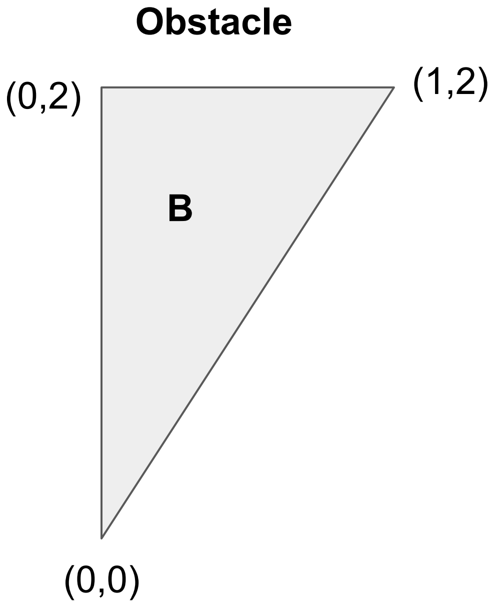
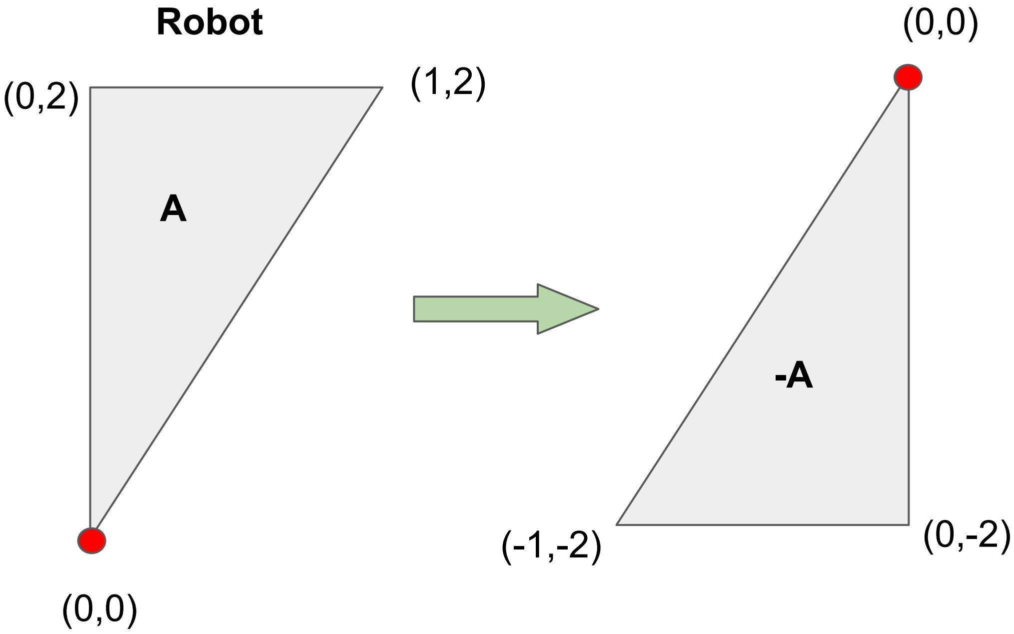
# Exercise 1.a



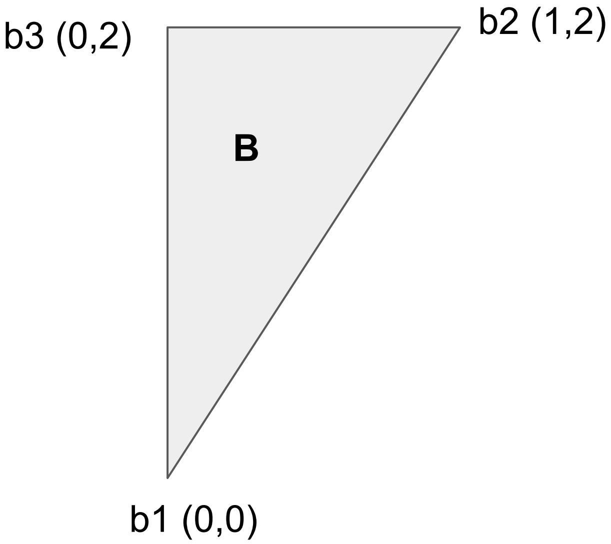

Obstacle B with the location of it vertices shown




Robot A with the location of it vertices shown. The red point is the reference point of the robot is at (0,0). The negative of A is taken by inverting all of the points and translating the reference point to (0,0)

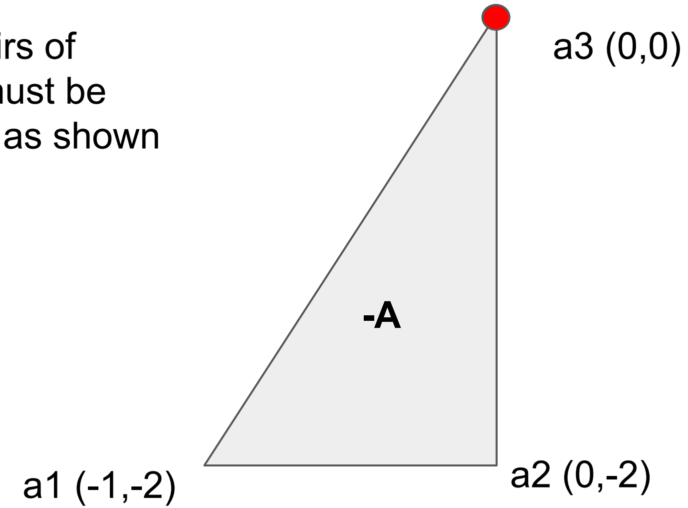
# Exercise 1.a

**Obstacle**

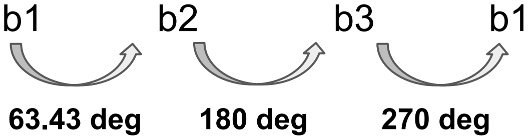


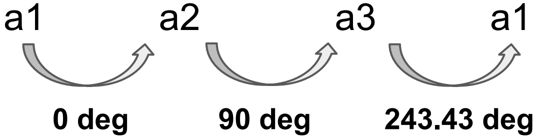

**Inverted Robot**

*The pairs of points must be ordered as shown




**Angle between the points of each triangle**



# Exercise 1.a

**Angle between the points of each triangle**

| b1 | | b2 | | b3 | | b1 |
|---|---|---|---|---|---|---|
| | **63.43 deg** | | **180 deg** | | **270 deg** | |

| a1 | | a2 | | a3 | | a1 |
|---|---|---|---|---|---|---|
| | **0 deg** | | **90 deg** | | **243.43 deg** | |

a1 + b1 = (-1,-2), always start here

a2 + b1 = (0,-2), a1➡a2 smaller than b1➡b2

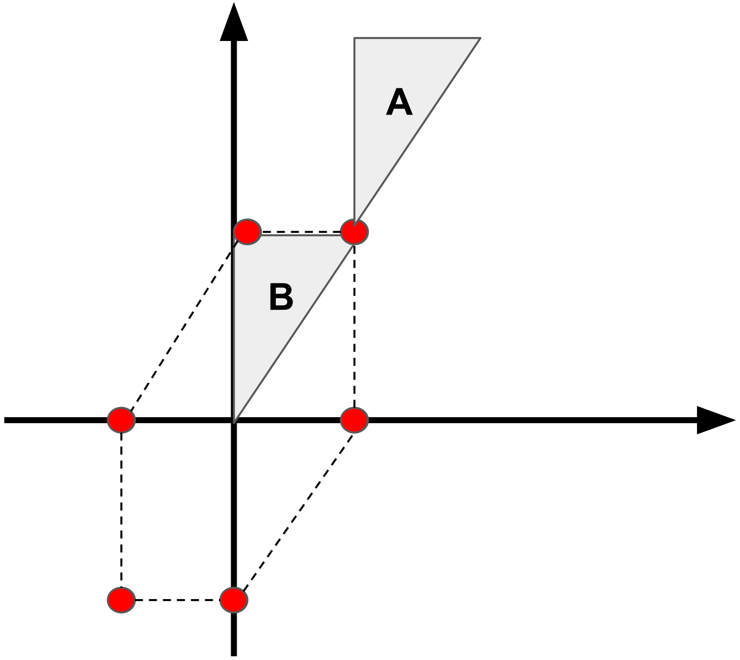
a2 + b2 = (1,0), b1➡b2 smaller than a2➡a3

a3 + b2 = (1,2), a2➡a3 smaller than b2➡b3

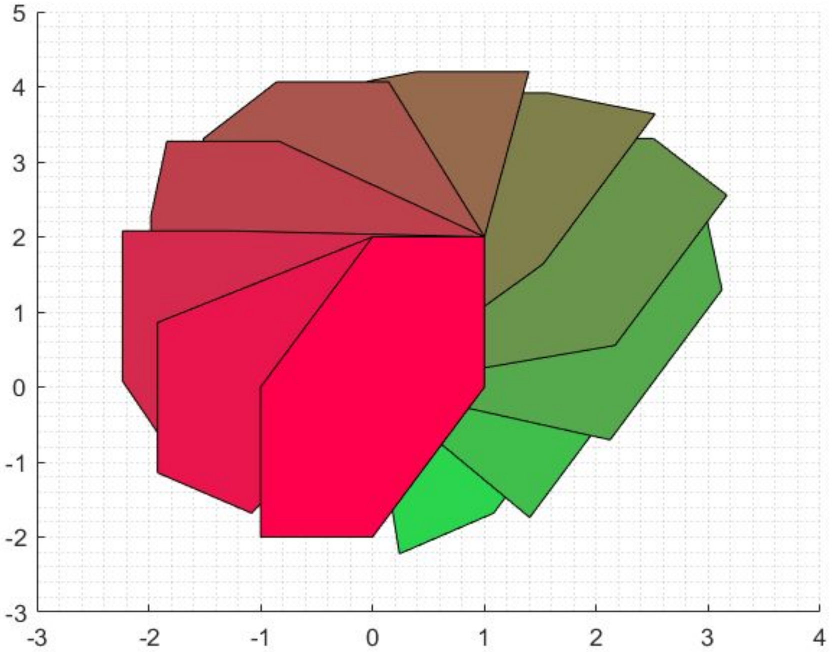
a3 + b3 = (0,2), b2➡b3 smaller than a3➡a1

a1 + b3 = (-1,0), vertices = 6 ➡ stop

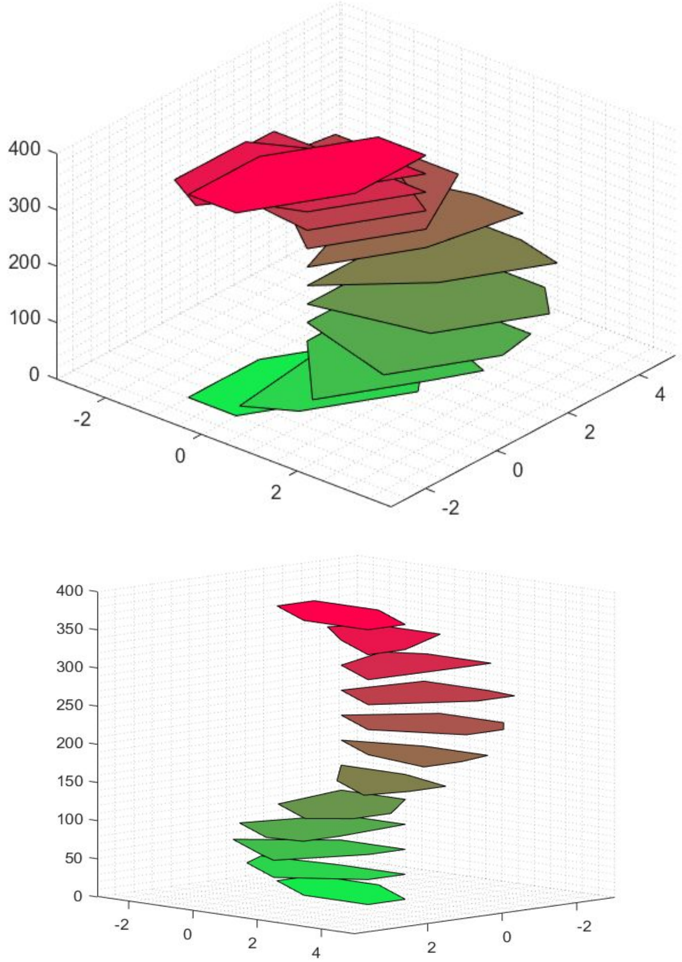
stop when the number of new vertices equals the sum of vertices of both objects



# Exercise 1.b

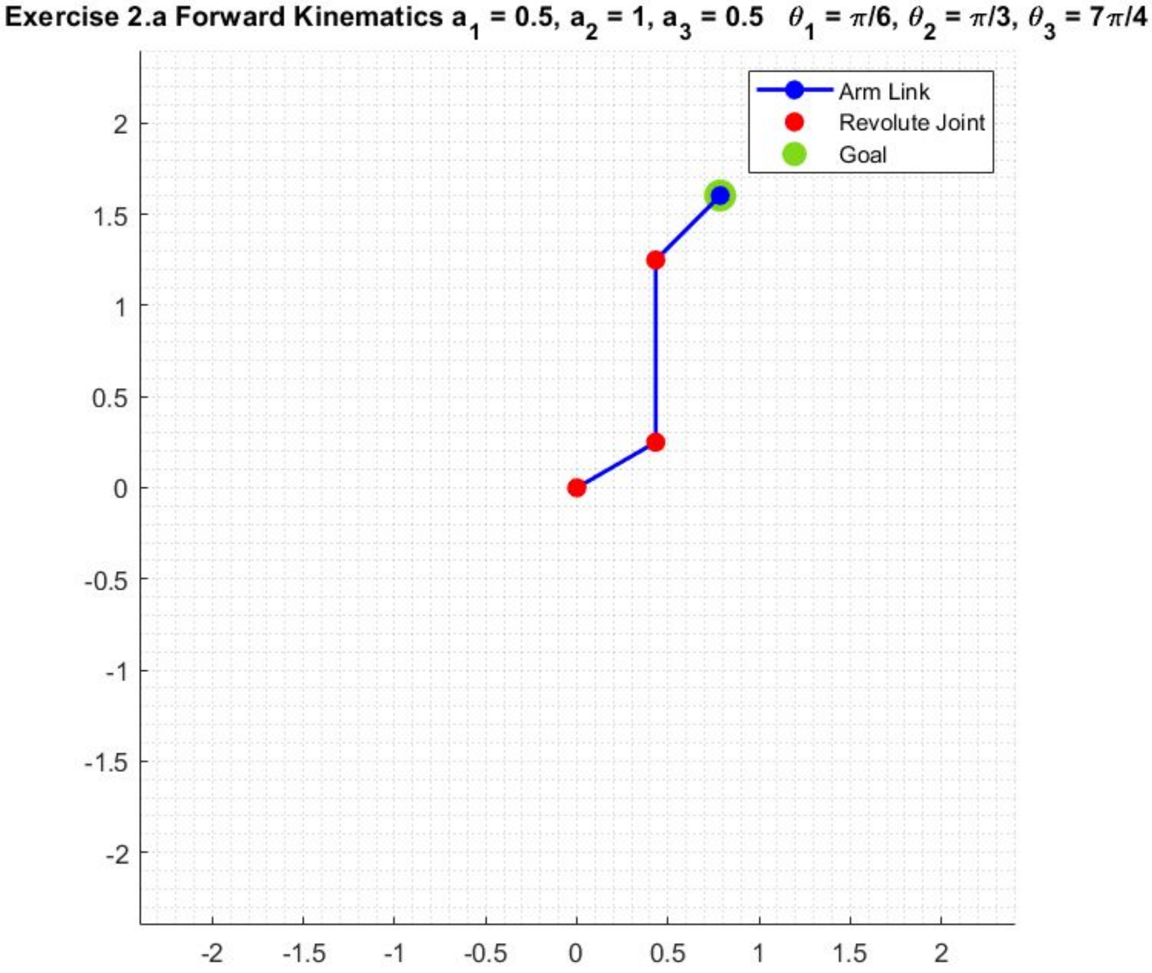



**Top View**



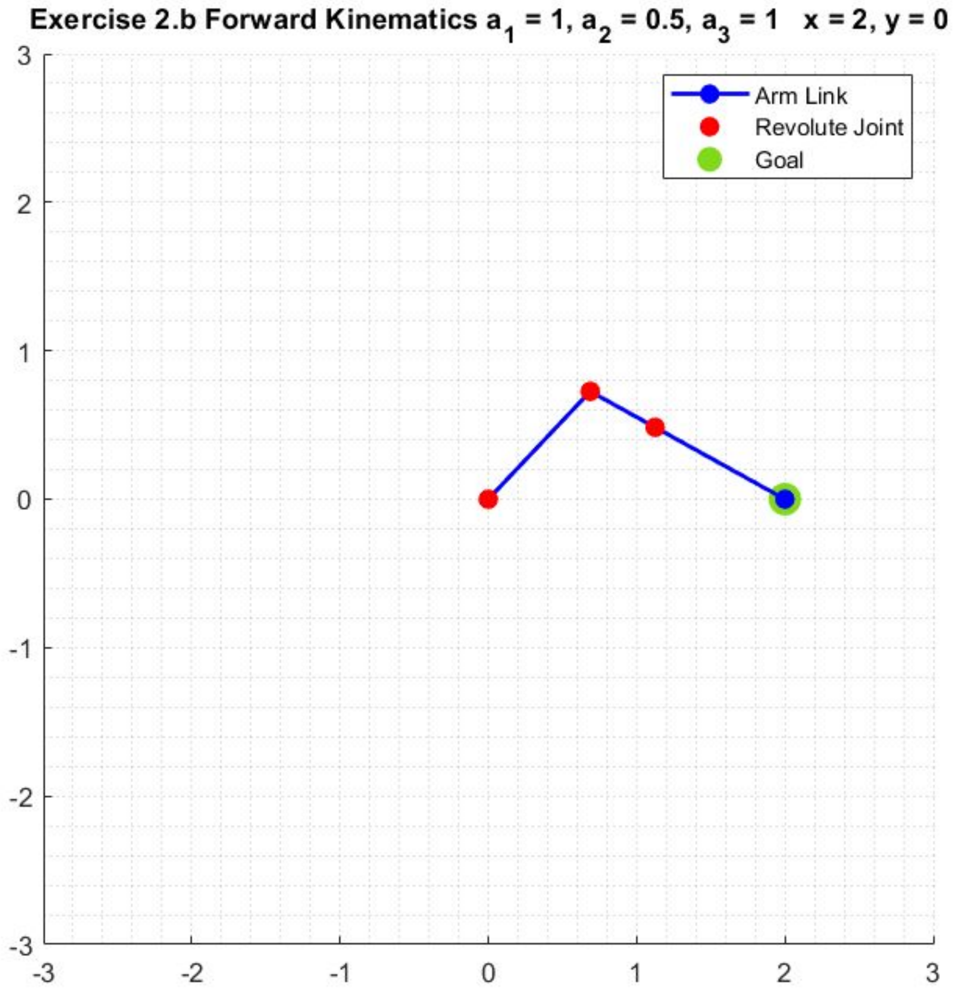

**Isometric Views**

# Exercise 2.a



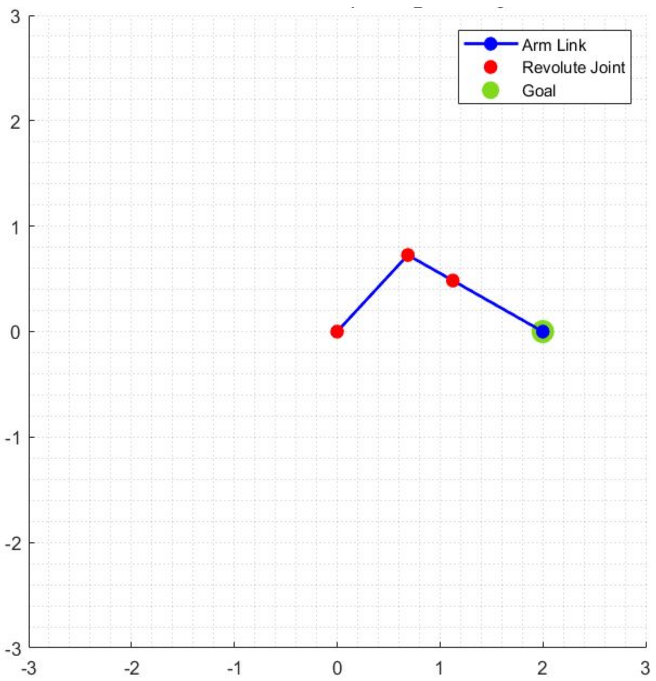
Exercise 2.a Forward Kinematics $a_1 = 0.5$, $a_2 = 1$, $a_3 = 0.5$ $\theta_1 = \pi/6$, $\theta_2 = \pi/3$, $\theta_3 = 7\pi/4$
Arm Link
Revolute Joint
Goal
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2

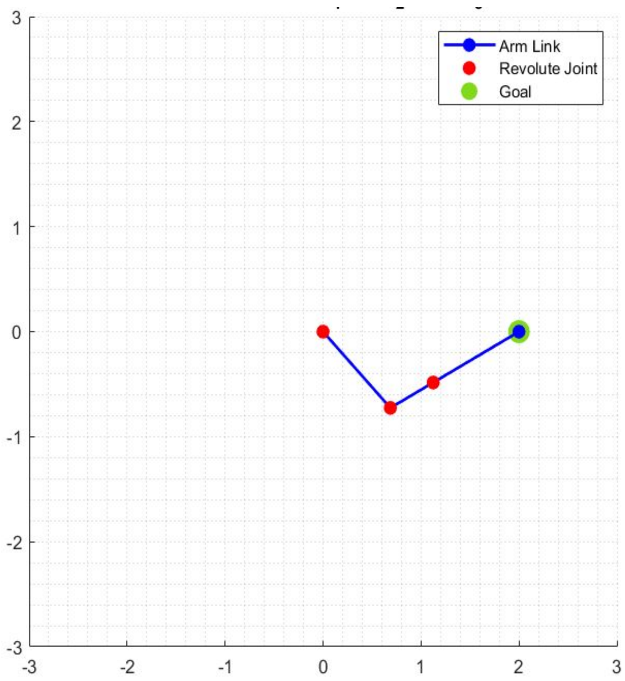
# Exercise 2.b



Exercise 2.b Forward Kinematics $a_1$ = 1, $a_2$ = 0.5, $a_3$ = 1   x = 2, y = 0
Arm Link
Revolute Joint
Goal
3
2
1
0
-1
-2
-3
-3
-2
-1
0
1
2
3

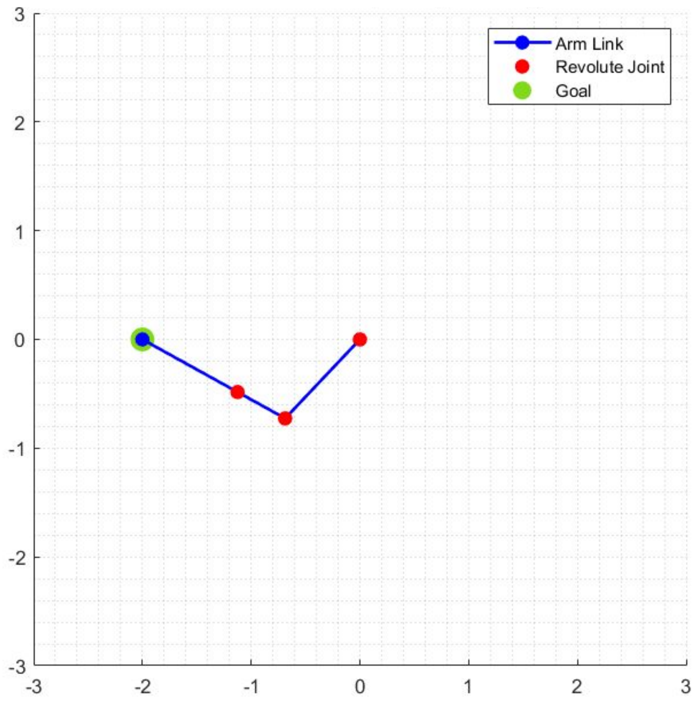
# Exercise 2.b Explanation

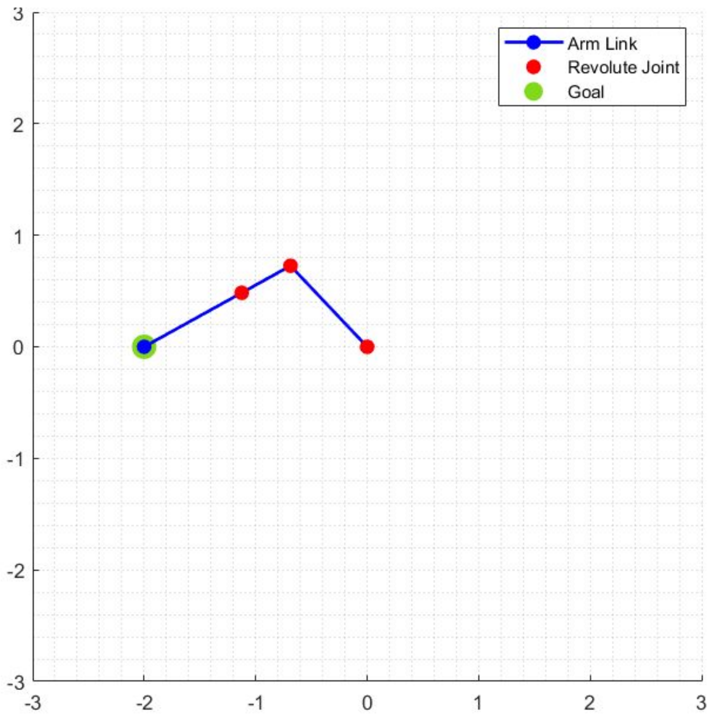



My inverse kinematic function uses a different “solver” depending on the position of goal. If goal is far enough from the origin, such that a triangle can be obtained with theta_3 =0, it will do so as seen above. There are two such triangles that can be made for a given goal location. My model uses the left configuration.

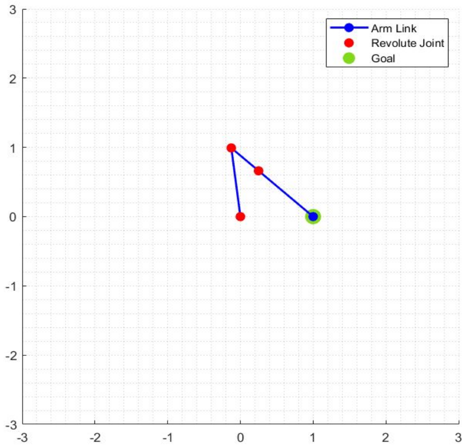
# Exercise 2.b Explanation



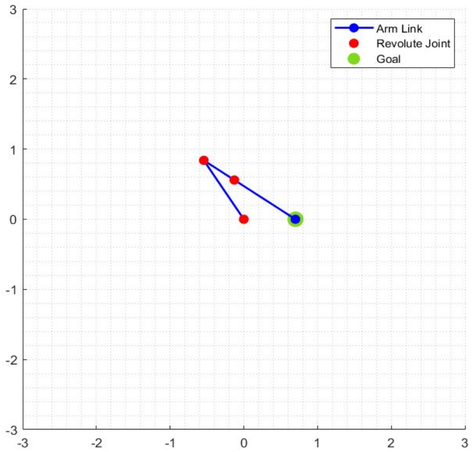




Here we see how my system behaves for the goal set at (-2,0)

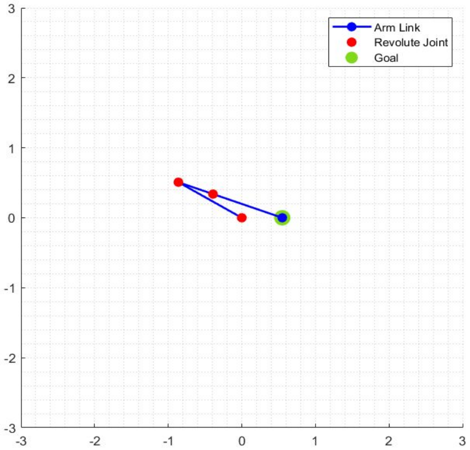
# Exercise 2.b Limitations



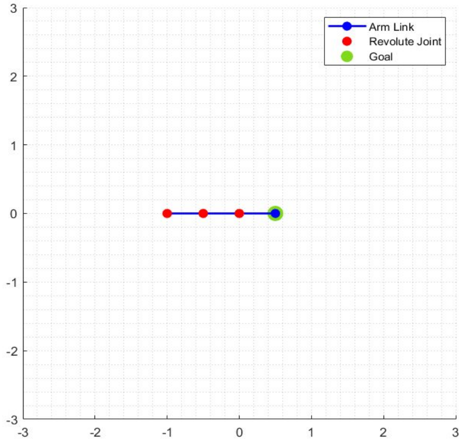

**Goal (1,0)**




**Goal (0.8,0)**



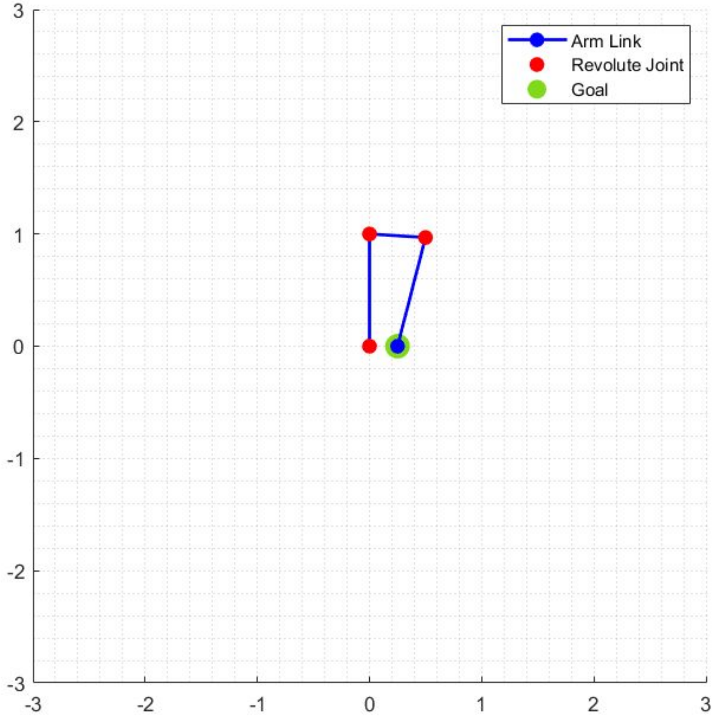

**Goal (0.55,0)**



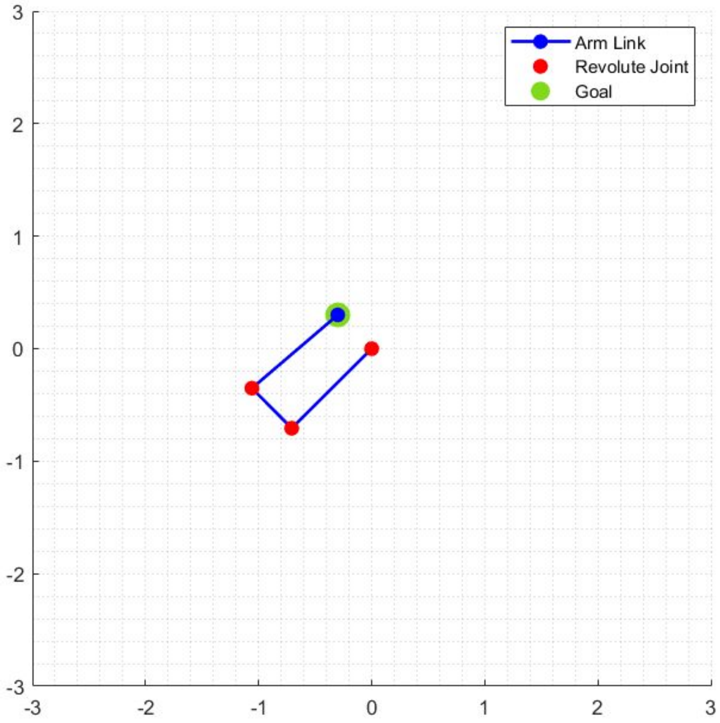

**Goal (0.5,0)**

The inverse kinematics described in the previous page breaks down when the distance to the goal is less than 0.5, which is equal to the a2+a3-a1. Next I will talk show how I solved this problem.

# Exercise 2.b Limitations



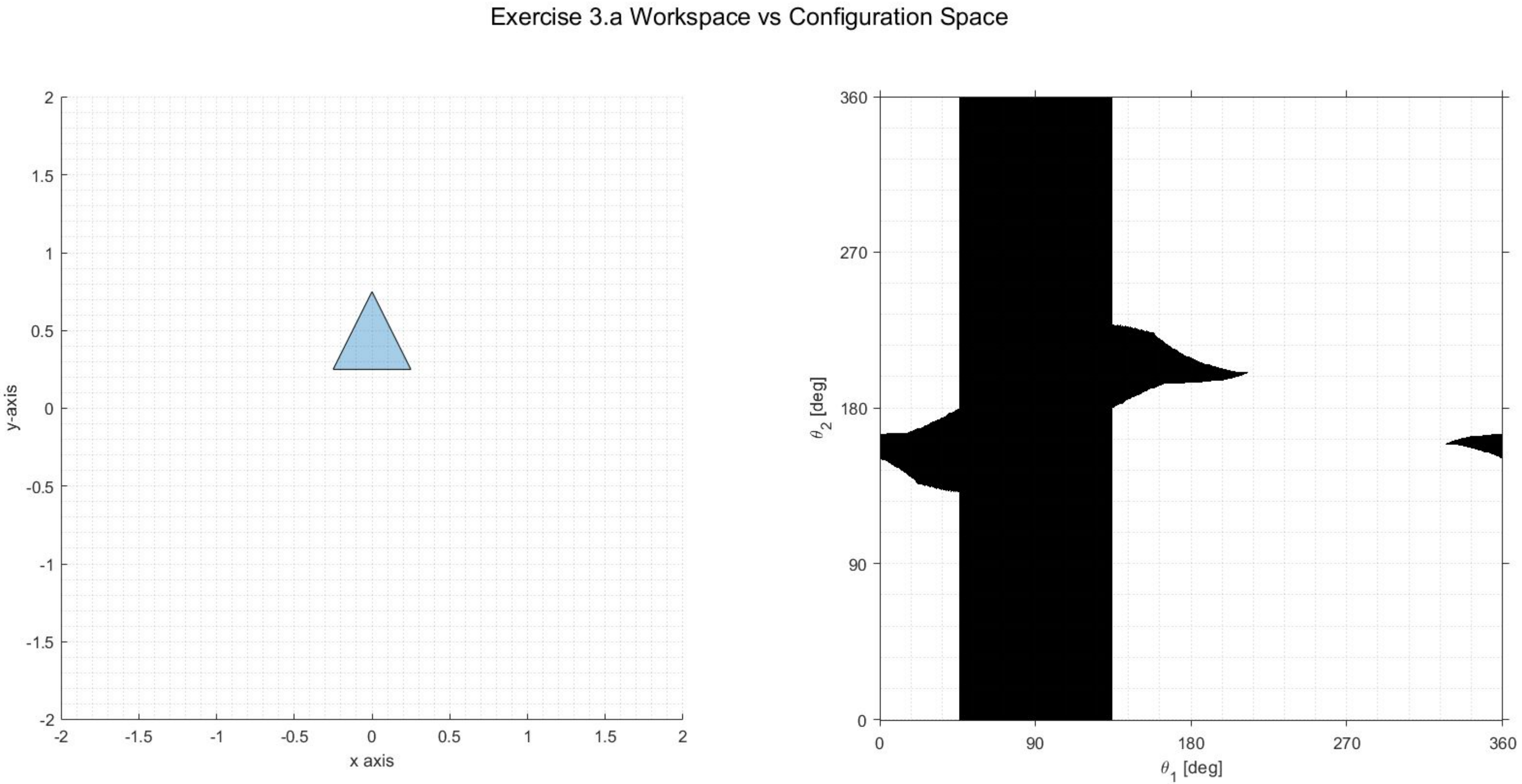

**Goal (0.25,0)**



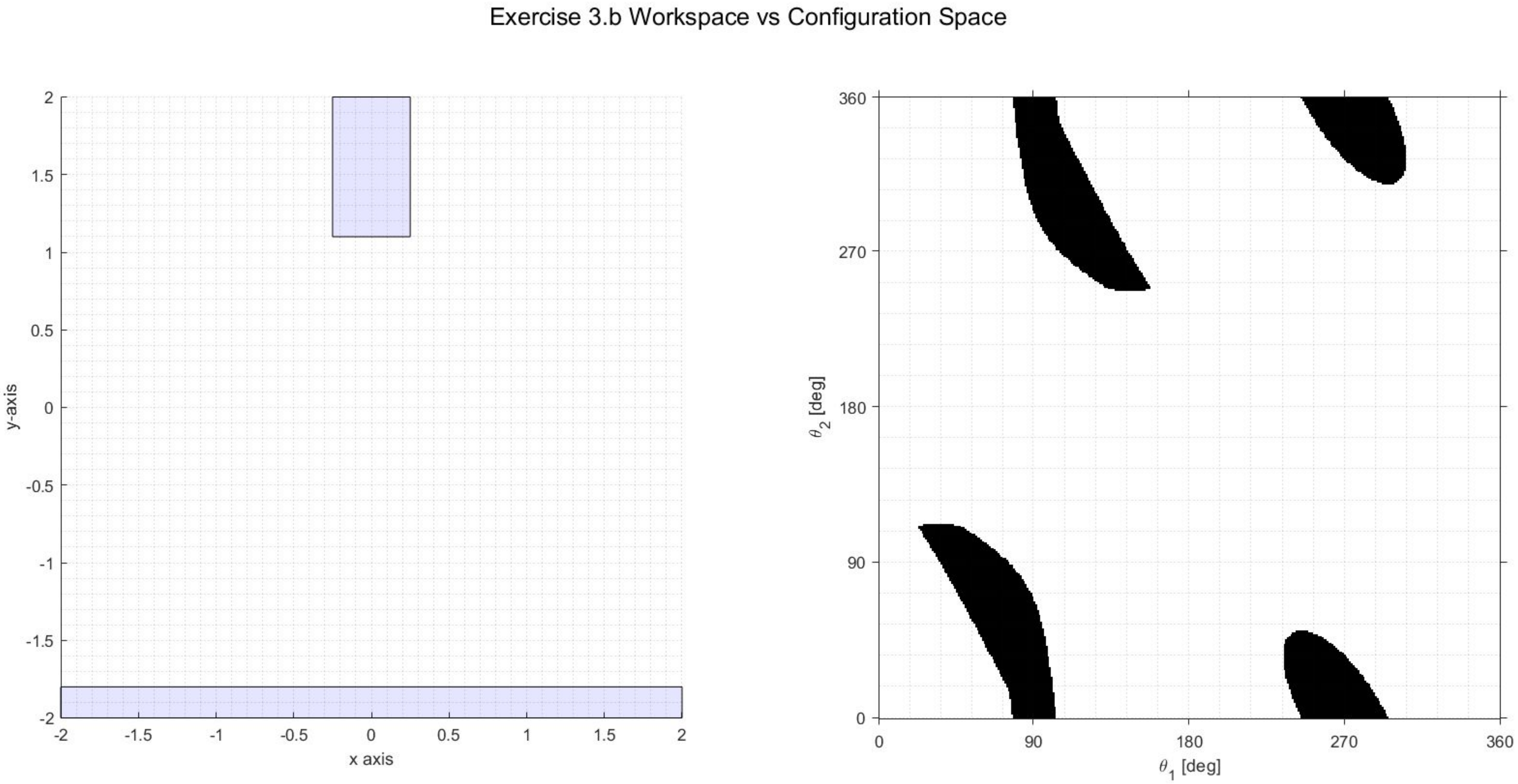

**Goal (-0.3,0.3)**

When the distance to the goal is less than a2+a3-a1 (0.5 in our case) I point a1 90 degrees from the vector between the origin and goal.Then I follow the same algorithm as I did before but with only a2 and a3.

# Exercise 3.a Workspace and C-Space #1



# Exercise 3.b Workspace and C-Space #2



# Exercise 3.c Workspace and C-Space #3