NAME: Solution

Problem 1: Design a fourbar linkage to carry the bolt in the figure from position 1 to position 2 to position 3 without regard to the fixed pivots shown.

The bolt is fed into the gripper in the z directing (into the paper). The gripper grabs the bolt, and our linkage moves it to position 3 to be inserted into the hole. A second degree of freedom within the gripper assembly (not shown) pushes the bolt into the hole.

Extend the gripper assembly as necessary to include the moving pivots. The fixed pivots should be on the base.

$p_{21}=[(13mm)^2+(99mm)^2]^{1/2}$

$= \mathbf{99.85\ mm}$

$p_{31}=[(111.3mm)^2+(151.8mm)^2]^{1/2}$

$= \mathbf{188.23\ mm}$

$\delta_{21}=\tan^{-1}[13mm/99mm]$

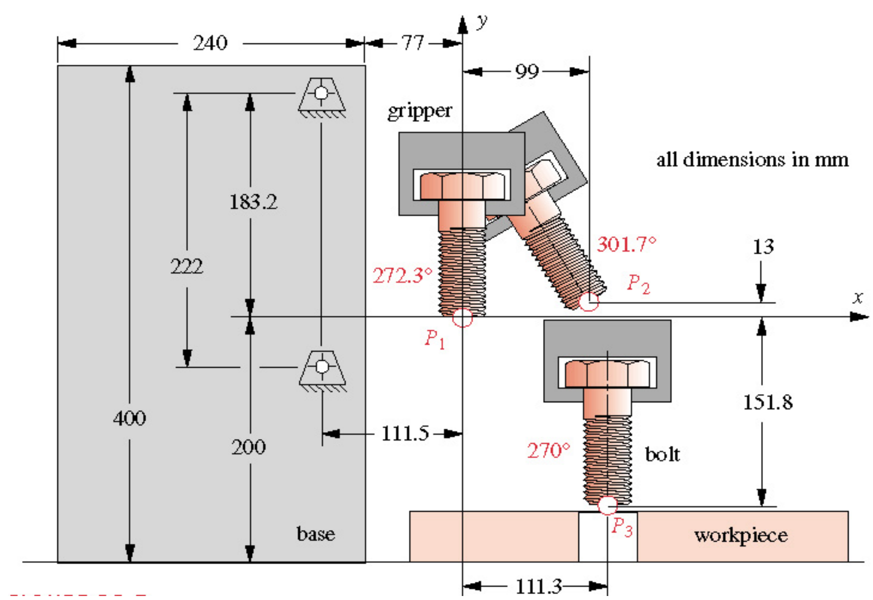
$= \mathbf{7.48°}$

$\delta_{31}=\tan^{-1}[151.8mm/111.3mm]$

$= \mathbf{306.2°}$

$\alpha_2=\theta_2-\theta_1=301.7°-272.3°= \mathbf{29.4°}$

$\alpha_3=\theta_3-\theta_1=270°-272.3°= \mathbf{-2.3°}$



1a. (10pts) Find the location of the ground and moving pivots using analytical methods. Use β_2=70°, β_3=140°, γ_2=-5°, and γ_3=-49°. Print out your computer solution and attach it to the back of this sheet. Summarize your results below.

THREE POSITION ANALYTICAL MOTION SYNTHESIS

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

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

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

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

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

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

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

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

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

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

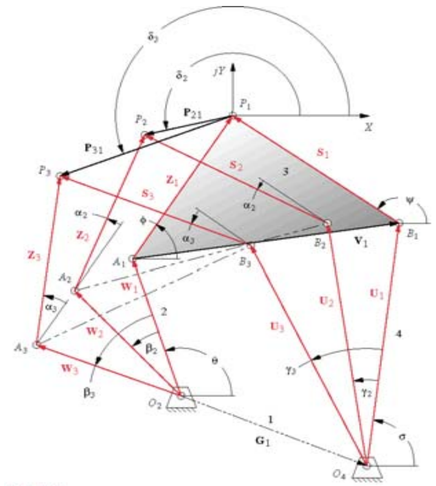


FIGURE 5-4
Three-position analytical synthesis

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

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

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

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

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

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

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

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

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

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

FIRST DYAD

GIVEN:		CHOSEN:		FIND:	
P12	99.85	β2	70.00	w	100.03
P13	188.23	β3	140.00	θ	149.94
δ2	7.48			z	306.21
δ3	306.20			ϕ	-49.69
α2	29.40			W1x	-86.58
α3	-2.30			W1y	50.10
				Z1x	198.11
				Z1y	-233.50

	x-coord	y-coord.
O2	-111.53	183.40
A1	-198.11	233.50
A2	-188.217	119.1738
A3	-77.4055	89.3654
P1	0.00	0.00
P2	99.00	13.00
P3	111.17	-151.89

$$\begin{bmatrix} -0.6580 & -0.9397 & -0.1288 & -0.4909 \\ 0.9397 & -0.6580 & 0.4909 & -0.1288 \\ -1.7660 & -0.6428 & -0.0008 & 0.0401 \\ 0.6428 & -1.7660 & -0.0401 & -0.0008 \end{bmatrix} \begin{Bmatrix} W1x \\ W1y \\ Z1x \\ Z1y \end{Bmatrix} = \begin{Bmatrix} 99.0003 \\ 12.9985 \\ 111.1697 \\ -151.8941 \end{Bmatrix}$$

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

SECOND DYAD

GIVEN:		CHOSEN:		FIND:	
P12	99.85	γ2	-5.00	u	231.81
P13	188.23	γ3	-49.00	σ	62.31
δ2	7.48			s	166.99
δ3	306.20			ψ	-88.84
α2	29.40			U1x	107.71
α3	-2.30			U1y	205.27
				S1x	3.39
				S1y	-166.95

	x-coord	y-coord.
O4	-111.11	-38.32
B1	-3.39	166.95
B2	14.09	156.78
B3	114.48	15.06
P1	0.00	0.00
P2	99.00	13.00
P3	111.17	-151.89

$$\begin{bmatrix} -0.0038 & 0.0872 & -0.1288 & -0.4909 \\ -0.0872 & -0.0038 & 0.4909 & -0.1288 \\ -0.3439 & 0.7547 & -0.0008 & 0.0401 \\ -0.7547 & -0.3439 & -0.0401 & -0.0008 \end{bmatrix} \begin{Bmatrix} U1x \\ U1y \\ S1x \\ S1y \end{Bmatrix} = \begin{Bmatrix} 99.0003 \\ 12.9985 \\ 111.1697 \\ -151.8941 \end{Bmatrix}$$

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

1b. (10pts) Using analytical methods design a linkage attached to dyad W that will drive this mechanism to place 10 bolts in one minute. Be sure to indicate the RPM's required of the motor. Print out your computer solution and attach it to the back of this sheet. Summarize your results below. (**Bonus 5pts**: solve with a quick return ration T_R=.75)

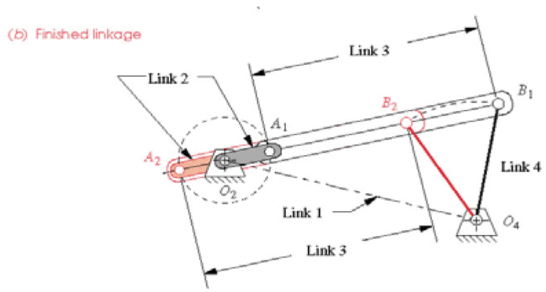
$$10\frac{Rev}{min}\cdot\frac{min}{60\ s}\cdot\frac{2\cdot\pi\ rad}{Rev}=1.047\,\frac{1}{s}$$

NON-QUICK-RETURN (From Three Position Results)

	X-pos	Y-pos	mag	angle	i	j
O4	**-111.53**	**183.40**	**214.64**	**121.3**	**-0.5196**	**0.8544**
3P-A1	**-198.11**	**233.50**	**306.21**	**130.3**	**-0.6470**	**0.7625**
3P-A2	**-188.22**	**119.17**	**222.77**	**147.7**	**-0.8449**	**0.5350**
3P-A3	**-77.41**	**89.37**	**118.23**	**130.9**	**-0.6547**	**0.7559**

Factors

P	0.5	**% dist up Link 4**
K	-2.5	**Length of Link 3+Link 2 to B1B2**
Link 1	**282.51**	
Link 2	**47.00**	
Link 3	**281.99**	
Link 4	**50.02**	**Grashof**



$\dot{\theta}_2 =$	1.0470	1/s
$\ddot{\theta}_2 =$	0.0000	1/s^2
ω3-1	0.1745	1/s
ω3-i	-0.0432	1/s
ω3-2	-0.1745	1/s
ω4-1	0.0000	1/s
ω4-i	-1.0235	1/s
ω4-2	0.0000	1/s
α3-1	-0.4183	1/s^2
α3-i	0.3777	1/s^2
α3-2	-0.5856	1/s^2
α4-1	2.5098	1/s^2
α4-i	0.3385	1/s^2
α4-2	-3.5138	1/s^2

		x comp	y comp	mag	angle	i	j	
	rO4	**-111.53**	**183.40**	**214.64**	**121.3**	**-0.5196**	**0.8544**	
	rO43P-A1	-86.58	50.10	100.03	149.9	-0.8655	0.5009	
	rO43P-A2	-76.69	-64.22	100.03	-140.1	-0.7667	-0.6420	
	rO43P-A3	34.12	-94.03	100.03	-70.1	0.3411	-0.9400	
	rB1	**-154.82**	**208.45**	**259.65**	**126.6**	**-0.5962**	**0.8028**	
	rO4B1	-43.29	25.05	50.02	149.9	-0.8655	0.5009	
	rB2	**-94.47**	**136.38**	**165.90**	**124.7**	**-0.5694**	**0.8221**	
	rO4B2	17.06	-47.02	50.02	-70.1	0.3411	-0.9400	
intermediate	**rBi**	**-149.87**	**151.29**	**212.95**	**134.7**	**-0.7038**	**0.7104**	
	rO4Bi	-38.35	-32.11	50.02	-140.1	-0.7667	-0.6420	
	rB1B2	60.35	-72.07	94.00	-50.1	0.6420	-0.7667	
	rO2	**-305.69**	**388.61**	**494.44**	**128.2**	**-0.6183**	**0.7860**	
	rB102	-150.87	180.16	234.99	129.9	-0.6420	0.7667	
	rBiO2	-155.82	237.33	283.91	123.3	-0.5488	0.8359	
	rA1	**-335.87**	**424.65**	**541.41**	**128.3**	**-0.6203**	**0.7843**	
	rO2A1	-30.17	36.03	47.00	129.9	-0.6420	0.7667	
	rA2	**-275.52**	**352.58**	**447.46**	**128.0**	**-0.6157**	**0.7880**	
	rO2A2	30.17	-36.03	47.00	-50.1	0.6420	-0.7667	
	rAi	**-263.52**	**409.36**	**486.85**	**122.8**	**-0.5413**	**0.8408**	
	rO2Ai	42.17	20.75	47.00	26.2	0.8972	0.4415	negatives b
	rB1A1	-181.05	216.20	281.99	129.9	-0.6420	0.7667	
	rBiAi	-113.65	258.08	281.99	113.8	-0.4030	0.9152	
	rB2A2	-181.05	216.20	281.99	129.9	-0.6420	0.7667	
	rO4O2	-194.16	205.22	282.51	133.4	-0.6873	0.7264	

Kinematics

	x comp	y comp	mag	angle	i	j
r1	194.16	-205.22	282.51	-46.6	0.6873	-0.7264
r4-1	-43.29	25.05	50.02	149.9	-0.8655	0.5009
r4-i	-38.35	-32.11	50.02	-140.1	-0.7667	-0.6420
r4-2	17.06	-47.02	50.02	-70.1	0.3411	-0.9400
r2-1	-30.17	36.03	47.00	129.9	-0.6420	0.7667
r2-i	42.17	20.75	47.00	26.2	0.8972	0.4415
r2-2	30.17	-36.03	47.00	-50.1	0.6420	-0.7667
r3-1	181.05	-216.20	281.99	-50.1	0.6420	-0.7667
r3-i	113.65	-258.08	281.99	-66.2	0.4030	-0.9152
r3-2	181.05	-216.20	281.99	-50.1	0.6420	-0.7667
vA-1	-37.73	-31.59	49.21	-140.1	-0.7667	-0.6420
vA-i	-21.73	44.15	49.21	116.2	-0.4415	0.8972
vA-2	37.73	31.59	49.21	39.9	0.7667	0.6420
vB-1	0.00	0.00	0.00	-120.1	-0.5009	-0.8655
vB-i	-32.87	39.25	51.19	129.9	-0.6420	0.7667
vB-2	0.00	0.00	0.00	-160.1	-0.9400	-0.3411
aA-1	33.08	-39.50	51.52	-50.1	0.6420	-0.7667
aA-i	-46.23	-22.75	51.52	-153.8	-0.8972	-0.4415
aA-2	-33.08	39.50	51.52	129.9	-0.6420	0.7667
aB-1	-62.87	-108.65	125.53	-120.1	-0.5009	-0.8655
aB-i	51.04	20.66	55.06	22.0	0.9269	0.3752
aB-2	-165.20	-59.95	175.74	-160.1	-0.9400	-0.3411

1c. (10 pts) Determine the angular velocity of each link in this mechanism and the velocity of P2 when the bolt is in position 2 using analytical methods. Attach your computer output to the back of this sheet. Summarize the results below.

KINEMATIC ANALYSIS - CRITICAL POSITIONS

	x-coord	y-coord.	mag	angle	i	j
O2	-111.53	183.40	214.64	121.3	-0.5196	0.8544
A1	-198.11	233.50	306.21	130.3	-0.6470	0.7625
A2	-188.22	119.17	222.77	147.7	-0.8449	0.5350
A3	-77.41	89.37	118.23	130.9	-0.6547	0.7559
P1	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!
P2	99.00	13.00	99.85	7.5	0.9915	0.1302
P3	111.17	-151.89	188.23	-53.8	0.5906	-0.8070

KINEMATIC ANALYSIS - CRITICAL POSITIONS

	x-coord	y-coord.	mag	angle	i	j
O4	-111.11	-38.32	117.53	-161.0	-0.9454	-0.3260
B1	-3.39	166.95	166.99	91.2	-0.0203	0.9998
B2	14.09	156.78	157.41	84.9	0.0895	0.9960
B3	114.48	15.06	115.46	7.5	0.9915	0.1304
P1	0.00	0.00	0.00	180.0	-1.0000	0.0000
P2	99.00	13.00	99.85	7.5	0.9915	0.1302
P3	111.17	-151.89	188.23	-53.8	0.5906	-0.8070

ω2-1	0.0000	1/s
ω2-2	-1.0235	1/s
ω2-3	0.0000	1/s
α2-1	2.5098	1/s^2
α2-2	0.3385	1/s^2
α2-3	-3.5138	1/s^2
ω3-1	0.0000	1/s
ω3-2	-0.2038	1/s
ω3-3	0.0000	1/s
ω4-1	0.0000	1/s
ω4-2	0.2976	1/s
ω4-3	0.0000	1/s
α3-1	1.2337	1/s^2
α3-2	-0.6974	1/s^2
α3-3	2.9970	1/s^2
α4-1	0.2126	1/s^2
α4-2	-0.6714	1/s^2
α4-3	2.0178	1/s^2

	x comp	y comp	mag	angle	i	j
r1	0.42	-221.72	221.72	-89.9	0.0019	-1.0000
r4-1	107.71	205.27	231.81	62.3	0.4647	0.8855
r4-2	125.19	195.10	231.81	57.3	0.5401	0.8416
r4-3	225.58	53.38	231.81	13.3	0.9731	0.2303
r2-1	-86.58	50.10	100.03	149.9	-0.8655	0.5009
r2-2	-76.69	-64.22	100.03	-140.1	-0.7667	-0.6420
r2-3	34.12	-94.03	100.03	-70.1	0.3411	-0.9400
r3-1	194.71	-66.55	205.77	-18.9	0.9463	-0.3234
r3-2	202.30	37.61	205.77	10.5	0.9832	0.1828
r3-3	191.88	-74.31	205.77	-21.2	0.9325	-0.3611
rAP-1	198.11	-233.50	306.21	-49.7	0.6470	-0.7625
rAP-2	287.22	-106.18	306.21	-20.3	0.9380	-0.3467
rAP-3	188.58	-241.26	306.21	-52.0	0.6158	-0.7879
vA-1	0.00	0.00	0.00	-120.1	-0.5009	-0.8655
vA-2	-65.73	78.49	102.38	129.9	-0.6420	0.7667
vA-3	0.00	0.00	0.00	-160.1	-0.9400	-0.3411
vB-1	0.00	0.00	0.00	152.3	-0.8855	0.4647
vB-2	-58.07	37.26	68.99	147.3	-0.8416	0.5401
vB-3	0.00	0.00	0.00	103.3	-0.2303	0.9731
vP-1	0.00	0.00	0.00	9.5	0.9864	0.1646
vP-2	-87.37	19.95	89.62	167.1	-0.9749	0.2226
vP-3	0.00	0.00	0.00	48.6	0.6614	0.7500
aA-1	-125.74	-217.30	251.06	-120.1	-0.5009	-0.8655
aA-2	102.08	41.32	110.12	22.0	0.9269	0.3752
aA-3	-330.41	-119.89	351.49	-160.1	-0.9400	-0.3411
aB-1	-43.65	22.90	49.29	152.3	-0.8855	0.4647
aB-2	119.90	-101.34	156.99	-40.2	0.7638	-0.6455
aB-3	-107.71	455.19	467.76	103.3	-0.2303	0.9731
aP-1	162.31	27.09	164.56	9.5	0.9864	0.1646
aP-2	16.10	-154.58	155.42	-84.1	0.1036	-0.9946
aP-3	392.66	445.28	593.67	48.6	0.6614	0.7500

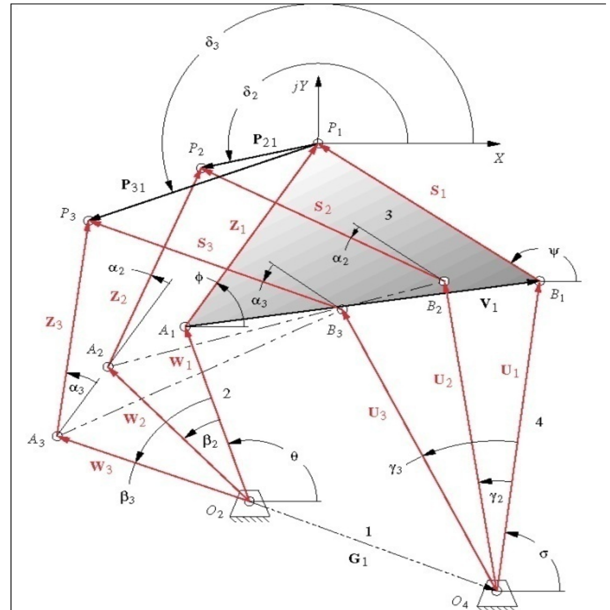
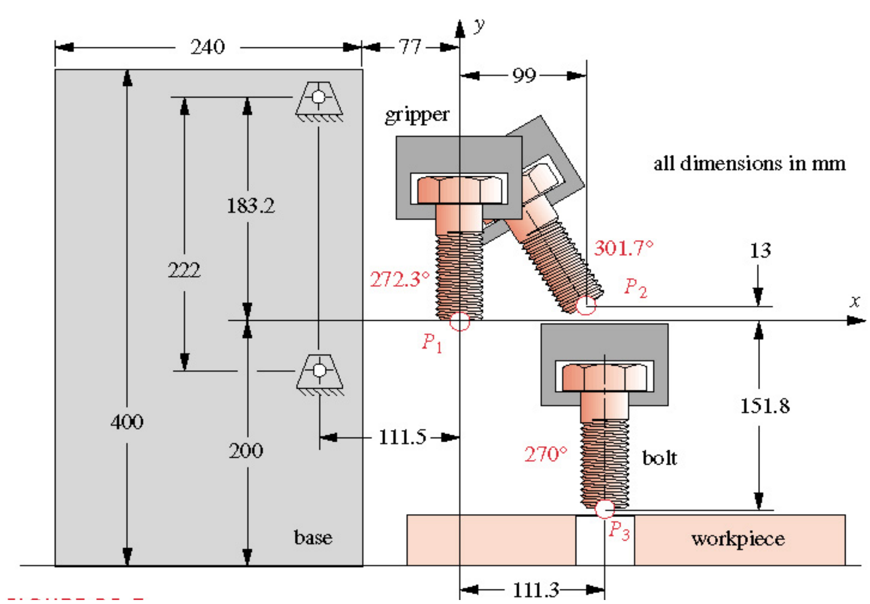


FIGURE 5-4
Three-position analytical synthesis

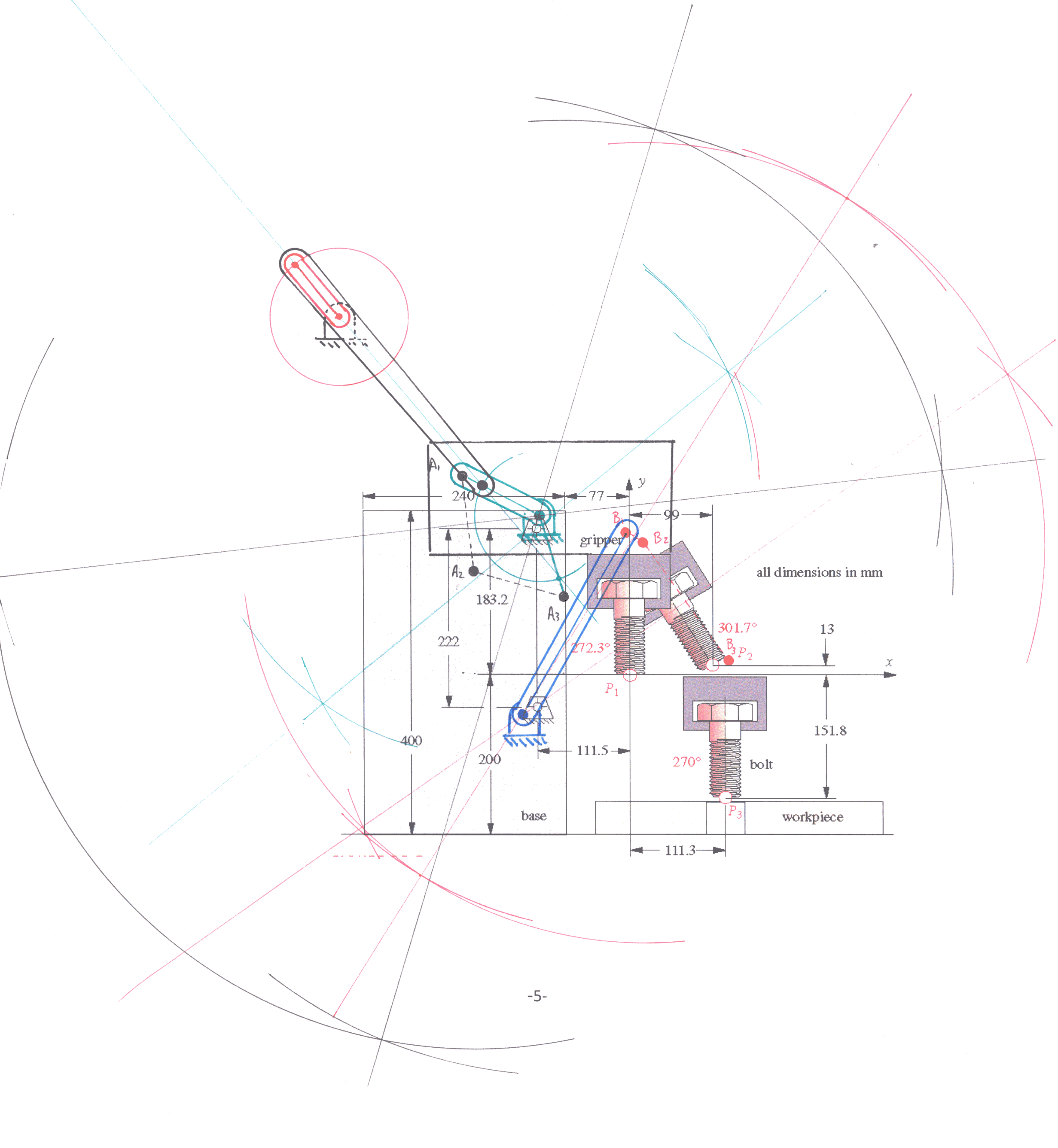
1d. (10pts) Using graphical methods design a linkage to perform the outlined task with fixed pivots on the base (not necessarily the ones shown).

1e. (10pts) Using graphical methods design the Grashof drive linkage attached to the Dyad W that will drive this mechanism to place 10 bolts in one minute.

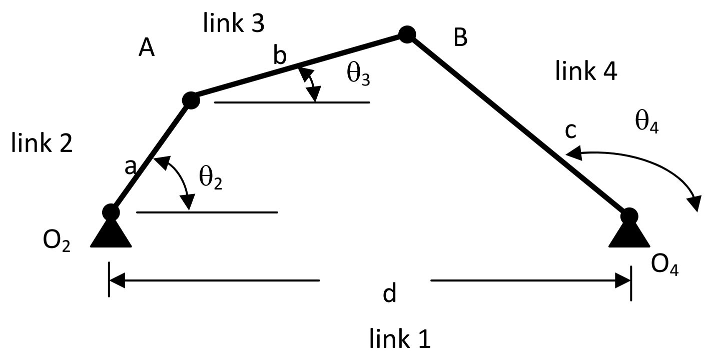


1d. (10pts) Using graphical methods design a linkage to perform the outlined task with fixed pivots on the base (not necessarily the ones shown).

1e. (10pts) Using graphical methods design the Grashof drive linkage attached to the Dyad W that will drive this mechanism to place 10 bolts in one minute.



Problem 2: (10pts) For the four bar linkage shown, in the configuration indicated, determine the angular velocities, linear velocities, angular accelerations, and linear accelerations of the links, moving pivots, and point p. Summarize your results below and attach our computer print out to the back of this sheet.



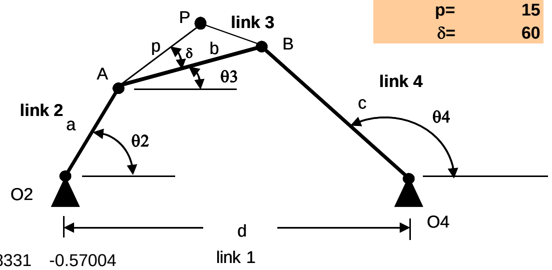
a=	3
b=	9
c=	4
d=	8
$\theta_2 =$	30
$\dot{\theta}_2 =$	15
$\ddot{\theta}_2 =$	-65

p=	15
δ=	60

4-Bar Linkage

a=	3	Link 2		
b=	9	Link 3		
c=	4	Link 4		
d=	8	Link 1		
$\theta_2 =$	30	0.523598776		
$\dot{\theta}_2 =$	15	$1/s$		
$\ddot{\theta}_2 =$	-65	$1/s^2$		
By=	**1.75**	**-3.36**		
Bx=	**11.59**	**10.17**		
$\theta_3 =$	**1.6**	**-32.7**	0.028331	-0.57004
$\theta_4 =$	**26.0**	**-57.1**	0.454191	-0.9959
$\dot{\theta}_3 =$	**8.3940E-01**	**-1.2088E+01**		
$\dot{\theta}_4 =$	**1.2943E+01**	**-2.4191E+01**		
$\ddot{\theta}_3 =$	**-1.1957E+00**	**3.5058E+02**		
$\ddot{\theta}_4 =$	**-6.2131E+01**	**4.1151E+02**		

K1=	1.1107E+01
K2=	2.7768E-01
K3=	-1.6021E+00
K4=	-5.8913E+00

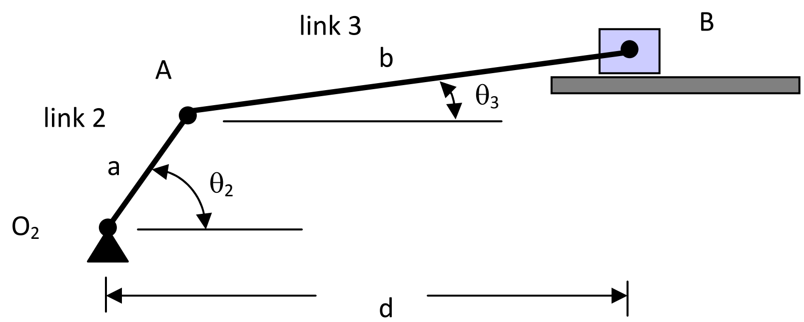


p=	**15**
δ=	**60**

	x comp	y comp	mag	angle	i	j
r04=	**8.00**	**0.00**	**8.00**	**0.0**	**1.000**	**0.000**
rA=	**2.60**	**1.50**	**3.00**	**30.0**	**0.866**	**0.500**
rBA=	9.00	0.25	9.00	1.6	1.000	0.028
rBO4=	3.59	1.75	4.00	26.0	0.899	0.439
rB=	**11.59**	**1.75**	**11.73**	**8.6**	**0.989**	**0.150**
rPA=	7.13	13.20	15.00	61.6	0.475	0.880
rP=	**9.73**	**14.70**	**17.62**	**56.5**	**0.552**	**0.834**
vA=	**-22.50**	**38.97**	**45.00**	**120.0**	**-0.500**	**0.866**
vBA=	-0.21	7.55	7.55	91.6	-0.028	1.000
vB=	**-22.71**	**46.52**	**51.77**	**116.0**	**-0.439**	**0.899**
vPA=	-11.08	5.98	12.59	151.6	-0.880	0.475
vP=	**-33.58**	**44.96**	**56.11**	**126.8**	**-0.598**	**0.801**
aA=	**-487.07**	**-506.37**	**702.60**	**-133.9**	**-0.693**	**-0.721**
aBA	-6.03	-10.94	12.49	-118.9	-0.483	-0.876
aB	**-493.10**	**-517.31**	**714.67**	**-133.6**	**-0.690**	**-0.724**
aPA=	10.76	-17.82	20.82	-58.9	0.517	-0.856
aP=	**-476.31**	**-524.20**	**708.28**	**-132.3**	**-0.672**	**-0.740**

ALT	x comp	y comp	mag	angle	i	j
rO4=	**8.00**	**0.00**	**8.00**	**0.0**	**1.000**	**0.000**
rA=	**2.60**	**1.50**	**3.00**	**30.0**	**0.866**	**0.500**
rBA=	7.58	-4.86	9.00	-32.7	0.842	-0.540
rBO4=	2.17	-3.36	4.00	-57.1	0.544	-0.839
rB=	**10.17**	**-3.36**	**10.71**	**-18.3**	**0.950**	**-0.313**
rPA=	13.32	6.89	15.00	27.3	0.888	0.459
rP=	**15.92**	**8.39**	**18.00**	**27.8**	**0.885**	**0.466**
vA=	**-22.50**	**38.97**	**45.00**	**120.0**	**-0.500**	**0.866**
vBA=	-58.71	-91.59	108.79	-122.7	-0.540	-0.842
vB=	**-81.21**	**-52.62**	**96.76**	**-147.1**	**-0.839**	**-0.544**
vPA=	83.27	-161.06	181.31	-62.7	0.459	-0.888
vP=	**60.77**	**-122.09**	**136.38**	**-63.5**	**0.446**	**-0.895**
aA=	**-487.07**	**-506.37**	**702.60**	**-133.9**	**FALSE**	**-0.721**
aBA	595.70	3365.94	3418.25	80.0	0.174	0.985
aB	**108.63**	**2859.57**	**2861.63**	**87.8**	**0.038**	**0.999**
aPA=	-4361.91	3664.77	5697.08	140.0	-0.766	0.643
aP=	**-4848.97**	**3158.39**	**5786.88**	**146.9**	**-0.838**	**-0.546**

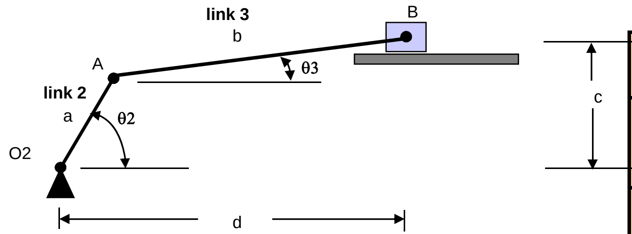
Problem 3: (10 pts) For slider crank linkage shown, in the configuration indicated, determine the angular velocities, linear velocities, angular accelerations, and linear accelerations of the links, and moving pivots. Summarize your results below and attach our computer print out to the back of this sheet.



a=	3
b=	9
c=	5
$\theta_2 =$	30
$\dot{\theta}_2 =$	100
$\ddot{\theta}_2 =$	18

Slider Crank

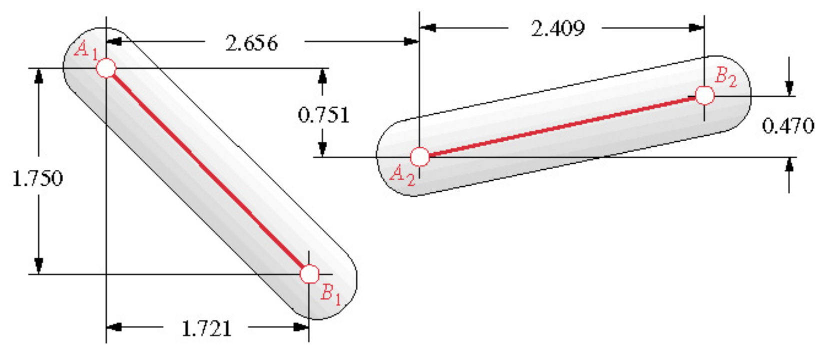
a=	3	Link 2	
b=	9	Link 3	
c=	5	Link 1	
$\theta_2 =$	30		0.523598776
$\dot{\theta}_2 =$	100	$1/s$	
$\ddot{\theta}_2 =$	18	$1/s^2$	
By=	5.00		5.00
Bx=	10.89		-5.69
$\theta_3 =$	22.9		157.1
$\dot{\theta}_3 =$	-31.33		31.33
$\ddot{\theta}_3 =$	2217.87		-2217.87
vB=	-40.33		-259.67
aB=	-41911.11		-10104.41



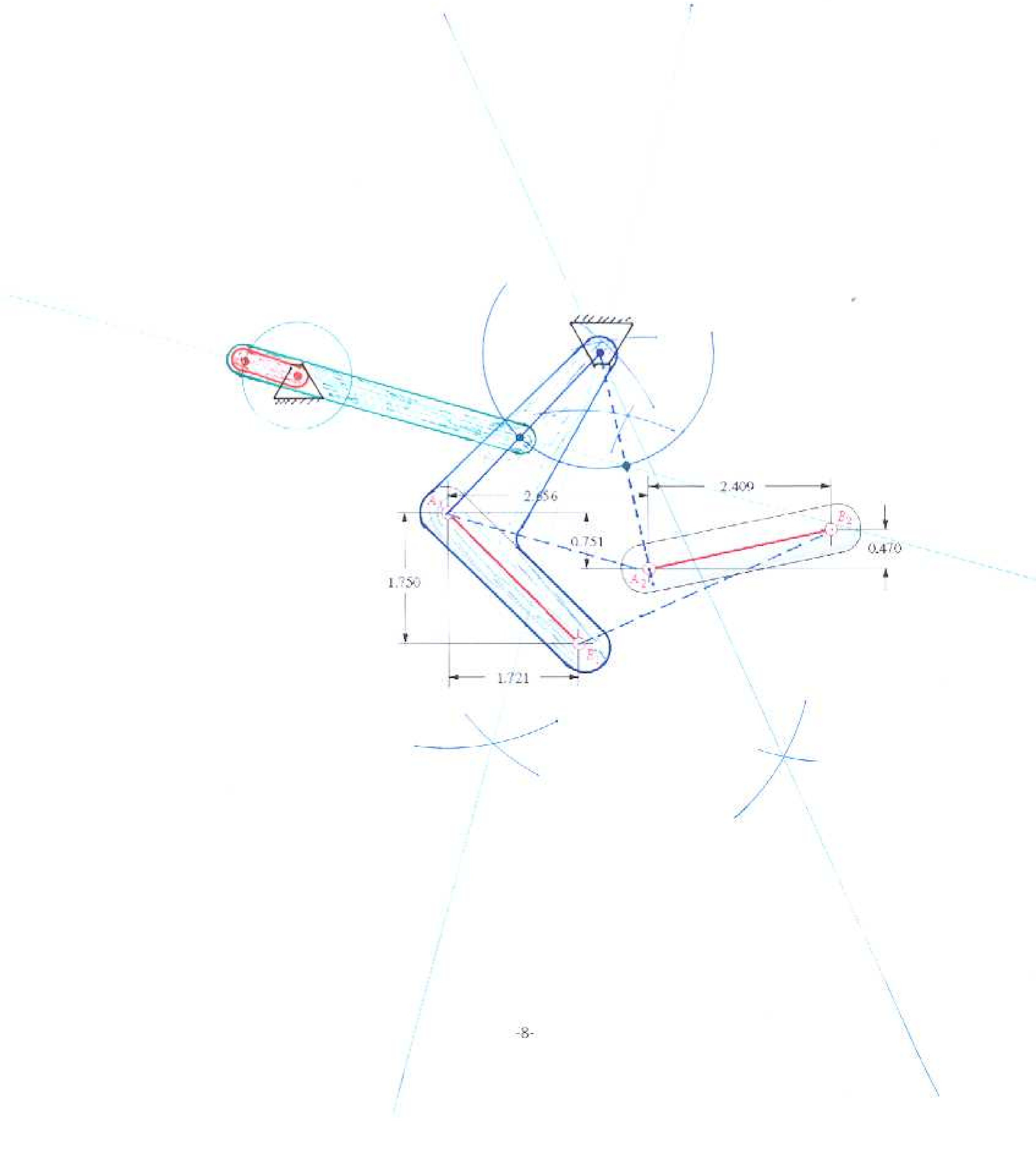
	x comp	y comp	mag	angle	i	j
rB=	10.89	5.00	11.98	24.7	0.909	0.417
rA=	2.60	1.50	3.00	30.0	0.866	0.500
rBA=	8.29	3.50	9.00	22.9	0.921	0.389
vB	-40.33	0.00	40.33	180.0	-1.000	0.000
vA	-150.00	259.81	300.00	120.0	-0.500	0.866
vBA	109.67	-259.81	282.01	-67.1	0.389	-0.921
aB	-41911.11	0.00	41911.11	180.0	-1.000	0.000
aA	-26007.76	-14953.23	30000.05	-150.1	-0.867	-0.498
aBA	-15903.35	14953.23	21829.24	136.8	-0.729	0.685

alt	x comp	y comp	mag	angle	i	j
rB=	-5.69	5.00	7.58	138.7	-0.751	0.660
rA=	2.60	1.50	3.00	30.0	0.866	0.500
rBA=	-8.29	3.50	9.00	157.1	-0.921	0.389
vB	-259.67	0.00	259.67	180.0	-1.000	0.000
vA	-150.00	259.81	300.00	120.0	-0.500	0.866
vBA	-109.67	-259.81	282.01	-112.9	-0.389	-0.921
aB	-10104.41	0.00	10104.41	180.0	-1.000	0.000
aA	-26007.76	-14953.23	30000.05	-150.1	-0.867	-0.498
aBA	15903.35	14953.23	21829.24	43.2	0.729	0.685

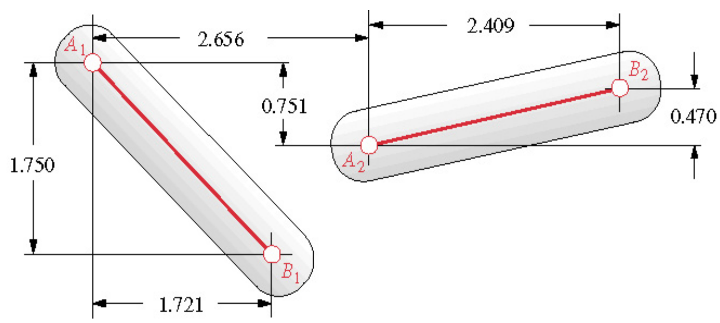
Problem 4: (15 pts) Using graphical methods design a non-quick return, Grashof, rocker linkage that will give the two positions shown.



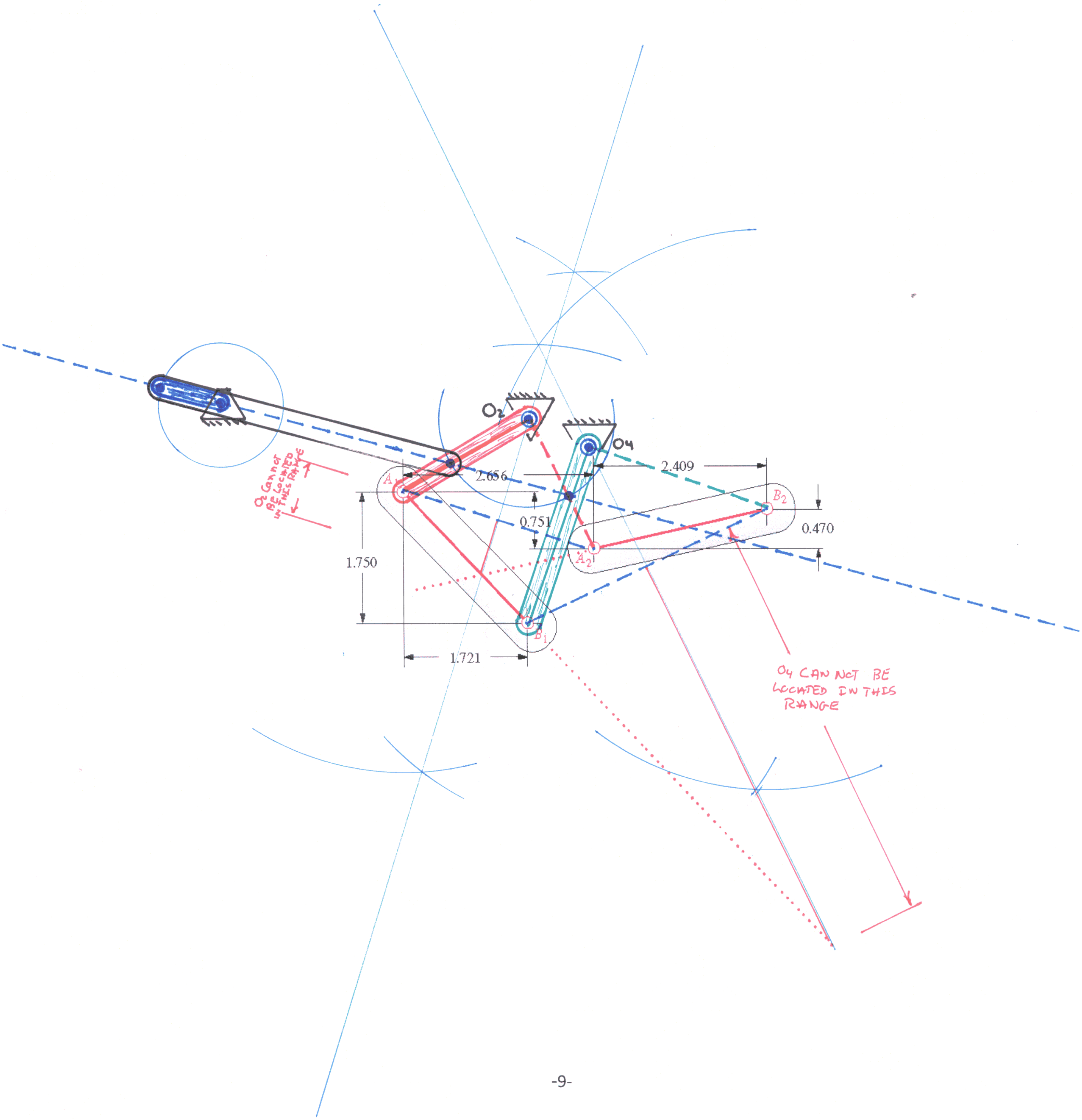
Problem 4: (15 pts) Using graphical methods design a non-quick return, Grashof, rocker linkage that will give the two positions shown.



Problem 5: (15 pts) Using graphical methods design a coupler linkage that will give the two positions shown.

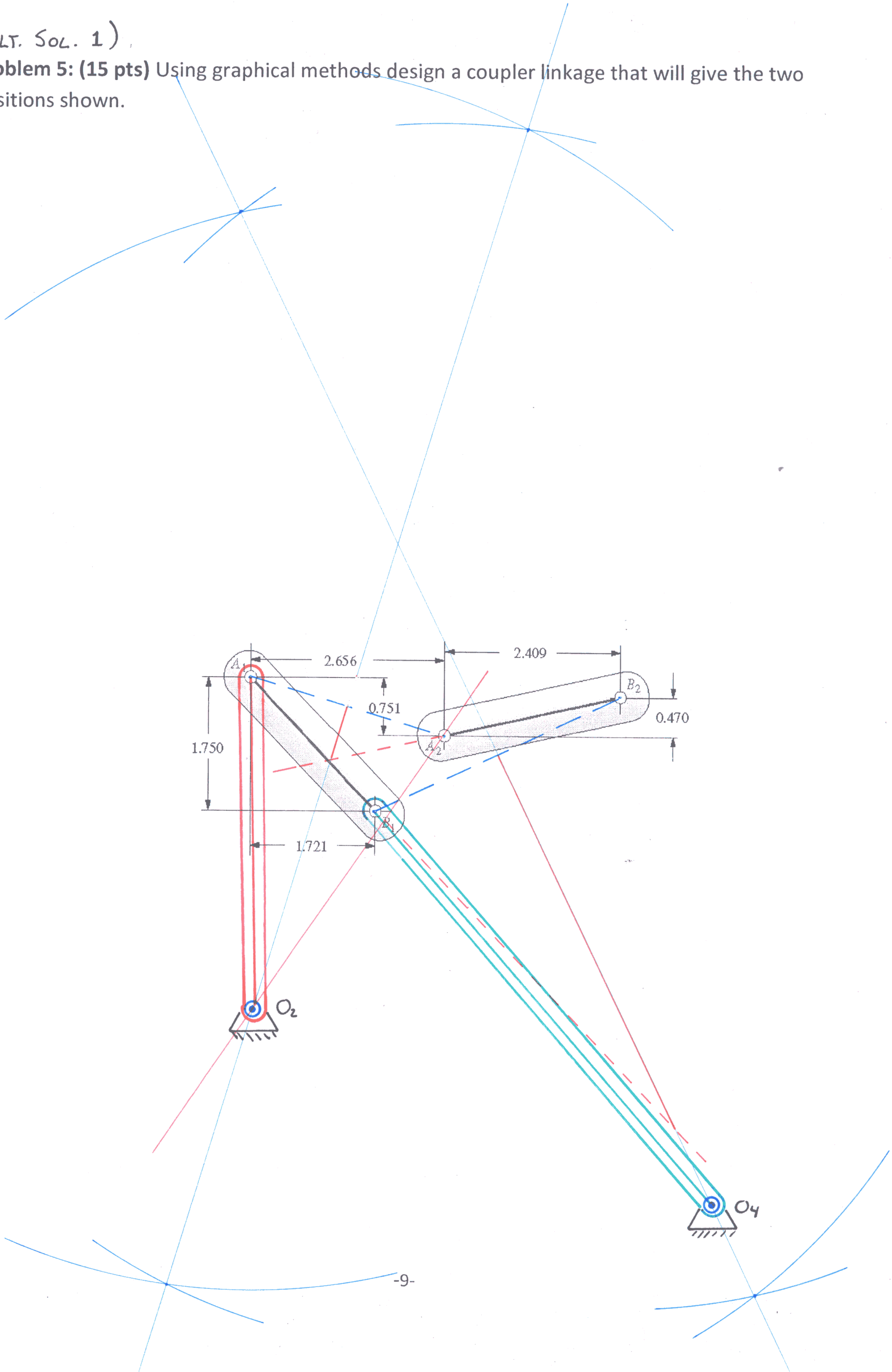


Problem 5: (15 pts) Using graphical methods design a coupler linkage that will give the two positions shown.



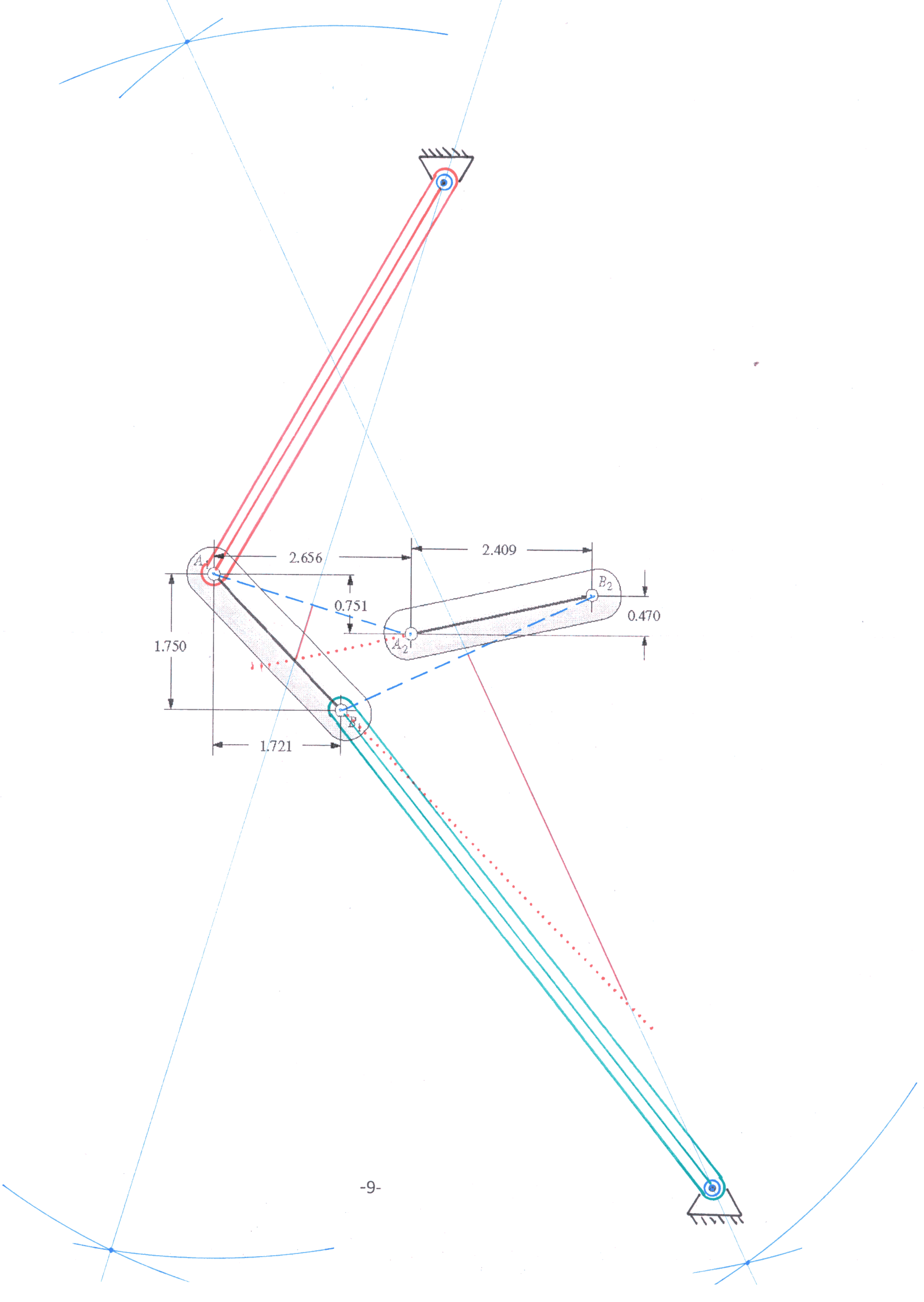
(ALT. SOL. 1)

Problem 5: (15 pts) Using graphical methods design a coupler linkage that will give the two positions shown.



(ALT. SOL. 2)

Problem 5: (15 pts) Using graphical methods design a coupler linkage that will give the two positions shown.



(ALT SOL 3)

Problem 5: (15 pts) Using graphical methods design a coupler linkage that will give the two positions shown.