Mechanics of Machinery Final Report

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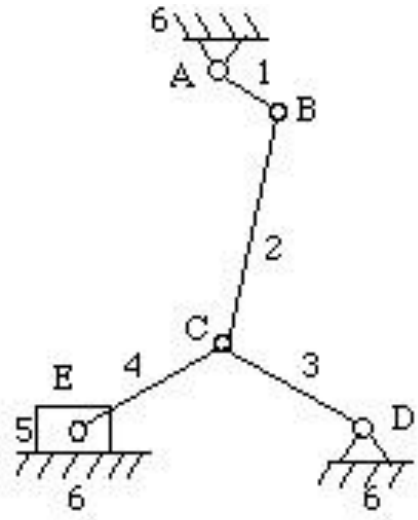
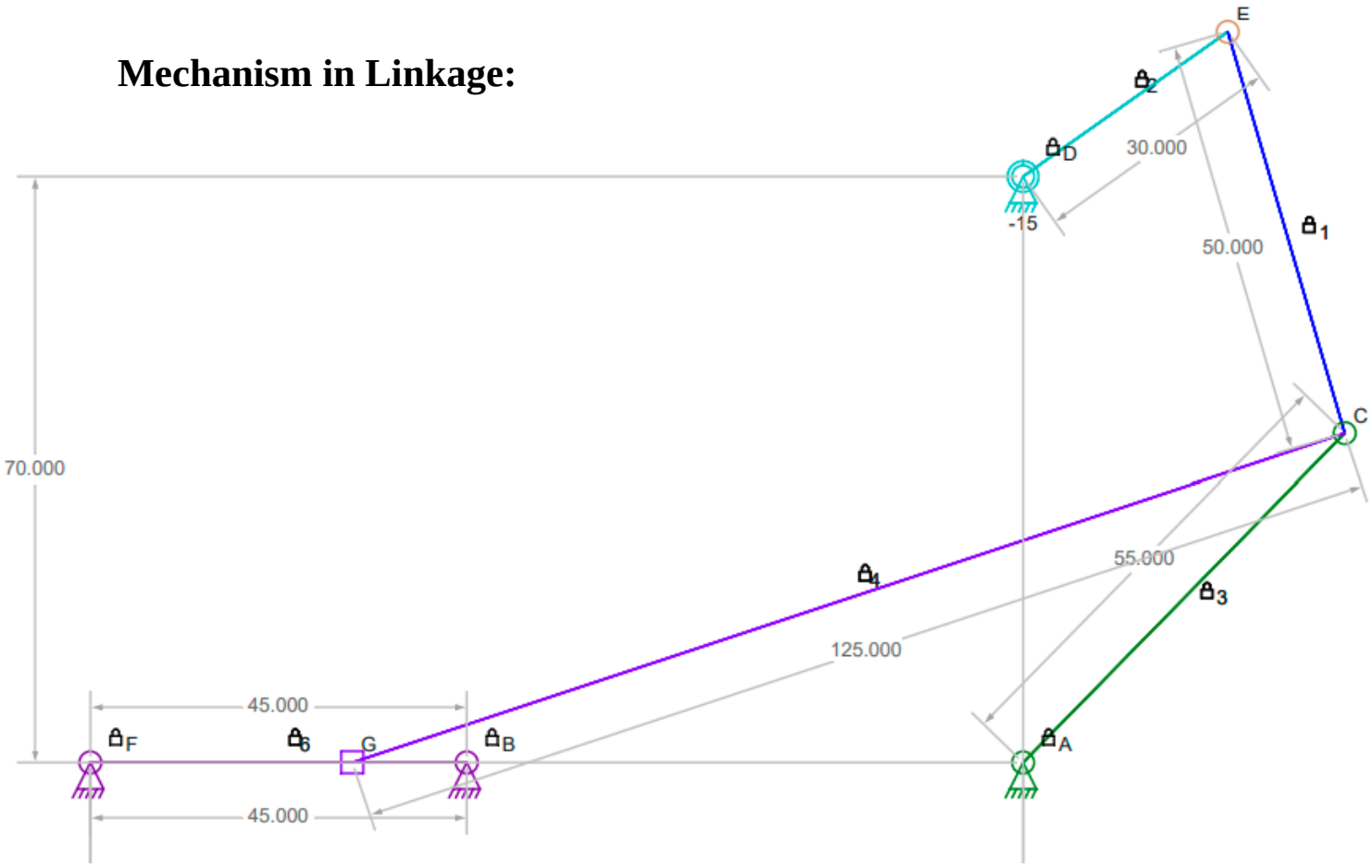
46-6804

T-29

Mechanism under study:

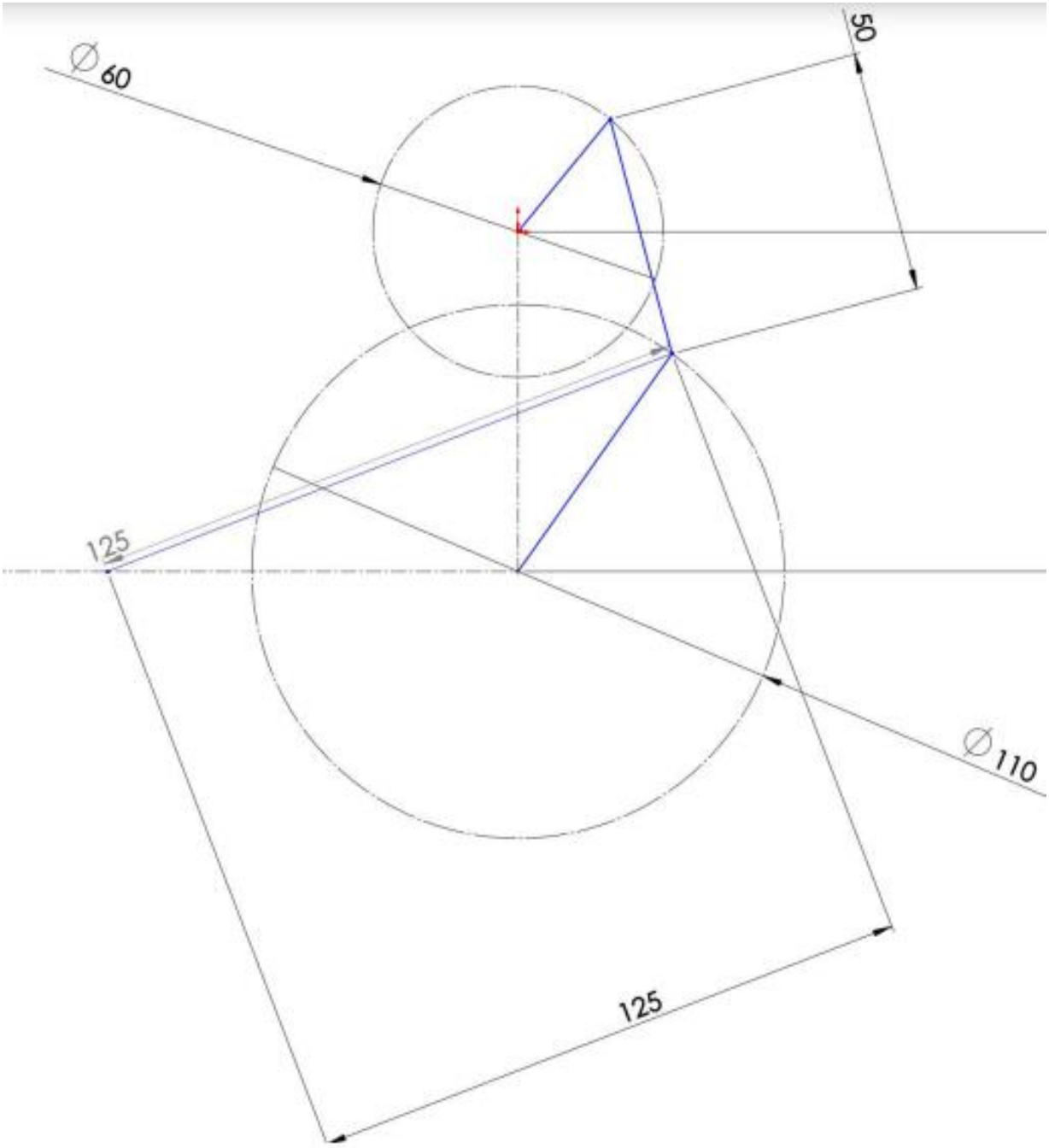


Mechanism in Linkage:

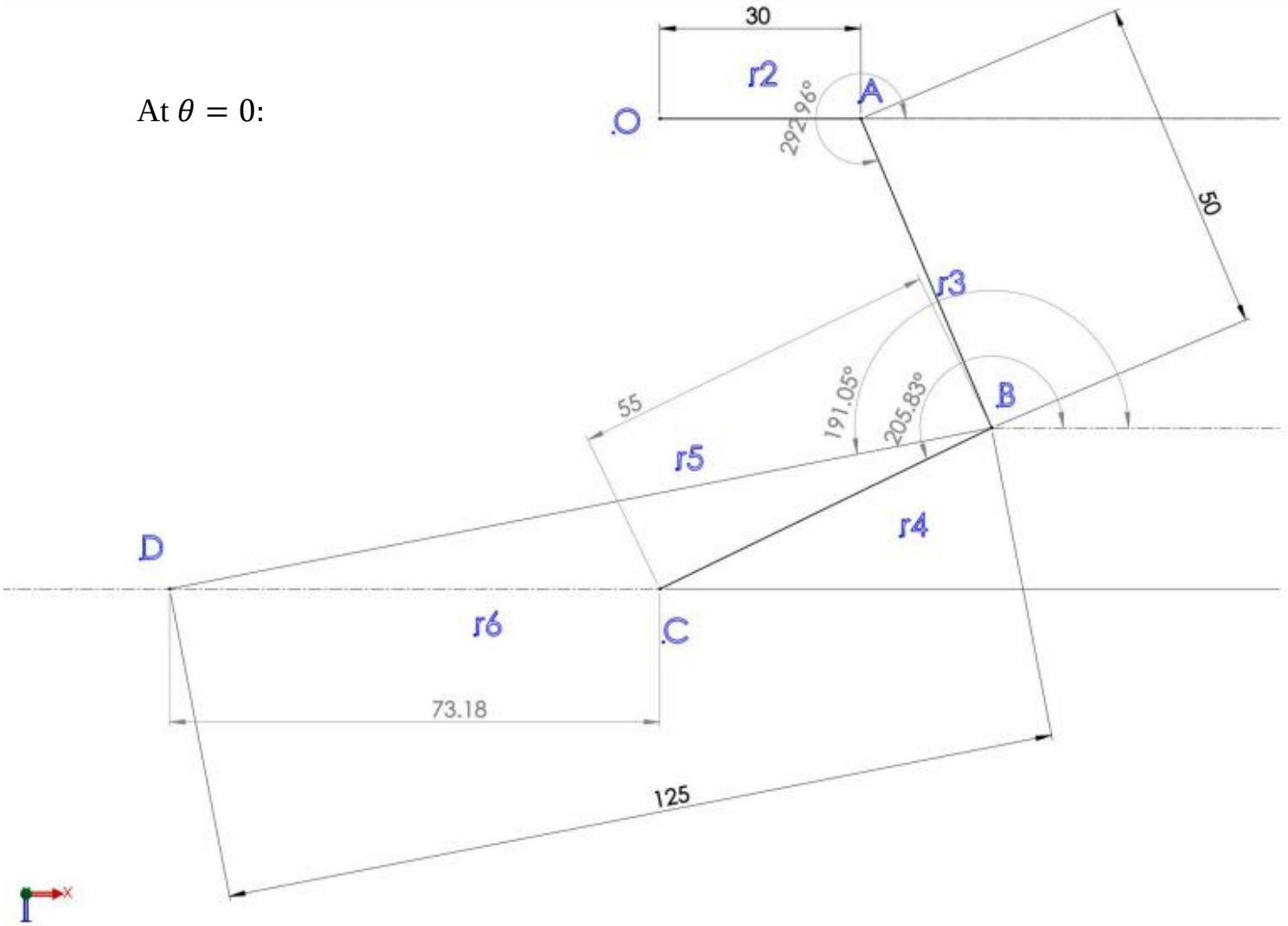


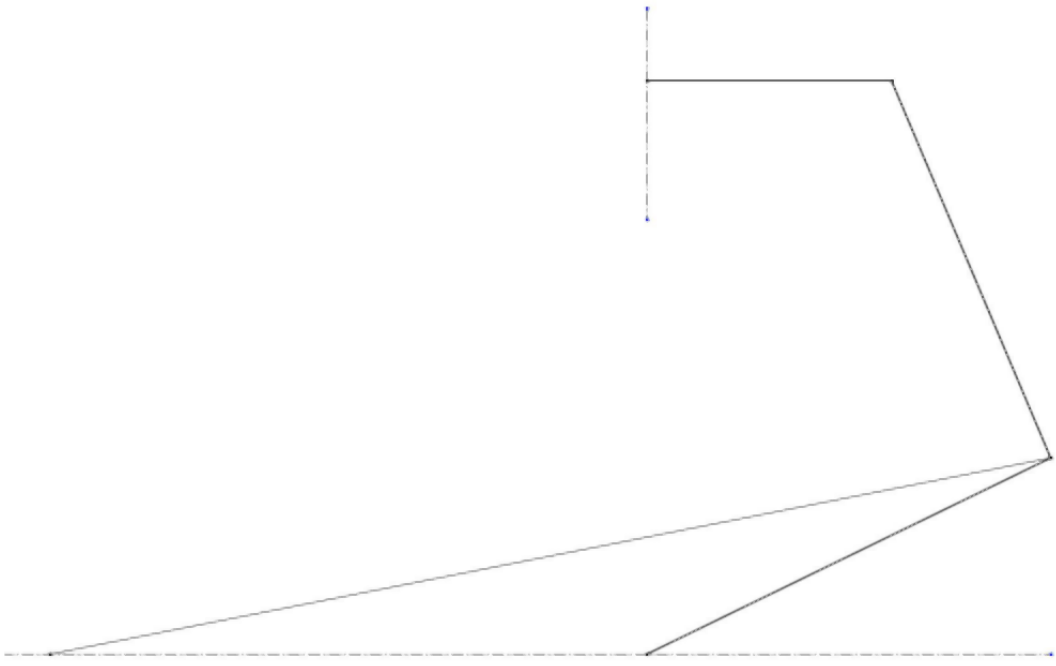
SolidWorks 2D Graphical Analysis:

- **Position Analysis**

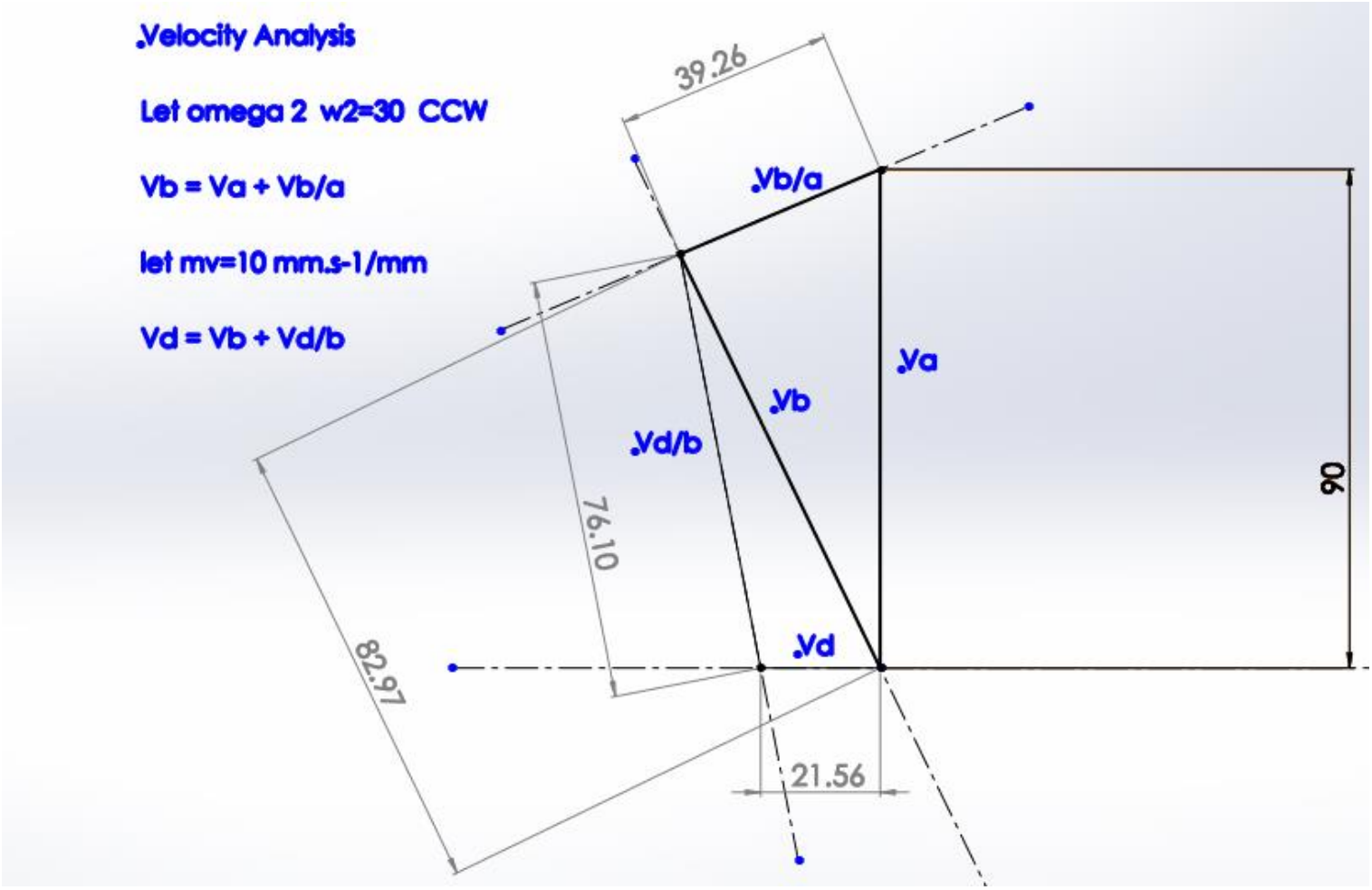


At $\theta = 0$:

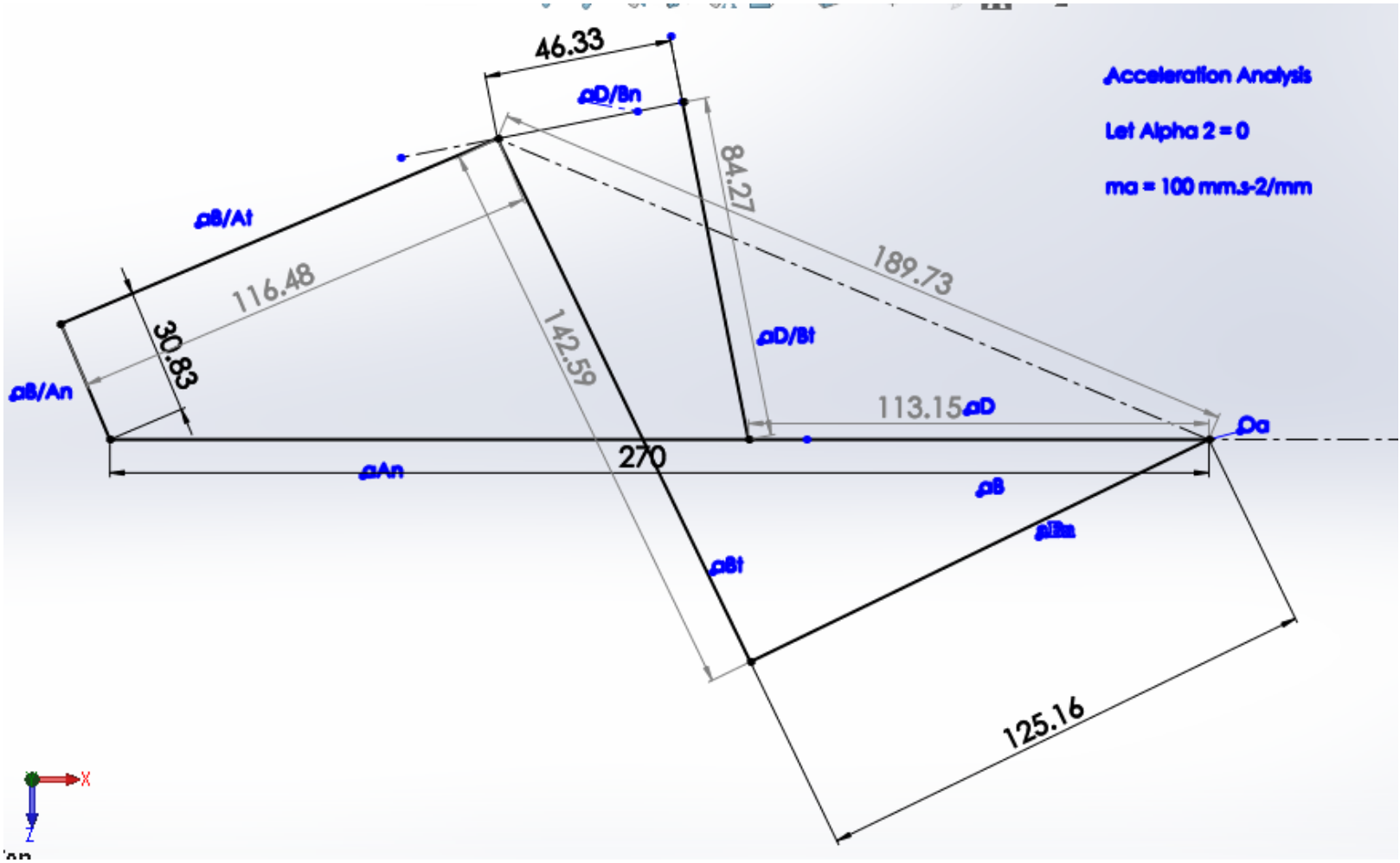




- **Velocity Analysis**



- **Acceleration Analysis:**



MATLAB Codes

Main Script:

```
close
clc %this line just clears your command window
clear
i=1;
options = optimset('display', 'off');

r=[70 30 50 55 125];
w2=30; %rad/sec
th1=270*pi/180;
prev_w3 = 1;
prev_w4 = 1;
for theta=0:1:360
    the(i)=theta*pi/180; % saves each value of the input theta in an array
    % Where theta is theta 2
    theta34(:,i)=fsolve(@position_1,[5.23 3.9],options,the(i),r);
    thetas = [th1 the(i) theta34(:,i)'];
    if theta34(1,i)<0
        theta34(1,i)=theta34(1,i)+2*pi;
    end
    if theta34(2,i)<0
        theta34(2,i)=theta34(2,i)+2*pi;
    end
    if theta34(1,i)>2*pi
        theta34(1,i)=theta34(1,i)-2*pi;
    end
    if theta34(2,i)>2*pi
        theta34(2,i)=theta34(2,i)-2*pi;
    end

    theta4=theta34(2,i);

    theta5r6(:,i)=fsolve(@position_2,[3.9 70],options,theta4,r);

    if theta5r6(1,i) < 0
        theta5r6(1,i)=theta5r6(1,i)+2*pi;
    end
    if theta5r6(1,i) > 2*pi
        theta5r6(1,i)=theta5r6(1,i)-2*pi;
    end
    thetas(5)=theta5r6(1,i);

    omega34(:,i)=fsolve(@velocity_1,[prev_w3 prev_w4], options, thetas, r,
w2);

    omegas = [0 w2 omega34(:,i)'];
    prev_w3 = omega34(1,i);
    prev_w4 = omega34(2,i);
    w4=omegas(4);
    omega5r6d(:,i)=fsolve(@velocity_2,[50 1], options, thetas, r, w4);
    omegas(5)=omega5r6d(1,i);
```

```
    alpha2=0;
    alpha34(:,i)=fsolve(@acceleration_1,[240 230], options, thetas, r,
omegas, alpha2);
    alpha4=alpha34(2,i);
    alpha5r6dd(:,i)=fsolve(@acceleration_2,[20 18100], options, thetas, r,
omegas, alpha4);

    i=i+1;
end
theta34=theta34*180/pi;
theta5r6(1,:)=theta5r6(1,:)*180/pi;

the = the*180/pi;
m=3;
n=4;
subplot(m,n,1)
plot(the(1,:),theta34(1,:)); legend('\theta_3')

subplot(m,n,2)
plot(the(1,:),theta34(2,:)); legend('\theta_4')

subplot(m,n,3)
plot(the(1,:),theta5r6(1,:)); legend('\theta_5')

subplot(m,n,4)
plot(the(1,:),theta5r6(2,:)); legend('r_6')

subplot(m,n,5)
plot(the(1,:),omega34(1,:)); legend('\omega_3')

subplot(m,n,6)
plot(the(1,:),omega34(1,:)); legend('\omega_4')

subplot(m,n,7)
plot(the(1,:),omega5r6d(1,:)); legend('\omega_5')

subplot(m,n,8)
plot(the(1,:),omega5r6d(2,:)); legend('v_6')

subplot(m,n,9)
plot(the(1,:),alpha34(1,:)); legend('\alpha_3')

subplot(m,n,10)
plot(the(1,:),alpha34(2,:)); legend('\alpha_4')

subplot(m,n,11)
plot(the(1,:),alpha5r6dd(1,:)); legend('\alpha_5')

subplot(m,n,12)
plot(the(1,:),alpha5r6dd(2,:));
hl = legend('$\ddot{r}_6$')
set(hl, 'Interpreter', 'latex');
grid;
```

Position1:

```
function w=position_1(output, th2, r)
r1=r(1);
r2=r(2);
r3=r(3);
r4=r(4);
th1=270*pi/180;

th3 = output(1);
th4 = output(2);
w=[-r1 * cos(th1) + r2 * cos(th2) + r3 * cos(th3) + r4 * cos(th4);
   -r1 * sin(th1) + r2 * sin(th2) + r3 * sin(th3) + r4 * sin(th4)];
end
```

Position2:

```
function w=position_2(output, th4, r)
r4=r(4);
r5=r(5);

th6=pi;

th5 = output(1);
r6 = output(2);

w=[ - ( r5 * cos(th5) ) + r4  * cos(th4) + r6 * cos(th6);

    - ( r5 * sin(th5) ) + r4 * sin(th4) + r6 * sin(th6);
  ];
end
```

Velocity1:

```
function w=velocity_1(output, theta, r, w2)
r1=r(1);
r2=r(2);
r3=r(3);
r4=r(4);

th2=theta(2);
th3=theta(3);
th4=theta(4);

w3=output(1);
w4=output(2);

w = [ w2 * r2 * cos(th2) + w3 * r3 * cos(th3) + w4 * r4 * cos(th4) ;

      w2 * r2 * sin(th2) + w3 * r3 * sin(th3) + w4 * r4 * sin(th4) ;
    ];
end
```

Velocity2:

```
function w=velocity_2(output, theta, r, w4)
r4=r(4);
r5=r(5);
th6=pi;

th4=theta(4);
th5=theta(5);

w5=output(1);
r6_dot=output(2);

w = [ w5 * r5 * sin(th5) + ...
     -w4 * r4 * sin(th4) + ...
      r6_dot * cos(th6) ;
    - w5 * r5 * cos(th5) + ...
      w4 * r4 * cos(th4) + ...
      r6_dot * sin(th6) ;
    ];
end
```

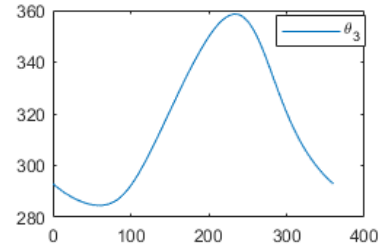
Acceleration1:

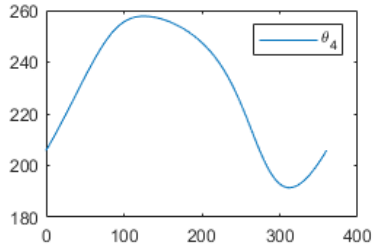
```
function w=acceleration_1(output, theta, r, w,a2)
r1=r(1);
r2=r(2);
r3=r(3);
r4=r(4);

%th1=theta(1);
th2=theta(2);
th3=theta(3);
th4=theta(4);

%w1=w(1);
w2=w(2);
w3=w(3);
w4=w(4);

a3=output(1);
a4=output(2);

w=[ -w2^2 * r2 * cos(th2) - a2 * r2 * sin(th2) + ...
    -w3^2 * r3 * cos(th3) - a3 * r3 * sin(th3) + ...
    -w4^2 * r4 * cos(th4) - a4 * r4 * sin(th4) ;

    -w2^2 * r2 * sin(th2) + a2 * r2 * cos(th2) + ...
    -w3^2 * r3 * sin(th3) + a3 * r3 * cos(th3) + ...
    -w4^2 * r4 * sin(th4) + a4 * r4 * cos(th4)
  ];
end
```

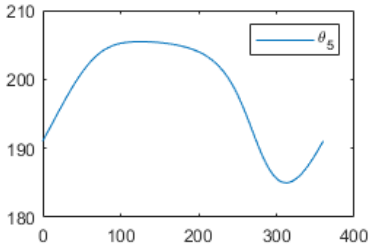
Acceleration2:

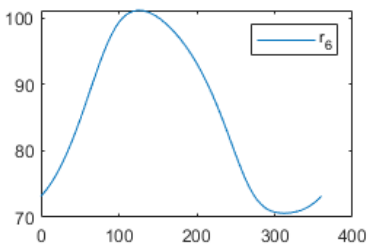
```
function w=acceleration_2(output, theta, r, w,a4)
r4=r(4);
r5=r(5);


th4=theta(4);
th5=theta(5);
th6=pi;

w4=w(4);
w5=w(5);

a4=a4;

a5=output(1);
r6_ddot=output(2);

w=[  -( -w5^2 * r5 * cos(th5) - a5 * r5 * sin(th5))+ ...
        -w4^2 * r4 * cos(th4) - a4 * r4 * sin(th4) + ...
        +r6_ddot * cos(th6) ;

     -( -w5^2 * r5 * sin(th5) + a5 * r5 * cos(th5))+ ...
        -w4^2 * r4 * sin(th4) + a4 * r4 * cos(th4) + ...
        +r6_ddot * sin(th6) ;
  ];
end
```

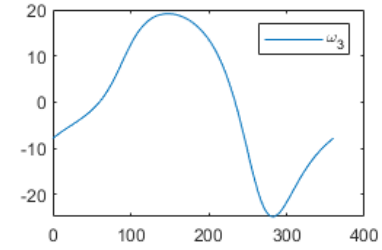
MATLAB Simulations:

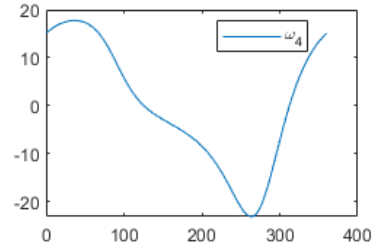


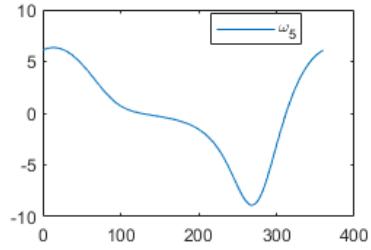


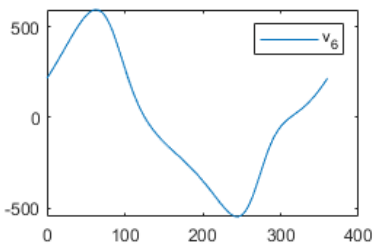


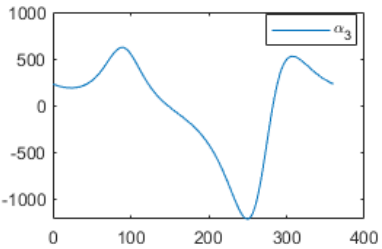


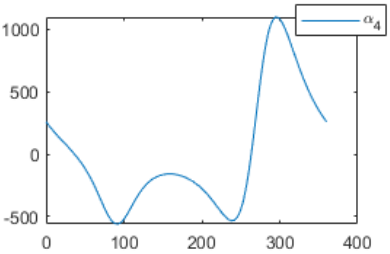


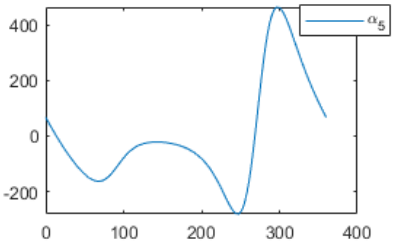


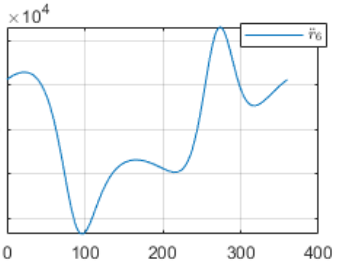












Comparing Results

for $\theta_2 = 0$, $\omega_2 = 30\ rad/s$ CCW, $\alpha_2 = 0$	MATLAB	SolidWorks
θ_3	292.9618	292.96
θ_4	205.8278	205.83
θ_5	191.0517	191.05
r_6	73.1759 mm	73.18
ω_3	-7.8519 rad/s	-7.852 CW
ω_4	15.0859 rad/s	15.085 CCW
ω_5	6.0876 rad/s	6.088 CCW
$\dot{r}_6$	215.6149 mm/s	215.6
α_3	232.9229 rad/s2	232.96 CCW
α_4	259.2629 rad/s2	259.2545 CCW
α_5	67.4077 rad/s2	67.416 CCW
$\ddot{r}_6$	11317 mm/s2	11315