ME 481 - H04 **Name** ______________________

1) A trunnion mount hydraulic cylinder actuates the arm of a skid steer loader as shown below.

Write a geometric equation to determine lift angle θ when given cylinder/rod length e.

$e^2 = (AB)^2 + (AC)^2 - 2\,(AB)(AC)\cos\theta$

Compute lift angle θ for e = 40 inches. θ 61.131°

Write a geometric equation to determine lift speed $\dot{\theta}$ when given cylinder rod velocity $\dot{e}$.

$e\dot{e} = (AB)(AC)\,\dot{\theta}\,\sin\theta$ $\dot{e} = -12$ ips

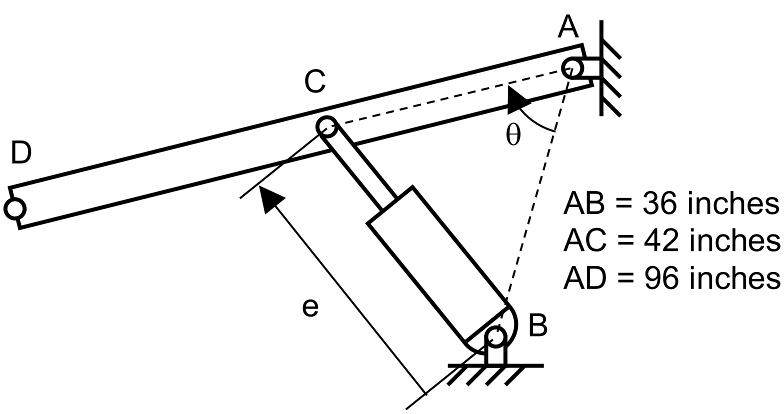
Compute lift speed $\dot{\theta}$ when the cylinder rod is retracting at 12 inches per second at this position.

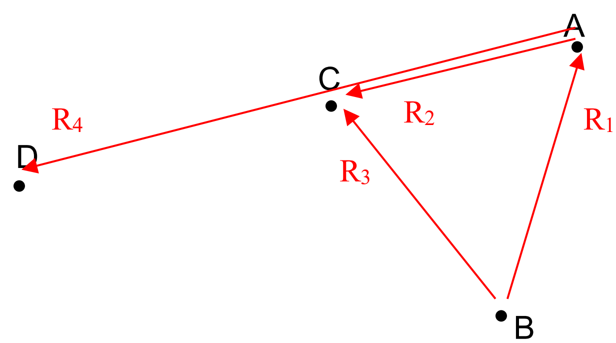
$\dot{\theta}$ -0.3625 rad/s = -20.77 deg/s

Use the dots to the right of the picture to draw and label complex number vectors that model this mechanism. Write a position loop equation to analyze this mechanism.

$\overline{R}_1 + \overline{R}_2 - \overline{R}_3 = 0$

For each vector in your loop equation, complete the table describing if the length and angle of each vector are constant, variable, constrained or driver information.





Vector #	Length	Angle
1	constant	constant
2	constant	variable
3	driver	variable
4	constant	constrained

ME 481 - H04 **Name** ________________________

2) Program the two variable Newton-Raphson algorithm for position analysis of a four bar mechanism as shown in Notes_03_02 and Notes_03_03. Complete the table shown below. Provide hardcopy of your code.

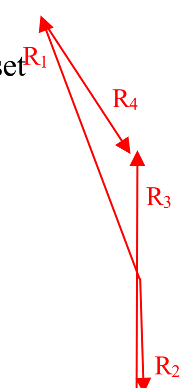
Given: $r_1 = 90$ cm, $r_2 = 30$ cm, $r_3 = 60$ cm, $r_4 = 45$ cm, $\theta_1 = 0°$, $\theta_2 = 10°$

k	$\{q\} = \begin{Bmatrix}\theta_3 \\ \theta_4\end{Bmatrix}$ [deg]	$\{\Phi\} = \begin{Bmatrix}f_H \\ f_V\end{Bmatrix}$ [cm]	$[\partial\Phi / \partial q]$ [cm/rad]	$[\partial\Phi / \partial q]^{-1}\{\Phi\}$ [rad]	$[\partial\Phi / \partial q]^{-1}\{\Phi\}$ [deg]
1	0 90	-0.4558 -39.7906	0 45.0000 60.0000 -0.0000	-0.6632 -0.0101	-37.9972 -0.5803
2	37.9972 90.5803	-12.7175 -2.8509	-36.9374 44.9977 47.2825 0.4558	-0.0571 -0.3295	-3.2727 -18.8797
3	41.2698 109.4600	-0.3674 2.3565	-39.5764 42.4293 45.0967 14.9917	0.0421 0.0306	2.4112 1.7530
4	38.8587 107.7071	-0.0472 -0.0146	-37.6441 42.8681 46.7218 13.6868	0.0000 -0.0011	0.0005 -0.0627
5	38.8581 107.7697	-0.00000820 0.00002564	det$[\Phi_q]$= -2519.2		

Check your solution by another method. Show your work. θ_3 38.86° θ_4 107.77°

checked using "Notes_03_01_four_bar_angles.xls"

3) Use your Newton-Raphson code to find θ_3 and θ_4 for the four bar portion of the sewing machine on page 5 of Notes_03_04 when the crank is straight down. Do not analyze the offset slider crank portion.



Given: $r_1 = 4.07$ cm, $r_2 = 1.60$ cm, $r_3 = 3.57$ cm, $r_4 = 2.24$ cm, $\theta_1 = 110.4°$, $\theta_2 = 270°$

θ_3 92.45° θ_4 304.41°

EXTRA CREDIT

Modify your Newton-Raphson algorithm to find θ_2 and θ_4 when $\theta_3 = 0°$ for the four bar in part 2) above. Provide hardcopy of your code.

θ_2 97.18° θ_4 138.59° checked using "Notes_03_01_four_bar_angles.xls"

```
% h04_02_03.m - ME 481 H04 Newton-Raphson for four bar
%   parts 2) and 3)
% HJSIII, 15.02.04

clear

% constants
d2r = pi /180;

% lengths and angles
r      = [ 90  30  60  45 ];  % [cm]  - part 2
th_deg = [  0  10   0  90 ];  % [deg] - part 2

r      = [ 4.07   1.60  3.57  2.24 ];  % [cm]  - part 3
th_deg = [ 110.4  135   60    0    ];  % [deg] - part 3 posture in drawing
th_deg = [ 110.4  270   90    330  ];  % [deg] - part 3 crank straight down

th = th_deg * d2r;

% iteration loop
q = [ th(3)  th(4) ]';
for iter = 1 : 5,
  th(3) = q(1);
  th(4) = q(2);
  iter
  q_deg = q / d2r

  PHI = [ r(2)*cos(th(2))+r(3)*cos(th(3))-r(4)*cos(th(4))-r(1)*cos(th(1)) ;
          r(2)*sin(th(2))+r(3)*sin(th(3))-r(4)*sin(th(4))-r(1)*sin(th(1)) ]

  JAC = [ -r(3)*sin(th(3))   r(4)*sin(th(4)) ;
           r(3)*cos(th(3))  -r(4)*cos(th(4)) ]

  update = inv(JAC) * PHI

  update_deg = update / d2r

  q = q - update;
  pause
end

det_JAC = det(JAC)

% bottom of h04_02_03
```

ME 481 - H04 Name ________________________

```
% h04_ec.m - ME 481 H04 Newton-Raphson for four bar
%   extra credit
% HJSIII, 15.02.04

clear

% constants
d2r = pi /180;

% lengths and angles
r      = [ 90  30  60   45 ];  % [cm]
th_deg = [  0  97   0  138 ];  % [deg]
th = th_deg * d2r;

% iteration loop
q = [ th(2)  th(4) ]';
for iter = 1 : 5,
  th(2) = q(1);
  th(4) = q(2);
  iter
  q_deg = q / d2r

  PHI = [ r(2)*cos(th(2))+r(3)*cos(th(3))-r(4)*cos(th(4))-r(1)*cos(th(1)) ;
          r(2)*sin(th(2))+r(3)*sin(th(3))-r(4)*sin(th(4))-r(1)*sin(th(1)) ]

  JAC = [ -r(2)*sin(th(2))   r(4)*sin(th(4)) ;
           r(2)*cos(th(2))  -r(4)*cos(th(4)) ]

  update = inv(JAC) * PHI

  update_deg = update / d2r

  q = q - update;
  pause
end

det_JAC = det(JAC)

% bottom of h04_ec
```