College Name : BRACT's Vishwakarma Institute of Technology, Pune (Team A)
Team Leader :
Mobile Number :
Email-Id :

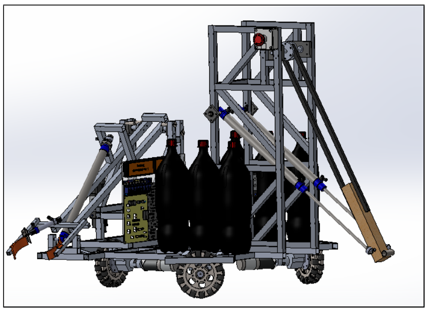
I Design of Passing Robot

I.1 Overall Dimensions and Weight

Table 1: Dimensions and Weight of PR

Sr No	Dimension	Value	Dimension	Value
1	Length	**834** mm	Game length	**1020** mm
2	Width	**825** mm	Game Width	**1034** mm
3	Height	**843** mm	Game Height	**843** mm
4	Weight			**15** Kg

Figure 1: Passing Robot



I.2 Type Of Drive

The drive used for the locomotion of the robot is a **three-wheel holonomic drive** made using **Omni wheels**. Three-wheel Omni drive is used because of its simplicity, agility and ease of control. It is made using **Aluminium 6061 square tubes** because of its optimum strength to weight ratio. For automating the three-wheel we have used an **Inertial Measurement Unit (IMU) MPU6050** which allows the robot to orient itself. For the distances feedback, we have used encoders with dummy wheels to **resolve locomotion along X and Y-axis**.

I.3 Actuators and Sensors Integrated

• Sensors • Actuators

Table 2: Sensors Integrated on PR

Sr No	Sensor	Specification	Quantity	Usage
1	**Incremental Optical Rotary Encoder**	**600** Pulses Per Rotation	2	For calculating distance required for locomotion.
2	**Intertial Measurement Unit (IMU) MPU6050**	3 - Axis Gyroscope 3 - Axis Accelerometer	1	To Control Angular Position of Robot.
3	**Ultrasonic Sensor (HC-SR04)**	**2 - 400cm** distance module, **0.3 cm** resolution	1	Distance calculation between ball rack and robot.

Table 3: Actuators Used on PR

Sr No	Actuators	Specifications	Quantity	Usage
1	**Pneumatic Cylinder**	**8 mm** bore diameter, **25 mm** stroke length.	1	For gripping the try ball.
2	**Pneumatic Cylinder**	**25 mm** bore diameter, **300 mm** stroke length.	1	For passing the try ball.
3	**PMDC Motor**	**12 V DC**, **3000 RPM**, Torque: **4 kg-cm**	2	For rotating disc wheels.
4	**Planetary Geared PMDC Motor**	**12 V DC**, **400 RPM**, Rated Torque: **4 kg-cm**	1	For rotating gripper arms.

I.4 Ball Picking and Passing Mechanism

I.4.1 Calculations

I.4.2 Working

A. Maintaining the desired distance from the ball rack with proper orientation:
MPU6050 is used for the orientation of pass Robot and for locomotion, Rotary encoder and MPU6050 feedback is used. **Ultrasonic sensor** feedback is used for the detection of ball and distance calculation between ball rack and robot.

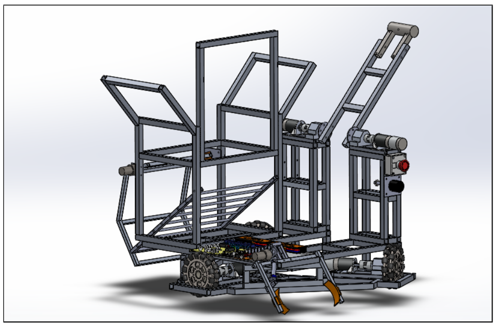
II Design of Trying Robot

II.1 Overall Dimensions and Weight

Table 4: Dimensions and Weight of TR

Sr No	Dimension	Value	Dimension	Value
1	Length	**855** mm	Game length	**1148** mm
2	Width	**940** mm	Game Width	**1045** mm
3	Height	**848** mm	Game Height	**848** mm
4	Weight			Kg

Figure 2: Trying Robot



II.2 Type Of Drive

The base frame has been manufactured with **Aluminium 6061** hollow square pipes of **19 mm x 19 mm x 1.5 mm** cross-sectional thickness. *Aluminium ensures an efficient light-weight frame with uniform weight distribution.* Since Aluminium has low density ($2.7g/cm^3$) compared to other common metals available, it made the robot lightweight while ensuring swift translation and sturdiness of the base. For determination of orientaion of robot, we have used **MPU6050 Inertial Measurement Unit** whereas **distance feedback taken using rotary encoder**. Being Holonomic in nature it enables fast locomotion as well as quick response to the change in direction of travel. The three wheeled robot reduces the overall weight of the robot and provides better load distribution over all the wheels.

II.3 Actuators and Sensors Integrated

- Sensors

Table 5: Sensors Integrated on TR

Sr No	Sensor	Specification	Quantity	Usage
1	**Incremental Optical Rotary Encoder**	**600** Pulses Per Rotation	2	To Control Position of the leg.
2	**Intertial Measurement Unit (IMU) MPU6050**	3 - Axis Gyroscope 3 - Axis Accelerometer	3	To Control Angular Position of Robot and for distance distance .
3	**Potentiometer**	10k linear taper 16 mm rotary potentiometer	2	To control ball placing Flap Actuation.
4	**Digital Proximity Sensor**	**0 - 80 cm** non contact type detection, **5V**	1	For detecting the kick ball.
5	**Ultrasonic Sensor (HC-SR04)**	**2 - 400 cm** distance module, **0.3 cm** resolution	1	Distance calculation of ball rack base frame.

- Actuators

Table 6: Actuators Used on TR

Sr No	Actuators	Specifications	Quantity	Usage
1	**Johnson Geared Motor**	**12 V DC**, **60 RPM**, Rated Torque: **20 kg-cm**	1	Used for actuating the placing flap.
2	**Planetary Geared PMDC Motor**	**12 V DC**, **850 RPM**, Stall Torque: **45 kg-cm**	2	Required for actuating the kicking mechanism.

II.4 Ball Recieving Mechanism

The try ball receiving mechanism resembles a basket-like structure having trapezoid-shaped opening to receive the try ball. The receiving mechanism is covered with nylon fibre net to absorb the momentum of the try ball. The structure is made using aluminium 6061 hollow square pipe since it provides optimum strength to the mechanism.

II.5 Try Mechainsm

The try mechanism is mounted just beneath the ball receiving mechanism. The try mechanism consists of a ramp, which is placed at an inclination of 32° to the ground and a flap which holds the ball inside of the try ball receiving mechanism. Once the try ball is received in the mechanism with the help of the net, the ball will fall on the ramp and slide down through it till it is obstructed by the flap. The rotation of the flap will stop at a point where the distance between the ramp and flap will be just enough to allow the ball to fall in the try spot. At this point, there will be **contact between the flap and ball and the ball and ground as well**. While making a try, the placing flap is actuated using Johnson geared motor. As the **ball must touch the robot and ground simultaneously**, the placing flap's angular movement must be controlled. A **10k Ohm potentiometer** coupled to the motor's shaft is used as feedback to control the movement of placing flap accurately.

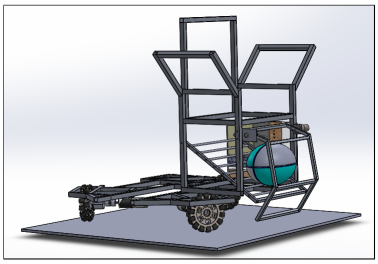


Figure 3: Try Ball Obstructed by placing flap.

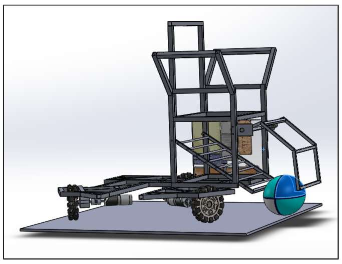


Figure 4: Putting try ball in try spot.

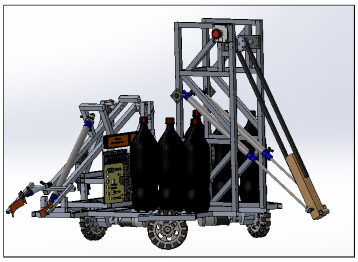


Figure 5: Step 3

• Alternate Gripping and Placing using Gripper:
In case, **if the ball is not received in the basket** and falls in the receiving zone then the ball can be picked up using a pneumatic gripper. The gripper will grip the ball along the major axis and lift the ball using a **12V DC Johnson motor** with a **10k potentiometer** as **feedback**. Then the ball will be released by the gripper in the try spot.

III Kicking Mechanism

III.1 Mechanism I

III.1.1 Components Used

III.1.2 Principle Involved in the mechanism

The kinetic energy of piston of air cylinder along with the potential energy of kicking link is converted into rotational energy of kicking link which is finally converted to the kinetic energy of the ball.

III.1.3 Design Calculations

o The calculation for angular travel of the hitting part of mechanism actuated using pneumatic air cylinder (Fig 3).
o In angular travel calculation, we are tracingan arc travelled by rod end bearing at the endpoint ofthe piston rod.

Table 7: Actuators Used on PR

Sr No	Name Of the Component	Specifications	Usage
1	**Rod End Bearing**	**ID: 10** mm	To accommodate the misalignment of the piston rod, rod end bearing is used. The shaft of the piston rod is placed in a ball swivel of bearing placed inside the outer casing.
2	**Pneumatic Cylinder**	**300 mm** stroke length **25 mm** bore diameter,	To provide angular travel and required force to thee hitting partof the mechanism.
3	**Direction Control Valve (DCV)**	**5/2** DCV	It is used for position control of the air cylinder at the end and starting position only.

A: Initial position of the endpoint of the piston rod.
B: The endpoint of the piston rod.
C: The pivot point of kicking link.
D: The pivot point of an air cylinder.
o Steps in calculations and deciding the height of pivot for air cylinder and the distance between 2 pivots:
1. Considering the length of the kicking part, an arc is drawn with centre at c with some clearance from the ground.
2. For a given cylinder, **90°** angular travel of the hitting part is preferred to impart maximum force and velocity to the kickball. **Angular travel more than 90 0 is not preferred since for that particular angle, piston motion inside air cylinder is restricted.**
3. A vertical line passing through centre C is drawn, ensuring a **30°** angle in forwarding **((B)** and a **60°** angle in the backward direction **(ponit A)**.
4. Considering the retracted position of the piston of the air cylinder, an arc taking **(A** as a centre with the length of retracted position (425 mm) is drawn. Again, extended length (725 mm) of the piston in air cylinder is taken into consideration to draw an arc with centre at B. The point of intersection of these 2 is point D which is actually the pivot point of the air cylinder.

III.1.4 Working

Two pneumatic cylinders are mounted on the top of the **support structure** and are connected to the leg. Initially, the piston of the air cylinder is retracted and is connected to the kicking link with the help of a rod end bearing. Just after the robot aligns itself at the required distance, the kick is initialized by actuating **5/2 direction control solenoid valve** and as soon as it gets extended, as per the principle, the kicking link travels an angular arc and finally hits the ball.

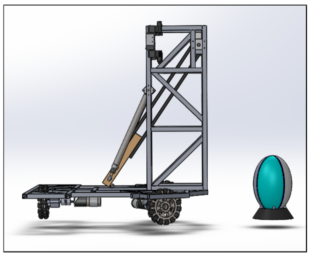


Figure 6: Initial Positon.

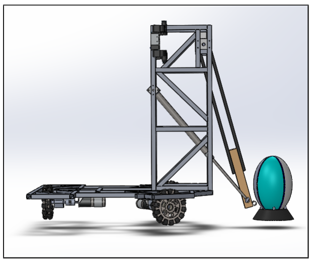


Figure 7: Intermediate Positon.

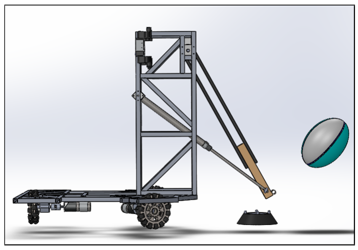


Figure 8: Final Position

III.2 Mechanism II

III.2.1 Construction

The mechanism consists of a leg which is used as a hitting part for a kick ball. This leg is actuated using teo two PMDC motors mounted coaxially and are opposite to each other.Two PMDC motors are mounted on a supported stucture which is made using aluminium 6061 hollow square pipes to provide optimum strength to the mechanism.

III.2.2 Calculation

Initially, using Adams simulation software, the initial velocity that needs to be imparted to the ball so that it passes the conversion post from the desired distance was obtained. This velocity will be imparted to the ball through the impact of the

leg. The leg should have a certain minimum velocity while the impact to achieve the desired results. This velocity will be provided by the motors.
To decide the torque and speed output required from the motor, the following energy conservation calculations were done.

$$\frac{1}{2}I\omega^2 = \frac{1}{2}m\nu^2$$

Where,
I = Moment of Inertia of the leg; ω = Angular speed of the leg.
ν = Velocity of the ball; m = Mass of the ball (340 g).
Based on the calculations, two motors of the following specifications are used
• RPM = 840 and Torque = 40 kg.cm

III.2.3 Working

• Ball Detection and Alignment:
The ball is detected using proximity and after detection ultrasonic sensor gives the distance of the ball from chassis, with the help of a lateral shifting robot is aligned for kicking.
• Steps for Kicking:
Motors are mounted on the top of the support structure and are connected to the Leg. 600 PPR rotary encoder is used for controlling the leg's angular position. The kick is initialized by moving the leg vertically upwards making an angle of 180 degrees with respect to the structure. Then the motors are actuated, and this makes the leg rotate. Once the leg makes an impact with the ball, the power supply to the motors is ceased. But the leg continues to rotate due to its inertia.

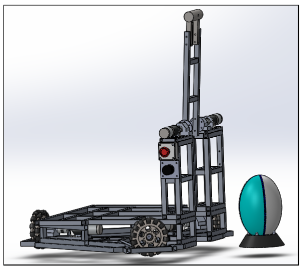


Figure 9: Initial Positon.

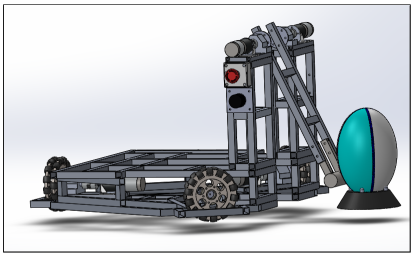


Figure 10: Intermediate Positon.

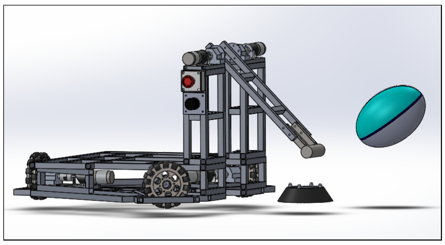


Figure 11: Final Position