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# AUTOMATIC FLOOR CLEANING MACHINE

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**Abstract -** With the advancement of technology, floor cleaning machine are getting more attention of researchers to make life of mankind comfortable. In early day a floor is clean by using a broom which is operated by human hand and in this a continuous movement of human hand is required which create fatigue and time consuming. Cleaning of floor is important for our health and this floor cleaning machine minimize our effort which require for cleaning that's why this project is very much useful in our daily life. Also there is need to design and develop a floor cleaning machine which is cost effective. Current project work focuses to use semi-automatic floor cleaner for large floor in auditorium, colleges, malls and office floors. This machine is capable of performing cleaning of floor in dry as well as wet condition. The cleaning purpose is specifically carried out by continuous relative motion between a scrubber and the floor surface. This Semi-automatic floor cleaning machine is designed by keeping the basic considerations for machine and efforts reduction, environment friendly and easy handling. This project is based on development and manufacturing of semi-automatic floor cleaning machine which will work on electricity.

***Key Words***: floor cleaning, cost effective, efforts reduction.

## 1. INTRODUCTION

The research and development of an autonomous mobile robot and a Manual Phone Application Control prototype able to floor cleaning an area or even an entire house is not an easy task. So on handle such a task, so as that it's going to rather be completed in six weeks, some simplifications and assumptions were made to the designers' initial idea of an 'ideal' autonomous/manual appliance. During this manner, some functional requirements which will improve the robot performance weren't taking into consideration due to their inherent complexity or due to their mechanical implications. These robots operate semi or fully autonomously to perform task useful to the daily routine of humans and equipment. With the goal of keeping our robot the most amount simple as possible, while able to perform the primary goals, i.e. an autonomous floor cleaner robot ready to randomly navigate through a locality or a house with the minimum human assistance, the next specifications were found:

- Obstacle avoidance
- Floor avoidance
- Collision Detection
- Cleansing
- Wet cleaning
- Automatic system

Four similar motors are accustomed perform different operations wish to maneuver the robot, for scrubbers, for pump. Motor drivers are accustomed drive the pump and cleaner motor. LM298N IC has been used to drive wheel motor. These specifications are related to variety of the expected operations which will be programmed into the robot.

### 1.1. BACKGROUND

Cleaning is incredibly important work approximate every place. Sometimes this is often easy and sometimes difficult. Sometimes we pay someone to clean floors, and sometimes cleaning is required in regions where the presence of live beings is harmful, so we can't assigned living being in every place. Some places have an outsized floor areas, so therein place we'd like over one person for cleaning purpose so we required some technique to recompense these problems. In advancement of science a robot comes in light but it operate by a personnel. To avoid this constraint of personnel we require more technologies. Automation is that the leading solution for this problem. So we make an automatic floor cleaning machine that mainly operated by NODEMCU. Infrared sensor is that the foremost vital electronic component of autonomous floor cleaning robot because Infrared sensor works as eyes of robot. Infrared sensor useful for turning of robot by sense the obstacle or wall. Sensing distance range of robot set by NODEMCU. During this range, robot detect the obstacle and stop at that position. Today the households became smarter and also more automated. Domestic robots are entering the homes and humans daily lives, but still it is a novel and not fully developed market. However, growth is expected, and domestic robot usage is evolving. There are several robotic vacuum cleaners on the market, but only a few do wet floor cleaning. Purpose of this project is design and implements a Vacuum Robot Autonomous and Manual via Phone Application named as Blynk. The foremost objective of this project is to style and develop a floor cleaning robot prototype by using NODEMCU, motor driver, infrared sensor and to appreciate the goal of this project. Floor cleaning Robot will have several features that are user-friendly.

### 1.2 OBJECTIVES

- To design and develop the process for cleaning the wet and dry surfaces.
- To increase work efficiency
- To reduce the price
- To reduce human effort
- To increase the effectiveness of floor cleaning

## 2. LITERATURE SURVEY

Kumar & Kapilan analyzed that the Parts of airport terminal stages, railroad stages, treatment facilities, transportation stands, and shopping malls use frequent floor cleaning equipment and in numerous other business places. These appliances require a power for its activity and are difficult to use. In India summers there's control emergency and majority of the bottom cleaning machine which isn't utilized successfully due to this problem, especially in transport stands. During this work, demonstration and investigation of the bottom cleaning machine was finished by utilizing appropriate programming. From the limited component investigation, we see that the feeling of stress within the physically work of floor cleaning machine is inside as far as possible.

Joshi et al. proposed that this undertaking report depends on the "Physically Determined Stage Cleaning Machine" which serves the essential needs of cleaning substantial floors.

Ghosh et al. proposed that this paper expounds the plan and manufacture of a story cleaner which runs simply on mechanical power and furthermore has the capacity of being ridden at low speeds by the client. The system accustomed drive the cleaning component would be rather like the one utilized as a part of a turning mop generally called an 'enchantment wipe'. The component works utilizing an incline adapt framework wherein rapid duplication are often gotten utilizing the correct apparatus determinations. The contribution to the framework would be within the form a foot pedal hospitable the client.

Meshram & Mehta reviewed that this paper introduces the outline and manufacture of Tricycle worked road cleaning machine with the related hunt. At display they'd few mechanized machines which were remote made and can be utilized as a part of our nation.

Kaur & Abrol analyzed that the Manual work is assumed control over the robot innovation and a significant number of the related robot machines are being utilized widely moreover. Here that they'd innovation that proposed the working of robot for Floor cleaning. This floor cleaning machine can add any of two modes i.e. 'Programmed and Manual'

## 3. METHODOLOGY

Currently, people lead a busy life. People in urban cities have long working hours. In such a situation an existent will always find ways of saving time. This floor cleaning robot is designed and developed keeping in mind following operation

- Typically bottom is gutted with the application of dry mopped or wet mopped using the hand as a base tool. They need to be dropped hard on the face.
- The cleaning is inspired from the conventional stages of any wiping or sweeping operation, which are mix with the design and placed in the functional order of working stages.
- Drawing medium directional control with automatic
- Handicap avoidance in time covering
- It consists of two devoted wipers that are attached to the platform. They're flat in figure, placed at the bottom of the Platform so as to insure effective cleaning and collection of dust.
- The scrubbers are placed at the front of the platform using proper links and motors.
- The cleaning is made effective using wet wiping system. This system employs a small water tank that carries water in it. This make sure a complete cleaning of the face. Only the wiper in the rear are made wet. This ensures that the scrubber from the reverse remove the water from the face when sweeping again on the face.
- The cleaning module includes cleaning of varied shells like cement bottoms, largely polished rustic or marble bottoms.

The rough face areas like cement bottom, are covered with heavy dust which consumes longer in cleaning.

## 4. DESIGN AND CALCULATIONS

### 4.1 CONCEPT DESIGN:

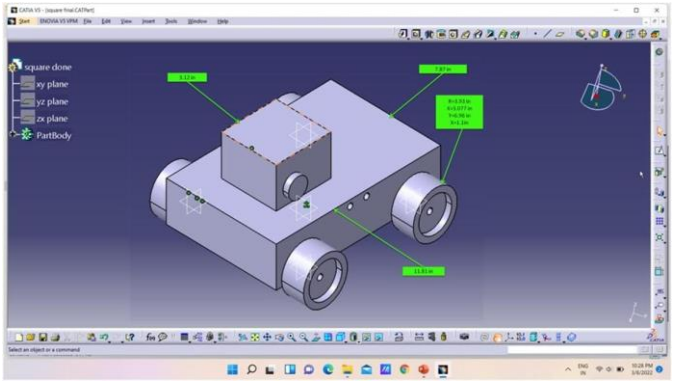


**Fig. 4.1.1** - CAD model for proposed experimental setup

Proposed model consists of –

**Table 4.1.1** - list of design components

| Title | Purpose | Material | Dimensions |
|---|---|---|---|
| Chassis | To carry load | Mild Steel | 30 * 20 * 15 cm |
| Wheels | Reducing the force of friction | plastic | Diameter =100 mm<br>Width = 40 mm |

## 4.2 COMPONENTS DESIGN

### A) CHASSIS:

- **Movement :**

Direction control 100 rpm geared motors provide the necessary forward motion on the floor, powered by 12V batteries and the directional control is done using a programmable NODEMCU ESP 8266, controlled by mobile phone. Infra-Red sensor is fitted at the front for obstacle detection.

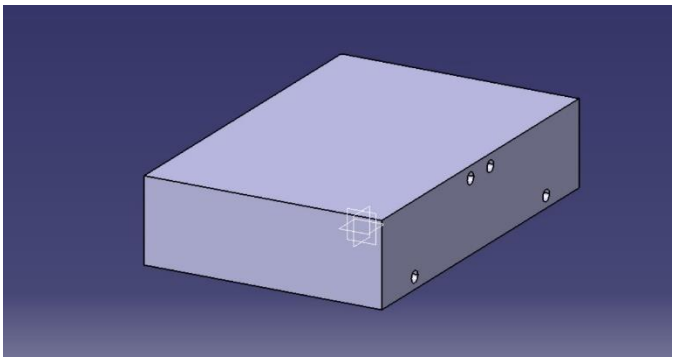

**Fig. 4.2.1 –** Chassis

- **CHASSIS CONSTRUCTION:**

Mild steel is selected for the metallic base because it has light weight. The thickness of the chassis is 2mm. The dimensions of chassis were decided according to the requirements considering difficulties in construction and overall weight of the machine. Two 100 mm diameter tires are fixed in symmetry to balance the COG (center of gravity) of chassis. Provision for scrubbers was made by making holes at the front side of chassis. The thin flat wiper that is 'T' shaped was screwed to the chassis at the rear. The roller scrubbers were placed at the front of the chassis. the thin wiper which is attached at rear is inclined at the angle so that it touches the ground to wipe the water The angle given ensures that the water is carried along with wiper after cleaning, making the duct collection part for floor cleaning very easy. The scrubbers present at the front make sure that floor must not have any hard spots. The wiper also collects dust that is larger in size. The 'T' shaped wiper at the rear is provided with a screw attachment such that it allows an advantage of adjusting height as per the surface roughness. The two scrubbers at the front are rotated using 100 rpm motors. This cleans the dust of floor through which vehicle moves.

## CALCULATION OF CHASSIS:-

Given: Total Weight = 4.25Kg

Chassis Weight = 1.25Kg

Wheels Weight = 125 * 4 = 500gm

Solution:

Total Weight = Chassis weight + Wheels weight + Components Weight

4.25 = 1.25 + 0.5 + X

X = 2.56Kg

Maximum Load = 2.5 * 9.81

= 24.525 N

So we assume that maximum load is 24.525N

Area = 350 * 250
= 87.50 $m^2$
GR = 4.25kg * sin (35°)
= 22.94 N

Stress=Force / Area
= 22.94/87.50

Ultimate strength = load / Area

= 24.525/87.50

= 0.28028

Factor of safety = 1.0691

### B) WHEEL DESIGN:

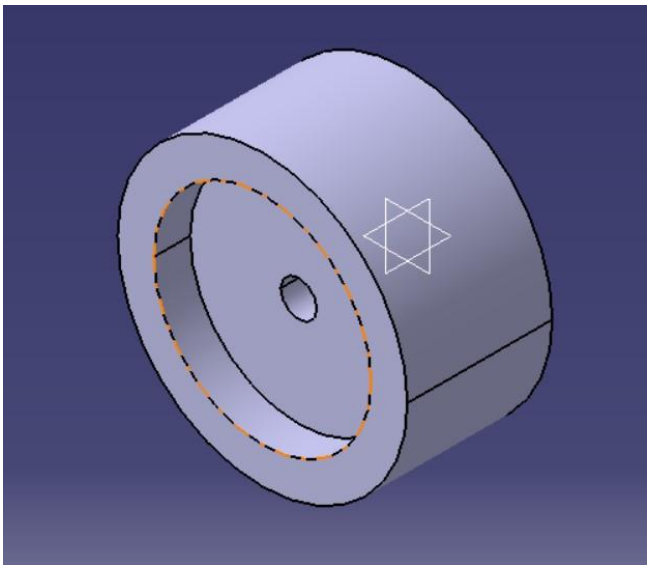

**Fig. 4.2.2 –** Wheel

This is a Robot Wheel with 100mm Diameter and 40mm Width. These wheels are mostly used for small robots since they are simple to install, sturdy and inexpensive. These wheels have an 8mm hole for a shaft with the screw for fitting makes it very easy to mount on motors.

**Calculations for wheels :**

**Maximum tractive force :**

Mass of robot: 4.25 kg

Weight of robot: 41.69 N

No of wheels: 4

Wheel Radius: 100 mm

$F_{t\ (max)}$: Maximum tractive force

μ: Coefficient of friction

N: Normal force at wheel

$F_{t(max)} = \mu * N$

$= 0.4 * 41.69$

$= 16.67$ N

**Maximum acceleration of Robot:**

$a_{r(max)}$ : Maximum acceleration of robot

$a_{r(max)} = F_{t(max)} / m$

$= 16.67 / 4.25$

$= 3.922$ m/s$^2$

**Rolling resistance force:**

$F_{rr}$ : Rolling resistance force

$C_{rr}$ : Rolling resistance coefficient

N : Normal force at wheel

$F_{rr} = C_{rr} * N$

$= 0.01 * 41.69$

$= 0.4169$ N

**Wheel force/tractive force for maximum acceleration of robot:**

$F_t$ = Tractive Force

$F_t - F_{rr} - F_d = m * a_{r(max)}$

$Ft - 0.42 - 0.14 = (4.25)*(3.922)$

$F_t = (4.25) * (3.922) + 0.42 + 0.14$

$F_t = 17.22$ N

## 4.3 COMPONENTS SELECTION

### 1. NODEMCU - ESP8266 Wi-Fi Development Board

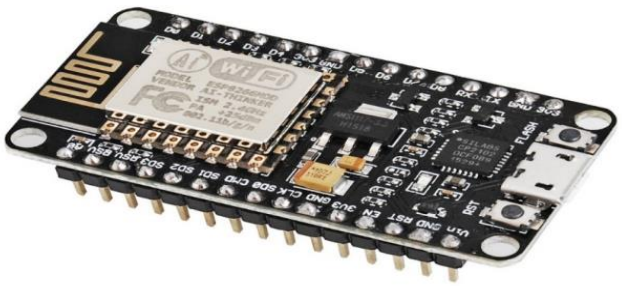

**Fig 4.3.1 -** NODEMCU – ESP8266

The NODEMCU with cp2102 Wi-fi Board is an all-in-one microcontroller Wi-fi platform that makes developing Wi-Fi and IoT projects a breeze. The board relies on the highly popular ESP8266 Wi-fi Module chip with the ESP-12 SMD footprint. This Wi-Fi development board already has all of the components needed to program and upload code to the ESP8266 (ESP-12E). It includes a USB to serial chip upload code, 3.3V regulator, and logic level converter circuit, allowing you to upload and connect your circuits instantly. This board contains the ESP-12E chip with a 4MB non-volatile storage so there aren't any difficulties in long code projects. The ESP8266 NODEMCU with cp2102 development board - a real plug-and-play solution for cheap projects using Wi-fi. Simply install your USB driver after the module is pre-flashed with NODEMCU firmware. The NODEMCU is an open-source project and you'll be able to find all the planning files and then on from their git hub page.

### 2. IR Sensor

**Fig. 4.3.2 -** IR Sensor

IR technology is used mainly in industries for different purposes. For example, televisions uses it so as to understand the signals which are transmitted from a remote control. The main benefits of IR sensors are their simple design, their convenient features and low power usage. The signals of IR sensors are not noticeable by the human eye. The IR radiations in the electromagnetic spectrum can be found in the regions of the microwave and visible. Usually, the wavelengths of these waves ranges from 0.7µm to 1000µm. The IR spectrum can be divided into three regions which are near-infrared, mid, and far-infrared. The near IR region's wavelength ranges from 0.75 to 3µm, the mid-infrared region's wavelength ranges from 3 to 6µm & the far IR region's wavelength is higher than 6µm.

### 3. Motor Driver L298N

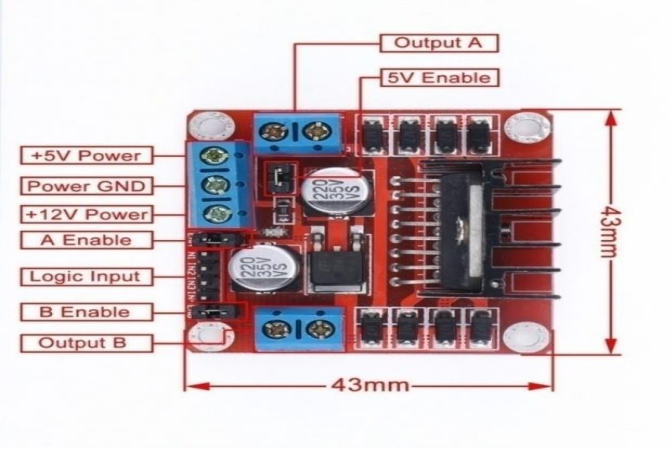


**Fig. 4.3.3 -** MOTOR DRIVER L298N

The ST L298N dual full-bridge driver, an integrated monolithic circuit during a 112-lead Multi-watt and Power SO20 package, is employed within the Double H driver module it is a high-voltage, high-current twin full-bridge driver which will handle typical TTL logic levels and drive inductive loads including relays, solenoids, DC motors, and stepping motors. The device is enabled or disabled independently of the input signals using two enable inputs. Each bridge's bottom transistors' emitters are coupled together, and an external sensing resistor is connected to the matching external terminal. To permit the logic to control at a lower voltage, an extra supply input is added.

**Wiring L298N motor driver module with NODEMCU:**

Start by connecting power supply to the motors. In our experiment we are using DC Gearbox Motors (also referred to as 'TT' motors) that are usually found in two-wheel-drive robots. They're rated for 3 to 12V. So, we'll connect external 12V power supply to the VCC terminal. Considering internal dip of L298N IC, the motors will receive 10V and can spin at slightly lower RPM.

Next, we want to produce 5 Volts for the L298N's logic circuitry. We'll make use of the on-board 5V regulator and derive the 5 volts from the motor power supply so, keep the 5V-EN jumper in situ.

Now, the input and enable pins (ENA, IN1, IN2, IN3, IN4 and ENB) of the L298N module are connected to 6 Arduino digital output pins (9, 8, 7, 5, 4 and 3). Note that the Arduino output pins 9 and three are both PWM-enabled. Finally, connect one motor to terminal A (OUT1 & OUT2) and therefore the other motor to terminal B (OUT3 & OUT4). You'll be able to interchange your motor's connections; technically, there's no right or wrong way.

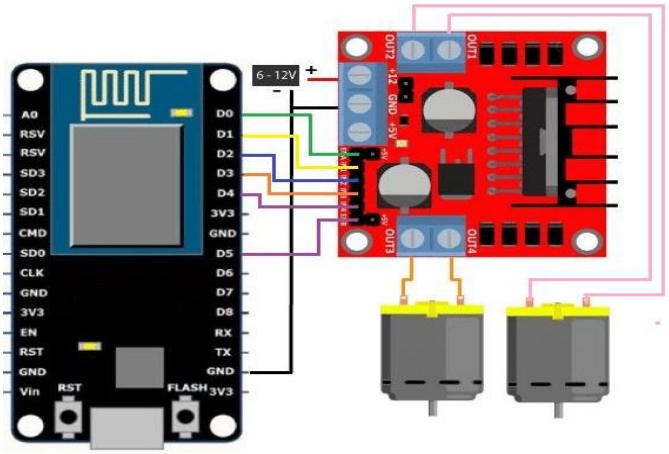


**Fig. 4.3.4** - Circuit Diagram

- The signal obtained from the controller cannot be used to activate motors directly. This is due to the fact that the controller's capabilities is extremely limited.
- The voltage is around 5 volts.
- The motors, on the other hand, require 12 volts to operate.
- The IC used in this driver board is the L298N.

## 4. Gear Motor

Connect your Arduino DC motor (BO) Battery Operation. Basically it converts electrical energy into mechanical energy. Why DC gear motor used in robot Motor control circuit. DC motor concept of where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. The DC motor is assembled in inside with multiple gear setups. Speed of motor is measured in rotations per minute which is called RPM. RPM means Revolution per Minute. This setup helps in reducing motor speed and increasing the torque. In all type of micro-controller based Robots, this type of DC motor can be used. Dc motor in any DC motor, RPM and Torque is inversely proportional. In all DC gear motor Pulse Width modulation (PWM) circuit is used. For light weight robot required low power plastic gear DC motor.

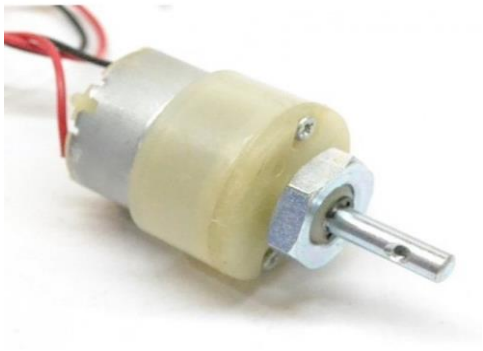

**Fig. 4.3.5** - Gear motor

## 5. Water Pump:

**Fig. 4.3.6** - Water Pump

The R385 6-12V DC Diaphragm Based Mini Aquarium Water Pump is a non-submersible pump that can handle a wide range of liquid movement applications. It has adequate pressure to create a spray system when used with a nozzle. This pump is able to handle heated liquids up to a temperature of 80°C and when it is suitably powered also can suck water through the tube from up to 2 m and pump water vertically up to 3 m. Possible uses/projects includes : a small aquarium pump, automatic plant watering system, making a water feature or music activated dancing water features to name but a few. The pump runs very quietly when pumping the liquid. As it is also capable of pumping air, it makes noises while pumping the air.

This particular pump requires current between 0.5 – 0.7A DC and voltage between 6 – 12V and delivers its maximum operating values when its power is at the upper end of these ranges. This pump also can be used to provide water to plants, make a fountain or waterfall and even can change fish tank water. It operates quietly, with a sound level of less than 30 decibels. The pump has a suction cup inside and also a filter which helps stick it to smooth surfaces tightly.

### 4.4 CALCULATIONS:

**Table 4.4.1** – Dimensions

| Title | Dimensions |
|---|---|
| Length of chassis | 350 mm |
| Height of chassis | 80 mm |
| Width of chassis | 250 mm |
| Thickness of sheet | 2 mm |
| Weight of Robot | 4.25 kg |
| Diameter of wheel | 100 mm |
| Total height of Robot | 100 mm |

**Table 4.4.2 -** Motor Details

| Title | Dimensions |
|---|---|
| Motor Diameter | 35 mm |
| Weight | approx. 150 gm. |
| Torque | 20 kg cm. |
| Base Motor RPM | 100 RPM |

**Design Considerations / Calculations (Force, Pressure, Thrust, Torque, Speed):**
No of Motors used: 4
Specification of motor: 12V, 0.46 Amp
Power = V * I
= 12 * 0.46 = 5.52 watt
Speed of Motor: 100 RPM
Power (in Watt) = torque * 2 * (3.147) * RPM
5.52 = torque * 6.294 * 100
Torque = 0.00877 N-m

**Drive wheel motor torque calculations:**
When we are selecting the motor of required maximum torque, number of factors is to be considered. They are as follows:
Different criteria:

- Gross vehicle weight (GVW): 4.25kg
- Weight on each wheel ($W_W$): 50 gm
- Wheel radius ($R_w$): 100mm
- Top speed ($V_{max}$) : 2m/sec (desired)
- Acceleration time ($t_a$): 1 sec (desired)
- Max. Inclination angle (α): 35 degree (Assume) Worst working surface: Mud (medium)

Now we have to calculate the total tractive effort (TTE) required for the vehicle in order to choose the motor of required torque:

**TTE = RR + GR+ FA**

Here:
TTE = total tractive effort

- RR = force necessary to overcome rolling resistance
- GR = force required to climb a grade
- FA = force required to accelerate to final velocity

Now we have to calculate the different components of the above equation.
The calculation is as follows:
**Step One: To determine rolling resistance**
Rolling Resistance (RR) is the force necessary to propel a vehicle over a surface. The worst conditions encountered by the vehicle on different surfaces are taken in consideration.
**RR = (a+bV) W, N**
Where:
RR = rolling resistance
W = weight of vehicle
V = velocity of the vehicle (2m/s) a, b= constants
a = 0.0112
b = 0.00006

RR = [0.0112 + (0.00006 * 2)] (40 * 9.81)
= 0.01132 * 392.4 = 4.56 N
**Step Two: To determine grade resistance (GR)**
The amount of force necessary to move a vehicle up a slope or grade. Here we have to take the value of the inclination angle into the equation.
**Gradient resistance: GR = W Sinα**
Where:

- GR = gradient resistance
- W = vehicle weight
- α = max. Inclination angle [degrees]

**GR** = 3.74kg * sin (35°)
= 22.94 N
Step Three: To determine acceleration force
Acceleration Force ($F_A$) is the force necessary to accelerate from rest to maximum speed in a desired time.

$$F_A = \frac{W\,[kg] * V_{max}\,[m/s]}{(g\,[m/s^2] * t_a\,[s])}$$

Where:
$F_A$ = force of acceleration
W = weight of vehicle
$V_{max}$ = max.
Speed (ta) = time required to achieve max.
Speed FA = 3.74 * 2 (9.81 * 1)
= 8.15 N
Step Five: To determine wheel motor torque
Now we have to calculate the required torque (Tw.) in order to verify that the vehicle will perform according to tractive effort and acceleration.

**$T_w$ = TTE * $R_w$**

Where:

- $T_w$ = wheel torque [Nm]
- TTE = total tractive effort [N]
- $R_w$ = radius of the wheel/tire [m]
- Tw = TTE * $R_w$ = 35.65 * 0.152 = 5.419 N-m

**Torque on each driving motor = total torque / no. of motor used**

= 5.419 / 4
= 1.355 N-m

## 5. FABRICATION

**1. Cutting Operation**: It involves the removal of excess material from a MS sheet and obtained 410 x 350 mm as a remaining part.

**2. Welding Operation**: It involves welding of two metal strips below the chassis for support.

**3. Grinding Operation**: It involves two types of operations i.e. cutting and grinding.

**4. Drilling Operation**: It involves drilling operation in which two holes are drill at the front side of chassis having 175mm distance between both holes.

**5. Assembly**: It involves assembly of chassis, wheel and motors.

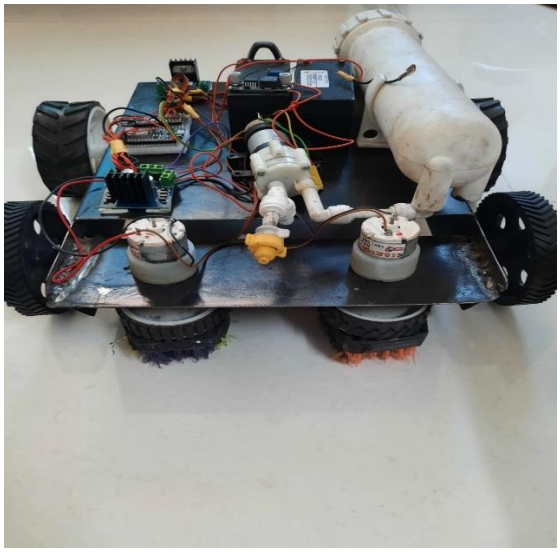

**Fig 5.1** - the model after assembly

## 6. TESTING

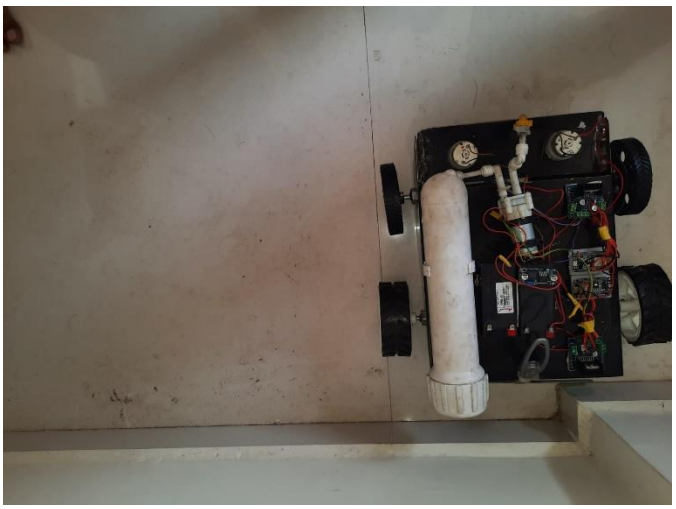

**Fig 8.1** - floor before cleaning

Testing of an automatic floor cleaning robot can be done in the following steps:

- The hardware assembly of the automatic floor cleaning robot connect to the battery and press the on button.
- After that, the automatic floor cleaning robot prototype will turn on like the supporting devices, namely NODEMCU ESP8266, Infrared sensor, Motor driver L298 and DC Motor.
- The infrared sensor will detect the distance After the automatic floor cleaning robot prototype is connected to its supporting devices,

When the automatic floor cleaning robot prototype detects the distance that is an obstacle the robot automatically looks for a direction where there is no a barrier.

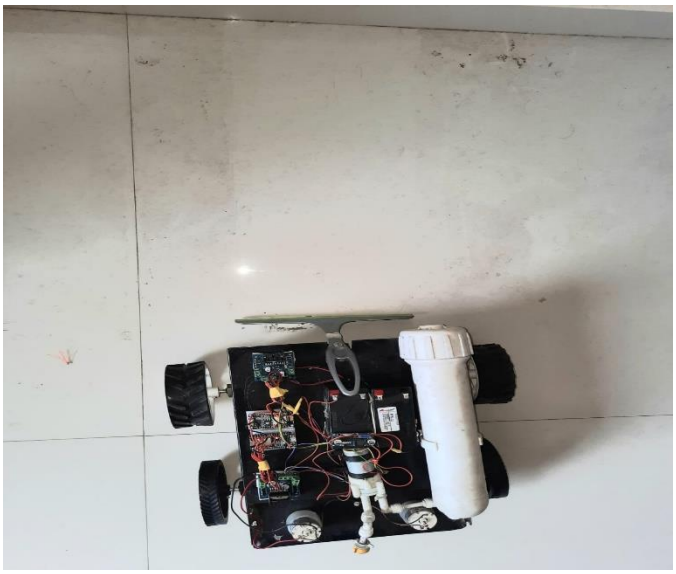

**Fig 8.2** - floor after cleaning

## 7. COST

**Table 7.1** - cost of model

| Sr. No. | Name of Parts | Specification | Unit price | Qty. | Total price |
|---|---|---|---|---|---|
| 1. | NODE MCU | ESP 8266 | 330 | 2 | 660.00 |
| 2. | DC Battery | 12 V 1.5 Ampere | 570 | 2 | 1140.00 |
| 3. | Scrubber | Rubber | 300 | 2 | 600.00 |
| 4. | DC Adapter | 12 V | 280 | 1 | 280.00 |
| 5. | MS sheet | 2*4 Sq ft; t = 2 mm | 1200 | 1 | 1200.00 |
| 6. | Motor Driver | L298N module | 180 | 1 | 180.00 |

| | | | | | |
|---|---|---|---|---|---|
| 7. | Wheel | Plastic | 120 | 4 | 480.00 |
| 8. | Infrared Sensor | 5VDC Operatig voltage | 150 | 1 | 150.00 |
| 9. | Gear motor | 12 V | 200 | 4 | 800.00 |
| 10. | Water pump | DC 6V to 12V (1 amps) | 179 | 1 | 180.00 |
| 11. | Wiper | Fiber | 30 | 1 | 30.00 |
| **Total** | | | | | 5700.00 |

## 8. RESULT AND DISCUSSION

As we successfully tested the developed model the following results were obtained :

- We have developed the Wi-fi controlled mobile robot which can detect the obstacles ahead using IR sensor which results in avoidance of collision during cleaning. Thus the product developed is fully operational on wet and dry surfaces as it is tested in a room which results in successful outcome.
- As a result of testing the machine increases the overall work efficiency as it is totally controlled by mobile application and operations such as sweeping and changing the path in case of obstacle are performed automatically which reduces human efforts and time taken to clean the floor as compare to manual cleaning of floors. Maintenance requirements are also minimized.
- As a result of using proximity sensors in machine we get more accuracy and effectiveness in movement as it has the capability to detect as well as move in the direction of dust and resulting in better cleaning of floors. It also results in reducing labor cost in commercial areas as only one person is required to operate the machine.

Overall the project is successful to its intent as well as the concept is very much helpful and in future there is scope of development in mechanical parts. As a whole this is a successful product developed that can be used in current Indian households.

## 9. CONCLUSIONS

The multiple applications in this automatic floor cleaning machine provides a wide range of functions in which we can clean the pipe, scrubbing of surface for proper cleaning of the floor, remove dust and dirt from the road.

Existing Experiment and its analysis provides following remarkable points:

- The use of innovative technology reduces the human effort and cost while increasing the effectiveness of floor cleaning.
- It reduces human efforts which means more frequent floor cleaning which results in increase in overall cleanliness and creates healthy well-being.
- This kind of small steps in technology advancement will have higher impact in future and will also make India a developed country.

The main motive of the project was to cover the aspects of cleanliness in the society.

## 10. FUTURE SCOPE

This robot can be modified in the future to perform more efficiently and will serve more purposes. Efficiency of floor cleaning can be improved. By using IR sensor and by adding other electronic components we can make a device that perfectly work for cleaning. If we add a timer so that it can work for a special time by starting automatically. This floor cleaning robot has some limitations such as it cannot clean stairs so it can be modified for cleaning of stairs. This floor cleaning robot can be modified for cleaning of more than one room by only one robot. This floor cleaning robot also can't clean circular shaped room so we can also work on that. So these are some important future scopes that we should look upon.

The model that is present above in the report can be improve as much as possible.

Few recommended improvements are as follows:

- By employing PVC polymer to construct the chassis, the overall weight of the system can be lowered.
- The setup can be completely automated without the need for human intervention. The sequence of operations for the suction portion can be automated using Programmable Logic Control.
- Vacuum removal can be used to collect the dust.
- Using a high-quality on-board camera, an image processing technique can be used to analyze the surface cleaning efficiency.

UV (ultraviolet light) exposure for germ-free cleaning can be fitted on the vehicle.

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