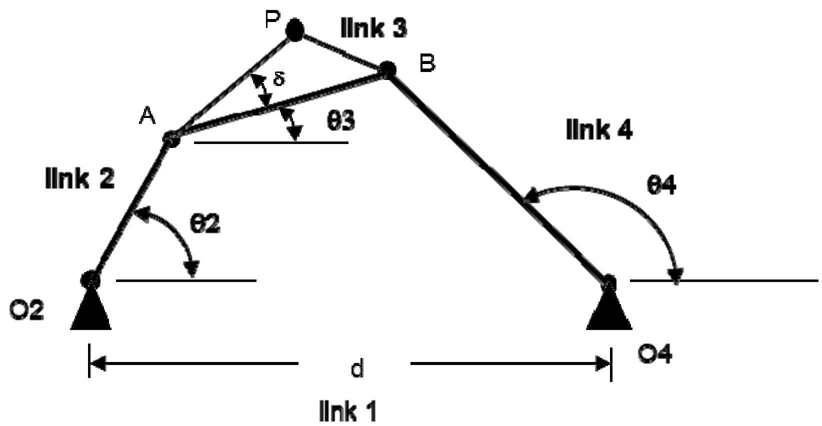
NAME: Solution

PROBLEM 1: (25pts) The dimensions for the four bar linkage shown below are as follows.

L_1= 4m	L_4= 7m	Θ_2= 88°
L_2= 6m	R_{pa}= 10m	ω_2= -80 1/s
L_3= 10m	δ_3= 330°	α_2= 30 1/s^2



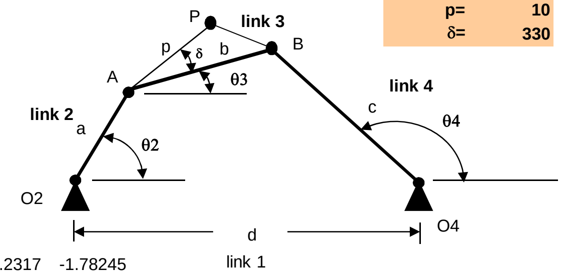
Using the program you developed in class print out the values for the following quantities for both the crossed and open configurations. Insert your print out directly behind this page.

- Position of all points on the mechanism.
- Angular velocities for all links in the mechanism.
- Velocities for points A, B, and P in Cartesian and magnitude-unit vector forms.
- Relative velocities of point B with respect to A and point P with respect to A in Cartesian and magnitude-unit vector forms.
- Angular Accelerations for all links in the mechanism.
- Accelerations for points A, B, and P in Cartesian and magnitude-unit vector forms.
- Relative accelerations of point B with respect to A and point P with respect to A in Cartesian and magnitude-unit vector forms.

4-Bar Linkage

a=	6	Link 2		
b=	10	Link 3		
c=	7	Link 4		
d=	4	Link 1		
$\theta_2 =$	88	1.535889742		
$\dot{\theta}_2 =$	-80	$1/s$		
$\ddot{\theta}_2 =$	30	$1/s^2$		
By=	3.70	-3.78		
Bx=	9.94	-1.89		
$\theta_3 =$	-13.3	-102.1	-0.2317	-1.78245
$\theta_4 =$	31.9	-147.3	0.556928	-2.57107
$\dot{\theta}_3 =$	-5.6156E+01	-5.5638E+01		
$\dot{\theta}_4 =$	-9.4798E+01	-1.6996E+01		
$\ddot{\theta}_3 =$	-2.6936E+03	3.1098E+02		
$\ddot{\theta}_4 =$	-4.0547E+03	1.6721E+03		

K1=	4.0891E+00
K2=	1.5819E+00
K3=	-8.0449E-02
K4=	-1.3988E+01

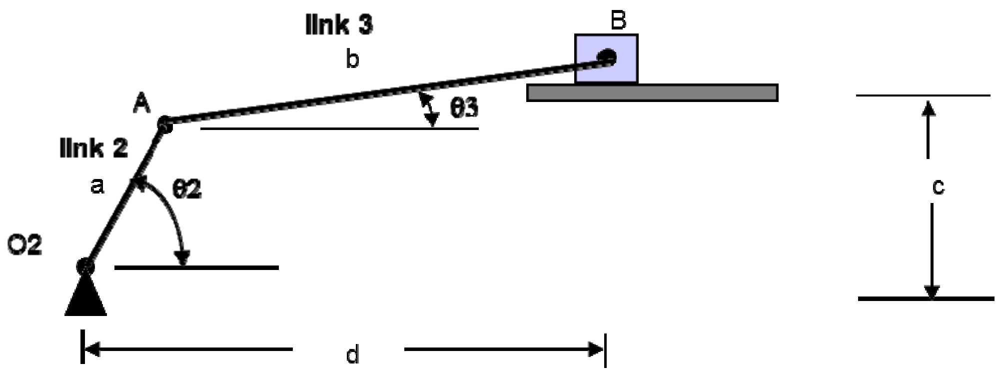


p=	10
δ=	330

	x comp	y comp	mag	angle	i	j
r04=	**4.00**	**0.00**	**4.000**	**0.0**	**1.000**	**0.000**
rA=	**0.21**	**6.00**	**6.000**	**88.0**	**0.035**	**0.999**
rBA=	9.73	-2.30	10.000	-13.3	0.973	-0.230
rBO4=	5.94	3.70	7.000	31.9	0.849	0.529
rB=	**9.94**	**3.70**	**10.608**	**20.4**	**0.937**	**0.349**
rPA=	7.28	-6.86	10.000	-43.3	0.728	-0.686
rP=	**7.49**	**-0.86**	**7.539**	**-6.5**	**0.993**	**-0.114**
vA=	**479.71**	**-16.75**	**480.000**	**-2.0**	**0.999**	**-0.035**
vBA=	-128.95	-546.55	561.559	-103.3	-0.230	-0.973
vB=	**350.76**	**-563.31**	**663.584**	**-58.1**	**0.529**	**-0.849**
vPA=	-384.95	-408.85	561.559	-133.3	-0.686	-0.728
vP=	**94.76**	**-425.61**	**436.027**	**-77.4**	**0.217**	**-0.976**
aA=	**-1520.03**	**-38370.33**	**38400.422**	**-92.3**	**-0.040**	**-0.999**
aBA	-36877.40	-18974.51	41472.574	-152.8	-0.889	-0.458
aB	**-38397.43**	**-57344.83**	**69012.986**	**-123.8**	**-0.556**	**-0.831**
aPA=	-41424.02	2006.30	41472.574	177.2	-0.999	0.048
aP=	**-42944.05**	**-36364.03**	**56271.964**	**-139.7**	**-0.763**	**-0.646**
ALT	**x comp**	**y comp**	**mag**	**angle**	**i**	**j**
rO4=	**4.00**	**0.00**	**4.000**	**0.0**	**1.000**	**0.000**
rA=	**0.21**	**6.00**	**6.000**	**88.0**	**0.035**	**0.999**
rBA=	-2.10	-9.78	10.000	-102.1	-0.210	-0.978
rBO4=	-5.89	-3.78	7.000	-147.3	-0.842	-0.540
rB=	**-1.89**	**-3.78**	**4.227**	**-116.6**	**-0.447**	**-0.894**
rPA=	-6.71	-7.42	10.000	-132.1	-0.671	-0.742
rP=	**-6.50**	**-1.42**	**6.652**	**-167.7**	**-0.977**	**-0.214**
vA=	**479.71**	**-16.75**	**480.000**	**-2.0**	**0.999**	**-0.035**
vBA=	-543.96	116.88	556.375	167.9	-0.978	0.210
vB=	**-64.25**	**100.13**	**118.970**	**122.7**	**-0.540**	**0.842**
vPA=	-412.64	373.20	556.375	137.9	-0.742	0.671
vP=	**67.06**	**356.45**	**362.702**	**79.3**	**0.185**	**0.983**
aA=	**-1520.03**	**-38370.33**	**38400.422**	**-92.3**	**FALSE**	**-0.999**
aBA	9543.26	29611.30	31111.140	72.1	0.307	0.952
aB	**8023.23**	**-8759.02**	**11878.243**	**-47.5**	**0.675**	**-0.737**
aPA=	23070.36	20872.51	31111.140	42.1	0.742	0.671
aP=	**21550.32**	**-17497.81**	**27759.503**	**-39.1**	**0.776**	**-0.630**

PROBLEM 2: (25pts) The dimensions for the slider crank mechanism shown below are as follows.

Offset= 0 m	Θ_2= 100°
L_2= 3 m	ω_2= -45 1/s
L_3= 13 m	α_2= 50 1/s^2



Using the program you developed in class print out the values for the following quantities for both the crossed and open configurations. Insert your print out directly behind this page.

- Position of all points on the mechanism.
- Angular velocities for all links in the mechanism.
- Velocities for points A and B in Cartesian and magnitude-unit vector forms.
- Relative velocities of point B with respect to A in Cartesian and magnitude-unit vector forms.
- Angular Accelerations for all links in the mechanism.
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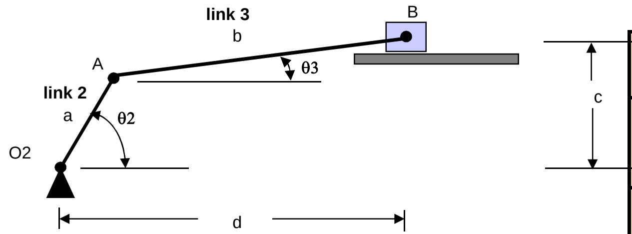
- Relative accelerations of point B with respect to A in Cartesian and magnitude-unit vector forms.

Slider Crank

a=	**3**	Link 2
b=	**13**	Link 3
c=	**0**	Link 1
$\theta_2 =$	**100**	1.745329252
$\dot{\theta}_2 =$	**-45**	$1/s$
$\ddot{\theta}_2 =$	**50**	$1/s^2$
By=	**0.00**	**0.00**
Bx=	**12.14**	**-13.18**
$\theta_3 =$	**-13.1**	**-166.9**
$\dot{\theta}_3 =$	**-1.85**	**1.85**
$\ddot{\theta}_3 =$	**473.83**	**-473.83**
vB=	**127.48**	**138.42**
aB=	**2263.68**	**-449.30**



	x comp	y comp	mag	angle	i	j
rB=	**12.14**	**0.00**	**12.14**	**0.0**	**1.000**	**0.000**
rA=	**-0.52**	**2.95**	**3.00**	**100.0**	**-0.174**	**0.985**
rBA=	12.66	-2.95	13.00	-13.1	0.974	-0.227
vB	**127.48**	**0.00**	**127.48**	**0.0**	**1.000**	**0.000**
vA	**132.95**	**23.44**	**135.00**	**10.0**	**0.985**	**0.174**
vBA	-5.47	-23.44	24.07	-103.1	-0.227	-0.974
aB	**2263.68**	**0.00**	**2263.68**	**0.0**	**1.000**	**0.000**
aA	**907.19**	**-6008.75**	**6076.85**	**-81.4**	**0.149**	**-0.989**
aBA	1356.49	6008.75	6159.97	77.3	0.220	0.975

alt	x comp	y comp	mag	angle	i	j
rB=	**-13.18**	**0.00**	**13.18**	**180.0**	**-1.000**	**0.000**
rA=	**-0.52**	**2.95**	**3.00**	**100.0**	**-0.174**	**0.985**
rBA=	-12.66	-2.95	13.00	-166.9	-0.974	-0.227
vB	**138.42**	**0.00**	**138.42**	**0.0**	**1.000**	**0.000**
vA	**132.95**	**23.44**	**135.00**	**10.0**	**0.985**	**0.174**
vBA	5.47	-23.44	24.07	-76.9	0.227	-0.974
aB	**-449.30**	**0.00**	**449.30**	**180.0**	**-1.000**	**0.000**
aA	**907.19**	**-6008.75**	**6076.85**	**-81.4**	**0.149**	**-0.989**
aBA	-1356.49	6008.75	6159.97	102.7	-0.220	0.975

Bonus: (5pts) The dimensions for the inverted slider crank mechanism shown below are as follows.

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		

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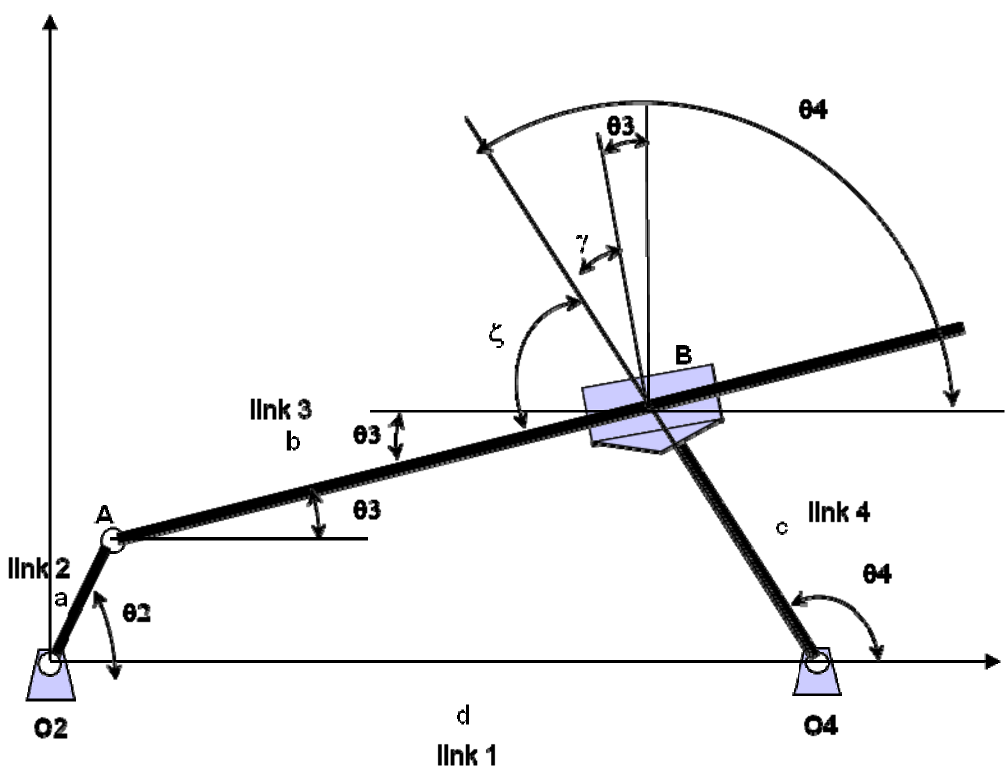
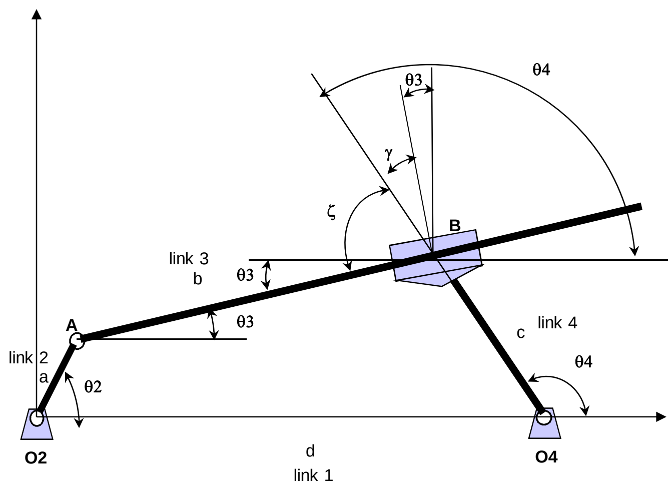


Inverted Slider Crank

a=	0.5	Link 2	
c=	0.3	Link 4	
d=	0.8	Link 1	
$\theta_2 =$	25		
γ=	-30		
$\dot{\theta}_2 =$	-50	$1/s$	
$\ddot{\theta}_2 =$	20	$1/s^2$	
b=	0.46		-0.16
$\theta_4 =$	68.42		168.88
$\theta_3 =$	8.42		108.88
$\dot{\theta}_4 =$	76.75		-8.54
$\dot{\theta}_3 =$	76.75		-8.54
b-dot=	-27.08		27.08
$\ddot{\theta}_4 =$	9523.12		2564.45
$\ddot{\theta}_3 =$	9523.12		2564.45
b-dotdot=	565.70		-565.70

ζ=	60
K1=	-0.356422129
K2=	0.194722974
K3=	0.259807621



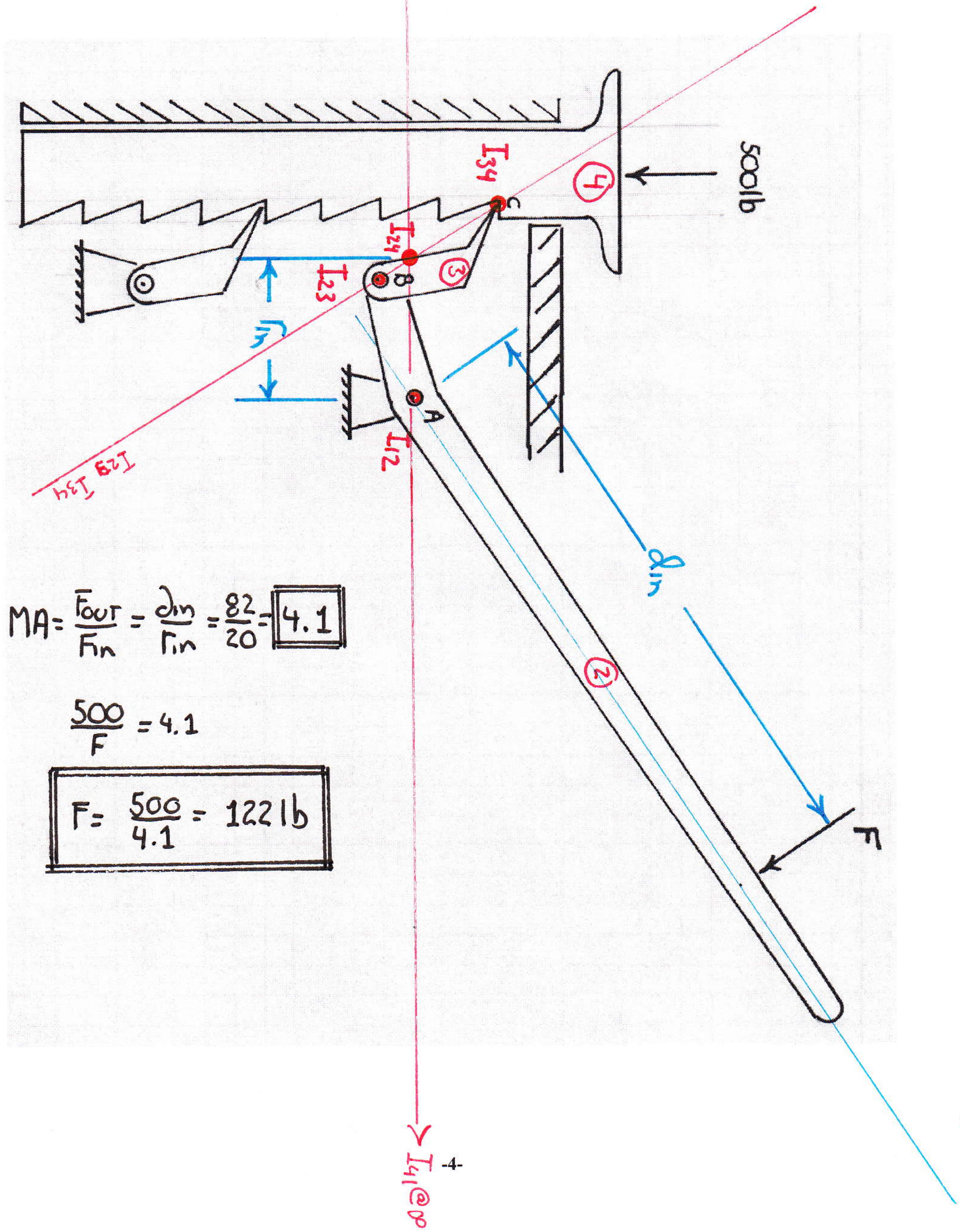
	x comp	y comp	mag	angle	i	j
rO4=	**0.80**	**0.00**	**0.80**	**0.0**	**1.000**	**0.000**
rA=	**0.45**	**0.21**	**0.50**	**25.0**	**0.906**	**0.423**
rBA=	0.46	0.07	0.46	8.4	0.989	0.146
rBO4=	0.11	0.28	0.30	68.4	0.368	0.930
rB=	**0.91**	**0.28**	**0.95**	**17.0**	**0.956**	**0.293**
vA=	**10.57**	**-22.66**	**25.00**	**-65.0**	**0.423**	**-0.906**
vBA=	-31.98	31.13	44.63	135.8	-0.717	0.698
vB=	**-21.41**	**8.47**	**23.03**	**158.4**	**-0.930**	**0.368**
aA=	**-1137.11**	**-519.21**	**1250.04**	**-155.5**	**-0.910**	**-0.415**
aBA=	-2169.60	-73.29	2170.84	-178.1	-0.999	-0.034
aB=	**-3306.71**	**-592.50**	**3359.37**	**-169.8**	**-0.984**	**-0.176**

alt	x comp	y comp	mag	angle	i	j
rO4=	**0.80**	**0.00**	**0.80**	**0.0**	**1.000**	**0.000**
rA=	**0.45**	**0.21**	**0.50**	**25.0**	**0.906**	**0.423**
rBA=	0.05	-0.15	0.16	-71.1	0.324	-0.946
rB04=	-0.29	0.06	0.30	168.9	-0.981	0.193
rB=	**0.51**	**0.06**	0.51	6.5	0.994	0.114
vA=	**10.57**	**-22.66**	**25.00**	**-65.0**	**0.423**	**-0.906**
vBA=	-10.07	25.17	27.11	111.8	-0.371	0.928
vB=	**0.49**	**2.51**	**2.56**	**78.9**	**0.193**	**0.981**
aA=	**-1137.11**	**-519.21**	1250.04	-155.5	-0.910	-0.415
aBA=	1010.19	-239.90	1038.29	-13.4	0.973	-0.231
aB=	-126.92	-759.11	769.65	-99.5	-0.165	-0.986

PROBLEM 3: (25pts) The figure below illustrates a mechanism that is found in a typical car jack. The load F is applied by the user and the 500lb represents the weight the jack is lifting. Point C in the ratchet can be treated as a pin joint during the lifting part of the motion.

Determine:

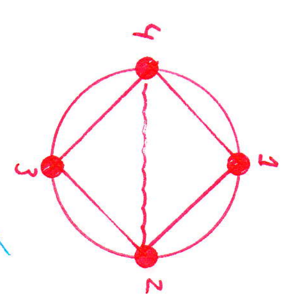
- The mechanical advantage of the mechanism.
- The value of F required to move the 500lb load upward.
- Suggest two ways to increase the mechanical advantage of the mechanism.
  1. EXTEND THE LENGTH OF THE HANDLE AND MOVE THE FORCE FARTHER OUT.
  2. RECONFIGURE THE MECHANISM SO B IS CLOSER TO A.



$$MA = \frac{F_{OUT}}{F_{in}} = \frac{d_{in}}{r_{in}} = \frac{82}{20} = \boxed{4.1}$$

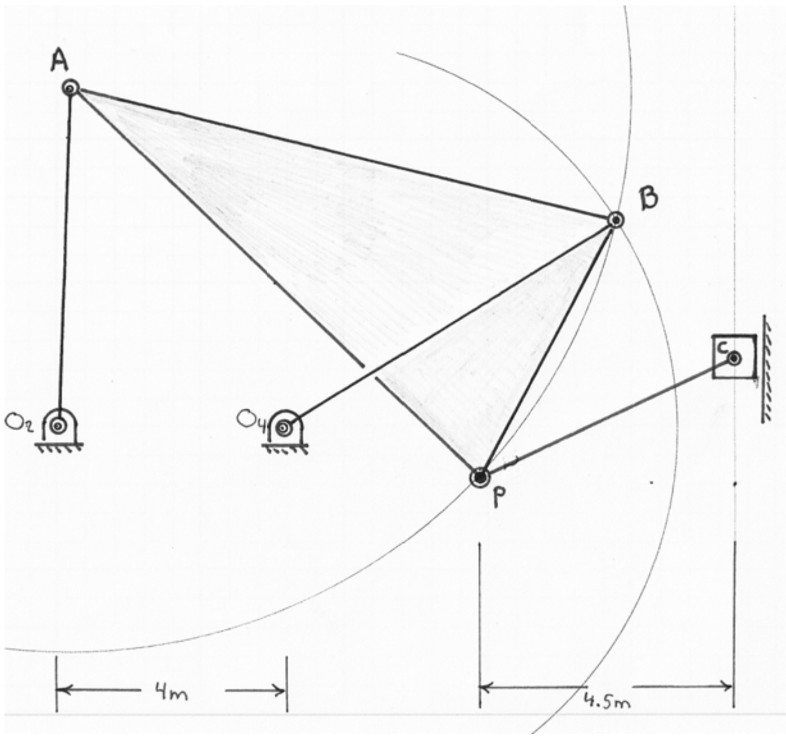
$$\frac{500}{F} = 4.1$$

$$\boxed{F = \frac{500}{4.1} = 122\,lb}$$



PROBLEM 4: (25pts) The dimensions for the mechanism shown below are as follows.

R_{O4O2}= 4m	R_{O4B}= 7m	Θ_2= 88°
R_{AO2}= 6m	R_{PA}= 10m	ω_2= -80 1/s
R_{BA}= 10m	∠BAP= 330°	R_{PC}=5m



Using the figure provided on the next page find the following quantities.

- All instant centers for this mechanism, make sure they are appropriately labeled.
- The angular velocities of each link of this mechanism.
- The linear velocities for points A, B, P, and C. Illustrate these values on the figure at the appropriate location.

$V_A = r_2 \omega_2 = (6m)(-80\,^1/_s) = \boxed{-480\,^m/_s}$

$\omega_3 = V_A / r_{I_{13}I_{23}} = (480\,^m/_s)/(8.6m) = \boxed{56\,^1/_s \text{ cw}}$

$V_{I_{24}} = r_{O_2I_{24}} \cdot \omega_2 = (25.7m)(-80\,^1/_s) = \boxed{-2056\,^m/_s}$

$\omega_4 = V_{I_{24}} / r_{O_4I_{24}} = (2056\,^m/_s)/(21.7m) = \boxed{94.7\,^1/_s \text{ cw}}$

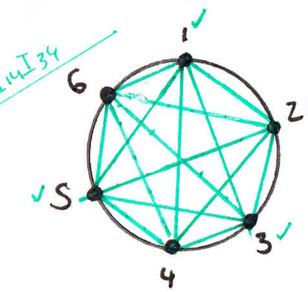
$V_B = r_{O_4I_{34}} \cdot \omega_4 = (7m)(94.7\,^1/_s) = \boxed{663\,^m/_s}$

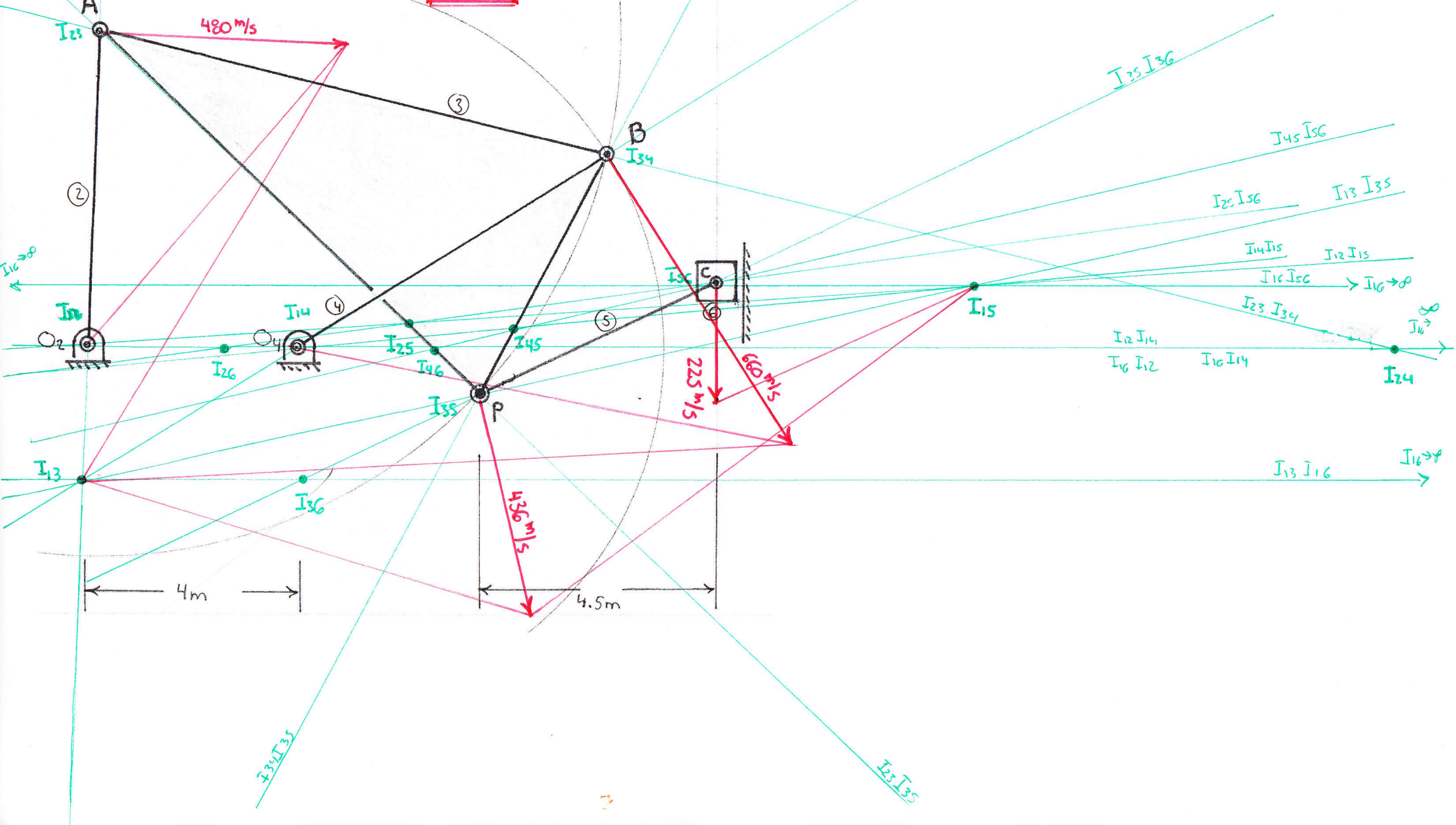
$= r_{I_{13}B} \cdot \omega_3 = (11.8m)(56\,^1/_s) = \boxed{660\,^m/_s}$

$V_P = r_{I_{13}P} \cdot \omega_3 = (7.8m)(56\,^1/_s) = \boxed{436\,^m/_s}$

$\omega_5 = V_P / r_{PI_{15}} = (436\,^m/_s)/(9.7m) = \boxed{44.9\,^1/_s \text{ ccw}}$

$V_C = r_{I_{15}C} \cdot \omega_5 = (5m)(44.9\,^1/_s) = \boxed{224.7\,^m/_s}$

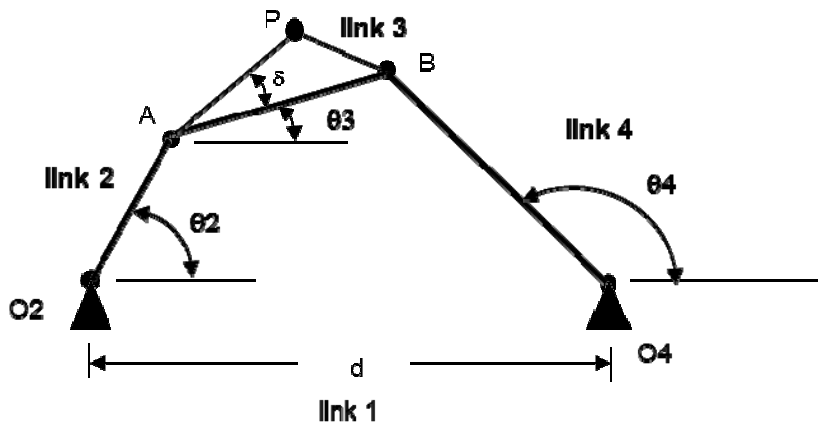




NAME: ______________________

PROBLEM 1: (25pts) The dimensions for the four bar linkage shown below are as follows.

L_1= 4m	L_4= 7m	Θ_2= 88°
L_2= 6m	R_{pa}= 10m	ω_2= -80 1/s
L_3= 10m	δ_3= 330°	α_2= 30 1/s^2



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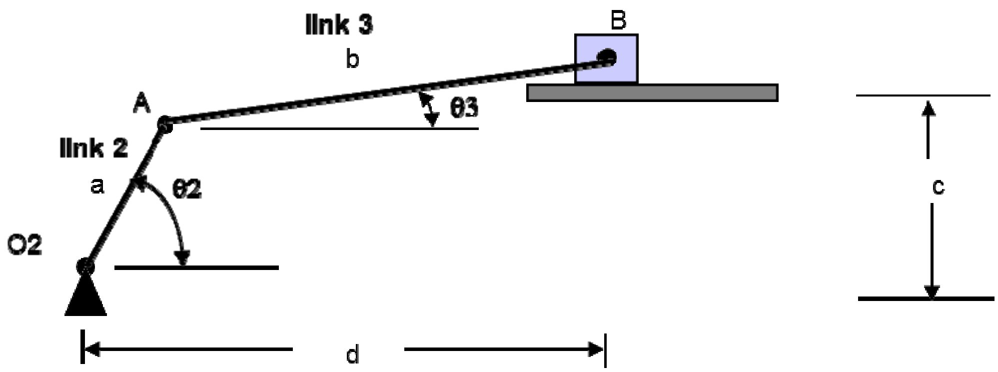
PROBLEM 2: (25pts) The dimensions for the slider crank mechanism shown below are as follows.

Offset= 0 m	Θ_2= 100°
L_2= 3 m	ω_2= -45 1/s
L_3= 13 m	α_2= 50 1/s^2



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- Relative accelerations of point B with respect to A in Cartesian and magnitude-unit vector forms.

Bonus: (5pts) The dimensions for the inverted slider crank mechanism shown below are as follows.

Link 1=0.8m.	Link 2=0.5m	Link 4=0.3m
γ=90°	θ_2=25°	ω_2=-50 /s
α_2=20 1/s^2		

Using the program you developed in class print out the values for the following quantities for both the crossed and open configurations. Insert your print out directly behind this page.

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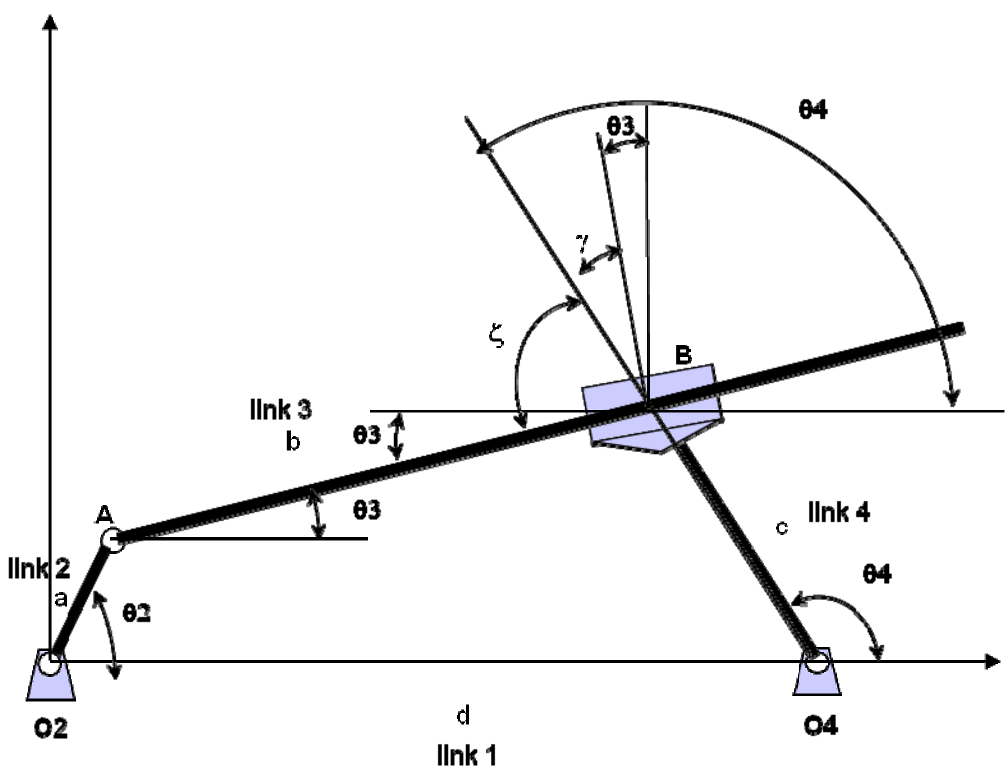
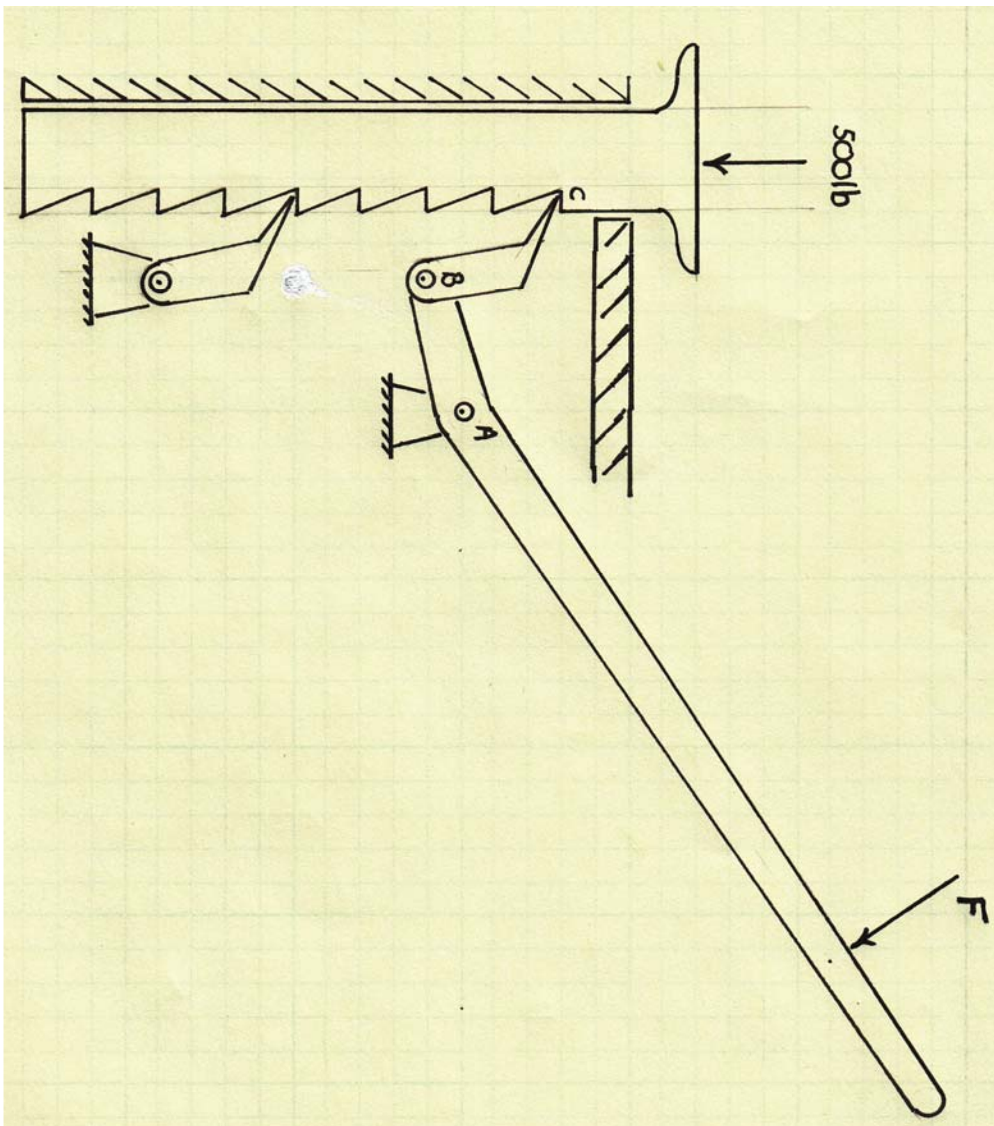


PROBLEM 3: (25pts) The figure below illustrates a mechanism that is found in a typical car jack. The load F is applied by the user and the 500lb represents the weight the jack is lifting. Point C in the ratchet can be treated as a pin joint during the lifting part of the motion.

Determine:

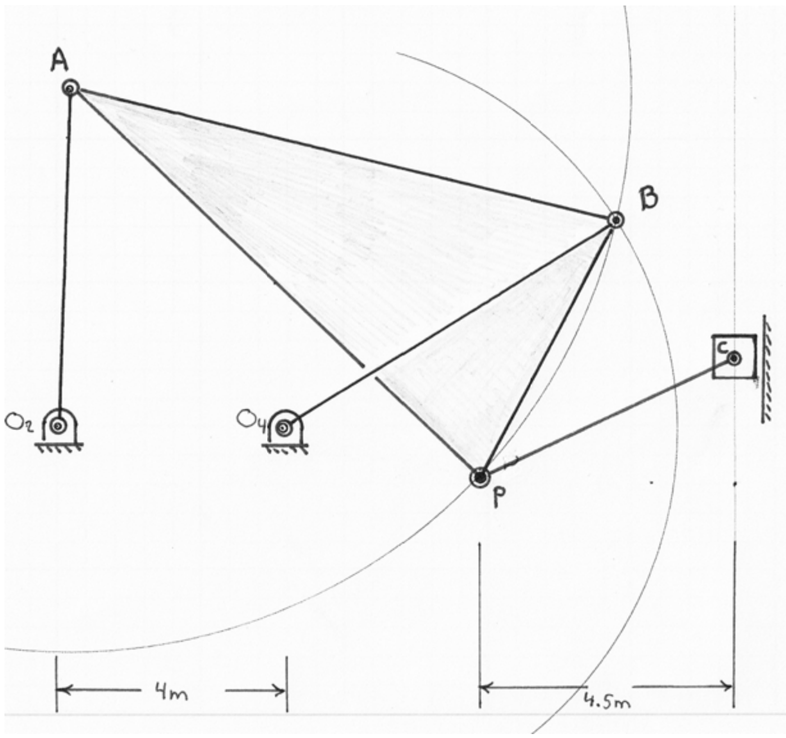
- The mechanical advantage of the mechanism.
- The value of F required to move the 500lb load upward.
- Suggest two ways to increase the mechanical advantage of the mechanism.
    1.

    2.



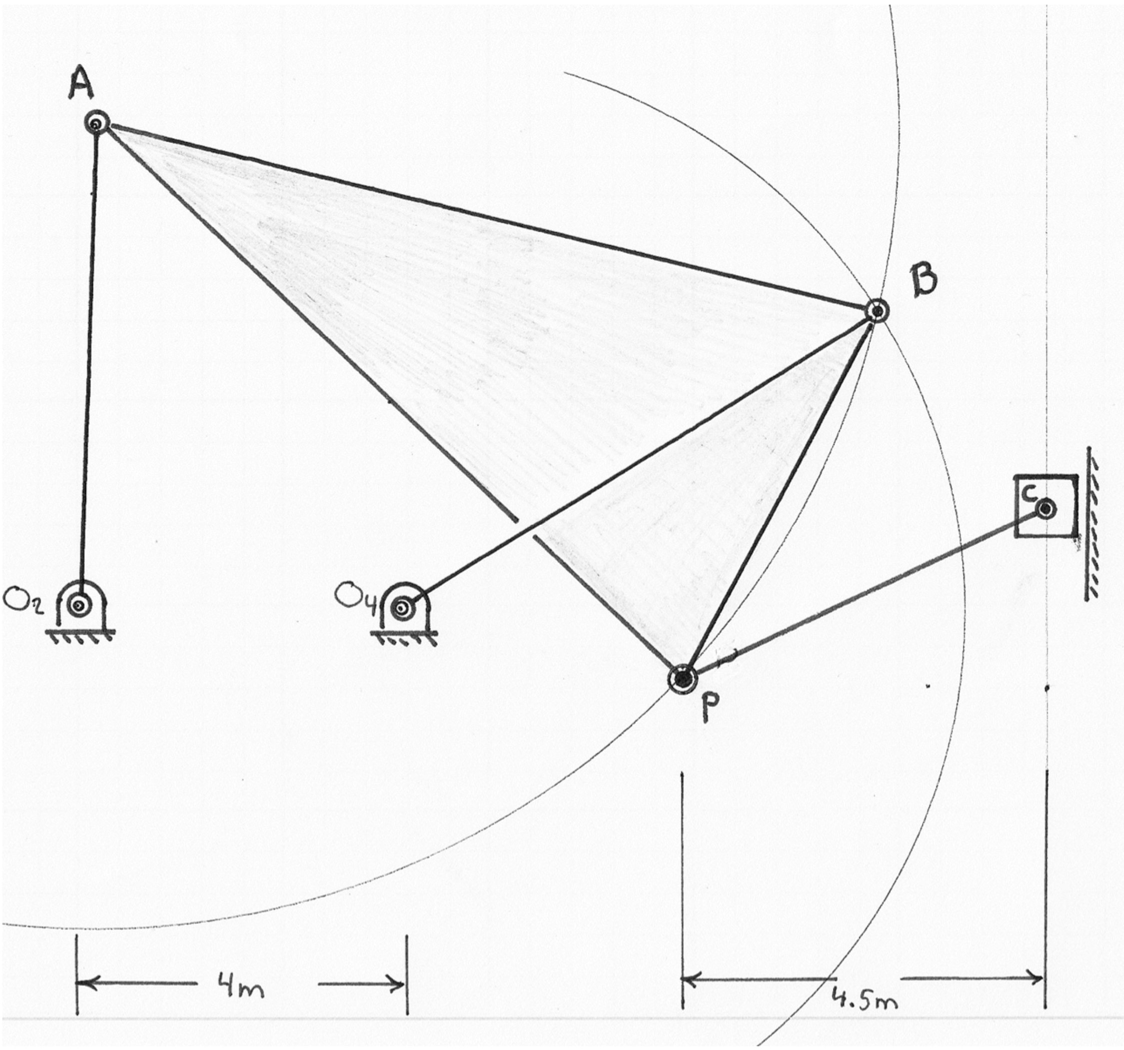
PROBLEM 4: (25pts) The dimensions for the mechanism shown below are as follows.

R_{O4O2}= 4m	R_{O4B}= 7m	Θ_2= 88°
R_{AO2}= 6m	R_{PA}= 10m	ω_2= -80 1/s
R_{BA}= 10m	$\angle$BAP= 330°	R_{PC}=5m



Using the figure provided on the next page find the following quantities.

- All instant centers for this mechanism, make sure they are appropriately labeled.
- The angular velocities of each link of this mechanism.
- The linear velocities for points A, B, P, and C. Illustrate these values on the figure at the appropriate location.


A
B
C
O2
O4
P
4m
4.5m