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```
%=========================================================================
% Homework #1
% MEA 263 D
%=========================================================================

clear all; clc;
syms t1 t2 t3 L1 L2 L3 d d1 d2 d3
syms t4 t5 t6 d4 L4
problemnumber=0;
for i = 1:8
    problemnumber=i;
    p = problemnumber;

if p == 1
```

Problem #1

```
DH = [0 0 0 0 0 0;...
      0 L1 0 0 0 0;...
      0 L2 0 0 0 0];

Robot1 = DH2Robot(DH,0)

T0_1 = Robot1.A([1],[t1 t2 0])
T1_2 = Robot1.A([2],[t1 t2 0])
T2_t = Robot1.A([3],[t1 t2 0])
Robot1.A([1 2 3],[t1 t2 0])
```

```
Robot1 =

noname (3 axis, RRR, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|          0|          0|
|  2|         q2|          0|         L1|          0|          0|
```

```
|  3|         q3|          0|         L2|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0          0  1  0  0
       9.81         0  0  1  0          0  0  1  0
                    0  0  0  1          0  0  0  1


T0_1 =

[ cos(t1), -sin(t1), 0, 0]
[ sin(t1),  cos(t1), 0, 0]
[       0,        0, 1, 0]
[       0,        0, 0, 1]


T1_2 =

[ cos(t2), -sin(t2), 0, L1]
[ sin(t2),  cos(t2), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


T2_t =

[ 1, 0, 0, L2]
[ 0, 1, 0,  0]
[ 0, 0, 1,  0]
[ 0, 0, 0,  1]


ans =

[ cos(t1)*cos(t2) - sin(t1)*sin(t2), - cos(t1)*sin(t2) - cos(t2)*sin(t1), 0, L2*(cos(
t1)*cos(t2) - sin(t1)*sin(t2)) + L1*cos(t1)]
[ cos(t1)*sin(t2) + cos(t2)*sin(t1),   cos(t1)*cos(t2) - sin(t1)*sin(t2), 0, L2*(cos(
t1)*sin(t2) + cos(t2)*sin(t1)) + L1*sin(t1)]
[                                 0,                                    0, 1,
                                                                           0]
[                                 0,                                    0, 0,
                                                                           1]
```

```
end

if p == 2
```

Problem #2

```
DH = [0 0 0 0 0 0;...
      0 L1 0 0 0 0;...
      0 L2 0 0 0 0];
```

```
Robot1 = DH2Robot(DH,0)

T0_1 = Robot1.A([1],[t1 t2 t3])
T1_2 = Robot1.A([2],[t1 t2 t3])
T2_3 = Robot1.A([3],[t1 t2 t3])
Robot1.A([1 2 3],[t1 t2 t3])
```

```
Robot1 =

noname (3 axis, RRR, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|          0|          0|
|  2|         q2|          0|         L1|          0|          0|
|  3|         q3|          0|         L2|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0           0  1  0  0
       9.81         0  0  1  0           0  0  1  0
                    0  0  0  1           0  0  0  1


T0_1 =

[ cos(t1), -sin(t1), 0, 0]
[ sin(t1),  cos(t1), 0, 0]
[       0,        0, 1, 0]
[       0,        0, 0, 1]


T1_2 =

[ cos(t2), -sin(t2), 0, L1]
[ sin(t2),  cos(t2), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


T2_3 =

[ cos(t3), -sin(t3), 0, L2]
[ sin(t3),  cos(t3), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


ans =

[ cos(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) - sin(t3)*(cos(t1)*sin(t2) + cos(t2)*si
n(t1)), - cos(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) - sin(t3)*(cos(t1)*cos(t2) - si
```

```
n(t1)*sin(t2)), 0, L2*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) + L1*cos(t1)]
[ cos(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) + sin(t3)*(cos(t1)*cos(t2) - sin(t1)*si
n(t2)),   cos(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) - sin(t3)*(cos(t1)*sin(t2) + co
s(t2)*sin(t1)), 0, L2*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) + L1*sin(t1)]
[
     0,
             0, 1,                                                    0]
[
     0,
             0, 0,                                                    1]
```

```
end


if p == 3
```

Problem #3

```
DH = [0 0 0 0 0 0;...
      -90 0 0 0 0 0;...
      0 L2 0 0 0 0;...
      0 L3 0 0 0 0];

Robot1 = DH2Robot(DH,0)
%Robot1.plot([0 0 0 0])

T0_1 = Robot1.A([1],[t1 t2 t3 0])
T1_2 = Robot1.A([2],[t1 t2 t3 0])
T2_3 = Robot1.A([3],[t1 t2 t3 0])
T2_4 = Robot1.A([4],[t1 t2 t3 0])
Robot1.A([1 2 3 4],[t1 t2 t3 0])
```

```
Robot1 =

noname (4 axis, RRRR, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|          0|          0|
|  2|         q2|          0|          0|      -pi/2|          0|
|  3|         q3|          0|         L2|          0|          0|
|  4|         q4|          0|         L3|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0           0  1  0  0
       9.81         0  0  1  0           0  0  1  0
                    0  0  0  1           0  0  0  1
```

```
T0_1 =

[ cos(t1), -sin(t1), 0, 0]
[ sin(t1),  cos(t1), 0, 0]
[       0,        0, 1, 0]
[       0,        0, 0, 1]


T1_2 =

[  cos(t2), -sin(t2), 0, 0]
[        0,        0, 1, 0]
[ -sin(t2), -cos(t2), 0, 0]
[        0,        0, 0, 1]


T2_3 =

[ cos(t3), -sin(t3), 0, L2]
[ sin(t3),  cos(t3), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


T2_4 =

[ 1, 0, 0, L3]
[ 0, 1, 0,  0]
[ 0, 0, 1,  0]
[ 0, 0, 0,  1]


ans =

[ cos(t1)*cos(t2)*cos(t3) - cos(t1)*sin(t2)*sin(t3), - cos(t1)*cos(t2)*sin(t3) - cos(
t1)*cos(t3)*sin(t2), -sin(t1), L2*cos(t1)*cos(t2) - L3*(cos(t1)*sin(t2)*sin(t3) - cos
(t1)*cos(t2)*cos(t3))]
[ cos(t2)*cos(t3)*sin(t1) - sin(t1)*sin(t2)*sin(t3), - cos(t2)*sin(t1)*sin(t3) - cos(
t3)*sin(t1)*sin(t2),  cos(t1), L2*cos(t2)*sin(t1) - L3*(sin(t1)*sin(t2)*sin(t3) - cos
(t2)*cos(t3)*sin(t1))]
[               - cos(t2)*sin(t3) - cos(t3)*sin(t2),                   sin(t2)*sin(t3
) - cos(t2)*cos(t3),        0,                       - L3*(cos(t2)*sin(t3) + cos(t3)*
sin(t2)) - L2*sin(t2)]
[                                                 0,
                  0,        0,
                    1]
```

```
end


if p == 4
```

Problem #4

```
DH = [0 0 0 0 0 0;...
      90 0 L2 0 0 0;...
      -90 0 d3 0 1 0];

Robot1 = DH2Robot(DH,0)
%Robot1.plot([0.3 0.4 4],'workspace',[-20 20 -20 20 -20 20])

T0_1 = Robot1.A([1],[t1 t2 d])
T1_3 = Robot1.A([2],[t1 t2 d])
T3_4 = Robot1.A([3],[t1 t2 d])
Robot1.A([1 2 3],[t1 t2 d])
```

```
Robot1 =

noname (3 axis, RRP, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|          0|          0|
|  2|         q2|         L2|          0|       pi/2|          0|
|  3|          0|         q3|          0|      -pi/2|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0           0  1  0  0
       9.81         0  0  1  0           0  0  1  0
                    0  0  0  1           0  0  0  1


T0_1 =

[ cos(t1), -sin(t1), 0, 0]
[ sin(t1),  cos(t1), 0, 0]
[       0,        0, 1, 0]
[       0,        0, 0, 1]


T1_3 =

[ cos(t2), -sin(t2),  0,   0]
[       0,        0, -1, -L2]
[ sin(t2),  cos(t2),  0,   0]
[       0,        0,  0,   1]


T3_4 =

[ 1,  0, 0, 0]
[ 0,  0, 1, d]
[ 0, -1, 0, 0]
[ 0,  0, 0, 1]
```

```
ans =

[ cos(t1)*cos(t2), -sin(t1), -cos(t1)*sin(t2),   L2*sin(t1) - d*cos(t1)*sin(t2)]
[ cos(t2)*sin(t1),  cos(t1), -sin(t1)*sin(t2), - L2*cos(t1) - d*sin(t1)*sin(t2)]
[         sin(t2),        0,          cos(t2),                       d*cos(t2)]
[               0,        0,                0,                              1]
```

```
end


if p == 5
```

Problem #5

```
DH = [0 0 0 0 0 0;...
      0 0 d2 90 1 0;...
      90 0 d3 0 1 0];

Robot1 = DH2Robot(DH,0)
%Robot1.plot([0 0 0],'workspace',[-20 20 -20 20 -20 20])

T0_1 = Robot1.A([1],[t1 d2 d3])
T1_2 = Robot1.A([2],[t1 d2 d3])
T2_3 = Robot1.A([3],[t1 d2 d3])
Robot1.A([1 2 3],[t1 d2 d3])
```

```
Robot1 =

noname (3 axis, RPP, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|          0|          0|
|  2|       pi/2|         q2|          0|          0|          0|
|  3|          0|         q3|          0|       pi/2|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0           0  1  0  0
       9.81         0  0  1  0           0  0  1  0
                    0  0  0  1           0  0  0  1


T0_1 =

[ cos(t1), -sin(t1), 0, 0]
[ sin(t1),  cos(t1), 0, 0]
[       0,        0, 1, 0]
```

```
[       0,        0, 0, 1]


T1_2 =

[ 0, -1, 0,  0]
[ 1,  0, 0,  0]
[ 0,  0, 1, d2]
[ 0,  0, 0,  1]


T2_3 =

[ 1, 0,  0,   0]
[ 0, 0, -1, -d3]
[ 0, 1,  0,   0]
[ 0, 0,  0,   1]


ans =

[ -sin(t1), 0, cos(t1), d3*cos(t1)]
[  cos(t1), 0, sin(t1), d3*sin(t1)]
[        0, 1,       0,         d2]
[        0, 0,       0,          1]
```

```
end


if p == 6
```

Problem #6

```
DH = [0 0 0 t4 0 0;...
      90 0 0 t5 0 0;...
      -90 0 0 t6 0 0];

Robot1 = DH2Robot(DH,0)
%Robot1.plot([0 0 0],'workspace',[-20 20 -20 20 -20 20])

T3_4 = Robot1.A([1],[t4 t5 t6])
T4_5 = Robot1.A([2],[t4 t5 t6])
T5_6 = Robot1.A([3],[t4 t5 t6])
Robot1.A([1 2 3],[t4 t5 t6])
```

```
Robot1 =

noname (3 axis, RRR, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
```

```
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|          0|          0|
|  2|         q2|          0|          0|       pi/2|          0|
|  3|         q3|          0|          0|      -pi/2|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0           0  1  0  0
       9.81         0  0  1  0           0  0  1  0
                    0  0  0  1           0  0  0  1


T3_4 =

[ cos(t4), -sin(t4), 0, 0]
[ sin(t4),  cos(t4), 0, 0]
[       0,        0, 1, 0]
[       0,        0, 0, 1]


T4_5 =

[ cos(t5), -sin(t5),  0, 0]
[       0,        0, -1, 0]
[ sin(t5),  cos(t5),  0, 0]
[       0,        0,  0, 1]


T5_6 =

[  cos(t6), -sin(t6), 0, 0]
[        0,        0, 1, 0]
[ -sin(t6), -cos(t6), 0, 0]
[        0,        0, 0, 1]


ans =

[ cos(t4)*cos(t5)*cos(t6) - sin(t4)*sin(t6), - cos(t6)*sin(t4) - cos(t4)*cos(t5)*sin(
t6), -cos(t4)*sin(t5), 0]
[ cos(t4)*sin(t6) + cos(t5)*cos(t6)*sin(t4),   cos(t4)*cos(t6) - cos(t5)*sin(t4)*sin(
t6), -sin(t4)*sin(t5), 0]
[                           cos(t6)*sin(t5),                           -sin(t5)*sin(
t6),          cos(t5), 0]
[                                         0,
  0,                0, 1]
```

```
end


if p == 7
```

Problem #7

```
DH = [0 0 0 t1 0 0;...
      0 L1 0 t2 0 0;...
      0 L2 0 t3 0 0;...
      0 0 -d4 0 1 0];

Robot1 = DH2Robot(DH,0)
%Robot1.plot([0 0 0 -5],'workspace',[-20 20 -20 20 -20 20])

T0_1 = Robot1.A([1],[t1 t2 t3 d4])
T1_2 = Robot1.A([2],[t1 t2 t3 d4])
T2_3 = Robot1.A([3],[t1 t2 t3 d4])
T3_4 = Robot1.A([4],[t1 t2 t3 d4])
Robot1.A([1 2 3 4],[t1 t2 t3 d4])
```

```
Robot1 =

noname (4 axis, RRRP, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|          0|          0|          0|          0|
|  2|         q2|          0|         L1|          0|          0|
|  3|         q3|          0|         L2|          0|          0|
|  4|          0|         q4|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0           0  1  0  0
       9.81         0  0  1  0           0  0  1  0
                    0  0  0  1           0  0  0  1


T0_1 =

[ cos(t1), -sin(t1), 0, 0]
[ sin(t1),  cos(t1), 0, 0]
[       0,        0, 1, 0]
[       0,        0, 0, 1]


T1_2 =

[ cos(t2), -sin(t2), 0, L1]
[ sin(t2),  cos(t2), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


T2_3 =

[ cos(t3), -sin(t3), 0, L2]
```

```
[ sin(t3),  cos(t3), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


T3_4 =

[ 1, 0, 0,  0]
[ 0, 1, 0,  0]
[ 0, 0, 1, d4]
[ 0, 0, 0,  1]


ans =

[ cos(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) - sin(t3)*(cos(t1)*sin(t2) + cos(t2)*si
n(t1)), - cos(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) - sin(t3)*(cos(t1)*cos(t2) - si
n(t1)*sin(t2)), 0, L2*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) + L1*cos(t1)]
[ cos(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) + sin(t3)*(cos(t1)*cos(t2) - sin(t1)*si
n(t2)),   cos(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) - sin(t3)*(cos(t1)*sin(t2) + co
s(t2)*sin(t1)), 0, L2*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) + L1*sin(t1)]
[
     0,
             0, 1,                                                  d4]
[
     0,
             0, 0,                                                   1]
```

```
end


if p == 8
```

Problem #8

```
DH = [0 0 d1 0 1 0;...
      0 0 L1 t2 0 0;...
      0 L2 0 t3 0 0;...
      0 L3 0 t4 0 0;...
      0 0 -L4 0 0 0];

Robot1 = DH2Robot(DH,0)
%Robot1.plot([0 0 0 0 0],'workspace',[-20 20 -20 20 -20 20])

T0_1 = Robot1.A([1],[d1 t2 t3 t4 0])
T1_2 = Robot1.A([2],[d1 t2 t3 t4 0])
T2_3 = Robot1.A([3],[d1 t2 t3 t4 0])
T3_4 = Robot1.A([4],[d1 t2 t3 t4 0])
T4_5 = Robot1.A([5],[d1 t2 t3 t4 0])
Robot1.A([1 2 3 4 5],[d1 t2 t3 t4 0])
```

```
Robot1 =

noname (5 axis, PRRRR, modDH, fastRNE)

+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|          0|         q1|          0|          0|          0|
|  2|         q2|         L1|          0|          0|          0|
|  3|         q3|          0|         L2|          0|          0|
|  4|         q4|          0|         L3|          0|          0|
|  5|         q5|        -L4|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+

grav =    0  base = 1  0  0  0   tool =  1  0  0  0
          0         0  1  0  0           0  1  0  0
       9.81         0  0  1  0           0  0  1  0
                    0  0  0  1           0  0  0  1


T0_1 =

[ 1, 0, 0,  0]
[ 0, 1, 0,  0]
[ 0, 0, 1, d1]
[ 0, 0, 0,  1]


T1_2 =

[ cos(t2), -sin(t2), 0,  0]
[ sin(t2),  cos(t2), 0,  0]
[       0,        0, 1, L1]
[       0,        0, 0,  1]


T2_3 =

[ cos(t3), -sin(t3), 0, L2]
[ sin(t3),  cos(t3), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


T3_4 =

[ cos(t4), -sin(t4), 0, L3]
[ sin(t4),  cos(t4), 0,  0]
[       0,        0, 1,  0]
[       0,        0, 0,  1]


T4_5 =

[ 1, 0, 0,   0]
[ 0, 1, 0,   0]
```

```
[ 0, 0, 1, -L4]
[ 0, 0, 0,   1]


ans =

[ cos(t4)*(cos(t2)*cos(t3) - sin(t2)*sin(t3)) - sin(t4)*(cos(t2)*sin(t3) + cos(t3)*si
n(t2)), - cos(t4)*(cos(t2)*sin(t3) + cos(t3)*sin(t2)) - sin(t4)*(cos(t2)*cos(t3) - si
n(t2)*sin(t3)), 0, L3*(cos(t2)*cos(t3) - sin(t2)*sin(t3)) + L2*cos(t2)]
[ cos(t4)*(cos(t2)*sin(t3) + cos(t3)*sin(t2)) + sin(t4)*(cos(t2)*cos(t3) - sin(t2)*si
n(t3)),   cos(t4)*(cos(t2)*cos(t3) - sin(t2)*sin(t3)) - sin(t4)*(cos(t2)*sin(t3) + co
s(t3)*sin(t2)), 0, L3*(cos(t2)*sin(t3) + cos(t3)*sin(t2)) + L2*sin(t2)]
[
     0,
             0, 1,                                          L1 - L4 + d1]
[
     0,
             0, 0,                                                    1]
```

```
end

end
```

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