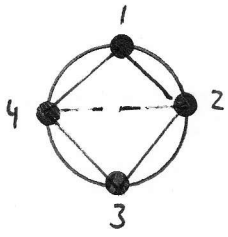
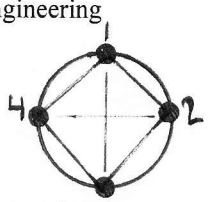
NAME: SOLUTION

PROBLEM 1 (30 pts): Use the mm scale on your ruler to measure all distances. For these problems 10mm=1m. Do two of the three mechanisms.

1a. Given that link 2 is rotating at a rate of 2 1/s ccw, calculate the velocity of point P_2 using instant *c*enters and illustrate v_{P2} on the figure in the appropriate location and to scale.

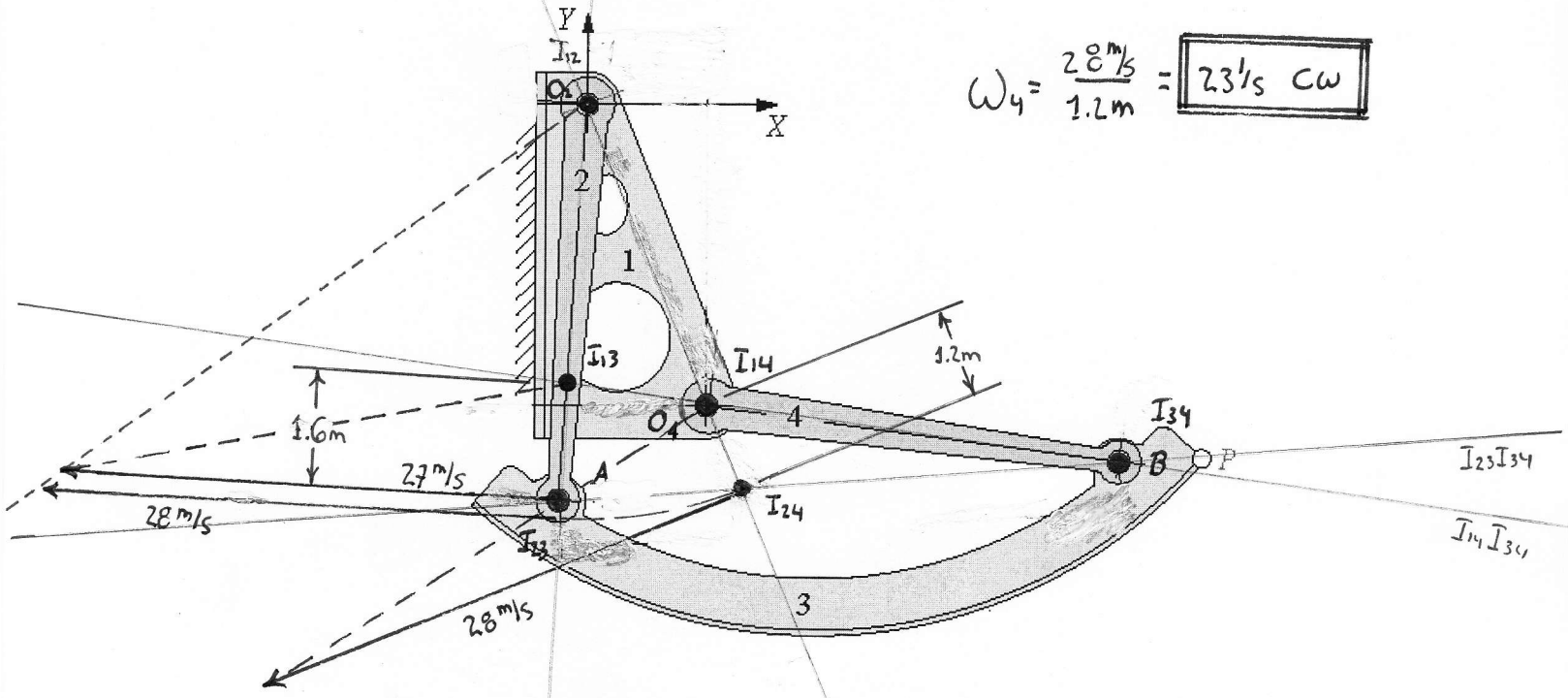




1b. Given that link 2 is rotating at a rate of 5 1/s cw, calculate the angular velocities of the other 3 links.

$\omega_3 = \frac{27\ m/s}{1.6\ m} = \boxed{17\ 1/s\ cw}$

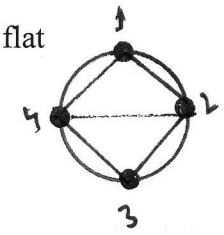
$\omega_4 = \frac{28\ m/s}{1.2\ m} = \boxed{23\ 1/s\ cw}$



$I_{12}I_{23}$

$I_{12}I_{14}$

1c. Given that link 2 is rotating at a rate of 10 1/s cw, calculate the velocity of the flat follower.



PROBLEM 2 (35pts): Design a double-dwell cam to move a follower from 0 to 2.5 inches in 60°, dwell for 120°, fall 2.5 inches in 30°, and dwell for the reminder. The total cycle must take 4s. Plot the s-*v*-*a*-*j* diagrams.

SEGMENT 1: FOLLOWER STARTS AT REST AND IS RAISED TO 2.5in. IN 60° ($\frac{\pi}{3}$)

SEGMENT 2: DWELL FOR 120° ($\frac{2}{3}\pi$)

SEGMENT 3: FOLLOWER RETURNS TO START POSITION in 30° ($\pi/6$)

SEGMENT 4: DWELL FOR 150° ($\frac{5\pi}{6}$)

$\omega = \frac{2\pi}{4s} = \frac{\pi}{2}\ \frac{rad}{s}$ (1)

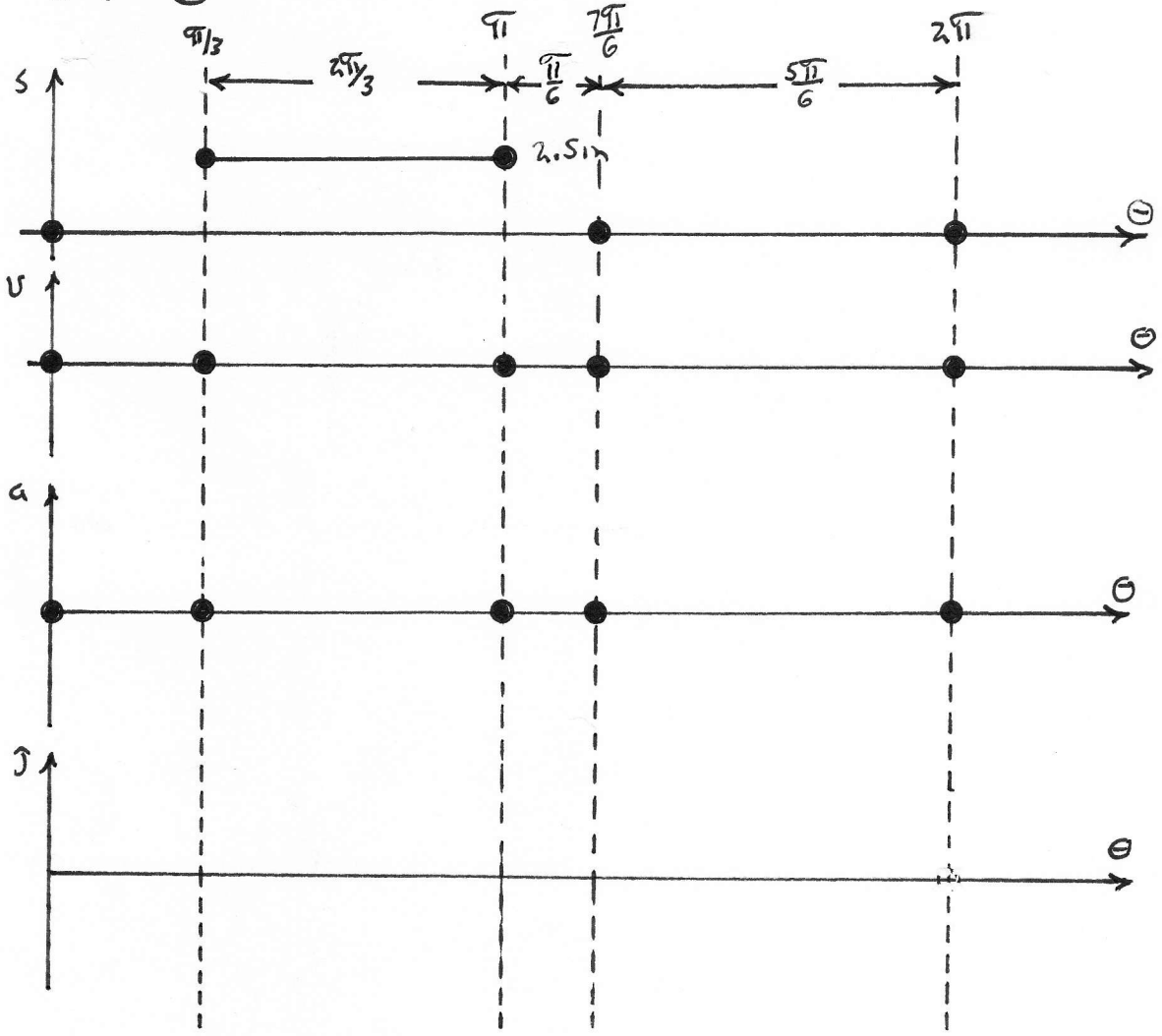


FIGURE (1): ILLUSTRATION OF THE BOUNDARY CONDITIONS FOR EACH SEGMENT OF THE PROFILE THAT ARE INFERED FROM THE PROBLEM-STATEMENT.

SEGMENT 1. $0 \le \theta \le \pi/3$, $0 \le \theta_1 \le \pi/3$, $\beta_1 = \pi/3$

$$s_1 = h\left[\frac{\theta_1}{\beta} - \frac{1}{2\pi}\sin\left(2\pi\frac{\theta_1}{\beta}\right)\right] = 2.5\text{in}\left[\frac{\theta_1}{\pi/3} - \frac{1}{2\pi}\sin\left(2\pi\frac{\theta_1}{\pi/3}\right)\right]$$

$$\boxed{s_1 = 2.5\text{in}\left[\frac{3\cdot\theta_1}{\pi} - \frac{1}{2\pi}\cdot\sin(6\theta_1)\right]}$$

$$v_1 = \frac{h}{\beta}\left[1-\cos\left(2\pi\frac{\theta_1}{\beta}\right)\right] = \frac{2.5\text{in}}{\pi/3\ \text{rad}}\left[1-\cos\left(2\pi\frac{\theta_1}{\pi/3}\right)\right]$$

$$\boxed{v_1 = \frac{7.5}{\pi}\frac{\text{in}}{\text{rad}}\left[1-\cos(6\theta_1)\right]}$$

$$a_1 = 2\pi\frac{h}{\beta^2}\sin\left(2\pi\frac{\theta_1}{\beta}\right) = 2\pi\cdot\frac{2.5\text{in}}{\pi^2/9\ \text{rad}}\cdot\sin\left(2\pi\frac{\theta_1}{\pi/3}\right)$$

$$\boxed{a_1 = \frac{45}{\pi}\frac{\text{in}}{\text{rad}^2}\sin(6\theta_1)}$$

$$j_1 = 4\pi^2\frac{h}{\beta^3}\cos\left(2\pi\frac{\theta_1}{\beta}\right) = 4\pi^2\frac{2.5\text{in}}{\pi^3/27}\cos\left(2\pi\,\theta_1/\pi/3\right)$$

$$\boxed{j_1 = \frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}\cos(6\cdot\theta_1)}$$

SEGMENT 2: $\pi/3 \le \theta \le \pi$, $0 \le \theta_2 \le 2\pi/3$, $\beta_2 = 2\pi/3$

$$\boxed{\begin{aligned} h &= 2.5\text{in} = s_2 \\ v_2 &= 0\ \tfrac{\text{in}}{\text{rad}} \\ a_2 &= 0\ \tfrac{\text{in}}{\text{rad}^2} \\ j_2 &= 0\ \tfrac{\text{in}}{\text{rad}^3} \end{aligned}}$$

SEGMENT 3: $\pi \le \theta \le 7\pi/6$, $0 \le \theta_3 \le \pi/6$, $\beta_3 = \pi/6$

$$s_3 = -\frac{h}{\beta}\left[\theta - \frac{\beta}{2\pi}\cdot\sin\left(2\pi\frac{\theta}{\beta}\right)\right] + h = -\frac{2.5\text{in}}{\pi/6}\cdot\left[\theta - \frac{\pi/6}{2\pi}\cdot\sin\left(2\pi\frac{\theta}{\pi/6}\right)\right] + 2.5\text{in}$$

$$\boxed{s_3 = \frac{15\text{in}}{\pi}\left[\theta - \frac{1}{12}\cdot\sin(12\cdot\theta)\right] + 2.5\text{in}}$$

$$v_3 = -\frac{h}{\beta}\left[1-\cos\left(2\pi\cdot\frac{\theta}{\beta}\right)\right] = -\frac{2.5\text{in}}{\pi/6}\left[1-\cos\left(2\pi\frac{\theta}{\pi/6}\right)\right]$$

$$\boxed{v_3 = -\frac{15\text{in}}{\pi\ \text{rad}}\left[1-\cos(12\theta)\right]}$$

$$a_3 = -\frac{2\pi\cdot 2.5\text{in}}{\pi^2/36}\cdot\sin\left(2\pi\cdot\frac{\theta}{\pi/6}\right) = -\frac{2\pi h}{\beta^2}\cdot\sin\left(2\pi\frac{\theta}{\beta}\right)$$

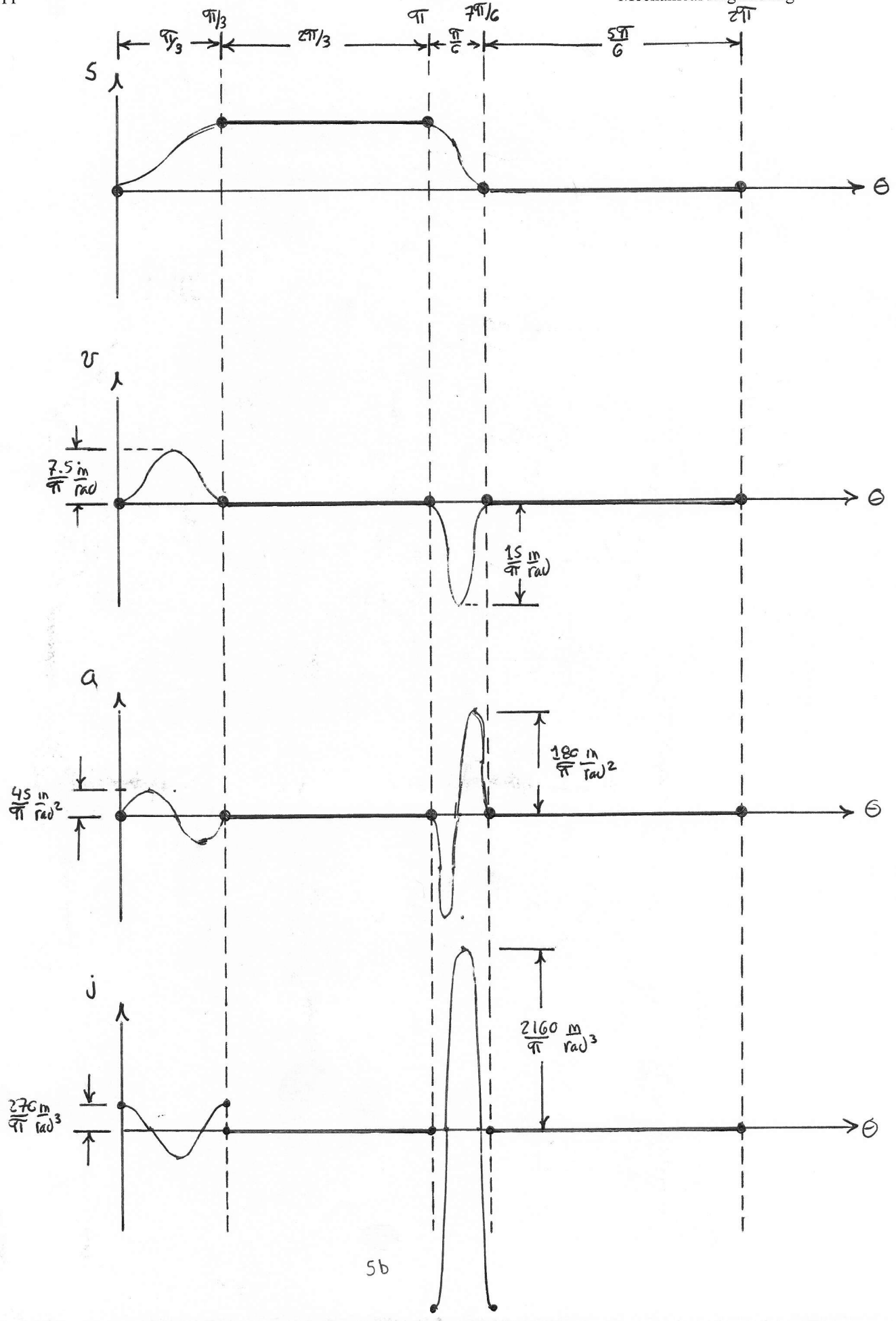
$$\boxed{a_3 = -\frac{180\text{in}}{\pi\ \text{rad}^2}\cdot\sin(12\cdot\theta)}$$

$$j_3 = -\frac{4\cdot\pi^2 h}{\beta^3}\cdot\cos\left(2\pi\frac{\theta}{\beta}\right) = -\frac{4\cdot\pi^2\cdot 2.5\text{in}}{\pi^3/216}\cdot\cos\left(2\pi\frac{\theta}{\pi/6}\right)$$

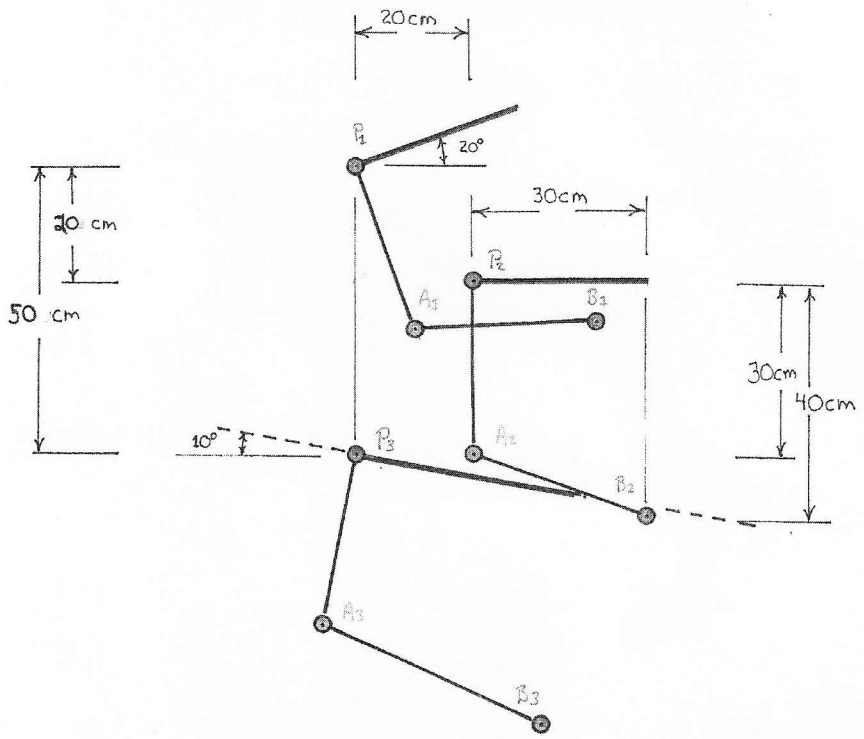
$$\boxed{j_3 = -\frac{2160}{\pi}\frac{\text{in}}{\text{rad}^3}\cdot\cos(12\theta)}$$

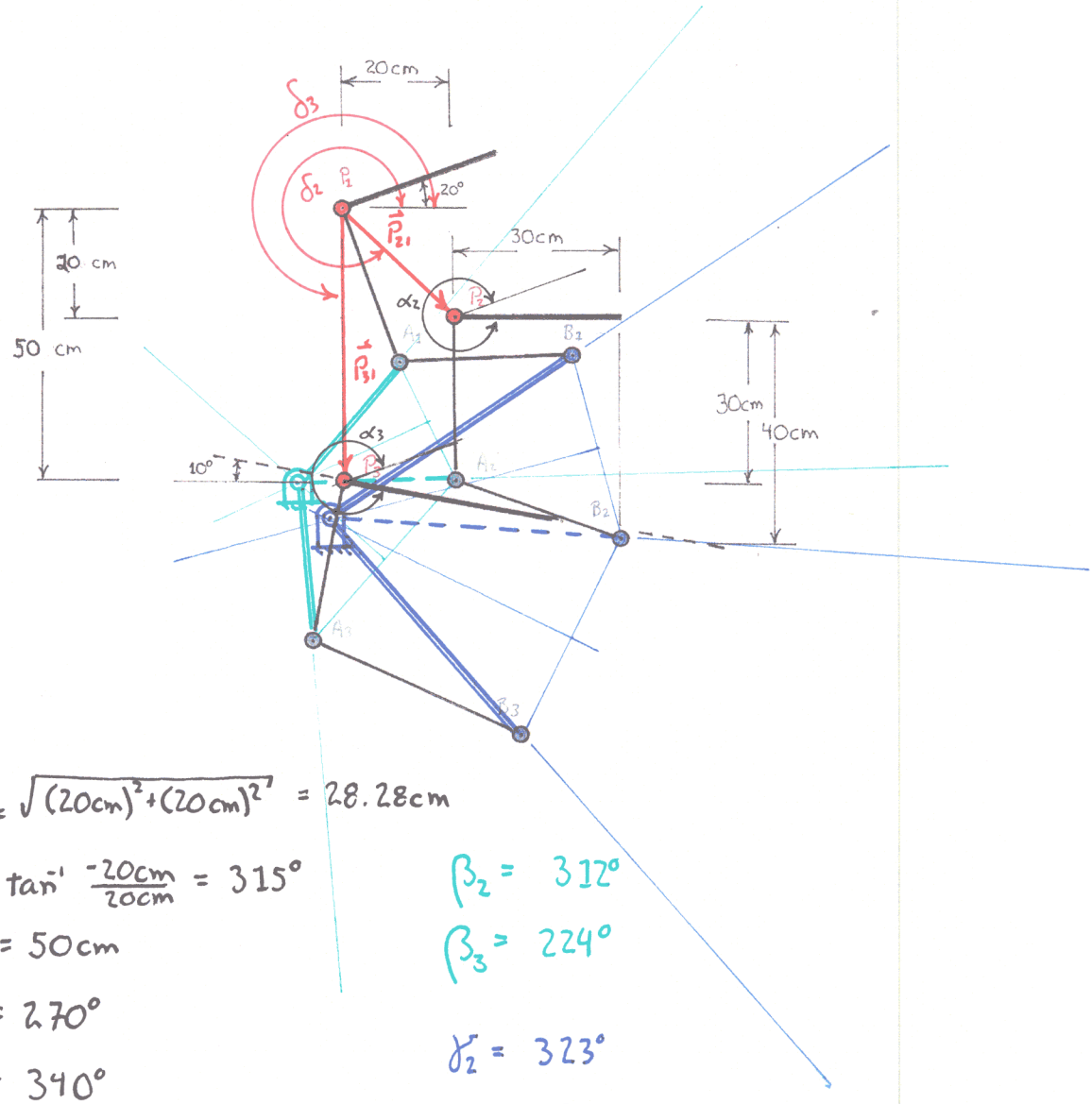
SEGMENT 4: $7\pi/6 \le \theta \le 2\pi$, $0 \le \theta_4 \le \frac{5\pi}{6}$, $\beta_4 = 5\pi/6$

$$\boxed{\begin{aligned} s_4 &= 0\text{in} \\ v_4 &= 0\ \text{in/rad} \\ a_4 &= 0\ \text{in/rad}^2 \\ j_4 &= 0\text{in/rad}^3 \end{aligned}}$$


π/3
2π/3
π
π/6
π/6
5π/6
2π
s
θ
v
7.5 in/π rad
15 in/π rad
θ
a
45 in/π rad²
180 in/π rad²
θ
j
270 in/π rad³
2160 in/π rad³
θ

PROBLEM 3 (35pts). Using your numerical program, compute the location of the ground points that will allow this linkage to pivot at A and B and travel through the three positions shown. Make sure to attach your output.





$\rho_{21} = \sqrt{(20cm)^2 + (20cm)^2} = 28.28cm$

$\delta_2 = \tan^{-1}\frac{-20cm}{20cm} = 315°$

$\rho_{31} = 50cm$

$\delta_3 = 270°$

$\alpha_2 = 340°$

$\alpha_3 = 330°$

$\beta_2 = 312°$

$\beta_3 = 224°$

$\gamma_2 = 323°$

$\gamma_3 = 278°$

THREE POSITION ANALYTICAL MOTION SYNTHESIS

$$\vec{W}_2 + \vec{Z}_2 = \vec{W}_1 + \vec{Z}_1 + \vec{P}_{21}; \quad \vec{W}_3 + \vec{Z}_3 = \vec{W}_1 + \vec{Z}_1 + \vec{P}_{31}$$

$$\left|\vec{W}_1\right| = \left|\vec{W}_2\right| = \left|\vec{W}_3\right| = w; \quad \left|\vec{Z}_1\right| = \left|\vec{Z}_2\right| = \left|\vec{Z}_3\right| = z$$

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

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

$$\vec{W}_3 = w \cdot \left[\cos(\theta + \beta_3)\hat{i} + \sin(\theta + \beta_3)\hat{j}\right]$$

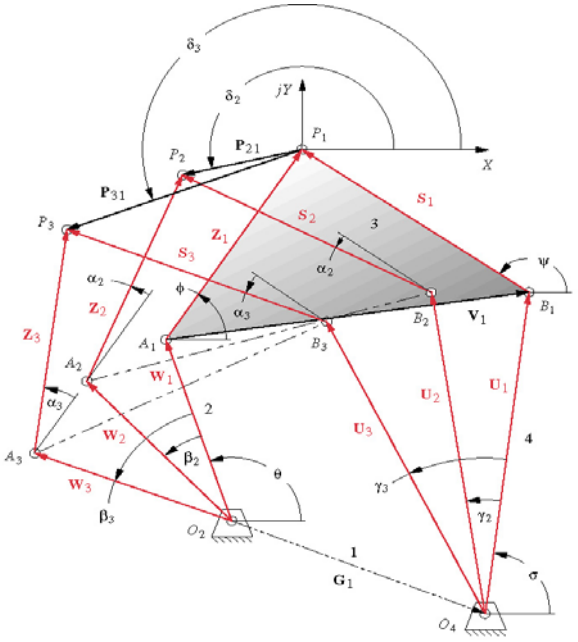
$$\vec{Z}_1 = z \cdot \left[\cos(\phi)\hat{i} + \sin(\phi)\hat{j}\right]$$

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

$$\vec{Z}_3 = z \cdot \left[\cos(\phi + \alpha_3)\hat{i} + \sin(\phi + \alpha_3)\hat{j}\right]$$

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

$$\vec{P}_{31} = p_{31} \cdot \left[\cos(\delta_3)\hat{i} + \sin(\delta_3)\hat{j}\right]$$



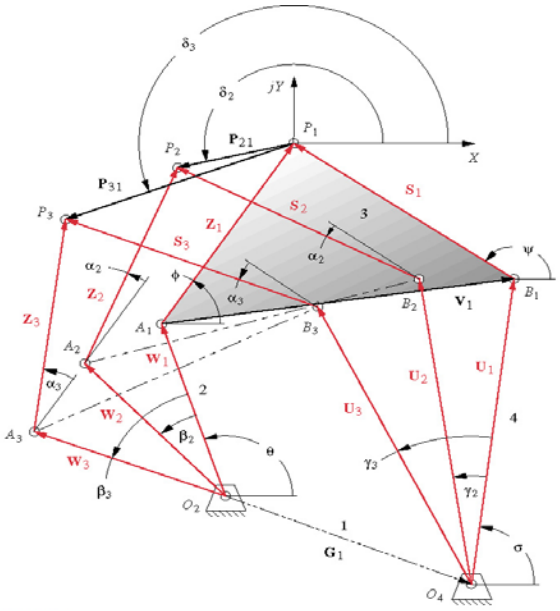
FIRST DYAD

GIVEN:		CHOSEN:		FIND:	
P12	28.28	β2	312.00	w	27.220
P13	50.00	β3	224.00	θ	51.086
δ2	315.00			z	28.561
δ3	270.00			ϕ	98.365
α2	340.00			W1x	17.098
α3	330.00			W1y	21.179
				Z1x	-4.155
				Z1y	28.257

	x-coord	y-coord.
O2	-12.943	-49.436
A1	4.155	-28.257
A2	14.237	-47.971
A3	-10.530	-76.548
P1	0.000	0.000
P2	19.997	-19.997
P3	0.000	-50.000

$$\begin{bmatrix} -0.3309 & 0.7431 & -0.0603 & 0.3420 \\ -0.7431 & -0.3309 & -0.3420 & -0.0603 \\ -1.7193 & 0.6947 & -0.1340 & 0.5000 \\ -0.6947 & -1.7193 & -0.5000 & -0.1340 \end{bmatrix} \begin{Bmatrix} W1x \\ W1y \\ Z1x \\ Z1y \end{Bmatrix} = \begin{Bmatrix} 19.9970 \\ -19.9970 \\ 0.0000 \\ -50.0000 \end{Bmatrix}$$

$$\begin{bmatrix} \cos\beta_2 - 1 & -\sin\beta_2 & \cos\alpha_2 - 1 & -\sin\alpha_2 \\ \sin\beta_2 & \cos\beta_2 - 1 & \sin\alpha_2 & \cos\alpha_2 - 1 \\ \cos\beta_3 - 1 & -\sin\beta_3 & \cos\alpha_3 - 1 & -\sin\alpha_3 \\ \sin\beta_3 & \cos\beta_3 - 1 & \sin\alpha_3 & \cos\alpha_3 - 1 \end{bmatrix} \cdot \begin{Bmatrix} W_{1x} \\ W_{1y} \\ Z_{1x} \\ Z_{1y} \end{Bmatrix} = \begin{Bmatrix} p_{21} \cdot \cos\delta_2 \\ p_{21} \cdot \sin\delta_2 \\ p_{31} \cdot \cos\delta_3 \\ p_{31} \cdot \sin\delta_3 \end{Bmatrix}$$



$$\vec{U}_2+\vec{S}_2=\vec{U}_1+\vec{S}_1+\vec{P}_{21};\quad \vec{U}_3+\vec{S}_3=\vec{U}_1+\vec{S}_1+\vec{P}_{31}$$

$$\left|\vec{U}_1\right|=\left|\vec{U}_2\right|=\left|\vec{U}_3\right|=u;\quad \left|\vec{S}_1\right|=\left|\vec{S}_2\right|=\left|\vec{S}_3\right|=s$$

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

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

$$\vec{U}_3=u\cdot\left[\cos(\sigma+\gamma_3)\hat{i}+\sin(\sigma+\gamma_3)\hat{j}\right]$$

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

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

$$\vec{S}_3=s\cdot\left[\cos(\psi+\alpha_3)\hat{i}+\sin(\psi+\alpha_3)\hat{j}\right]$$

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

$$\vec{P}_{31}=p_{31}\cdot\left[\cos(\delta_3)\hat{i}+\sin(\delta_3)\hat{j}\right]$$

SECOND DYAD

GIVEN:		CHOSEN:		FIND:	
P12	28.28	γ2	323.00	u	64.865
P13	50.00	γ3	278.00	σ	18.920
δ2	315.00			s	83.248
δ3	270.00			ψ	147.062
α2	340.00			U1x	61.361
α3	330.00			U1y	21.033
				S1x	-69.867
				S1y	45.265

	x-coord	y-coord.
O4	8.506	-66.298
B1	69.867	-45.265
B2	70.169	-86.428
B3	37.874	-124.134
P1	0.000	0.000
P2	19.997	-19.997
P3	0.000	-50.000

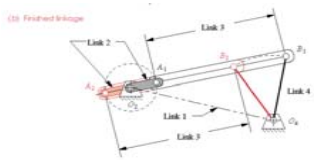
$$\begin{bmatrix} -0.2014 & 0.6018 & -0.0603 & 0.3420 \\ -0.6018 & -0.2014 & -0.3420 & -0.0603 \\ -0.8608 & 0.9903 & -0.1340 & 0.5000 \\ -0.9903 & -0.8608 & -0.5000 & -0.1340 \end{bmatrix} \begin{Bmatrix} U1x \\ U1y \\ S1x \\ S1y \end{Bmatrix} = \begin{Bmatrix} 19.9970 \\ -19.9970 \\ 0.0000 \\ -50.0000 \end{Bmatrix}$$

$$\begin{bmatrix} \cos\gamma_2-1 & -\sin\gamma_2 & \cos\alpha_2-1 & -\sin\alpha_2 \\ \sin\gamma_2 & \cos\gamma_2-1 & \sin\alpha_2 & \cos\alpha_2-1 \\ \cos\gamma_3-1 & -\sin\gamma_3 & \cos\alpha_3-1 & -\sin\alpha_3 \\ \sin\gamma_3 & \cos\gamma_3-1 & \sin\alpha_3 & \cos\alpha_3-1 \end{bmatrix} \cdot \begin{Bmatrix} U_{1x} \\ U_{1y} \\ S_{1x} \\ S_{1y} \end{Bmatrix} = \begin{Bmatrix} p_{21}\cdot\cos\delta_2 \\ p_{21}\cdot\sin\delta_2 \\ p_{31}\cdot\cos\delta_3 \\ p_{31}\cdot\sin\delta_3 \end{Bmatrix}$$

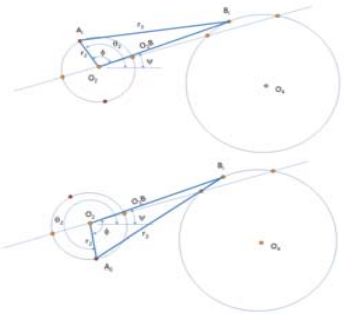
NON-QUICK-RETURN (From Three Position Results)

	X-pos	Y-pos	mag	angle	i	j
3P-O2 => O4	-12.943	-49.436	51.102	-104.7	-0.2533	-0.9674
3P-A1	4.155	-28.257	28.561	-81.6	0.1455	-0.9894
3P-A2	14.237	-47.971	50.039	-73.5	0.2845	-0.9587
3P-A3	-10.530	-76.548	77.269	-97.8	-0.1363	-0.9907

Factors		
P	0.5	% dist up Link 4
K	2.5	Length of Link 3+Link 2 wrt B1B2
Link 1	50.732	
Link 2	12.619	
Link 3	50.475	
Link 4	13.610	Grashof



ϕ=	59.6
ψ=	65.1
θ_{2i}=	124.8
θ_{2ii}=	365.5



$$r_3^2 = r_2^2 + (O_2B)^2 - 2 \cdot r_2 \cdot (O_2B) \cdot \cos\phi$$

$$\phi = \cos^{-1} \frac{r_2^2 + (O_2B)^2 - r_3^2}{2 \cdot r_2 \cdot (O_2B)}$$

$$\psi = \tan^{-1} \frac{B_{iy} - O_{2y}}{B_{ix} - O_{2x}}$$

$$\theta_{2i} = \phi + \psi$$

$$\theta_{2ii} = 360 + \psi - \phi$$

					Normal (r)		Perpendicular (θ)	
	x comp	y comp	mag	angle	i	j	i	j
rO4	**-12.943**	**-49.436**	**51.102**	**-104.7**	**-0.2533**	**-0.9674**	**0.9674**	**-0.2533**
rP3O2-A1	17.098	21.179	27.220	51.1	0.6282	0.7781	-0.7781	0.6282
rP3O2-A2	27.180	1.465	27.220	3.1	0.9985	0.0538	-0.0538	0.9985
rP3O2-A3	2.413	-27.112	27.220	-84.9	0.0887	-0.9961	0.9961	0.0887
rB1	**-4.394**	**-38.846**	**39.094**	**-96.5**	**-0.1124**	**-0.9937**	**0.9937**	**-0.1124**
rO4B1	8.549	10.590	13.610	51.1	0.6282	0.7781	-0.7781	0.6282
rB2	**-11.737**	**-62.992**	**64.076**	**-100.6**	**-0.1832**	**-0.9831**	**0.9831**	**-0.1832**
rO4B2	1.207	-13.556	13.610	-84.9	0.0887	-0.9961	0.9961	0.0887
rBi	**0.647**	**-48.703**	**48.708**	**-89.2**	**0.0133**	**-0.9999**	**0.9999**	**0.0133**
rO4Bi	13.590	0.733	13.610	3.1	0.9985	0.0538	-0.0538	0.9985
rB1B2	-7.342	-24.146	25.238	-106.9	-0.2909	-0.9567	0.9567	-0.2909
rO2	**-22.750**	**-99.211**	**101.786**	**-102.9**	**-0.2235**	**-0.9747**	**0.9747**	**-0.2235**
rB102	-18.356	-60.365	63.094	-106.9	-0.2909	-0.9567	0.9567	-0.2909
rBi02	-23.397	-50.508	55.664	-114.9	-0.4203	-0.9074	0.9074	-0.4203
rB202	-11.014	-36.219	37.856	-106.9	-0.2909	-0.9567	0.9567	-0.2909
rA1	**-19.079**	**-87.138**	**89.202**	**-102.4**	**-0.2139**	**-0.9769**	**0.9769**	**-0.2139**
rO2A1	3.671	12.073	12.619	73.1	0.2909	0.9567	-0.9567	0.2909
rA2	**-26.422**	**-111.284**	**114.377**	**-103.4**	**-0.2310**	**-0.9730**	**0.9730**	**-0.2310**
rO2A2	-3.671	-12.073	12.619	-106.9	-0.2909	-0.9567	0.9567	-0.2909
rAi	-29.950	-88.848	93.760	-108.6	-0.3194	-0.9476	0.9476	-0.3194
rO2Ai	-7.200	10.363	12.619	124.8	-0.5705	0.8213	-0.8213	-0.5705
rAii	-10.190	-98.001	98.530	-95.9	-0.1034	-0.9946	0.9946	-0.1034
rO2Aii	12.561	1.210	12.619	5.5	0.9954	0.0959	-0.0959	0.9954
rB1A1	-14.685	-48.292	50.475	-106.9	-0.2909	-0.9567	0.9567	-0.2909
rBiAi	-30.597	-40.144	50.475	-127.3	-0.6062	-0.7953	0.7953	-0.6062
rBiAii	-10.837	-49.298	50.475	-102.4	-0.2147	-0.9767	0.9767	-0.2147
rB2A2	-14.685	-48.292	50.475	-106.9	-0.2909	-0.9567	0.9567	-0.2909
rO4O2	-9.807	-49.775	50.732	-101.1	-0.1933	-0.9811	0.9811	-0.1933

$\dot{\theta}_2$ =	1.047 1/s
$\ddot{\theta}_2$ =	0.000 1/s^2
ω3-1	-0.262 1/s
ω3-i	0.292 1/s
ω3-ii	0.011 1/s
ω3-2	0.262 1/s
ω4-1	0.000 1/s
ω4-i	-1.213 1/s
ω4-ii	0.959 1/s
ω4-2	0.000 1/s
α3-1	-0.848 1/s^2
α3-i	-0.783 1/s^2
α3-ii	0.027 1/s^2
α3-2	-0.509 1/s^2
α4-1	-3.392 1/s^2
α4-i	1.259 1/s^2
α4-ii	-0.069 1/s^2
α4-2	2.035 1/s^2

Kinematics					Normal (r)		Perpendicular (θ)	
	x comp	**y comp**	**mag**	**angle**	**i**	**j**	**i**	**j**
r1	9.807	49.775	50.732	78.9	0.1933	0.9811	-0.9811	0.1933
r4-1	8.549	10.590	13.610	51.1	0.6282	0.7781	-0.7781	0.6282
r4-i	13.590	0.733	13.610	3.1	0.9985	0.0538	-0.0538	0.9985
r4-2	1.207	-13.556	13.610	-84.9	0.0887	-0.9961	0.9961	0.0887
r2-1	3.671	12.073	12.619	73.1	0.2909	0.9567	-0.9567	0.2909
r2-i	-7.200	10.363	12.619	124.8	-0.5705	0.8213	-0.8213	-0.5705
r2-ii	12.561	1.210	12.619	5.5	0.9954	0.0959	-0.0959	0.9954
r2-2	-3.671	-12.073	12.619	-106.9	-0.2909	-0.9567	0.9567	-0.2909
r3-1	14.685	48.292	50.475	73.1	0.2909	0.9567	-0.9567	0.2909
r3-i	-30.597	-40.144	50.475	-127.3	-0.6062	-0.7953	0.7953	-0.6062
r3-ii	-10.837	-49.298	50.475	-102.4	-0.2147	-0.9767	0.9767	-0.2147
r3-2	14.685	48.292	50.475	73.1	0.2909	0.9567	-0.9567	0.2909
vA-1	-12.640	3.844	13.212	163.1	-0.9567	0.2909	-0.2909	-0.9567
vA-i	-10.850	-7.538	13.212	-145.2	-0.8213	-0.5705	0.5705	-0.8213
vA-ii	-1.266	13.151	13.212	95.5	-0.0959	0.9954	-0.9954	-0.0959
vA-2	12.640	-3.844	13.212	-16.9	0.9567	-0.2909	0.2909	0.9567
vB-1	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
vB-i	0.889	-16.485	16.509	-86.9	0.0538	-0.9985	0.9985	0.0538
vB-ii	-0.702	13.027	13.046	93.1	-0.0538	0.9985	-0.9985	-0.0538
vB-2	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
aA-1	-4.024	-13.234	13.833	-106.9	-0.2909	-0.9567	0.9567	-0.2909
aA-i	7.892	-11.360	13.833	-55.2	0.5705	-0.8213	0.8213	0.5705
aA-ii	-13.769	-1.326	13.833	-174.5	-0.9954	-0.0959	0.0959	-0.9954
aA-2	4.024	13.234	13.833	73.1	0.2909	0.9567	-0.9567	0.2909
aB-1	35.915	-28.994	46.158	-38.9	0.7781	-0.6282	0.6282	0.7781
aB-i	-20.920	16.026	26.353	142.5	-0.7938	0.6081	-0.6081	-0.7938
aB-ii	-12.437	-1.612	12.541	-172.6	-0.9917	-0.1285	0.1285	-0.9917
aB-2	27.586	2.455	27.695	5.1	0.9961	0.0887	-0.0887	0.9961

BONUS - Mechanism Kinematics

KINEMATIC ANALYSIS - CRITICAL POSITIONS					Normal (r)		Perpendicular (θ)	
	x-coord	y-coord.	mag	angle	i	j	i	j
O2	-12.943	-49.436	51.102	-104.7	-0.2533	-0.9674	0.9674	-0.2533
A1	4.155	-28.257	28.561	-81.6	0.1455	-0.9894	0.9894	0.1455
A2	14.237	-47.971	50.039	-73.5	0.2845	-0.9587	0.9587	0.2845
A3	-10.530	-76.548	77.269	-97.8	-0.1363	-0.9907	0.9907	-0.1363
P1	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
P2	19.997	-19.997	28.280	-45.0	0.7071	-0.7071	0.7071	0.7071
P3	0.000	-50.000	50.000	-90.0	0.0000	-1.0000	1.0000	0.0000

KINEMATIC ANALYSIS - CRITICAL POSITIONS					Normal (r)		Perpendicular (θ)	
	x-coord	y-coord.	mag	angle	i	j	i	j
O4	8.506	-66.298	66.841	-82.7	0.1273	-0.9919	0.9919	0.1273
B1	69.867	-45.265	83.248	-32.9	0.8393	-0.5437	0.5437	0.8393
B2	70.169	-86.428	111.326	-50.9	0.6303	-0.7764	0.7764	0.6303
B3	37.874	-124.134	129.783	-73.0	0.2918	-0.9565	0.9565	0.2918
P1	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
P2	19.997	-19.997	28.280	-45.0	0.7071	-0.7071	0.7071	0.7071
P3	0.000	-50.000	50.000	-90.0	0.0000	-1.0000	1.0000	0.0000

SYNTHESIZED LINKAGE KINEMATICS

Input from Drive Link	DLω4-1 => ω2-1	0.0000 1/s
	DLω4-2i => ω2-2i	-1.2130 1/s
	DLω4-2ii => ω2-2ii	0.9586 1/s
	DLω4-3 => ω2-3	0.0000 1/s
	DLα4-1 => α2-1	-3.3915 1/s^2
	DLα4-2i => α2-2i	1.2586 1/s^2
	DLα4-2ii => α2-2ii	-0.0691 1/s^2
	DLα4-3 => α2-3	2.0349 1/s^2
Angular Velocity	ω3-1	0.0000 1/s
	ω3-2i	-0.6209 1/s
	ω3-2ii	0.4907 1/s
	ω3-3	0.0000 1/s
	ω4-1	0.0000 1/s
	ω4-2i	-1.0979 1/s
	ω4-2ii	0.8676 1/s
	ω4-3	0.0000 1/s
Angular Acceleration	α3-1	-1.3142 1/s^2
	α3-2i	-0.1754 1/s^2
	α3-2ii	-0.5471 1/s^2
	α3-3	0.9531 1/s^2
	α4-1	-2.3524 1/s^2
	α4-2i	0.2077 1/s^2
	α4-2i	-0.6442 1/s^2
	α4-3	1.7381 1/s^2

		x comp	y comp	mag	angle	Normal (r) i	Normal (r) j	Perpendicular (θ) i	Perpendicular (θ) j
Displacements	r1	21.449	-16.862	27.284	-38.2	0.7862	-0.6180	0.6180	0.7862
	r4-1	61.361	21.033	64.865	18.9	0.9460	0.3243	-0.3243	0.9460
	r4-2i	61.663	-20.130	64.865	-18.1	0.9506	-0.3103	0.3103	0.9506
	r4-2ii	61.663	-20.130	64.865	-18.1	0.9506	-0.3103	0.3103	0.9506
	r4-3	29.368	-57.836	64.865	-63.1	0.4528	-0.8916	0.8916	0.4528
	r2-1	17.098	21.179	27.220	51.1	0.6282	0.7781	-0.7781	0.6282
	r2-2i	27.180	1.465	27.220	3.1	0.9985	0.0538	-0.0538	0.9985
	r2-2ii	27.180	1.465	27.220	3.1	0.9985	0.0538	-0.0538	0.9985
	r2-3	2.413	-27.112	27.220	-84.9	0.0887	-0.9961	0.9961	0.0887
	r3-1	65.712	-17.008	67.878	-14.5	0.9681	-0.2506	0.2506	0.9681
	r3-2i	55.932	-38.457	67.878	-34.5	0.8240	-0.5666	0.5666	0.8240
	r3-2ii	55.932	-38.457	67.878	-34.5	0.8240	-0.5666	0.5666	0.8240
	r3-3	48.404	-47.586	67.878	-44.5	0.7131	-0.7011	0.7011	0.7131
	rAP-1	-4.155	28.257	28.561	98.4	-0.1455	0.9894	-0.9894	-0.1455
	rAP-2i	5.760	27.974	28.561	78.4	0.2017	0.9795	-0.9795	0.2017
	rAP-2ii	5.760	27.974	28.561	78.4	0.2017	0.9795	-0.9795	0.2017
	rAP-3	10.530	26.548	28.561	68.4	0.3687	0.9295	-0.9295	0.3687
Velocities	vA-1	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
	vA-2i	1.778	-32.971	33.019	-86.9	0.0538	-0.9985	0.9985	0.0538
	vA-2ii	-1.405	26.054	26.092	93.1	-0.0538	0.9985	-0.9985	-0.0538
	vA-3	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
	vB-1	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
	vB-2i	-22.101	-67.699	71.216	-108.1	-0.3103	-0.9506	0.9506	-0.3103
	vB-2ii	17.465	53.497	56.276	71.9	0.3103	0.9506	-0.9506	0.3103
	vB-3	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
	vP-1	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
	vP-2i	19.147	-36.547	41.259	-62.4	0.4641	-0.8858	0.8858	0.4641
	vP-2ii	-15.130	28.880	32.604	117.6	-0.4641	0.8858	-0.8858	-0.4641
	vP-3	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
Accelerations	aA-1	71.830	-57.988	92.316	-38.9	0.7781	-0.6282	0.6282	0.7781
	aA-2i	-41.839	32.052	52.705	142.5	-0.7938	0.6081	-0.6081	-0.7938
	aA-2ii	-24.873	-3.224	25.082	-172.6	-0.9917	-0.1285	0.1285	-0.9917
	aA-3	55.171	4.910	55.389	5.1	0.9961	0.0887	-0.0887	0.9961
	aB-1	49.478	-144.346	152.590	-71.1	0.3243	-0.9460	0.9460	0.3243
	aB-2i	-70.146	37.071	79.339	152.1	-0.8841	0.4672	-0.4672	-0.8841
	aB-2ii	-59.381	-24.569	64.263	-157.5	-0.9240	-0.3823	0.3823	-0.9240
	aB-3	100.525	51.044	112.742	26.9	0.8916	0.4528	-0.4528	0.8916
	aP-1	108.964	-52.528	120.965	-25.7	0.9008	-0.4342	0.4342	0.9008
	aP-2i	-39.154	20.258	44.084	152.6	-0.8882	0.4595	-0.4595	-0.8882
	aP-2ii	-10.955	-13.110	17.084	-129.9	-0.6412	-0.7674	0.7674	-0.6412
	aP-3	29.868	14.947	33.399	26.6	0.8943	0.4475	-0.4475	0.8943