Design Details Document - Team Robotics SKNCOE

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Transaction (Registration fee) unique number: T2502162141489542166536

1] **Ball Handling Mechanism**

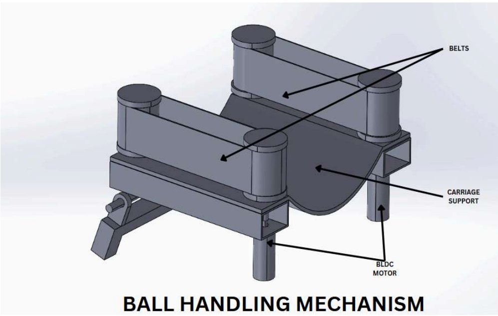
The ball handling mechanism is responsible for controlling and manipulating the ball inside the robot. It includes systems for gripping, holding, and passing the ball.

Robot 1 :

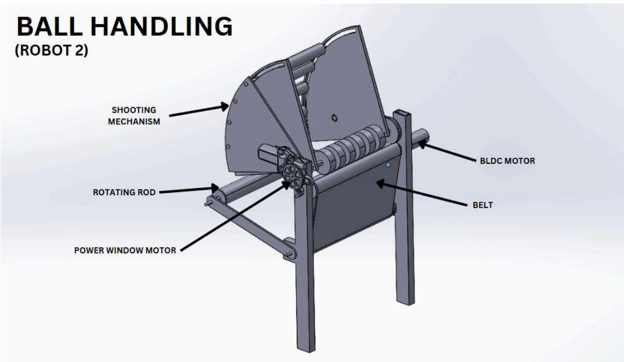
Actuators
Purpose: Controlling and manipulating the ball inside the robot.
Types: Motor driven belt conveyor
Usage: Belt conveyor is used to handle the ball and move it to the passing mechanism.

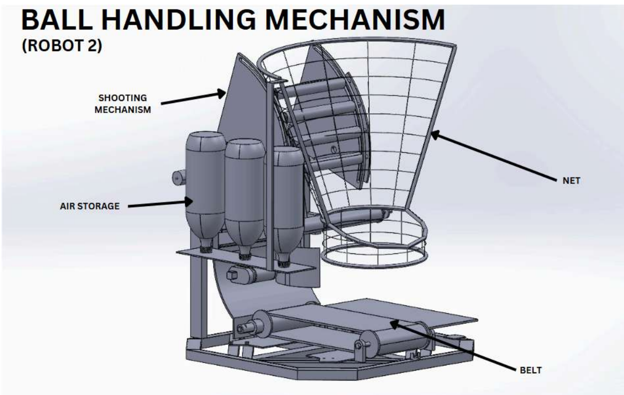
Motors
Purpose: Motors control the rotation or movement of parts (e.g., wheels or robotic arms) that interact with the ball.
Types: DC motors Johnson Geared Motor 12V 200 RPM, Torque (15.6 kg.cm)
Usage: A motor will rotate a wheel that picks up the ball and moves it into position for shooting or passing.

Working
The ball handling mechanism typically uses actuators to pick up the ball, hold it in place, and adjust its orientation. Motors provide the power to move the robotic arm or other mechanisms holding the ball. The system will detect when the ball is properly gripped and in the correct position for subsequent actions.



▲ball handling mechanism for Robot 1





▲ball handling mechanism for Robot 2

2] **Passing/Shooting Mechanism (ROBOT 1)**

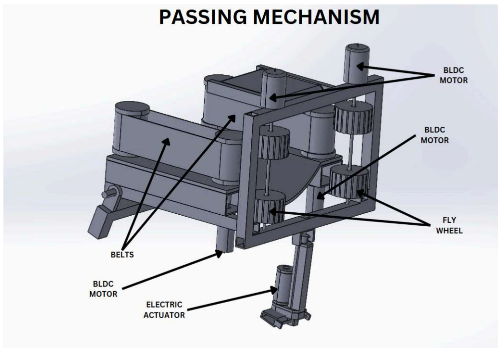
The passing mechanism is designed to pass the ball to the second robot.

Actuators
Purpose: To push or propel the ball toward a target, such as another robot or player.
Types: Linear electric actuators to be used to provide the angle of shooting needed for the pass.
Usage: The linear actuator is used to change the angle at which the ball will be passed at.

Motors
Purpose: Motors provide the rotational force necessary to rotate wheels, rollers that is responsible for propelling the ball.
Types: BLDC motors: Motor KV(530RPM/V); Idle Current (1.98 A); LiPo Cell Support (3-12S); Weight (492g); Shaft Diameter (6mm); Length of motor (61mm).
Usage: A set of wheels are to be spun by a motor at specific RPMs to launch the ball through a specific trajectory.

Sensors
Purpose: Sensors help in determining the ball's position, speed, and angle to optimize the passing action.
Types: Camera Sensor, Laser sensor, Gyroscope (BNO055)
Usage: Camera sensors and laser to be used to detect when the ball is in position for passing by judging the second bot's position, speed and alignment. Laser to be used for reference in case of manual-override.

Working
Once the ball reaches the passing mechanism, the ball is stored in the mechanism till the right time. When the two bots are aligned with one another such that this robot can pass the pass and the other robot can receive the ball. The camera sensor and the gyroscope is used to confirm both robot's positions before the passing processes can be initiated.



3] **Passing/Shooting Mechanism (ROBOT 2)**

The shooting mechanism is designed to shoot the ball towards the hoop, or other target.

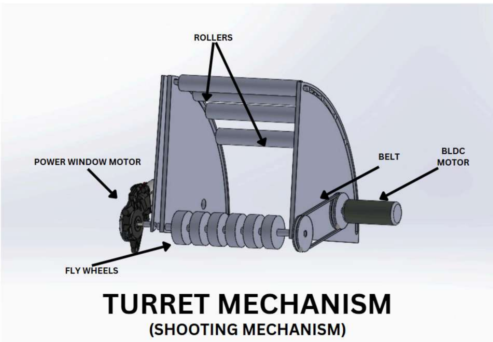
Actuators
Purpose: To change the trajectory of the ball for shooting.
Types: Power window, BLDC motor
Usage: Power window motor will be used to change the angle of the shooting mechanism while BLDC motor drives the shooting mechanism to shoot the ball.

Motors
Purpose: Motors control the components responsible for applying force to the ball, and changing its trajectory.

Types: Power window motor: 3A motor; Speed (100 RPM); Voltage (12V).
BLDC motors: Motor KV(530RPM/V); Idle Current (1.98 A); LiPo Cell Support (3-12S); Weight (492g); Shaft Diameter (6mm); Length of motor (61mm).
Usage: BLDC motor will drive the mechanism to shoot the ball. Power window motor will help to change the angle.

Sensors
Purpose: Sensors ensure the bot is properly positioned and help with targeting and accuracy.
Types: Camera, laser sensor.
Usage: Camera sensors and laser to be used to detect when the ball is in position for passing by judging the second bot's position, speed and alignment. Laser to be used for reference in case of manual-override.

Working
The BLDC motor turns the belt, which in turn spins the fly wheels at high speed which is used to provide the ball with the necessary force to shoot the ball. The power window motor controls the position of the free moving rollers which change the angle at which the ball is released from the shooting mechanism.



TURRET MECHANISM
(SHOOTING MECHANISM)

4] <u>Dribbling Mechanism</u>

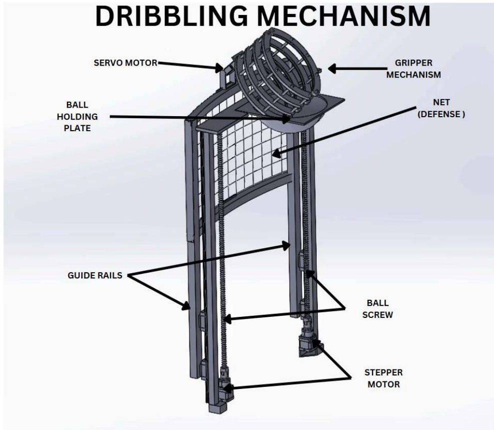
The dribbling mechanism is designed to dribble the ball, to maintain ball control and maneuverability.

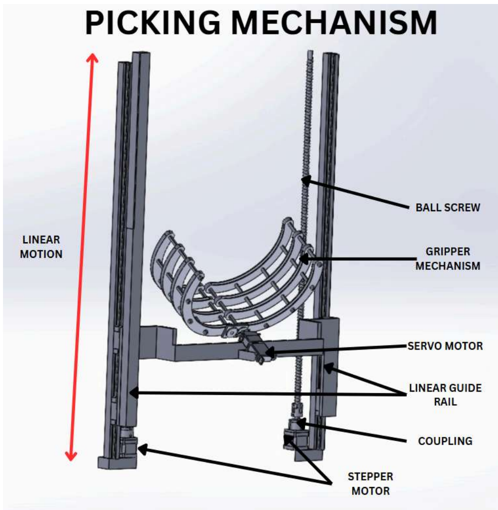
Robot 1 & 2:

Actuators
Purpose: To provide the physical movement or action necessary to dribble the ball.
Types: Ball Screw (900 mm), linear guide-way (MG12, HG15CC)
Usage: Ball screw (12 mm diameter) and linear guide way are essential to guide the ball up and down and releasing the ball from a height for dribbling motion

Motors
Purpose: Motors help control the mechanisms that maintain contact with the ball to dribble.
Types: Servo Motor - 5V; Weight (60g); Torque (19 kg.cm)
Stepper Motor - 5V; Weight (60g); Torque (3.2 kg.cm)
Usage: Two stepper motors will be used to control precise up and down movement of the gripping mechanism. A servo motor will be used to control the gripping mechanism.

Working
The ball will be precisely controlled using a ball screw to move it downward. Upon reaching a specific height, the ball will be released with sufficient force, ensuring it hits the floor and bounces back up. The gripping hand will then catch it again, completing the cycle efficiently.





5] <u>Jumping Mechanism</u>

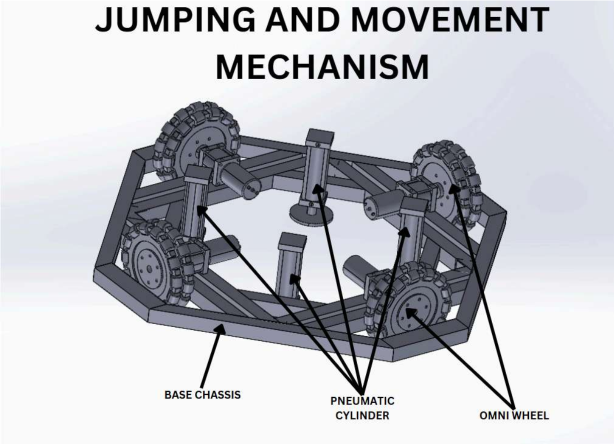
The jumping mechanism enables the robot to jump.

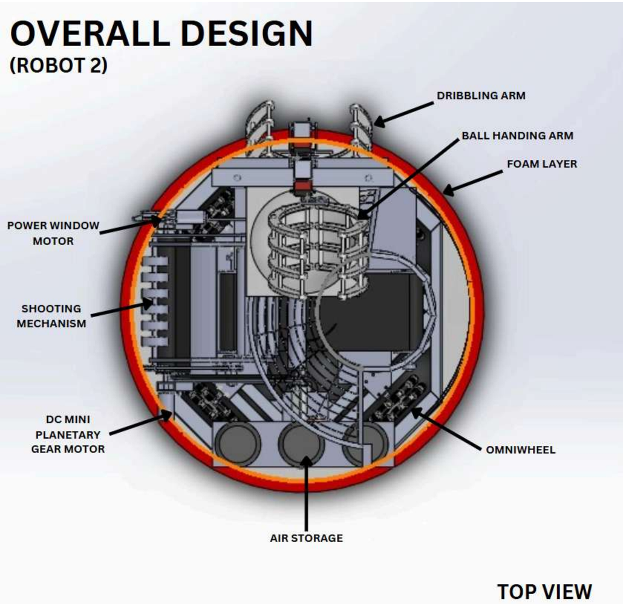
Robot 1 & 2:

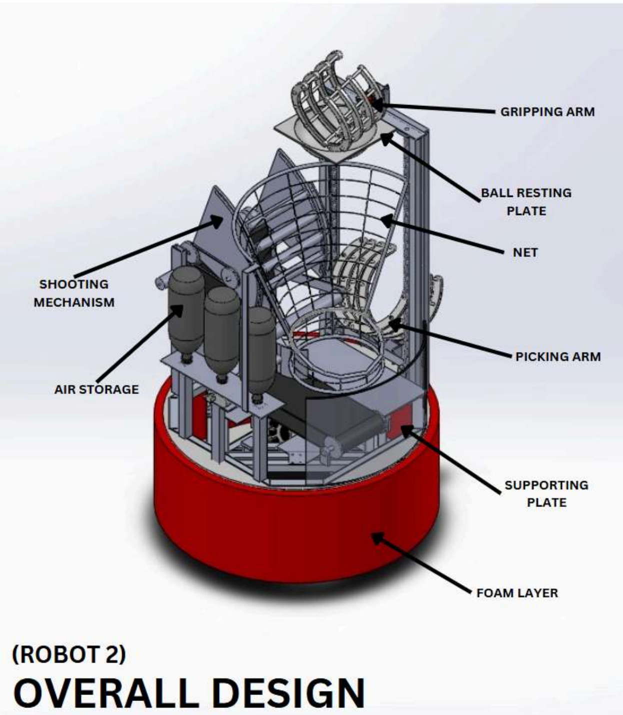
Actuators
Purpose: To create the force necessary to lift the robot off the ground.
Types: 4 x Pneumatic cylinders - 32mm bore, 150 mm stroke
Usage: Pneumatic actuators can release compressed air to quickly lift a robot

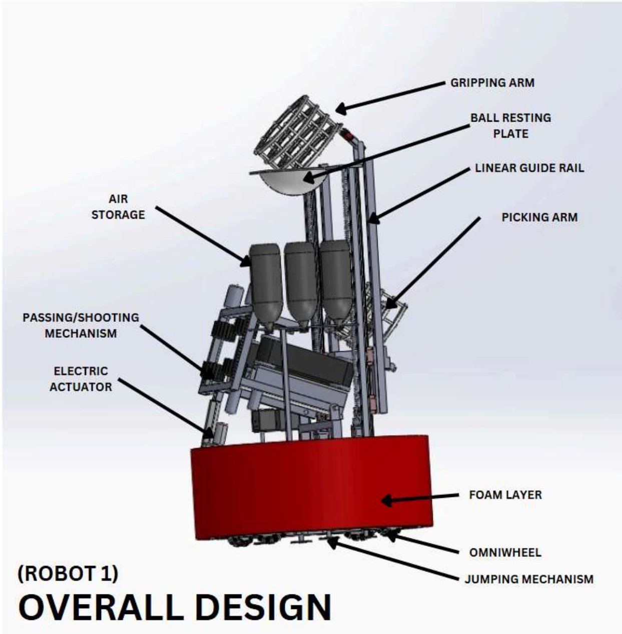
Sensors
Purpose: Sensors ensure the robot is exactly at the location where it needs to jump at
Types: Camera, Gyroscope (BNO055)
Usage: Sensors ensure the jumping mechanism operates at the correct timing and location.

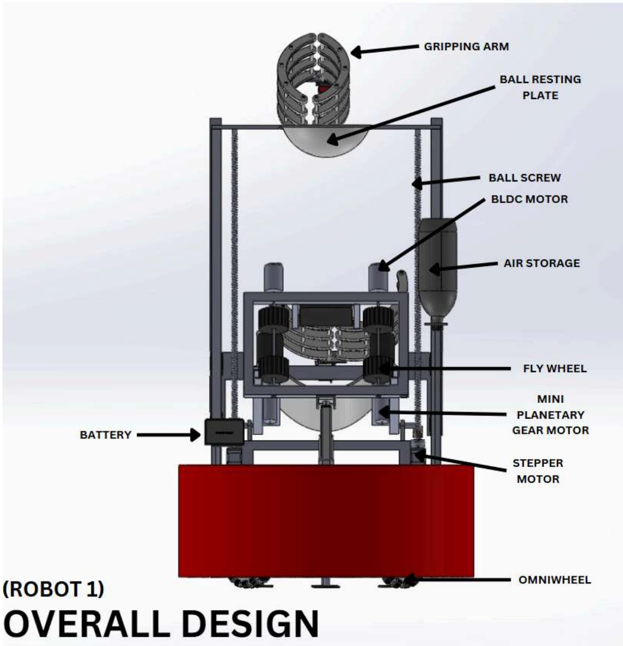
Working
The jumping mechanism works by using pneumatic cylinders to apply a rapid force, lifting the robot off the ground. Sensors provide feedback on the motion and timing of the jump, ensuring the system achieves the desired height and the robot is at the correct location.


JUMPING AND MOVEMENT MECHANISM
BASE CHASSIS
PNEUMATIC CYLINDER
OMNI WHEEL


OVERALL DESIGN
(ROBOT 2)
DRIBBLING ARM
BALL HANDING ARM
FOAM LAYER
POWER WINDOW MOTOR
SHOOTING MECHANISM
DC MINI PLANETARY GEAR MOTOR
OMNIWHEEL
AIR STORAGE
TOP VIEW


GRIPPING ARM
BALL RESTING PLATE
NET
SHOOTING MECHANISM
PICKING ARM
AIR STORAGE
SUPPORTING PLATE
FOAM LAYER
(ROBOT 2)
OVERALL DESIGN


GRIPPING ARM
BALL RESTING PLATE
LINEAR GUIDE RAIL
AIR STORAGE
PICKING ARM
PASSING/SHOOTING MECHANISM
ELECTRIC ACTUATOR
FOAM LAYER
OMNIWHEEL
JUMPING MECHANISM
(ROBOT 1)
OVERALL DESIGN


GRIPPING ARM
BALL RESTING PLATE
BALL SCREW
BLDC MOTOR
AIR STORAGE
FLY WHEEL
MINI PLANETARY GEAR MOTOR
BATTERY
STEPPER MOTOR
OMNIWHEEL
(ROBOT 1)
OVERALL DESIGN

CALCULATIONS

Dribbling:

Formula for coefficient of restitution (e) :
The coefficient of restitution is given by

$$e = \frac{Velocity\ after\ impact}{Velocity\ before\ impact}$$

or in terms of height:

$$e = \sqrt{\frac{h_f}{h_i}}$$

Where

- e = coefficient of restitution
- h_i = initial drop height
- h_f = rebound height

From FAQ B.4, we calculated the coefficient of restitution to be e = 0.7583.

Velocity Just Before Impact :

The velocity of the ball right before it hits the ground is given by :

$$v_i = \sqrt{v_0^2 + 2gh_0}$$

Where:

- v_0 = initial velocity (upward is positive, downward is negative)
- h_0 = initial height
- g = gravitational acceleration 9.81 m/s^2

For instance,
The Initial Velocity: V_0 = 2.495 m/s (minimum)
Initial Height: h_0 = 0.9 m
And the velocity of ball just before hitting ground:
v_i = 4.88716 m/s

Height reached after first bounce:

The maximum height after the first bounce is:

$$h_1 = \frac{(ev_i)^2}{2g}$$

Using the above equation we calculated,
v_i = 4.88716 m/s (impact speed)
e = 0.7583 (coefficient of restitution)
h_1 = 0.7 m

Jumping:

Given data,
Robot Mass (estimate): 25 kg
Number of Pistons: 4
Pressure: 1.5 bar = 150,000 Pa
Bore Diameter: 32 mm = 0.032 m
Stroke Length: 150 mm = 0.15 m
Acceleration due to Gravity: 9.81 m/s²
The force exerted by a single piston is given by:

F = P x A

where,

- P = 150000 Pa
- A = $\pi(d/2)^2 = \pi(0.032/2)^2 = 8.024 \times 10^{-4}$ m^2

F = 150000 x 8.042 x 10^{-4} = 120.63 N
Since there are 4 pistons, the total force is:
Total = 4 x 120.63 = 482.52 N
Using Newton's Second Law:

$$a = \frac{F}{m} = \frac{482.52}{25} = 19.3 \text{ m/s}^2$$

The effective acceleration is:
A_{eff} = a - g = 19.3 - 9.81 = 9.49 m/s^2

Using the kinematic equation:

$$v^2 = u^2 + 2as$$

Since the initial velocity u = 0 m/s,

$$v^2 = 2 \times 9.49 \times 0.15$$

$$v = \sqrt{2.85} = 1.69 \text{ m/s}$$

Now, using:

$$h = \frac{v^2}{2g}$$

$$h = \frac{1.69^2}{2 \times 9.81} = \frac{2.86}{19.62} = 0.146 \text{ m}$$

As per calculations, the robot can jump approximately 0.146 m.

Passing:

Range (horizontal distance when projectile lands)

$$R = \frac{v_0^2 sin2\theta}{g}$$

Where,

- V_0 = initial velocity
- θ = launch angle
- g = acceleration due to gravity (9.81 m/s^2)

Where,
R = distance between two robots (sensor input)
θ = angle at which ball is shot (user input)
V_0 = initial speed of ball (user input) (depends of RPM of motor)

Shooting:

Horizontal motion:

$$x = v_0\cos\theta.t$$

where,

- x = horizontal displacement
- v_0 = initial velocity
- θ = launch angle
- t = time of flight

Vertical Motion:

$$y = v_0\sin\theta.t - \frac{1}{2}gt^2$$

where,

- y = vertical displacement
- g = acceleration due to gravity (9.81 m/s^2)
- The term $v_0\sin\theta.t$ accounts for the initial vertical motion
- The term $\frac{1}{2}gt^2$ represents the downward gravitational effect

Now,

1. The horizontal motion equation:
   $$L = v_0 cos\theta.t$$
   Solving for t:
   $$t = \frac{L}{v_0 cos\theta}$$
2. The vertical motion equation:
   $$h = v_0 sin\theta.t - \frac{1}{2}gt^2$$
3. Substituting t:
   $$h = v_0\sin\theta \cdot \frac{L}{v_0 cos\theta} - \frac{1}{2}g\left(\frac{L}{v_0 cos\theta}\right)^2$$
   Simplifying:
   $$h = L\tan\theta - \frac{gL^2}{2v_0^2cos^2\theta}$$
   Where,
   h = difference between the heights of shooting mechanism and hoop.
   L = distance between bot and base of hoop (pole)

NOTE: All the above calculations have been made considering ideal conditions.