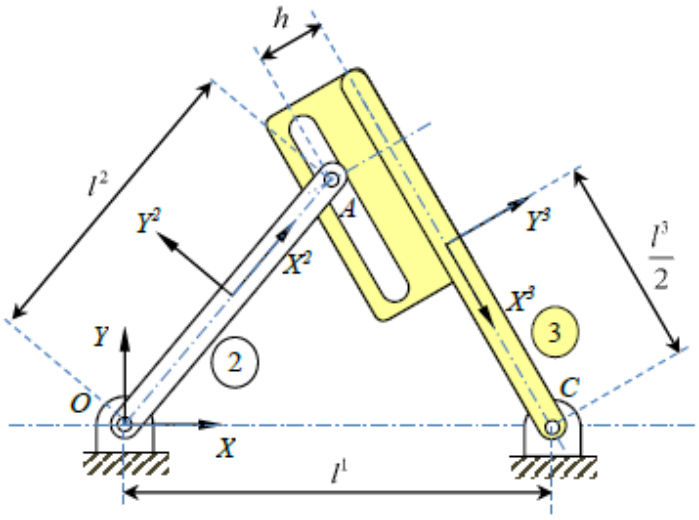
three bar mechanism



(4) Three bar mechanism

l^1	0.6 m	θ^1	0 °
l^2	0.3 m	θ^2	60 °
l^3	0.8 m	θ^3	-52.64 °
h	0.2 m	ω^2	4 rad/s

Plot (for a simulation time of 2 seconds)

1. θ^4 versus time
2. $\dot{\theta}^4$ versus time
3. The trace of a point (0.15, 0.25) defined in body 4 coordinate system.

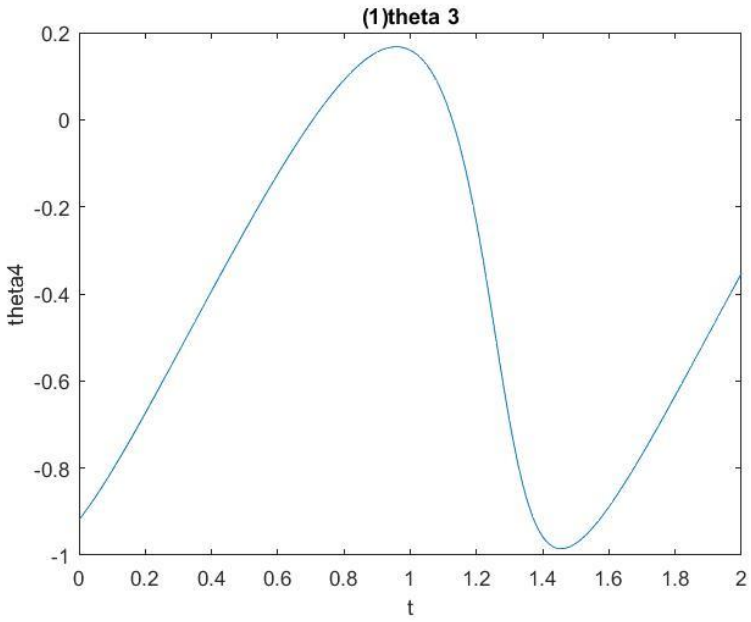
Code

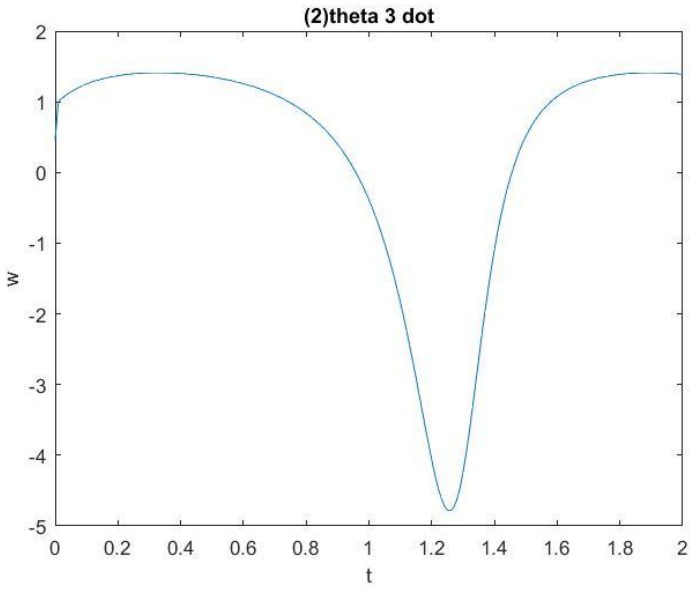
```
% three bar mechanism
clear all
close all
clc
l1=0.6; l2=0.3; l3=0.8; h=0.2; omg2=4; tho1=0;
tho2=60*pi/180; tho3 =(-52.64*pi)/180; a=0;
dt=0.01;% Step size
t_end=2; t_start=0;
n_sol=(t_end-t_start)/dt+1; %Number of Steps
error_tol=1.0E-6;

Res_mat=zeros(n_sol,28);

q_num=[0 0 0 0.5*l2*cos(tho2) 0.5*l2*sin(tho2) tho2 l1-
.5*l3*cos(tho3) .5*l3*sin(-tho3) tho3];
qd_num=zeros(1,9);
qdd_num=zeros(1,9);


syms q1 q2 q3 q4 q5 q6 q7 q8 q9  t
syms qd1 qd2 qd3 qd4 qd5 qd6 qd7 qd8 qd9
q=[q1 q2 q3 q4 q5 q6 q7 q8 q9 ];
qd=[qd1 qd2 qd3 qd4 qd5 qd6 qd7 qd8 qd9 ];

C=[ q1;
    q2;
    q3;
    q4-0.5*l2*cos(q6);
    q5-0.5*l2*sin(q6);
  (q4+0.5*l2*cos(q6)-q7+a*cos(q9)-h*sin(q9))*-
sin(q9)+(q5+0.5*l2*sin(q6)-q8+a*sin(q9)+h*cos(q9))*cos(q9);
    q7+0.5*l3*cos(q9)-l1;
    q8+0.5*l3*sin(q9);
    q6-omg2*t-tho2];
% For podition
Cq=jacobian(C,q);
% For velocity you need also
Ct=diff(C,t);
% For acceleration you need in addition to Cq the following
Ctt=diff(Ct,t);
Cqt=diff(Cq,t);

Cq_qd=Cq*qd.';
Cq_qdq=jacobian(Cq_qd,q);
```

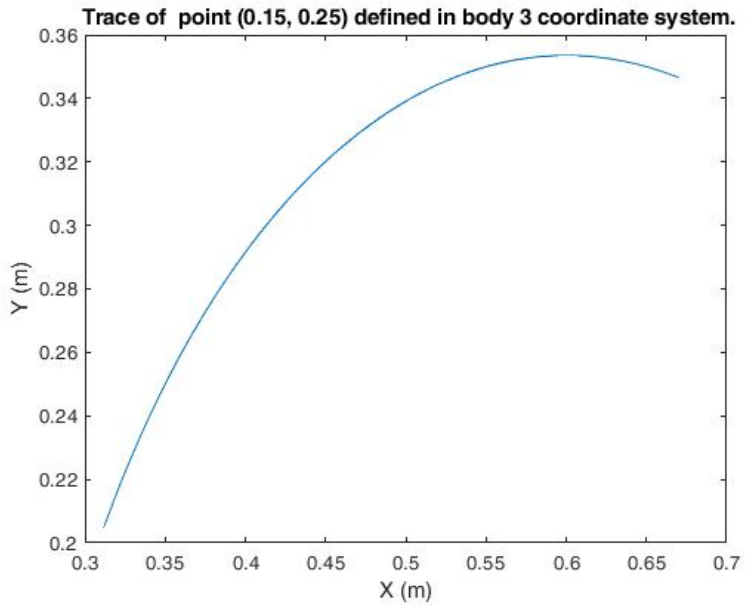
```
Qd=-Cq_qdq*qd.'-2*Cqt*qd.'-Ctt;


% At t=0
% For verification
C_num1=subs(C,q,q_num);
C_num2=subs(C_num1,t,0);
Cq_num=subs(Cq,q,q_num);
qd_num=-(Cq_num\Ct)';

Qd_num1=subs(Qd,q,q_num);
Qd_num2=subs(Qd_num1,qd,qd_num);
qdd_num=Cq_num\Qd_num2;

Res_mat(1,2:10)=q_num;
Res_mat(1,11:19)=qd_num;
Res_mat(1,20:28)=qdd_num;
Res_mat(1:n_sol,1)=t_start:dt:t_end;



for i_res=2:n_sol
    t_num=Res_mat(i_res,1);
    q_num_n=Res_mat(i_res-1,2:10)+dt*Res_mat(i_res-
1,11:19);
    error1=1.0;
    while abs(error1)>error_tol,
    C_num1=subs(C,q,q_num_n);
    C_num2=subs(C_num1,t,t_num);
    Cq_num=subs(Cq,q,q_num_n);

    C_num2 = vpa(C_num2);
    C_num2 = simplify(C_num2);
    Cq_num = vpa(Cq_num);
    Cq_num = simplify(Cq_num);

    d_q_num_n=-(Cq_num\C_num2)';
    q_num_np1=q_num_n+d_q_num_n;
    error1=eval(norm(C_num2));
    error2=eval(norm(d_q_num_n));
    q_num_n=q_num_np1;

    end

    Cq_num=subs(Cq,q,q_num_n);
```

```
    qd_num=-(Cq_num\Ct)';

    Qd_num1=subs(Qd,q,q_num_n);
    Qd_num2=subs(Qd_num1,qd,qd_num);
    qdd_num=Cq_num\Qd_num2;

    Res_mat(i_res,2:10)=q_num_n;
    Res_mat(i_res,11:19)=qd_num;
    Res_mat(i_res,20:28)=qdd_num;

end

%required(1)
figure(1);
plot(Res_mat(:,1), Res_mat(:,10));
title('(1)theta 3');
xlabel('t');
ylabel('theta4');

%required(2)
figure(2);
plot(Res_mat(:,1),Res_mat(:,19));
title('(2)theta 3 dot');
xlabel('t');
ylabel('w');

%required(3)
figure(3);
PX= Res_mat(:,8)+ 0.15*cos(Res_mat(:,10))-0.25*sin(Res_mat
(:,10));
PY=
Res_mat(:,9)+0.15*sin(Res_mat(:,10))+0.25*cos(Res_mat(:,10)
);
plot(PX,PY);
title('(3) Trace of  point (0.1, 0.15) defined in body 3
coordinate system.');
xlabel('x');
ylabel('y');
```

Result


(1)theta 3
theta4
t
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


(2)theta 3 dot
w
t
2
1
0
-1
-2
-3
-4
-5
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2


Trace of point (0.15, 0.25) defined in body 3 coordinate system.
Y (m)
X (m)
0.36
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7