NAME: Solution

PROBLEM #1: Consider the mechanism shown in the figure below. The triangular wedge, coupler CDB, is attached to two sliders at B and C. The joints at B and C are full joints. Both sliders move frictionlessly along the walls shown and are constrained to move along the wall. Point B is being forced to move at a *constant* velocity of 6.10 m/s to the left. For the position shown the loop closure equation is as follows.

$$\vec{R}_{BO} + \vec{R}_{OC} = \vec{R}_{BC}$$

where

$$R_{BO}e^{j\theta_1} = 69.77mme^{j0^\circ} = 69.77mm$$

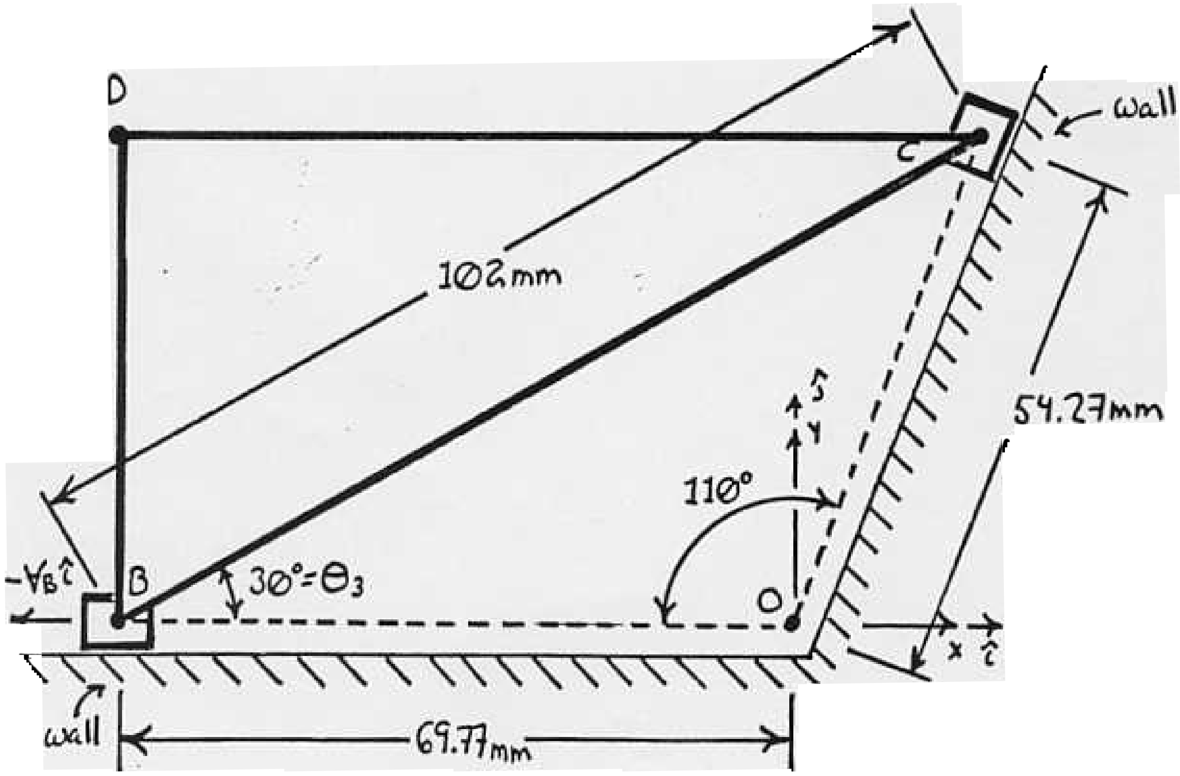
$$R_{BO}\hat{e}_{BO} = 69.77mm\ \hat{\imath}$$

$$\vec{R}_{OC} = R_{OC}e^{j\theta_2} = 54.77mme^{j70^\circ} = 18.56mm + j51.0mm$$

$$R_{OC}\hat{e}_{OC} = 54.27mm\ (0.3420\hat{\imath} + 0.9397\hat{\jmath})$$

$$R_{BC}e^{j\theta_3} = 102mme^{j30^\circ} = 88.33mm + j51.0mm$$

$$R_{BC}\hat{e}_{BC} = 102mm\ (0.866\hat{\imath} + 0.5\hat{\jmath})$$



1a) From a velocity analysis it was found that $\dot{\theta}_3 = -73.4\ \frac{1}{s}$ and $\dot{R}_{OC} = -5.396\ \frac{m}{s}$. differentiate the loop closure equation twice and determine $\ddot{R}_{OC}$ using one of the analyitical approaches.

Complex Method

$$R_{BO}e^{j\theta_1} + R_{OC}e^{j\theta_2} = R_{BC}e^{j\theta_3}$$

(10)

$$\dot{R}_{BO}e^{j\theta_1} + R_{BO}j\cancel{\dot{\theta}_1}e^{j\theta_1} + \dot{R}_{OC}e^{j\theta_2} + R_{OC}j\cancel{\dot{\theta}_2}e^{j\theta_2} = \cancel{\dot{R}_{BC}}e^{j\theta_3} + R_{BC}j\dot{\theta}_3e^{j\theta_3}$$

$$\dot{R}_{BO}e^{j\theta_1} + \dot{R}_{OC}e^{j\theta_2} = R_{BC}j\dot{\theta}_3e^{j\theta_3}$$

(10)

$$\cancel{\ddot{R}_{BO}}e^{j\theta_1} + \dot{R}_{BO}j\cancel{\dot{\theta}_1}e^{j\theta_1} + \ddot{R}_{OC}e^{j\theta_2} + \dot{R}_{OC}j\cancel{\dot{\theta}_2}e^{j\theta_2} = \cancel{\dot{R}_{BC}}j\dot{\theta}_3e^{j\theta_3} + R_{BC}j\ddot{\theta}_3e^{j\theta_3} - R_{BC}\dot{\theta}_3^2e^{j\theta_3}$$

$$\ddot{R}_{OC}e^{j\theta_2} = R_{BC}j\ddot{\theta}_3e^{j\theta_3} - R_{BC}\dot{\theta}_3^2e^{j\theta_3}$$

$$\ddot{R}_{OC}(\cos\theta_2 + j\sin\theta_2) = R_{BC}j\ddot{\theta}_3(\cos\theta_3 + j\sin\theta_3) - R_{BC}\dot{\theta}_3^2(\cos\theta_3 + j\sin\theta_3)$$

(10)

$$\ddot{R}_{OC}\cos\theta_2 = -R_{BC}\ddot{\theta}_3\sin\theta_3 - R_{BC}\dot{\theta}_3^2\cos\theta_3$$

$$\ddot{R}_{OC}\sin\theta_2 = R_{BC}\ddot{\theta}_3\cos\theta_3 - R_{BC}\dot{\theta}_3^2\sin\theta_3$$

(10)

$$\ddot{R}_{OC}\cos\theta_2\cos\theta_3 = -R_{BC}\ddot{\theta}_3\sin\theta_3\cos\theta_3 - R_{BC}\dot{\theta}_3^2\cos\theta_3\cos\theta_3$$

$$+\quad \ddot{R}_{OC}\sin\theta_2\sin\theta_3 = R_{BC}\ddot{\theta}_3\cos\theta_3\sin\theta_3 - R_{BC}\dot{\theta}_3^2\sin\theta_3\sin\theta_3$$

$$\ddot{R}_{OC}\cos(\theta_2-\theta_3) = -R_{BC}\dot{\theta}_3^2$$

(10)

$$\ddot{R}_{OC} = \frac{-R_{BC}\dot{\theta}_3^2}{\cos(\theta_2-\theta_3)} = \frac{(102mm)(-73.4\frac{1}{s})^2}{\cos(70°-30°)} = -7\ 7.4(10^3)\frac{mm}{s^2} = 717.4\frac{M}{s^2}$$

Vector Method

$$R_{BO}\hat{e}_{BO} + R_{OC}\hat{e}_{OC} = R_{BC}\hat{e}_{BC}$$

$$\dot{R}_{BO}\hat{e}_{BO} + R_{BO}\cancel{\dot{\hat{e}}_{BO}}^{\varnothing} + \dot{R}_{OC}\hat{e}_{OC} + R_{OC}\cancel{\dot{\hat{e}}_{OC}}^{\varnothing} = \cancel{\dot{R}_{BC}}^{\varnothing}\hat{e}_{BC} + R_{BC}\dot{\hat{e}}_{BC}$$

$$\dot{R}_{BO}\hat{e}_{BO} + \dot{R}_{OC}\hat{e}_{OC} = R_{BC}\dot{\Theta}_3(\hat{k}\times\hat{e}_{BC})$$

$$\cancel{\ddot{R}_{BO}}^{\varnothing}\hat{e}_{BO} + \dot{R}_{BO}\cancel{\dot{\hat{e}}_{BO}}^{\varnothing} + \ddot{R}_{OC}\hat{e}_{OC} + \dot{R}_{OC}\cancel{\dot{\hat{e}}_{OC}}^{\varnothing} = \cancel{\dot{R}_{BC}}^{\varnothing}\dot{\Theta}_3(\hat{k}\times\hat{e}_{BC}) + R_{BC}\ddot{\Theta}_3(\hat{k}\times\hat{e}_{BC})$$
$$+ R_{BC}\dot{\Theta}_3^2(\hat{k}\times(\hat{k}\times\hat{e}_{BC}))$$

$$\ddot{R}_{OC}\hat{e}_{OC} = R_{BC}\ddot{\Theta}_3(\hat{k}\times\hat{e}_{BC}) + R_{BC}\dot{\Theta}_3^2(\hat{k}\times(\hat{k}\times\hat{e}_{BC}))$$

Dotting with $\hat{e}_{BC}$

$$\ddot{R}_{OC}\,\hat{e}_{BC}\cdot\hat{e}_{OC} = R_{BC}\ddot{\Theta}_3\overbrace{\hat{e}_{BC}\cdot(\hat{k}\times\hat{e}_{BC})}^{\varnothing} + R_{BC}\dot{\Theta}_3^2\overbrace{\hat{e}_{BC}\cdot(\hat{k}\times(\hat{k}\times\hat{e}_{BC}))}^{-1}$$

$$\ddot{R}_{OC} = R_{BC}\dot{\Theta}_3^2\frac{\hat{e}_{BC}\cdot(\hat{k}\times(\hat{k}\times\hat{e}_{BC}))}{\hat{e}_{BC}\cdot\hat{e}_{OC}}$$

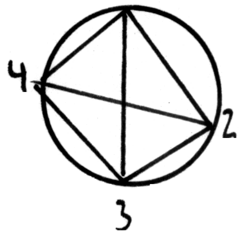
$$\hat{e}_{BC}\cdot\hat{e}_{OC} = (.866\hat{i} + .5\hat{j})\cdot(.3420\hat{i} + .9397\hat{j}) = 0.7660$$

$$\ddot{R}_{OC} = 102\text{mm}\,(-73.4\tfrac{1}{s})^2\,\frac{-1}{.7660} = -717.4(10)^3\frac{\text{mm}}{s} = -717.4\frac{\text{m}}{s^2}$$

PROBLEM #2: The linl shov scale The gth of the links

0:

6:



2a) Knowing that $\dot{\theta}$ dete the location of all instant centers for this mechanism and the es of A nd $\dot{\theta}_4$ graphically

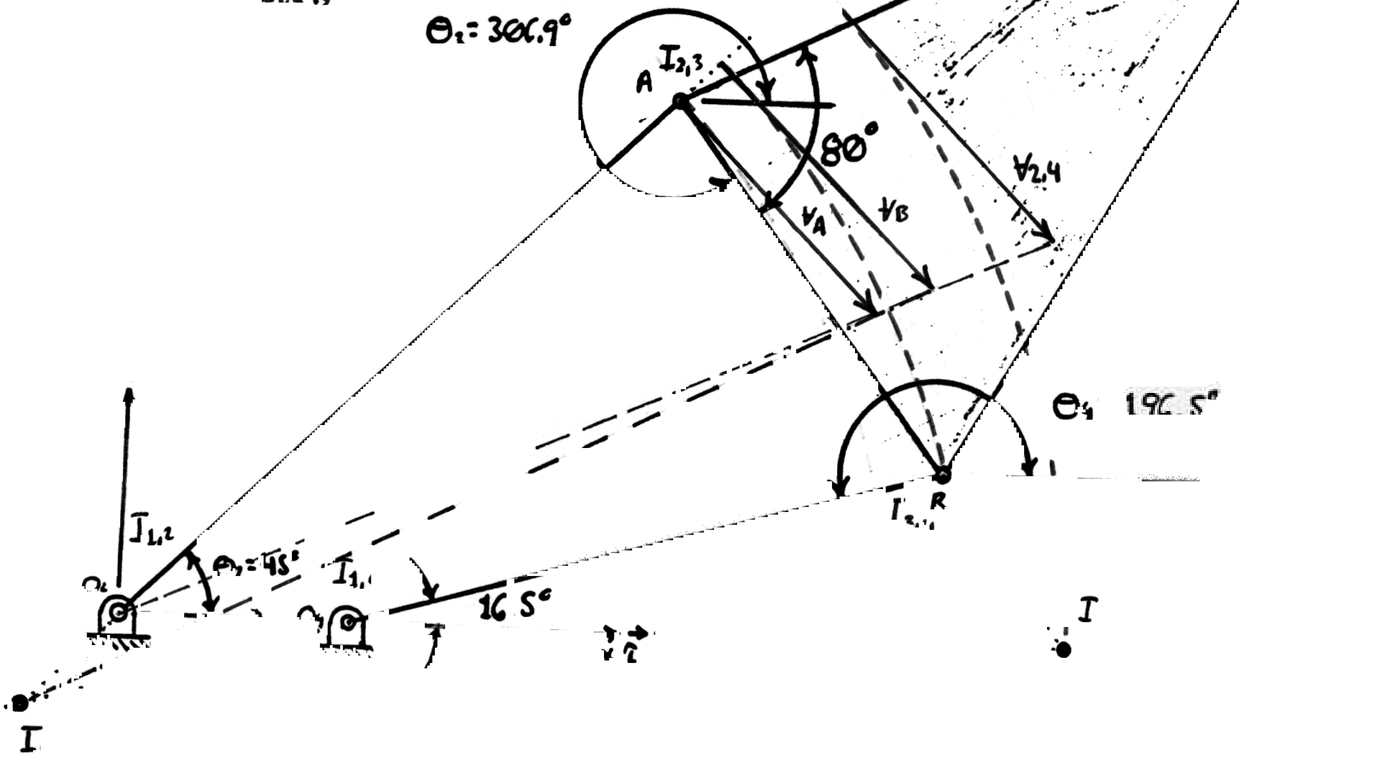
$V_A = (10 in)(-15 \tfrac{1}{s}) = -150 \tfrac{in}{s}$

$V_B = 165 \tfrac{in}{s}$

$V_{24} = 190 \tfrac{in}{s}$

$\omega_3 = \dfrac{V_A}{R_{I_{13}A}} = \dfrac{150 in/s}{11.8 in} = -12.71 \tfrac{1}{s}$

$\omega_4 = \dfrac{V_B}{R_{I_{14}B}} = \dfrac{165 in/s}{8 in} = -20.63 \tfrac{1}{s}$



2b) Knowing that $\ddot{\theta}_2 = -15 \frac{1}{s^2}$ determine $\ddot{\theta}$ ıd $\ddot{\theta}$ graphically

$A^{(N)}_{O_2A} = A^{(N)}_{A} = \omega_2^2 R_{O_2A} = (-15\tfrac{1}{s})^2(10in) = 2250\frac{in}{s^2}$

$A^{(T)}_{O_2A} = A^{(T)}_{A} = \alpha_2 R_{O_2A} = (-10\tfrac{1}{s^2})(10in) = -100\frac{in}{s^2}$

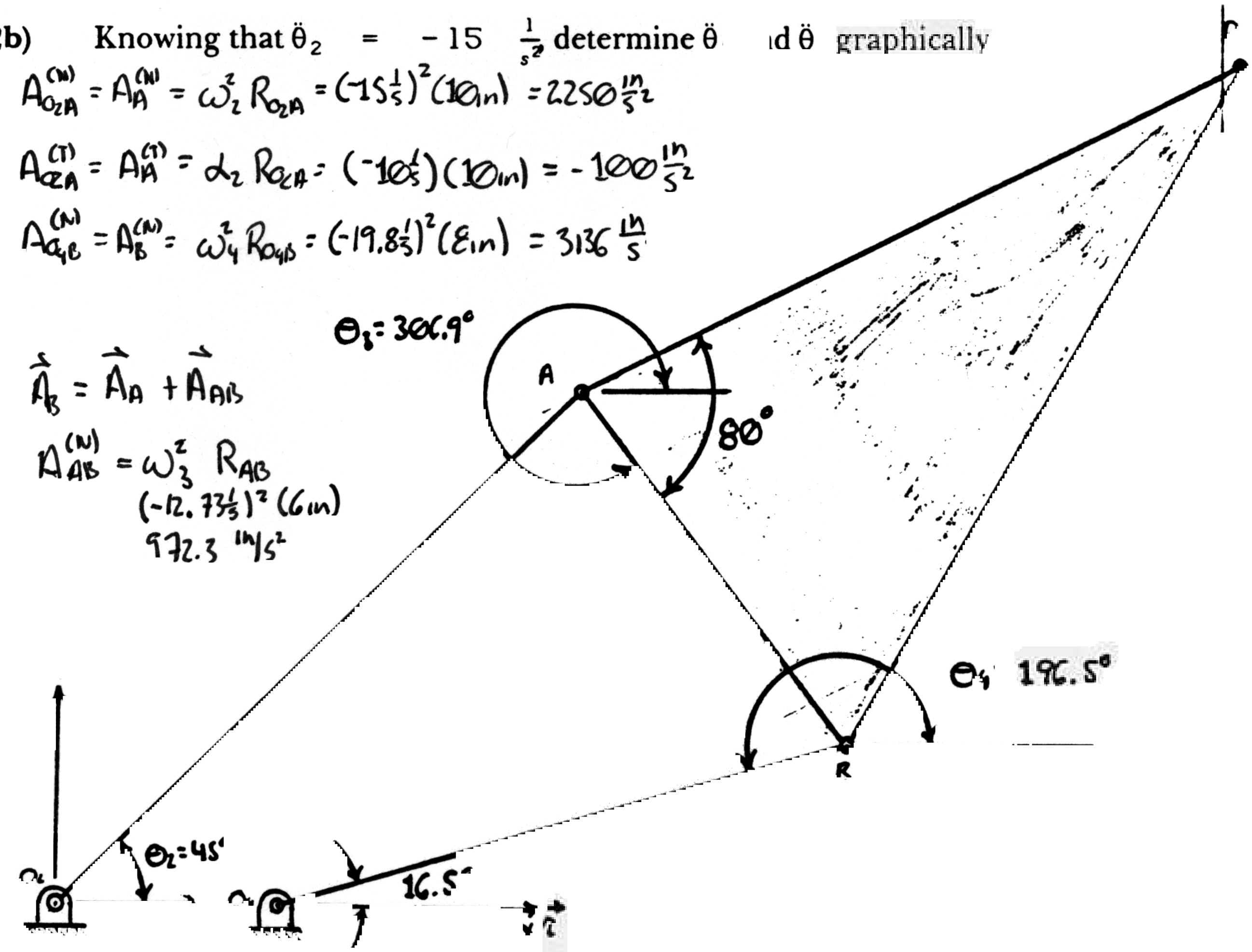
$A^{(N)}_{O_4B} = A^{(N)}_{B} = \omega_4^2 R_{O_4B} = (-19.8\tfrac{1}{s})^2(8in) = 3136\frac{in}{s}$

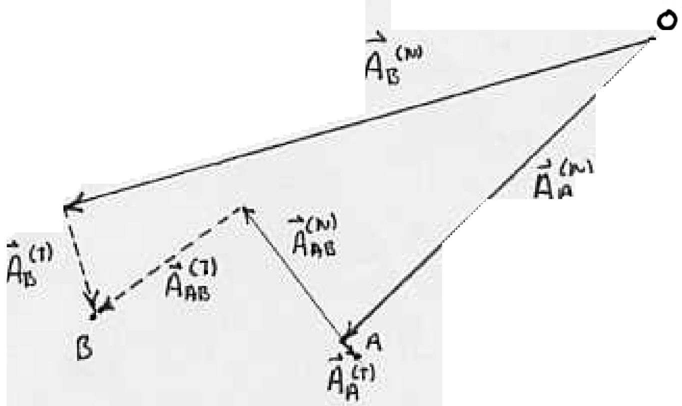
$\vec{A}_B = \vec{A}_A + \vec{A}_{AB}$

$A^{(N)}_{AB} = \omega_3^2 R_{AB}$

$(-12.73\tfrac{1}{s})^2(6in)$

$972.3 \ in/s^2$





$\ddot{\Theta}_4 = \frac{A_B^{(T)}}{R_{O_4B}} = \frac{575 \ in/s^2}{8in} = 71.9 \ 1/s$

$\ddot{\Theta}_3 = \frac{A_{AB}^{(T)}}{R_{AB}} = \frac{925 \ in/s^2}{6} = 154 \ 1/s$