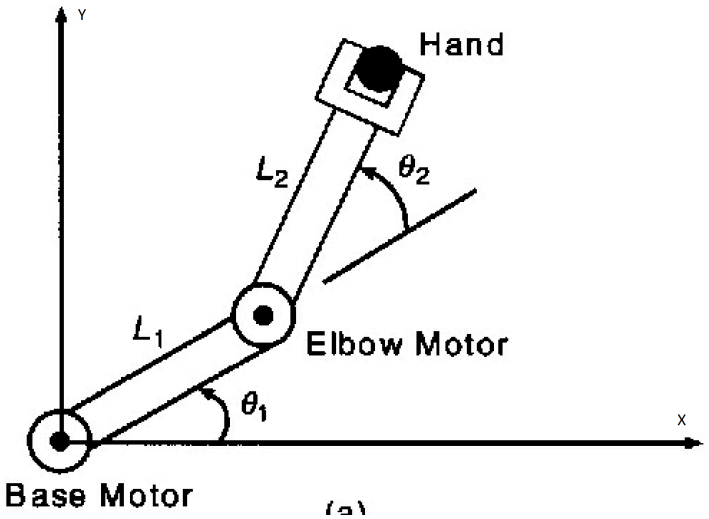
Robotic arm motion



$$x_e = L_1 \cos(\theta_1)$$

$$y_e = L_1 \sin(\theta_1)$$

$$x_h = L_1 \cos(\theta_1) + L_2 \cos($$

$$y_h = L_1 \sin(\theta_1) + L_2 \sin($$

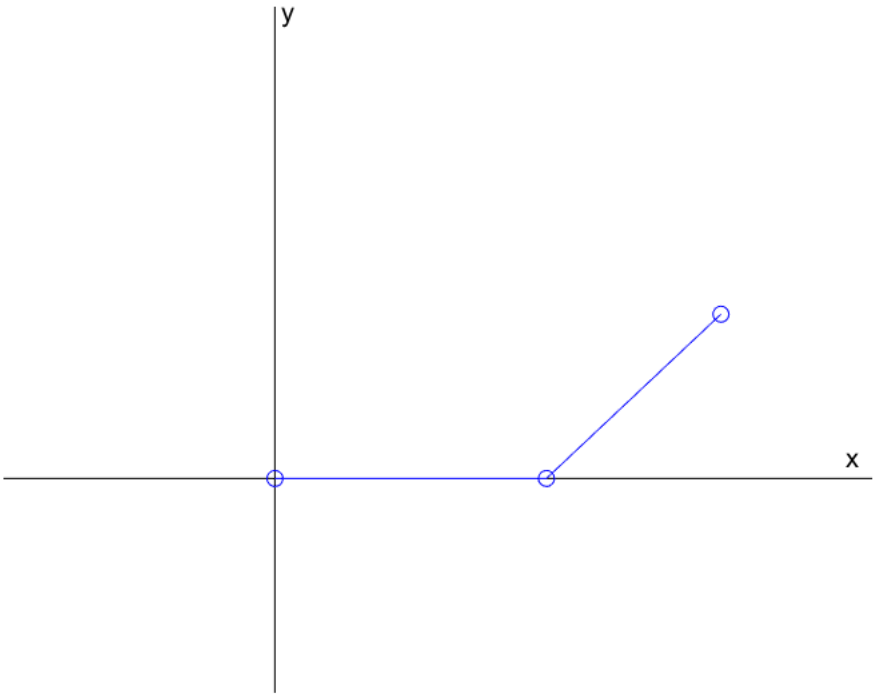
```
L1=50;
L2=50;
T1=-25% -30 ... 60
```

```
T1 = 0
```

```
T2=50% 0 ... 150
```

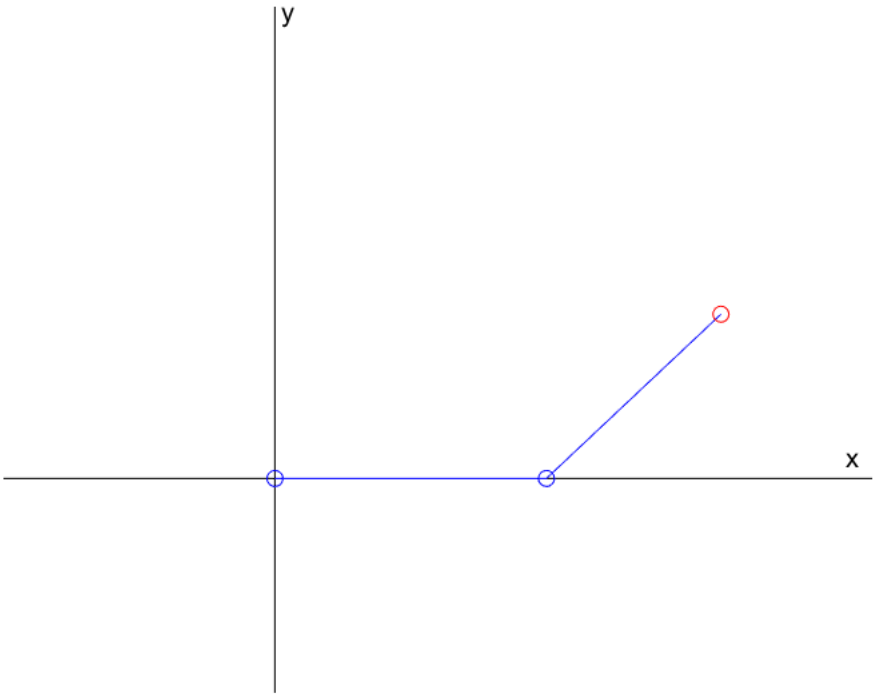
```
T2 = 50
```

```
xe=L1*cosd(T1);
ye=L1*sind(T1);
xh=L1*cosd(T1)+L2*cosd(T1+T2);
yh=L1*sind(T1)+L2*sind(T1+T2);
figure;
set(gca,'Visible','off')
hold on;
plot([-50 110],[0 0],"-k")
plot([0 0],[-50 110],"-k")
text(105,5,"x")
text(1,109,"y")
plot([0 xe xh],[0 ye yh],"-b","Marker","o")
axis([-50 110 -50 110])
hold off
```



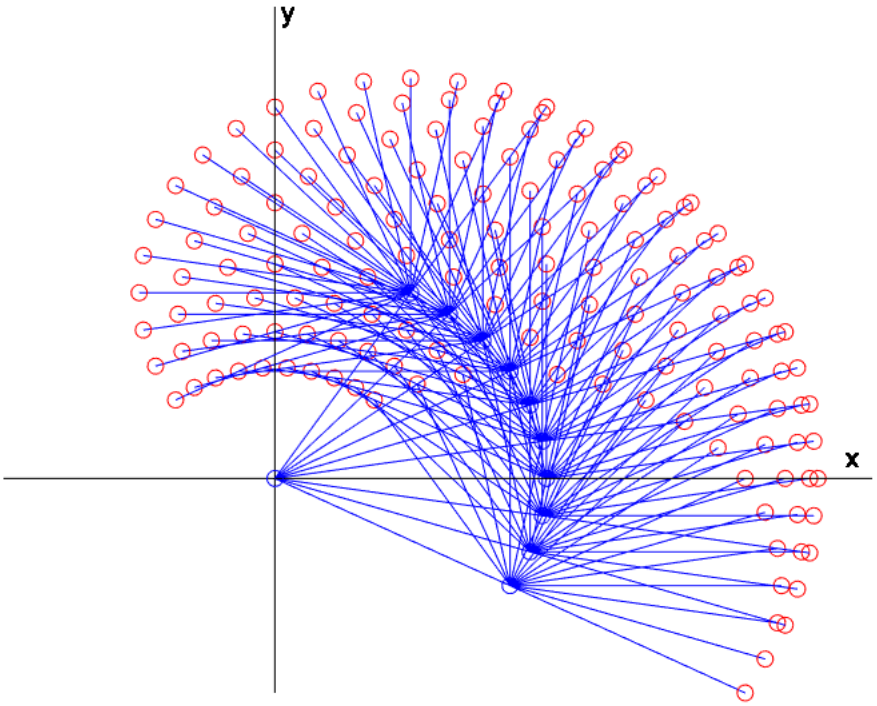
We create a function that displays the robotic arm based on information about the angles and the lengths of the two links.

```
figure;
plotarm(T1,T2,L1,L2);
```



What is the area covered by the endpoint of the second link (hand)?

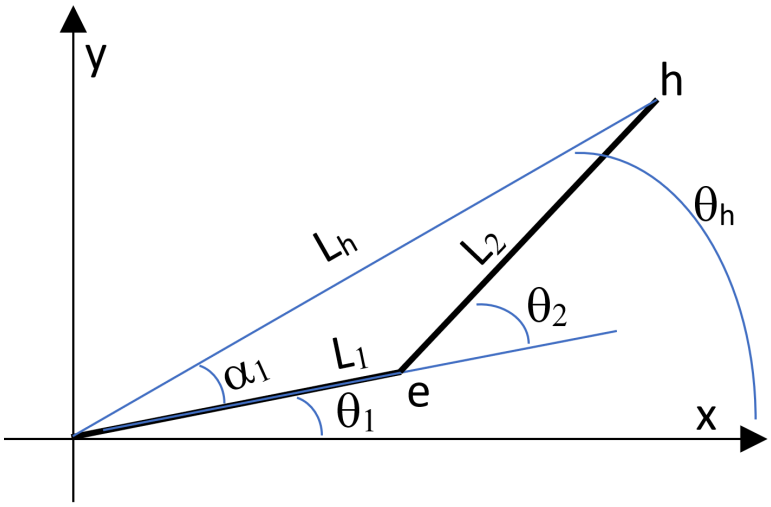
```
L1=50;
L2=50;
figure
pause on
for T1=-30:10:60
    for T2=0:10:150
        plotarm(T1,T2,L1,L2)
        pause(0.05)
    end
    pause(0.2)
end
```



Homework 1

Create a script that draws the boundary of the area covered by the hand of the robotic arm.

How can we determine the angles T1 and T2 knowing the position of the endpoint of the second link (hand)?



$$\tan(\theta_h) = \frac{y_h}{x_h},$$

$$\theta_h = arctan\left(\frac{y_h}{x_h}\right)$$

$$L_h = \sqrt{x_h^2 + y_h^2}$$

$$\cos \propto_1 = \frac{L_1^2 + L_h^2 - L_2^2}{2L_1L_h}$$

$$\propto_1 = arccosd\left(\frac{L_1^2 + L_h^2 - L_2^2}{2L_1L_h}\right)$$

$$\theta_1 = \theta_h - \propto_1$$

$$\cos(\theta_1 + \theta_2) = \frac{x_h - x_e}{L_2}$$

$$\theta_2 = arccosd\left(\frac{x_h - x_e}{L_2}\right) - \theta_1$$

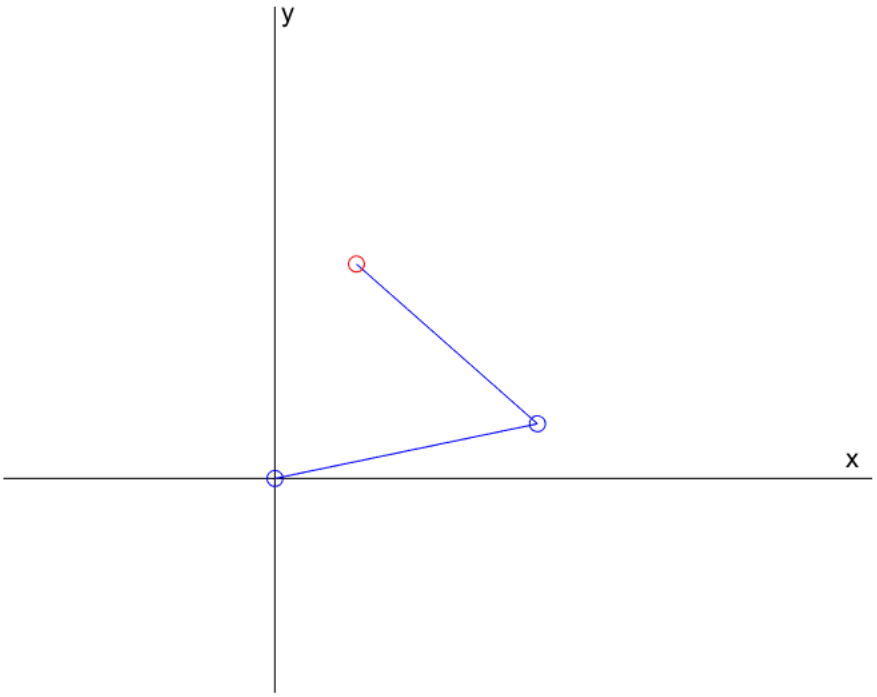
```
xh=15
```

```
xh = 15
```

```
yh=50
```

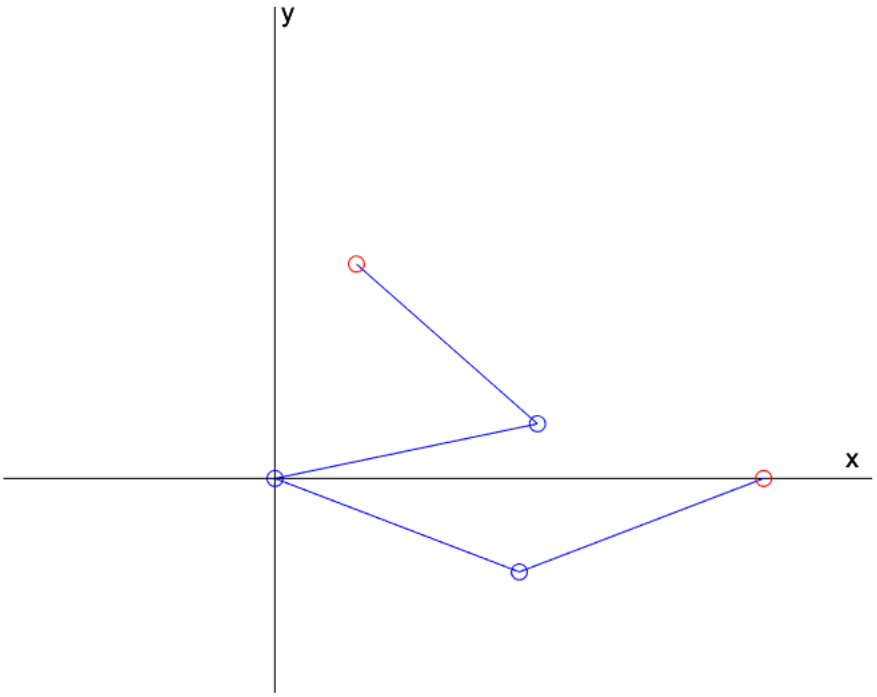
```
yh = 50
```

```
Th=atand(yh/xh);
Lh=sqrt(xh*xh+yh*yh);
A1=acosd((L1*L1+Lh*Lh-L2*L2)/2/L1/Lh);
T1=Th-A1;
xe=L1*cosd(T1);
ye=L1*sind(T1);
T2=acosd((xh-xe)/L2)-T1;
figure;
plotarm(T1,T2,L1,L2);
```



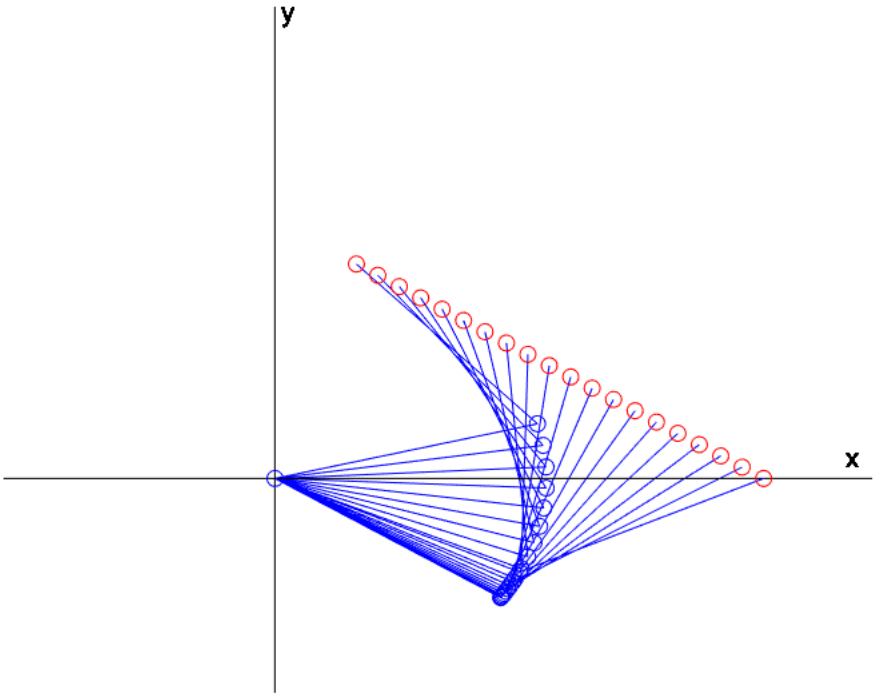
Create a script that draws the robotic arm for two different hand positions (xh0,yh0 and xh1,yh1)

```
L1=50;
L2=50;
figure;
xh0=15;
yh0=50;
[T10,T20]=getT(xh0,yh0,L1,L2);
plotarm(T10,T20,L1,L2);
xh1=90;
yh1=0;
[T11,T21]=getT(xh1,yh1,L1,L2);
plotarm(T11,T21,L1,L2);
```



Define a linear trajectory between the two hand positions with 20 points

```
x=linspace(xh0,xh1,20);
y=linspace(yh0,yh1,20);
figure
hold off
for i=1:length(x)
    [T1i,T2i]=getT(x(i),y(i),L1,L2);
    plotarm(T1i,T2i,L1,L2);
    pause(0.2)
end
```



Homework 2

Define a non-linear (e.g. arc) trajectory between the two hand positions