ROBOCON 2025 -Technical Design Document

This design paper comprehensively details all the mechanisms considered by the VIIT college team for Robocon, evaluating both the mathematical and manufacturing aspects of each component. It provides in-depth explanations supported by CAD drawings, ensuring alignment with the correct principles of physics and mathematics.

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1. ROBOT 1:

1.1 INTRODUCTION:

Robot R1 is designed primarily to perform major tasks: shooting the ball from the different pointer zones, dribbling the ball to assist in shooting, and passing the ball to another robot. The robot's locomotion is based on an omnidirectional four-wheel chassis. The estimated weight is approx. **24 kg**. The precisely measured dimensions of the robot are as follows:
[630 x 630 x 1400] mm.

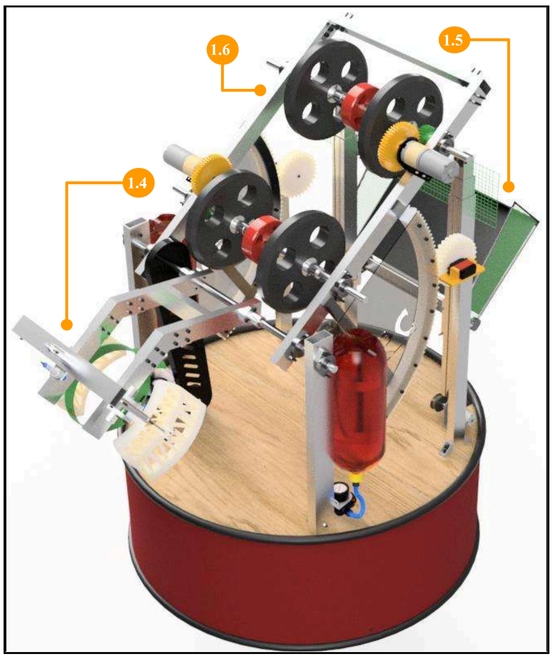


Figure 1.1 Robot (R1)

1.2 TYPE OF DRIVE:

Robot R1 employs a quad holonomic drive system with four 45°oriented **omni-wheels**[1.21] for maximum directional versatility and efficiency. Velocity compounding ensures precise trajectory control, minimizing slippage and backlash. We are using **LIDAR**[1.22], which enables precise navigation and obstacle detection. It provides accurate distance measurements and real-time mapping, enabling dynamic navigation and collision avoidance. The **chassis**[1.23] is made of aluminum, and each wheel is powered by a 12 V, 500 RPM **DC motor**[1.24].

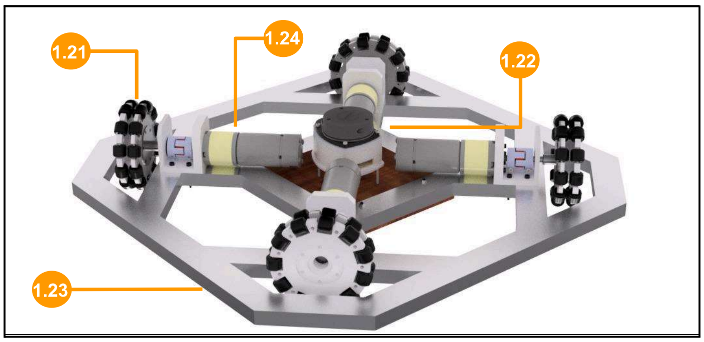


Figure 1.2 Omni Directional Drive

1.3BALL HANDLING:

To align and synchronize both robots for accurate ball receiving. When R1 receives the ball from R2, two scenarios are possible. In the first, the **receiving mechanism**[1.5] opens to guide the ball along a path that directs it onto the dribbling hand. The **dribbling hand**[1.3] controls the ball and moves it toward the **shooting frame**[1.6] along a curved path for an accurate shot into the basket.

Alternatively, the receiving mechanism opens to guide the ball directly onto the dribbling hand, where the ball is controlled and dribbled then fed into the shooting mechanism either to shoot or pass. Based on our game strategy, we determine whether to transition the ball toward the shooting frame for a shot or use the dribbling hand to control and pass the ball strategically. This process of receiving, dribbling, and shooting is precisely coordinated for optimal ball handling.

1.4 DRIBBLING MECHANISM:

The dribbling mechanism consists of a robotic linkage with two interconnected rods and a **pneumatic gripper**[1.44], designed for controlled ball dribbling. Mounted on a motor-driven **shaft**[1.42], the arm allows for 360-degree rotation, ensuring precise handling. The pneumatic system maintains consistent pressure to dribble and receive the ball at a set height. After dribbling, the **arm**[1.43] rotated inwards to transfer the Ball to the shooting mechanism, ensuring accurate positioning. The motor facilitates smooth rotation, integrating seamlessly with the shooting system for optimal performance.

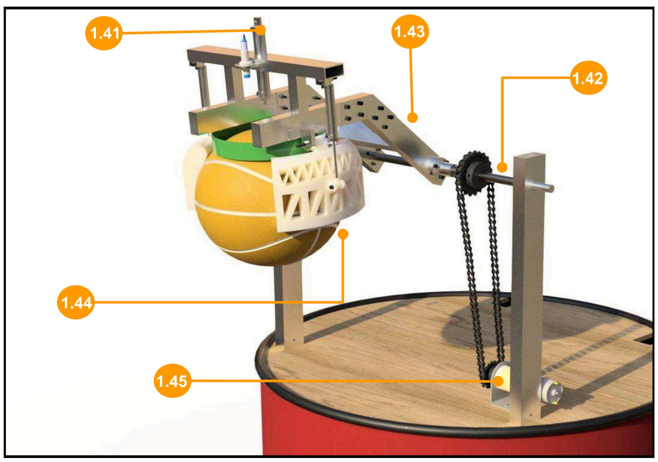


Figure 1.4 Dribbling Mechanism

1.4.1 Calculation :

Dribbling hand

Where, mass of ball(m) = 0.58kg;

Initial height(h1) = 0.9m;

Rebound Height(h2)=0.9m;

Acceleration due t gravity = 9.8m/sec2

1.velocity at impact(v) using the principle of conservation of energy : [P.E = KE],

$mgh1 = \frac{1}{2}(mv^2)$

*0.58*9.81*0.9 = 0.5*0.58*V^2,, V1 = 4.2m/sec*

2. Velocity after rebound (V2),

Since the ball rebounded to a height of 0.9m the velocity just after rebonding can be found using: $V2 = \sqrt{2gh2}$, $V_2 = 4.2$ *m/sec*

3.Force required during dribbling:

$= m*(V_{impact}+V_{rebound})/\triangle t$

$= 0.58*(4.2+4.2)/0.42=11..6N$

1.5 SHOOTING MECHANISM:

1.5.1 Principle:

Using the principle of projectile motion and conservation of energy, the flywheel-based throwing mechanism launches the ball with the required velocity along a single diagonal path. The structural design ensures that the desired throwing trajectory is achieved.

1.5.2 Construction:

The shooting mechanism consists of **flywheels**[1.51] mounted on each of the two shafts. These shafts are powered by **DC motors**[1.52]. The power transmission incorporates a gear ratio of 1:2, enhancing the flywheel speed for effective shooting. Additionally, the frame of this shooting mechanism is equipped with a **gear and rack mechanism**[1.53] allowing the angle of the mechanism to be adjusted as needed.

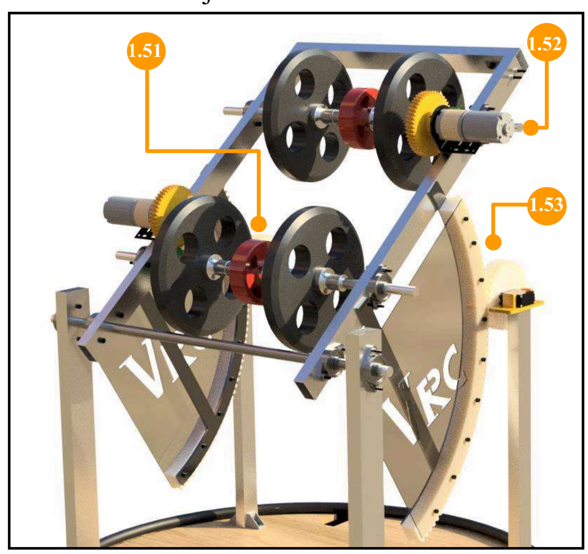


Figure 1.5 Shooting Mechanism

1.5.3 Working:

The shooting mechanism utilizes high-speed rotating **flywheels**[1.51] to grip and propel the basketball, effectively transferring both rotational and linear energy to achieve the desired initial velocity. A **dual-servo system**[1.53] allows precise adjustment of the launch angle from different shooting zones.

To maintain shot consistency, the flywheels operate at a controlled speed. The servo-driven angle adjustment mechanism ensures fine-tuned control, providing repeatability and adaptability based on real-time conditions. By assuming a launch angle of 76° when the robot is positioned 6.5 meters away from the hoop, we have determined the required velocity and time of flight for the shot. The calculations are detailed below.

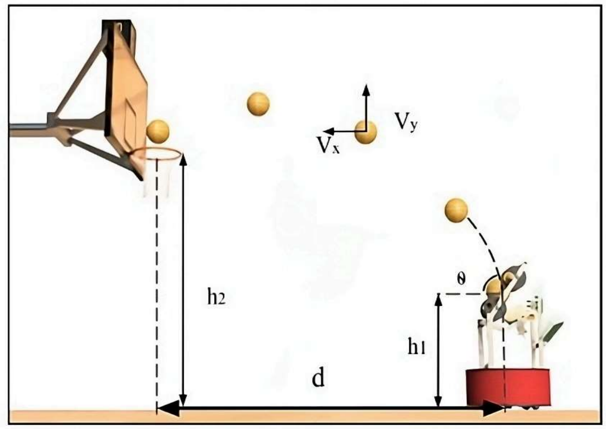
1.5.4 Shooting calculation:

1. The **initial velocity** required for the ball to reach the basket:
   $X=V_x*t$—**1**; $Y=h-V_y*t-1/2(gt^2)$—**2**

   From above eq^n: **$V=\sqrt{gx^2/2(x\tan\theta-h)\cos^2\theta}$**
   $=9.81*6.5^2/2(6.5\tan 76^\circ-1)\cos^2 76^\circ=$ **$11.95 m/sec$**

2. **Time of flight** when the ball follows trajectory,
   $t=x/V\cos\theta=6.5/11.95*0.241=$ **$2.2 sec$**

3. **Angular velocity** of flywheel using linear velocity
   $w=V/r$, $w=11.95/0.101=119.5 rad/sec=$**$1141.41 rpm$**
4. Angular velocity **(gear ratio 1:2):**
   *Motor rpm = 2*flywheel rpm= 2*1141.14*
   =2282.28 rpm



ADDITIONAL NOTE:
As part of our strategic approach, we have deliberately excluded the jumping mechanism to optimize R1's efficiency in long-range shooting. This decision aligns with our objective of maximizing scoring potential while minimizing the risks associated with physical confrontations. Given that the rulebook penalizes physical contact between bots as a foul, R1 is designed to maintain continuous mobility and avoid close-range engagements. Rather than attempting to navigate through defenders, our bot capitalizes on precision-driven long-range shooting, ensuring a safer and more effective scoring strategy.

2. ROBOT 2

2.1 INTRODUCTION:

Robot R2 is dynamically designed to execute basketball dunking maneuvers with precision and agility. It coordinates with a companion robot R1 to **receive**[2.21] a passed basketball and align it with its flywheel-based **shooting mechanism**[2.12]**.** Equipped with a mechanism, can **dribble**[2.13] and elevate to a specified height for shooting. The robot's dimensions are Length*Weight*Height.

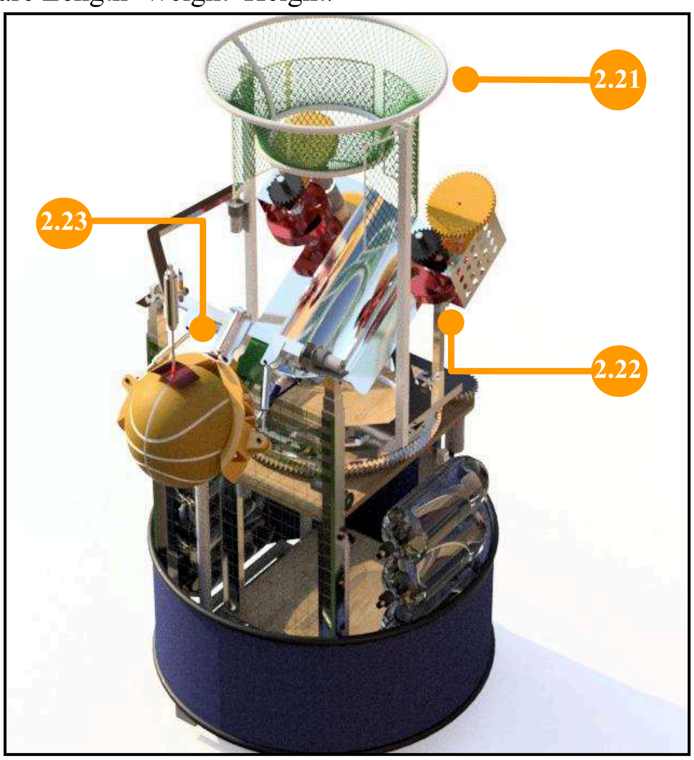
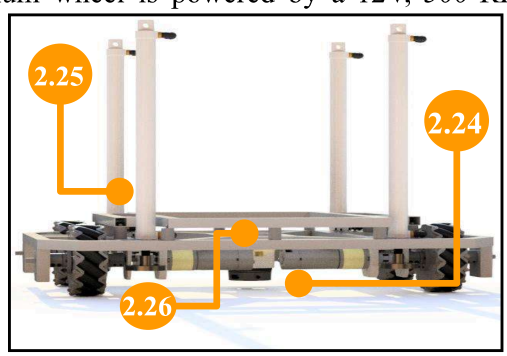


Figure 2.1 Robot 2

2.2 TYPE OF DRIVE AND JUMPING MECHANISM

2.2.1 Chassis Design:

Based on R2's functional requirements, a robust 4-wheel Mecanum drive configuration is used. Which enhances traction, and stability. We used **LIDAR**[2.26] which ensures precise navigation and obstacle detection. The chassis is made of aluminum, and each Mecanum wheel is powered by a 12V, 500 RPM DC motor.



2.2.2 Jumping:

R2 is designed to jump to a height of up to 20 cm using four **pneumatic actuators**[2.25] strategically positioned on the chassis to ensure equal weight distribution. A uniform 4.8 bar pressure is applied to these actuators, enabling a controlled and stable lift of the robot into the air. **Anti-vibration mounts**[2.26] (AVMs) with optimal stiffness are integrated into the chassis to absorb shocks and minimize vibrations for a safe and stable landing. robot's weight of 24 kg, these AVMs effectively dissipate impact forces, ensuring a smooth landing and maintaining overall stability

2.2.3 Calculation:

Jumping: Four pneumatics are used to dunk.
Mass distributed on each pneumatic is 6.25kg.

Pressure = Force/Area

P = ma/A , since F = ma; P = 343.349/706.5 = 0.4859N/mm^2 = 4.8bar

By using the formula, *Ktotal = (2π*5)2*24 = 37.536N/m*

Outward stroke force,

*F = P*A = 4.8*706.5 = 70.62N. Since, A= 706.5mm*

∴ Pressure generated will be a minimum of 5 bar.

AVM:

Fn = 5Hz
M = 24kg

For 8 AVMs:
Keach=Ktotal/8=37.536/8=4.692

∴ Stiffness should be 4.692 for each AVM to achieve a natural frequency of 5Hz for a comfortable landing.

2.3 BALL HANDLING:

Our ball handling coordinates with **LiDAR**[2.24] for precise positioning, ensuring smooth and efficient ball reception for R1. The mechanism guides the ball along a common path, making it easier for other mechanisms to collect and handle, ultimately improving efficiency and reducing travel time.

Once received, the ball rests on an inclined path leading to the **shooting mechanism**[2.12], where a pneumatic system provides the initial push to direct it into the shooter. For dribbling and dunking, the ball stays on an inclined path until a **pneumatic gripper**[2.23] picks it up with a dribbling hand and completes the dunk.

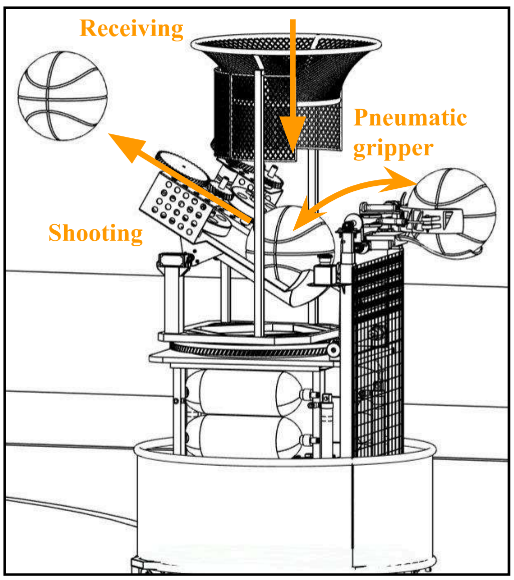


Figure 2.3 Ball Handling

2.4 SHOOTING MECHANISM:

The turntable shooting mechanism, powered by an 85 RPM, 12V DC motor, adjusts shooting angles for precise aiming. Its flywheel system ensures optimal speed, angle, and trajectory, enabling accurate scoring from various positions.

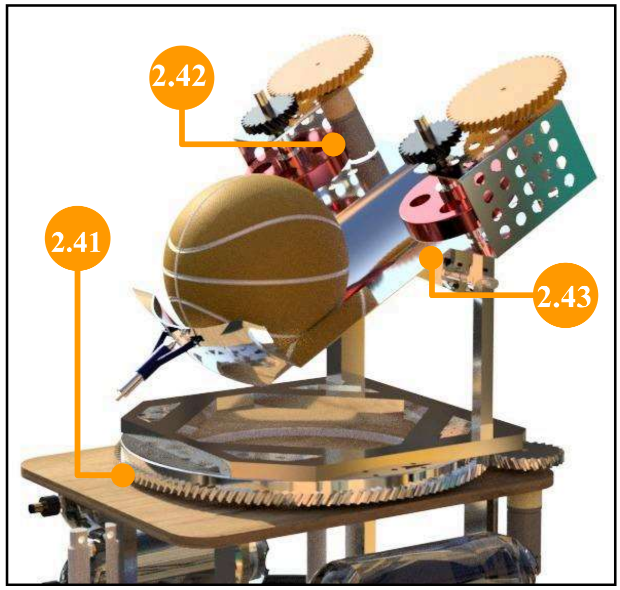


Figure 2.4 Shooting Mechanism

2.4.2 Working:

The **turntable**[2.41] shooting mechanism utilizes a **DC motor**[2.42] to drive the **flywheel system**[2.43], which propels the ball toward the rim. The turntable rotates to adjust the shooting angle. This allows the robot to aim and shoot from any position, optimizing accuracy by following the ideal projectile motion trajectory. Once the shooting angle is set, the motor activates the flywheel, propelling the ball with the correct speed, angle, and trajectory to ensure successful scoring. The mechanism's precise alignment and rotational flexibility enable consistent, accurate shots from various positions on the field.

2.4.3 Calculation:

1. *Initial velocity: X= Vx*t; Y= h-Vy*t-½(gt²),*
2. *using these Eqn:*
   $V=gx^2/2(x\tan\theta-h)\cos2\theta$
   $=9.81*(3.1)2/2(3.1\tan76-1)\cos^2 76$
   $= 8.396$ m/sec
3. *Time, the ball follows trajectory:*
   T=X/Vcosϴ= 3.⅛.396cos(76)= 1.53sec
4. *Angularvelocity:w=V/r, 8.396/0.075 = 111.9rad/sec = 1076.34 RPM.*

Flywheel Material selection calculation:

Radius of wheel :0101m *Height of wheel(h) :0.0304m* *Angular Velocity (ω) :119.5rad/sec*

Density of ABS = 1000 kg/m³

Ultimate tensile strength : $\sigma max = 3/8 \rho \omega^2 r^2 = 0.0546MPa = 5.46*10^4\ Pa$

Yield Strength : $\sigma y = 0.273Mpa = 2.73*10^5\ Pa$

2.5 Dribbling:

2.5.1 Construction:

For dribbling, we have designed a **Telescopic Gripper Mechanism** consisting of two rods with nested rectangular sections that slide to extend or retract to a specified height. A **pneumatically powered gripper**[2.51] is mounted at the end, used for movement of the gripper and dribbling, and it also shoots the ball into the rim during dunking. The gripper rotates about its axis, enabling precise ball orientation and manipulation.

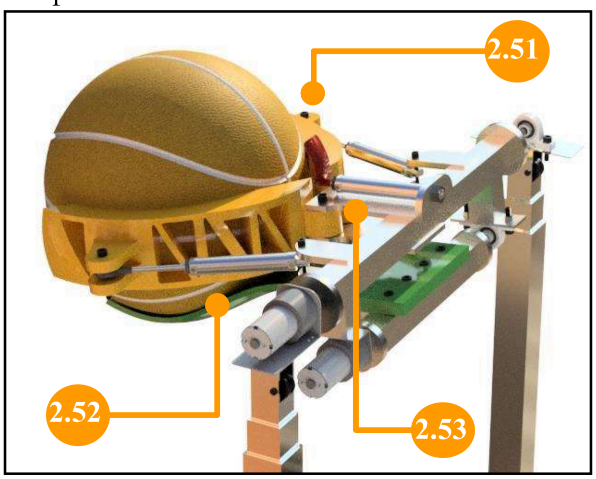


Figure 2.5 Dribbling gripper

2.5.2 Working:

The dribbling mechanism employs a **telescopic design**[2.61] with dual **pneumatic cylinders**[2.52] to facilitate smooth extension and retraction, ensuring precise height adjustment. A **third pneumatic cylinder**[2.53] delivers the necessary force to dribble the ball to a predetermined height effectively. Upon reaching the optimal dunking position, this cylinder propels the ball into the rim with controlled velocity. Additionally, the gripper's rotational capability allows for precise ball alignment and orientation throughout handling and shooting. By integrating telescopic motion, pneumatic actuation, and rotational flexibility, this mechanism enables seamless dribbling, precise ball manipulation, and efficient dunking.

Figure 2.6 Telescopic Mechanism

2.5.3 Calculation: Dribbling

Where the mass of the ball = 0.58kg

Initial Height = 0.8m

Rebound Height = 0.8m

Acceleration due to gravity = 9.8m/sec

1. ***Velocity impact*** *using the principle of conservation of energy [PE = KE]:*

   $Mgh_1 = \frac{1}{2} mv^2$

   $0.58*9.81*0.8 = \frac{1}{2} 0.58*V^2$

   $\boldsymbol{V=3.96\ m/sec}$

2. *Velocity after* ***Rebound(V_2),*** *science the ball rebounds to a height of 0.8m. The velocity just after rebounding can be found using:* $V_2=\sqrt{2gh}=$ ***3.94m/sec***

3. ***Force required during dribbling****:*

   $m(V_{impact}+V_{rebound})/\Delta t$

   $0.58*7.88/0.403 =$ ***11/3N***

4. ***Time to hit the ground(t)****:* $\sqrt{2h/g} = \sqrt{1.6/9.81}$

   =0.403sec*.*