Question 1 - Symbolic Computation of T Matrix

```
clear L
close all
clc

syms t1 t2 t3 L1 L2 L3

% Create the links using modified D&H convention
Link1 = link([0 0 t1 0], 'modified');
Link2 = link([0 L1 t2 0], 'modified');
Link3 = link([0 L2 t3 0], 'modified');
Link4 = link([0 L3 0 0], 'modified');  % End effector

% Define the robot model
robot_2 = robot({Link1 Link2 Link3 Link4}, 'HW2_Question1', 'Hambal',
'unknown');

robot_2.name = "HW2_Question1";
robot_2.manuf = 'Hambal';

Qsym = [t1 t2 t3 0];

% Forward kinematics
Tsym = fkine(robot_2, Qsym)
pretty(Tsym) % To make it more readable
```

```
Tsym =

[cos(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) - sin(t3)*(cos(t1)*sin(t2) +
cos(t2)*sin(t1)), - cos(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) -
sin(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)), 0, L2*(cos(t1)*cos(t2) -
sin(t1)*sin(t2)) + L1*cos(t1) + L3*(cos(t3)*(cos(t1)*cos(t2) -
sin(t1)*sin(t2)) - sin(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)))]
[cos(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)) + sin(t3)*(cos(t1)*cos(t2) -
sin(t1)*sin(t2)),   cos(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)) -
sin(t3)*(cos(t1)*sin(t2) + cos(t2)*sin(t1)), 0, L2*(cos(t1)*sin(t2) +
cos(t2)*sin(t1)) + L1*sin(t1) + L3*(cos(t3)*(cos(t1)*sin(t2) +
cos(t2)*sin(t1)) + sin(t3)*(cos(t1)*cos(t2) - sin(t1)*sin(t2)))]
[

0,
               0,
1,
                                                                      0]
[

0,
               0,
0,
                                                                      1]
```

```
/ #1, - cos(t3) #4 - sin(t3) #3, 0, L2 #3 + L1 cos(t1) + L3 #1 \
\                                                              |
|                                                              |
| #2,             #1,            0, L2 #4 + L1 sin(t1) + L3 #2 |
|                                                              |
|  0,             0,             1,              0             |
|                                                              |
\  0,             0,             0,              1            /
```

where

#1 == cos(t3) #3 - sin(t3) #4

#2 == cos(t3) #4 + sin(t3) #3

#3 == cos(t1) cos(t2) - sin(t1) sin(t2)

#4 == cos(t1) sin(t2) + cos(t2) sin(t1)

Plotting with numerical inputs

```
clear L
close all
clc

% Create the links using modified D&H convention
Link1 = link([0 0 pi/2 0], 'modified');
Link2 = link([0 10 -pi/2 0], 'modified');
Link3 = link([0 10 -pi/2 0], 'modified');
Link4 = link([0 5 0 0], 'modified');  % End effector

% Define the robot model
robot_2 = robot({Link1 Link2 Link3 Link4}, 'HW2_Question2', 'Hambal',
'unknown');

robot_2.name = "HW2_Question2";
robot_2.manuf = 'Hambal';

% Define joint angles
Q = [pi/2 -pi/2 -pi/2 0];

% Forward kinematics
Tsym = fkine(robot_2, Q)


% Plot the robot
plot(robot_2, Q)
```

Tsym =

```
    0.0000    1.0000         0   10.0000
   -1.0000    0.0000         0    5.0000
         0         0    1.0000         0
         0         0         0    1.0000

Warning: Robot name is invalid or not set.
Warning: The EraseMode property is no longer supported and will error in a
future release.
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future release.
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future release.
```

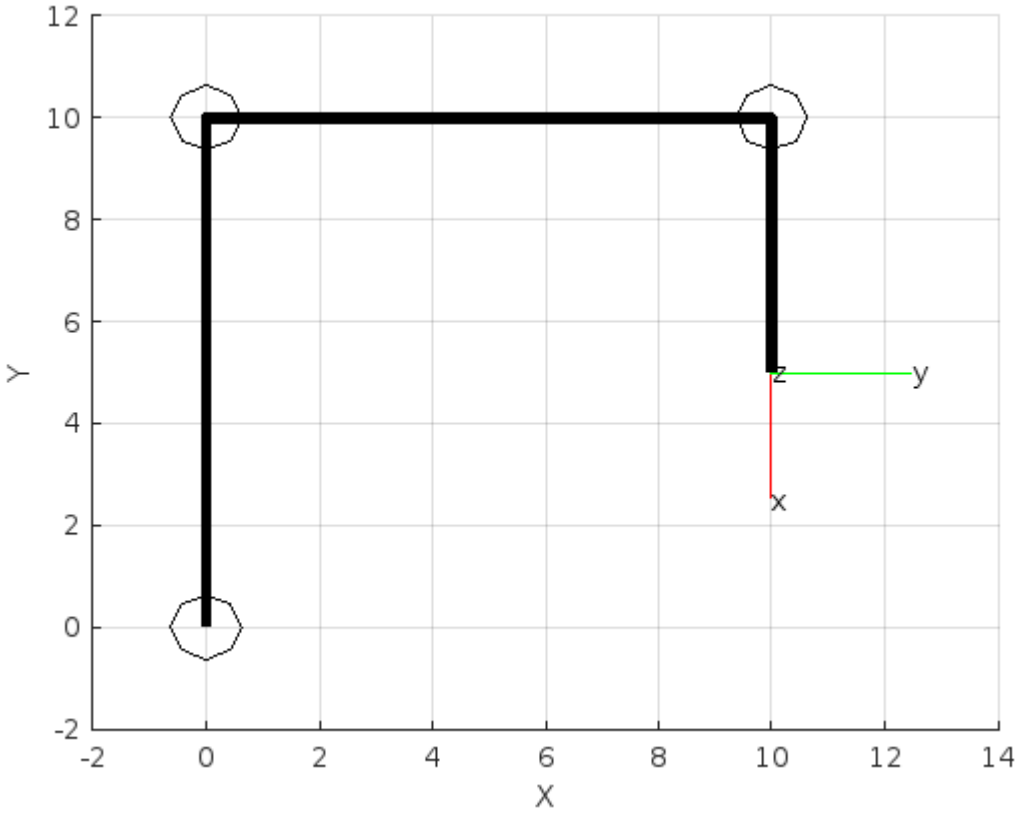

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