

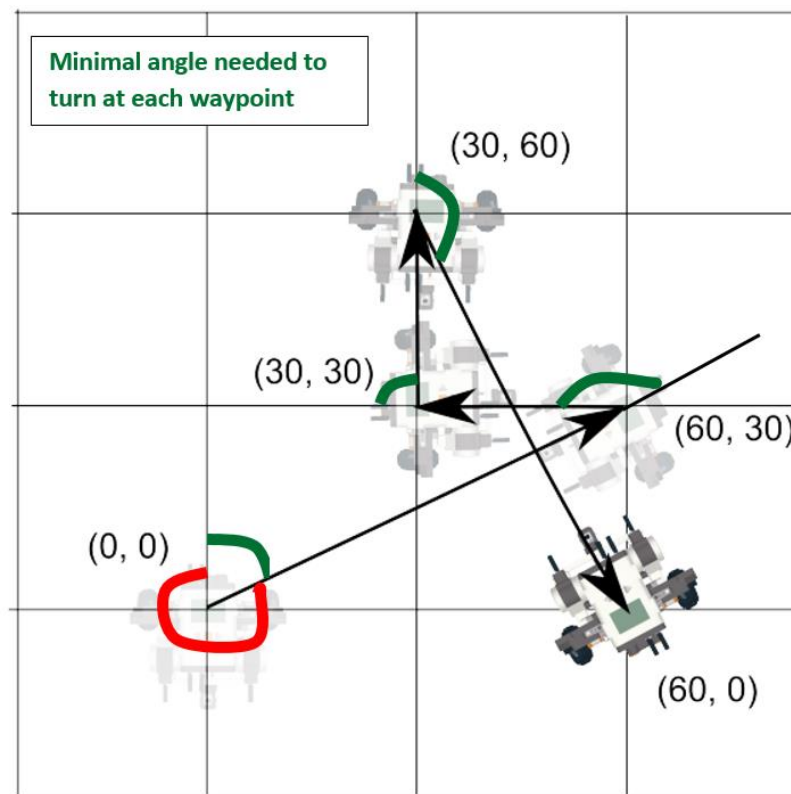
## Lab 3: Navigation and Obstacle Avoidance

### Demo 1: Simple Navigation (10 points)

Starting from the (0, 0) origin point on the 4x4 tile grid, the robot must travel to the waypoints (60, 30), (30, 30), (30, 60) and (60, 0) shown below in **Figure 1** using a **minimal angle** needed to turn at each waypoint. A **maximal angle turn** should be avoided (check **FAQ 1**).

- **5 points** are given for turning using a **minimal angle** at all the waypoints. **0 points** are given if the robot turns using a **maximal** (not **minimal**) angle at one or more waypoints.
- **5 points** are given for reaching waypoint (60, 0) within an error tolerance of **3 cm** using a *Euclidean distance*. A penalty of **-1 point per cm** is used. Hence, the following table is used:
 

▪ [0, 3] cm	→	<b>5 points</b>
▪ (3, 4] cm	→	<b>4 points</b>
▪ (4, 5] cm	→	<b>3 points</b>
▪ (5, 6] cm	→	<b>2 points</b>
▪ (6, 7] cm	→	<b>1 point</b>
▪ (7, ∞) cm	→	<b>0 point</b>



**Figure 1. Robot Path (to be navigated) in Demo 1**

## Demo 2: Navigation with Obstacle Avoidance (20 points)

Starting from the (0, 0) origin point on the 4x4 tile grid, the robot must travel to the waypoints (0, 60) and (60, 0) shown below in **Figure 2** using a **minimal angle** needed to turn at each waypoint. Please note that a wooden block obstacle can be placed **ANYWHERE** in the robot's trajectory, and **NOT NECESSARILY** between waypoints (0, 60) and (60, 0)! The robot must avoid the obstacle during the navigation **without touching it** (check **FAQ 2 & 3**).

- **5 points** are given for turning using a **minimal angle** at all waypoints. **0 points** are given if the robot turns using a **maximal** (not **minimal**) angle at one or more waypoints.
- **5 points** are given for successfully avoiding the obstacle by passing through points **A** and **B**.
- **5 points** are given for successfully avoiding the obstacle by passing through points **C** and **D**.
- **5 points** are given for reaching waypoint (60, 0) within an error tolerance of **3 cm** using a *Euclidean distance*. A penalty of **-1 point per cm** is used. Hence, the following table is used:
 

▪ [0, 3] cm	→	<b>5 points</b>
▪ (3, 4] cm	→	<b>4 points</b>
▪ (4, 5] cm	→	<b>3 points</b>
▪ (5, 6] cm	→	<b>2 points</b>
▪ (6, 7] cm	→	<b>1 point</b>
▪ (7, ∞) cm	→	<b>0 point</b>

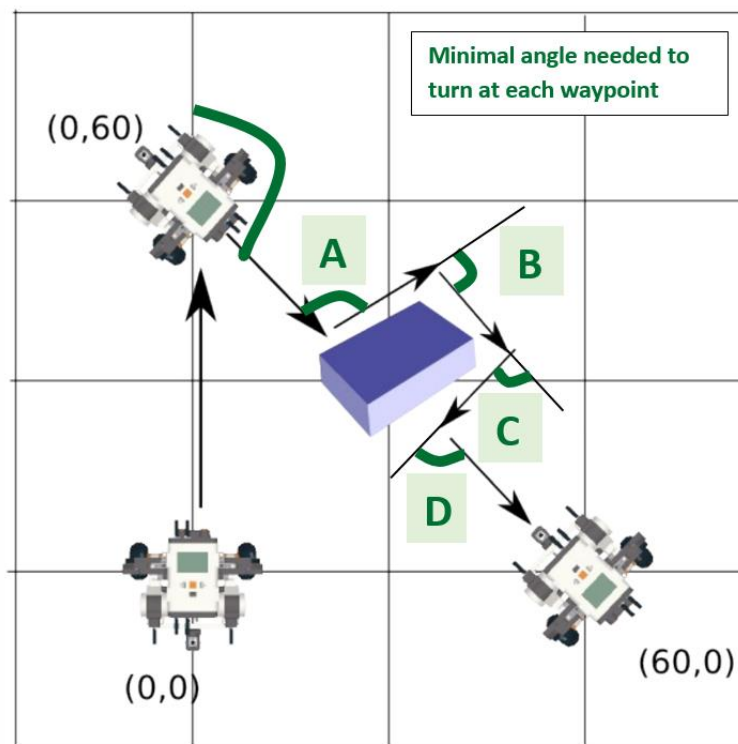


Figure 2. Robot Path (to be navigated) in Demo 2

### Frequently Asked Questions (FAQ)

1. What is a **minimal angle**?

Referring to the (0, 0) waypoint in **Figure 1**, its **minimal turning angle** is approximately **60° clockwise**, as opposed to a **maximal turning angle** of **300° counterclockwise**.

2. What if my robot avoids the obstacle (passes through **A** and continues moving in that same direction), but does not move past **C** and **D**?

You will only get **5 points** for the obstacle avoidance by passing through points **A** and **B**.

3. Do I need to avoid the obstacle exactly as shown in **Figure 2** (turn left to avoid)?

No, you do not need to. **5 points** are awarded for avoiding the obstacle, and another **5 points** are given for approaching the final destination at the (60, 0) waypoint. Within that context, you may wish to implement *object avoidance* or *wall follower* (Lab 1).

4. Do I need to move through point **D** in **Figure 2** while avoiding the obstacle?

No, you do not need to. Point **D** is an extra point that can be ignored. Once the robot moves past **A**, **B** and **C** as in **Figure 2**, it can go directly to the (60, 0) waypoint without passing through **D**. In this case, **5+5 points** are awarded for avoiding the obstacle.