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Design Documentation Details

Robocon India 2020

Design of Pass Bot

Overall dimensions- (in mm) and estimated weight (in kg)

- Length = 965mm
- Game Length = 1195mm
- Width = 915mm
- Game Width = 915mm
- Height = 490mm
- Game Height = 500mm
- Weight = 29.5kgs

*Type of drive- **4 wheeled mecanum Holonomic drive**-*

The base chassis has been created by welding **Aluminium 6061** hollow square channels with cross sectional dimensions of **19mmX19mmX2mm**. Aluminium (density = 2.70 g/cm^3) not only ensured that our robot was **light, agile, and capable of swift responses**, but also distributed weight evenly across the base of the chassis, providing us with an ideal CoG, to prevent toppling of the bot. All the components are connected using nuts and bolts and where such a provision was not possible threading has been created to fasten the components.

A four wheeled drive was picked to ensure more stability (when compared to a three wheel drive) coupled with a fairly easy controlling system. Since our main focus was firmness of our structure, and since the field of play is fairly flat, we eliminated the need of a 3 wheeled drive which would be applicable for changing contours of the field. Hence a four wheeled drive was the most obvious choice when ensured good structural integrity on flat surfaces.

We employed the use of a 12V **DC** motor which gave us a **stall torque of 27** kgcm along with **300 rotations** per minute. DC motors are easier to control and provide good low-speed accuracy, which is necessary to correctly position the bot during picking and kicking the rugby. The robot is controlled using an Xbox controller. The receiver is connected to an **Arduino with a USB host shield.** The Arduino decodes the Xbox signals and relays to **Hercules 6V-24V, 16Amp Motor Driver**, which controls the motors. **Mecanum wheels** are used as they are vectored wheels, and give 360degree movement to the bot. By controlling the direction of rotation of individual wheels, the direction of the bot is controlled

Actuators and sensors integrated-

Sr No	Component	Specification	Quantity	Usage
1	Linear Actuator	Stroke Length 500mm, 7mm/, 1500N, 12V	2	*To bring about variations in height of the throw*
2	Ebike Motor MY1016Z3	*24V, 350W, 324 Geared*	*1*	*To pull the elastic band for striking*
3	Solenoid	*24V*	*1*	*To hold the striking plate*

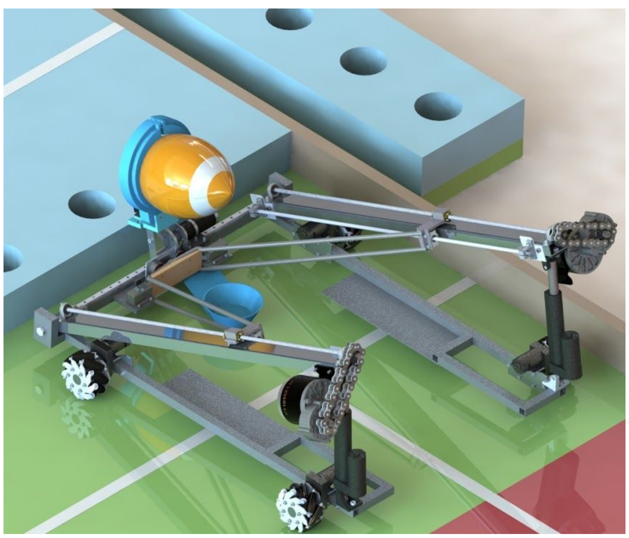
4	Square Geared Motor	*12v, 300rpm, Stall Torque 27kgcm*	*4*	*Wheel Drive Motor*
5	Digital Servo	*8.4V, Stall Torque: 20kgcm, 180Degree*	*2*	*Rugby Gripping Mechanism*

Senors-

Sr No	Component	Specification	Quantity	Usage
1	LSA08	12v, Advanced Auto-Calibrating Line Sensor	4	Detecting line in the arena, help navigate the bot.
2	Orange 2500 Optical Rotary Encoder	2500 CPR encoder	1	Feedback mechanism to know how much the elastic band has been stretched.

Ball picking mechanism-

The rugby is picked using a **robotic gripper** (custom-designed to fit the rugby), which is controlled by a **digital servo**. This entire assembly is on an arm, which is connected to a **Planetary Encoded Motor,** which lifts it and place it on an on-board rugby holder.

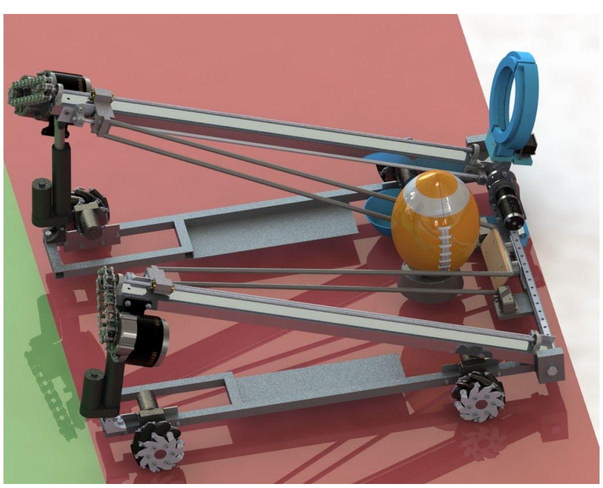


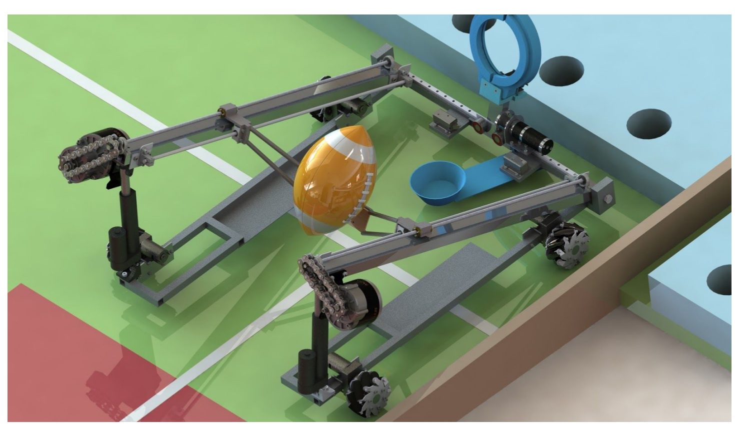
Ball passing mechanism-

The ball passing and kicking have essentially been coalesced into a single mechanism. By varying the pull on the band through the **Ebike motor**, we can change the amount of impulsive force applied to the ball which eventually brings about a change in the distance travelled by the rugby. This is a major advantage of our system. It is capable of variable force outputs without changing components or varying the rugby.

Ball throwing mechanism-

The ball is placed in its proper position and a **doubled resistance band** with a **maximum force of about 32.4830 Newtons** at maximum elongation is used to slingshot the ball at a distance suitable for the goal post. The band is extended back a **distance of 900mm** to provide this impulsive force.





***Design of Try bot*:**

Overall dimensions-

Length: 685mm
Game length: 779mm
Width: 790mm
Game Width: 790mm
Height: 883mm
Game Height: 883mm
Weight: 19.7kg

Type Of Drive-

Omni Wheels were used which were connected to **Johnson Motors** with a **rating of 12v** along with a **stall torque of 300Ncm**. The wheels and motor assembly are attached in **Plus Configuration**. Due to the plus configuration, only 2 motors are required to move the bot front/back. Hence giving more speed and using less energy. Try bot does not have to rotate, only move front/back/left/right.

Actuators-

Sr No	Component	Specification	Quantity	Usage
1	Johnson Motor	12v, 300rpm, Stall Torque 300kgcm	4 + 1	Wheel Drive+ Rack Pinion
2	Digital Servo	8.4V, Stall Torque: 20kgcm, 180Degree	1	Rugby Dropping Mechanism
3	Encoded Motor	24v, 468rpm, Stall Torque 526Ncm	1	Try Mechanism

Sensors-

Sr No	Component	Specification	Quantity	Usage
1	LSA08	12v, Advanced Auto-Calibrating Line Sensor	4	Detecting line in the arena, help navigate the bot.

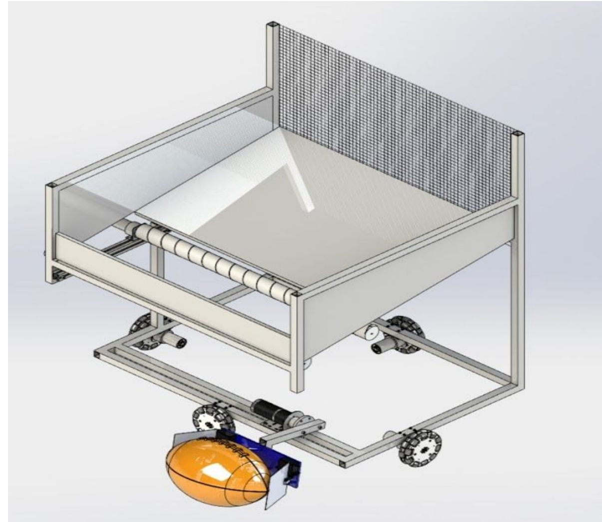
Rugby Receiving Mechanism-

To receive the rugby from MR1, there is a basket-shaped box, with front and bottom open. The sides are covered by a net, as it will not rebounce the rugby, and this entire configuration will receive the rugby from the front, due to the ramp, the rugby will roll to the bottom of the ramp, where it will fall on 2 aligning rollers(3d printed)(white roller with helix on its surface), which will feed the rugby into the gripper. This is how the rugby rolls and falls in the gripper.

Rugby Gripper Mechanism-

When the rugby is in the gripper, the encoded motor will take the gripper with rugby and place it in front of the bot. Here the gripper will open, releasing the rugby.This ensures that the rugby does not roll when placed on the arena. The following are the steps of how it will work.

Receiving mechanism



Gripping mechanism

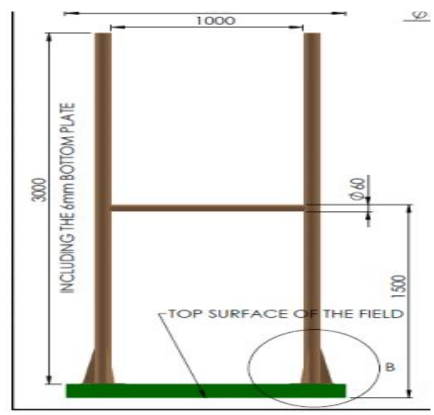
Kicking Calculations-

For Kicking Mechanism we use elastic tubes which will be stretched using motors**.**By taking the mean height to be kicked we calculated the velocity and angle of attack for the ball to achieve desired height. During the kick the elastic tubes will be stretched and on releasing the band the elastic potential energy converts into kinetic energy of plate and the plate will hit the ball at rest with certain velocity and there will be a elastic collision between ball and plate and the ball will travel with certain velocity.

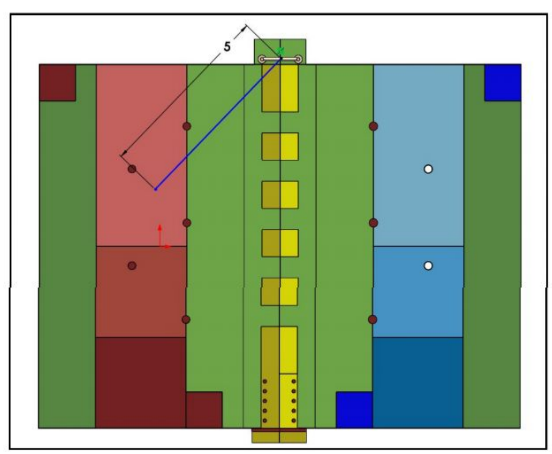
Maximum Height $h1 = 3m$
Minimum Height $h2 = 1.5m$
Mean height(h): $h = \frac{h1+h2}{2}$
h=2.25m
The calculations for the projectile of rugby is given by the equations stated below:

$$Hmax = \frac{u^2 sin^2\theta}{2\times g}$$

$$R = \frac{u^2 sin2\theta}{g}$$



$m2 \rightarrow (mass\ of\ plate) = 0.25kg$
$m1 \rightarrow (mass\ of\ rugby\ ball) = 0.3kg$
$v \rightarrow 2(velocity\ of\ plate\ before\ collision)$
$v2^1 \rightarrow (velocity\ of\ plate\ after\ collision)$
$v1 \rightarrow (velocity\ of\ ball\ before\ collision) = 0m/s$
$v1^1 \rightarrow (velocity\ of\ ball\ after\ collision) = 9.93m/s \Rightarrow zone\ 1$
$12.91m/s \Rightarrow zone\ 2; \quad 16.18m/s \Rightarrow zone\ 3;$
Taking the data from theraband website.
We found the value of spring constant $k = 21.29N/m$ for one elastic tube



Kicking zone 1:
$Hmax = 2.25m$
$R = 10m$
Using these values
Velocity: $9.93m/s$
Angle: 41.99°
Initial velocity of rugby ball ($v1$) is zero and the velocity of ball after collision with the plate ($v1^1$) for this zone will be $9.927m/s$
There is an elastic collision in which the momentum and kinetic energy is conserved

On conserving momentum the equation is:
$m1 \times v1 + m2 \times v2 = m1 \times v1^1 + m2 \times v2^1$ ……………..(1)

On conserving kinetic energy:

$\frac{1}{2} \times m1 \times v1^2 + \frac{1}{2} \times m2 \times v2^2 = \frac{1}{2} \times m1 \times v1^{1^2} + \frac{1}{2} \times m2 \times v2^{1^2}$ …………(2)

On solving equation 1 and 2

$v2 = 10.92 m/s$

As elastic potential energy changes to KE, equation will be $\Rightarrow$ $\frac{1}{2} \times keq \times \Delta x^2 = \frac{1}{2} \times m2 \times v2^2$ $\Rightarrow$ $keq = 172.85\ N/m$;

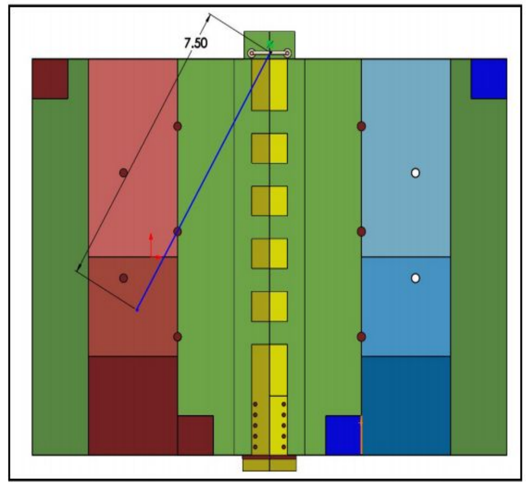
$(with\ xi = 0.5m;\ xf = 0.65m)$

For kicking Zone 2:

$Hmax = 2.25m$

$R = 15m$

$\Rightarrow$ **Velocity:** $12.91 m/s$; **Angle:** 30.96°



Initial velocity of rugby ball ($v1$) is zero and the velocity of ball after collision with the plate ($v1^1$) for this zone will be $16.83 m/s$.
There is an elastic collision in which the momentum and kinetic energy is conserve

On conserving momentum the equation is:

$m1 \times v1 + m2 \times v2 = m1 \times v1^1 + m2 \times v2^1$ ……………..(3)

On conserving kinetic energy:

$\frac{1}{2} \times m1 \times v1^2 + \frac{1}{2} \times m2 \times v2^2 = \frac{1}{2} \times m1 \times v1^{1^2} + \frac{1}{2} \times m2 \times v2^{1^2}$ ………………(4)

On solving equation 3 and 4; $\Rightarrow$ $v2 = 14.2 m/s$

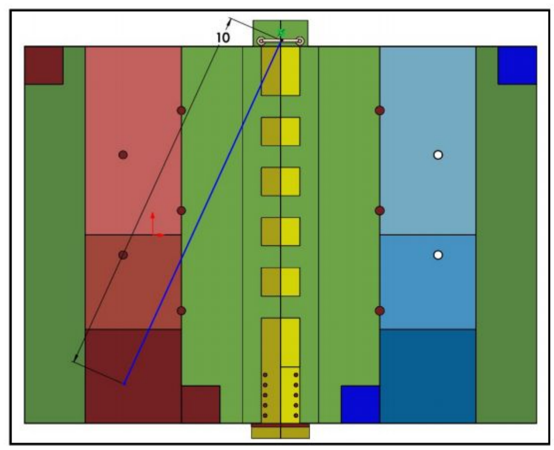
$(with\ xi = 0.5m;\ xf = 0.70m)$

$\frac{1}{2} \times keq \times \Delta x^2 = \frac{1}{2} \times m2 \times v2^2$ $\Rightarrow$ $keq = 210.04 N/m$

Kicking Zone 3:

$Hmax = 2.25m$

$R = 20m$



Using these values
Angle: 24.25°
Velocity: $16.18 m/s$

On conserving momentum the equation is:

$m1 \times v1 + m2 \times v2 = m1 \times v1^1 + m2 \times v2^1$ ……………(5)

On conserving kinetic energy:

$\frac{1}{2} \times m1 \times v1^2 + \frac{1}{2} \times m2 \times v2^2 = \frac{1}{2} \times m1 \times v1^{1^2} + \frac{1}{2} \times m2 \times v2^{1^2}$ ……...(6)

On solving equation 5 and 6; $\Rightarrow$ $v2 = 17.80 m/s$

$(with\ xi = 0.5m;\ xf = 0.80m)$

$\frac{1}{2} \times keq \times \Delta x^2 = \frac{1}{2} \times m2 \times v2^2$ $\Rightarrow$ $keq = 203.10\ N/m$;