Updated on 13.01.2023

Solutions to exercise#6

Project

A description of our annual project

How to take part in the project...

Group formation

Please build groups of five people (choose a group that you will be able to work with and learn from)
To register your group, send an e-mail to peter.sahm@uni-siegen.de

The e-mail should include the following information:

1. Your 5 full names
2. Matriculation numbers and
3. Student e-mail addresses (should also be linked to a **Sciebo** account)

Please complete the group formation by **21.10.22**. The robots will be accessible starting from **26.10.22**.

During the exercise session on 26.10.22, the first 15 minutes will be dedicated to a presentation about laboratory safety instructions. At the end of which you will have confirm that you will observe all safety measures when working in our laboratories, by signing the consent form.

Students are not allowed to work in our laboratories without attending and consenting to the safety instructions.

After group registration, Mr. Sahm will share a **Sciebo** folder with each member of each group, so that the project data can be accessed by anyone, anywhere.

The groups can then work on these group folders.

Working on the robots online or in the LAB H-A 5119

- To work on the robots, groups have to book a time slot that is available in the Moodle timetable and once the appointment is confirmed, they can start working with the robots either via zoom for online access or in the lab for offline access.
- There is a total of **five** robots, all of which are accessible online.
- During any time slot, at most two groups may choose to work in parallel (offline/ in presence) in the lab or have some members work online and others in the lab.
- To access the computers connected with the robots, 'Zoom' meeting rooms have been created. In these meetings rooms, you have full access to MATLAB and Simulink, and to a camera connected to the PCs that will provide optical feedback of the robot movements.
- The installed MATLAB and Simulink software includes a support package for LEGO MINDSTORMS EV3 hardware. Find more information about this package here.
- Access to the 'Zoom' meeting rooms and to the robots in general will be only possible from Wednesdays to Fridays.
- Also, remember to save your work progress in your **Sciebo** folder at the end of your time slot.

- Afterwards please delete the local copy in MATLAB so that the next group does not continue to work with your results as this is considered cheating and is frowned upon.

If you run into difficulties accessing the robots, contact:

- Mr. Sahm (08:00 - 16:00 hrs) via e-mail peter.sahm@uni-siegen.de

Time slots

- To book a time slot, first of all, make sure the slot you desire is still free.
- Then request for it by e-mail to peter.sahm@uni-siegen.de including your group number, the robot number and the time you want to work on the system.
- Each time slot is strictly **2 hours**. Please make sure not to exceed your access to the robots.
- Booking multi-slots can only be with permission from Mr. Sahm.
- The Lab will be closed from **19.12.22** to 11.01.23. (winter break)
- Time slots will be created after group registration and can be viewed in Moodle.
- If there are repeated violations of the time slots, we will exclude your group from the laboratory.

Robots

- Robot 1-5 are all accessible online.
- At most two robots (1 and 2) will also be accessible offline (in presence) during any time slot.
- We try to keep the access as flexible as possible. If something changes during the semester as a result of the energy situation, we will flexibly adapt the lab.

Sciebo cloud storage

- You can login to Sciebo under *https://uni-siegen.sciebo.de* and your ZIMT user account; xxx@uni-siegen.de

Manipulator Robot - Pick and Place Tasks

Figure 1 Manipulator Robot

In this project, you will remotely or physically access the manipulator in Figure 1 and program it in MATLAB and Simulink to achieve a set of pick-and-place tasks.

The manipulator is driven by three actuating motors (See Figure 2):

- Motor A
- Motor B
- Motor C

In addition to the three actuators, there are also five sensors (See Figure 2):

- Touch sensor #1
- Touch sensor #2
- Motor A encoder
- Motor B encoder
- Motor C encoder

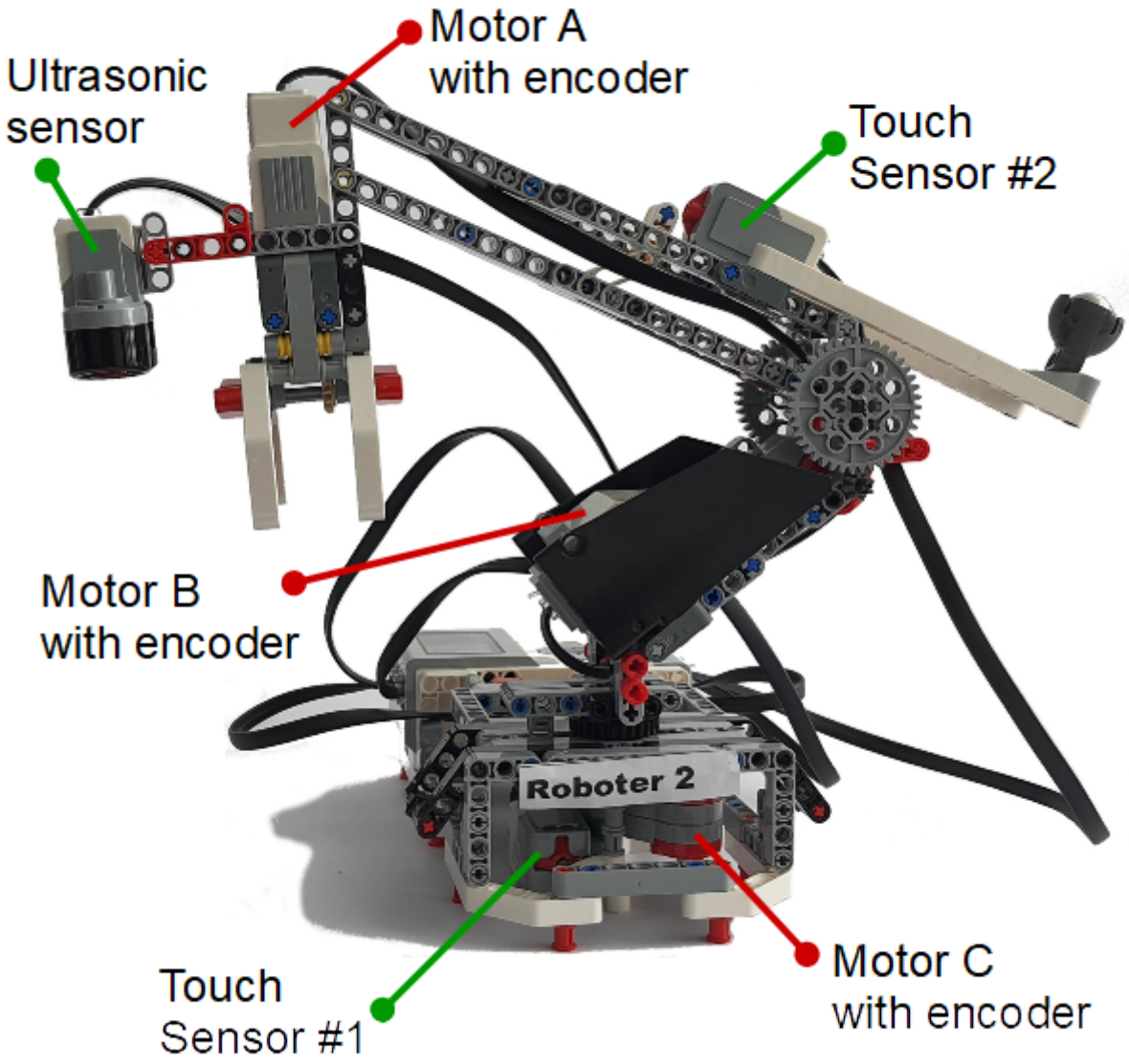

Figure 2 Sensors and actuators

The manipulator is made of four links (See Figure 3):

- Link-0 (to be measured by you)
- Link-1 of 50mm
- Link-2 of 95mm
- Link-3 of 185mm
- Link-4 of 110mm

Among kinematic constraints include:

- Link-1 is rigidly connected to link-2 at an obtuse angle of 135°
- Link-4 is always perpendicular to the ground plane
- The rotation of link-3 is bounded by link-2 on the lower side and touch sensor #2 on the upper side
- The base rotation is bounded by touch sensor #1 on one side

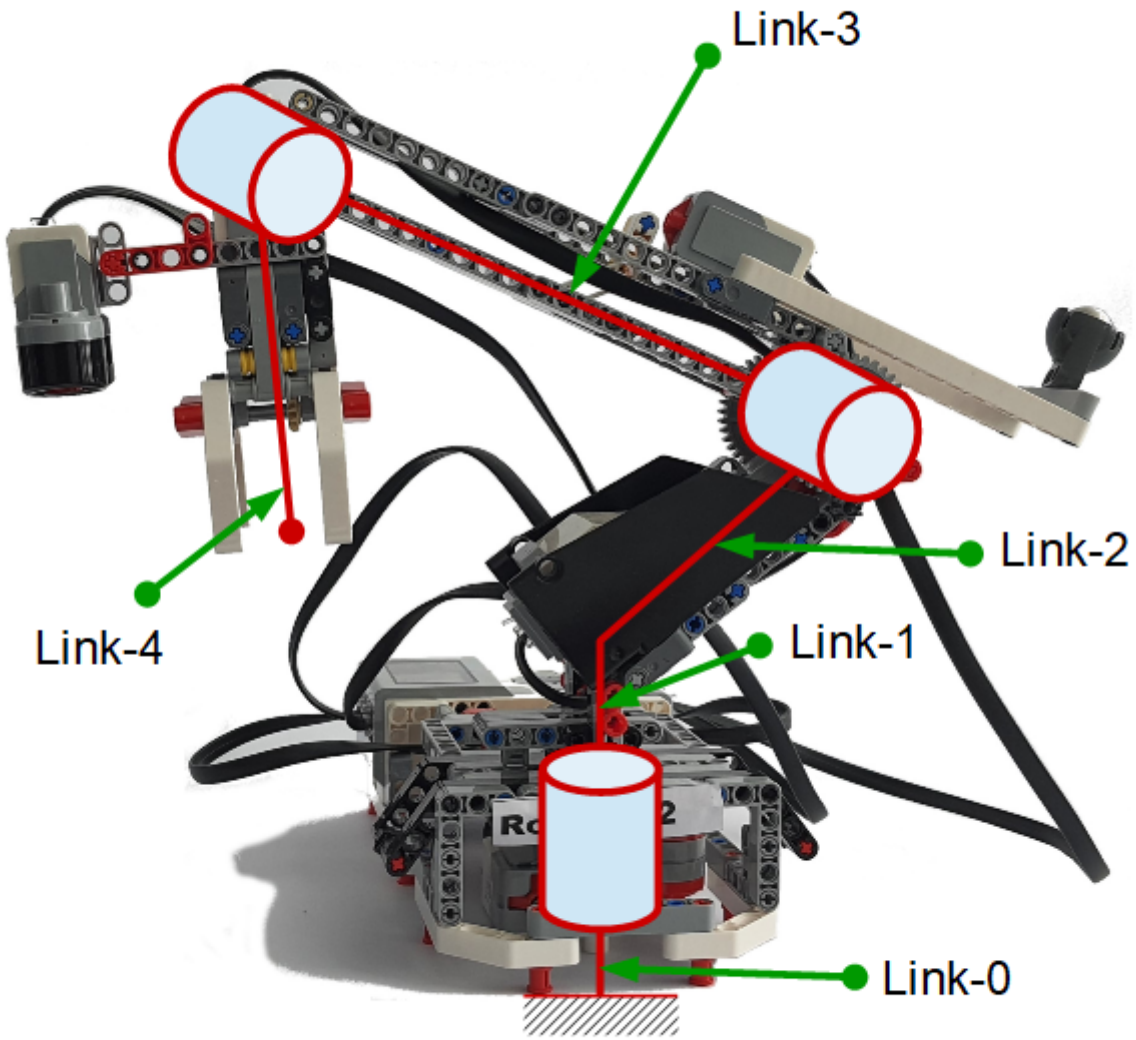

Figure 3 Kinematic diagram

Last but not least, all motors are coupled through gearboxes. Of interest are gearboxes for motor A and motor B. The gear details are presented in Figure 4.

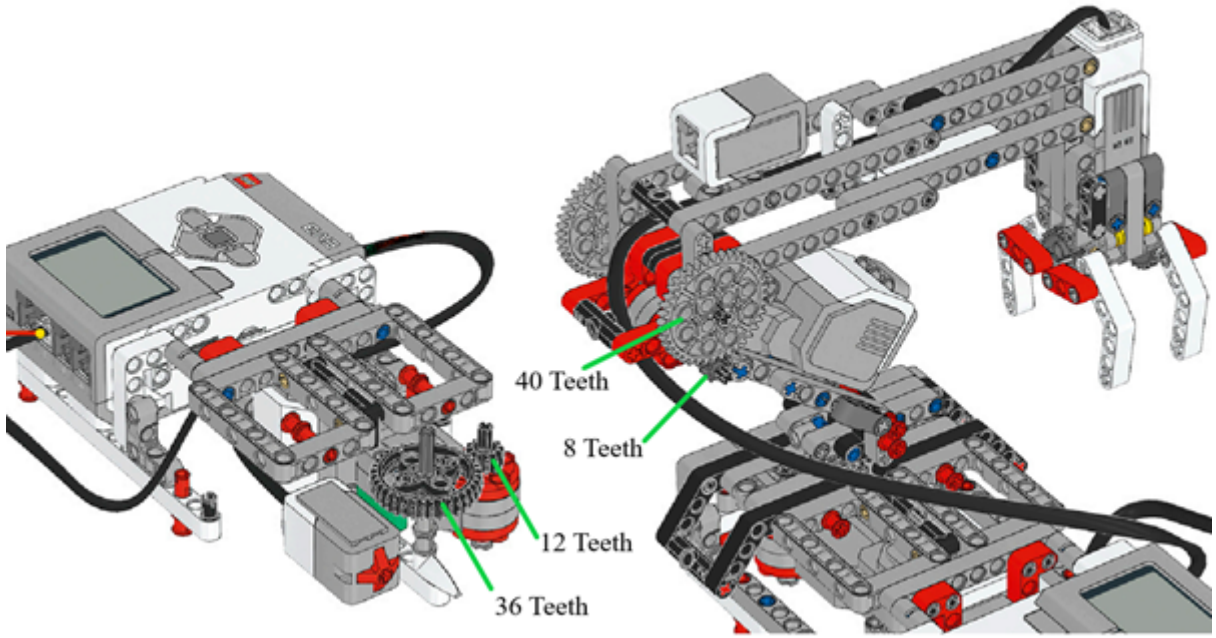

Figure 4 Gear specifications

The operating area is made of thee stations (See Figure 5):

- Station A at a height a as indicated in Figure 6
- Station B
- Station C at a height c as indicated in Figure 6

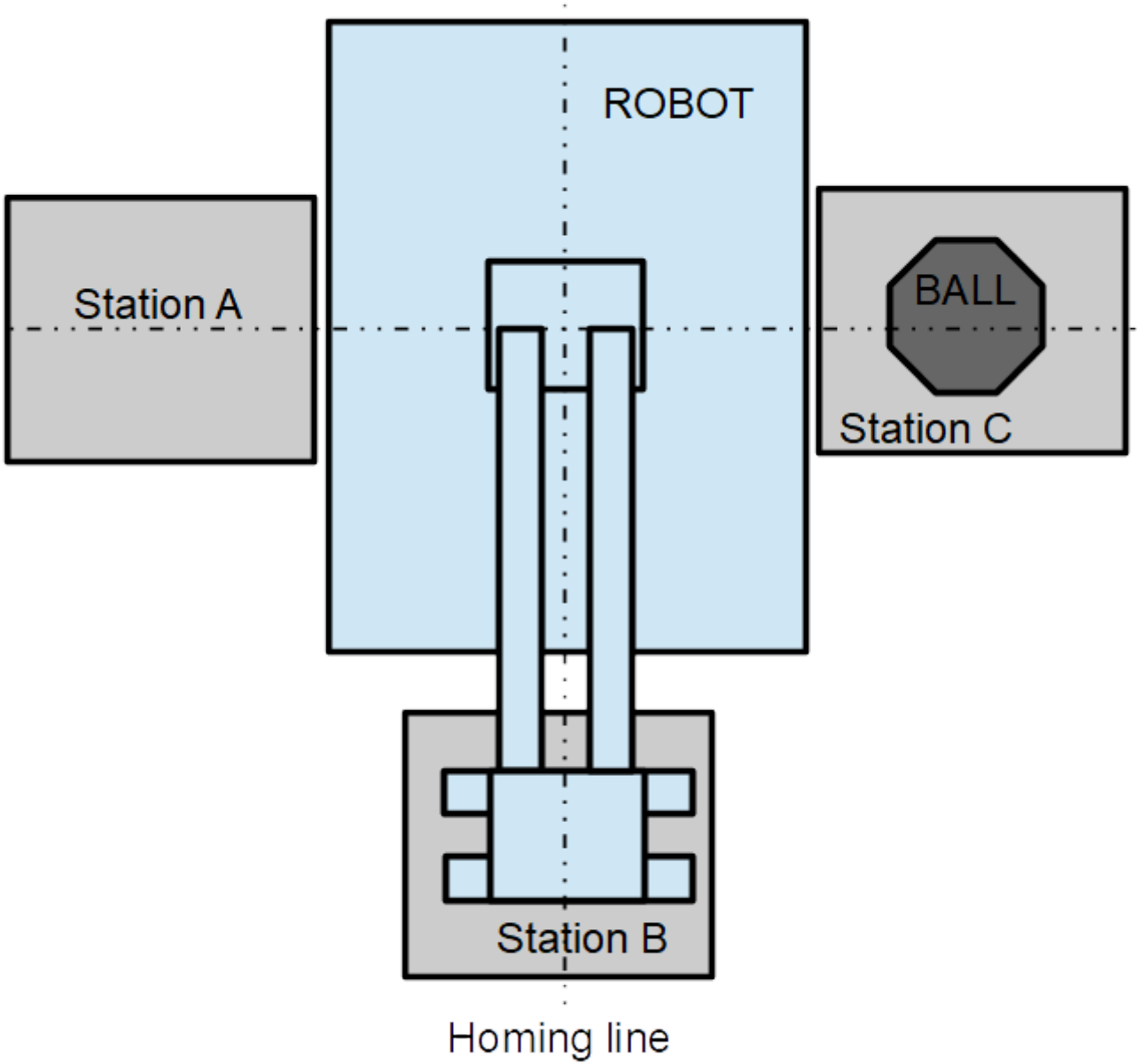

Figure 5 Operating areas

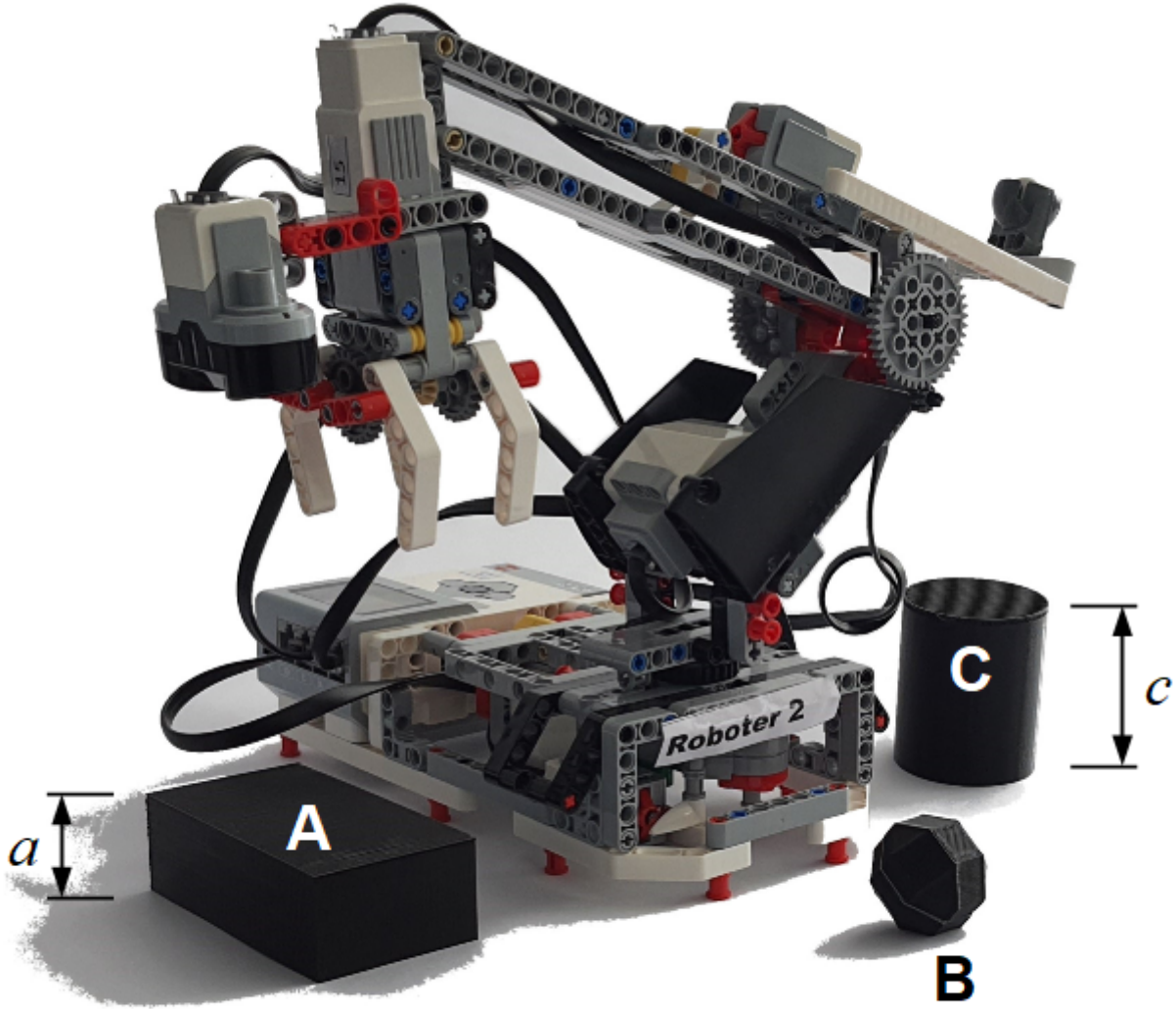
Roboter 2
A
a
B
C
c

Figure 6 Stations A, B and C. The payload is the ball located at station B in this case.

Tasks:

1. Develop the inverse kinematic model (equations) for this manipulator using the geometric approach.
2. Program the manipulator to grasp and release the payload (ball).
3. Develop behaviours for picking, placing and homing (the home point is the topmost position at station B).
4. Use the behaviours in (3) to command the manipulator to home.
5. Use the behaviours in (3) to pick the ball from station B, place it at station C and then return to home without collidin station.
    - Use the depth sensor to measure the height of the sections.
    - Pick and place should adapt to different section height (do not hard-code heights as this will definitely fail the fina
    - We will be changing the section height over the semester duration.
6. Use the behaviours in (3) to command the manipulator to pick the ball from station C, place it at station A and then re home without colliding into the station.
7. Use the behaviours in (3) to command the manipulator to pick the ball from station A, place it at station B and then re home without colliding into the station.
8. Use the behaviours in (3) to command the manipulator to pick the ball from station B, place it at station A and then re home without colliding into the station.
9. Use the behaviours in (3) to command the manipulator to pick the ball from station A, place it at station C and then r home without colliding into the station.

10. Use the behaviours in (3) to command the manipulator to pick the ball from station C, place it at station B and then re home without colliding into the station.

Submission

Submission of project results will be done through Sciebo. The submitted material must include the following files:

- Pdf report (3-5 pages)
- MATLAB and/or Simulink files
- Video recording of the robot while executing the assigned tasks

---

How do I connect to the robots?

List of the groups

Group	Last Name	First Name
	Saripella	Sai Vijji Raju
	Dulala	Jahnavi
1	Medarametla	Pavan kumar
	jain	chetan
	Ravi	Sai Praneeth

	Dihora	Savan
	Balar	Nishilkumar
2	Nayak	Manthan
	Patel	Manthan
	Patel	Neel
	Thakare	Janmesh Devidas
	Patel	Harsh Vallabhbhai
3	Gurav	Sairaj
	Inti	Gowtham Sai
	Shelke	Akash
	Joshi	Amey Sandeep
	Savaliya	Nayan
4	Panchal	Nisargkumar Sunilkumar
	Patil	Piyush Sham
	Mehta	Zainil
	Raju	Augustin
	Rajan	Ronson
5	Vijoy	Ciya Sara
	Gijo	Jose
	Thacharon	Anand
	Ismatli	Elchin
	Yazdani	Alireza
6	Kayhan	Gökhan
	Nguyen	Dinh Tan