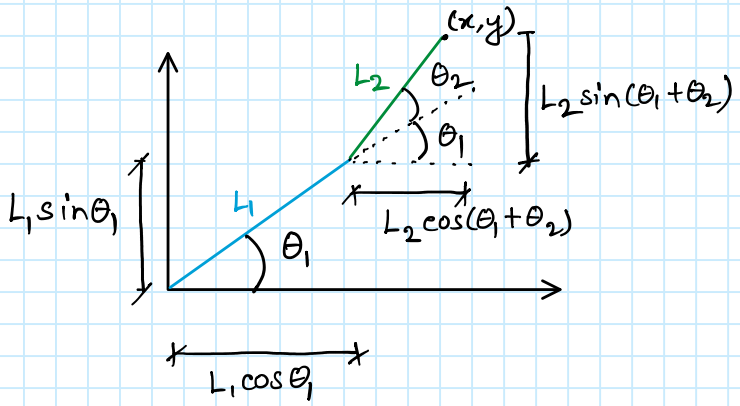
Design Project 2 Solution

Thursday, January 18, 2024 22:58

Problem a

$$x = L_2\cos(\theta_1+\theta_2) + L_1\cos\theta_1$$

$$y = L_2\sin(\theta_1+\theta_2) + L_1\sin\theta_1$$



Problem b and c

$$x = 2\cos(\theta_1+\theta_2) + 4\cos\theta_1$$

$$y = 4\sin(\theta_1+\theta_2) + 2\sin\theta_1$$

$[L_1 = 4',\ L_2 = 2']$

N.B. : I have mentioned symbolic math Toolbox to be a requirement for the project in class. However, in the problem statement "it is strongly recommended." is mentioned.

Thus, I suggest being lenient on the students as long as they make the correct plots, even if they do not use Symbolic Math Toolbox.

For full extension of robot arm : $\theta_2 = 0$; $0^\circ \le \theta_1 \le 360^\circ$

When only the smaller link moves: θ_1 = constant ; $0^\circ \le \theta_2 \le 360^\circ$

↳ can assume any constant value

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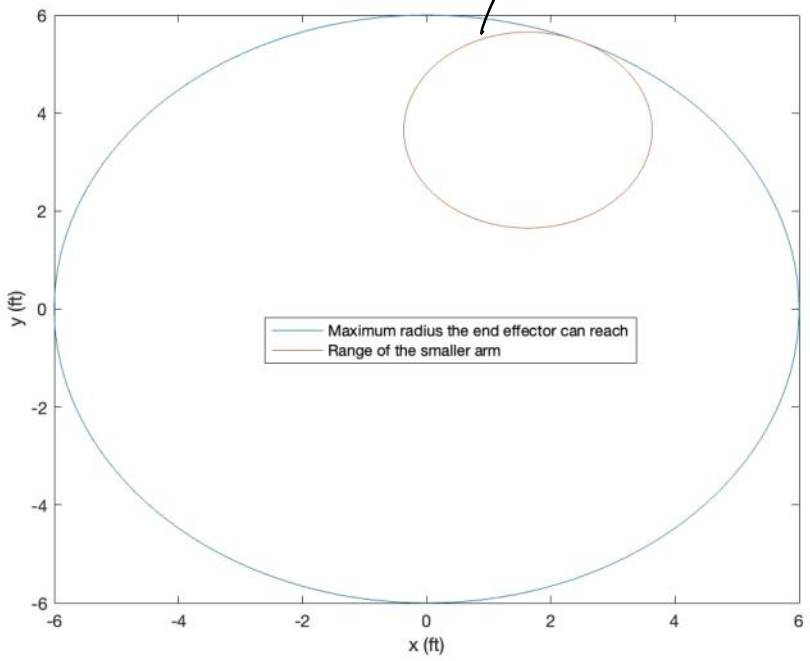
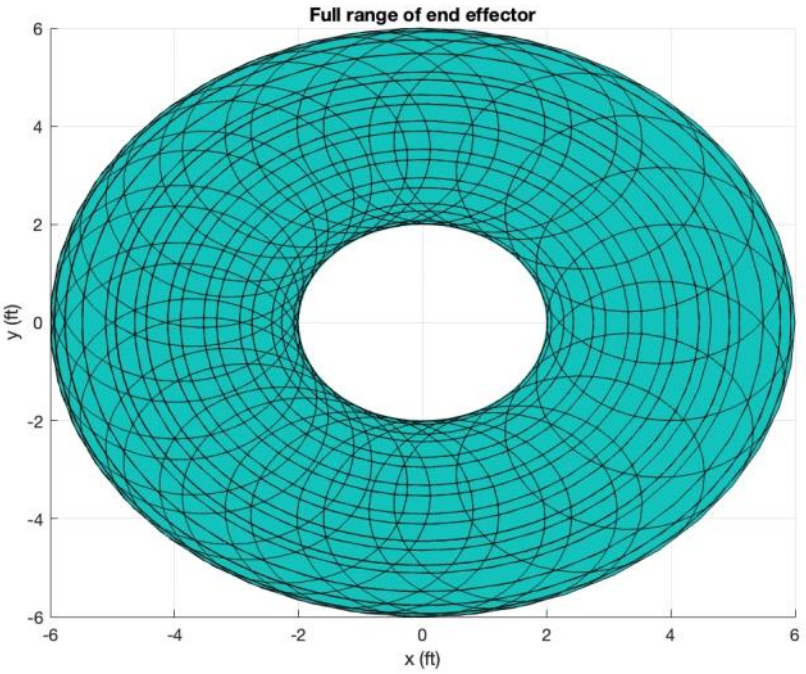


The smaller ellipse's position will depend on what constant value of θ_1 was used. However, it should touch the bigger ellipse.

Problem d



End effector can reach all parts within the cyan region.

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```
clc
clear all

% Define symbolic variables
syms L1 L2 theta1 theta2

% x and y co-ordinates of the end effector
x = L2*cos(theta1+theta2) + L1*cos(theta1)
```

x = $L_2\cos(\theta_1+\theta_2)+L_1\cos(\theta_1)$

```
y = L2*sin(theta1+theta2) + L1*sin(theta1)
```

y = $L_2\sin(\theta_1+\theta_2)+L_1\sin(\theta_1)$

```
% Substituting the lengths of the links
fx(theta1,theta2) = subs(x,[L1 L2],[4 2])
```

fx(theta1, theta2) = $2\cos(\theta_1+\theta_2)+4\cos(\theta_1)$

```
fy(theta1,theta2) = subs(y,[L1 L2],[4 2])
```

fy(theta1, theta2) = $2\sin(\theta_1+\theta_2)+4\sin(\theta_1)$

```
% Position of end effector when arm is
% fully extended
figure()
fplot(fx(theta1,0),fy(theta1,0))
hold on

% Position of end effector when only
% L2 moves
fplot(fx(20,theta2),fy(20,theta2))
legend('Maximum radius the end effector can reach','Range of the smaller arm')
xlabel('x (ft)')
ylabel('y (ft)')
hold off
```

can assume any constant value instead of 20

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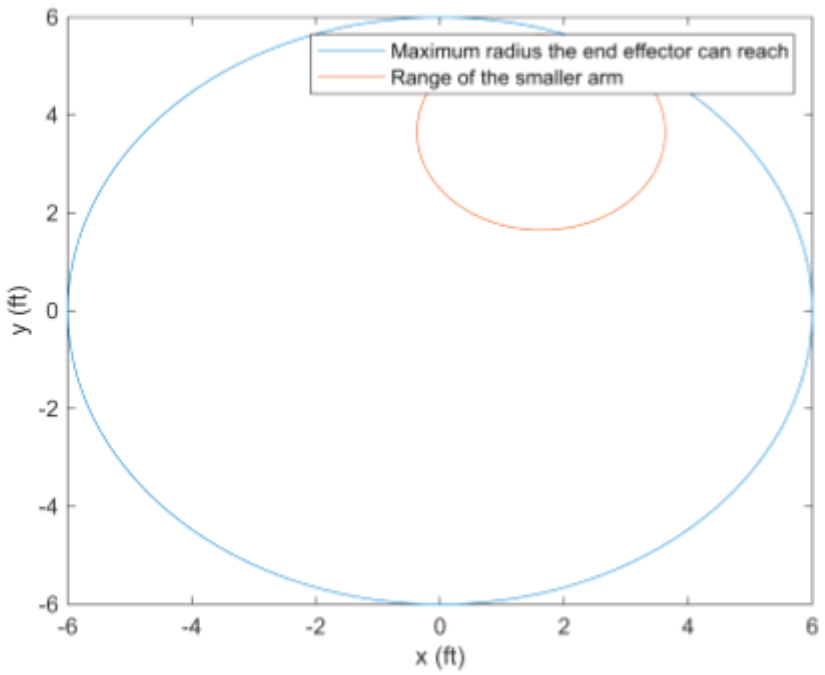


```
% Position of end effector
figure()
fsurf(fx,fy,0)
view(2)
title('Full range of end effector')
xlabel('x (ft)')
ylabel('y (ft)')
```

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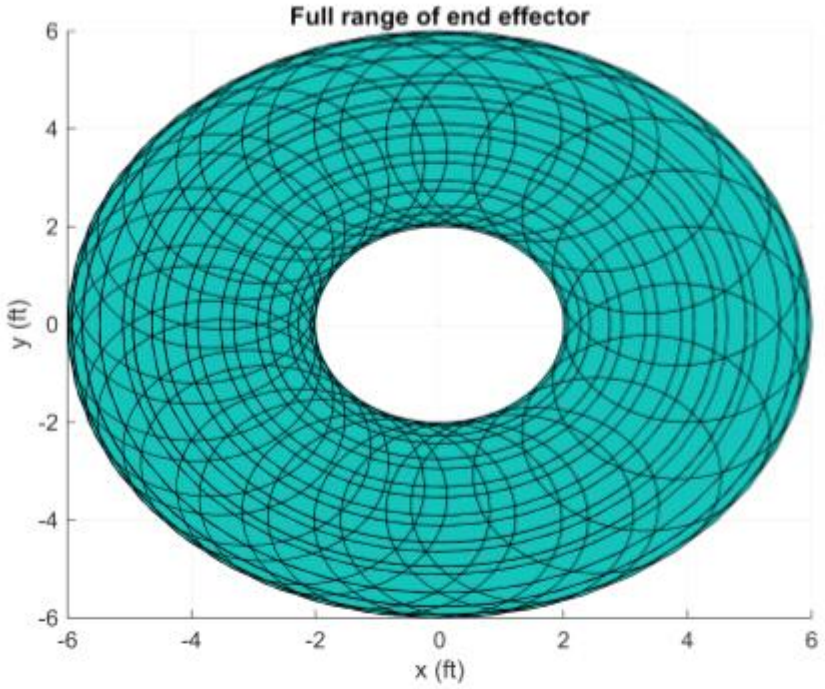

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