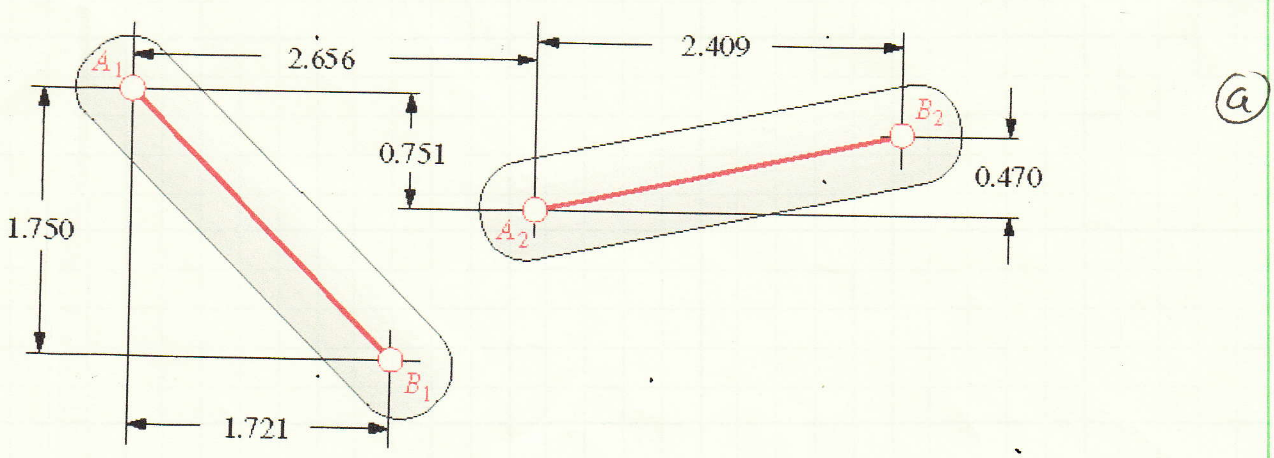
PROBLEM 3-4 | DESIGN A FOURBAR MECHANISM TO GIVE THE TWO POSITIONS SHOWN IN THE FIGURE OF COUPLER MOTION. BUILD A MODEL AND DETERMINE THE TOGGLE POSITIONS AND THE MINIMUM TRANSMISSION ANGLE FROM THE MODEL. ADD A DRIVE DYAD.

GIVEN:
1) LINK POSITIONS SHOWN
2) LINK IS A COUPLER

ASSUMPTIONS:
1) LINKS ARE RIGID
2) NO FRICTION IN THE JOINTS
3) ALL MOTION IS PLANAR

FIND:
1) DESIGN A LINKAGE THAT MOVES THE COUPLER THROUGH THE TWO POSITIONS SHOWN.
2) BUILD A MODEL
3) DETERMINE THE TOGGLE POSITION
4) DETERMINE THE MINIMUM TRANSMISSION ANGLE
5) DESIGN A DRIVE DYAD.

FIGURE:



Homework Solution
MER312: Adv. Dynamics & Kinematics

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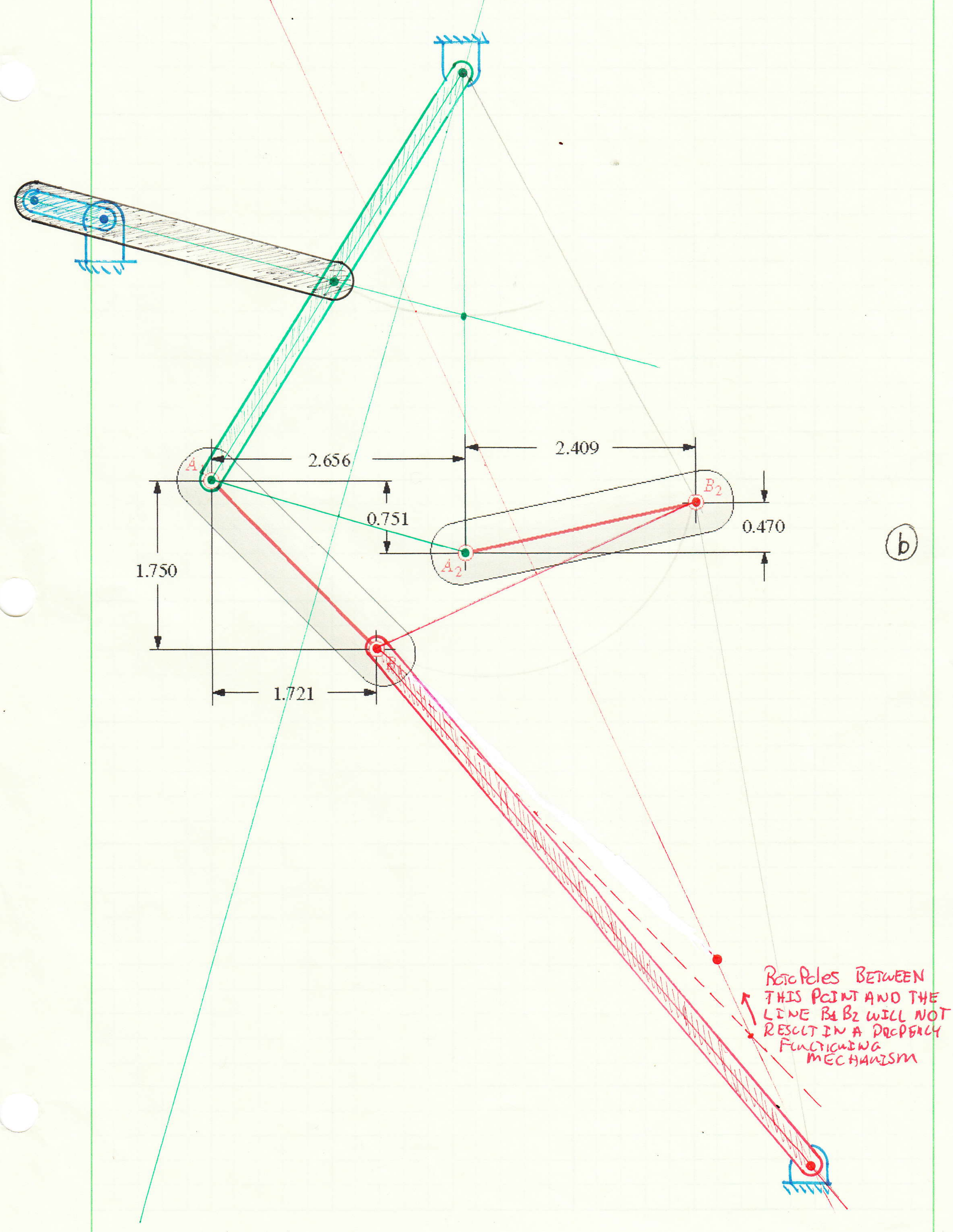
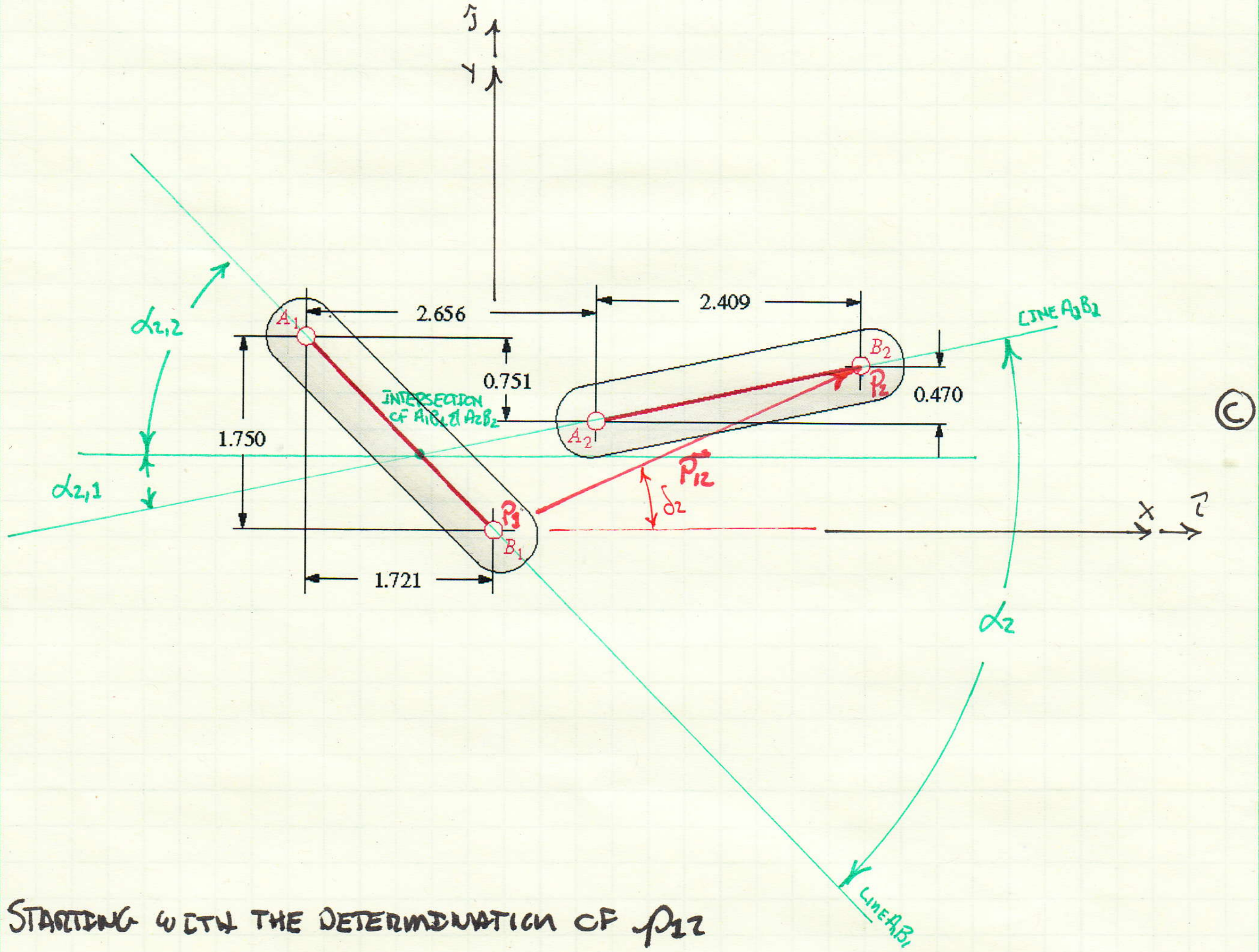


CONSIDER SOLVING THIS PROBLEM USING ANALYTICAL SYNTHESIS APPROACH A.

THE PROBLEM GIVENS ARE SHOWN ON THE DIAGRAM BELOW. VALUES FOR THESE NEED TO BE CALCULATED FROM THE DIMENSION GIVEN.




STARTING WITH THE DETERMINATION OF $\rho_{12}$

$$\rho_{12x} = -1.721 + 2.656 + 2.409 = 3.344$$

$$\rho_{12y} = 1.750 - 0.751 + 0.470 = 1.469$$

$$\rho_{12} = \sqrt{(3.344)^2 + (1.469)^2} = \underline{\underline{3.344}} \quad (1)$$

$$\delta_2 = \tan^{-1}\left(\frac{1.469}{3.344}\right) = \underline{\underline{23.7}} \quad (2)$$

$$\alpha_2 = \alpha_{2,1} + \alpha_{2,2} = \mathrm{TAN}^{-1}\frac{0.470}{2.409} + \mathrm{TAN}^{-1}\frac{1.750}{1.721} = 11.0° + 45.5°$$

$$= \underline{\underline{56.5°}} \quad (3)$$

THERE ARE TWO DYADS THAT HAVE TO BE SYNTHESIZED FOR APPROACH A. THE FREE CHOICES AND VARIABLES THAT NEED TO BE FOUND FOR THESE TWO DYADS ARE

**FIRST DYAD**

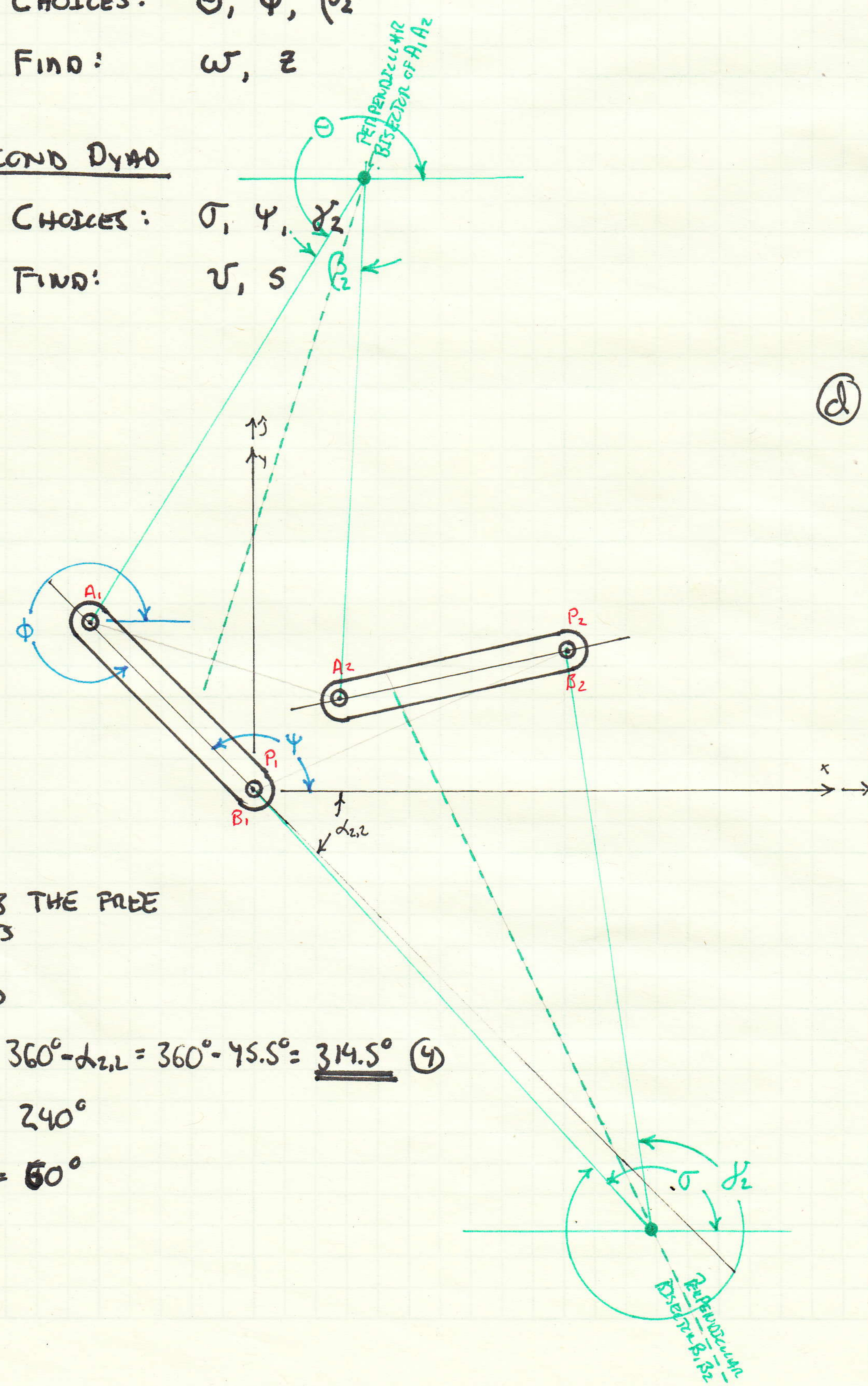
CHOICES: $\theta, \phi, \beta_2$

FIND: $W, Z$

**SECOND DYAD**

CHOICES: $\sigma, \psi, \gamma_2$

FIND: $V, S$




(d) ILLUSTRATES THE FREE CHOICE INPUTS

FIRST DYAD

$$\phi = 360^\circ - \alpha_{2,2} = 360^\circ - 45.5^\circ = \underline{\underline{314.5^\circ}} \quad (4)$$

$$\theta = 240^\circ$$

$$\beta_2 = 50^\circ$$

SECOND DYAD

$\sigma = 130°$

$\psi = 180 - \alpha_{2,2} = 180 - 45.5° = 134.5°$

$\gamma_2 = 330°$

THESE VALUES ARE INPUT INTO THE ALGORITHM FOR TWO POSITION SYNTHESIS APPROACH A. THE RESULTS ARE SEEN ON THE NEXT PAGE

## SUMMARY:

THE FREE CHOICES $\phi$ AND $\psi$ ARE DICTATED BY THE CHOICE OF $P_1$. THE REST OF THE FREE CHOICES ARE INFLUENCED BY THE DESIRE TO ACHIEVE ROT-POLES AT THE LOCATION DETERMINED USING THE GRAPHICAL APPROACH. THEREFORE, THE GRAPHICAL SOLUTION IS USED TO DEFINE $\theta$, $\beta_2$, $\sigma$, & $\gamma_2$. FIGURE ② ATTEMPTS TO ILLUSTRATE HOW THESE VALUES ARE MEASURED,

TWO POSITION ANALYTICAL MOTION SYNTHESIS

$$\vec{W}_2+\vec{Z}_2=\vec{W}_1+\vec{Z}_1+\vec{P}_{21}$$

$$\left|\vec{W}_1\right|=\left|\vec{W}_2\right|=w$$

$$\left|\vec{Z}_1\right|=\left|\vec{Z}_2\right|=z$$

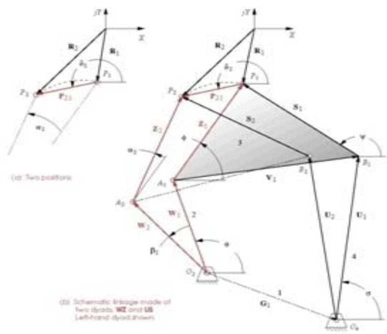
$$\vec{W}_1=w\cdot\left[\cos(\theta)\hat{i}+\sin(\theta)\hat{j}\right]$$

$$\vec{W}_2=w\cdot\left[\cos(\theta+\beta_2)\hat{i}+\sin(\theta+\beta_2)\hat{j}\right]$$

$$\vec{Z}_1=z\cdot\left[\cos(\phi)\hat{i}+\sin(\phi)\hat{j}\right]$$

$$\vec{Z}_2=z\cdot\left[\cos(\phi+\alpha_2)\hat{i}+\sin(\phi+\alpha_2)\hat{j}\right]$$

$$\vec{P}_{21}=p_{21}\cdot\left[\cos(\delta_2)\hat{i}+\sin(\delta_2)\hat{j}\right]$$



APPROACH A — FIRST DYAD

| GIVEN: | | CHOSEN: | | FIND: | |
|---|---|---|---|---|---|
| P12 | 3.344 | θ | 240 | w | 2.645 |
| δ2 | 23.7 | ϕ | 314.5 | z | 1.487 |
| α2 | 56.5 | β2 | 60 | | |

| | x-coord | y-coord |
|---|---|---|
| W1 | -1.322 | -2.290 |
| W2 | 1.322 | -2.290 |
| Z1 | 1.042 | -1.060 |
| Z2 | 1.459 | 0.284 |

| | x-coord | y-coord |
|---|---|---|
| O2 | 0.280 | 3.351 |
| A1 | -1.042 | 1.060 |
| A2 | 1.603 | 1.060 |
| P1 | 0.000 | 0.000 |
| P2 | 3.062 | 1.344 |

$$\begin{bmatrix} 1 & 0.280717919 \\ 0 & 0.904059445 \end{bmatrix}\begin{Bmatrix} w \\ Z \end{Bmatrix} = \begin{Bmatrix} 3.061976 \\ 1.344113 \end{Bmatrix}$$

| | |
|---|---|
| 1 | -0.31051 |
| 0 | 1.106122 |

$$\vec{U}_2+\vec{S}_2=\vec{U}_1+\vec{S}_1+\vec{P}_{31}$$

$$\left|\vec{U}_1\right|=\left|\vec{U}_2\right|=u$$

$$\left|\vec{S}_1\right|=\left|\vec{S}_2\right|=s$$

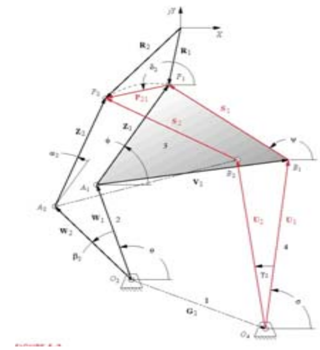
$$\vec{U}_1=u\cdot\left[\cos(\sigma)\hat{i}+\sin(\sigma)\hat{j}\right]$$

$$\vec{U}_2=u\cdot\left[\cos(\sigma+\gamma_2)\hat{i}+\sin(\sigma+\gamma_2)\hat{j}\right]$$

$$\vec{S}_1=s\cdot\left[\cos(\psi)\hat{i}+\sin(\psi)\hat{j}\right]$$

$$\vec{S}_2=s\cdot\left[\cos(\psi+\alpha_2)\hat{i}+\sin(\psi+\alpha_2)\hat{j}\right]$$

$$\vec{P}_{21}=p_{21}\cdot\left[\cos(\delta_2)\hat{i}+\sin(\delta_2)\hat{j}\right]$$



APPROACH A — SECOND DYAD

| GIVEN: | | CHOSEN: | | FIND: | |
|---|---|---|---|---|---|
| P12 | 3.344 | σ | 130 | u | 6.592 |
| δ2 | 23.7 | ψ | 134.5 | s | 0.108 |
| α2 | 56.5 | γ2 | 330 | | |

| | x-coord | y-coord |
|---|---|---|
| U1 | -4.237 | 5.049 |
| U2 | -1.145 | 6.491 |
| S1 | -0.076 | 0.077 |
| S2 | -0.106 | -0.021 |

| | x-coord | y-coord |
|---|---|---|
| O4 | 4.313 | -5.127 |
| B1 | 0.076 | -0.077 |
| B2 | 3.168 | 1.365 |
| P1 | 0.000 | 0.000 |
| P2 | 3.062 | 1.344 |

$$\begin{bmatrix} 0.469139 & -0.28072 \\ 0.218763 & -0.90406 \end{bmatrix}\begin{Bmatrix} w \\ Z \end{Bmatrix} = \begin{Bmatrix} 3.061976 \\ 1.344113 \end{Bmatrix}$$

| | |
|---|---|
| 2.49245 | -0.77393 |
| 0.60312 | -1.2934 |