SIMULATION OF A ROBOT ARM
DRAWING THE WORDS "21ECE"

PROJECT

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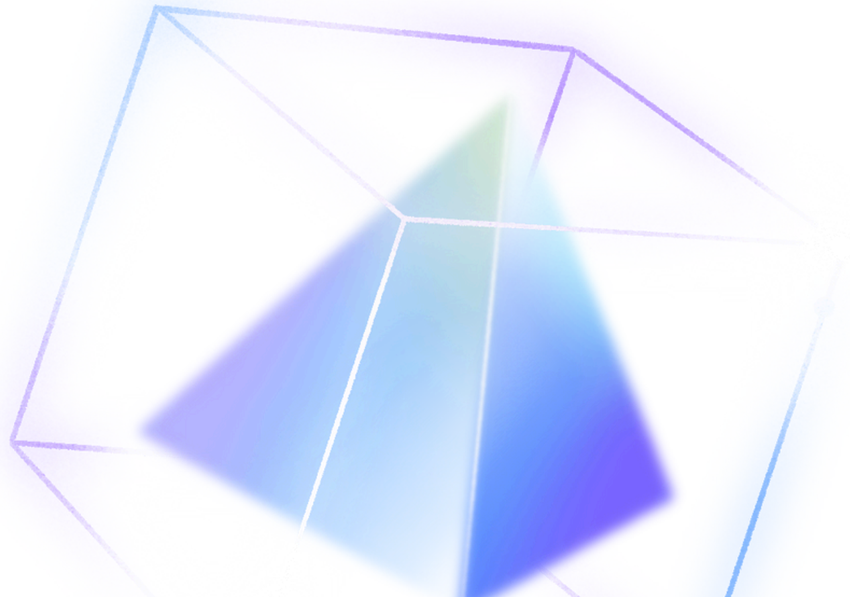
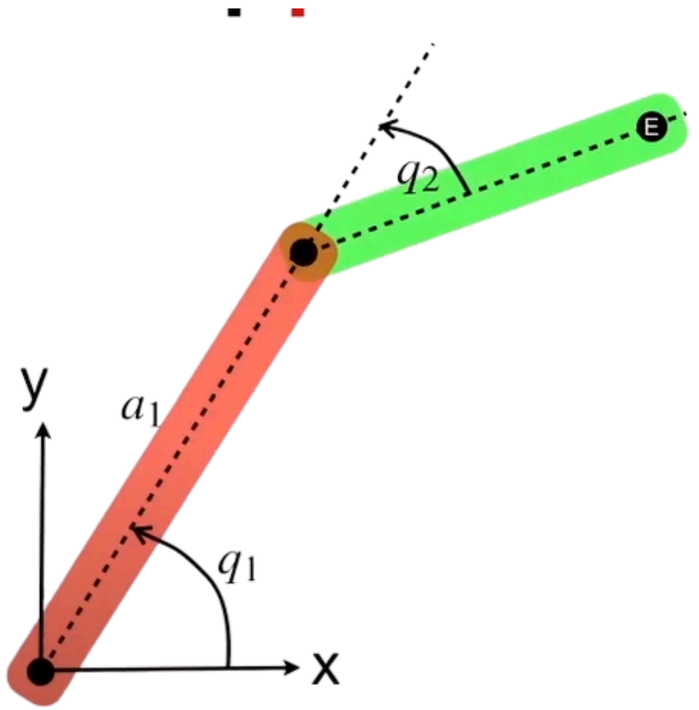


2DOF ROBOT MODEL

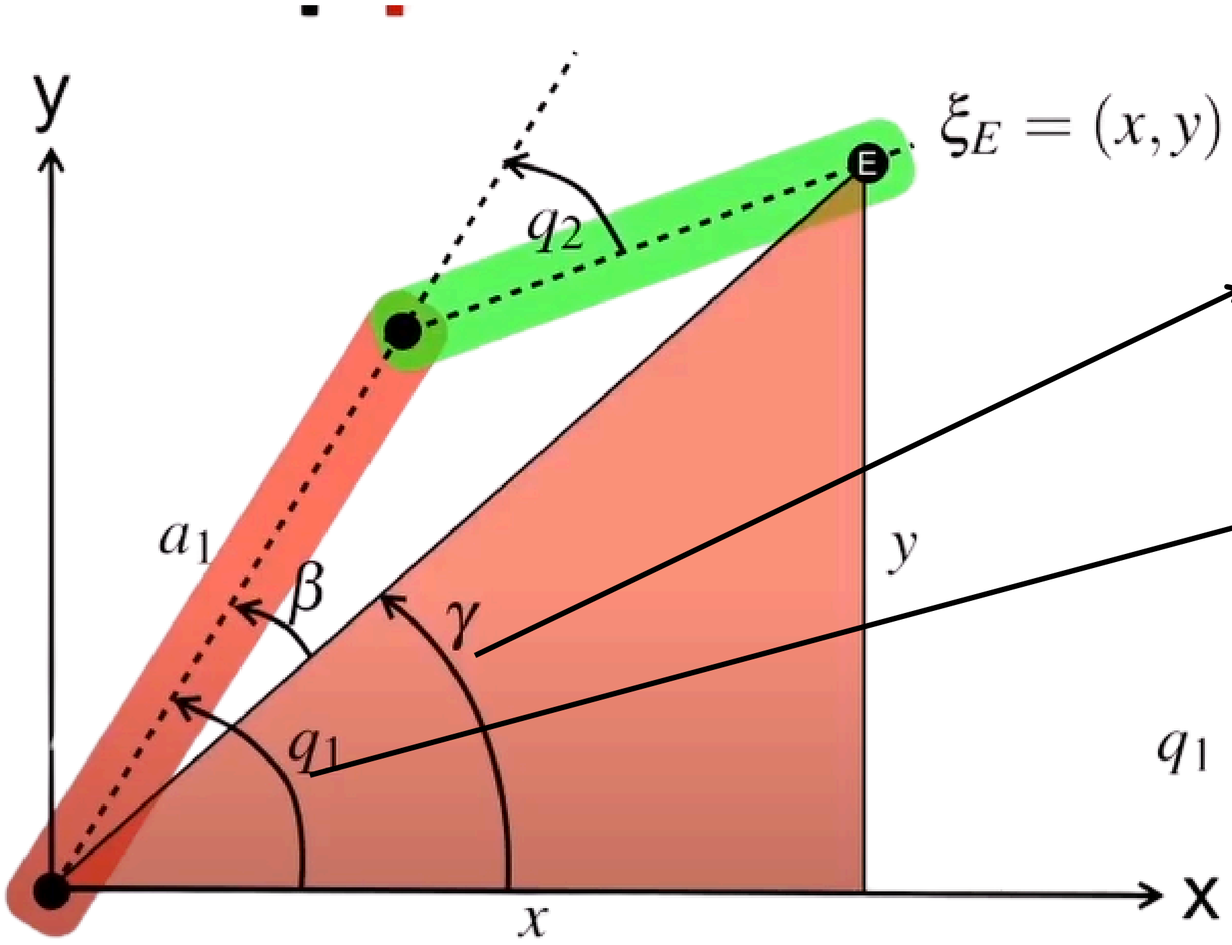
The pose of this robot is described simply by two numbers, the coordinates x and y with respect to the world coordinate frame. So, the problem here is that given x and y, we want to determine the joined angles, Q1 and Q2.

2DOF Model is Elbow up



$$q_2 = -\cos^{-1}\frac{x^2 + y^2 - a_1^2 - a_2^2}{2a_1a_2}$$

INVERSE KINEMATICS



$$\xi_E = (x, y)$$

$$\gamma = \tan^{-1} \frac{y}{x}$$

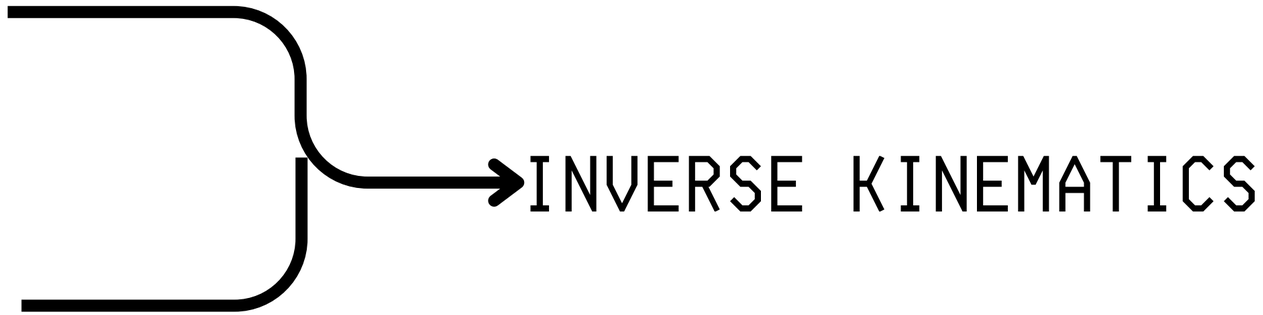
$$\beta = \tan^{-1} \frac{a_2 \sin q_2}{a_1 + a_2 \cos q_2}$$

$$q_1 = \gamma + \beta$$

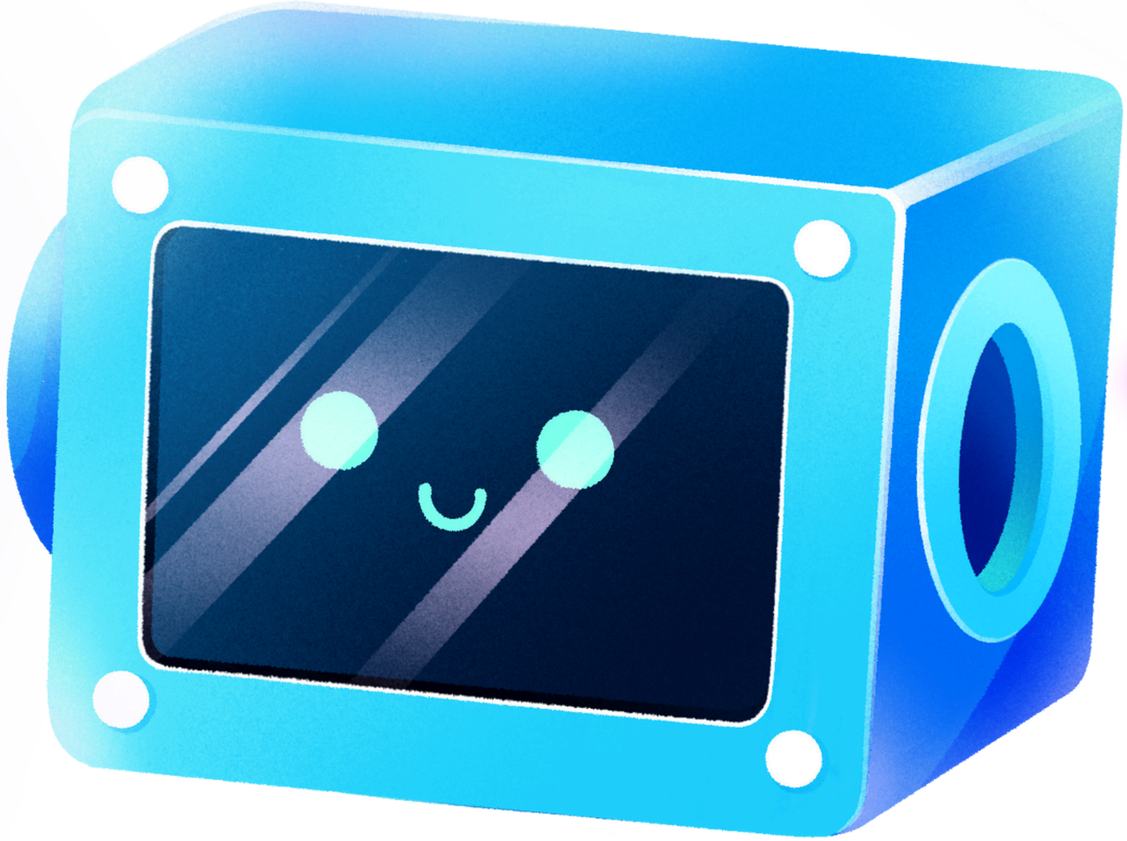
$$q_1 = \tan^{-1} \frac{y}{x} + \tan^{-1} \frac{a_2 \sin q_2}{a_1 + a_2 \cos q_2}$$

$$q_2 = \cos^{-1} \frac{x^2 + y^2 - a_1^2 - a_2^2}{2a_1 a_2}$$

$$q_1 = \tan^{-1} \frac{y}{x} - \tan^{-1} \frac{a_2 \sin q_2}{a_1 + a_2 \cos q_2}$$



PROJECT SCOPE



Quỹ đạo đa thức bậc 3

$$q(t) = a_3 t^3 + a_2 t^2 + a_1 t + a_0,$$

$$q(t_0) = q_i, \quad q(t_f) = q_f, \quad \dot{q}(t_0) = \dot{q}_i, \quad \dot{q}(t_f) = \dot{q}_f$$

Phương trình xác định các hệ số:

$$q(t_0) = a_3 t_0^3 + a_2 t_0^2 + a_1 t_0 + a_0 = q_i$$
$$\dot{q}(t_0) = 3a_3 t_0^2 + 2a_2 t_0 + a_1 = \dot{q}_i$$
$$q(t_f) = a_3 t_f^3 + a_2 t_f^2 + a_1 t_f + a_0 = q_f$$
$$\dot{q}(t_f) = 3a_3 t_f^2 + 2a_2 t_f + a_1 = \dot{q}_f,$$

$$\mathbf{Ma} = \mathbf{b}$$

$$\mathbf{a} = \mathbf{M}^{-1}\mathbf{b}$$

hay

$$\begin{bmatrix} 1 & t_0 & t_0^2 & t_0^3 \\ 0 & 1 & 2t_0 & 3t_0^2 \\ 1 & t_f & t_f^2 & t_f^3 \\ 0 & 1 & 2t_f & 3t_f^2 \end{bmatrix} \begin{bmatrix} a_0 \\ a_1 \\ a_2 \\ a_3 \end{bmatrix} = \begin{bmatrix} q_i \\ \dot{q}_i \\ q_f \\ \dot{q}_f \end{bmatrix}$$

Trường hợp thời điểm đầu $t_0 = 0$, ta có

$$a_0 = q_i, \qquad a_1 = \dot{q}_i,$$

$$a_2 = \frac{3(q_f - q_i) - (2\dot{q}_i + \dot{q}_f)t_f}{t_f^2}, \qquad a_3 = \frac{-2(q_f - q_i) + (\dot{q}_i + \dot{q}_f)t_f}{t_f^3}.$$

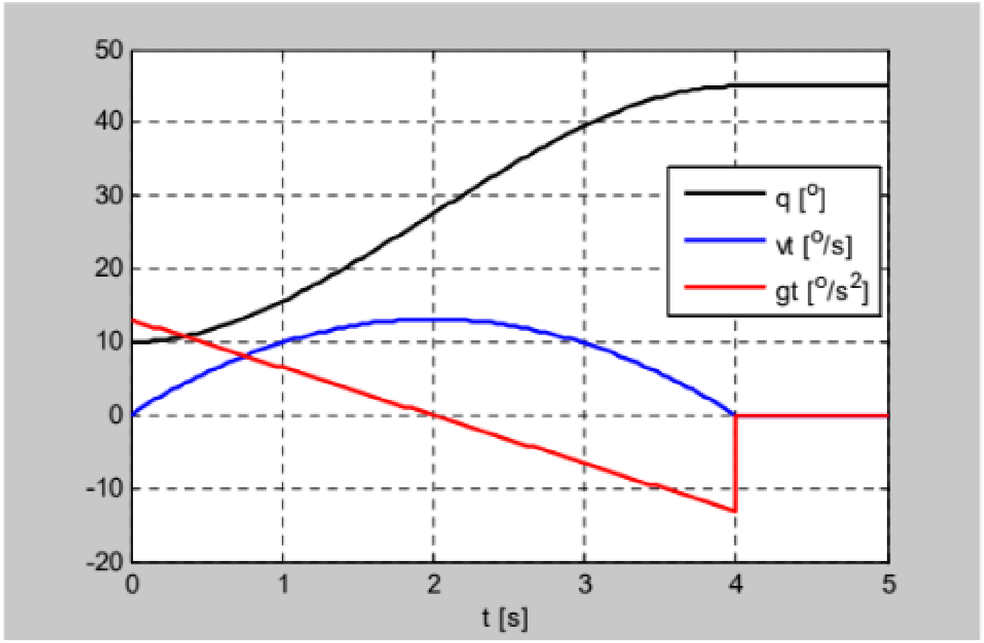
Ví dụ:

$$t_i = 0, \qquad t_f = 4,$$
$$q(0) = 10, \qquad q(t_f) = 45,$$
$$\dot{q}(0) = 0, \qquad \dot{q}(t_f) = 0$$

Kết quả

$$\mathbf{a} = [10.00, \quad 0, \quad 6.5625, \quad -1.0938]^T$$

$$q(t) = 10 + 6.5625t^2 - 1.0938t^3$$



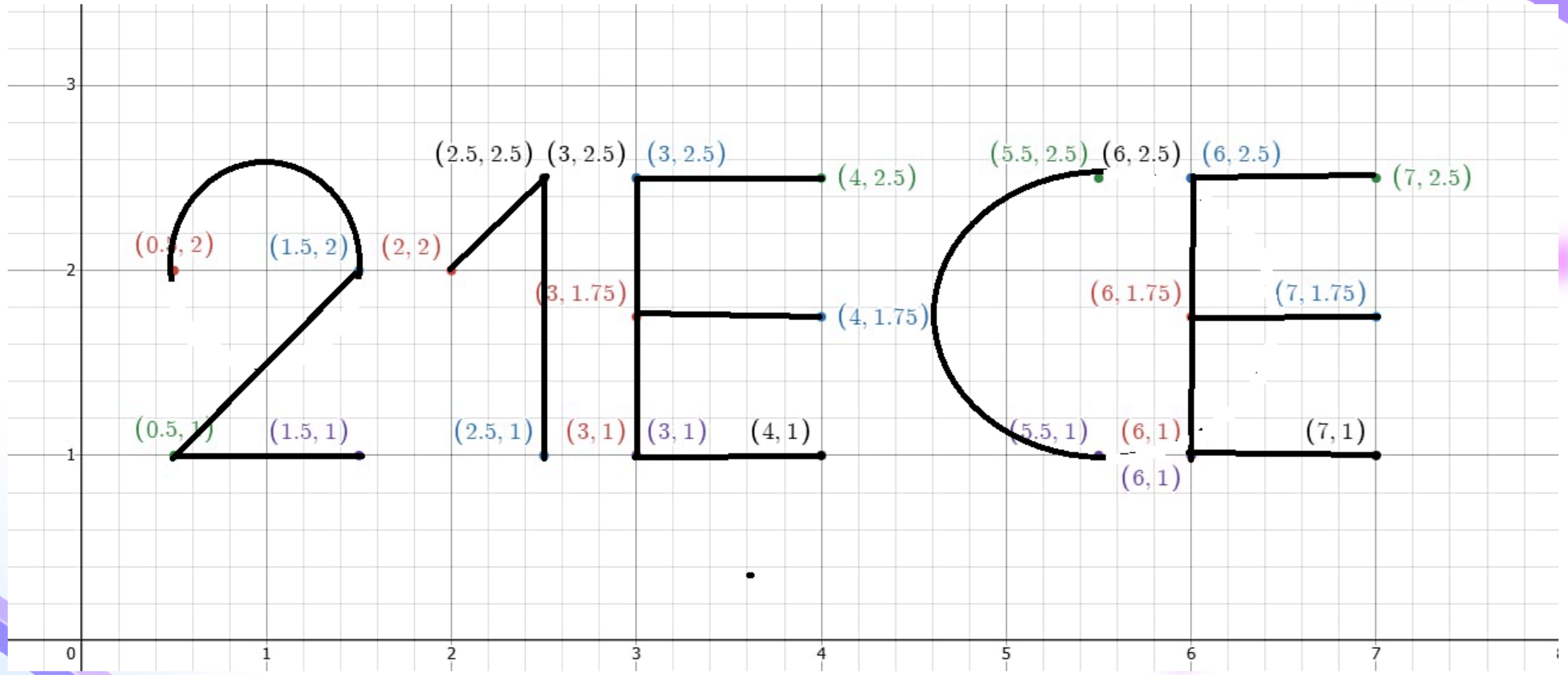
Obviously:

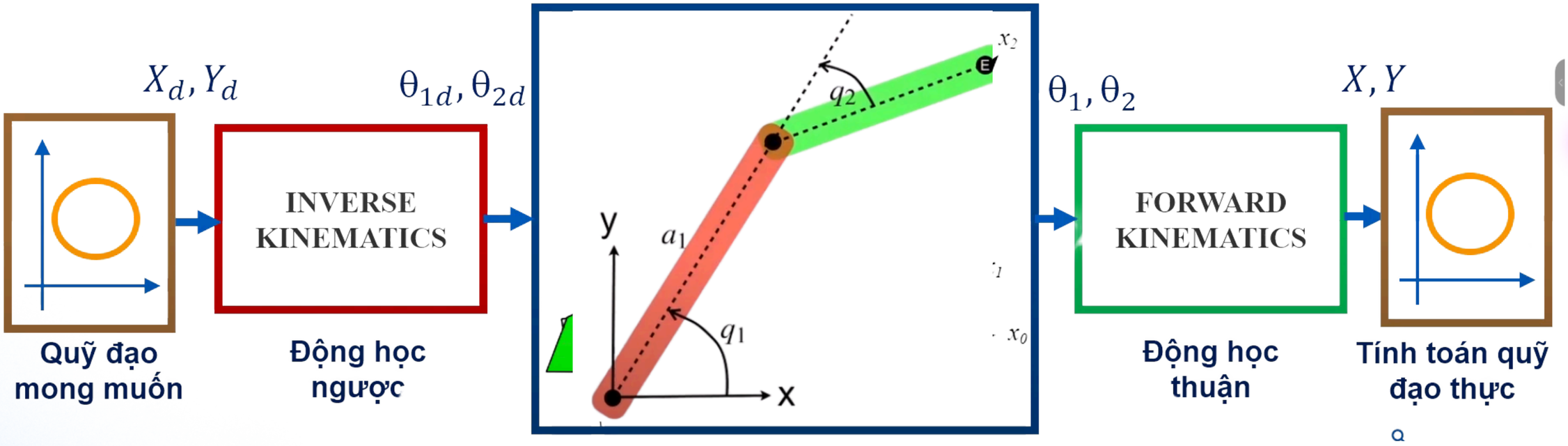
Editor - D:\download\Robot\Arm_analyser-main\TinhQuyDao.m

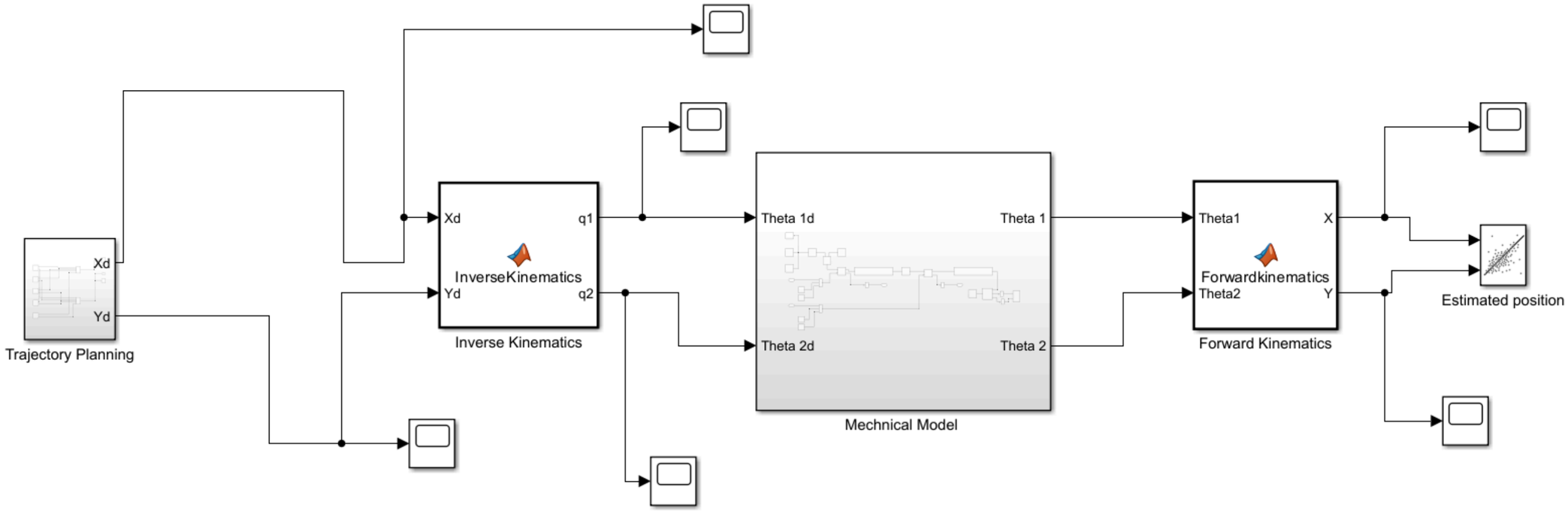
TinhQuyDao.m

```
% Define the variables
t0 = 0; % Replace with actual value of t_0
tf = 4; % Replace with actual value of t_f
qi = 10;
qf =45;
qi_dot = 0;
qf_dot = 0;

% Construct the matrix T
M = [1  t0  t0^2  t0^3;
     0  1   2*t0  3*t0^2;
     1  tf  tf^2  tf^3;
     0  1   2*tf  3*tf^2];

% Define the vector q
b = [qi; qi_dot ; qf; qf_dot];


a = inv(M)*b
```

```
>> TinhQuyDao

a =

   10.0000
         0
    6.5625
   -1.0938

fx >>
```

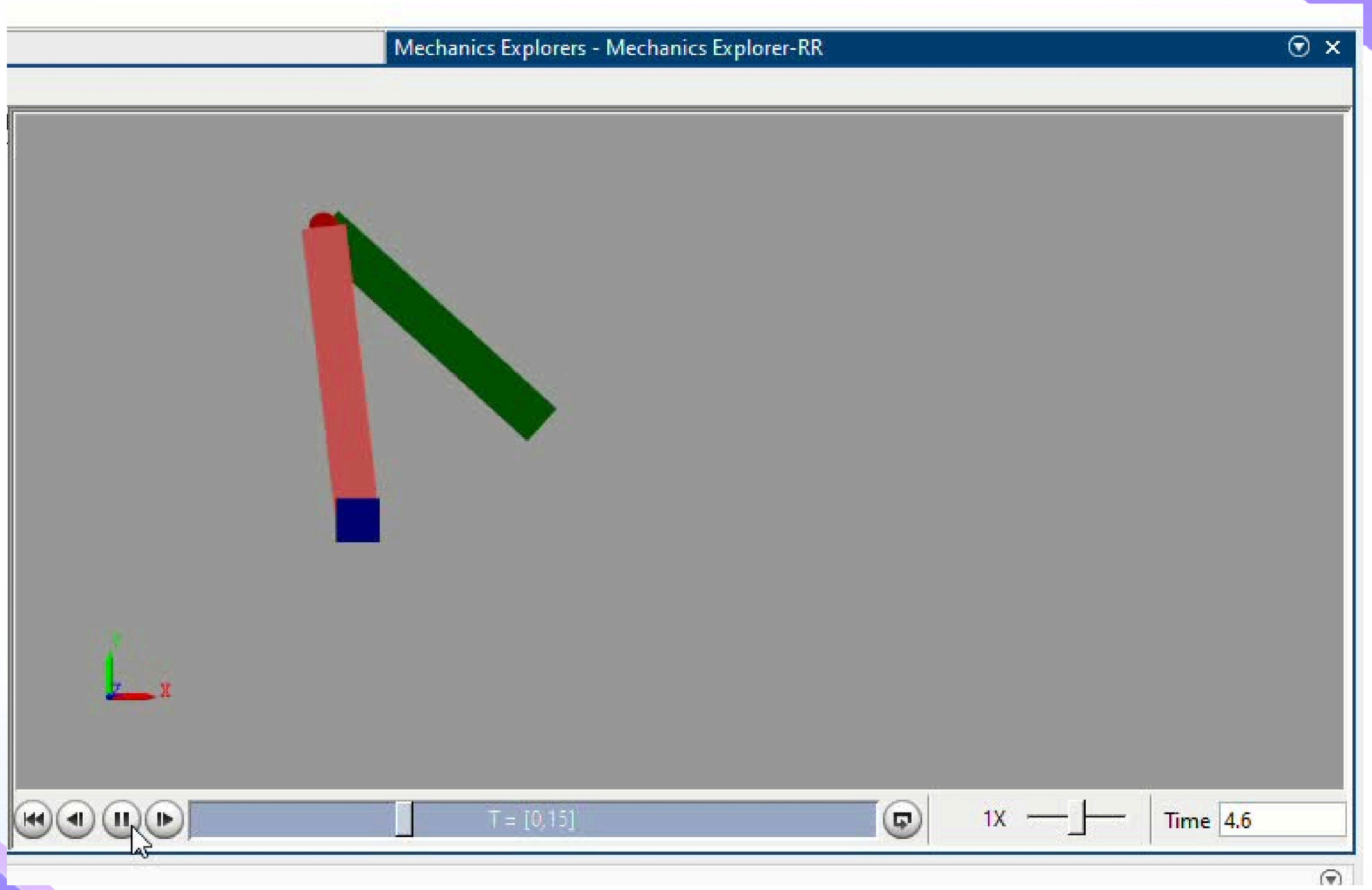

(2.5, 2.5)
(3, 2.5)
(3, 2.5)
(4, 2.5)
(5.5, 2.5)
(6, 2.5)
(6, 2.5)
(7, 2.5)
(1.5, 2)
(2, 2)
(3, 1.75)
(4, 1.75)
(6, 1.75)
(7, 1.75)
(0.5, 1)
(1.5, 1)
(2.5, 1)
(3, 1)
(3, 1)
(4, 1)
(5.5, 1)
(6, 1)
(7, 1)
(6, 1)
0
1
2
3
4
5
6
7

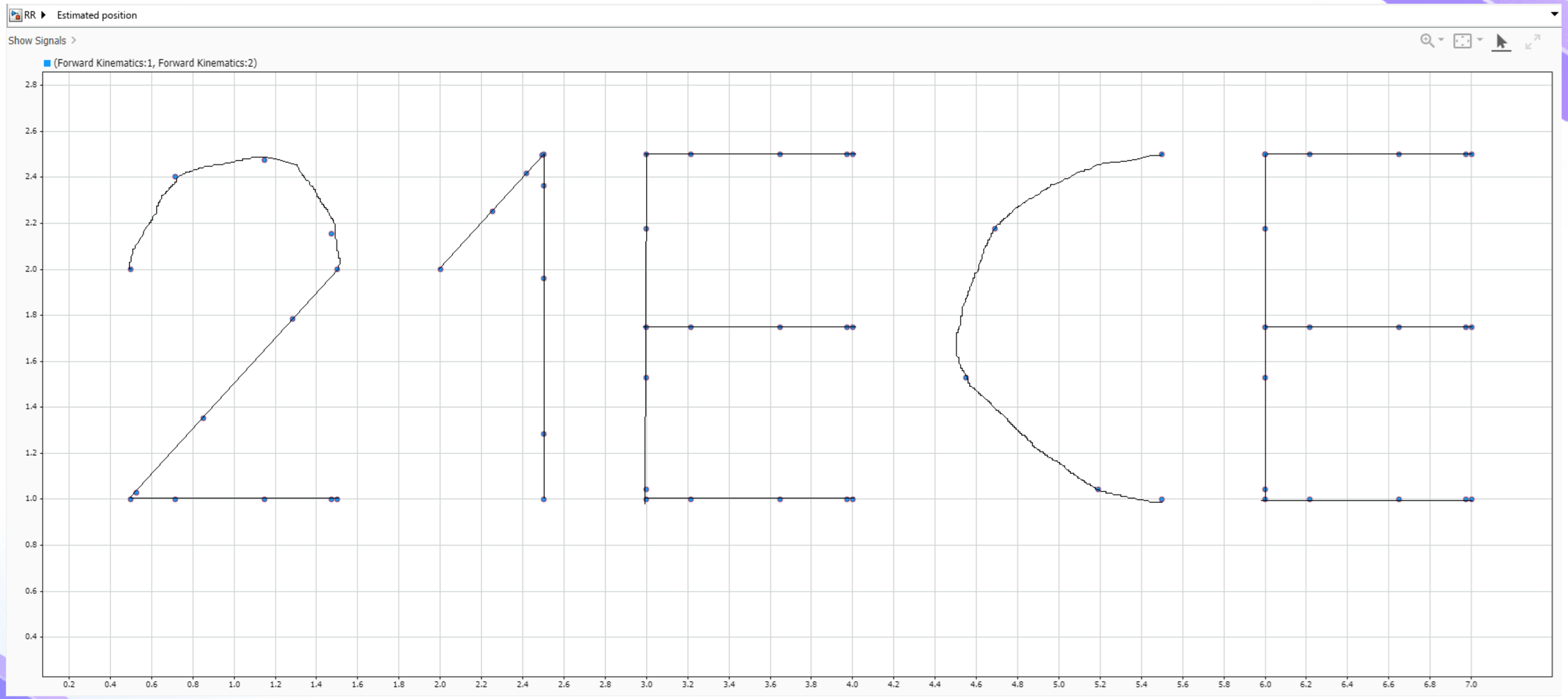

X_d, Y_d
θ_{1d}, θ_{2d}
θ_1, θ_2
X, Y
INVERSE KINEMATICS
FORWARD KINEMATICS
Quỹ đạo mong muốn
Động học ngược
Động học thuận
Tính toán quỹ đạo thực
y
x
a_1
q_1
q_2
E
x_2
x_0

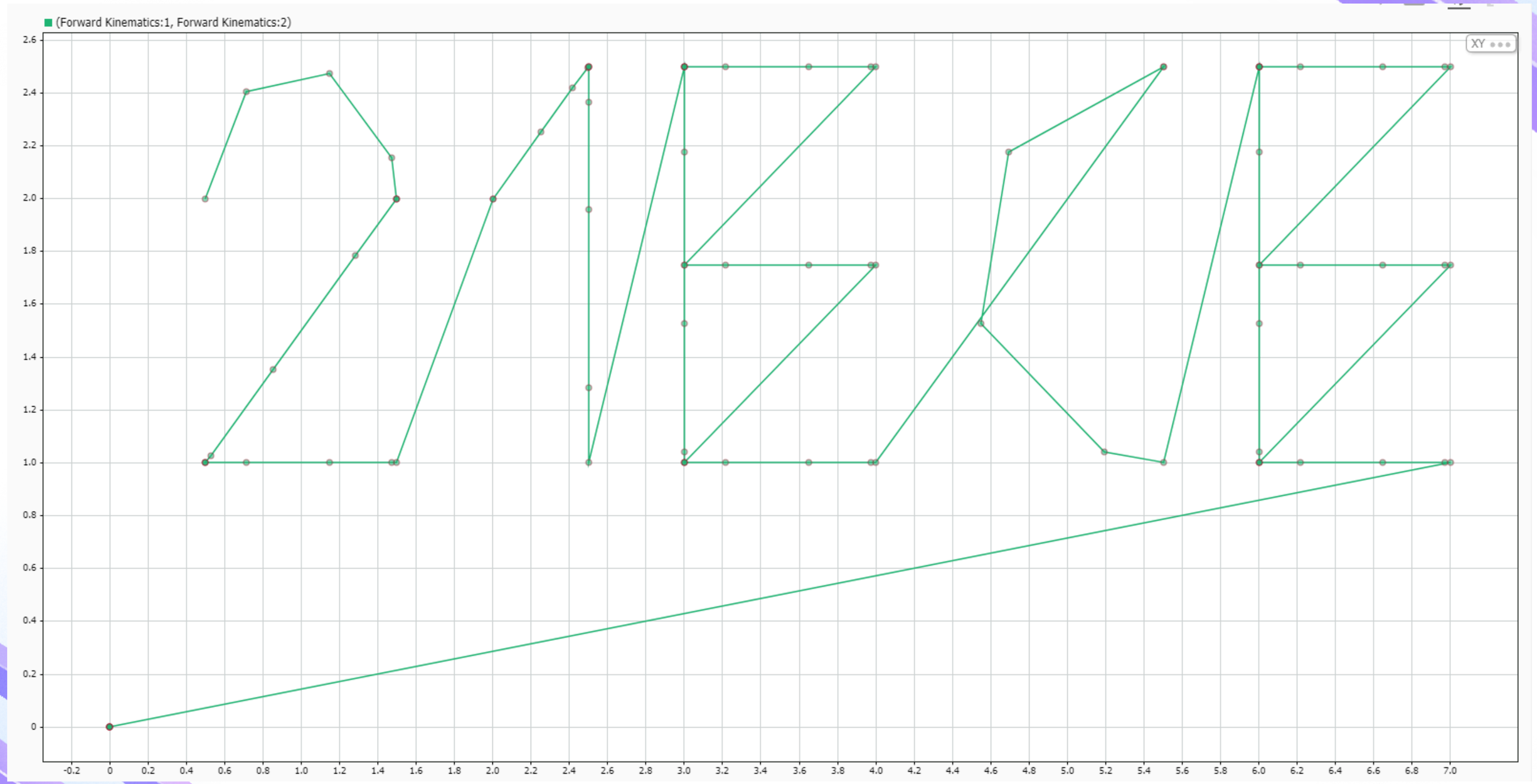

Xd
Yd
Trajectory Planning
Xd
Yd
q1
q2
InverseKinematics
Inverse Kinematics
Theta 1d
Theta 2d
Theta 1
Theta 2
Mechnical Model
Theta1
Theta2
X
Y
Forwardkinematics
Forward Kinematics
Estimated position

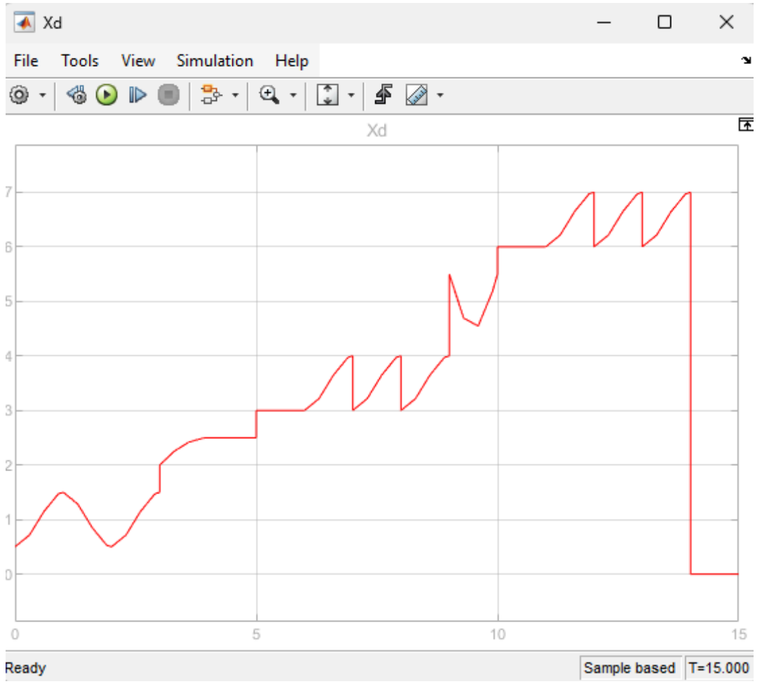
RR ▸ Inverse Kinematics

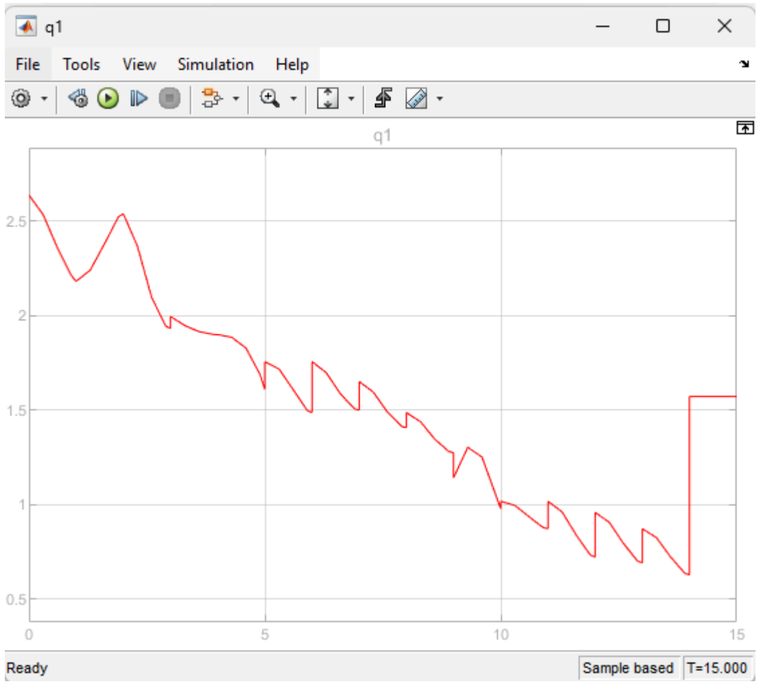
```
function [q1,q2] = InverseKinematics(Xd,Yd)

l1 = 4;
l2 = 4;

q2 = -real(acos(complex((Xd^2+Yd^2 - l1^2 - l2^2)/(2*l1*l2))));

s_q2 = sin(q2);
c_q2 = cos(q2);

q1 = atan2(Yd,Xd) - atan2(real(l2*s_q2), real((l1+l2*c_q2)));

```

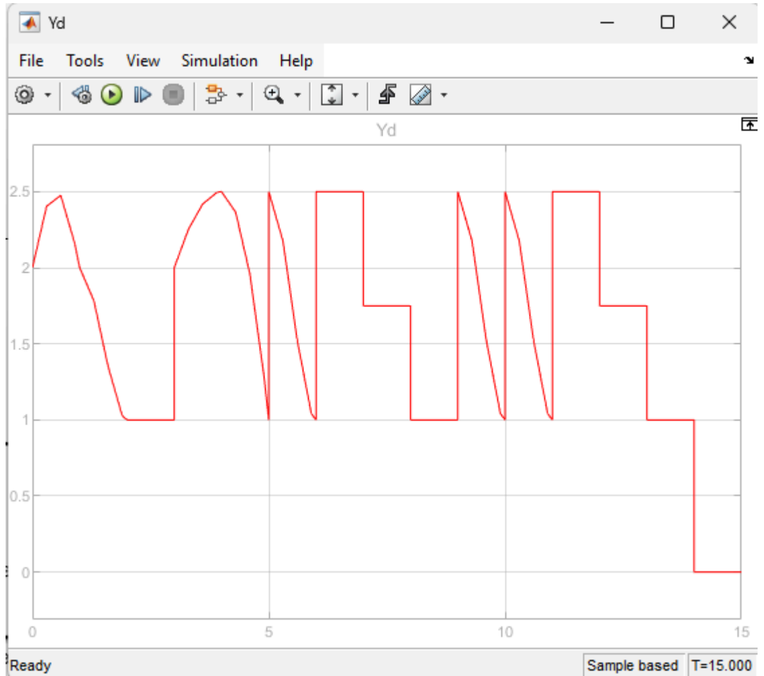

Mechanics Explorers - Mechanics Explorer-RR
T = [0,15]
1X
Time
4.6

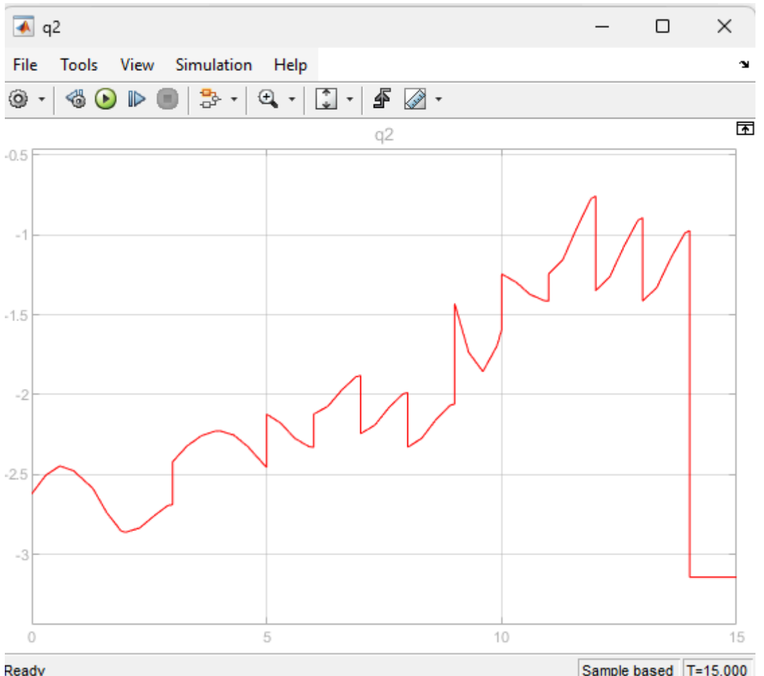

RR
Estimated position
Show Signals
(Forward Kinematics:1, Forward Kinematics:2)


(Forward Kinematics:1, Forward Kinematics:2)
XY
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2 0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0 4.2 4.4 4.6 4.8 5.0 5.2 5.4 5.6 5.8 6.0 6.2 6.4 6.6 6.8 7.0


Xd
File Tools View Simulation Help
Xd
7
6
5
4
3
2
1
0
0 5 10 15
Ready
Sample based
T=15.000


q1
File Tools View Simulation Help
q1
2.5
2
1.5
1
0.5
0 5 10 15
Ready
Sample based
T=15.000


Yd
File Tools View Simulation Help
Yd
2.5
2
1.5
1
0.5
0
0 5 10 15
Ready
Sample based
T=15.000


q2
File Tools View Simulation Help
q2
-0.5
-1
-1.5
-2
-2.5
-3
0 5 10 15
Ready
Sample based
T=15.000