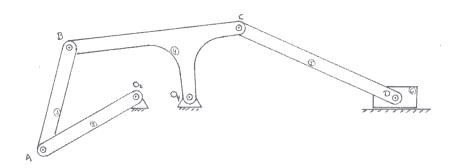
NAME: SOLUTION

PROBLEM 1: (50pts) The dimensions for the linkage shown below are as follows.

$\Theta_2 = 210^{\circ}$	BC=8m	ω_2 =2 1/s
$L_2=5m$	$O_2O_4=2.5m$	$\alpha_2 = -10 \text{ 1/s}^2$
$L_3=5m$	$O_4B=6m$	
$L_5=8m$	$O_4C=4m$	



This mechanism is a combination of a four bar linkage and a slider crank.

1a. Using analytical methods, determine

- the velocity and acceleration of points A, B, C, &D; and
- the angular velocity and acceleration of links 2, 3, 4, &5.

Yours answers need to be written in vector form. This is where you should use your computer program and then you can just print out the answers and place them directly after this page.

	dino	y comp	Hay	aligie		
r04=	2.50	0.00	2.50	0.0	1.000	0.000
rA=	4.33	-2.50	2.00	-150.0	-0.866	-0.500
rBA=	1.30	4.83	2.00	74.9	0.260	0.966
rB04=	-5.53	2.33	6.00	157.2	-0.922	0.388
-B=	-3.03	2.33	3.82	142.5	-0.793	0.609
rPA=	0.00	00.00	00.00	#DIV/OI	#DIV/0i	#DIV/0i
rP=	4.33	-2.50	9.00	-150.0	-0.866	-0.500
vA= vBA=	5.00	-8.66 2.09	10.00 8.04	- 60.0	0.500	-0.866
vB=	-2.77	-6.57	7.13	-112.8	-0.388	-0.922
vPA=	0.00	0.00	00:00	#DIV/0I	#DIV/0i	#DIV/0i
vP=	2.00	-8.66	10.00	-60.0	0.500	-0.866
aA=	-7.68	53.30	53.85	98.2	-0.143	0.990
aBA	30.24	-21.54	37.12	-35.5	0.814	-0.580
aB	22.56	31.76	38.96	54.6	0.579	0.815
aPA=	0.00	0.00	0.00	#DIV/0I	#DIV/0I	i0//i0#
100	00.7-	00.00	00.00	2000	-0.143	0.990
AL I	A COMP	ycomp	2 50	angle	4 000	0000
rA=	4.33	-2.50	5.00	-150.0	-0.866	-0.500
rBA=	4.11	-2.85	2.00	-34.7	0.822	-0.570
rB04=	-2.72	-5.35	00.9	-117.0	-0.453	-0.891
ã.	-0.22	-5.35	5.35	-92.4	-0.041	-0.999
rPA=	0.00	0.00	0.00	#DIV/oi	10//IQ#	#DIV/0i
vA=	5.00	8.66	10.00	-60.0	0.500	-0.866
vBA=	3.13	4.52	5.50	55.3	0.570	0.822
vB=	8.13	4.14	9.13	-27.0	0.891	-0.453
vPA=	0.00	0.00	0.00	#DIV/0i	#DIV/0i	#DIV/0i
vP=	2.00	-8.66	10.00	-60.0	0.500	-0.866
aA=	-7.68	53.30	53.85	98.2	FALSE	0.990
aBA	-22.78	-22.24	31.83	-135.7	-0.716	-0.699
acs aDA=	-30.45	37.07	0000	#DIV/01	#DIV/01	#DIV/0!
- Eda	7 80	E2 20	E2 0E	080	2443	2000

Iink 2	
Link 3 Link 4 Link 1 3.665191429 1,5 1,2 -5.36 -0.22 -34.7 -117.0 1.1005E+00 -6.2498E+00 -6.2498E+00	
2.5 2.5 2.10 2.33 -3.03 74.9 1.6084E+00 1.1879E+00 6.9596E+00	-2.1779E+00 -3.6603E-01 -3.0198E+00 -1.2450E+01
4-Bar Linkage 4-Bar Linkage 6. 6. 6. 6. 6. 6. 6. 6. 6. 6. 6. 6. 6. 6	X X X X X X X X X X X X X X X X X X X

II II

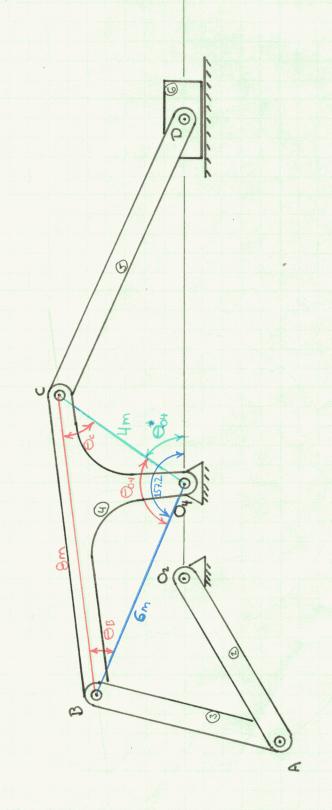
link 4

4

40

LAW OF COSINES: Q2 = 6+C2-2.6.C. COS Oa FOR THE ANGLE GOY

$$\Theta_{04} = \cos^{-1}\left(\frac{(4m)^2 + (6m)^2 - (8m)^2}{2 \cdot (4m) \cdot (6m)}\right) = \frac{104.5}{2}$$



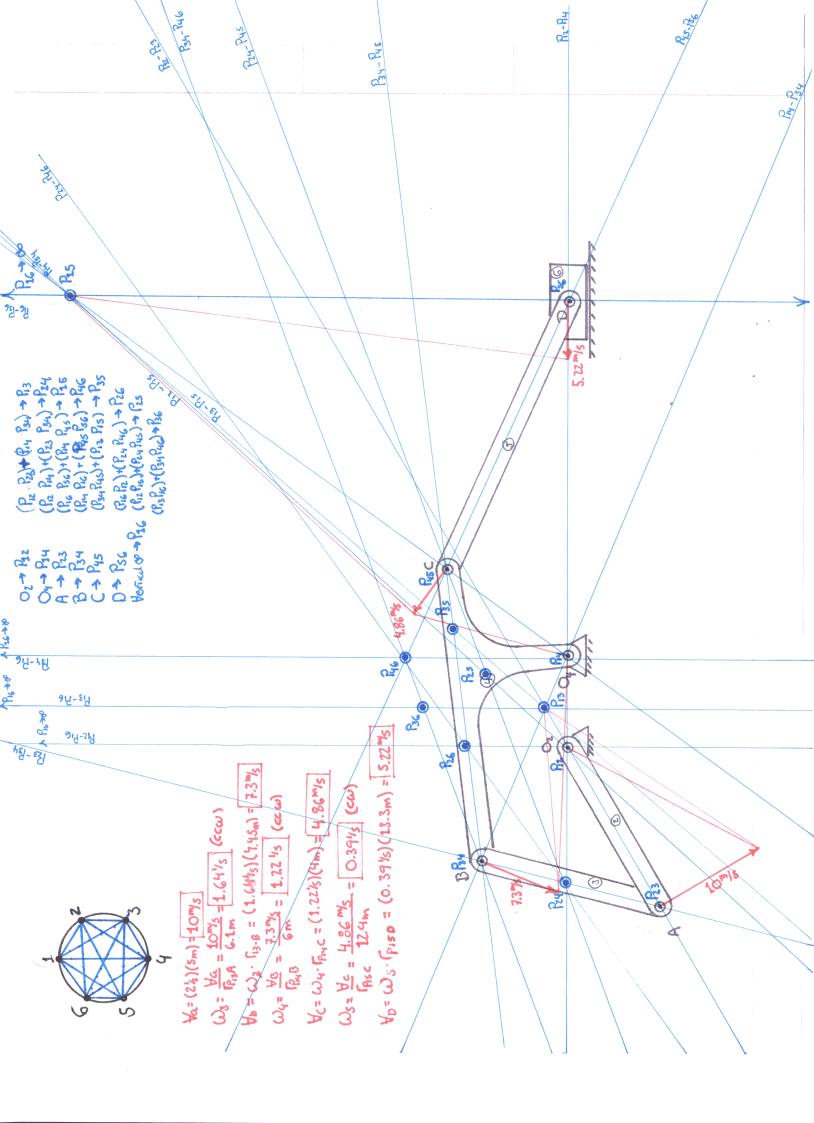
		2017	-3.78 2.88 4.75 142.7 -0.795	D 278 0.00 9.78 0.00 1.000	x comp y comp mag	
105 000 014	105 000 014	200	-3.78 2.88 4.75	1000	Ink 2	Innk 2
125 - 288 - 214 - ARR	125 - 288 - 214 - ARR	2017	-3.78 2.08 1 4.79 142.7	1 Ink 2	Ink 2	III A
-3.78 2.88 4.75 142.7	-3.78 2.88 4.75 142.7 -0.795	-3 78 2 88 47K 142 7 -0 79K		1 ink 2	Hink 2 1919788516 1000	Ink 2
-3.78 2.88 4.75 142.7	-2.53 0.00 2.53 180.0 -1.000 -3.78 2.88 4.76 142.7 -0.795	-2.53 0.00 2.53 180.0 -1.000	-2.53 0.00 2.53 180.0 -1.000	IIIIK 2	Int 2	Innk 2
VB -2.53 0.00 2.53 180.0 VA -3.78 2.88 4.75 142.7	VB -2.53 0.00 2.53 180.0 -1.000 vA -3.78 2.88 4.75 142.7 -0.795	VB -2.53 0.00 2.53 180.0 -1.000 1.00	VB -2.53 0.00 2.53 180.0 -1.000	1 ink 2	Ink 2	Ink 2
18A	VB -2.53 0.00 2.53 180.0 -156.6 -0.917 vB -3.78 2.88 4.75 142.7 -0.795	18A= -7.34 -3.18 8.00 -156.6 -0.917 VB -2.53 0.00 2.53 180.0 -1.000 VB -3.78 2.83 180.0 -1.000 VB -3.78 2.88 4.78 442.7 0.700 VB -3.78 2.88 4.78 4.78 4.78 4.78 4.78 4.78 4.78 4	rBA= -7.34 -3.18 8.00 -156.6 -0.917 VB -2.53 0.00 2.53 180.0 -1.000	I I K 2 4 5 5 5 5 5 5 5 5 5	Ink 2	Ink 2
BA	TBA= -7.34 -3.18 8.00 -15.6.6 -0.317 vB -2.5.3 0.00 2.5.3 180.0 -1.000 vA -3.78 2.88 4.75 142.7 -0.795	9.48	FIRST -7.34 -3.18 8.00 -156.6 -0.917 VB -2.53 180.0 -1.000	1 ink 2	Ilink 2	Ink 2
rA= 2.42 3.18 4.00 62.7 rBA= -7.34 -3.18 8.00 -156.6 vB -2.53 0.00 2.53 180.0 vA -3.78 2.88 4.75 142.7	18A	-2.53 -2.42 3.18 4.00 62.7 0.606 FBA= -7.34 -3.18 8.00 -156.6 -0.917 VB -2.53 0.00 2.53 180.0 -1.000 -1.000 VB -2.53 0.00 2.53 180.0 -1.000 -1	-2.53 -2.63 -2.63 -2.63 -2.65 -2.63 -180.0 -1.000 -1.000 -1.000 -1.000	Ink 2	1 Init 2	Ink 2
TB=	TB=	-2.64 -4.92 0.00 4.92 180.0 -1.000	-2.64 -4.92 0.00 4.92 180.0 -1.000 1	11111 2	191788516 a	Ink 2
rA= -4.92 0.00 4.92 rA= 2.42 3.18 4.00 rBA= -7.34 -3.18 8.00 vB -2.53 0.00 2.53 vA -3.78 2.88 4.75	rA= 4.92 0.00 4.92 180.0 1.000 rA= 2.42 3.18 4.00 52.7 0.606 rBA= 7.34 -3.18 8.00 -156.6 -0.917 vB -2.53 0.00 2.53 180.0 -1.000 vA -3.78 2.88 4.75 142.7 -0.795	2.5.4 -4.92 0.00 4.92 180.0 1.2.5.3 1.8 -4.00 52.7 180.0 1.2.5.3 1.8 1.0.0 1.5.6 1.0.0 1.0	-2.64 -4.92 0.00 4.92 180.0 -1.000 rA= 2.42 3.18 4.00 62.7 0.606 rBA= -7.34 -3.18 8.00 -156.6 -0.917 VB -2.53 180.0 -1.000	1.25 -2.88 3.14 -113.4 -0.398 a. 16.75 -19.85 25.97 -49.9 0.344 a. 15.6.6 a. 19.85 21.14 69.9 0.344	Hink 2 Ink 2 Ink 2 Ink 2 Ink 2 Ink 2 Ink 3 Ink 2 Ink 3 Ink 4 Ink 6 Ink 6 Ink 6 Ink 7 Ink 7 Ink 7 Ink 6 Ink	Ink 2
rB=	rB= 4.92 0.00 4.92 180.0 -1.000 rA= 2.42 3.18 4.00 52.7 0.606 rBA= -7.34 -3.18 8.00 -156.6 -0.917 vB -2.53 0.00 2.53 180.0 -1.000 vA -3.78 2.88 4.75 142.7 -0.795	0.39 alt x comp y comp mag angle i rB= -4.92 0.00 4.92 180.0 -1.000 rA= -2.53 0.00 2.53 180.0 -156.6 -0.917 vB -2.53 0.00 2.53 180.0 -156.6 -0.917 vB -2.53 0.00 2.53 180.0 -1.000	0.39 alt x comp y comp mag angle i 1 -2.64 -4.92 0.00 4.92 180.0 -1.000 IA 2.42 3.18 4.00 62.7 0.606 IAA 2.42 3.18 8.00 -156.6 -0.917 VB -2.53 180.0 -1.000	1 ink 2	Ilink 2	Ink 2
aft x comp y comp mag angle RB	alt x comp y comp mag angle i Comp real x comp y comp mag angle i Comp real x comp y comp mag angle i Comp real x comp y comp mag angle i Comp real x comp x comp neal x comp real x comp	156.6 156.6 10.39 att x comp y comp mag angle i 1.26 1.26 1.39 1.00 1.000	-156.6 o.39 alt x comp y comp mag angle i comp real angle i comp r	Ink 2	1919788516	Ink 2
alt x comp y comp mag angle rB= 4.92 0.00 4.92 180.0 rA= 2.42 3.18 4.00 52.7 rBA= -7.34 -3.18 8.00 -156.6 vB -2.53 0.00 2.53 180.0	alt x comp y comp mag angle i rB= 4.92 0.00 4.92 180.0 -1.000 rA= 2.42 3.18 4.00 52.7 vB -2.53 0.00 2.53 180.0 -1.500 vA -3.78 2.88 4.75 142.7 -0.795	alt x comp y comp mag angle 1 R	alt x comp y comp mag angle i 1.000 rA= 2.53 180.0 -150.6 1.000 vB -2.53 180.0 -150.6 1.000 rA= 2.53 180.0 -150.0 1.000 rA= 2.53 180.0 -150.0 1.000 rA= 2.53 180.0 -150.0 rA= 2.53 180.0 rA= 2.53	919788516 aB 0.00 24.01 0.00 52.7 0.006 52.7 0.006 52.7 0.006 52.7 0.006 52.7 0.006 52.7 0.007 52.8 5.03 180.0 1.000 52.4 0.017 5.03 180.0 1.000 52.0 0.00 52.0 1.000 52.0 0.00 52.0 1.000 52.0 0.00 52.0 1.000 52.0 1.000 52.0 1.000	Hink 2	Ink 2
ak 16.75 - 19.85 25.97 49.9 ak 7.26 - 19.85 21.14 69.9 alt x comp y comp mag angle ref x comp y comp nag angle ref x comp nag angle	aA 16.75 - 19.85 25.97 49.9 0.645 alt x comp y comp mag angle i TB= 4.92 0.00 4.92 180.0 -1.000 TA= 2.42 3.18 4.00 52.7 0.606 VB -2.53 0.00 2.53 180.0 -156.6 -0.917 VB -2.53 0.00 2.53 180.0 -156.6 -0.9	4.92 4 16.7519.85 25.97 49.9 0.645 -166.6	4.92 4 16.7519.85 25.97 49.9 0.845 -166.6	ink 2 ink 2 ink 2 ink 2 ink 2 ink 3 ink 2 ink 3	Hink 2	Ink 2
aB 24.01 0.00 24.01 0.0 aBA 16.7519.85 25.97 49.9 alt x comp y comp mag angle RB= 4.92 0.00 4.92 180.0 RA= 2.42 3.18 4.00 52.7 RBA= -7.34 -3.18 8.00 -156.6 VB -2.53 0.00 2.53 180.0	aB 24.01 0.00 24.01 0.00 1.000	ab 24.01 0.00 24.01 0.00 1.000	aB 24.01 0.00 24.01 0.00 1.000	Ink 2 Ink 3 Ink 2 Ink 3 Ink 3	Hink 2 A B B B B B B B B B B B B B B B B B B	Ink 2 A A B B B B B B B B
VBA -1.25 -2.88 3.14 -113.4 ABB 24.01 -0.00 24.01 0.0 ABA 7.26 -19.85 25.97 -49.9 ABA 7.26 -19.85 21.14 69.9 ABB -4.92 0.00 4.92 180.0 ABB -7.34 -3.18 4.00 -156.6 VB -2.53 0.00 2.53 180.0 VB -2.53 0.00 2.53 180.0 VB -2.53 0.00 2.53 180.0 VB -3.78 2.88 4.75 142.7 VB -3.78 3.88 4.75 142.7 VB -3.78 4.75 4.75 4.75 VB -3.78 4.75 4.75	ABA -1.25 -2.88 3.14 -113.4 -0.398 ABBA 16.75 - 19.85 24.01 0.0 1.000 ABBA 7.26 19.85 21.14 69.9 0.344 ABBA 2.42 3.18 4.00 62.1 1000 ABBA 2.42 3.18 8.00 -156.6 10.917 ABBA 2.88 2.88 4.75 148.0 1.796	VBA -1.25 -2.88 3.14 -113.4 -0.398 A 16.75 - 19.85 25.97 -49.9 0.645 -1.66.6 aBA 7.26 19.85 21.14 69.9 0.344 alt x comp y comp mag angle i RB= -4.92 0.00 4.92 180.0 -1.000 RA= 2.42 3.18 4.00 52.7 0.606 -2.53 180.0 -1.56 -0.917 VB -2.53 180.0 2.53 180.0 -1.000 A 278 2.88 4.75 180.0 -1.000 A 278 2.88 180.0 -1.000 A 280 180.0 -1.000 A 30 180.0 -1.56 -0.917 A 40 180.0 -1.56 -0.917 A	A 16.75 - 2.88 3.14 -113.4 -0.398 -4.92	Ink 2 1 1 1 1 1 1 1 1 1	Hink 2	Ink 2 A A A A A A A A A
aB 24.01 0.00 24.01 0.0 aA 16.7519.85 26.97 49.9 aBA 7.26 - 19.85 21.14 69.9 alt x comp y comp mag angle rB= 4.92 0.00 4.92 180.0 rA= 2.42 3.18 4.00 156.6 vB -2.53 0.00 2.53 180.0	VBA -1.25 -2.88 3.14 -113.4 -0.398 aB 24.01 0.00 24.01 0.0 1.000 aA 16.75 -19.85 25.97 -49.9 0.645 aBA 7.26 -19.85 21.14 69.9 0.344 alt x comp y comp y comp -1.000 rA= 2.4.92 0.00 4.92 180.0 -1.000 rA= 2.42 3.18 4.00 52.7 0.606 rBA= -7.34 -3.18 8.00 -156.6 -0.917 vB -2.53 0.00 2.53 180.0 -156.6 -0.917 vB -3.78 2.88 4.75 142.7 -0.795	A 1.25 - 2.88 3.14 -113.4 -0.398 4.92 - 0.00 4.93 - 0.00 4.93 - 0.00 4.94 - 0.00 4.95 - 0.0	1,000 4,92 0.00 4,92 0.00 4,92 0.00 4,92 0.00 4,92 0.00 4,92 0.00 4,92 0.39 0.34 0.39 0.39 0.39 0.39 0.39 0.39 0.39 0.39	Ink 2 A 4.00 52.7 0.000 link 2 A 5.03 180.0 -23.4 0.917	Hink 2	TR X Comp Y Comp Train
02	VA	4.75 142.7 -0.795 VBA -1.25 -2.86 3.14 -113.4 -0.398 4.92 0.00 24.01 0.0 1.000 4.92 18.0 1.000 1.000	15. 0.00 4.92 4.75 6.00 4.92 4.75 6.00 4.92 4.75 6.00 4.92 6.00 4.92 6.00 6.00 6.00 6.00 6.00 6.00 6.00 6.0	Ink 2 1.000	Ink 2	TB
VBA -1.25 -2.88 4.75 142.7 VBA -1.25 -2.88 3.14 -113.4 aB 24.01 0.00 24.01 0.0 aA 16.75 - 19.85 25.97 49.9 aBA 7.26 19.85 21.14 69.9 aR x comp y comp mag angle IB= 4.92 0.00 4.92 180.0 IA= 2.42 3.18 4.00 156.6 VB -2.53 0.00 2.53 180.0	VBA -3.78 2.88 4.75 142.7 -0.795 VBA -1.25 -2.88 3.14 -113.4 -0.398 BBA 24.01 0.00 24.01 0.0 AA 16.75 -19.85 25.97 49.9 0.645 BBA 7.26 19.85 21.14 69.9 0.344 alt x comp y comp mag angle i TB= 4.92 0.00 4.92 180.0 -1.000 TA= 2.42 3.18 4.00 52.53 180.0 -1.000 VB -2.53 0.00 2.53 180.0 -1.795 VB -2.53 180.0 -1.795 VA -3.78 2.88 4.75 142.7 -0.795	O2 VBA -3.78 2.88 4.75 142.7 -0.795 VBA -1.25 -2.88 3.14 -113.4 -0.398 aB 24.01 0.00 24.01 0.0 1.000 aA 16.75 -19.85 24.01 0.0 1.000 AB 24.01 0.00 4.92 180.0 -1.000 IB= 4.92 0.00 4.92 180.0 -1.000 IB= 4.92 0.00 4.92 180.0 -1.000 VB -2.53 0.00 2.53 180.0 -1.56.6 -0.917 VB -2.53 0.00 2.53 180.0 -1.56.6 -0.917 AB 2.2.53 0.00 2.53 180.0 -1.56.6 -0.917 AB 2.2.53 0.00 2.53 180.0 -1.56.6 -0.917	02	Ink 2 A 3.18 4.00 52.7 0.606	TR= 9.76 0.00 9.76 0.00 1.000 1.00	TR= 9.76 0.00 9.76 0.00 1.000
A	0.919788516 0.919788516 0.000 0.0100 0.0100 0.0100 0.01000 0.01000 0.01000 0.01000 0.01000 0.01000 0.01000 0.010000 0.010000 0.010000 0.010000 0.0100	0.919788516 0.010 0.919788516 0.02 0.03 0.046 0.039 0.046 0.040	0.919788516 0.00 0.919788516 0.00 0.01 0.01 0.01 0.01 0.02 0.02 0.03	A 4.00 52.7 0.806	A A B B B B B B B B B B B B B B B B B B	TR= 9.76 0.00 9.76 0.00 1.000
O.00 O.00	Uink 1 0.919788516 a 602 0.919788516 a 602 0.919788516 a 602 a 7.34 -3.18 B 0.00 -2.34 0.917 v A -3.78 -3.78 -3.78 -3.78 -3.78 -3.78 -3.78 -3.78 -3.78 -3.78 -3.78 -3.89 -4.92 -3.78	Link 1	Link 1		TB= 9.76 0.00 9.76 0.00 1.000	TR= 9.76 0.00 9.76 0.00 1.000
Init 2	Link 3 Link 2 Link 3 Link 1 Link 1	Link 3	Link 3 Link 4 Link 5 Link 7 Link 7 Link 7 Link 7 Link 1 Link 1		000 926 000 1000	X ZOMP Y COMP MISS SINGLE A ZOMP WISS SINGLE TO THE A ZOMP
Ink 3	Ink 3	Ink 3	Ink 3	x comp y comp mag		

Slider Crank

- 1b. Using graphical methods and the drawing provided on the following page,
 - locate all of the instant centers;
 - the velocity of points A, B, C, &D; and
 - the angular velocity of links 2, 3, 4, &5.

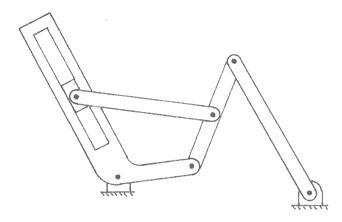
Be sure to show all your calculations.

Do these results confirm the calculations made in 1a.



PROBLEM 2: (45pts) The mechanism shown on the next page is rotating with a constant angular velocity of 2 rad/s ccw. Using instant centers to find the following:

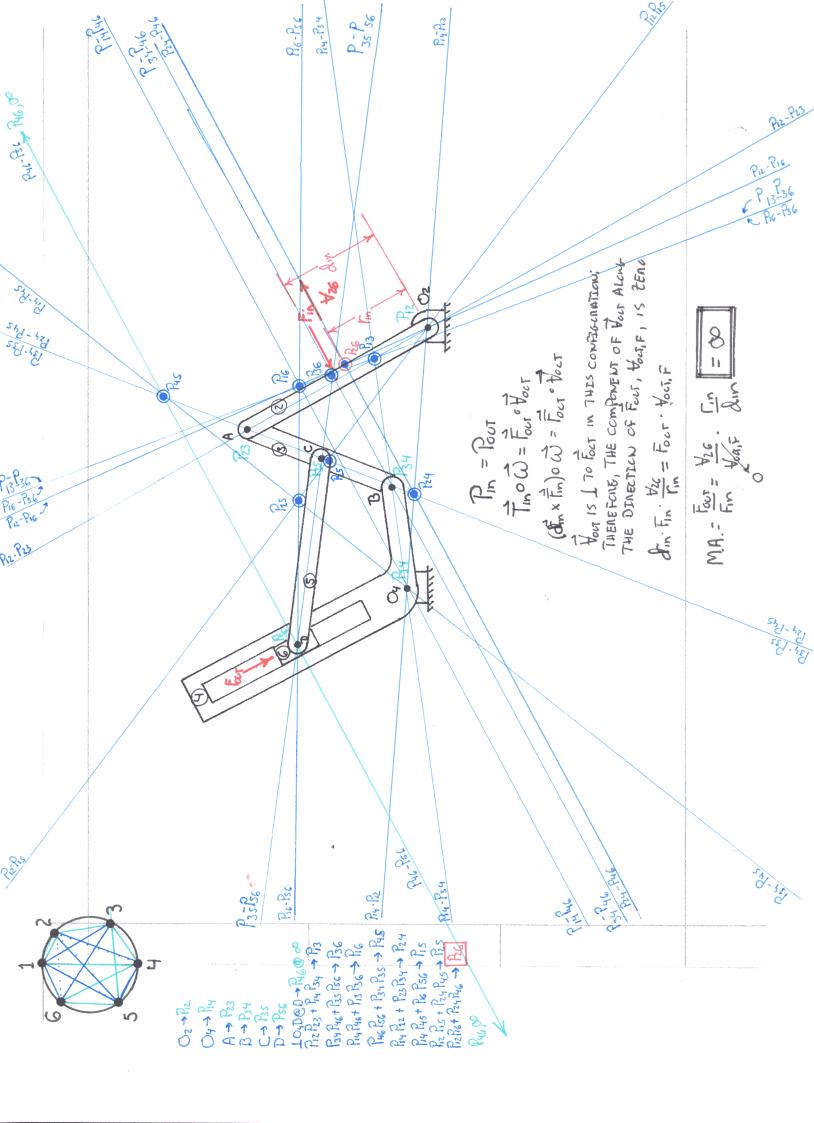
Θ ₂ =120°	BC=2.25m	$\omega_2=2 1/s$
$O_2A = 6.2m$	CD=5.60m	$\alpha_2 = -10 \text{ 1/s}^2$
$O_2B=3.0m$	$O_4B=6m$	
AC=2.25m	/BO₄D=110°	



Using the figure provided on the next page,

- 2a. Locate and label all the instant centers associated with this mechanism.
- **2b.** Given F_{in} is located half way up link 2 and is directed perpendicular to the link and the F_{out} is acting on link 6, determine the mechanical advantage of the mechanism.
- **2c.** Describe how the linkage can be altered to increase the mechanical advantage of the mechanism.
- 2d. Describe how the link can be altered to decrease the mechanical advantage of the mechanism.

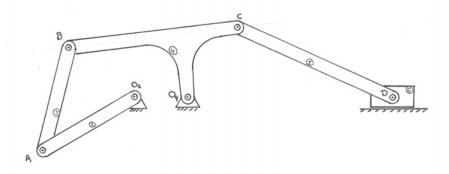
Make sure you show all of you work.



NAME:

PROBLEM 1: (50pts) The dimensions for the linkage shown below are as follows.

Θ_2 =210°	BC=8m	$\omega_2=2 1/s$
$L_2=5m$	$O_2O_4=2.5m$	$\alpha_2 = -10 \text{ 1/s}^2$
$L_3=5m$	$O_4B=6m$	
$L_5=8m$	$O_4C=4m$	



This mechanism is a combination of a four bar linkage and a slider crank.

1a. Using analytical methods, determine

- the velocity and acceleration of points A, B, C, &D; and
- the angular velocity and acceleration of links 2, 3, 4, &5.

Yours answers need to be written in vector form. This is where you should use your computer program and then you can just print out the answers and place them directly after this page.

1b. Using graphical methods and the drawing provided on the following page,

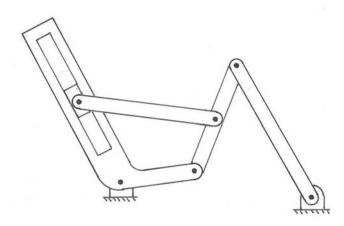
- locate all of the instant centers;
- the velocity of points A, B, C, &D; and
- the angular velocity of links 2, 3, 4, &5.

Be sure to show all your calculations.

Do these results confirm the calculations made in 1a.

PROBLEM 2: (45pts) The mechanism shown on the next page is rotating with a constant angular velocity of 2 rad/s ccw. Using instant centers to find the following:

Θ ₂ =120°	BC=2.25m	$\omega_2=2 1/s$
$O_2A = 6.2m$	CD=5.60m	$\alpha_2 = -10 \text{ 1/s}^2$
$O_2B=3.0m$	$O_4B=6m$	
AC=2.25m	∠BO ₄ D=110°	



Using the figure provided on the next page,

- **2a.** Locate and label all the instant centers associated with this mechanism.
- **2b.** Given F_{in} is located half way up link 2 and is directed perpendicular to the link and the F_{out} is acting on link 6, determine the mechanical advantage of the mechanism.
- **2c.** Describe how the linkage can be altered to increase the mechanical advantage of the mechanism.
- 2d. Describe how the link can be altered to decrease the mechanical advantage of the mechanism.

Make sure you show all of you work.

Exam I

-5-

PROBLEM 3: (5pts) For the slider crank shown and the parameters

Link 1=0.8m.	Link 2=0.5m	Link 4=0.3m
γ=90°	θ ₂ =25°	ω_2 =-50 /s
$\alpha_2 = 20 \text{ 1/s}^2$		

Determine

- the velocity and acceleration of points A, B, & B relative to A; and
- the angular velocity and acceleration of links 2, 3, & 4.

Yours answers need to be written in vector form. This is where you should use your computer program and then you can just print out the answers and place them directly after this page.

