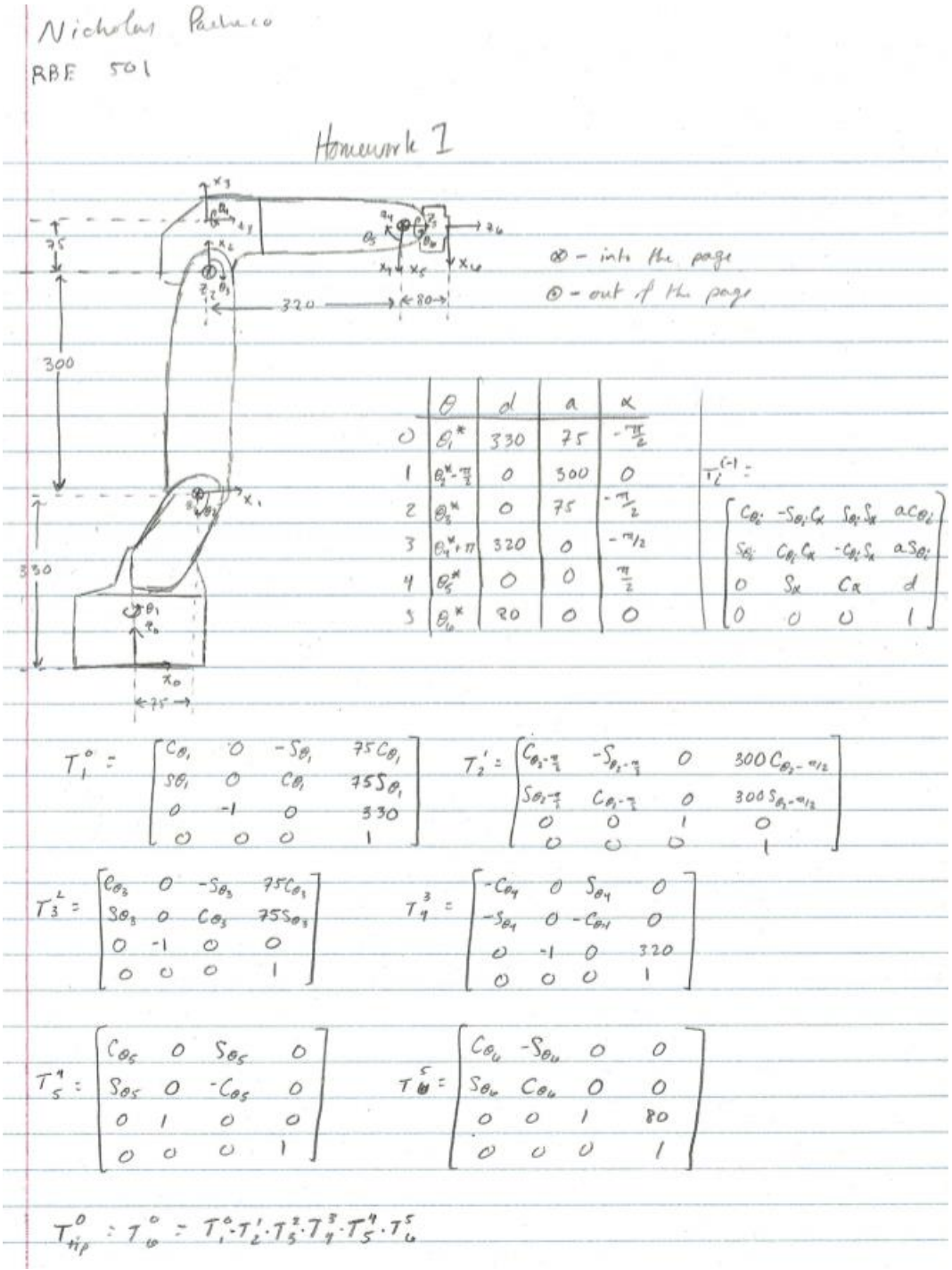
Homework 1

```
clc; clear; close all;
```



Homogeneous Transformation Matrices

```
syms t1 t2 t3 t4 t5 t6
DH_table = [t1 330 75 -sym(pi)/2;
            t2-sym(pi)/2 0 300 0;
            t3 0 75 -pi/2;
            t4+sym(pi) 320 0 -sym(pi)/2;
            t5 0 0 sym(pi)/2;
```

```
             t6 80 0 0];
T01 = tdh(DH_table(1,:));
T12 = tdh(DH_table(2,:));
T23 = tdh(DH_table(3,:));
T34 = tdh(DH_table(4,:));
T45 = tdh(DH_table(5,:));
T56 = tdh(DH_table(6,:));
```

Composite Transformation

```
T0_6 = T01*T12*T23*T34*T45*T56;
T0_6 = simplify(T0_6,'Steps', 100);
pretty(T0_6)
input = deg2rad([0,75,30,135,-45,60]);
T0_6_val = subs(T0_6, [t1,t2,t3,t4,t5,t6],input);
T0_6_val = vpa(T0_6_val,4)
```

```
[[sin(t6) #4 - cos(t6) #2, cos(t6) #4 + sin(t6) #2,

  cos(t2 + t3) cos(t1) cos(t5) - sin(t5)

  (sin(t1) sin(t4) + cos(t1) cos(t2) cos(t4) sin(t3) + cos(t1) cos(t3)

  cos(t4) sin(t2)), 75 cos(t1) + 300 cos(t1) sin(t2) - 320

   cos(t1) sin(t2) sin(t3) - 80 sin(t1) sin(t4) sin(t5) + 320

   cos(t1) cos(t2) cos(t3) + 75 cos(t1) cos(t2) sin(t3) + 75

   cos(t1) cos(t3) sin(t2) + 80 cos(t1) cos(t2) cos(t3) cos(t5) - 80

   cos(t1) cos(t5) sin(t2) sin(t3) - 80

   cos(t1) cos(t2) cos(t4) sin(t3) sin(t5) - 80

   cos(t1) cos(t3) cos(t4) sin(t2) sin(t5)],

  [sin(t6) #3 - cos(t6) #1, cos(t6) #3 + sin(t6) #1,

  cos(t2 + t3) cos(t5) sin(t1) - sin(t5)

  (cos(t2) cos(t4) sin(t1) sin(t3) - cos(t1) sin(t4) + cos(t3) cos(t4)

  sin(t1) sin(t2)), 75 sin(t1) + 300 sin(t1) sin(t2) + 75

   cos(t2) sin(t1) sin(t3) + 75 cos(t3) sin(t1) sin(t2) + 80

   cos(t1) sin(t4) sin(t5) - 320 sin(t1) sin(t2) sin(t3) + 320

   cos(t2) cos(t3) sin(t1) + 80 cos(t2) cos(t3) cos(t5) sin(t1) - 80

   cos(t5) sin(t1) sin(t2) sin(t3) - 80
```

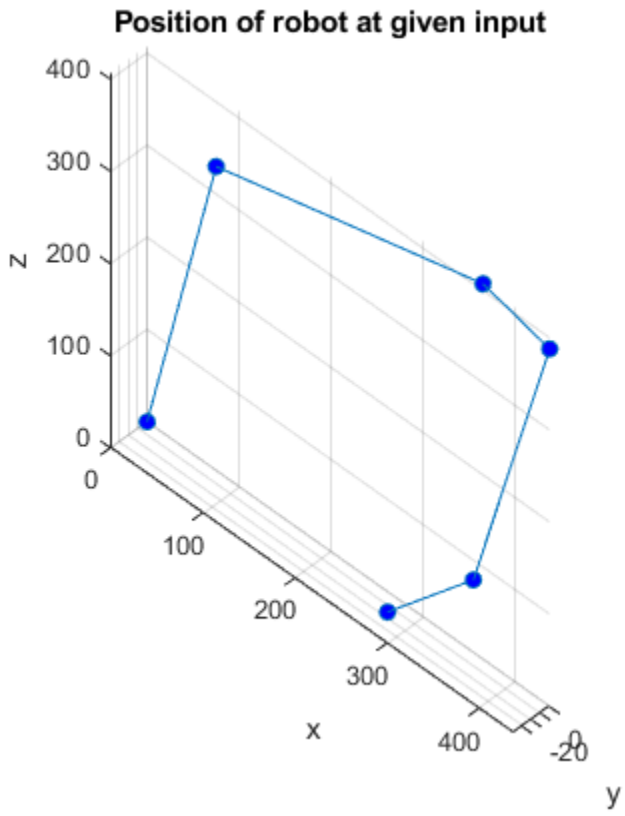
```
   cos(t2) cos(t4) sin(t1) sin(t3) sin(t5) - 80
   cos(t3) cos(t4) sin(t1) sin(t2) sin(t5)],
  [cos(t6) #5 + cos(t2 + t3) sin(t4) sin(t6),
  cos(t2 + t3) cos(t6) sin(t4) - sin(t6) #5,
  - sin(t2 + t3) cos(t5) - cos(t2 + t3) cos(t4) sin(t5),
  300 cos(t2) + 75 cos(t2) cos(t3) - 320 cos(t2) sin(t3) - 320
   cos(t3) sin(t2) - 75 sin(t2) sin(t3) - 80 cos(t2) cos(t5) sin(t3) - 80
   cos(t3) cos(t5) sin(t2) - 80 cos(t2) cos(t3) cos(t4) sin(t5) + 80
   cos(t4) sin(t2) sin(t3) sin(t5) + 330],
  [0, 0, 0, 1]]
where
   #1 == cos(t2 + t3) sin(t1) sin(t5) - cos(t1) cos(t5) sin(t4) + cos(t2)
     cos(t4) cos(t5) sin(t1) sin(t3) + cos(t3) cos(t4) cos(t5) sin(t1)
     sin(t2)
   #2 == cos(t5) sin(t1) sin(t4) + cos(t2
      + t3) cos(t1) sin(t5) + cos(t1) cos(t2) cos(t4) cos(t5)
     sin(t3) + cos(t1) cos(t3) cos(t4) cos(t5) sin(t2)
   #3 == cos(t1) cos(t4) + cos(t2) sin(t1) sin(t3) sin(t4) + cos(t3)
     sin(t1) sin(t2) sin(t4)
   #4 == cos(t1) cos(t2) sin(t3) sin(t4) - cos(t4) sin(t1) + cos(t1)
     cos(t3) sin(t2) sin(t4)
   #5 == sin(t2 + t3) sin(t5) - cos(t2 + t3) cos(t4) cos(t5)


T0_6_val =

[  0.7415, 0.08174,  -0.666, 301.1]
[ -0.3624, -0.7866,    -0.5, -40.0]
[ -0.5647,  0.6121, -0.5536, 34.85]
[       0,       0,       0,   1.0]
```

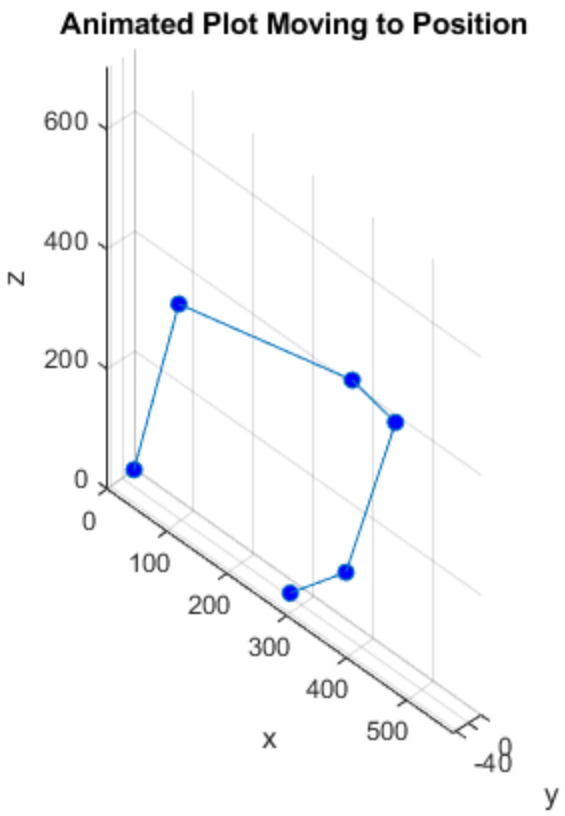
Plotting the robot

```
plot_robot([0,75,30,135,-45,60]);
title('Position of robot at given input')
xlabel('x');
ylabel('y');
zlabel('z');
snapnow
```



bonus

```
fanimator(@(t)animator(t));
title('Animated Plot Moving to Position')
xlabel('x');
ylabel('y');
zlabel('z');
view([45,45])
axis equal
grid on
playAnimation;
snapnow
```



Functions

```
function p = plot_robot(q)
% assumes q is in degrees
q = deg2rad(q);
t1 = q(1); t2 = q(2); t3 = q(3); t4 = q(4); t5 = q(5); t6 = q(6);
DH_table = [t1 330 75 -pi/2;
            t2-pi/2 0 300 0;
            t3 0 75 -pi/2;
            t4+pi 320 0 -pi/2;
            t5 0 0 pi/2;
            t6 80 0 0];
T01 = tdh(DH_table(1,:));
T12 = tdh(DH_table(2,:));
T23 = tdh(DH_table(3,:));
T34 = tdh(DH_table(4,:));
T45 = tdh(DH_table(5,:));
T56 = tdh(DH_table(6,:));
T02 = T01*T12;
T03 = T01*T12*T23;
T04 = T01*T12*T23*T34;
T05 = T01*T12*T23*T34*T45;
T0_tip = T01*T12*T23*T34*T45*T56;

x = [0 T01(1,4) T02(1,4) T03(1,4) T04(1,4) T05(1,4) T0_tip(1,4)];
y = [0 T01(2,4) T02(2,4) T03(2,4) T04(2,4) T05(2,4) T0_tip(2,4)];
```

```
z = [0 T01(3,4) T02(3,4) T03(3,4) T04(3,4) T05(3,4) T0_tip(3,4)];
p = plot3(x,y,z, '-o','MarkerFaceColor', 'b');
view([45,45])
axis equal
grid on
end

function p = animator(t)
initial_pos = zeros(1,6);
increment = [0,75,30,135,-45,60]./10;
q = initial_pos+increment*t;
p = plot_robot(q);
end
```

Published with MATLAB® R2019b