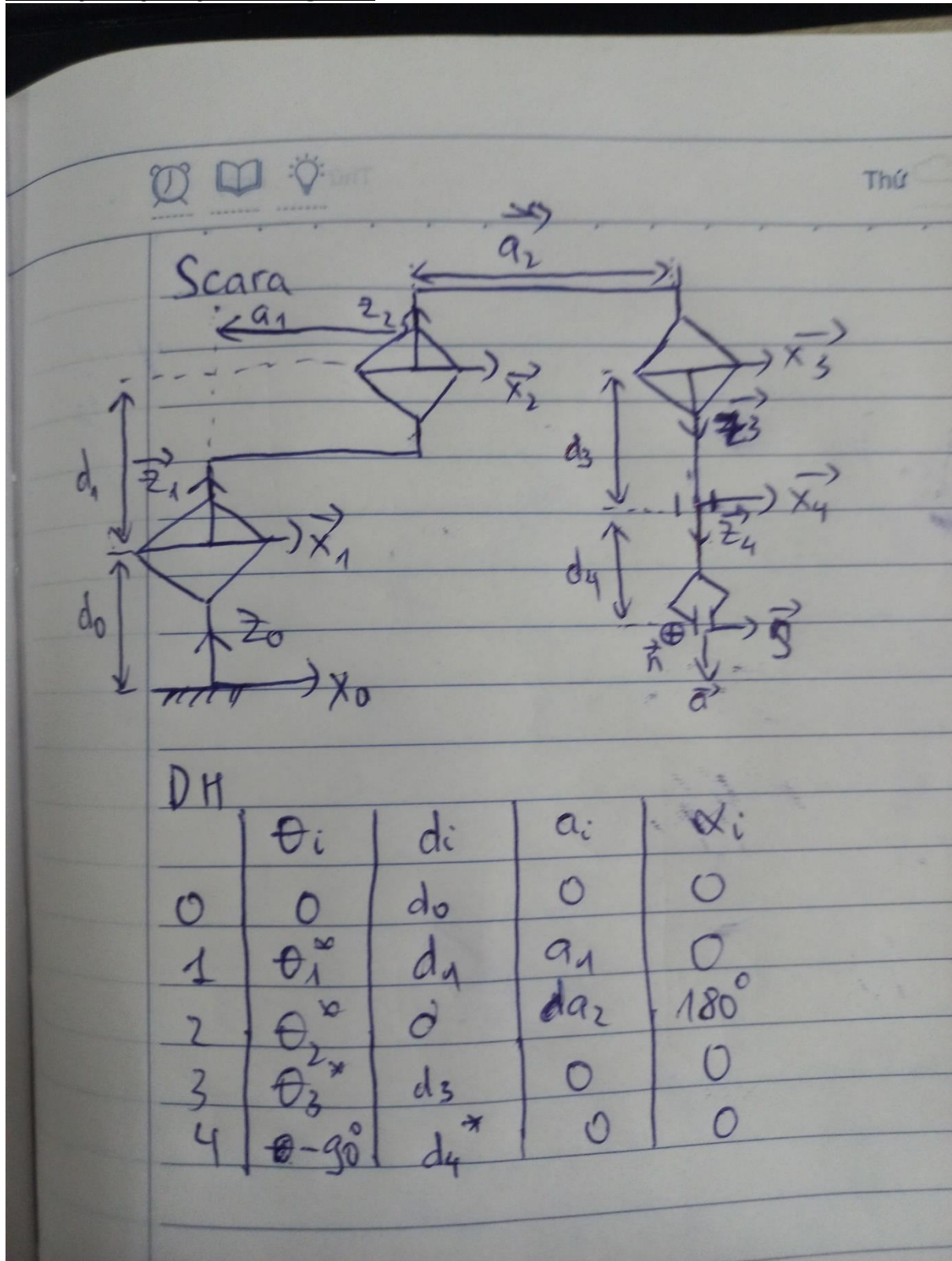


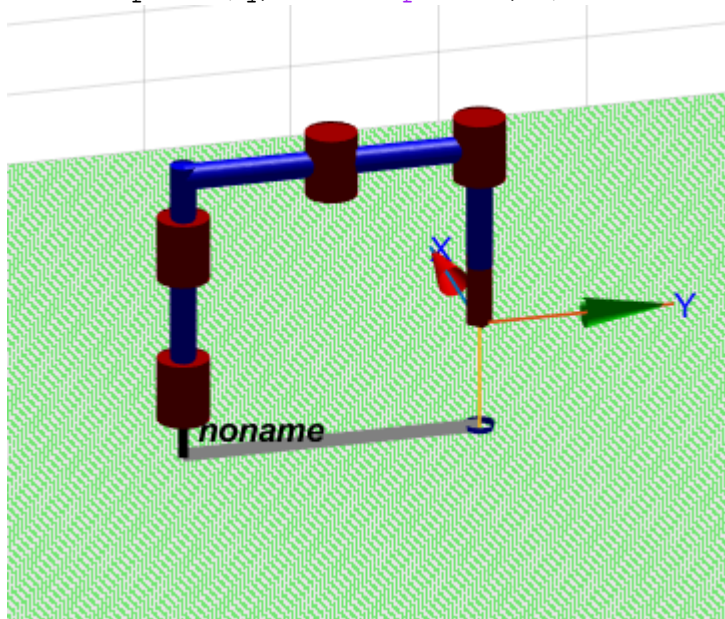
# SCARA

Xác định toạ độ và bảng DH:



### Code mô phỏng:

```
d0=20;d1=10;d3=15;a1=20;a2=20;
L(1)=Link([0,d0,0,0,0]);
L(2)=Link([0,d1,a1,0,0]);
L(3)=Link([0,0,a2,pi,0]);
L(4)=Link([0,d3,0,0,0]);
L(5)=Link([-pi/2,0,0,0,1]);
SCARA = SerialLink(L);
q=[0,0,0,0,10];
w=[-100 100 -100 100 -10 60];
SCARA.plot(q, 'workspace',w);
```



### Động học thuận:

```
syms t1 t2 t3 d4 a1 a2 d0 d1 d2 d3;
T0 = [1 0 0 0;
      0 1 0 0;
      0 0 1 d0;
      0 0 0 1];
T1 = [cos(t1) -sin(t1) 0 a1*cos(t1);
      sin(t1), cos(t1), 0, a1*sin(t1);
      0 0 1 d1;
      0 0 0 1];
T2 = [cos(t2) sin(t2) 0 a2*cos(t2);
      sin(t2), -cos(t2), 0, a2*sin(t2);
      0 0 -1 d2;
      0 0 0 1];
T3 = [cos(t3) -sin(t3) 0 0;
      sin(t3), cos(t3), 0 0;
```

```

0 0 1 d3;
0 0 0 1];
T4 = [0 1 0 0;
-1, 0, 0, 0;
0 0 1 d4;
0 0 0 1];
E=T0*T1*T2*T3*T4;

```

### **KQ:**

```

% E= [-sin(t1 + t2 - t3), cos(t1 + t2 - t3), 0, a2*cos(t1 + t2) + a1*cos(t1)]
% [ cos(t1 + t2 - t3), sin(t1 + t2 - t3), 0, a2*sin(t1 + t2) + a1*sin(t1)]
% [ 0, 0, -1, d0 - d1 - d3 - d4]
% [ 0, 0, 0, 1]

```

### **Động học nghịch:**

```

E= [nx,sx,ax,px]
    [ny,sy,ay,py]
    [nz,sz,az,pz]
    [0,0,0,1];

```

$$px = a2 * \cos(t1 + t2) + a1 * \cos(t1) \rightarrow a2 * \cos(t1 + t2) = a1 * \cos(t1) - px \quad (1)$$

$$py = a2 * \sin(t1 + t2) + a1 * \sin(t1) \rightarrow a2 * \sin(t1 + t2) = a1 * \sin(t1) - py \quad (2)$$

Lấy tổng bình phương 2 vế (1) và (2) ta có:

$$\begin{aligned}
& a2^2 * (\cos^2(t1 + t2) + \sin^2(t1 + t2)) \\
& = (a1 * \cos(t1) - px)^2 + (a1 * \sin(t1) - py)^2 \\
& \rightarrow a2^2 = a1^2 * (\cos^2(t1) + \sin^2(t2)) - 2a1 * px * \cos(t1) - 2a1 * py * \sin(t1) + px^2 + py^2 \\
& \rightarrow 2a1 * (py * \sin(t1) + px * \cos(t1)) = a1^2 + px^2 + py^2 - a2^2 \\
& \rightarrow py * \sin(t1) + px * \cos(t1) = \frac{a1^2 + px^2 + py^2 - a2^2}{2a1}
\end{aligned}$$

$$\text{Đặt } A = py, B = px, C = \frac{a1^2 + px^2 + py^2 - a2^2}{2a1}.$$

Đưa phương trình về dạng  $A * \sin x + B * \cos x = C$ .

$$\text{Đặt } u = \tan \frac{t1}{2}, \sin t1 = \frac{2u}{1+u^2}, \cos t1 = \frac{1-u^2}{1+u^2}$$

$$\rightarrow \frac{2Au}{1+u^2} + B * \frac{1-u^2}{1+u^2} = C \rightarrow 2 * A * u + B - B * u^2 = C + C * u^2$$

$$\rightarrow (B + C) * u^2 - 2 * A * u - B + C = 0$$

$$\rightarrow u_{1,2} = \frac{A \pm \sqrt{A^2 + B^2 - C^2}}{-B - C}$$

$$\rightarrow t1 = 2 * \arctan u1, t2 = 2 * \arctan u2$$

$$px = a2 * c12 + a1 * c1 \rightarrow c12 = \frac{px - a1 * c1}{a2}$$

$$py = a2 * s12 + a1 * s1 \rightarrow s12 = \frac{py - a1 * s1}{a2}$$

$$\rightarrow t12 = \text{atan2}(s12, c12) \rightarrow t2 = t12 - t1$$

$$t1 + t2 - t3 = \text{atan2}(sy, sx) \rightarrow t3 = t1 + t2 - \text{atan2}(sy, sx)$$

### Mô phỏng đường thẳng:

```
d0=20;d1=10;d3=15;a1=20;a2=20;
L(1)=Link([0,d0,0,0,0]);
L(2)=Link([0,d1,a1,0,0]);
L(3)=Link([0,0,a2,pi,0]);
L(4)=Link([0,d3,0,0,0]);
L(5)=Link([-pi/2,0,0,0,1]);
SCARA = SerialLink(L);
q=[0,0,0,0,10];
w=[-100 100 -100 100 -10 60];
SCARA.plot(q,'workspace',w);
E=SCARA.fkine(q);
hold on;
sx=E(1,2);
sy=E(2,2);
px0=E(1,4);
pz0=E(3,4);
py0=E(2,4);
t1_old=0;
for t=0:-1:-20
    px=t+px0;
    py=py0;
    pz=pz0;
    A=py;
    B=px;
    C=(px^2+py^2+a1^2-a2^2)/(2*a1);
    t1x=(A+sqrt(A^2+B^2-C^2))/(-B-C);
    t1y=(A-sqrt(A^2+B^2-C^2))/(-B-C);
    t1_1=2*atan(t1x)
    t1_2=2*atan(t1y)
    if(abs(t1_1-t1_old)>abs(t1_2-t1_old))
        t1=t1_2;
    else
        t1=t1_1;
    end
    t12=atan2((py-a1*sin(t1))/a2,(px-a1*cos(t1))/a2);
    t2=t12-t1;
    t123=atan2(sy,sx);
    t3=t1+t2-t123;
    d4=d0+d1-d3-pz;
    qreal=[0,t1,t2,t3,d4];

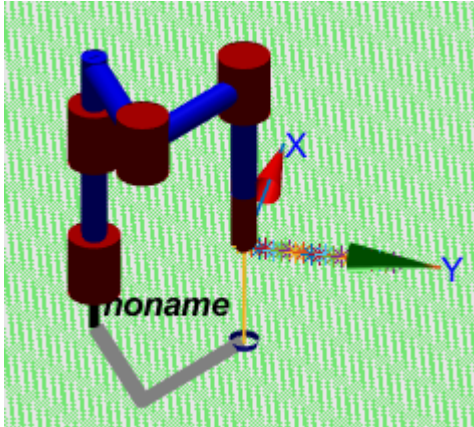
SCARA.plot(qreal,'workspace',w,'delay',0.3,'zoom',1.5,'workspace',w);
E=SCARA.fkine(qreal);
p=transl(E);
```

```

plot3(p(1),p(2),p(3),'*');
sx=E(1,2);
sy=E(2,2);
px=E(1,4);
pz=E(3,4);
py=E(2,4);
t1_old=t1;

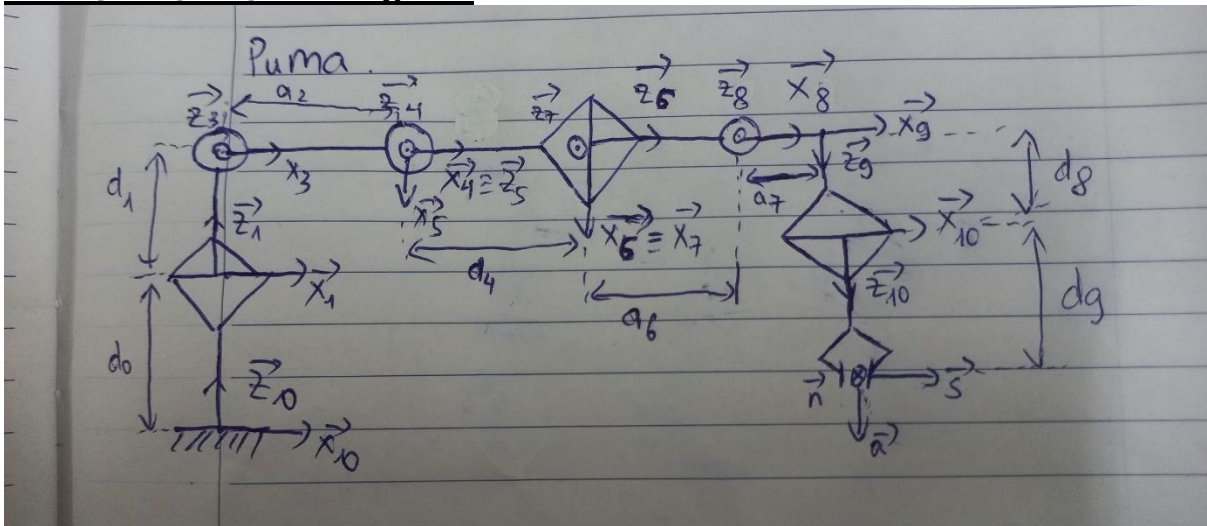
```

end



## PUMA

Xác định tọa độ và bảng DH:





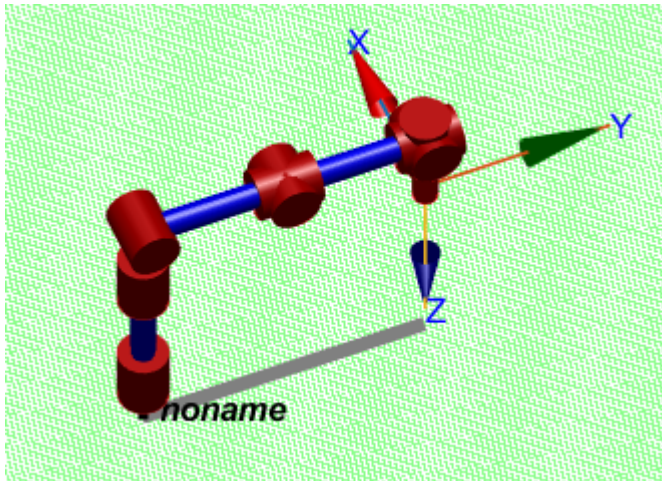
	$\theta_i$	$d_i$	$a_i$	$\alpha_i$
0	0	$d_0$	0	0
1	$\theta_1^*$	$d_1$	0	$90^\circ$
2	$\theta_2^*$	0	$a_2$	0
3	$\theta_3^* - 90^\circ$	0	0	$-90^\circ$
4	$\theta_4^*$	$d_4$	0	0
5	0	0	0	$90^\circ$
6	$\theta_6^* + 90^\circ$	0	$a_6$	0
7	0	0	$a_7$	$90^\circ$
8	$\theta_8^*$	$d_8$	0	0
9	$\theta_9^* - 90^\circ$	$d_9$	0	0

### Code mô phỏng:

```

d0=20;d1=10;a2=20;d4=20;a6=0;a7=0;d8=0;d9=10;
L(1)=Link([0,d0,0,0,0]);
L(2)=Link([0,d1,0,pi/2,0]);
L(3)=Link([0,0,a2,0,0]);
L(4)=Link([0,0,0,-pi/2,0]);
L(5)=Link([0,d4,0,0,0]);
L(6)=Link([0,0,0,pi/2,0]);
L(7)=Link([0,0,a6,0,0]);
L(8)=Link([0,0,a7,pi/2,0]);
L(9)=Link([0,d8,0,0,0]);
L(10)=Link([0,d9,0,0,0]);
PUMA = SerialLink(L);
q=[0,0,0,-pi/2,0,0,pi/2,0,0,-pi/2];
w=[-100 100 -100 100 -10 60];
PUMA.plot(q,'workspace',w);

```



### Động học thuận:

```

syms t1 t2 t3 t4 t5 t6 a1 d0 d1 d4 d8 d9 a2 a6 a7;
T0 = [1 0 0 0;
      0 1 0 0;
      0 0 1 d0;
      0 0 0 1];
T1 = [cos(t1) 0 sin(t1) 0;
      sin(t1), 0, -cos(t1), 0;
      0 1 0 d1;
      0 0 0 1];
T2 = [cos(t2) -sin(t2) 0 a2*cos(t2);
      sin(t2), cos(t2), 0, a2*sin(t2);
      0 0 1 0;
      0 0 0 1];
T3 = [0 0 1 0;
      -1, 0, 0, 0;
      0 -1 0 0;
      0 0 0 1];
T4 = [cos(t3) -sin(t3) 0 0;
      sin(t3), cos(t3), 0, 0;
      0 0 1 d4;
      0 0 0 1];
T5 = [1 0 0 0;
      0, 0, -1, 0;
      0 1 0 0;
      0 0 0 1];
T6 = [-sin(t4) -cos(t4) 0 a6*-sin(t4);
      cos(t4), -sin(t4), 0, a6*cos(t4);
      0 0 1 0;
      0 0 0 1];
T7 = [1 0 0 a6;
      0, 0, -1, 0;
      0 1 0 0;

```

```

    0 0 0 1];
T8 = [cos(t5) -sin(t5) 0 0;
      sin(t5), cos(t5), 0, 0;
      0 0 1 d8;
      0 0 0 1];
T9 = [sin(t6) cos(t6) 0 0;
      -cos(t6), sin(t6), 0, 0;
      0 0 1 d9;
      0 0 0 1];
T=T0*T1*T2*T3*T4*T5*T6*T7*T8*T9;

```

### Kết quả

```

T= [   cos(t6)*(sin(t5)*(sin(t4)*(sin(t1)*sin(t3) -
cos(t1)*cos(t3)*sin(t2)) + cos(t1)*cos(t2)*cos(t4)) -
cos(t5)*(cos(t3)*sin(t1) + cos(t1)*sin(t2)*sin(t3))) +
sin(t6)*(cos(t5)*(sin(t4)*(sin(t1)*sin(t3) -
cos(t1)*cos(t3)*sin(t2)) + cos(t1)*cos(t2)*cos(t4)) +
sin(t5)*(cos(t3)*sin(t1) + cos(t1)*sin(t2)*sin(t3))),
cos(t6)*(cos(t5)*(sin(t4)*(sin(t1)*sin(t3) -
cos(t1)*cos(t3)*sin(t2)) + cos(t1)*cos(t2)*cos(t4)) +
sin(t5)*(cos(t3)*sin(t1) + cos(t1)*sin(t2)*sin(t3))) -
sin(t6)*(sin(t5)*(sin(t4)*(sin(t1)*sin(t3) -
cos(t1)*cos(t3)*sin(t2)) + cos(t1)*cos(t2)*cos(t4)) -
cos(t5)*(cos(t3)*sin(t1) + cos(t1)*sin(t2)*sin(t3))),
cos(t1)*cos(t2)*sin(t4) - cos(t4)*(sin(t1)*sin(t3) -
cos(t1)*cos(t3)*sin(t2)), a2*cos(t1)*cos(t2) +
d4*cos(t1)*cos(t2) + 2*a6*cos(t1)*cos(t2)*cos(t4) +
d8*cos(t1)*cos(t2)*sin(t4) + d9*cos(t1)*cos(t2)*sin(t4) -
d8*cos(t4)*sin(t1)*sin(t3) - d9*cos(t4)*sin(t1)*sin(t3) +
2*a6*sin(t1)*sin(t3)*sin(t4) +
d8*cos(t1)*cos(t3)*cos(t4)*sin(t2) +
d9*cos(t1)*cos(t3)*cos(t4)*sin(t2) -
2*a6*cos(t1)*cos(t3)*sin(t2)*sin(t4)]
[ - cos(t6)*(sin(t5)*(sin(t4)*(cos(t1)*sin(t3) +
cos(t3)*sin(t1)*sin(t2)) - cos(t2)*cos(t4)*sin(t1)) -
cos(t5)*(cos(t1)*cos(t3) - sin(t1)*sin(t2)*sin(t3))) -
sin(t6)*(cos(t5)*(sin(t4)*(cos(t1)*sin(t3) +
cos(t3)*sin(t1)*sin(t2)) - cos(t2)*cos(t4)*sin(t1)) +
sin(t5)*(cos(t1)*cos(t3) - sin(t1)*sin(t2)*sin(t3))),
sin(t6)*(sin(t5)*(sin(t4)*(cos(t1)*sin(t3) +
cos(t3)*sin(t1)*sin(t2)) - cos(t2)*cos(t4)*sin(t1)) -
cos(t5)*(cos(t1)*cos(t3) - sin(t1)*sin(t2)*sin(t3))) -
cos(t6)*(cos(t5)*(sin(t4)*(cos(t1)*sin(t3) +
cos(t3)*sin(t1)*sin(t2)) - cos(t2)*cos(t4)*sin(t1)) +
sin(t5)*(cos(t1)*cos(t3) - sin(t1)*sin(t2)*sin(t3))),
cos(t4)*(cos(t1)*sin(t3) + cos(t3)*sin(t1)*sin(t2)) +

```



```

cos(t2)*sin(t1)*sin(t4), a2*cos(t2)*sin(t1) +
d4*cos(t2)*sin(t1) + 2*a6*cos(t2)*cos(t4)*sin(t1) +
d8*cos(t1)*cos(t4)*sin(t3) + d9*cos(t1)*cos(t4)*sin(t3) -
2*a6*cos(t1)*sin(t3)*sin(t4) + d8*cos(t2)*sin(t1)*sin(t4)
+ d9*cos(t2)*sin(t1)*sin(t4) +
d8*cos(t3)*cos(t4)*sin(t1)*sin(t2) +
d9*cos(t3)*cos(t4)*sin(t1)*sin(t2) -
2*a6*cos(t3)*sin(t1)*sin(t2)*sin(t4)]
[
cos(t6)*(sin(t5)*(cos(t4)*sin(t2) +
cos(t2)*cos(t3)*sin(t4)) + cos(t2)*cos(t5)*sin(t3)) +
sin(t6)*(cos(t5)*(cos(t4)*sin(t2) +
cos(t2)*cos(t3)*sin(t4)) - cos(t2)*sin(t3)*sin(t5)),
cos(t6)*(cos(t5)*(cos(t4)*sin(t2) +
cos(t2)*cos(t3)*sin(t4)) - cos(t2)*sin(t3)*sin(t5)) -
sin(t6)*(sin(t5)*(cos(t4)*sin(t2) +
cos(t2)*cos(t3)*sin(t4)) + cos(t2)*cos(t5)*sin(t3)),
sin(t2)*sin(t4) - cos(t2)*cos(t3)*cos(t4),
d0 + d1 + a2*sin(t2) + d4*sin(t2) + 2*a6*cos(t4)*sin(t2)
+ d8*sin(t2)*sin(t4) + d9*sin(t2)*sin(t4) -
d8*cos(t2)*cos(t3)*cos(t4) - d9*cos(t2)*cos(t3)*cos(t4) +
2*a6*cos(t2)*cos(t3)*sin(t4)]
[
0,
0,
0,
1]

```

### **Mô phỏng đường tròn:**

```

d0=20;d1=10;a2=20;d4=20;a6=0;a7=0;d8=0;d9=10;
L(1)=Link([0,d0,0,0,0]);
L(2)=Link([0,d1,0,pi/2,0]);
L(3)=Link([0,0,a2,0,0]);
L(4)=Link([0,0,0,-pi/2,0]);
L(5)=Link([0,d4,0,0,0]);
L(6)=Link([0,0,0,pi/2,0]);
L(7)=Link([0,0,a6,0,0]);
L(8)=Link([0,0,a7,pi/2,0]);
L(9)=Link([0,d8,0,0,0]);
L(10)=Link([0,d9,0,0,0]);
PUMA = SerialLink(L);
q=[0,0,0,-pi/2,0,0,pi/2,0,0,-pi/2];
w=[-100 100 -100 100 -10 60];
PUMA.plot(q,'workspace',w);
E=PUMA.fkine(q);
hold on;

```

```

for t1=0:5:270
    qreal=[0,deg2rad(t1),0,-pi/2,0,0,pi/2,0,0,-pi/2];

PUMA.plot(qreal,'workspace',w,'delay',0.3,'zoom',1.5,'wor
kspace',w);
    E=PUMA.fkine(qreal);
    p=transl(E);
    plot3(p(1),p(2),p(3),'*');
end

```

