# Design

The process and thinking behind the Chassis and Mechanism Design.

## Introduction

The design presented here is the implementation of a ripe fruit detector and harvesting robot developed for the National Engineering and Robotics Competition in the Indigenous Category. The robot is designed to follow a predefined path marked by a line and detect ripe fruits at specific junctions. Upon detecting ripe fruits, the robot collects them using servo-controlled harvesting arms and stores them until it reaches the loading area to drop them off. The robot then returns to its initial position and parks itself.

## Constraints

The constraints that had to be kept in mind while designing the bot were as follows.

- **Size**
  The bot had to fit inside a 10" x 10" frame (254mm x 254mm)
- **Manufacturability**
  The design had to be easily manufacturable.
- **Cost effectiveness**
  The design had to cater to our limited budget.
- **Availability of components and materials**
  Parts and material had to be easily sourced.

## Design Ethos

The philosophy behind the design was to create the best robot within the constraints of the project and one that would most effectively complete the task laid out.

The chassis was designed to be lightweight, ridged and spacious inside to house the various electronics and motors. The Mechanism was designed to be robust, quick, and accurate; some might even call it over engineered.

## Design Fundamentals

I chose to work with aluminum extrusions and acrylic sheets as my primary building blocks. The acrylic allowed me a great amount of flexibility and precision in my design as I could use a CNC Lazer cutting machine to cut out my parts to sub millimeter precision. It was also significantly cheaper than making similar parts out of 3D printed PLA or PETG and resulted in stronger, less fragile parts. The only limitation being that complicated parts had to be designed as an assembly of multiple 2D parts and joined together using glue or fasteners. The backbone of the chassis was the aluminum extrusions, specifically 2040 extrusions, which also provided great mounting locations for the vital electronics (sensors, motor drivers etc.). The fasteners used are mostly M4 and M3 screws and nuts, with some M5 as well. This was a design limitation since the aluminum extrusions T nuts were in M4 size and most electronics had M3 sized mounting holes. Therefore, to simplify procurement the design was based on these standard sizes. Hex screws were preferred since they are less prone to stripping.

## Chassis

The chassis is made out of 6 main parts. Two 180mm aluminum extrusions in the front and back, and four 6mm thiccc acrylic panels for the other 4 sides of the cuboid shape design. It being cuboid to make maximum use of the internal space. All four panels are screwed to the aluminum extrusions but are also interlocked with each other by design to increase stiffness and stability of the chassis. The bot has 4 wheels, 2 central driven wheels via the motor and a 20mm ball caster wheel on the front and rear. The two driven wheels are attached to the motor and the motos are mounted in the center of the bot, this is to maintain a center of rotation with the center of the bot.

The aluminum extrusions are cut to size, deburred and have M5 tapped holes in them to receive M5 screws, which mount the side panels. All panels have holes for attaching them to the extrusions. The bottom panel features additional holes for securing the battery and screwing down the Arduino mega to avoid movement, as well as a big cutout for the caster wheels and the IR sensor array. The side panels have cutouts for the usb port of the Arduino, cutouts for routing wires of external sensors and devices, mounting points for the motors and larger diameter holes for the on-off button and input power jack. The top plate is the base of the whole mechanism, so it has holes for additional screws for additional support and cutouts for the other pieces of the mechanism to fit into.

## Mechanism

The mechanism consists of two identical systems mirroring each other. This is dictated by the task; that the left and right side of the mechanism have to function independently of each other. To this end both sides function identically.

The mechanism comprises of two offset slider mechanisms, one on top of the other on each side. The mechanism is built on two stories, one for the lower ball which is also closer to reach and one for the upper ball that is further to reach, hence requiring a longer reaching plucking system. All the structural parts of the mechanism are made from 6mm thick acrylic to maintain its strength and stability and all non-structural, non-load bearing parts are made from 3mm acrylic.

The two offset sliders have a common crank arm but different output arms. The crank arm is attached to a big servo that rotates it a few degrees. This in turn drives the sliders in a linear direction out of the bot, extending them towards the trees. All the arms are made of 6mm thick acrylic and fastened together loosely with M5 and M4 screws and nuts.

The sliders function as the ball plucking mechanism as well as the ball storage. It plucks the balls with the gate and a small servo attached to it and stores them until drop off, at which point the gates open, and the balls are launched due to the change in momentum of the bot. Most of the slider is made from 3mm thick acrylic and glued together, and the hinges being small 20mm hinges.

## Miscellaneous

Brackets for various sensors are made out of 3mm acrylic since they are not structural in nature. These are designed to be mounted to the aluminum extrusions which is straight forward as it can be done simply by sliding a T nut inside the rails of the extrusions.