DEPARTMENT OF MECHANICAL ENGINEERING

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MACHINE DESIGN (MEP205) LABORATORY REPORT

For

Lab Project

Submitted by:

Lab-Group MD/E

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CONTENTS:

1. AIM:
   To make a moving robot which is controlled with mobile (which, in our case, is an obstacle climbing robot rough terrain rover).

2. Problem Statement:
   Navigating rocky terrain poses significant challenges for traditional robot. To address this, we have set to develop a mobile robot capable of climbing obstacles efficiently.

3. Basic Description:
   Our project is basically based on Rocker-Bogie mechanism. It is a simple suspension mechanism which comprises of three parts:
   - Rocker: It is meant by a larger link that has an aspect of rocking motion. This part is connected to the other parts too.
   - Body: It is meant by the main body of the mechanism which has to be carried forward.
   - Bogie: It is meant by the conjoining links that have a drive wheel attached to its each end. These are an important part of the mechanism as this helps in stabilising the motion the whole body.

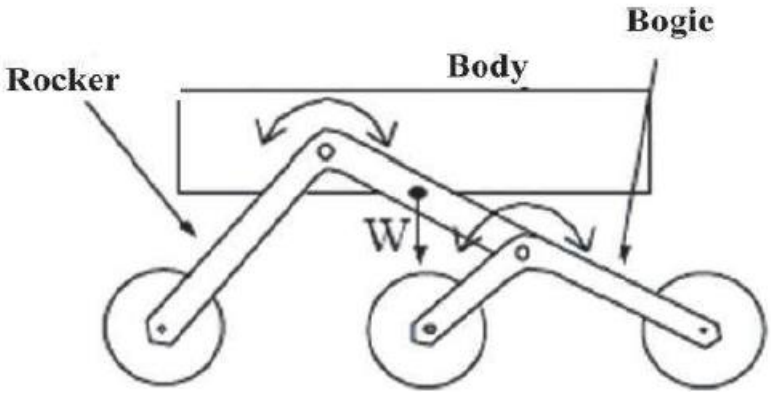
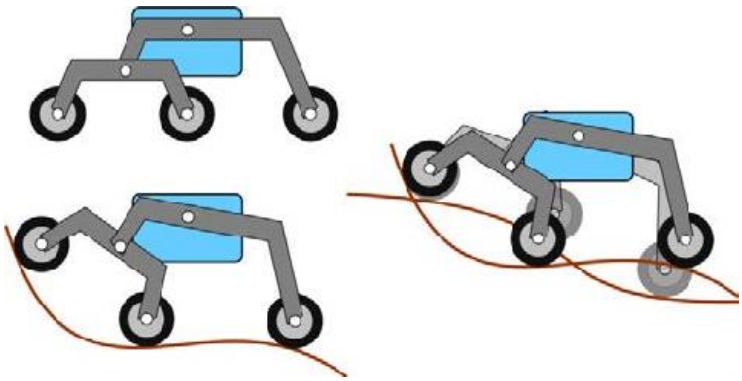


Figure 1 Shows a simple Rocker-Bogie Mechanism.

This mechanism not only is really simple, but is really helpful is improving the stability of a moving body as the Bogie is joined by pin joint and independent to rotate.

Although, being a simple mechanism, it has a complex physics. In research and practical applications, numerous points have to taken into consideration, for instance, how it interacts with the environment.



A few examples of this mechanism can be easily seen in exploration missions that have been sent to space in order to research the surfaces of other planetary bodies.

It was developed in 1988 for use in NASA's Mars rover *Sojourner,* which later on became a famous design for rovers. It has been used in the 2003 Mars Exploration Rover mission robots *Spirit* and *Opportunity*, on the 2012 Mars Science Laboratory (MSL) mission's rover *Curiosity*, the Mars 2020 rover *Perseverance* and ISRO's Chandrayaan-3 rover Pragyan in 2023.

4. Making:

- **<u>Main Body:</u>**
  - Our project robot's main body has been made with the help of PVC pipes, which is cost efficient and quite sturdy.
  - It comprises of pipes of different lengths (2 x 18cm, 2 x 15cm, 4 x 13cm, 2 x 10cm, 2 x 9cm) which has been joined by 90 degree and 45-degree PVC elbow joints.
  - For joining together, nuts, bolts and washers were used by drilling holes of appropriate size in pipes.
  - For joining the Rocker and the Bogie, metal strips were used as its readily available.
  - To increase their strength, they were folded and used so that the Bogie might not dangle, lest done forcibly.

- **<u>Motors and wheels:</u>**
  - For movement, six motors were used with six wheels. Each of these are L-shaped, 154 rpm motors that can work between 3V and 12V DC input.
  - These motors were joined by a metal strip that was passed through a cut made at the end of each rocker and bogie pipes.
  - The motors of each side are then joined together so than they perform in a unison, i.e. the motors are connected in parallel.

- **Circuit:**
  - In case of circuit, ESP32 has been used which comprises both, WIFI and Bluetooth for connecting with devices of our choice.
  - A L298N motor driver has been used for driving the whole mechanism with a 12V- 2200mAh DC battery as a power source.
  - The connections have been made in a way that only analog output is received from esp32 (pins 0,2,12and 13 are used) to the motor driver.

- **Code and Control:**
  - We aim to control a mobile rover using an ESP32 microcontroller and the Blynk app. The code is designed to establish a Wi-Fi connection, connect to the Blynk server, and control the rover's movements based on button inputs from the Blynk app.

LN298 MOTOR DRIVER:

"This motor driver interfaces with a microcontroller to regulate motor speed.
The motor driver features four digital pins that control the four output terminals of the motors. Additionally, it has two PWM pins responsible for enabling the motors of the rover and controlling their speed.

The four digital pins are connected to four digital pins on the ESP32. When a signal is sent to these pins, they are set to a high state to produce the corresponding motor rotation. For instance, when the rover moves forward, both the left and right sets of wheels rotate anticlockwise to propel the rover. If a left turn is needed, the left set of wheels moves clockwise while the right set moves anticlockwise, enabling the rover to turn.

The Blynk platform server is utilized to send control signals to the rover. With the ESP32's built-in Wi-Fi capability, the rover can be controlled from anywhere with an internet connection. By connecting to the Blynk server using a preset authentication token, signals can be transmitted from a mobile phone to the rover. The Blynk server communicates with the rover using the provided token, allowing the ESP32 to set the corresponding pin to a high state.

However, since there are six input pins required to configure the rover's output, continuously setting or changing all six different outputs is not feasible. Additionally, the Blynk platform allows only five data streams at a time. To address this limitation, we leveraged a feature called virtual pin. This virtual pin can be toggled to a high state from the Blynk app and identified by the ESP32. We assigned four virtual pins to four functions: forward, backward, left, and right. The ESP32 constantly checks the current state of these virtual pins in a loop. For example, if virtual pin 1 is high, the code sets O1 and O3 (motor driver outputs) to high and O2 and O4 to low. This configuration allows the left and right sets of motors to rotate in the same direction, and a single virtual pin controls all six pins for all four functions."

Function	Virtual Pin	Digital Pin Outputs
Forward	V1	O1, O3 High; O2, O4 Low
Backward	V2	O1, O3 Low; O2, O4 High

Right	V3	O1 High; O2 Low; O3 Low; O4 High
Left	V4	O1 Low; O2 High; O3 High; O4 Low

- Motor Control Pins: Defines the GPIO pins connected to the motor driver for controlling the rover's movements.
- Authentication and Wi-Fi Credentials: Defines the Blynk authentication token and Wi-Fi SSID/password for network connectivity.
- Motor Pins: Sets the motor control pins (A, B, E) as output pins.
- Main Loop (loop())
- Blynk Tasks: Continuously runs Blynk tasks to maintain communication between the ESP32 and the Blynk app.
- Blynk Virtual Pin Handlers (BLYNK_WRITE())
- V1: Handles the forward and stop actions for the rover.
- V2: Handles the backward and stop actions.
- V3: Handles the right turn and stop actions.
- V4: Handles the left turn and stop actions.

The code successfully establishes a connection between the ESP32 and the Blynk app, enabling remote control of the mobile rover's movements. It utilizes Blynk virtual pins to interpret button inputs from the app and control the rover's motor movements accordingly.

5. Advantages of the mechanism:

- The load on each wheel of a Rocker-bogie mechanism is nearly similar.
- The mechanism helps us to move in rough terrain and even climb the blocks that are even twice the height of the wheels.
- This mechanism is really helpful in researching the areas that are beyond human reach, i.e. moon rovers and mars rovers.
- Rocker Bogie Suspension can withstand a tilt of at least 50 degrees in any direction without overturning, which is the biggest advantage of heavy loaded vehicle.
- As there are motors for each wheel, the design is simple and more reliable as no springs or axles are needed.

6. Difficulties faced:

- During the making of the robot, the initial problem was to chose the wheels and motors of suitable size and power.
- As ESP32 comprises of its own WIFI for connection, it was really difficult to connect as information for connection had to be coded and thus connected.
- Using small tyres (with plastic grips) made it difficult to climb the rover over obstacles as it couldn’t generate enough frictional force to overcome the weight.

- Orientation of each motor had to be perfectly aligned or else it will result in wastage of power in cancelling out each other's movement that has to be used in moving and climbing.

7. Discussion:

The Rocker-Bogie mechanism is a great spring-type mechanism which has great applications in surface explorations of other planetary bodies.

This mechanism, though being complex to design due to numerous calculations involved such as mass of bogie and rocker, material selection, wheel size and design, so on and so forth, has its advantages overwhelm them.