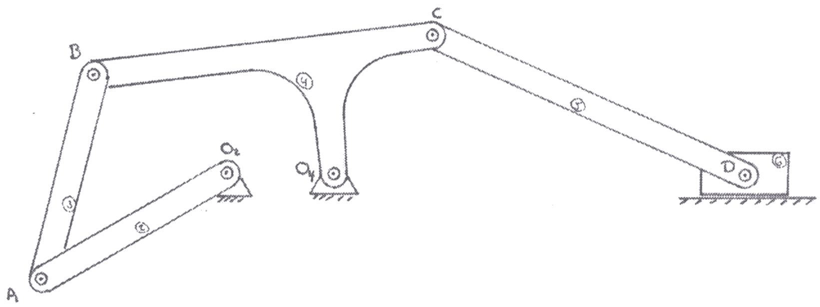
NAME: SOLUTION

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

Θ_2=210°	BC=8m	ω_2=2 1/s
L_2=5m	O_2O_4=2.5m	α_2=-10 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.

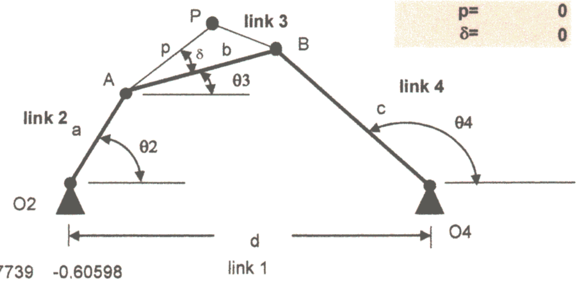
1a. Using analytical methods, determine
- the velocity and acceleration of points A, B, C, &D; and
- the angular velocity and acceleration of links 2, 3, 4, &5.

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.

4-Bar Linkage

a=	5	Link 2			
b=	5	Link 3			
c=	6	Link 4			
d=	2.5	Link 1			
θ_2 =	210	3.665191429			
$\dot{\theta}_2$ =	2	$1/s$			
$\ddot{\theta}_2$ =	-10	$1/s^2$			
By=	2.33	-5.35			
Bx=	-3.03	-0.22			
θ_3 =	74.9	-34.7	1.307739	-0.60598	
θ_4 =	157.2	-117.0	2.743133	-2.04137	
$\dot{\theta}_3$ =	1.6084E+00	1.1005E+00			
$\dot{\theta}_4$ =	1.1879E+00	1.5210E+00			
$\ddot{\theta}_3$ =	-6.9596E+00	-6.2498E+00			
$\ddot{\theta}_4$ =	-6.3378E+00	-6.8716E+00			

K1=	-2.1779E+00
K2=	-3.6603E-01
K3=	-3.0198E+00
K4=	-1.2450E+01



p=	0
δ=	0

	x comp	y comp	mag	angle	i	j
r04=	2.50	0.00	2.50	0.0	1.000	0.000
rA=	-4.33	-2.50	5.00	-150.0	-0.866	-0.500
rBA=	1.30	4.83	5.00	74.9	0.260	0.966
rBO4=	-5.53	2.33	6.00	157.2	-0.922	0.388
rB=	-3.03	2.33	3.82	142.5	-0.793	0.609
rPA=	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!
rP=	-4.33	-2.50	5.00	-150.0	-0.866	-0.500
vA=	5.00	-8.66	10.00	-60.0	0.500	-0.866
vBA=	-7.77	2.09	8.04	164.9	-0.966	0.260
vB=	-2.77	-6.57	7.13	-112.8	-0.388	-0.922
vPA=	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!
vP=	5.00	-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/0!	#DIV/0!	#DIV/0!
aP=	-7.68	53.30	53.85	98.2	-0.143	0.990

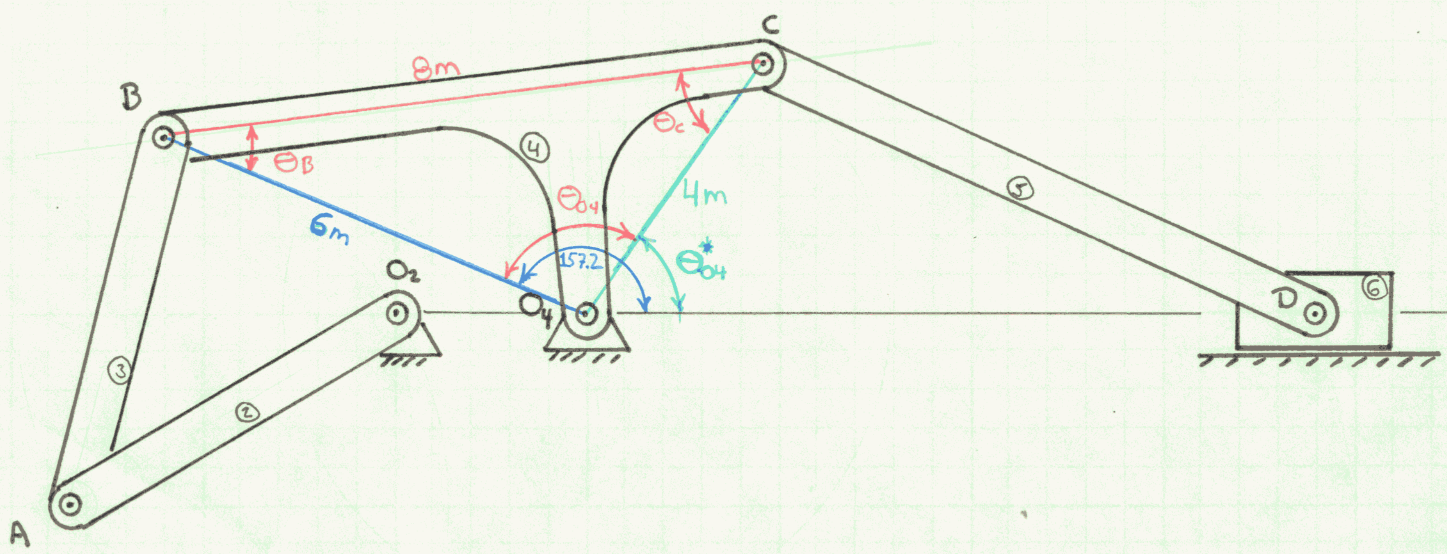
ALT	x comp	y comp	mag	angle	i	j
rO4=	2.50	0.00	2.50	0.0	1.000	0.000
rA=	-4.33	-2.50	5.00	-150.0	-0.866	-0.500
rBA=	4.11	-2.85	5.00	-34.7	0.822	-0.570
rBO4=	-2.72	-5.35	6.00	-117.0	-0.453	-0.891
rB=	-0.22	-5.35	5.35	-92.4	-0.041	-0.999
rPA=	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!
rP=	-4.33	-2.50	5.00	-150.0	-0.866	-0.500
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/0!	#DIV/0!	#DIV/0!
vP=	5.00	-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
aB	-30.45	31.07	43.50	134.4	-0.700	0.714
aPA=	0.00	0.00	0.00	#DIV/0!	#DIV/0!	#DIV/0!
aP=	-7.68	53.30	53.85	98.2	-0.143	0.990

LAW OF COSINES: $a^2 = b^2 + c^2 - 2 \cdot b \cdot c \cdot \cos\theta_a$

FOR THE ANGLE θ_{O4}

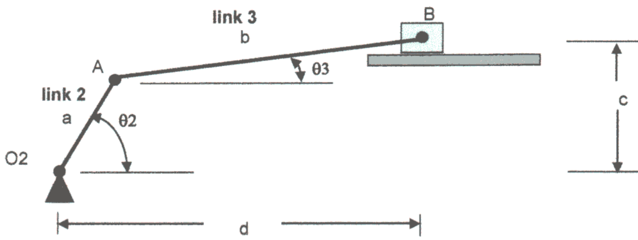
$$\theta_{O4} = \cos^{-1}\left(\frac{(4m)^2 + (6m)^2 - (8m)^2}{2 \cdot (4m) \cdot (6m)}\right) = \underline{\underline{104.5}}$$

$$\theta^*_{O4} = 157.2 - 104.5 = 52.7^\circ$$



Slider Crank

a=	4	Link 2	
b=	8	Link 3	
c=	0	Link 1	
$\theta_2 =$	52.7		0.919788516
$\dot{\theta}_2 =$	1.187900656	$1/s$	
$\ddot{\theta}_2 =$	-6.337783351	$1/s^2$	
By=	0.00		0.00
Bx=	9.76		-4.92
$\theta_3 =$	-23.4		-156.6
$\dot{\theta}_3 =$	-0.39		0.39
$\ddot{\theta}_3 =$	2.64		-2.64
vB=	-5.03		-2.53
aB=	24.01		9.48



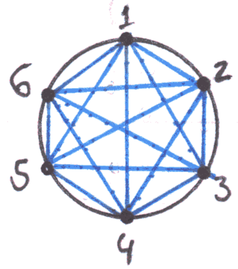
	x comp	y comp	mag	angle	i	j
rB=	9.76	0.00	9.76	0.0	1.000	0.000
rA=	2.42	3.18	4.00	52.7	0.606	0.795
rBA=	7.34	-3.18	8.00	-23.4	0.917	-0.398
vB	-5.03	0.00	5.03	180.0	-1.000	0.000
vA	-3.78	2.88	4.75	142.7	-0.795	0.606
vBA	-1.25	-2.88	3.14	-113.4	-0.398	-0.917
aB	24.01	0.00	24.01	0.0	1.000	0.000
aA	16.75	-19.85	25.97	-49.9	0.645	-0.764
aBA	7.26	19.85	21.14	69.9	0.344	0.939
alt	**x comp**	**y comp**	**mag**	**angle**	**i**	**j**
rB=	-4.92	0.00	4.92	180.0	-1.000	0.000
rA=	2.42	3.18	4.00	52.7	0.606	0.795
rBA=	-7.34	-3.18	8.00	-156.6	-0.917	-0.398
vB	-2.53	0.00	2.53	180.0	-1.000	0.000
vA	-3.78	2.88	4.75	142.7	-0.795	0.606
vBA	1.25	-2.88	3.14	-66.6	0.398	-0.917
aB	9.48	0.00	9.48	0.0	1.000	0.000
aA	16.75	-19.85	25.97	-49.9	0.645	-0.764
aBA	-7.26	19.85	21.14	110.1	-0.344	0.939

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.



$O_2 \rightarrow P_{12}$
$O_4 \rightarrow P_{14}$
$A \rightarrow P_{23}$
$B \rightarrow P_{34}$
$C \rightarrow P_{45}$
$D \rightarrow P_{56}$
Vertical $\infty \rightarrow P_{16}$

$(P_{12}\ P_{23}) + (P_{14}\ P_{34}) \rightarrow P_{13}$
$(P_{12}\ P_{14}) + (P_{23}\ P_{34}) \rightarrow P_{24}$
$(P_{16}\ P_{56}) + (P_{14}\ P_{45}) \rightarrow P_{15}$
$(P_{14}\ P_{16}) + (P_{45}\ P_{56}) \rightarrow P_{46}$
$(P_{34}\ P_{45}) + (P_{13}\ P_{15}) \rightarrow P_{35}$
$(P_{16}\ P_{12}) + (P_{24}\ P_{46}) \rightarrow P_{26}$
$(P_{12}\ P_{15}) + (P_{24}\ P_{45}) \rightarrow P_{25}$
$(P_{13}\ P_{16}) + (P_{34}\ P_{46}) \rightarrow P_{36}$

$V_a = (2\,{}^1/_s)(5m) = \boxed{10\,{}^m/_s}$

$\omega_3 = \frac{V_a}{r_{P_{13}A}} = \frac{10\,{}^m/_s}{6.1m} = \boxed{1.64\,{}^1/_s}$ (ccw)

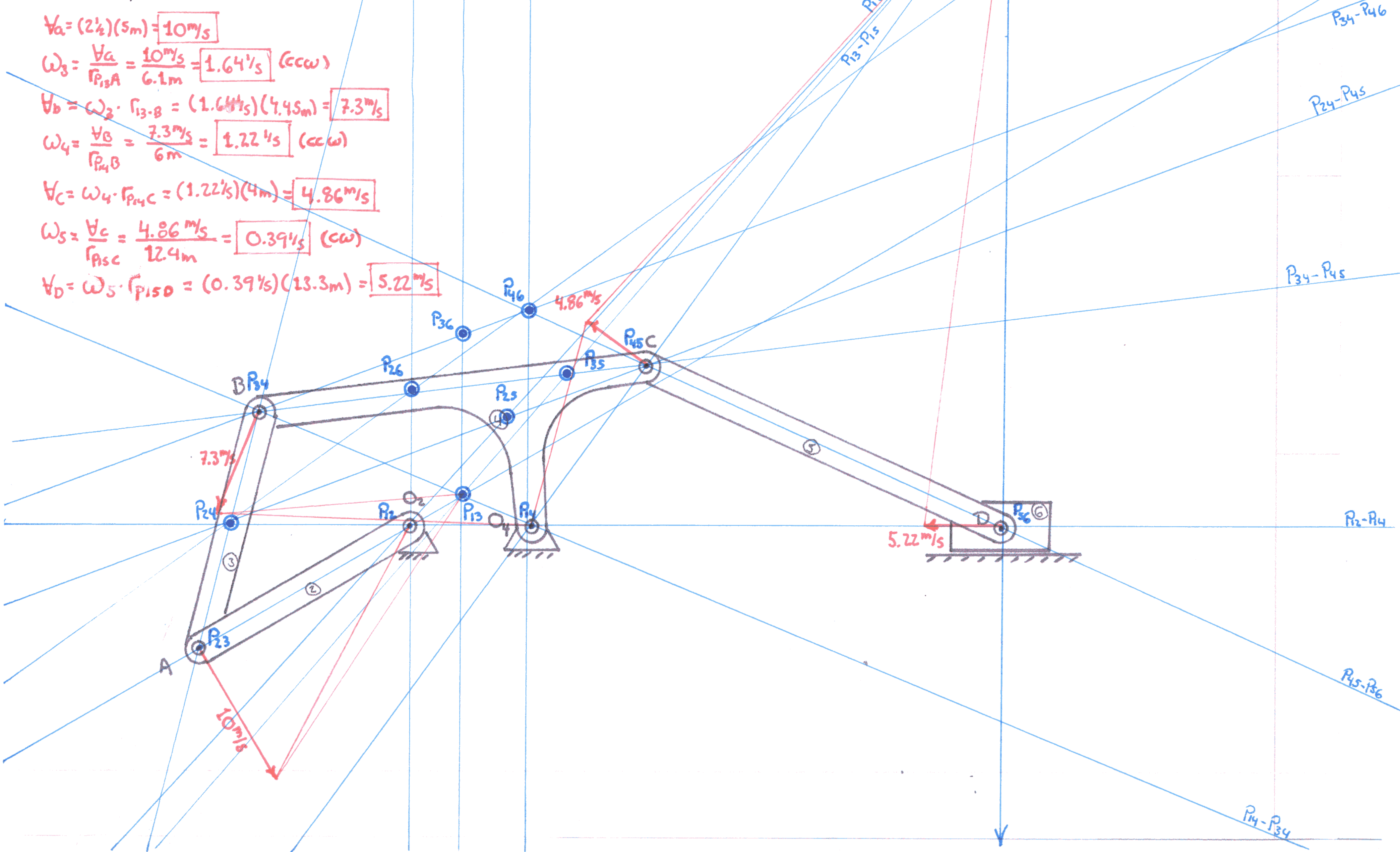
$V_b = \omega_3 \cdot r_{13\text{-}B} = (1.64\,{}^1/_s)(4.45m) = \boxed{7.3\,{}^m/_s}$

$\omega_4 = \frac{V_B}{r_{P_{14}B}} = \frac{7.3\,{}^m/_s}{6m} = \boxed{1.22\,{}^1/_s}$ (ccw)

$V_C = \omega_4 \cdot r_{P_{14}C} = (1.22\,{}^1/_s)(4m) = \boxed{4.86\,{}^m/_s}$

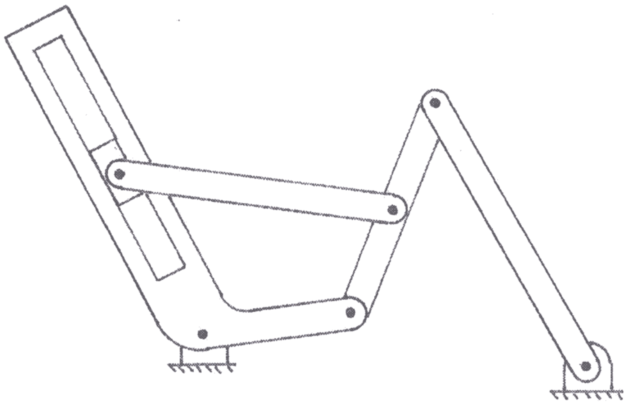
$\omega_5 = \frac{V_C}{r_{P_{15}C}} = \frac{4.86\,{}^m/_s}{12.4m} = \boxed{0.39\,{}^1/_s}$ (cw)

$V_D = \omega_5 \cdot r_{P_{15}D} = (0.39\,{}^1/_s)(13.3m) = \boxed{5.22\,{}^m/_s}$



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:

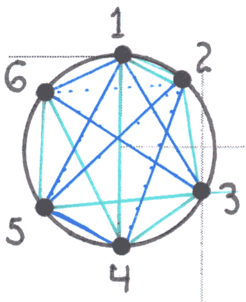
Θ_2=120°	BC=2.25m	ω_2=2 1/s
O_2A=6.2m	CD=5.60m	α_2=-10 1/s^2
O_2B=3.0m	O_4B=6m	
AC=2.25m	$\angle BO_4D$=110°	

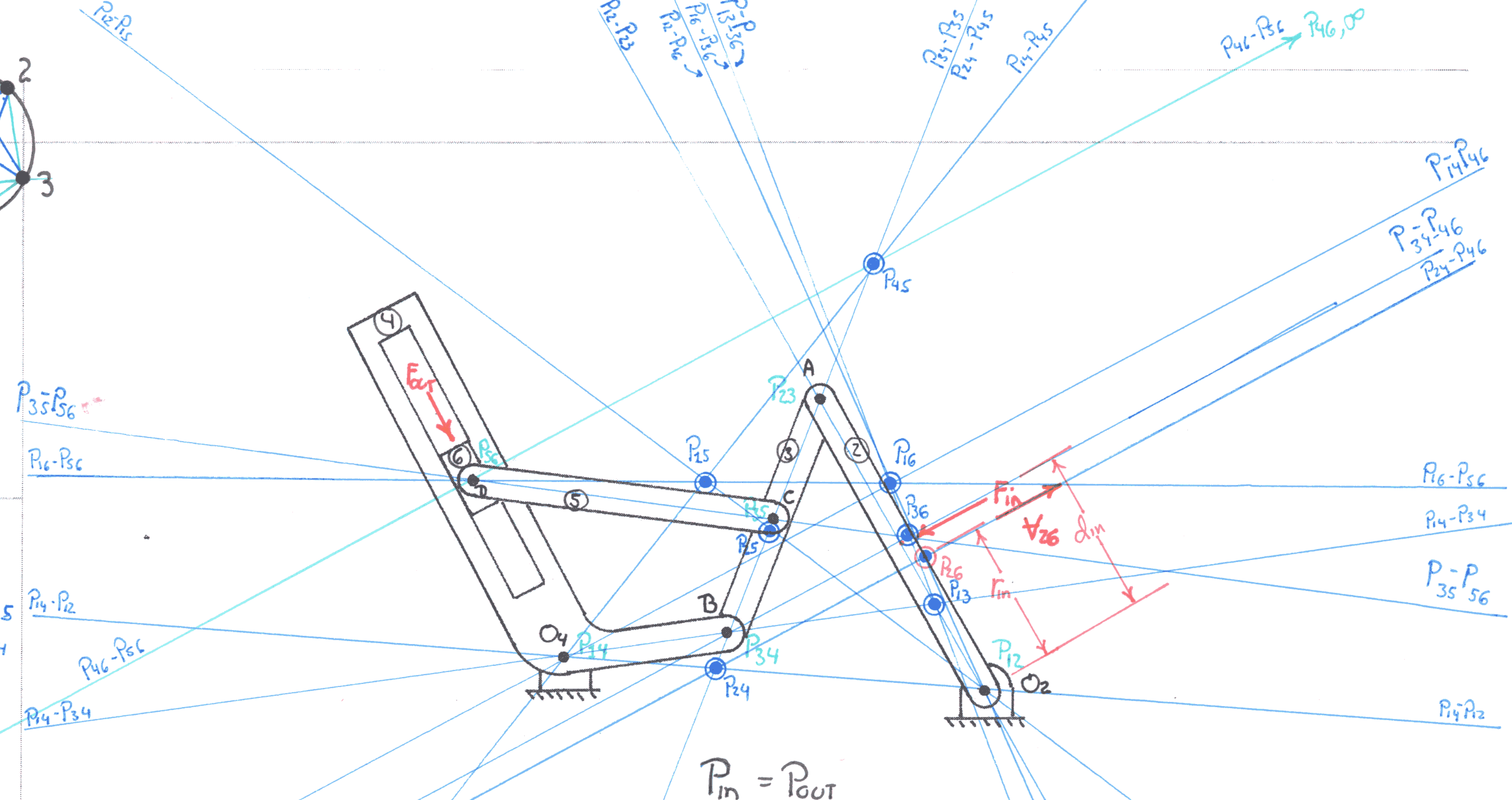


Using the figure provided on the next page,

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.





$O_2 \rightarrow P_{12}$

$O_4 \rightarrow P_{14}$

$A \rightarrow P_{23}$

$B \rightarrow P_{34}$

$C \rightarrow P_{35}$

$D \rightarrow P_{56}$

$\perp O_4D @ D \rightarrow P_{46} @ \infty$

$P_{12}P_{23} + P_{14}P_{34} \rightarrow P_{13}$

$P_{34}P_{46} + P_{35}P_{56} \rightarrow P_{36}$

$P_{14}P_{46} + P_{13}P_{36} \rightarrow P_{16}$

$P_{46}P_{56} + P_{34}P_{35} \rightarrow P_{45}$

$P_{14}P_{12} + P_{23}P_{34} \rightarrow P_{24}$

$P_{14}P_{45} + P_{16}P_{56} \rightarrow P_{15}$

$P_{12}P_{15} + P_{24}P_{45} \rightarrow P_{25}$

$P_{12}P_{16} + P_{24}P_{46} \rightarrow \boxed{P_{26}}$

$P_{46}\ \infty$

$$P_{in} = P_{OUT}$$

$$\vec{T}_{in} \circ \vec{\omega} = \vec{F}_{OUT} \circ \vec{V}_{OUT}$$

$$(\vec{d}_{in} \times \vec{F}_{in}) \circ \vec{\omega} = \vec{F}_{OUT} \circ \vec{V}_{OUT}$$

$\vec{V}_{OUT}$ IS $\perp$ TO $\vec{F}_{OUT}$ IN THIS CONFIGURATION; THEREFORE, THE COMPONENT OF $\vec{V}_{OUT}$ ALONG THE DIRECTION OF $\vec{F}_{OUT}$, $V_{OUT,F}$, IS ZERO

$$d_{in} \cdot F_{in} \cdot \frac{V_{26}}{r_{in}} = F_{OUT} \cdot V_{OUT,F}$$

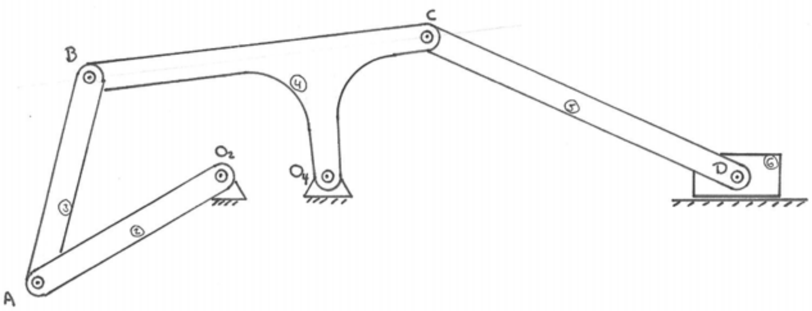
$$M.A. = \frac{F_{OUT}}{F_{in}} = \frac{V_{26}}{V_{OUT,F}} \cdot \frac{r_{in}}{d_{in}} \boxed{= \infty}$$

0

NAME: ________________________

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

Θ_2=210°	BC=8m	ω_2=2 1/s
L_2=5m	O_2O_4=2.5m	α_2=-10 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,

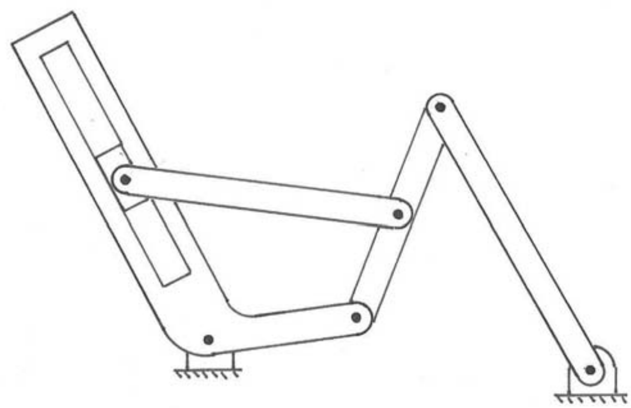
- locate all of the instant centers;
- the velocity of points A, B, C, &D; and
- the angular velocity of links 2, 3, 4, &5.

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	ω_2=2 1/s
O_2A=6.2m	CD=5.60m	α_2=-10 1/s^2
O_2B=3.0m	O_4B=6m	
AC=2.25m	$\angle BO_4D$=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.

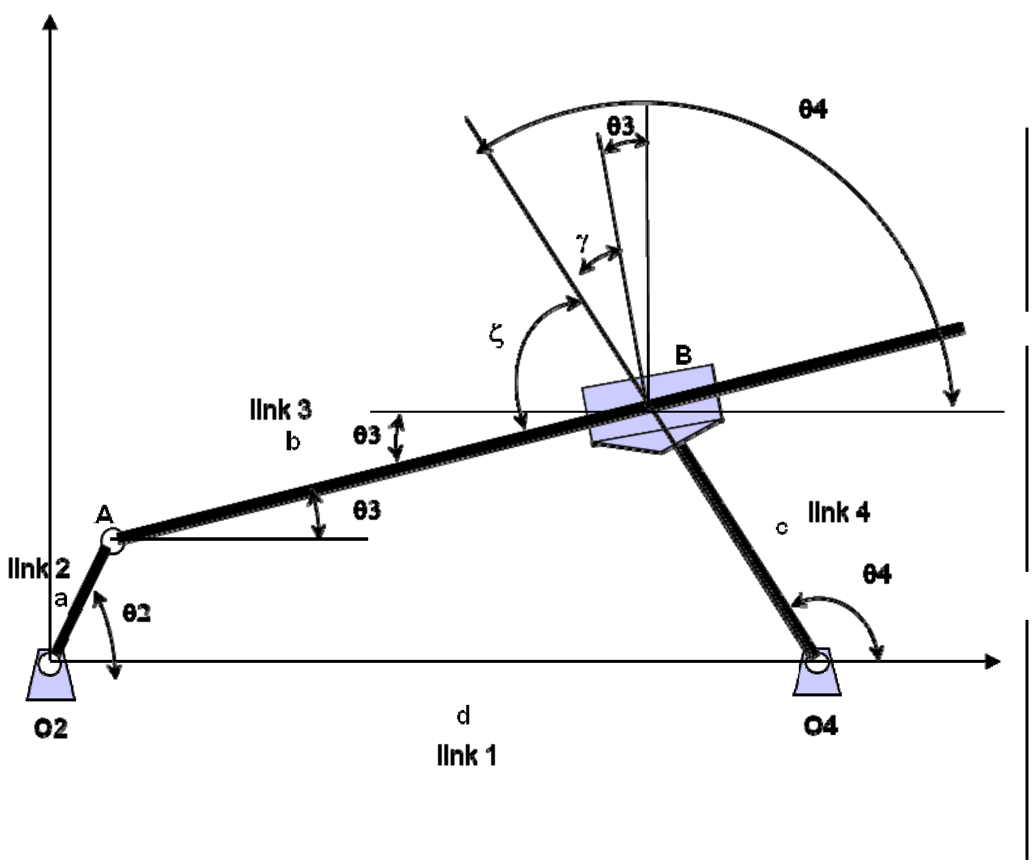
PROBLEM 3: (5pts) For the slider crank shown and the parameters

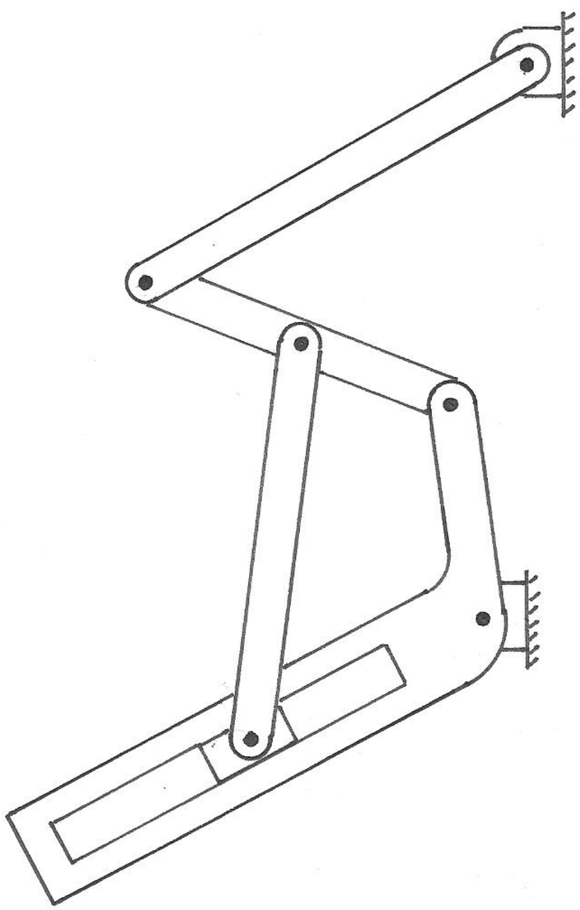
Link 1=0.8m.	Link 2=0.5m	Link 4=0.3m
$\gamma=90°$	$\theta_2=25°$	$\omega_2=-50$ /s
$\alpha_2=20$ 1/s^2		

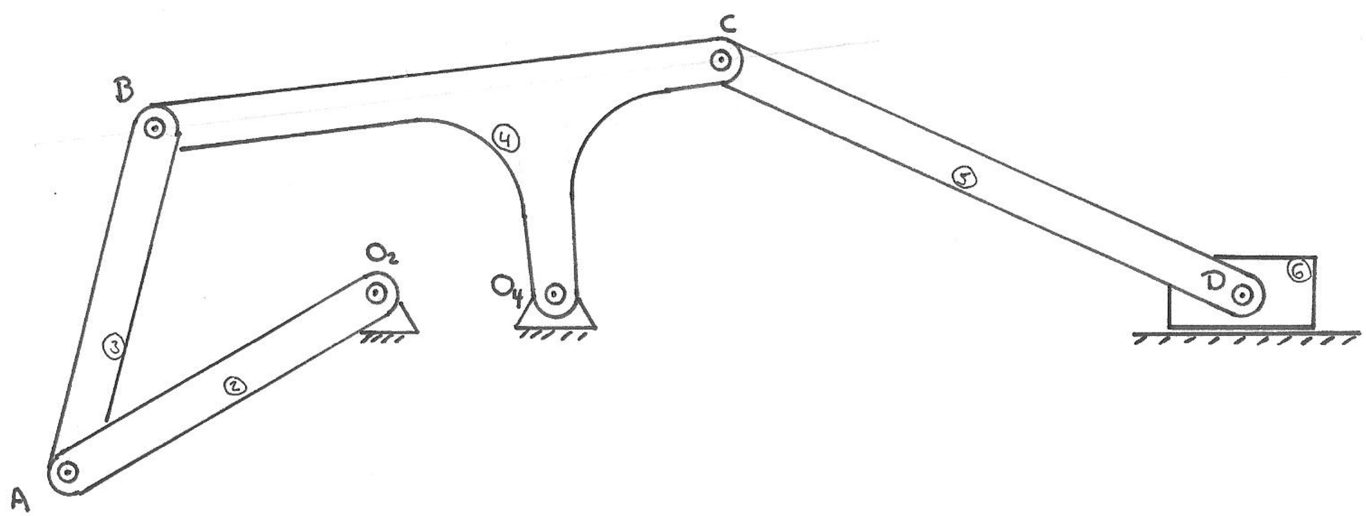
Determine

- 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.






A
B
C
D
O_2
O_4
2
3
4
5
6