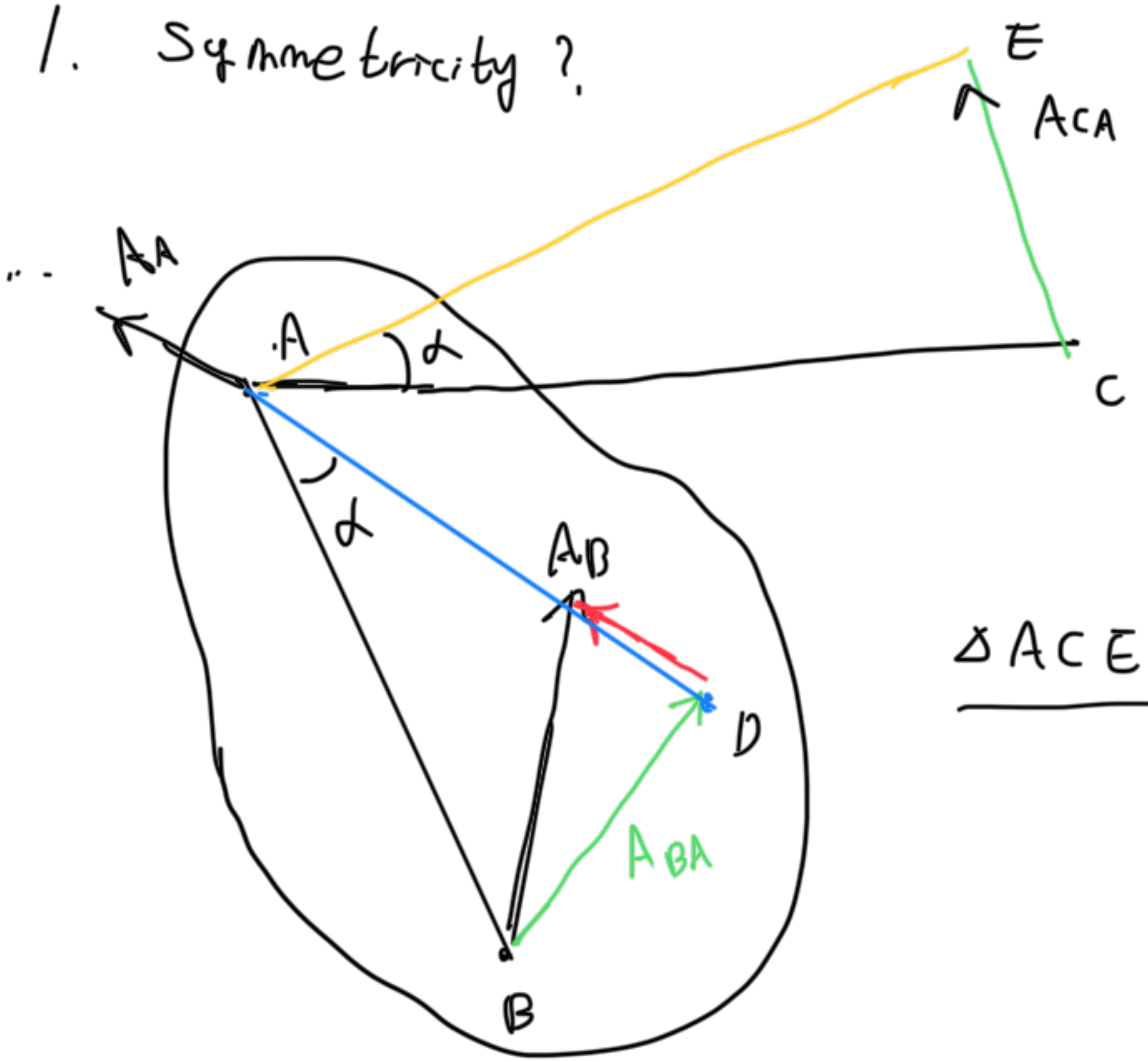
$\overline{A_1P_1} = \overline{A_4P_4}$

$\triangle B_0A_4P_4 \equiv \triangle B_0A_1P_1$ (SAS)



슬라이드 15/61

1. Symmetricity ?



$\triangle ACE \sim \triangle ABD$.

(i) A_A, A_B, V_C 가 주어질 때 $\rightarrow V_D$

$$\vec{A_B} = \vec{A_A} + \vec{A_{BA}}$$

$$A_{BA} = (\underbrace{-\omega^2}_{} + \underbrace{j\alpha}_{})\underbrace{\vec{R_{BA}}}_{\text{know}} \Rightarrow \omega, \alpha \text{ know.}$$

$$\vec{V_D} = \vec{V_C} + \vec{V_{DC}} = \underbrace{\vec{V_C}}_{\text{know}} + j\underbrace{\omega}_{\text{know}}\underbrace{\vec{R_{DC}}}_{\text{know}} \rightarrow \underline{\text{fixed}}\ V_D.$$

(ii) V_A, V_B, A_C 가 주어질 때. $\rightarrow A_D$

$$\vec{V_B} = \vec{V_A} + \vec{V_{BA}}$$

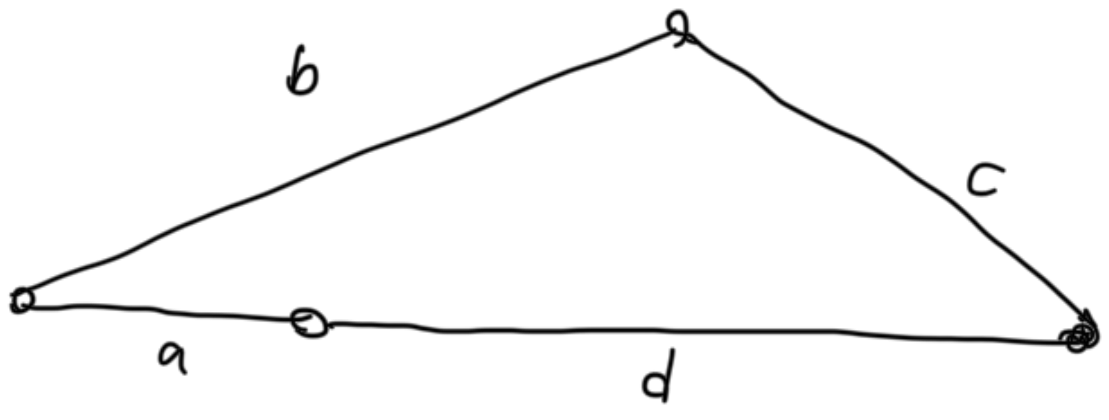
$$\vec{V_{BA}} = j\omega\underbrace{\vec{R_{BA}}}_{\text{know}} \Rightarrow \omega \text{ know}$$

$$\vec{A_D} = \underbrace{\vec{A_C}}_{\text{know}} + \vec{A_{DC}} \Rightarrow \text{unfixed } A_D$$

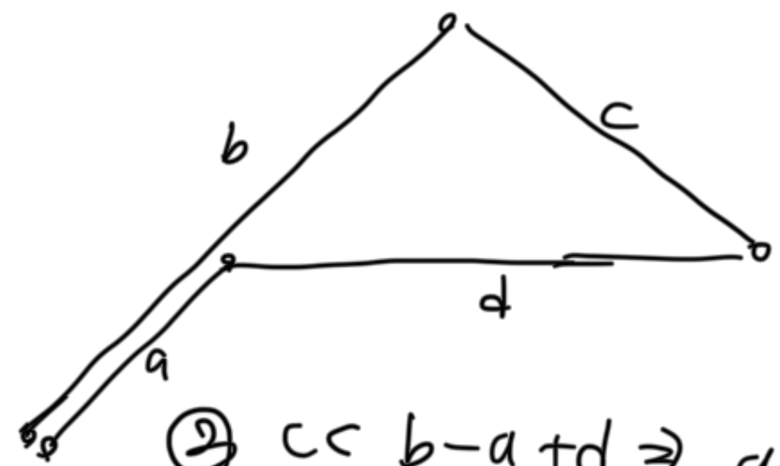
$$\vec{A_{DC}} = (\underbrace{-\omega^2}_{\text{know}} + \underbrace{j\alpha}_{\text{unknown}})\vec{R_{DC}}$$

$b-a < c+d$

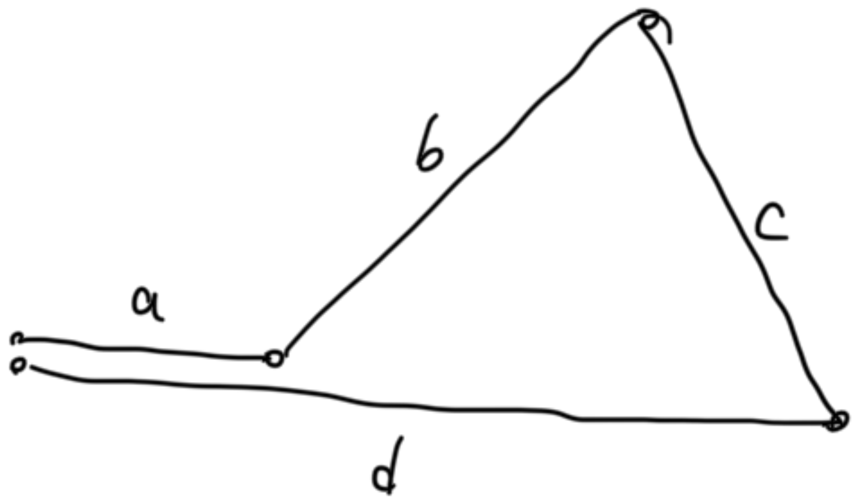
2. Grashof mechanism. $\left\{ \begin{array}{l} a = s \text{ (shortest)} \\ d = l \text{ (longest.)} \end{array} \right\}$



① $a+d < b+c$

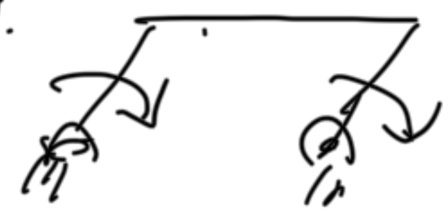


② $c < b-a+d \Rightarrow a+c < b+d$



③ $b < d-a+c \Rightarrow a+b < c+d$.

회전운동 ≠ 병진운동. but 원운동하는 병진운동 존재.



① $a+d < b+c$

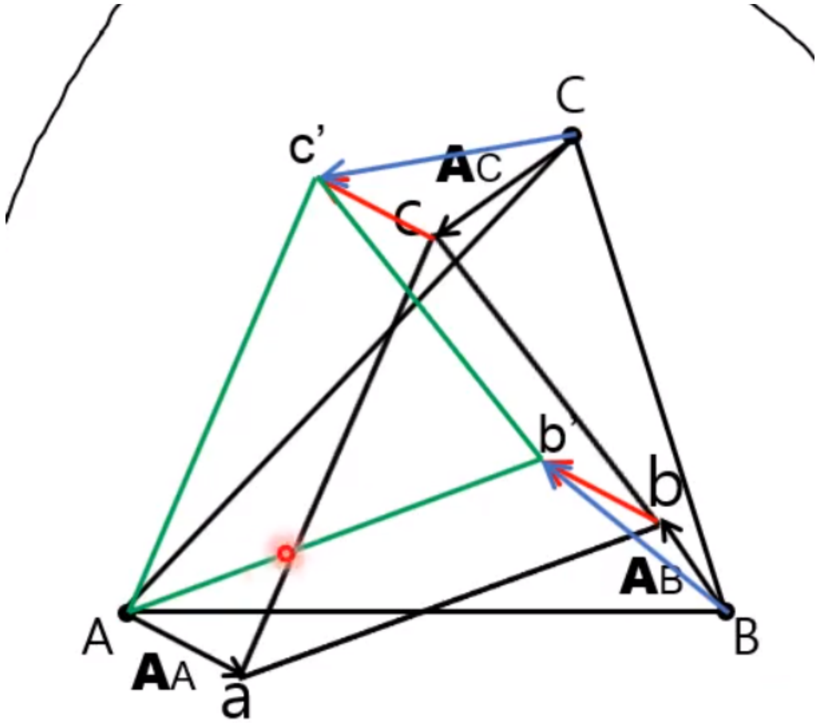
② $a+c < b+d$ $\Rightarrow$ $s+l < p+q$

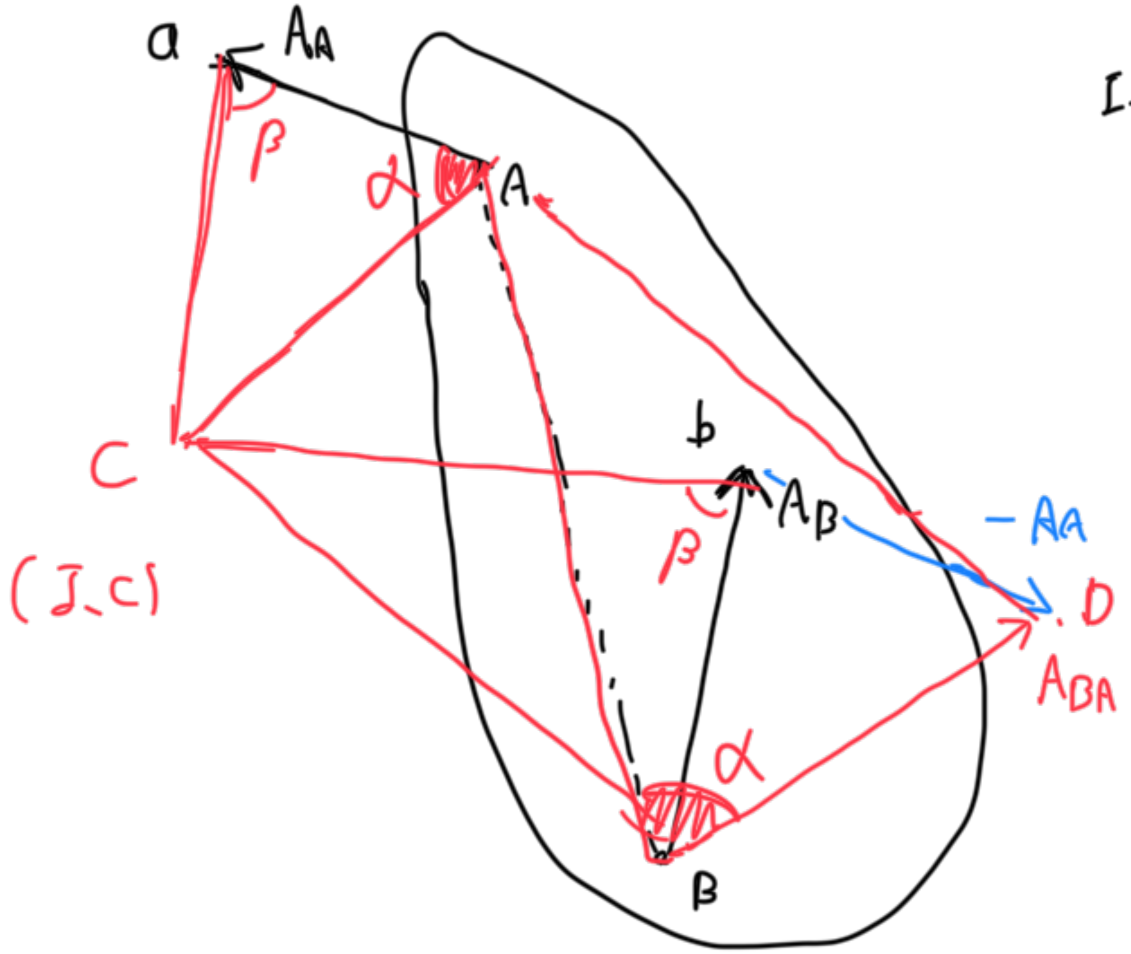
③ $a+b < c+d$

$\overline{I}$

a

3. I.C (Acceleration = 0 .)


C
c'
A C
c
b'
b
A B
A
B
A A
a



If $\vec{A_C} = \vec{0}$, $\quad \vec{A_{CA}} + \vec{A_A} = \vec{A_C}$

$$\Rightarrow \vec{A_{CA}} = -\vec{A_A}$$

$$\underline{\vec{A_{AC}} = \vec{A_A}}$$

$$\vec{A_{BA}} = (-\omega^2 + j\alpha)\,\vec{R_{BA}}$$

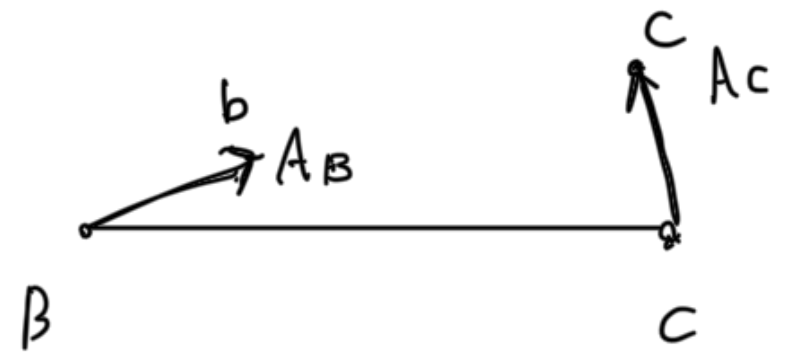
$$\vec{A_{AC}} = (-\omega^2 + j\alpha)\,\vec{R_{AC}}$$

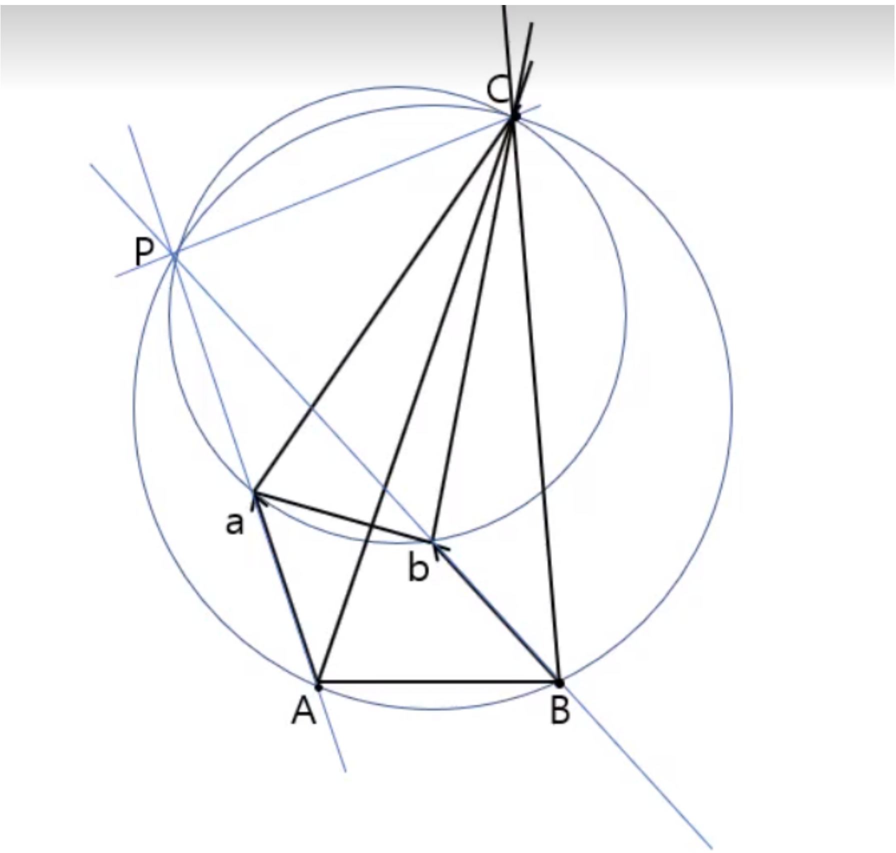
Note : $\triangle Cab \sim \triangle CAB$

✓ if $A_A = 0$, (A is I.C of acceleration), it's as follows .

There exists A, s/t ABC ∽ Abc .

⇒ Find A → I.C of acceleration.





$$\vec{z}_p = r\, e^{j\theta_2} \qquad \dot{\vec{z}}_p = \dot{r}\, e^{j\theta_2} + r\,\omega_2\, j e^{j\theta_2}$$

$$\dot{r}\cos\theta_2 - r\omega_2 \sin\theta = 0$$

$$\underline{\dot{r} = r\omega_2 \tan\theta = 32}$$

$$\vec{V}_p = 32\, e^{j\theta_2} + \left(24 \cdot \frac{2}{\sqrt{3}}\right) \cdot 2 \cdot \hat{j}\, e^{j\theta_2} = 64 \text{ q.}$$

$$\vec{A}_p = \ddot{r}\, e^{j\theta_2} - r\omega_2^2\, e^{j\theta_2} + 2\dot{r}\omega\, j e^{j\theta_2}$$

$$(\ddot{r} - r\omega_2^2)\cos\theta - 2\dot{r}\omega \sin\theta = 0$$

$$\ddot{r} - r\omega_2^2 = 2\dot{r}\omega \tan\theta$$

$$\Rightarrow \ddot{r} = \frac{320}{\sqrt{3}}$$

73.9 $\nearrow$ + $\nwarrow$ 128