Annual Report

MISSION STATEMENT 2023

PERFORMANCE THROUGH STAGES

- STAGE ONE

98/100 HIghest among all IITs, but concept was not applicable in real scenario due to lack of experience and money

- STAGE TWO

Incomplete implementation, worked out many issues however picking and shooting remained as core issues

- STAGE THREE

Make an optimal shooting using pneumatic, however picking mechanism was not robust and reliable.

2 matches againts LDCoE, unable to attend practise matches as we arrived late.

PROBLEM STATEMENT

(summarise)

The ABU Asia-Pacific Robot Contest 2023, with the theme "Casting Flowers over Angkor Wat," challenges teams to design and operate rabbit and elephant robots that cooperate to toss rings into poles located in the Angkor Wat Area. The contest emphasizes safety, efficient robot performance, strategic cooperation, and adaptability to the venue conditions.

To succeed in the contest, teams should focus on designing and building efficient robots that can accurately pick up and toss rings. Additionally, strategic cooperation between the rabbit and elephant robots plays a crucial role, requiring teams to develop effective communication and coordination mechanisms.

The chief mechanisms we needed here were

- DRIVE
    - We used mecanum on RR and omni wheels on ER.
    - Mecanum wheels kept wearing off
    - Issue with driving both straight, use Gyro or Encoder based PID control, in the actual contest we calibrated all wheels manually, not precise but workable
    - We used commands from the App

- SHOOTING
    - Many mechanisms were tried out for shooting, a 90-degree, 120 degree and straight plane with rotating discs. Issue with grip, we used rubbers. Also learnt from other teams that badminton grips could be used.
    - However, we came up with an alternate, consistent shooting mechanism, we optimized actuators, used thin bore and long stroke cylinders with 75 psi pressure, lubricate with WD40 while ensuring no dust gets inside (install filters on the compressor. With this we were able to achieve shooting distances exceeding 4-5 meters at best.
- PICKING
    - Picking was the most difficult mechanism, At first we designed a pneumatic and servo setup to pick up rings with a claw type arm. Issue was unbalanced load on pneumatic actuator which could cause the rod to bend,

- Next, we installed 2 servos which did not provide sufficient torque
    - Again, we reduced the moment and dimensions and made a smaller functioning picking mechanism, loading would be a little cumbersome. Since, it flipped the stack.
    - Then we tried 2 stepper and screw rods setup to lift the stack, it worked but wasn't reliable we also attached supports to maintain the screw rod straight.
    - Ultimately, the steppers were not optimized well.
- LOADING
- ALIGNMENT (OPTIONAL)

STAGE 3 (NATIONAL FINALS)

SHORTCOMINGS AND REFORMS

OBSERVATIONS FROM OTHER TEAMS

- They had plenty of sponsors
- Hired professional Mentors
- Brought plenty of students to the finals to work on the robots due to better finances
- Had much larger spending on the bots
- IITD Package is mandatory, constant ID Card checks were carried out.

ISSUES	FIXES	COMMENTS
Less budget	Approach more sponsors Update Sponsorship Brochure	
Screw Thread Mechanism unreliable	Prefer using V Roll+Extrusions+ Timing belt setup instead	Requires less rotations Also can be replaced with string mechanism

ESP 32 needed extra setup for servo and steppers, etc	Prefer MEGA+ESP32 setup, Mega for interfacing	
Issue with permissions while transporting bot	Get 2 permission letters from HOD, one for the Robot and other for the team	Confusion and extra procedures cost us time and risked our participation in the finals.
Only 6 members working on the bots in finals, not sufficient workforce	Arrange Logistics/finances to carry more members to the national finals	
Lack of mentor/professor with experience in Mechatronics	Approach professor of Mechatronics, Atul Sir for Guidance on various mechanisms	
Steppers were unreliable	Nema 17 did not provide sufficient Torque, Use of micro steppers were recommended by other teams	
Low Torque Output from Steppers	Learnt that Geared motors have higher torque output however they have less standing torque	
Wires often smoked up and produced too much heat	Using the header wires provides too much resistance, use single or multiple thick stranded copper wires	
Red connectors could be reverse connected resulting in negative polarity	Prefer batteries and connectors of yellow type	
Couldn't find grip in initial shooting mechanisms	Use Anti-Slip Badminton Grips	
ER steppers faced reliability issues	Prefer Micro step and Nema 23	Nema 17, not preferred for high torque applications
Appropriate Spares were not packed	Ensure that spares are packed, including extra microcontrollers, power banks and Extension Cords	

Mecanum Tyre rubber fell apart Lipo Batteries lasted short and swelled up	Purchase replacement rollers, prefer omni first, do not use mecanum on rough surfaces Always use balance mode for charging and use with bettery testers	
Arrived Late for Sessions	All 4 days are crucial, make sure to attend all days	
1. Distribution of work 2. Money	In the past, work distribution seemed to be completely random, with whoever happened to be present in the lab being assigned small tasks. Over time, it has become more organized, but I believe there is still room for improvement. For instance, if we have 2-3 projects to work on simultaneously, we could benefit from outlining and assigning specific responsibilities to each team member. While it may not be a major problem, I believe there is an opportunity to enhance our approach. I suggest designating one or two individuals to oversee sponsorship and related matters. This focused responsibility could streamline the process and yield better results.	
3. Knowing more about project	To enhance the understanding of the project among both new and existing members, we can plan more frequent short meetups or group chats. These sessions will serve as opportunities to provide comprehensive explanations about the project's objectives and what we are currently developing. Additionally, conducting weekly progress meetings where we discuss the challenges we encounter will foster better communication and collaboration within the team.	
People operating components with less knowledge and blowing them off	One need to have complete understanding of what he is dealing with. while one is learning about any component they can document what resources they have used and how did that helped them with resources links. this helps in handbook.	

Having basic material to build anything at hand all the time	Need to get more sponsors asap. buy them all. Helps in fast prototyping. Waiting for part to come after the whole plan is ready is a waste of time.	
Batteries swelling	Having knowledge about usage, safety (swelling), and everyone needs to know everything about batteries.	
Having basic material to build anything at hand all the time	Need to get more sponsors asap. buy them all. Helps in fast prototyping. Waiting for part to come after the whole plan is ready is a waste of time.	Sabertooth Drivers do not have circuit protection
Batteries swelling	Having knowledge about usage, safety (swelling), and everyone needs to know everything about batteries.	

OVERVIEW

IIT Patna's Robocon team achieved this remarkable feat without the presence of a mentor or a substantial budget, distinguishing themselves from other teams. Despite the challenges posed by limited resources and lack of prior experience, their dedication, resourcefulness, and sheer determination propelled them to success. Their accomplishment demonstrates the team's exceptional skills, problem-solving abilities, and the spirit of innovation that thrives within IIT Patna. It is a testament to their unwavering commitment and passion for robotics, solidifying their position as an upcoming formidable force in the competition.

Previous report
https://docs.google.com/document/d/1ZQRrYOxOX1bCGXVqAqn76Lcfwh5efLXFnQxX9QpM0p8/edit

ABU ROBOCON 2023

Design Details Document

Casting Flowers Over Angkor Wat

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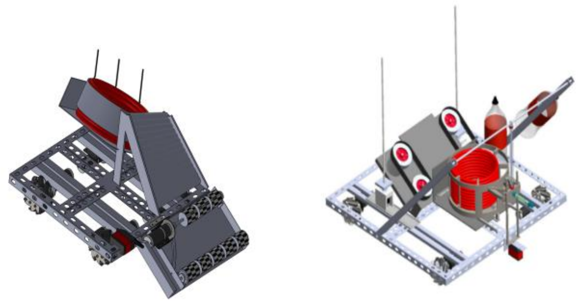
I. INTRODUCTION

For this year's ABU Robocon Problem statement, we have to build two robots: Rabbit Robot (RR) and Elephant Robot (ER). The primary aim of both robots is to throw the rings into the poles. RR and ER can accomplish the task by mutual coordination. The report contains detailed design of RR and ER, description of various mechanisms used in these robots, along with proper CAD models, and calculations for those mechanisms to achieve this task.



Rabbit Robot Elephant Robot

Fig. 1

PID CONTROL OF MOTORS

PID stands for Proportional Integral Derivative. We are using PID control for precise position and speed control of our drive. This allows for automation of navigation procedures. The controller adjusts motor power based on current error, accumulated error, and rate of change of error using proportional, integral, and derivative of the error data read by the encoder or other sensors.

In order to implement PID, Arduino UNO, MEGA have insufficient Interrupt pins. Therefore, we decided to use NodeMCU ESP32.

II. COMPONENTS USED

SN	COMPONENTS	SPECIFICATIONS	MECHANISM	REFERENCE/ REASON
1	Planetary DC Geared motor	24V 468 RPM Stall Torque : 72.6 N-c	RR & ER drive mechanism	Simulation
2	Cytron Motor Driver MDD10A*	5V-25V Voltage range 10A current rating	for use with component 1	To control the 12/24V motors.
3	Pneumatic Cylinder (2)	Stroke length: 20cm & 3cm Bore diameter: 16mm	Throwing mechanisms	Speed and Power
4	Rotary Encoder	400 Transitions per rotation	RR & ER drive mechanism	More accurate bot movement
5	Stepper Motor	4.8Kg-cm Holding Torque	Angle control in throwing mechanism	precision
6	Arduino AtMega 2560 Rev3	AtMega2560 Rev3	RR & ER processing	More no. of I/O pins
7	Nodemcu ESP32	Dual core, 32 bit, 30 pin	Communi cation with ER and RR	Less latency, comms, more range, accuracy.
8	Ultra torque Quarter Scale Metal gear Servo motor	6-8.4V Stall Torque: 58-70kg.cm	Picking & ring loading mechanism	High torque to support the weight of the arms
9	LiPo batteries	12 V (3s, 30c) 8000mah	Powering the components	High power density
10	MY6812B motor	3000 rpm 120w stall Torque : 35N-cm	Shooting rings	——

III. STRATEGY

After completely analyzing the rule book of ABU ROBOCON ’23, we came up with this strategy:

1. The RR and ER will both start from the start zone.

The RR will follow its setup path towards the bridge (wedge), climb into the Angkor middle level area.

2. The RR will not climb the Angkor center area as it can cover the type 3 poles with its shooting range.

The RR will approach the ring zone and pick up the sets of rings using rollers.

3. The RR will now position itself in the Angkor medium level area and target the type 2 and type 3 poles.
4. The ER will start its game by going to one corner to pick up the rings(10) by its stack mechanism.
5. Then ER will move towards the next corner but on its way it will position itself at right positions, to shoot rings at the type 1 poles on our side.
6. The RR will recycle the rings thrown by the ER which miss the poles.
7. Then ER will go to the other corner picking up the second stack of 10 rings, then it will go to the edge of the blue zone to position itself for targeting the type 1 and type 2 poles of the opponent.

IV. DRIVE MECHANISM OF RR AND ER

Type of Drive:
Four Wheel Rectangular Mecanum Drive

Overview of the Drive:

These robots will have a parallel 4-wheel mecanum drive within 1m x 1m in size. The frame is made of perforated iron bars and the chassis of the drive is made of aluminum rods for flexibility. The drive uses 10cm diameter mecanum wheels controlled by 12V motors for movement in any direction.

The 4600 RPM will be decreased down to a few hundred RPM using mounted gears on the motor.

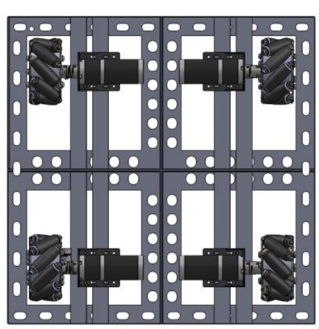


Fig. 2.1: Mecanum Drive

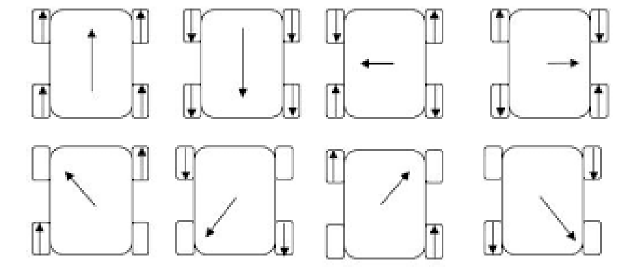


Fig 2.2: Motion of Drive

The above picture illustrates the movement of the drive depending on the rotation of the wheel. The arrows parallel to the wheel show wheel rotation whereas the inner arrows show the direction of movement of Robot. We are using a mecanum drive with an X configuration (rollers on wheels point towards center when seen from top) for better control.

V. ANGLE CHANGING MECHANISM OF SHOOTING PLATFORM FOR ER AND RR

To change the angle of the shooting platform of both robots we are using stepper motors and threaded rods.

It will work similarly as a CD tray or 3D printer.

NOTE: We are using one stepper motor for RR because we are using one BLDC motor for throwing on one side of the shooting platform, therefore lighter. We are using two stepper

motors at the both sides of the shooting platform in ER because we are using two BLDC motors for throwing and the motors are at both ends of the platform, which is heavier.

VI. THROWING MECHANISM OF ER AND RR

RR:

It will use a belt drive mechanism with a rectangular platform made of rolling beads material (abacus) for minimum friction with rings. One conveyor belt made of rubber material to maximize friction with rings, is placed on the side of the platform. The belt is powered by high-speed BLDC motors and are controlled using encoders, a PID controller, and a servo. The rings will be loaded onto the platform using a servo and a wooden block with a semicircular cut. A rectangular plate ensures only one ring is on the platform at a time and accelerates the rings. The launch angle is controlled by a stepper motor.

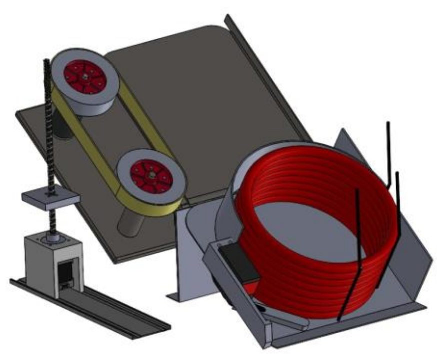


Fig. 3: Throwing Mechanism of RR

Note : We are using only one belt and slightly lower rpm for RR, because it can move anywhere and needs lesser range than ER

Calculations :

a. Shooting wheel dimension

Radius: 5cm

Breadth of shooting platform: Slightly less than outer diameter of rings

Launching Height Platform: 10cm above ground

b. Landing Phase Projection

Length of projection of Ring's diameter over pole , taking projection angle as 60° by default :

1. *Horizontal projection = 21cos 60° =10.5 cm* (VI.1)
2. *Vertical projection = 21sin 60° = 18.18 cm* (VI.2)

C. Projectile Calculations

MY6812B motors for shooting projectiles

The tip velocity of a 5 cm radius wheel attached to the my6812B motor that operates at 12V and has a loaded RPM of 2600, we can use the following formula:

*Velocity=(2π*radius*rpm)/60* (VI.3)

Velocity = 13.61 m/s

Therefore, the tip velocity of a 5 cm radius wheel attached to the my6812B motor that operates at 12V and has a loaded RPM of 2600 is approximately 13.61 m/s.

Refer Fig 3. for CAD Model

Extreme cases of ring projectile :-

Case (I):-Targeting maximum height

Since the height of type 3 pole is maximum i.e. 1.5 meter and height of the Angkor center from the ground level is 0.4m. Therefore Hmax = 1.5+0.4 = 1.9 m

Also the maximum angle of projection is 60˙

Therefore,

$$H_{max} = \frac{u^2 \sin^2\theta}{2g} \quad \text{(VI.4)}$$

$\Rightarrow$ $1.9 = \quad + 0.4$ (VI.5)

$\Rightarrow$ $u = 6.2$ m/s

Here u is the initial speed of projection.

Case (II):- Targeting maximum range required

Similarly, for maximum range cases we are considering the case when ER will target the Type-1 corner pole of the opponent area. Using the equation of trajectory of the projectile, taking y coordinate (height of the pole from the ER platform) as 0.9 meters and

taking x coordinate =

$$(2.15)2 + (3.4)2 \quad \text{(VI.6)}$$

$$= 4.02 \text{ m}$$

We get,

$$0.9 = 4.02 \tan(60°) - g(4.02)2/2u2\cos2(60°) \quad \text{(VI.7)}$$

$\Rightarrow$ $u=7.23$ m/sec

Maximum Range

$= u^2 \sin2\theta g + u\cos 2(\text{height of ER above the ground})g$ (VI.8) $= 7.23^2 \sin(260)9.81 + 7.23\cos(60)(2\ 0.1)9.81$

= 5.13 m

***Note** : Here we took an error margin of 15-18% in height in order to account for momentum loss.*

Conclusion : From calculations, we know that to implement our strategy and achieve required range and height we need a maximum velocity of 7.23m/s.

ER:

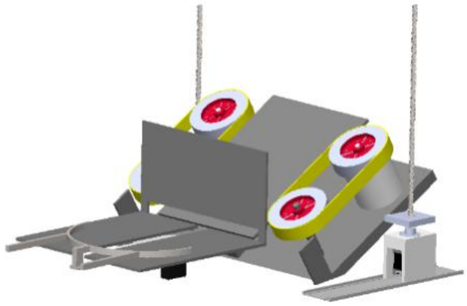


Fig 4: Throwing Mechanism of ER

Ring throwing mechanism for ER is almost the same as that for RR. The only difference is the Launching height. BLDC motors used in ER will have higher RPM than RR to throw the rings at longer distances and two belts instead of one in RR.

Calculations :

a) *For a rotating wheel of radius r and rpm of x, the tip velocity of the wheel (90% of speed of tip velocity).*

r(radius of wheel)=5cm

Angular velocity of rotating wheel ()

= 2x/60 *(VI.9)*

Where x is RPM

*Tip velocity of the wheel (u) = r**

*= 2x*r/60* *(VI.10)*

Assuming that 90% of the tip velocity is imparted to the ring, u=0.9V

Here, u = 90V100 *(VI.11)*

If we want u=6.2m/s(From previous calculations), tip velocity must be 6.889m/s.
Therefore,

$$6.889 = 2\pi x 60 * r \qquad (VI.12)$$

*6.889 = 0.00523*x*

x = 1317

RPM = 1317 revolutions/second (For 6.2m/s)

b) *Weight of the rings=0.11kg*

u=0m/s, v=7.23m/s

Distance of the belt in contact with ring while

throwing = 0.19488m

*Velocity of the belt = (10/9)*7.23=8.033m/s* *(VI.13)*

Change in momentum of the ring

= (mass)(v–u)* *(VI.14)*

= (0.11kg)(7.23m/s-0m/s)*

Force on ring = (Change in momentum)/ Time

(VI.15)

Contact time of the ring with belt=(0.19488/8.033)s

Force of rings = 0.7953/(contact time of the ring) = 32.7824N *(VI.16)*

Torque = 32.7824 x *(5* x *10-2) N-m =1.64N-m* *(VI.17)*

NOTE: We will take slightly different RPM for the two motors to apply gyroscopic precision and to maintain the axis of rotation. Ring will obtain 90% the belt velocity.

VII. DESIGN OF RR

Four Wheel Rectangular Mecanum Drive

Overview of the Drive:

This robot will have a parallel 4-wheel mecanum drive that is less than 1m x 1m in size. The frame is made of perforated iron bars and the chassis of the drive is made of aluminum rods for flexibility. The drive uses 10cm diameter mecanum wheels controlled by 12V motors for movement in any direction.

The 4600 RPM will be decreased down to a few hundred RPM using mounted gears on the motor.

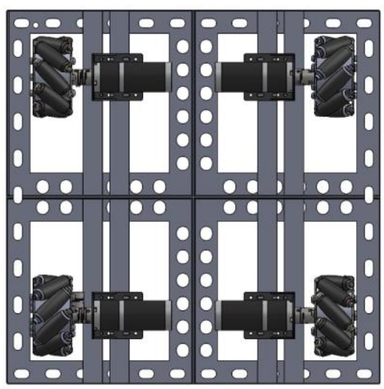


Fig. 3.1: Mecanum Drive

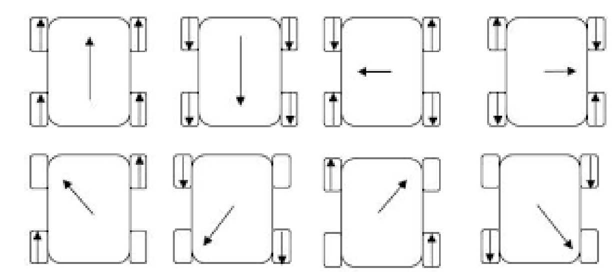


Fig 3.2: Motion of Drive

The above picture illustrates the movement of the drive depending on the rotation of the wheel. The arrows parallel to the wheel show wheel rotation whereas the inner arrows show the direction of movement of Robot. We are using a mecanum drive with an X configuration (rollers on wheels point towards center when seen from top) for better control.

Fig. 5: RR

A. Overview of RR :-

The RR, Fig. 2, has a mecanum 4-wheel drive in parallel configuration. Its purpose is to recycle rings thrown by the ER. The frame is made up of perforated iron bars for strength and aluminum rods for flexibility. The drive uses 10cm diameter mecanum wheels powered by 12V batteries, connected to 8mm shafts, clamps, pillow bearing, and couplers for efficient movement. PID control is used for precise speed and distance control.

Note : The robot will have a foldable flap to accommodate a picking mechanism while obeying the dimension regulations

. *Picking Rings*

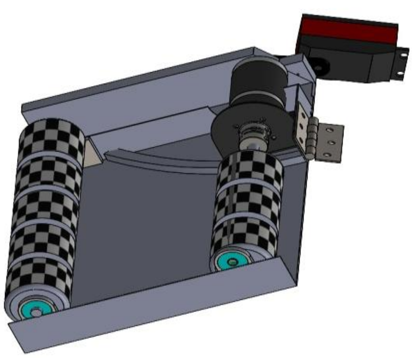


Fig. 6: Ring picking by RR

The mechanism will work in 3 steps which are:

1. Picking up the ring from the ground with the help of flaps attached to a roller.

2. Loading and stacking up of rings.
3. Passing the stacked rings one by one to the ring throwing platform.

Calculation:
For RPM for motor attached to roller:
Average height of COM of ring from the top of the roller to the top of the ramp: **19.5 cm**

The speed imparted by roller to the ring:

$$v = r \qquad \text{(VII.1)}$$

r *(radius of roller)=2.35cm*

Potential energy gained by the ring to fall in stack is equal to the kinetic energy acquired by the ring

Note: a margin of 30% is taken for frictional losses for experimental analysis.

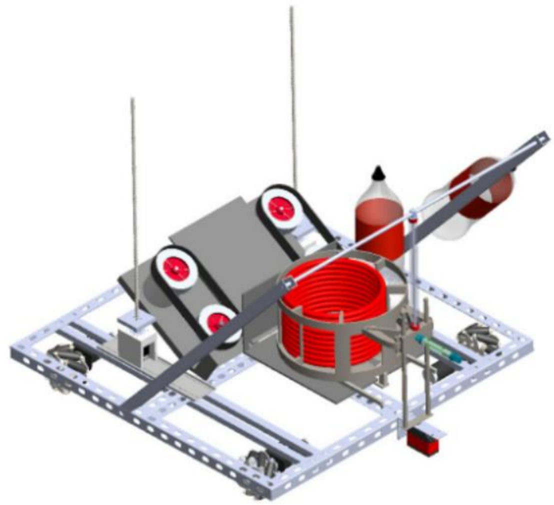
$$(mgh) \times 1.3 = 0.5m \qquad \text{(VII.2)}$$

$$=(2gh*1.3)/r2=94.85rad/s \qquad \text{(VII.3)}$$

$$RPM\ to\ be\ provided\ by\ motor = *60/2$$

$$=905.78 \qquad \text{(VII.4)}$$

Note: There will be a flat belt which connects the two rollers, transferring the rotatory motion from the roller with the motor to the other roller.



VIII. DESIGN OF ER

Fig. 7.1: Front View

A. Overview of ER:-

Similar to RR, but 2 steppers for alignment and 2 shooting belts. It also has 2 pneumatic actuators one for picking stack, second for grabbing.

B. Mechanism of Mecanum Drive:-

Same as RR, refer fig 3.2

C. Picking and Passing Mechanism

i. Picking rings

Following our strategy, we designed a ground-ring picking mechanism for RR whereas a stack-ring picking mechanism for ER which can pick up the stack of the rings at once

For implementing the picking mechanism, we have used pneumatic actuators powered using highly pressurized bottles. ER will grab the stack of rings altogether using the semi-circular claws. Rings will then be lifted using a pulley mechanism as shown in Fig 7.3. Servo motor is used after that to place the stack of rings in its launching position at the launching platform.

Later the actuator placed in the launching platform pushes rings one by one to the throwing conveyor from where shooting will be performed.

This mechanism can also be used to pick up fallen single rings. And can stack them one by one, by dropping the previous ring over the next one and then can be loaded to the loading platform.

Calculations:

a. *Pressure to open/close elephant claws*

Pressure in actuator $= Force / A_p$ (VIII.1)

$Force = 4N, A_p = 100mm^2$

Pressure difference in actuator $= 4N / 100mm^2 = 40\ kPa.$

Hence, inside pressure will be 1.4 atm

To calculate the pressure needed in a 2.25 litre bottle to achieve a certain pressure in the actuator, we can use the following work done equation:

$P_{bottle} * V_{bottle} = P_{act} * ((A_p * l) + V_{bottle})$ (VIII.2)

$P_{bottle} * 2.25\ L = 1.4\ atm * ((100\ mm^2 * 30mm) + 2.25\ L)$

$P_{bottle} = 1.401\ atm$ or $20.589\ psi$

Note: *The rings may tend to fall out, it may make an angle with vertical.*

*Therefore the force exerted to fall is 1.1kg sin 10° *9.8 which is less than 4N.*

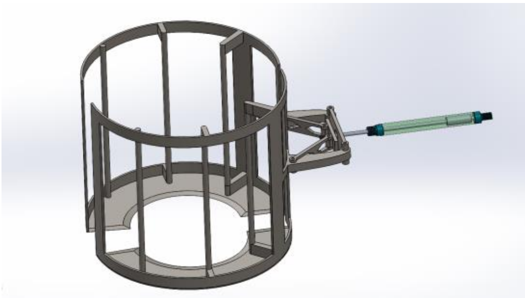


Fig. 7.2: Picking Mechanism (Close up view)

Fig 7.3: Pulley Mechanism of Claw

Calculations:

Same points as that for RR

ii. Passing Rings

Note: *Since we have designed both robots to be capable of shooting, and RR will recycle rings thrown by ER, there is no need for a separate passing mechanism.*

IX. Communication System : *NODEMCU ESP32*

ESP32 was the optimal choice, because it has 32 Interrupt pins that are needed for PID Control, also it has reliable wireless communications.

Both ER and RR will be controlled wirelessly using WiFi. The team will be using the Nodemcu ESP32 module for wireless communication.

To control the robots with precision, the team has developed a custom-made app for the competition.. This app provides more flexibility and control over the robots than handheld PS2 controllers. The app will also allow the team to monitor and control various parameters of the robots in real-time.

X. CONCLUSION

Our robots for ABU Robocon 2023 have a semicircular claw mechanism for picking and stacking rings, a high-speed conveyor system for launching rings, and use Mecanum wheels, ESP32 NodeMCU, SR-04 ultrasonic sensor, and LiPo batteries,PID for precise control. They are controlled wirelessly with a custom app. The calculations and results achieved are in accordance with the dimensions and limitations specified in the rule book of ABU Robocon 2023.

https://docs.google.com/document/d/1ZQRrYOxOX1bCGXVqAqn76Lcfwh5efLXFnQxX9QpM0p8/edit