A PROJECT REPORT ON REFORESTOR

DRISHTI
A Revolutionary Concept

TEAM MEMBERS

Yash Faldu
Uttkarsh Sachan
Mukul Sharma
Shashwat Pandya
Aayushi Nahar
Somoeita Sardar
Shivansh Mishra
Dharmik Raval
Shrangarika Gupta
Dharmik Parmar
Rutvik Master
Mihir Chanpura

ACKNOWLEDGEMENT

We take this opportunity to thank our college SVNIT to let us work on such an interesting project. We would also like to thank the other members of DRISHTI who were constantly helping us during the making of this project.

ABSTRACT

The objective of this project is to design and prototype a ***TREE PLANTING ROBOT*** that can traverse around an area of forest, dig soil, plant a tree, cover it with soil again and repeat the procedure by the auto-load mechanism. Deforestation is emerging as a threat to this planet. Doing tree plantation on macro-scale manually is a quite tedious and difficult job, so using a remotely operated robot to plant trees can help us. This project is such an attempt for a change from 'Deforestation to Reforestation'.

AIM

The aim is to design, manufacture and simulate a tree plantation robot. The robot will be capable of performing the entire tree plantation procedure, which was done manually before.

MOTIVATION

Humans are trying their best to reach out far in space and find a planet suitable for habitation. The first step towards this may be considered that the planet should have breathable oxygen which can further be increased by planting trees. Thus this project is an attempt to achieve the same. The main aim of this project is to bring change in increasing deforestation and plant more trees in a lesser amount of time and at places which are out of human reach.

1.PRE-PROJECT RESEARCH:

We read about the following topics:

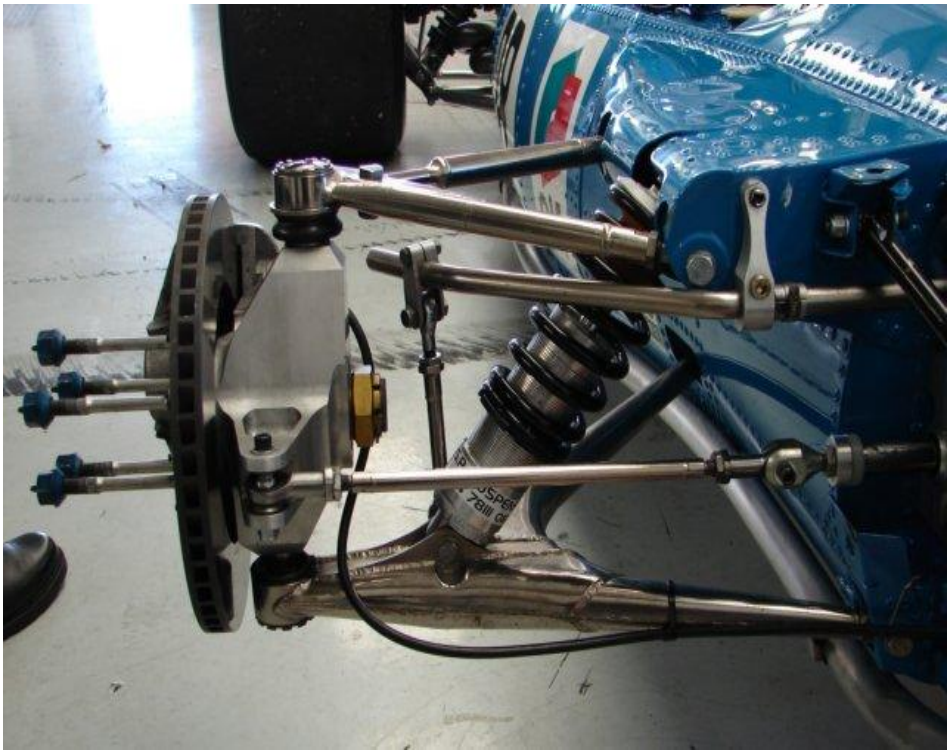
- Types of actuation and their application
- Suspension system
- Types of wheels and drivetrains
- Linear actuators
- Pneumatics

1.1 SUSPENSION

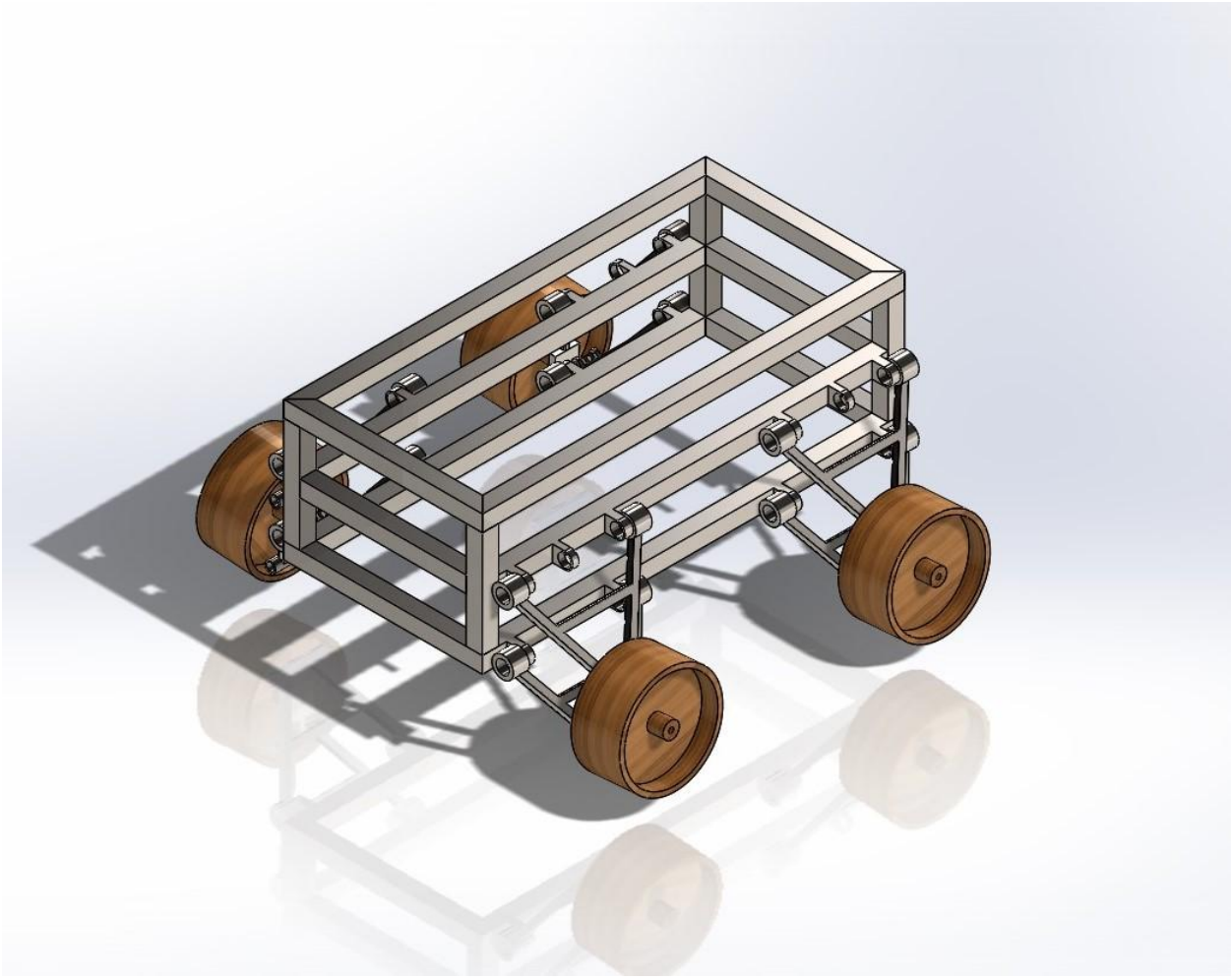
- **Double wishbone:**

It has two "A" shaped links (lower link and upper link) horizontally connected to each other by a vertical link and this assembly is connected to the chassis by a knuckle.

- This suspension system is difficult to manufacture and is quite heavy.
- This type of suspension is costly to manufacture.



This is the following image of CAD model :



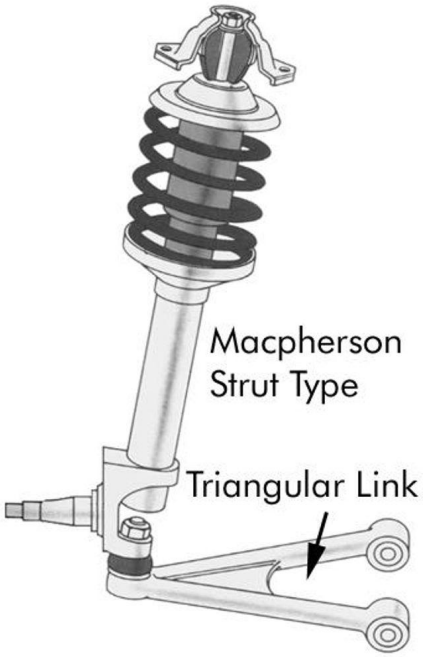
This is the link to Motion Analysis video.

https://drive.google.com/open?id=1Wm6iJ_YgcbWUhwxkJ1sZuXcMFSVzATwh

- **MacPherson strut :**

  - It has an upper arm and a lower control arm. The upper arm has coil spring and shock absorber. Lower arm provides both lateral and longitudinal location of the wheel.

  - It is a complex suspension system and very difficult to manufacture.

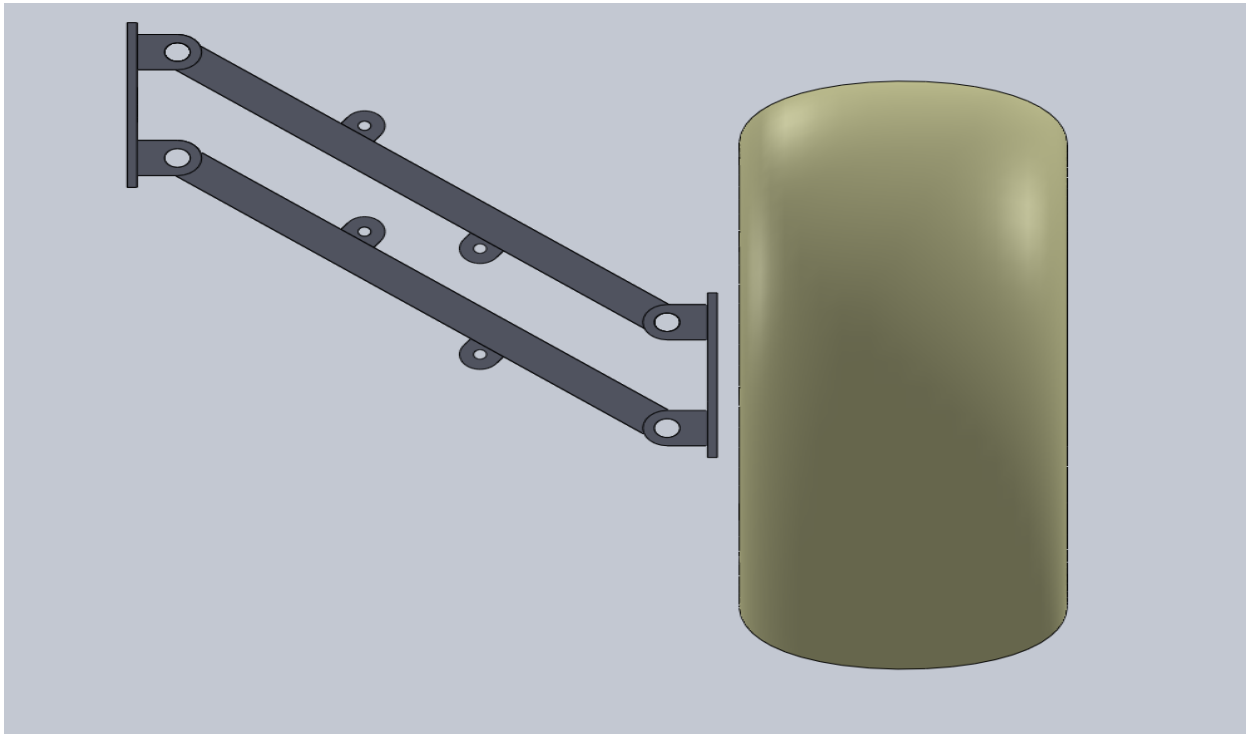


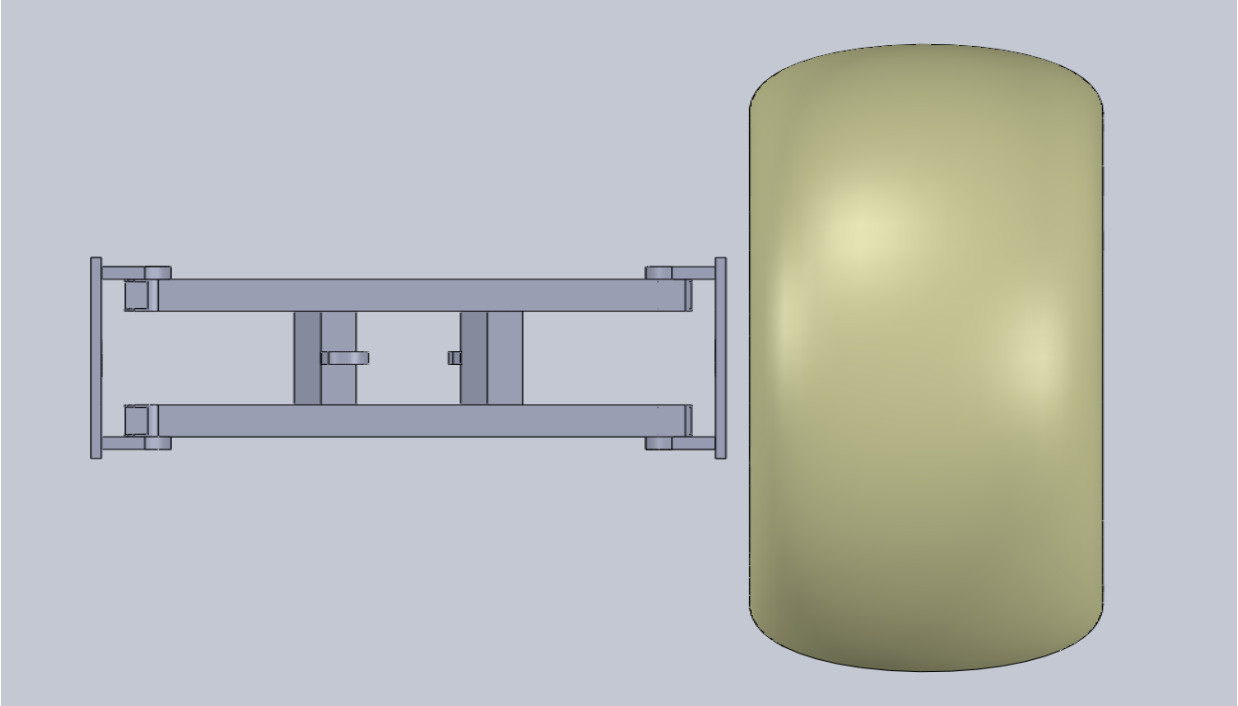
Four Bar Suspension

The four-bar suspension is basically a four-link mechanism forms a parallelogram in which two links always remain vertical and other two links always remain parallel. Springs are attached between the parallel links i.e. either tensile spring or compressive spring (both type of springs arranged in different arrangements). When any object comes in between the wheels and ground then the links moves and the springs stretch or compress according to tensile springs or compressive springs respectively.

In this design we have used compressive springs arranged parallelly. When any object comes in between the ground and the wheels then links moves upward and spring compresses. When wheels move forward, springs regain their shape and links come at their initial position.

These are the images of the cad model :





Result:

- The suspension system is quite good and give a stable motion to the chassis.

Cad design link:
https://drive.google.com/drive/mobile/folders/1fkevA_jlzBScv0ytvr4A-fT13NGkOVJz?usp=drive_open

https://drive.google.com/drive/mobile/folders/1BrelfDzawecggfVACoLpQ7c9CiXH1hUx?usp=drive_open

Testing video link :

https://drive.google.com/file/d/1Juhy6uuHnJBIBkjcYMOVqvgy2dRdC4ik/view

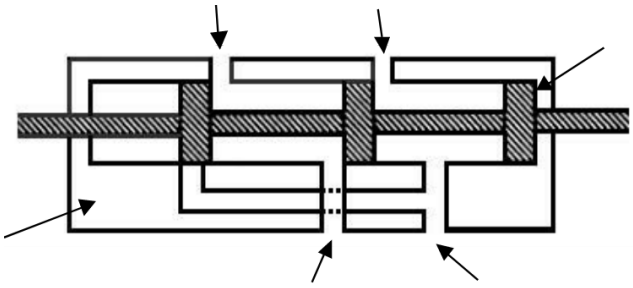
Crawler suspension

The crawler suspension is provided with directional wheels which can be turned at any angle as per the requirement. Each wheel is mounted on aluminium brackets (a horizontal and a vertical one). Two adjacent horizontal brackets are joined together with the other two horizontal brackets using flanged shafts. And it is connected with the chassis with the flanged shaft. The motion of the chassis is stabilize using the dampers along with compression spring.
CAD model
https://drive.google.com/folderview?id=1fkevA_jlzBScv0ytvr4A-fT13NGkOVJz

PNEUMATIC

There are different types of valves used in pneumatic circuits to control the flow of working fluid and ultimately to get the desired motion of the piston in the cylinder.

Valves are distinguished based on a number of ports they have and possible numbers of a position of the spool.



Valve body: valve body is an airtight cylinder with spool and ports in it. As shown in the figure, it has grooves to pass shaft of the spool and has ports at a particular position to allow the fluid to pass.

Spool: it is the moving part of a valve which decides the flow of working fluid.it has a shaft passing through the body. Discs are attached to this shaft at positions to isolate chamber between them from each other.

Ports: holes provided in the body of the valve to allow the fluid to pass are known as port. Pipes are connected to it using connectors.

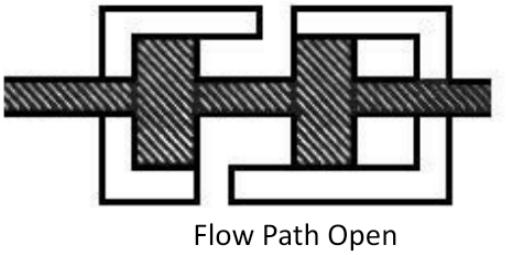
There are many types of valves used in pneumatic circuits:

1) two ports two-way valve (2/2 valve)
2) three ports two-way valve (3/2valve)
3) five ports two-way valve (5/2 valve)
4) five ports three-way valve (5/3 valves)
5) four ports two way valve (4/2 valve)

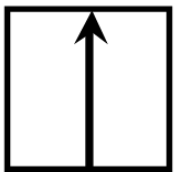
(1) 2/2 valve

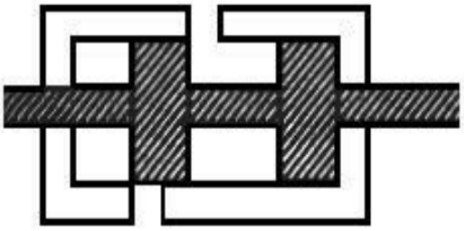
This type of valve has two ports and two possible positions of the spool. the circuit diagram of this type of valve is shown below. Ports are

1) Supply
2) Passage **A**



Flow Path Open





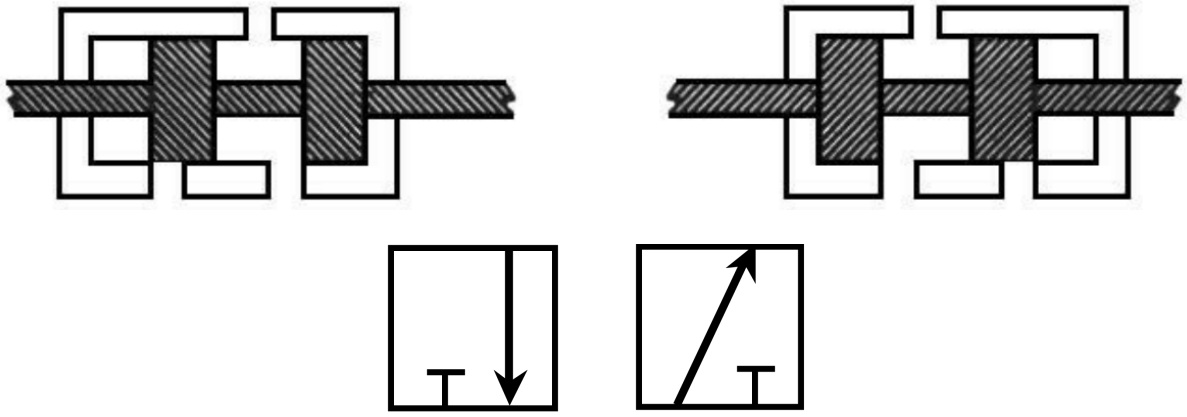
Flow Path Closed

When the spool is in first position two ports are connected and so the fluid can pass through it and the valve is open.
In the second position, ports are not connected, and the valve is off.
This type of valve is generally used to connect pressurised gas supply or storage with a circuit of the pneumatic cylinder.

(2) Three by two-valve

This valve has three ports and two possible positions of the spool.
Ports are:

1) Supply
2) Passage
3) Exhaust

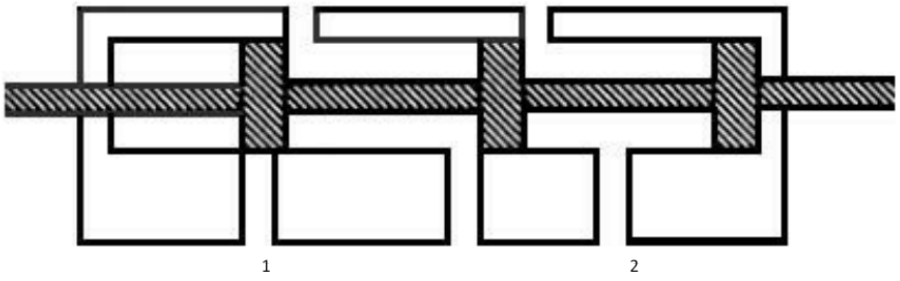


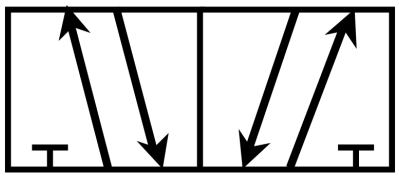
As shown in fig. in the first position of the spool, passage is connected to supply and pressurized air is going to passage from supply.
In the second position, the passage is connected to the exhaust port so the air from the circuit gets flushed out in the exhaust.
This type of valve is used in the single-acting type of pneumatic cylinder.

(3) five by two-valve

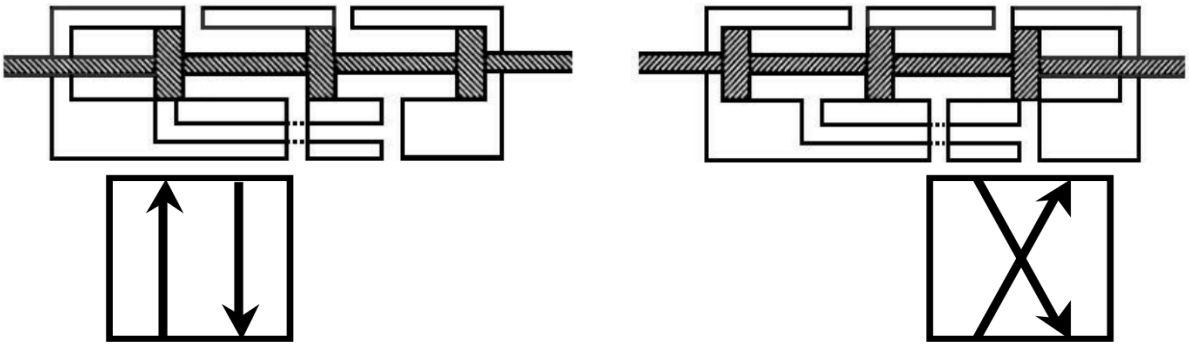
This valve has five ports and two possible positions of the spool. five ports are:

1) Passage **A**
2) Passage **B**
3) Exhaust **1**
4) Exhaust **2**
5) Supply





In the first position of the spool, supply is connected with the passage A and exhaust 2 is connected to passage B.



In the second position of the spool, supply is connected to passage B and exhaust 1 is connected to passage A.
This type of valve is used in the double-acting type of pneumatic systems.

(4) four by two-valve
This valve has four ports and two possible positions of the spool. ports are

1) Supply
2) Exhaust
3) Passage **A**
4) Passage **B**

In the first position of the spool, supply is connected to passage A and passage B is connected to exhaust.
In the second position of the spool, passage B is connected to supply and passage A is connected to exhaust.

Working of four by two valve is similar to the 5/2 valve, the difference is instead of having two different exhaust 4/2 valve has only one common exhaust which is internally opened at two different places.

Linear Actuator

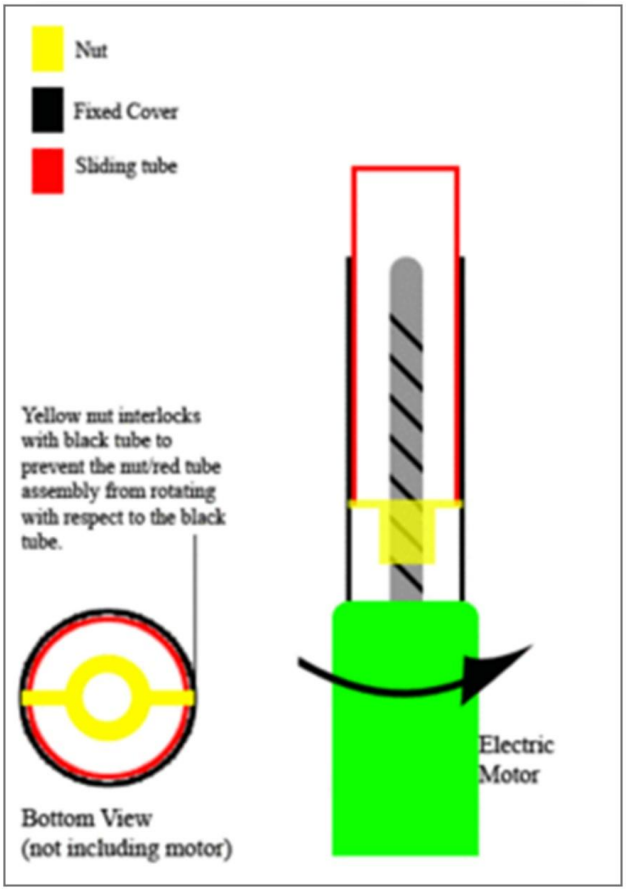
A linear actuator is a device which creates motion in a straight line. They are used in machine tools and industrial machinery and in many other things.
Various type of linear actuators is used such as pneumatic, hydraulic, electric linear actuators etc.

Electric linear actuator advantages

Electric linear actuators are widely used in various applications due to the following advantages:-
1) Able to handle complex motion profile – Electric linear actuators provide precise control of speed, acceleration, deceleration and force. They offer accuracy, infinite positioning capabilities with data feedback and are able to handle complex motion profiles.
2) Able to adapt to changing needs – An electric actuator's programming can be changed. If parameters change the actuator can be adjusted to meet new requirements.
3) Lower lifetime cost with higher efficiency – Electrically powered systems operate at 70-80% total power efficiency.

Working

Basically, In linear actuator, an electric motor is mechanically connected to rotate a lead screw. The electric motor drives a screw, which can either be an acme screw or a ball screw, depending on the application. A nut within a nut housing, which is connected to the thrust tube, travels over the screw in both directions depending on the rotational direction of the motor. Since the nut housing is blocked from rotation, it moves automatically in an axial direction once the drive motor is activated.



Specifications :

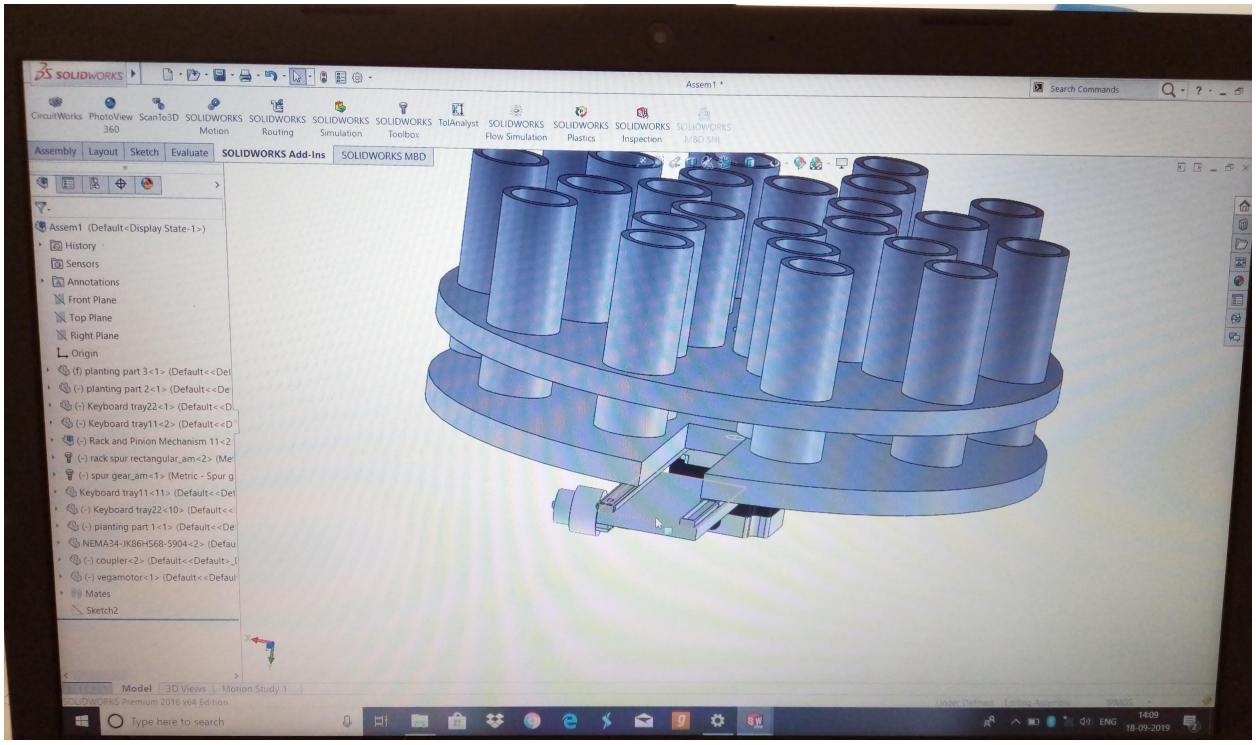
- Stroke length: 100 mm
- Input voltage: 24v DC
- Speed: 8 mm/s
- Max load: 3000 N
- Duty cycle: Max 10%

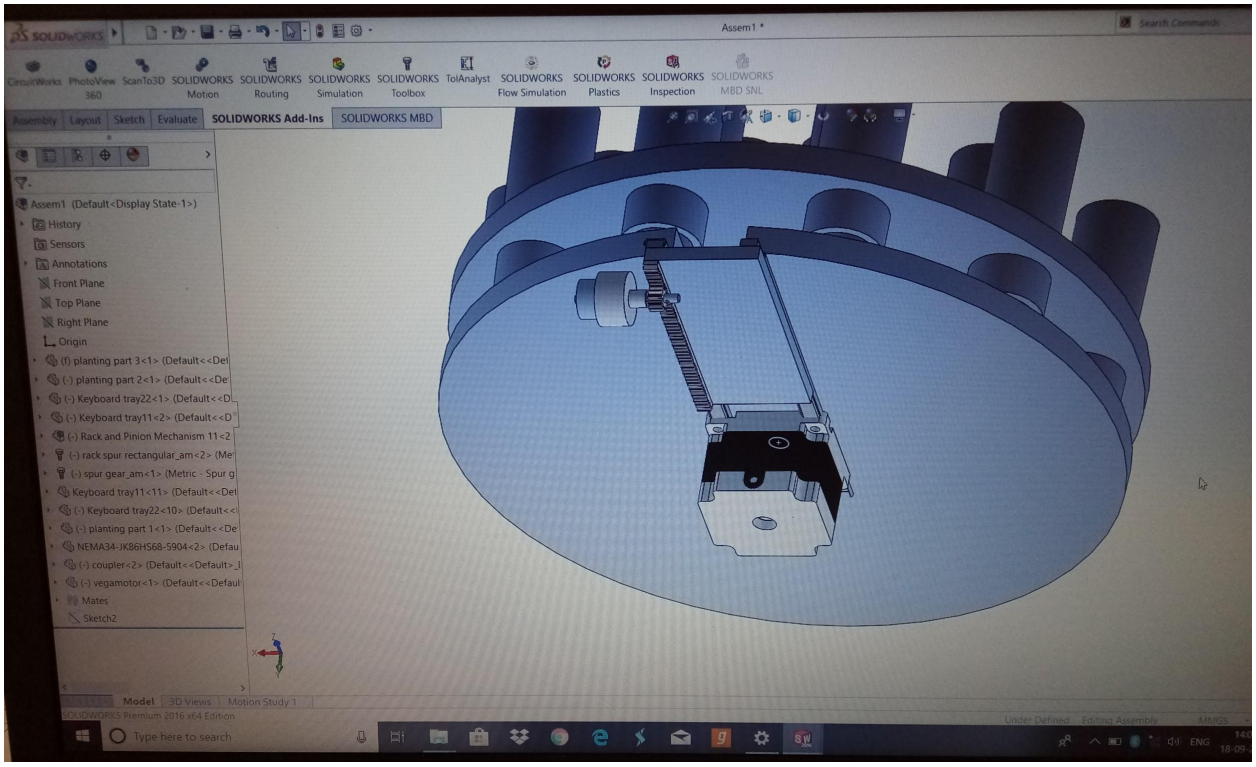
Components of linear actuator

1) Front/Rear Clevis.
2) Outer Tube.
3) Inner Tube.
4) Spindle
5) Safety Stop
6) Drive Nut
7) Wipe
8) Gear
9) Motor Housing
10) DC motor

STORAGE UNIT

The storage unit can accommodate 24 plants. It is made circular to maximize the number of plants. A slider is used for the plants to fall on the ground, the slider has three positions, Initially, we thought of having a slot in the very base plate but three plants were falling together And the slider is kept in the same plane so that the grid movement is not obstructed as the plants of other layers may get stuck due to it. In the CAD model we have used PVC pipes for each plant and while manufacturing two grids have been used one base plate and slider assembly. The slider is made to move using rack and pinion along with keyboard slider, the pinion is attached to a Vega motor which provides its motion. The grid is rotating using a stepper motor and testing is done for 6 positions three consecutive positions of inner and middle part respectively.





CAD model:
https://drive.google.com/folderview?id=1vMfMUOQ0MK0G_R0B2xAdTTD1XlJQIaol

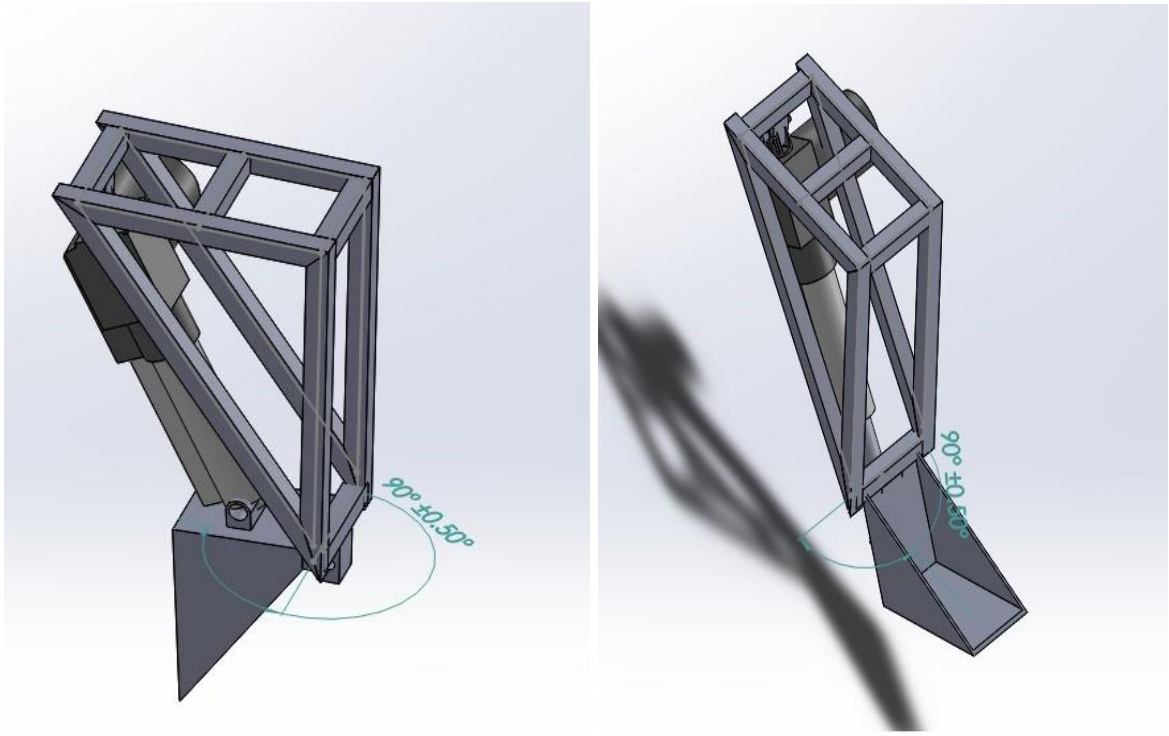
Testing prototype photos:
https://drive.google.com/folderview?id=1-0fMlKIvPxdU2urCaRDR9WsH8PAyjekq

Testing videos:
https://drive.google.com/folderview?id=1-4yTRuYyTNzwam18daUefDtyrUFXRqrh

DIGGING MECHANISM

Digging Mechanism 1:

This mechanism is made to dig a hole of 15 mm in the ground using a claw and a linear actuator.



One end of the linear actuator is hinged with frame and other is hinged with a claw at some offset from 90-degree angle. Claw is hinged with frame and the linear actuator is hinged to it as shown. When linear actuator actuates, claw gets motion about the hinged end with frame and it digs the ground to desired depth.soil is collected in the claw. The frame is designed in such a way that it is able to bear all types of stresses generated due to the linear actuator.

Materials and Machine Specifications:

- The frame is made up of aluminium box section of 1'*1' and has a thickness of 1mm. Claw is made up of relatively hard material such as mild steel.
- The linear actuator used is having 100 mm stroke length, the maximum force of 3000 N and 8mm/s the speed at the rated maximum voltage of 24 V.

Testing prototype :

The testing frame was made of wooden triangles and they were separated by means of wooden bars. The linear actuator was hinged with two aluminium plates connected to frame by the aluminium rod of 10 mm.The other end was hinged with the same type of aluminium bar passing through the linear actuator and vertical shaft support mounted on the claw. Claw was hinged using door hinges to the frame.

Result:

1) It was able to dig in hard ground.
2) The stroke of the linear actuator was enough to give proper angular displacement to claw to dig the soil.
3) The reaction force from the ground was very high and too much force is required in order to prevent movement of the whole body.
4) The depth of hole dug was not enough.

Cad model: **https://drive.google.com/drive/u/1/folders/1ZTqC470htjpi0eVqvFzoZ0di7rM0sP0L**

Testing prototype images:
https://drive.google.com/drive/u/1/folders/14zAb3KXWTkcUOdlTj-UmLrf_QR2EivH2

Testing videos:
https://drive.google.com/drive/u/1/folders/10-p9W2z6WQi7oMFa8id2WzaTlFx5u21K

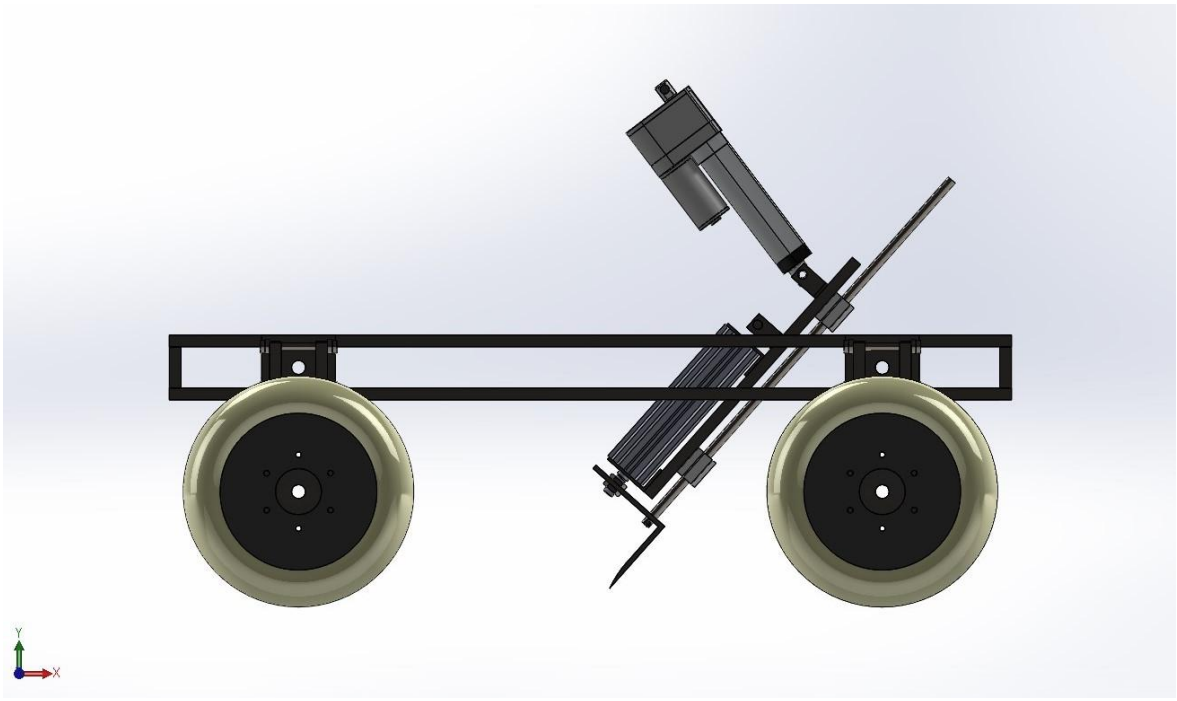
.

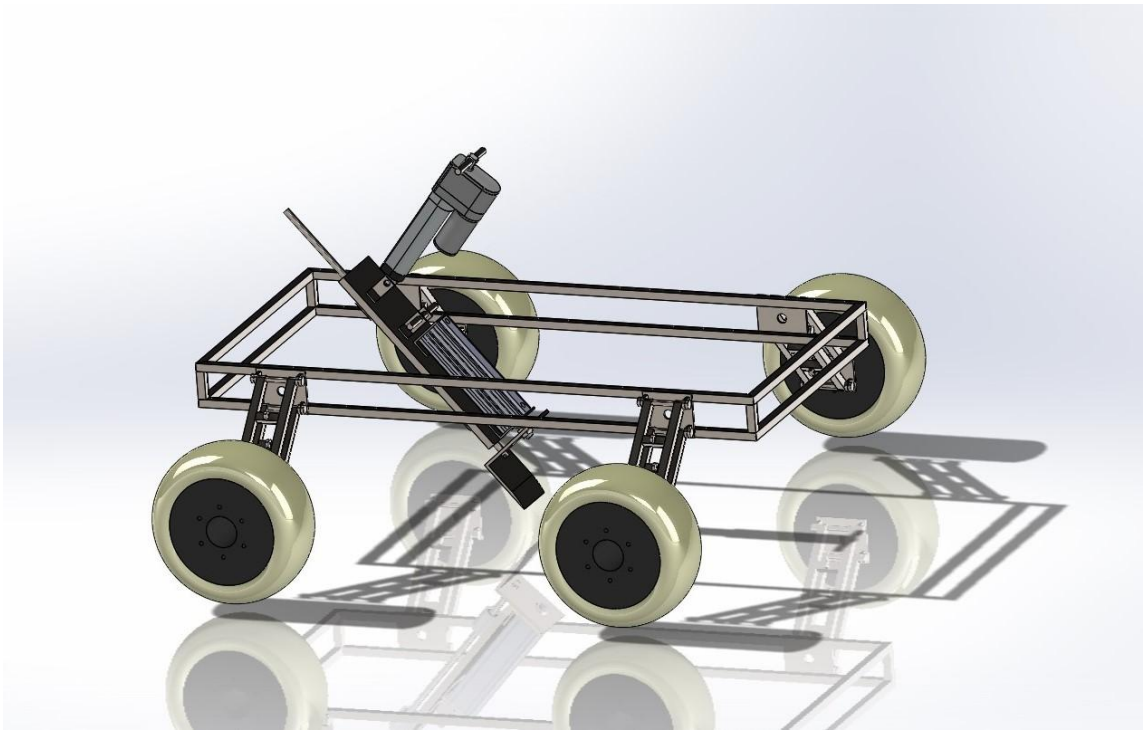
Digging Mechanism 2:

- This mechanism is designed to dig ground up to 15 cm of height and 7 cm wide. Spade is connected to the shaft of the pneumatic actuator. The pneumatic actuator is hinged with the chassis and rotates about the hinge point. At maximum stroke length spade will penetrate in the ground and then Linear actuator will rotate the pneumatic actuator using a first-class lever mechanism. Initially, the angle between the Linear actuator and the Pneumatic actuator is 90 degrees of the Pneumatic actuator.

PROBLEM FACED

1. The reaction forces from the ground are at an angle to the vertical. So, the whole assembly was moved in the opposite direction by the horizontal component of the force.





CAD model: **https://drive.google.com/open?id=1ADAzCHPKnrADfJ6-RLQaRPnKnrduVkgs**

Testing video:
https://drive.google.com/open?id=12tMfQ4sKFT-KfWFUV47o6_P55MTzPDfQ

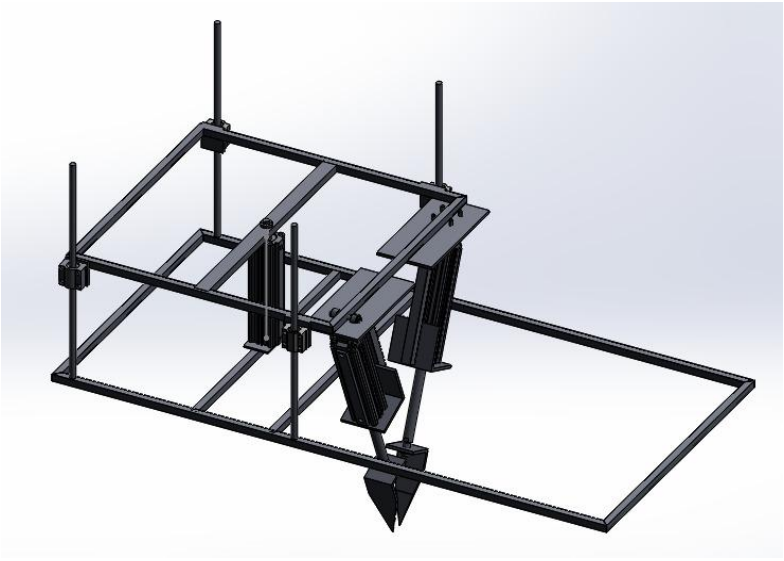
Actual Prototype photos:
https://drive.google.com/open?id=11o3gOef_bR7w1g4z7JC3PIUaIwFXTRzo

Digging mechanism 3:

This mechanism consists of two spades connected to two pneumatic actuators (tie rod cylinders) which are connected at an angle using male and female clevis mounted on a platform. The third pneumatic actuator(compact cylinder) is mounted such that it will lift this platform consisting of Digging pneumatics when digging is done. In the previous two mechanisms, the reaction force was inclined with the vertical axis but this design is made such that reaction forces are vertically downwards.

In actual design, 3 shafts have been positioned forming an equilateral triangle.
The wooden ply used is of 18 mm thickness.

The centre of gravity of the assembly was not in the centre, It was shifted towards digging pneumatic pistons. It was counterbalanced by using an extended wooden ply.



Cad model:

https://drive.google.com/open?id=1nR5Y1dZAGbx9VZ8o01_05WyUkJK01d1o

Design of spade

All the spades mentioned here were used in the above mentioned design. And two spades are used at a time.

To get a required depth of 120mm and width of 90mm there should be an optimal design of spade. To achieve the above goal we calculated the relationship between the angle of mounting of pneumatic actuators and angle of cutting of L-clamp to design a spade. The relationship was found using two methods

1. By using a CAD software.
2. By hand calculations.

Prototypes

Double Spade 1.0

The spade is flat, triangular in shape. Having a vertical length of 120mm. The edges of the spade are made sharp using a buffing disc, the pneumatic actuator is mounted at an angle of 19° from the vertical axis.

The spades were offering a good penetration but they were not at all holding any soil
So to hold a good volume of soil another design of spade was made.
Testing video

Double Spade 1.1

The spade was cut from an L-clamp at a calculated angle. The surface of the L clamp was cut at an angle of 30° from the vertical. The pneumatic actuator are mounted at an angle of 35° from the vertical axis.

Testing video

Double Spade 1.2

The spade angle is changed to 45° and the whole assembly of pneumatic actuators was the same as in the previous design. Required depth was not achieved but good width was achieved.

Testing video

Double Spade 1.3

The spade angle was changed to 23° from the vertical and pneumatic actuators were mounted at an angle of 17° from the vertical. It was designed to get a required depth of 120mm and width of 90mm. The penetration and width achieved were close to the required dimensions.

ENFORCER

Mechanism 1:

In this simple enforcing mechanism a wooden block, having cut a section more than the diameter of the plant, was considered suitable for pressing the required sand around the plant which also has jaws so that nearby sand will also come during the process. It was simply pressed using a linear actuator, supported on two L sections using a shaft. The whole assembly stands on two legs.

PROBLEMS FACED:

Apart from manufacturing difficulties major problems faced during testing were:-

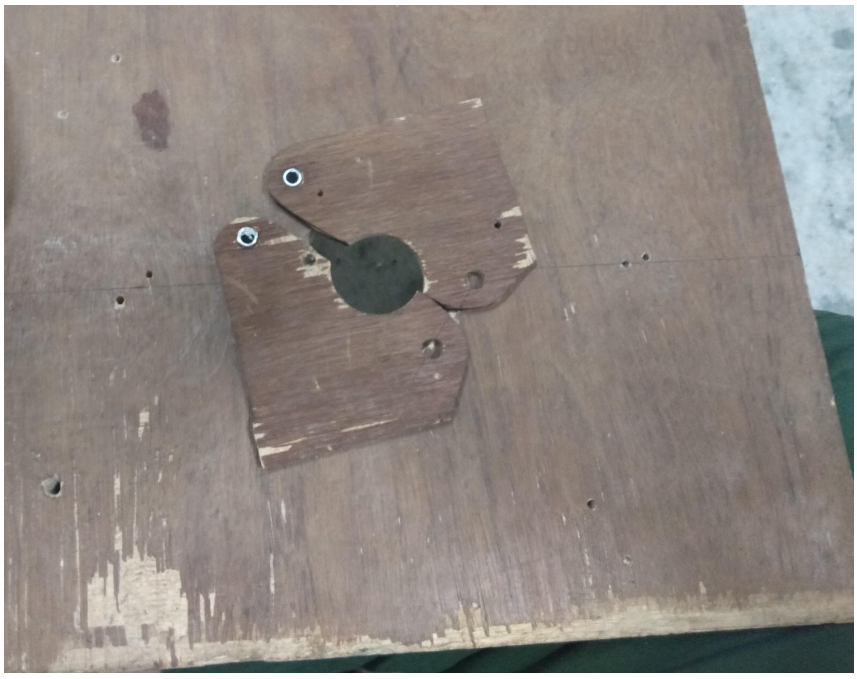
- The mechanism was unable to compress as expected due to the larger surface area of the enforcer.
- Proper penetration and gather of sand was not noticed due to larger reaction force.
- There was no province for opposing the force of linear actuator resulting in the lifting of assembly.

RESULT:

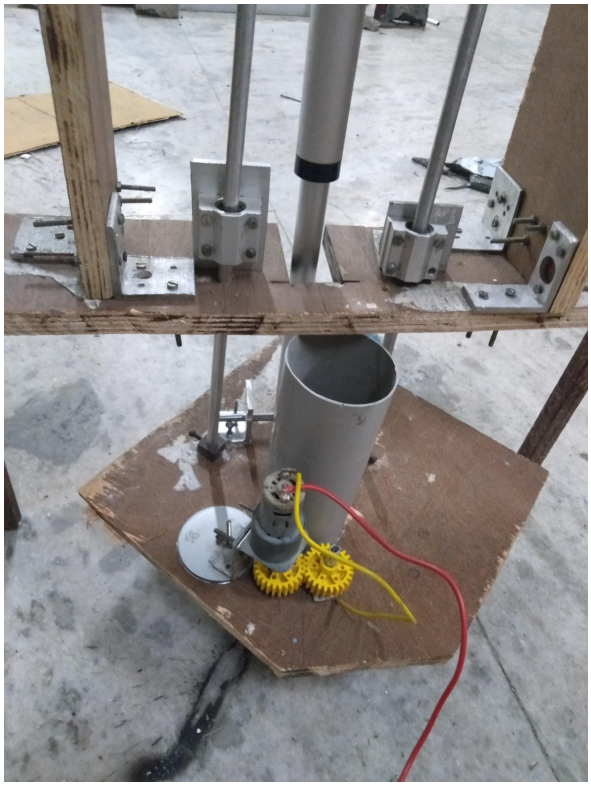
Due to above-mentioned factors, there was a need to modify to alter the mechanism for better results.

Mechanism 2:

Due to constant problems of having soil around the plant this time we decided to use the soil of the plant itself for enforcing it. In this mechanism there were two grippers below the circular frame, having a hole at the center providing the opportunity for the plant to enter the excavated area of ground. The assembly of the grippers were controlled using two spur gears at a distance of 6cm from the center of the pipe hole.



Further the grippers having holes less than the diameter of the plant would encircle the plant. Afterwards the whole assembly being actuated by linear actuator would compress the soil of the annular area between gripper hole and plant diameter.



RESULTS:

Being compact in size it enabled easy handling for enforcing and plant falling. Further it gave very good results. Also there is no load concentration on any particular section of assembly (load is uniformly divided). Giving optimum results this mechanism seems suitable for enforcing.

Result obtained

TESTING VIDEO:

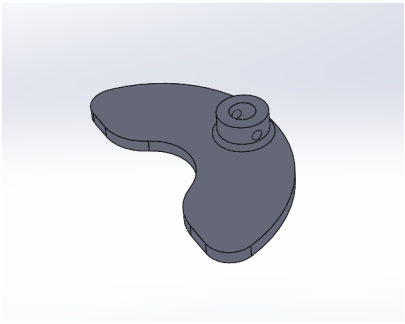
https://drive.google.com/file/d/1nCvSlfn0m46LOiMSM5t2SdeEQbLBk0Mr/view?usp=drivesdk

Final Enforcer

Mechanism 2 is employed for compacting the soil and keeping the plant intact. The plate is made of acrylic and its shape is a regular octagon obtained after optimizing the shape in Solidworks. The distance of shafts is also increased w.r.t. to actuator.The whole assembly is mounted as mentioned above. When it was tested the actuator was moving downward swiftly but in the

opposite direction due to torque at the point of mounting of actuator the plate was inclined to an angle and got stuck.To solve this we made a coupler to couple the actuator shaft and enforcer plate so that being a single assembly they can move together.

Image of coupler



Suspension

Prototype 1

Initially, we used double-wishbone suspension, It has two "A" shaped links (lower link and upper link) horizontally connected to each other by a vertical link and this assembly is connected to the chassis by a knuckle.

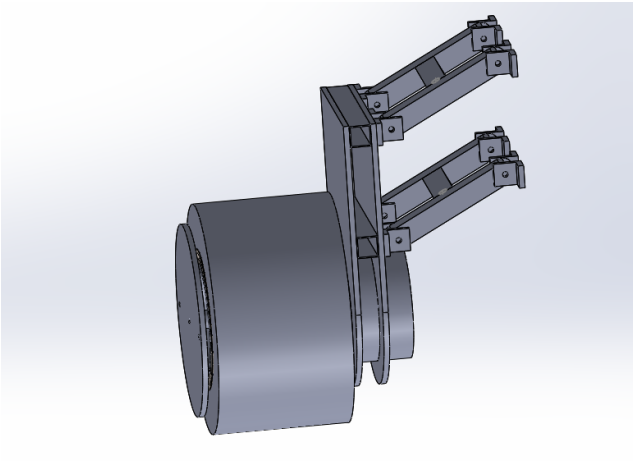
- This suspension system is difficult to manufacture and is quite heavy.
- This type of suspension is costly to manufacture.
- Also this suspension was very wide and was not feasible with our dimensions of the chassis

Four bar suspension

It's similar to a double-wishbone but far simpler in structure and is capable enough to travel on plantation terrain.In this suspension two H shapes(for support by) are made from links and clamped to the chassis.The location of suspension is at ¼ distance from one end of the chassis so that they can bear the weight of half the chassis.We are using back coupling wheels which means the motor is attached to an aluminium plate to save the motor from any probable damage while traversing which is coupled to the coupler.The coupler is attached to an aluminum plate which is bolted back to the wheel.

This suspension is connected to the chassis by springs.
Various combinations of springs were tried and tested which are described below

Image of Suspension



Electronics and control of the bot

Different motors and actuators are controlled using Arduino and motor drivers. Our aim was to control the bot wirelessly. So, we achieved it by

1) Using wireless PS-2 controller
2) Using Raspberry Pi and ROS for communication between different modules

1) Wireless communication using PS-2 controller

To do this, a wireless PS-2 controller and receiver were used. For that, the receiver of the PS-2 controller was directly connected to Arduino and all the other motor drivers were connected to Arduino. When the command is sent to Arduino via receiver from PS-2 controller by pressing a button, Arduino will execute the certain task and hence bot will do the task. For this, a code was written and stored in Arduino. The codes were written in Arduino IDE. To do interfacing with the PS-2 controller and Arduino, pre-made libraries were used.

Problems faced

(1) PS-2 controller and receiver transmission have a limited range and hence it limits the range of the bot.

(2) Connection of the receiver to Arduino which is the main link to transfer data was not accurate. so it was giving different results every time for the same instructions.

(3) The built-in library we used was having issues recognizing the type of PS-2 controller we had and hence and because of that we were not able to use some of the buttons and joysticks.

Due to these issues we decide to change the mode of communication between base and the bot.

2) Communication using Raspberry-Pi and ROS

By using raspberry pi and ROS, we changed the mode of communication between the bot and base.

ROS (Robot Operating System)

It is a package available in ubuntu operating system.it can be used to do many things but we utilized it to get data from a wired controller, modify the data in the desired form and publish this data on Raspberry-Pi computer. It works on the principle of node and topic.when two or more different computers are connected on same hotspot network through wifi it is possible to run all the devices to connect their ROSCORE and hence data published within one device in its own ROSCORE can be subscribed and obtain by the other device.

Raspberry-Pi: It is a small size computer that can work as normal computer once we attach different hardware like monitor, keyboard and power supply.it is very small in size and can be easily mounted on the bot.it has the ability to communicate through wireless communication means such as Bluetooth and wifi.

In this, the control of the motors has been done using Arduino and motor drivers the same as the previous method. First commands are taken from a wired controller in the form of different types of data and stored in the form of a variable in a computer at the base. this data is published on a topic as it is. Another node subscribes to this data and modifies it and then data is obtained in the desired range and type. A Raspberry-Pi is mounted on the bot and both the base computer and the Raspberry-Pi are connected on the same network. using this connection and

ROSCORE modified data published by the computer at the base can be obtained by Raspberry-Pi at the bot. Now Raspberry-Pi gives the command to Arduino according to data received from the base computer. This Arduino controls the motor through motor drivers according to data received from Raspberry-Pi and instruction stored in it.

Pros & cons

(1) Primary communication occurs through the hotspot network, it is possible to communicate at a long distance using the long-range antenna.

(2) The control achieved using this method is very reliable.

(3) By using ROS, many other tasks like GPS location, obstacle avoiding and many more features can be added to the system.

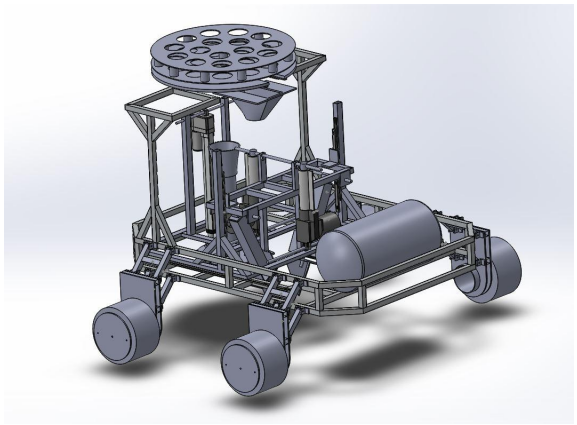
GPS Module:

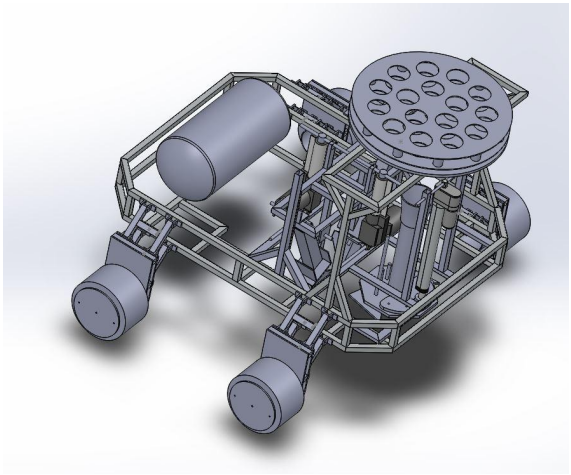
Ublox GPS module has been used to detect the exact location of the bot. GPS data is obtained using this module and used in the package of ROS named MapViz which visualizes the data in the form of a red dot on the map.

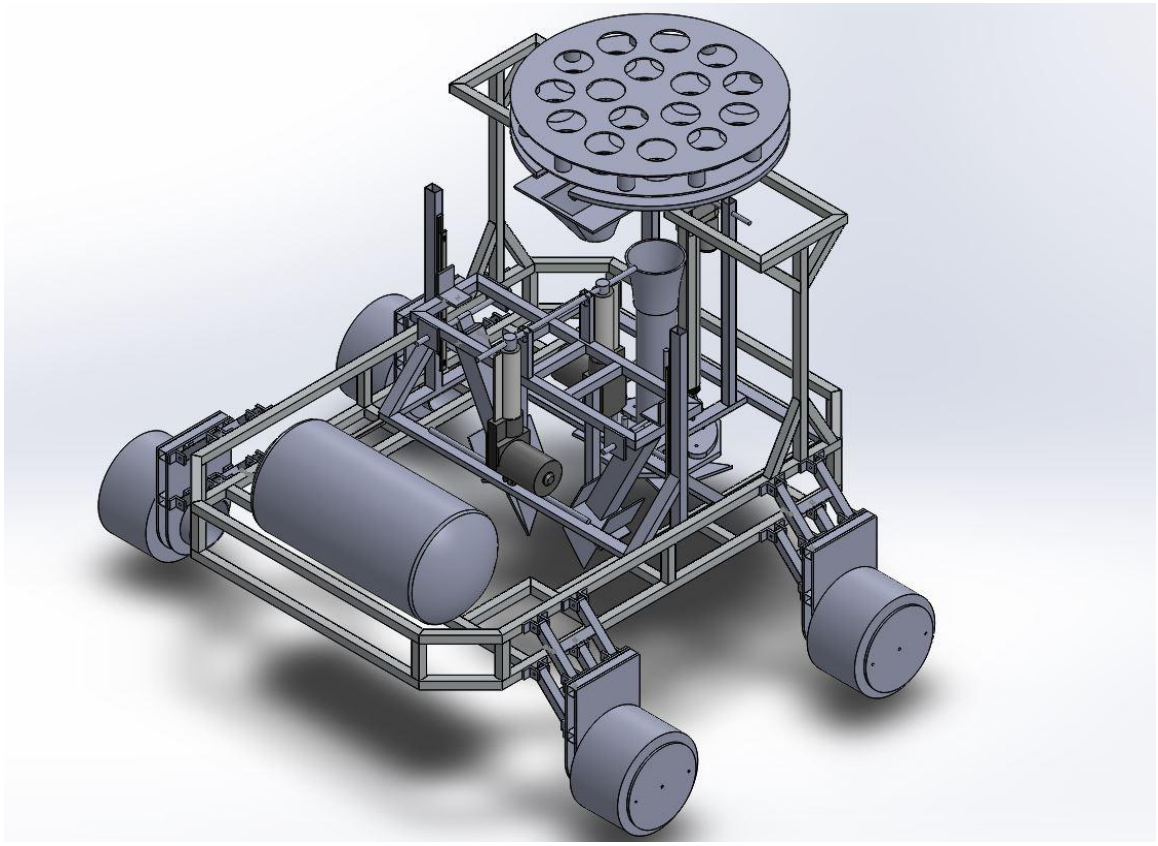
Mapviz is a ROS-based visualization tool with a plug-in system similar to rviz focused on visualization 2D data.

We can directly install packages from github by using the command on ROS “git clone”
For e.g.
git clone https://github.com/swri-robotics/mapviz.git

Final chassis



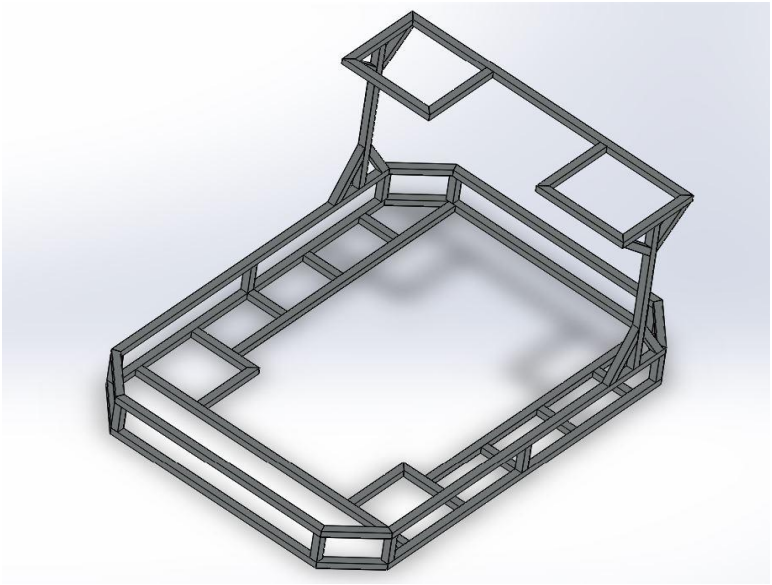




The final chassis is designed to plant 15 plants in a single run.

Chassis : The chassis is 1750*788mm. It has two layers connected by vertical links.

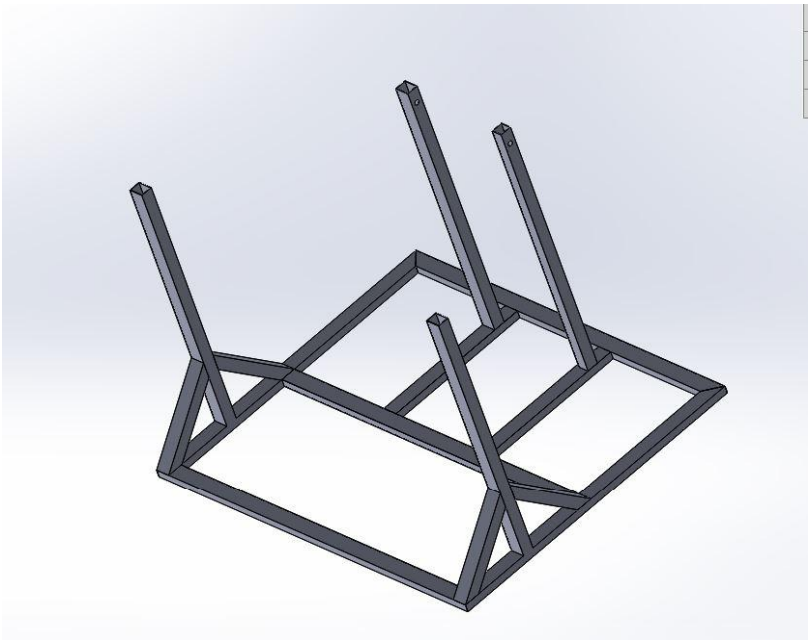
It is designed to properly accommodate all mechanisms and other necessary storages and devices.

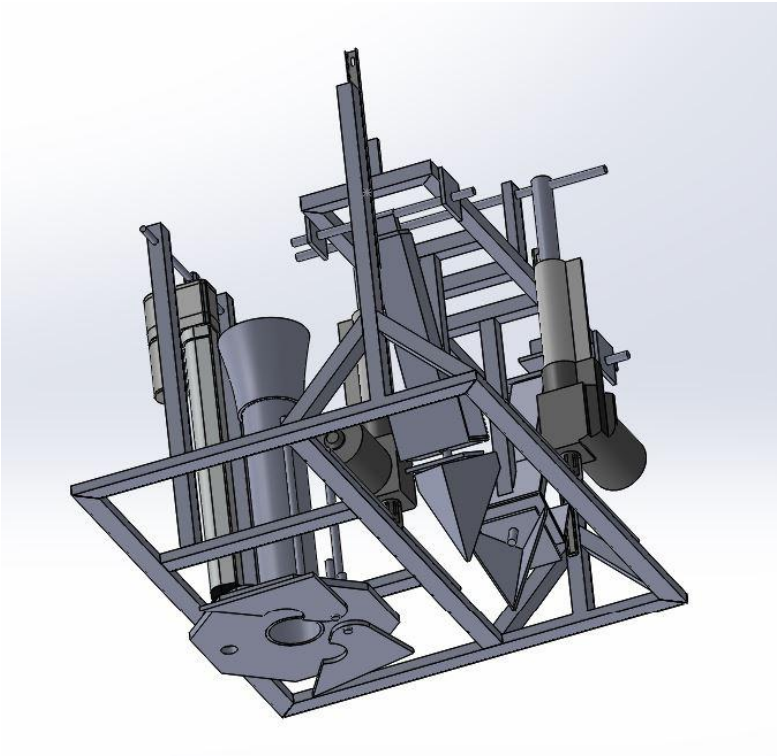


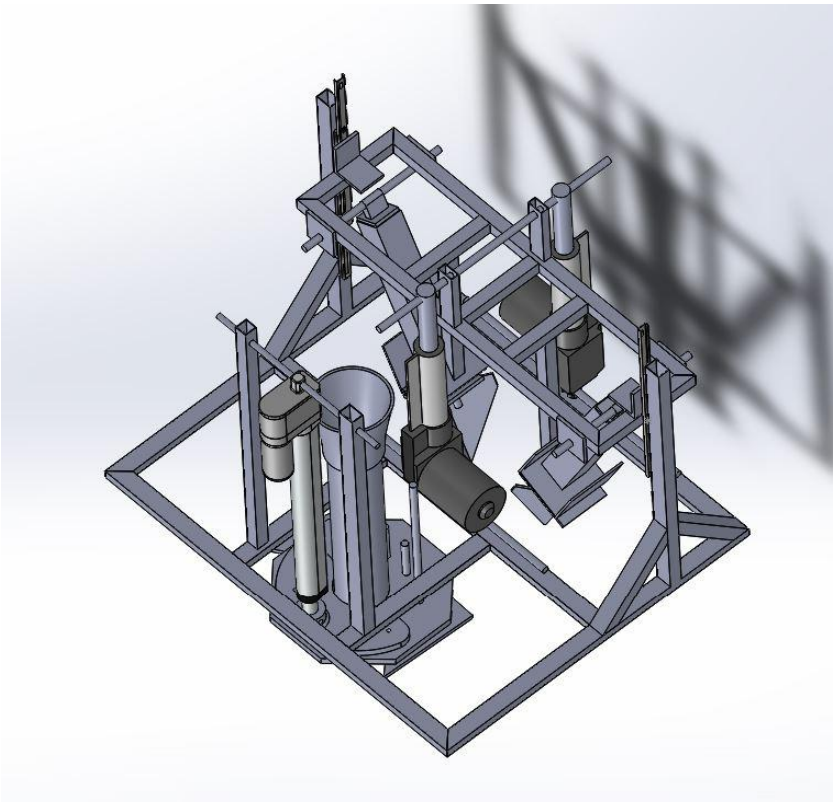
Slider mechanism is designed in order to complete the whole plating process without moving the bot. To mount the slider mechanism and slider two long links are made along the length which is supported by three small links each.no link or elements are introduced in the space between this two long links in order to get free path for mechanism to reach to ground.

Two vertical links are made from the side of the bot which provides a platform to mount plant storage and plants will drop from there.

Slider:assembly of digging mechanism and enforcer is called slide here.slider assembly moves on the bot . for that a frame is made.







Here the up and down movement of the digging mechanism is made possible using keyboard sliders.and to achieve that motion two linear actuators of stroke length 10 cm are mounted as shown in assembly.

Both digging and enforcing mechanisms are designed in such a way that both mechanisms will need to stay right above the digging area.To do that it is necessary to take the digging mechanism away and place enforcer there.here is the need of the slider Assembly . There are two possible positions of slider assembly. in the first position it is at the back end of the bot.here digging mechanism will dig the hole in ground and then the slider will move. It will put the enforcer right above the hole made by the digging mechanism.
This motion is provided by two pneumatic pistons. And to move the assembly freely it is mounted on two keyboard sliders attached to the chassis.

Pneumatic circuit:

There are a total four pneumatic piston - two for digging and two for movement of the slider.to provide pressurized air a storage unit is mounted on the bot.the pneumatic circuit is shown below.