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PROTOTYPE OF ROCKER BOGIE MECHANISM (MARS ROVER)

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Abstract

This project outlines how we designed, built, and tested a working prototype vehicle using the rocker-bogie suspension, which is well-known from NASA's rovers. It's made to stay stable and move easily over uneven ground. With six wheels, it can handle obstacles that are up to twice the size of the wheels without needing active suspension. We used light materials like aluminum and mild steel, and it includes a differential for smooth movement. It's powered by DC gear motors and can be controlled manually or run on its own with microcontrollers like Arduino or Raspberry Pi. We tested the rover on different surfaces—like ramps, gravel, sand, and rocks—and it showed great stability, grip, and handling. The project also includes some analysis of movement and forces, proving that the rocker-bogie system works well for off-road use in both Earth and space settings.

Keywords: Rocker-bogie system, rover, all-terrain movement, suspension system, DC gear motor, self-driving vehicle, obstacle handling, Arduino, Raspberry Pi, movement analysis.

1. Introduction

Mobile robots are becoming more important for working in rough terrains where humans can't easily go or where it's risky for them to be. A key part of these robots is their mobility system, which needs to be built for all kinds of tricky landscapes. One of the top designs for this is the rocker-bogie suspension system. It was first used in NASA's Mars rover, Sojourner, and is still popular for exploring other planets. The rocker-bogie setup allows six-wheeled robots to keep all their wheels on the ground, even on bumpy surfaces. This has two main perks: it spreads the weight evenly, which helps prevent sinking in soft ground, and it gives steady traction across all wheels for climbing over obstacles. Usually, each wheel has its own power, which helps with movement. But there's a downside—the current rocker-bogie design isn't very fast. When dealing with large obstacles, it has to move slowly, which isn't great for places where speed would be helpful, like on flat ground. This area is still being explored, but it has uses beyond just space missions. It could be useful for military scouting, bomb disposal, stair-climbing wheelchairs, and moving materials on their own. Creating a tough rover for rough environments on Earth could speed up tech development for exploring other planets, lower costs, and provide a practical trial run for future missions to the Moon or Mars.

This research aims to design, build, and test a rover that combines key features for planetary travel while also looking in real-world uses for the rocker-bogie system.

2. Literature Review

The rocker-bogie suspension system is a simple, passive mobility design that NASA first used in the Mars Pathfinder mission. It also made its way into the Mars Exploration Rovers and the Curiosity rover from the Mars Science Laboratory mission. It's still NASA's go-to option for moving around on other planets because it's reliable and handles rough terrain well.

The system has two main parts: the rocker, which is a long arm attached to the vehicle's body, and the bogie, a shorter arm with wheels on both ends. This setup helps all six wheels stay on the ground, even when the surface is bumpy. The differential mechanism averages out how the left and right rockers move, which keeps the chassis stable.

2.1 Some of the main perks are:

- It can climb over obstacles that are up to twice the wheel size.

- The left and right suspension can move independently.

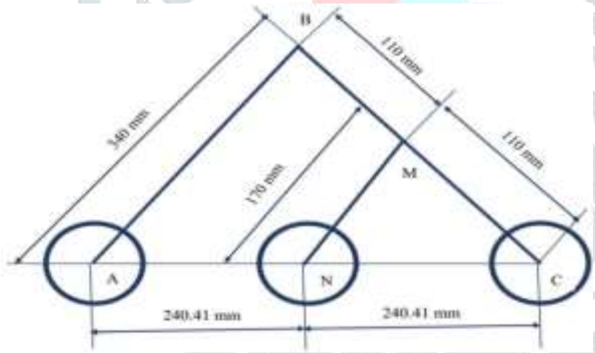
- It can tilt quite a bit, with rovers like Curiosity able to handle tilts over 45°, though it's limited to 30° by sensors for safety.

- It has less body motion and fewer shocks because it doesn't use springs or stub axles.

- Each wheel has its own motor, and the cleats on the wheels help grip loose or rocky surfaces.

This system lets rovers navigate tough terrains at slow speeds (around 10 cm/s), which is great for scientific missions. But it won't cut it for future needs that require faster movement, like helping astronauts or working on the Moon. Its ability to deal with rough paths and stay stable means it could be useful beyond space exploration, like in military or assistive robotics. Over the years, the rocker-bogie design has really proven itself and is a key part of many modern rovers. Still, there's room for improvement in areas like speed, adaptability, and how it can be used on Earth.

3. Design Links



This chapter goes over the key calculations for the rocker bogie mechanism project.

We'll look at picking the right wheels and designing the links, differential, and joints to keep the vehicle moving smoothly. Choosing the right motor is also important to make sure we have enough power and speed. These calculations are crucial for making sure the project works well and is reliable in different situations.

If horizontal length of stair 400mm then
Wheel base= horizontal length of stairs–(Rf+Rr) Rf = radius of front wheel Rr= radius of rear wheel So,

Wheelbase=400–(25+25)=Wheelbase=350mm Let θ = 45°

In Triangle BNC, Angle BNC=90°

Angle NBC=Angle NCB=45° Therefore, NC=NB

$NC^2+NB^2=BC^2$ (from Pythagoras theorem)

$BC^2=2(NC^2)$…….(1) $BC=2(240^2)=339.41$mm

Rounding off to340mm

AB= 340mm

Substituting in eqn (1)we get,
$340^2=2(NC^2)$

NC=240.41mmAlso,

NC= AN =240.41mm

In Triangle NMC, Angle NMC = 90º $NM^2+MC^2=NC^2$ $2(MC^2)=NC^2$

MC= 110mm

Now due to symmetry,

BM=MC= 110mm

BM=BC– MC= 220 –110

Height of RBM

$Height^2=AB^2–NM^2$ $Height^2=340^2–170^2$ Height = 294.4 mm Net Height= Height +radius of wheel =294.4+ 25 **=319.4mm**

3.1 DESIGN OF WHEELS:-

V=πDN/60 Assumed required speed is 10cm/si.e.100mm/s 100 = π D N/60
DN=1909.86
Now value of D&N is taken from table

D	N
50	38.2
60	31.83
70	27.28
80	23.87

So, the selected D-N combination is–D =50mm, N=38.2 rpm

Now, Drafting of wheel is do neon Solid works with wheel diameter of 50mm.

3.2 DESIGN OF DIFFERENTIAL:-

Diameter of differential is taken as holes present in rocker i.e. 8 mm Length of differential is equal to width of RBM.
Let width of RBMis300 mm

So length of differential=300mm

3.3 DESIGN OF FREE PIVOT-JOINT:-

Diameter of joint is equal to hole diameter i.e 8mm

Length of joint is 20 mm

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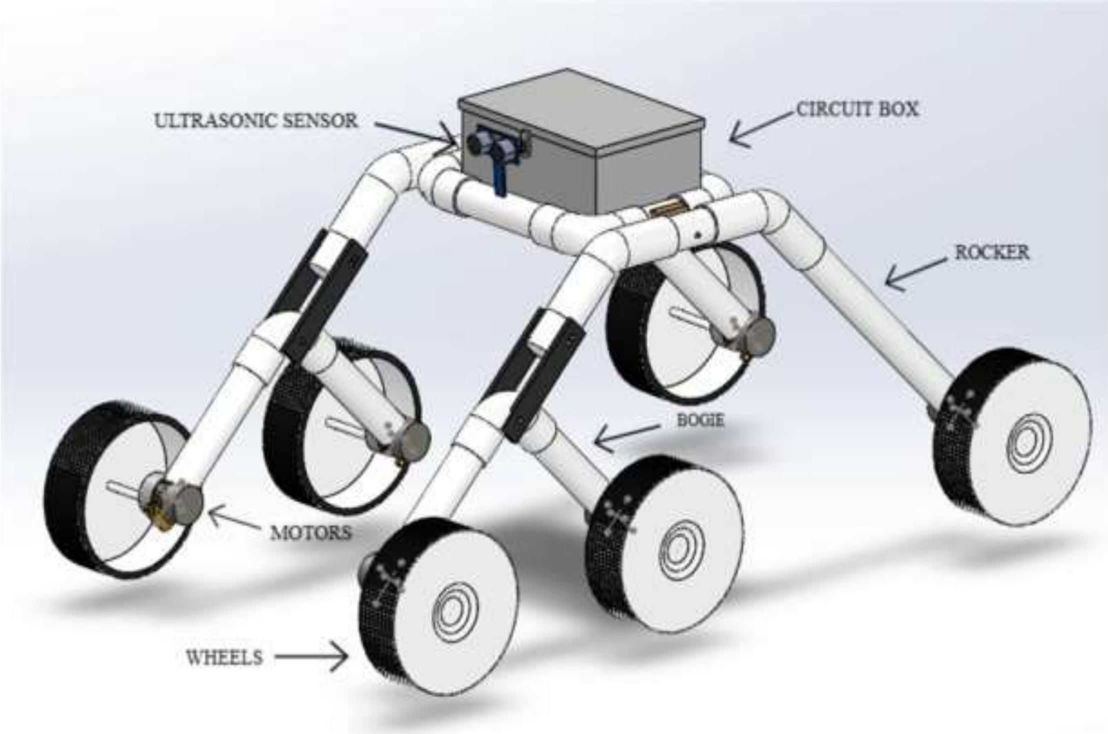
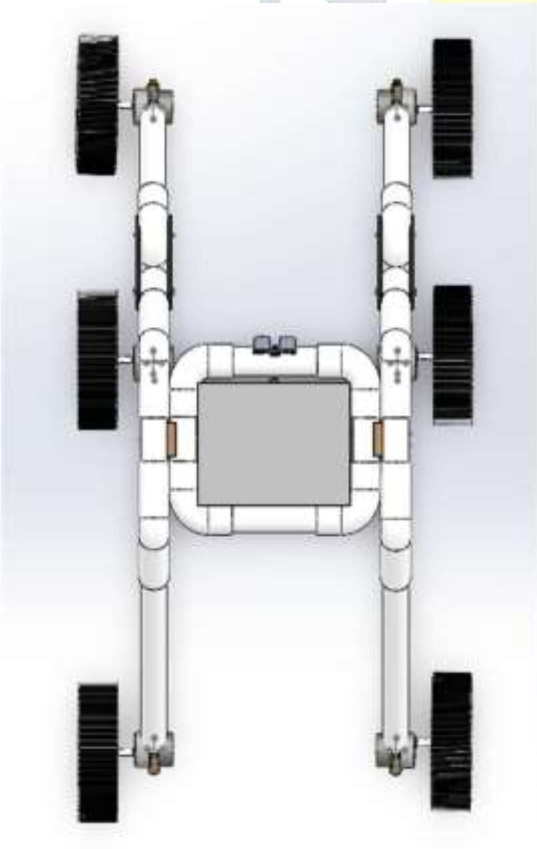
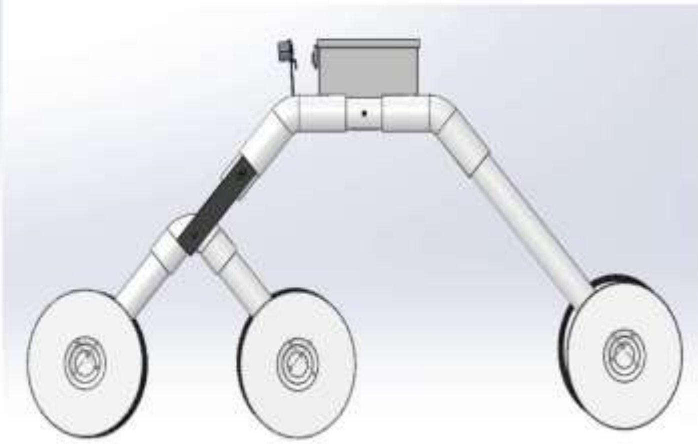
4. *Project Model*

The CAD model of the Rocker Bogie Mechanism shows all the parts clearly, like the motor, battery, ultrasonic sensor, and control system. This model makes it easy to see how everything fits together, which helps in understanding the whole design. It's an important guide for when we start building, ensuring everything assembles correctly to work as expected.


ULTRASONIC SENSOR
CIRCUIT BOX
ROCKER
BOGIE
MOTORS
WHEELS





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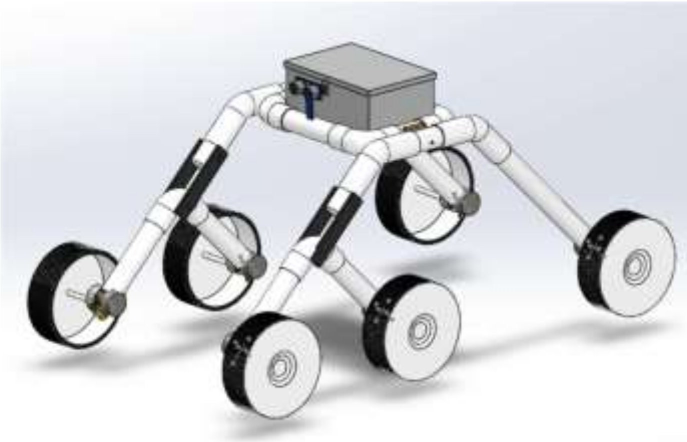
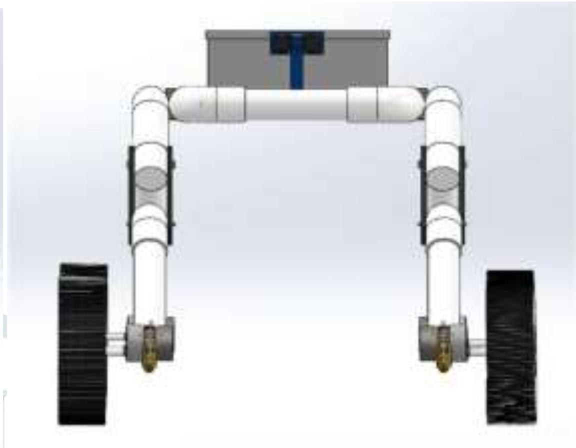




4.1 WORKING PRINCIPLE:-

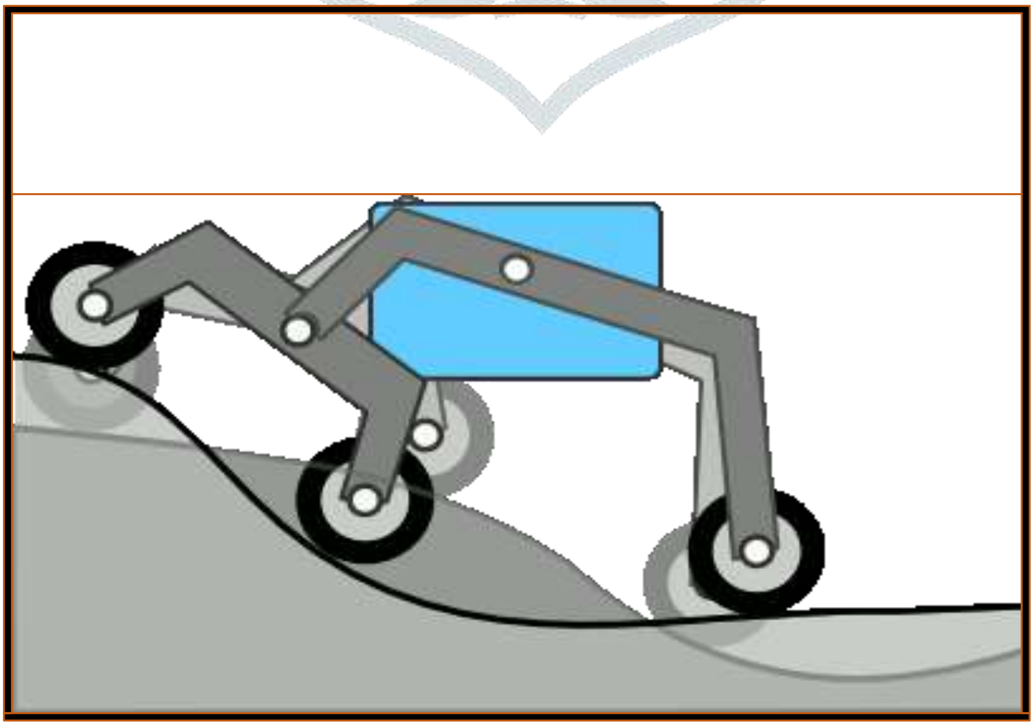
-To get over a vertical obstacle, the front wheels push against it thanks to the center and rear wheels, which help generate the needed torque.

- When the front wheel rotates, it lifts the front of the vehicle up and over the obstacle.

- The middle wheels get pressed against the obstacle by the rear wheels and pulled by the front wheels until they go over. Eventually, the rear wheel is pulled up and over the obstacle by the front wheels.

- As each wheel goes over the obstacle, the vehicle slows down or even stops, which helps keep its center of gravity stable.

- Also, with a tweak to the "Obstacle-Sensing" feature, it can detect obstacles and let us know with a beeping buzzer.



4.2 RESULTS AND DISCUSSION

4.3 FUTURESCOPE

- We could turn it into a wheelchair too. It could navigate through rough areas like valleys or jungles where people might be

at risk.
- With tech advancements, the rover could be handy for scouting with its built-in cameras, while also being smaller in size.
- If we add arms to the rover, it could help bomb disposal teams by cutting wires to defuse bombs.
- A larger model could be designed for carrying people and supplies over rough terrain or obstacles like stairs.
- We could also look into making it a suspension system for cars with some solid research.
- Adding servo or stepper motors for front-wheel steering could make turns smoother and more precise.
- Implementing Ackermann steering or four-wheel steering would really help with cornering, especially in tight spaces.
- Instead of simple spur gears, we could switch to planetary or worm gear sets for better torque in compact setups.
- Introducing gear reduction systems could help with climbing or carrying heavier loads.

5. CONCLUSION:

The rocker bogie mechanism is mainly used in Mars rovers to handle rough terrains while staying stable. It's a go-to design for NASA when it comes to space vehicles and rovers. The system has two arms with wheels attached to each, linked by a movable joint. This setup helps evenly spread the vehicle's weight, even when going over bumps and uneven surfaces. It features a suspension-based drive system that lets the bogie easily roll over rocks and pebbles. The sensors and cameras on the rover need to be steady to function well and last longer. Too many vibrations and jolts can cause faster wear on sensors, circuit boards, and cameras. That's why the rocker bogie mechanism focuses on providing stability across all types of terrain.

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