NAME: SOLUTION

PROBLEM 1 (40 pts): Below are three positions of desired coupler motion. The grounds O_2 and O_4 are to be ignored because they are not considered in this problem.

1a) Using the computer program that you developed in this course, design a four bar mechanism to give the three positions of coupler motion shown. Print your solution on a single piece of paper and attach it directly behind this sheet of paper.

THE CHOOSEN VALUES CAN BE MEASURED FROM THE GRAPHICAL SYNTHESIS

$\beta_2 = 78°$

$\beta_3 = 135°$

$\gamma_2 = 51°$

$\gamma_3 = 96°$

$\rho_{21} = \sqrt{(1.905)^2 + (2.019)^2} = 2.776$

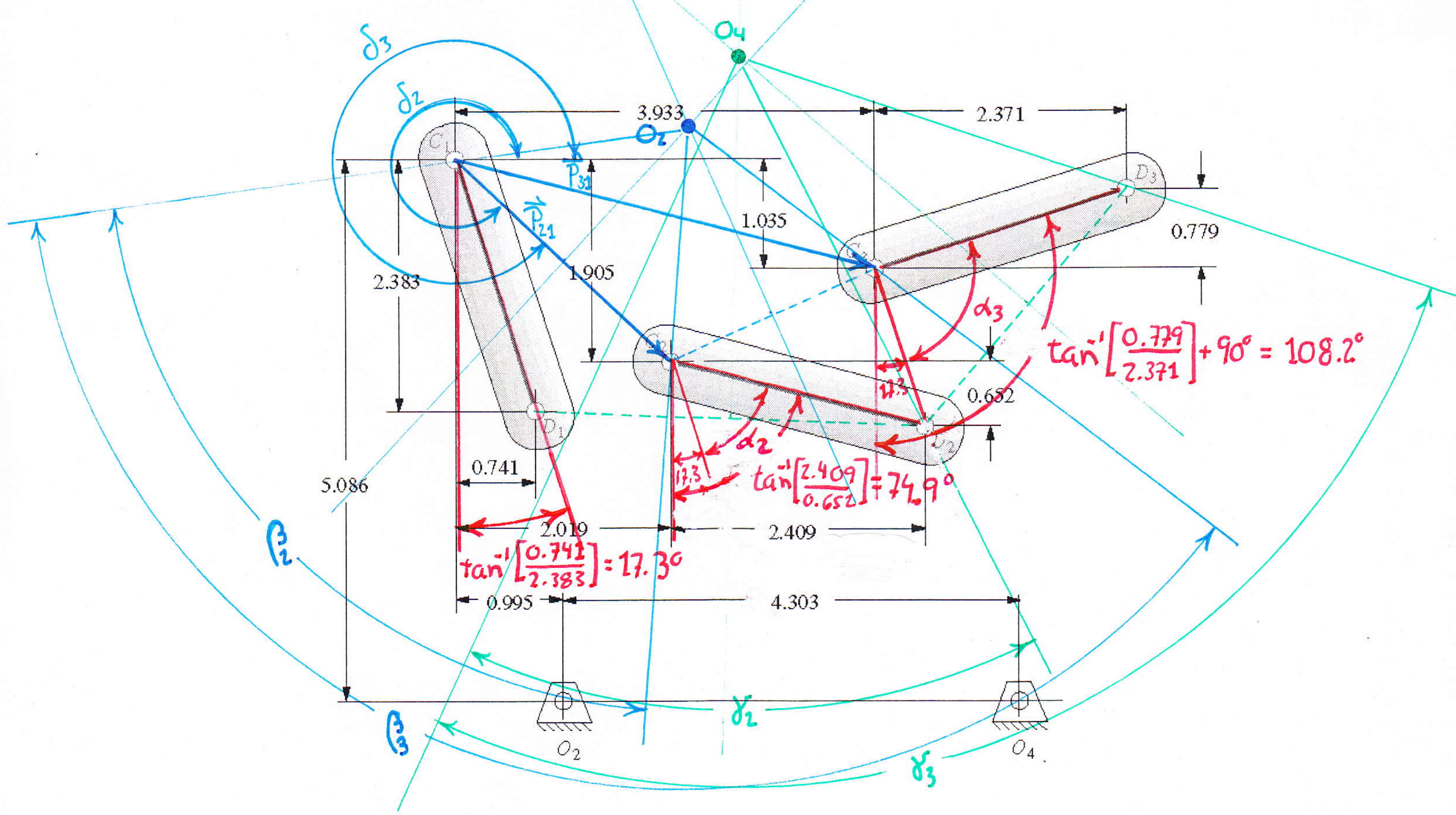
$\rho_{31} = \sqrt{(1.035)^2 + (3.933)^2} = 4.067$

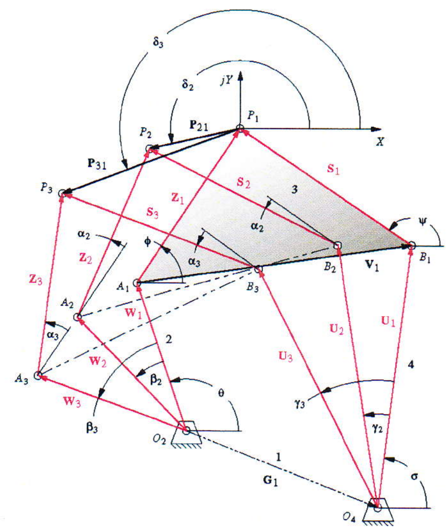
$\delta_2 = \tan^{-1}\left[\frac{-1.905}{2.019}\right] = 316.7°$

$\delta_3 = \tan^{-1}\left[-\frac{1.035}{3.933}\right] = 345.3°$

$\alpha_2 = 74.9° - 17.3° = 57.6°$

$\alpha_3 = 108.2° - 17.3° = 90.9°$





FIRST DYAD

GIVEN:		CHOSEN:		FIND:	
P12	2.78	β2	78.00	w	2.223
P13	4.07	β3	135.00	θ	-171.708
δ2	316.70			z	0.037
δ3	345.30			ϕ	71.321
α2	57.60			W1x	-2.199
α3	90.90			W1y	-0.321
				Z1x	0.012
				Z1y	0.035

	x-coord	y-coord.
O2	2.188	0.285
A1	-0.012	-0.035
A2	2.044	-1.933
A3	3.969	-1.043
P1	0.000	0.000
P2	2.020	-1.904
P3	3.934	-1.032

$$\begin{bmatrix} -0.7921 & -0.9781 & -0.4642 & -0.8443 \\ 0.9781 & -0.7921 & 0.8443 & -0.4642 \\ -1.7071 & -0.7071 & -1.0157 & -0.9999 \\ 0.7071 & -1.7071 & 0.9999 & -1.0157 \end{bmatrix} \begin{Bmatrix} W1x \\ W1y \\ Z1x \\ Z1y \end{Bmatrix} = \begin{Bmatrix} 2.0203 \\ -1.9038 \\ 3.9339 \\ -1.0320 \end{Bmatrix}$$

SECOND DYAD

GIVEN:		CHOSEN:		FIND:	
P12	2.78	γ2	51.00	u	3.343
P13	4.07	γ3	96.00	σ	-96.667
δ2	316.70			s	3.030
δ3	345.30			ψ	137.249
α2	57.60			U1x	-0.388
α3	90.90			U1y	-3.320
				S1x	-2.225
				S1y	2.057

	x-coord	y-coord.
O4	2.613	1.264
B1	2.225	-2.057
B2	4.949	-1.127
B3	5.955	1.225
P1	0.000	0.000
P2	2.020	-1.904
P3	3.934	-1.032

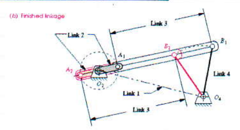
$$\begin{bmatrix} -0.3707 & -0.7771 & -0.4642 & -0.8443 \\ 0.7771 & -0.3707 & 0.8443 & -0.4642 \\ -1.1045 & -0.9945 & -1.0157 & -0.9999 \\ 0.9945 & -1.1045 & 0.9999 & -1.0157 \end{bmatrix} \begin{Bmatrix} U1x \\ U1y \\ S1x \\ S1y \end{Bmatrix} = \begin{Bmatrix} 2.0203 \\ -1.9038 \\ 3.9339 \\ -1.0320 \end{Bmatrix}$$

1b. Design a drive dyad using the computer program you developed in this course to drive the mechanism that was designed in the previous part of this problem. Print the solution out on a single piece of paper and attach it directly behind this page of the exam.

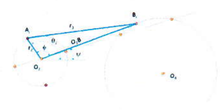
NON-QUICK-RETURN (From Three Position Results)

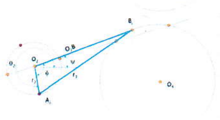
	X-pos	Y-pos	mag	angle	i	j
3P-O2 => O4	2.188	0.285	2.206	7.4	0.9916	0.1293
3P-A1	-0.012	-0.035	0.037	-108.7	-0.3203	-0.9473
3P-A2	2.044	-1.933	2.813	-43.4	0.7265	-0.6871
3P-A3	3.969	-1.043	4.104	-14.7	0.9671	-0.2542

Factors		
P	0.5	% dist up Link 4
K	-2.5	Length of Link 3+Link 2 wrt B1B2
Link 1	6.175	
Link 2	1.027	
Link 3	6.161	
Link 4	1.111	Grashof



ϕ=	72.1
ψ=	-20.2
θ2i=	51.9
θ2ii=	267.7





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

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

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

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

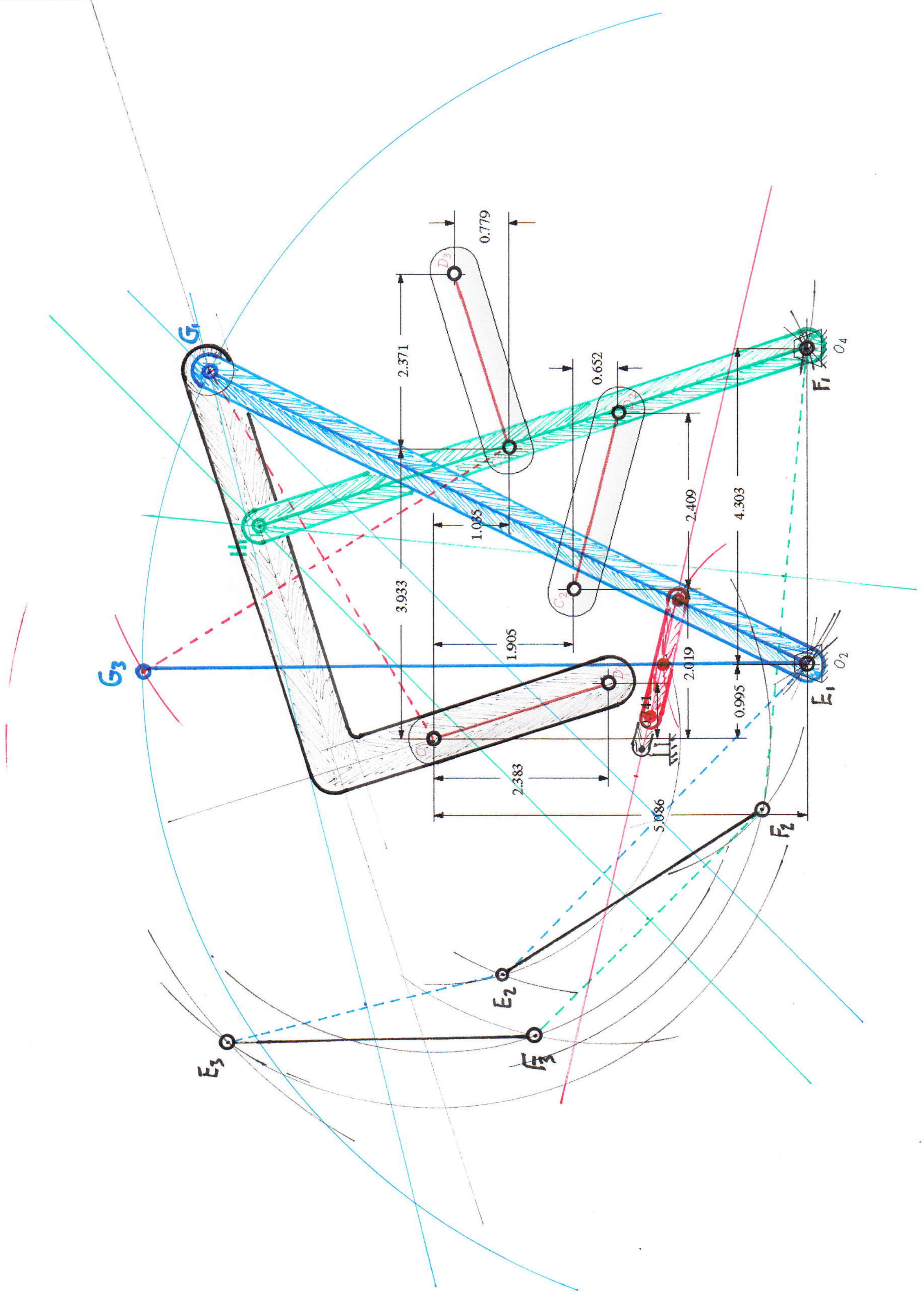
$$\theta_{2ii} = 360 + \psi - \phi$$

$\dot{\theta}_2 =$	1.047 1/s
$\ddot{\theta}_2 =$	0.000 1/s^2
ω3-1	0.175 1/s
ω3-i	0.109 1/s
ω3-ii	0.004 1/s
ω3-2	-0.175 1/s
ω4-1	0.000 1/s
ω4-i	-1.060 1/s
ω4-ii	0.964 1/s
ω4-2	0.000 1/s
α3-1	-0.368 1/s^2
α3-i	-0.398 1/s^2
α3-ii	0.015 1/s^2
α3-2	-0.515 1/s^2
α4-1	2.205 1/s^2
α4-i	0.441 1/s^2
α4-ii	-0.035 1/s^2
α4-2	-3.088 1/s^2

					Normal (r)		Perpendicular (θ)	
	x comp	y comp	mag	angle	i	j	i	j
rO4	2.188	0.285	2.206	7.4	0.9916	0.1293	-0.1293	0.9916
rP3O2-A1	-2.199	-0.321	2.223	-171.7	-0.9895	-0.1442	0.1442	-0.9895
rP3O2-A2	-0.144	-2.218	2.223	-93.7	-0.0647	-0.9979	0.9979	-0.0647
rP3O2-A3	1.782	-1.329	2.223	-36.7	0.8017	-0.5977	0.5977	0.8017
rB1	1.088	0.125	1.095	6.6	0.9935	0.1141	-0.1141	0.9935
rO4B1	-1.100	-0.160	1.111	-171.7	-0.9895	-0.1442	0.1442	-0.9895
rB2	3.078	-0.379	3.102	-7.0	0.9925	-0.1222	0.1222	0.9925
rO4B2	0.891	-0.664	1.111	-36.7	0.8017	-0.5977	0.5977	0.8017
rBi	2.116	-0.824	2.270	-21.3	0.9318	-0.3629	0.3629	0.9318
rO4Bi	-0.072	-1.109	1.111	-93.7	-0.0647	-0.9979	0.9979	-0.0647
rB1B2	1.991	-0.504	2.054	-14.2	0.9694	-0.2455	0.2455	0.9694
rO2	-3.889	1.385	4.128	160.4	-0.9420	0.3355	-0.3355	-0.9420
rB102	-4.977	1.260	5.134	165.8	-0.9694	0.2455	-0.2455	-0.9694
rBi02	-6.005	2.209	6.398	159.8	-0.9385	0.3452	-0.3452	-0.9385
rB202	-6.967	1.764	7.187	165.8	-0.9694	0.2455	-0.2455	-0.9694
rA1	-4.884	1.637	5.151	161.5	-0.9482	0.3178	-0.3178	-0.9482
rO2A1	-0.995	0.252	1.027	165.8	-0.9694	0.2455	-0.2455	-0.9694
rA2	-2.894	1.133	3.108	158.6	-0.9312	0.3646	-0.3646	-0.9312
rO2A2	0.995	-0.252	1.027	-14.2	0.9694	-0.2455	0.2455	0.9694
rAi	-3.256	2.193	3.925	146.0	-0.8294	0.5587	-0.5587	-0.8294
rO2Ai	0.633	0.808	1.027	51.9	0.6169	0.7871	-0.7871	0.6169
rAii	-3.930	0.359	3.947	174.8	-0.9959	0.0910	-0.0910	-0.9959
rO2Aii	-0.041	-1.026	1.027	-92.3	-0.0402	-0.9992	0.9992	-0.0402
rB1A1	-5.972	1.512	6.161	165.8	-0.9694	0.2455	-0.2455	-0.9694
rBiAi	-5.371	3.017	6.161	150.7	-0.8719	0.4897	-0.4897	-0.8719
rBiAii	-6.046	1.183	6.161	168.9	-0.9814	0.1920	-0.1920	-0.9814
rB2A2	-5.972	1.512	6.161	165.8	-0.9694	0.2455	-0.2455	-0.9694
rO4O2	-6.076	1.100	6.175	169.7	-0.9840	0.1781	-0.1781	-0.9840

Kinematics					Normal (r)		Perpendicular (θ)	
	x comp	y comp	mag	angle	i	j	i	j
r1	6.076	-1.100	6.175	-10.3	0.9840	-0.1781	0.1781	0.9840
r4-1	-1.100	-0.160	1.111	-171.7	-0.9895	-0.1442	0.1442	-0.9895
r4-i	-0.072	-1.109	1.111	-93.7	-0.0647	-0.9979	0.9979	-0.0647
r4-2	0.891	-0.664	1.111	-36.7	0.8017	-0.5977	0.5977	0.8017
r2-1	-0.995	0.252	1.027	165.8	-0.9694	0.2455	-0.2455	-0.9694
r2-i	0.633	0.808	1.027	51.9	0.6169	0.7871	-0.7871	0.6169
r2-ii	-0.041	-1.026	1.027	-92.3	-0.0402	-0.9992	0.9992	-0.0402
r2-2	0.995	-0.252	1.027	-14.2	0.9694	-0.2455	0.2455	0.9694
r3-1	5.972	-1.512	6.161	-14.2	0.9694	-0.2455	0.2455	0.9694
r3-i	-5.371	3.017	6.161	150.7	-0.8719	0.4897	-0.4897	-0.8719
r3-ii	-6.046	1.183	6.161	168.9	-0.9814	0.1920	-0.1920	-0.9814
r3-2	5.972	-1.512	6.161	-14.2	0.9694	-0.2455	0.2455	0.9694
vA-1	-0.264	-1.042	1.075	-104.2	-0.2455	-0.9694	0.9694	-0.2455
vA-i	-0.846	0.663	1.075	141.9	-0.7871	0.6169	-0.6169	-0.7871
vA-ii	1.074	-0.043	1.075	-2.3	0.9992	-0.0402	0.0402	0.9992
vA-2	0.264	1.042	1.075	75.8	0.2455	0.9694	-0.9694	0.2455
vB-1	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
vB-i	-1.176	0.076	1.178	176.3	-0.9979	0.0647	-0.0647	-0.9979
vB-ii	1.069	-0.069	1.071	-3.7	0.9979	-0.0647	0.0647	0.9979
vB-2	0.000	0.000	0.000	undefined	undefind	undefind	undefind	undefind
aA-1	1.091	-0.276	1.126	-14.2	0.9694	-0.2455	0.2455	0.9694
aA-i	-0.694	-0.886	1.126	-128.1	-0.6169	-0.7871	0.7871	-0.6169
aA-ii	0.045	1.125	1.126	87.7	0.0402	0.9992	-0.9992	0.0402
aA-2	-1.091	0.276	1.126	165.8	-0.9694	0.2455	-0.2455	-0.9694
aB-1	0.353	-2.425	2.451	-81.7	0.1442	-0.9895	0.9895	0.1442
aB-i	0.570	1.215	1.342	64.9	0.4248	0.9053	-0.9053	0.4248
aB-ii	0.027	1.033	1.033	88.5	0.0266	0.9996	-0.9996	0.0266
aB-2	-2.051	-2.751	3.431	-126.7	-0.5977	-0.8017	0.8017	-0.5977

PROBLEM 2 (30 pts): Using graphical techniques, design a four bar mechanism to give the three positions of coupler motion below using the fixed pivots O_2 and O_4. Add a drive dyad to the final mechanism.



PROBLEM 3 (25 pts): Design a Double Dwell cam to move a follower from 0 to 2.5in in 60°, dwell for 120°, fall 2.5in in 30°, and dwell for the remainder. The total cycle must take 4 seconds.

a. Calculate the required constant angular velocity of the cam.
b. Choose a suitable function for the rise and fall to minimize accelerations.
   i. Determine the equations for the position, velocity, acceleration, and jerk for each segment of the cam.
   ii. Calculate the value of the position, velocity, acceleration, and jerk at the beginning and end of each segment.
c. Draw the position, velocity, acceleration, and jerk diagrams.

a. ANGULAR VELOCITY OF THE CAM

$$\omega = \frac{2\pi \text{ rad}}{4 \text{ s}} = \frac{\pi}{2} \frac{\text{rad}}{\text{s}} = \boxed{\frac{\pi}{2} \frac{1}{s}}$$

b. CALCULATE S-V-A-J FOR EACH SEGMENT

<u>SEGMENT 1: RISE, $\beta_1 = 60° = \frac{\pi}{3}$ rad, $0 \leq \theta \leq 60°$, $0 \leq \theta_1 \leq 60°$</u>

$$S_1 = h\left[\frac{\theta_1}{\beta_1} - \frac{1}{2\pi}\cdot\sin\left(\frac{2\pi}{\beta_1}\cdot\theta_1\right)\right] = 2.5\text{in}\left[\frac{\theta_1}{\pi/3} - \frac{1}{2\pi}\cdot\sin\left(\frac{2\pi}{\pi/3}\cdot\theta_1\right)\right] = \underline{2.5\text{in}\left[\frac{3\cdot\theta_1}{\pi} - \frac{1}{2\pi}\cdot\sin(6\cdot\theta_1)\right]}$$

$$S_1(0) = 2.5\text{in}\left[\frac{3\cdot 0}{\pi} - \frac{1}{2\pi}\cdot\sin(6\cdot 0)\right] = 2.5\text{in}\,[0-0] = \underline{0\text{in}}$$

$$S_1(\pi/3) = 2.5\text{in}\left[\frac{3}{\pi}\cdot\frac{\pi}{3} - \frac{1}{2\pi}\cdot\sin\left(6\cdot\frac{\pi}{3}\right)\right] = 2.5\text{in}\,[1-0] = \underline{2.5\text{in}}$$

$$V_1 = \frac{h}{\beta_1}\left[1-\cos\left(\frac{2\pi}{\beta_1}\cdot\theta_1\right)\right] = \frac{2.5\text{in}}{\pi/3\text{ rad}}\left[1-\cos\left(\frac{2\pi}{\pi/3}\cdot\theta_1\right)\right] = \underline{\frac{7.5}{\pi}\frac{\text{in}}{\text{rad}}\left[1-\cos(6\cdot\theta_1)\right]}$$

$$V_1(0) = \frac{7.5\text{in}}{\pi\text{ rad}}\cdot\left[1-\cos(6\cdot 0)\right] = \frac{7.5\text{in}}{\pi\text{ rad}}\,[1-1] = \underline{0\frac{\text{in}}{\text{rad}}}$$

$$V_1\left(\frac{\pi}{3}\right) = \frac{7.5\text{in}}{\pi\text{ rad}}\cdot\left[1-\cos\left(6\cdot\frac{\pi}{3}\right)\right] = \frac{7.5\text{in}}{\pi\text{ rad}}\,[1-1] = \underline{0\frac{\text{in}}{\text{rad}}}$$

$$a_1 = \frac{2\pi\cdot h}{\beta_1^2}\cdot\sin\left(\frac{2\pi}{\beta_1}\cdot\theta_1\right) = \frac{2\pi\cdot 2.5\text{in}}{\pi^2/9\text{ rad}^2}\cdot\sin\left(\frac{2\pi}{\pi/3}\cdot\theta_1\right) = \underline{\frac{45}{\pi}\frac{\text{in}}{\text{rad}^2}\cdot\sin(6\cdot\theta_1)}$$

$$a_1(0) = \text{—}\ \frac{\text{in}}{\text{rad}^2}\cdot\sin(6\cdot 0) = \frac{45}{\pi}\frac{\text{in}}{\text{rad}^2}(0) = \underline{0\frac{\text{in}}{\text{rad}^2}}$$

$$a_1\left(\frac{\pi}{3}\right) = \frac{45}{\pi}\frac{\text{in}}{\text{rad}^2}\cdot\sin\left(6\cdot\frac{\pi}{3}\right) = \frac{45}{\pi}\frac{\text{in}}{\text{rad}^2}(0) = \underline{0\frac{\text{in}}{\text{rad}^2}}$$

$$J_1 = \frac{4\pi^2}{\beta_1^3}h\cdot\cos\left(\frac{2\pi}{\beta_1}\cdot\theta_1\right) = \frac{4\pi^2}{\pi^3/27}\cdot 2.5\text{in/rad}\cdot\cos\left(\frac{2\pi}{\pi/3}\cdot\theta_1\right) = \underline{\frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}\cdot\cos(6\cdot\theta_1)}$$

$$j_1(0) = \frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}\cdot\cos(6\cdot 0) = \frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}(1) = \underline{\frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}}$$

$$j_1\left(\frac{\pi}{3}\right) = \frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}\cdot\cos\left(6\cdot\frac{\pi}{3}\right) = \frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}(1) = \underline{\frac{270}{\pi}\frac{\text{in}}{\text{rad}^3}}$$

SEGMENT 2: DWELL, $\beta_2 = 2\pi/3 = 120°$, $60° \le \theta \le 180°$, $0 \le \theta_2 \le 120°$

$S_2 = 2.5 in$
$v_2 = 0\ in/rad$
$a_2 = 0\ in/rad$
$j_2 = 0\ in/rad^3$

SEGMENT 3: FALL, $\beta_3 = \pi/6 = 30°$, $180° \le \theta \le 210°$, $0 \le \theta_3 \le 30°$

$$S_3 = h\left[1 - \theta_3/\beta_3 + \tfrac{1}{2\pi}\cdot\sin\left(\tfrac{2\pi}{\beta_3}\right)\right] = 2.5 in\left[1 - \tfrac{\theta_3}{\pi/6} + \tfrac{1}{2\pi}\cdot\sin\left(\tfrac{2\pi}{\pi/6}\cdot\theta_3\right) = \underline{2.5 in\left[1 - \tfrac{6}{\pi}\cdot\theta_3 + \tfrac{1}{2\pi}\cdot\sin(12\cdot\theta_3)\right]}$$

$$S_3(0) = 2.5 in\left[1 - \tfrac{6}{\pi}\cdot 0 + \tfrac{1}{2\pi}\cdot\sin(12\cdot 0)\right] = 2.5 in\,[1 - 0 + 0] = \underline{2.5 in}$$

$$S_3\left(\tfrac{\pi}{6}\right) = 2.5 in\left[1 - \tfrac{6}{\pi}\cdot\tfrac{\pi}{6} + \tfrac{1}{2\pi}\cdot\sin\left(12\cdot\tfrac{\pi}{6}\right)\right) = 2.5 in[1 - 1 + 0] = \underline{0 in}$$

$$v_3 = \frac{h}{\beta_3}\left[\cos\left(\tfrac{2\pi}{\beta_3}\cdot\theta_3\right) - 1\right] = \frac{2.5}{\pi/6}\frac{in}{rad}\left[\cos\left(\tfrac{2\pi}{\pi/6}\cdot\theta_3\right) - 1\right] = \underline{\frac{15}{\pi}\frac{in}{rad}\left[\cos(12\cdot\theta_3) - 1\right]}$$

$$v_3(0) = \frac{15}{\pi}\frac{in}{rad}\left[\cos(12\cdot 0) - 1\right] = \frac{15}{\pi}\frac{in}{rad}[1-1] = \underline{0\frac{in}{rad}}$$

$$v_3\left(\tfrac{\pi}{6}\right) = \frac{15}{\pi}\frac{in}{rad}\left[\cos\left(12\cdot\tfrac{\pi}{6}\right) - 1\right] = \frac{15}{\pi}\frac{in}{rad}[1-1] = \underline{0\frac{in}{rad}}$$

$$a_3 = -\frac{2\pi}{\beta_3^2}\cdot h\cdot\sin\left(\tfrac{2\pi}{\beta_3}\theta_3\right) = -\frac{2\pi}{\pi^2/36}\cdot 2.5\frac{in}{rad^2}\cdot\sin\left(\tfrac{2\pi}{\pi/6}\cdot\theta_3\right) = \underline{-\frac{180}{\pi^2}\frac{in}{rad^2}\cdot\sin(12\cdot\theta_3)}$$

$$a_3(0) = -\frac{180}{\pi^2}\frac{in}{rad^2}\cdot\sin(12\cdot 0) = \underline{0\frac{in}{rad^2}}$$

$$a_3\left(\tfrac{\pi}{6}\right) = -\frac{180}{\pi^2}\frac{in}{rad^2}\cdot\sin\left(12\cdot\tfrac{\pi}{6}\right) = \underline{0\frac{in}{rad^2}}$$

$$j_3 = -\frac{4\pi^2}{\beta_3^3}\cdot h\cdot\cos\left(\tfrac{2\pi}{\beta_3}\cdot\theta_3\right) = -\frac{4\cdot\pi^2}{\pi^3/216}\cdot 2.5\frac{in}{rad^3}\cdot\cos\left(\tfrac{2\pi}{\pi/6}\cdot\theta_3\right) = \underline{-\frac{2160}{\pi}\frac{in}{rad^3}\cdot\cos(12\cdot\theta_3)}$$

$$j(0) = -\frac{2160}{\pi}\frac{in}{rad^3}\cdot\cos(12\cdot 0) = \underline{-\frac{2160}{\pi}\frac{in}{rad^3}}$$

$$j\left(\tfrac{\pi}{6}\right) = -\frac{2160}{\pi}\frac{in}{rad^3}\cdot\cos\left(12\cdot\tfrac{\pi}{6}\right) = \underline{-\frac{2160}{\pi}\cdot\frac{in}{rad^3}}$$

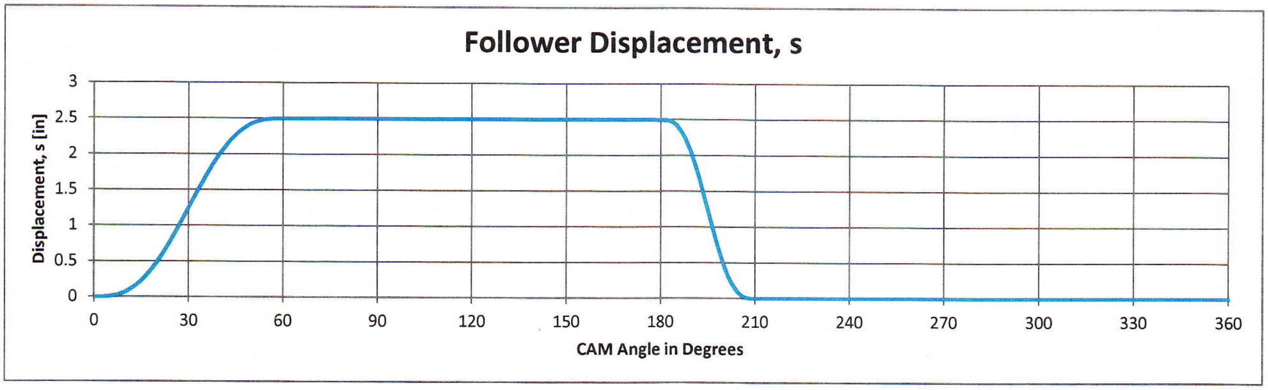
SEGMENT 4: DWELL, $\beta_4 = \frac{5}{6}\pi = 150°$, $210° \le \theta \le 360°$, $0 \le \theta_4 \le 150°$

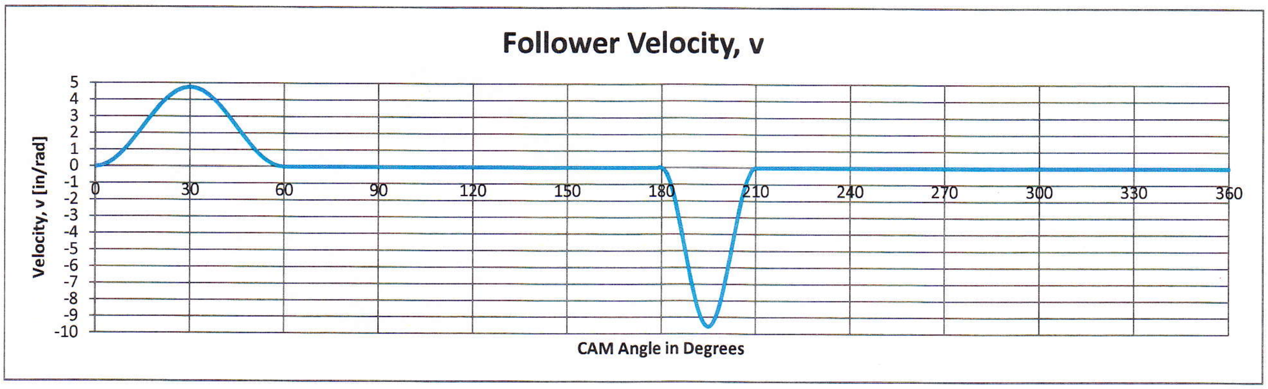
$S_4 = 0 in$

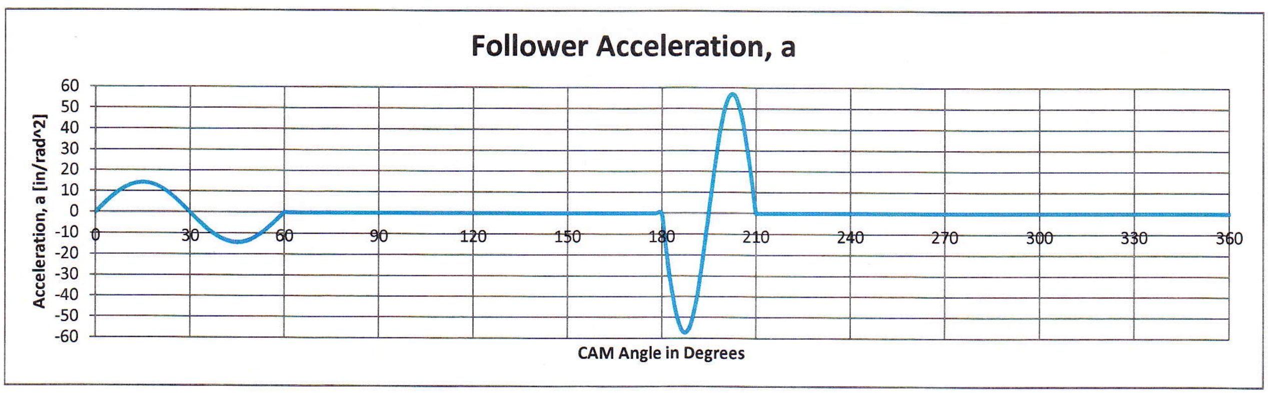
$v_4 = 0\ in/rad$

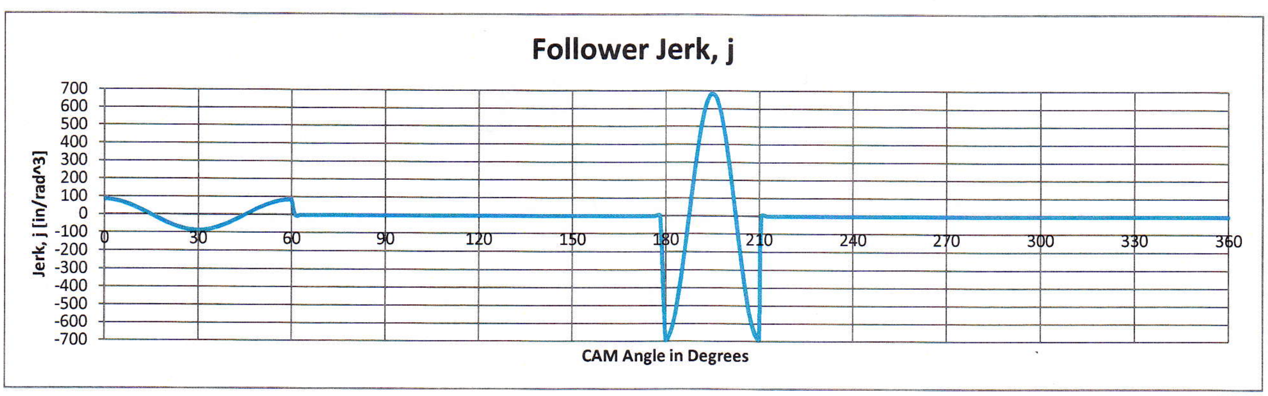
$a_4 = 0\ in/rad^2$

$j_4 = 0\ in/rad^3$


Follower Displacement, s
Displacement, s [in]
3
2.5
2
1.5
1
0.5
0
0 30 60 90 120 150 180 210 240 270 300 330 360
CAM Angle in Degrees


Follower Velocity, v
Velocity, v [in/rad]
5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10
0 30 60 90 120 150 180 210 240 270 300 330 360
CAM Angle in Degrees


Follower Acceleration, a
Acceleration, a [in/rad^2]
60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60
0 30 60 90 120 150 180 210 240 270 300 330 360
CAM Angle in Degrees


Follower Jerk, j
Jerk, j [in/rad^3]
700 600 500 400 300 200 100 0 -100 -200 -300 -400 -500 -600 -700
0 30 60 90 120 150 180 210 240 270 300 330 360
CAM Angle in Degrees

As a student at Union College, I am part of a community that values intellectual effort, curiosity and discovery. I understand that in order to truly claim my educational and academic achievements, I am obligated to act with academic integrity. Therefore, I affirm that I carried out the work on this exam with full academic honesty, and I rely on my fellow students to do the same.

For this exam I understand that:

1. I **must** work alone in writing out the answers to this exam.
2. I **can** use the computer program that I prepared for this course in the solution to the problems on this exam. I affirm that the computer program used was written my me and not copied from any other student, person, or resource.
3. I **cannot** copy solutions to these problems from any person or resource.
4. I **cannot** use any electronic resources to assist me in the solution to the questions on this exam.
5. I **cannot** discuss any part of this exam or discuss what was covered on this exam with anyone else, post it in any electronic form, or communicate in any way that would provide assistance to anyone as to what is being covered on the exam.

Signature: ______________________________

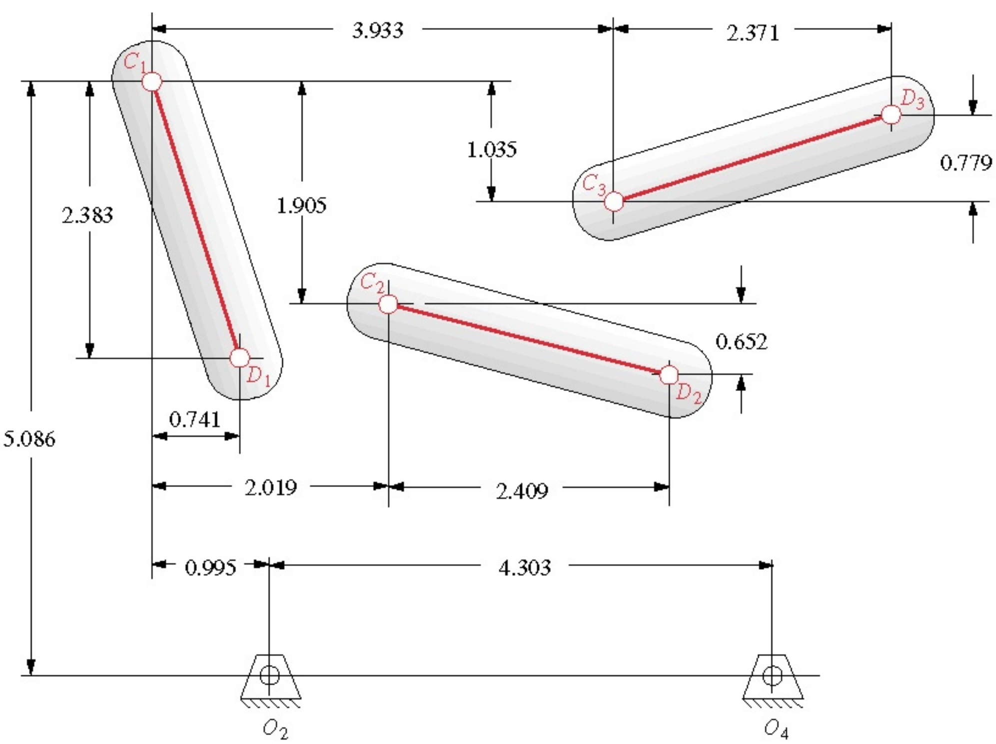
Print Name: ______________________________

Exam Date: ______________________________

NAME: ______________________

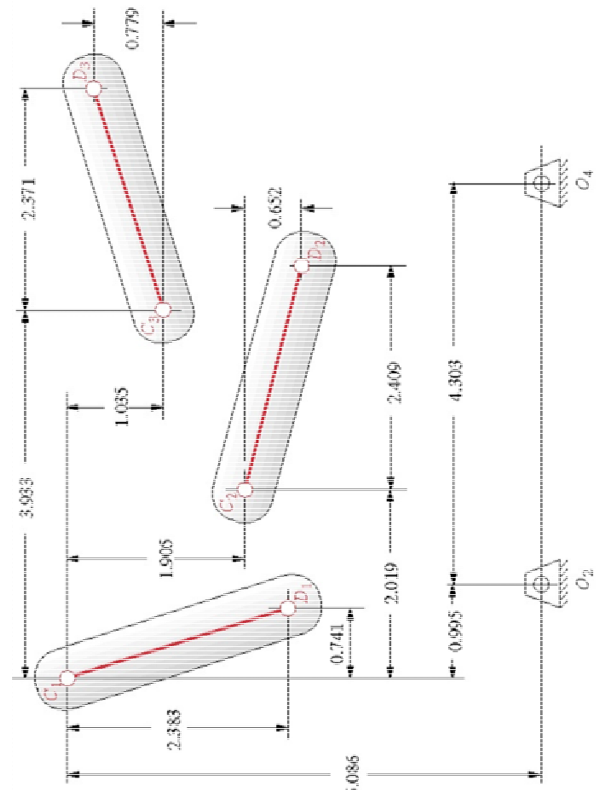
PROBLEM 1 (40 pts): Below are three positions of desired coupler motion. The grounds O_2 and O_4 are to be ignored because they are not considered in this problem.

1a) Using the computer program that you developed in this course, design a four bar mechanism to give the three positions of coupler motion shown. Print your solution on a single piece of paper and attach it directly behind this sheet of paper.



1b. Design a drive dyad using the computer program you developed in this course to drive the mechanism that was designed in the previous part of this problem. Print the solution out on a single piece of paper and attach it directly behind this page of the exam.

PROBLEM 2 (30 pts): Using graphical techniques, design a four bar mechanism to give the three positions of coupler motion below using the fixed pivots O_2 and O_4. Add a drive dyad to the final mechanism.



PROBLEM 3 (25 pts): Design a Double Dwell cam to move a follower from 0 to 2.5in in 60°, dwell for 120°, fall 2.5in in 30°, and dwell for the remainder. The total cycle must take 4 seconds.

a. Calculate the required constant angular velocity of the cam.
b. Choose a suitable function for the rise and fall to minimize accelerations.
   i. Determine the equations for the position, velocity, acceleration, and jerk for each segment of the cam.
   ii. Calculate the value of the position, velocity, acceleration, and jerk at the beginning and end of each segment.
c. Draw the position, velocity, acceleration, and jerk diagrams. (If you have prepared an excel program to print these out, you may use the program to prepare the graphs.)