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DESIGN & DEVELOPMENT OF FIRE FIGHTING ROBOT

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Abstract : This advanced project allows a user to control a fire fighter robot equipped with water tank and gun remotely wirelessly for extinguishing fires. For these purposes the system uses an Bluetooth module for wireless remote operation along with rf receive based microcontroller circuit for operating the robotic vehicle and water pump. The rf based remote transfers users' commands through rf signals which are received by the receiver circuit. The receiver circuit now decodes the data commands sent. It then forwards it to the microcontroller. Now the microcontroller processes these instructions and then instructions the vehicle motors to run the vehicle in desired directions. It also operates the water pump motor and pump direction motor to spray water based on users' commands. This allows the user to operate the robot and put off the fire by standing at a safe distance.

***IndexTerms* - Bluetooth Module, Microcontroller, Water pump & Fire Fighter.**

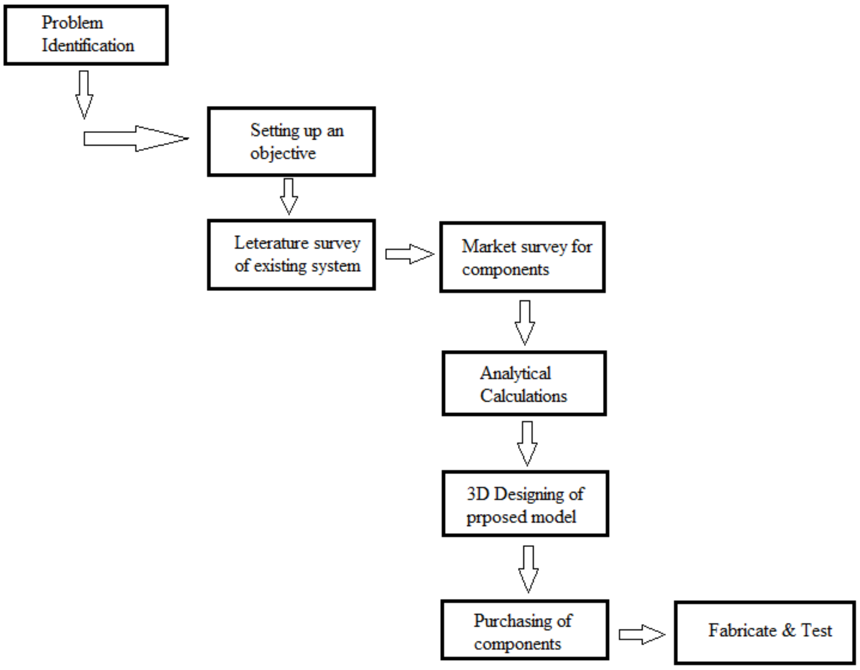
1. INTRODUCTION

When a robot which is designed to withstand high temperature and capable of extinguishing fire is used in industries, the fire can be easily sensed by the robot and quickly extinguished within a very short time. Thus, robotics can be effectively used to extinguish fire by cyber security automation process A similar transformation can lead to analogous benefits for fire protection and firefighting. The introduction of appropriate technologies and systems will facilitate the fusionand use of a wide array of real-time sensor data from the community, buildings, fire fighters, equipment, and fire apparatus during not only an emergency event but also the pre-events (e.g., code enforcement, prevention, training) and the post-events (e.g., overhaul, salvage, investigation). These data have the potential to enhance fire protection and situational awareness on the fire ground and, together with information from cloud-based databases, will provide valuable input for computational models and decision tools. The result will be better predictions of the likely evolution of an incident, leading to better tactical decisions. The use of technology in this manner, referred to here as Smart Fire Fighting, includes all areas of fire protection engineering and phases of fire service emergency response: pre-incident, during-incident, and post-incident. Smart Fire Fighting will transform traditional fire prevention and protection strategies and fire-fighting practices by ensuring the flow of critical information where and when it is needed

1.1 PROBLEM STATEMENT

- Just by using the wrong class of fire extinguisher, you can make things worse. Massive flashes and huge flames might occur, and you may result burned or electrocuted. Given the scenario, it is possible for the electricity to run through the conductive water or foam, and kill you.
- All fires can be extinguished by cooling, smothering, starving or by interrupting the combustion process to extinguish the fire. One of the most common methods of extinguishing a fire is by cooling with water.
- Manual process takes time
- More labours are required
- Wages must be provided.

2.METHODOLOGY



2.1 PROPOSED SYSTEM

The robot will be constructed from scratch using plywood frame work. Using plywood from the framework is desirable for its stability and strength. Build a chassis such that the robot has to enough space for the water can and all the electronic components equipment's that required for this project. The chassis uses four rubber dummy wheels. Fixed two dc motor on each side at the bottom and water can between two plywood frames. The sensors have to be fixed in front of the robot such way that sensor can detect the flame in front of the robot. Design the Circuit using Arduino and mounting all electronic components on it.

The outlet of the water pump should be fixed at centre of the robot facing towards front of the robot. Wireless camera is for user to detect the fire.

2.2 Software development

The robot is implemented using simple open-source technologies. For communications a modified Arduino IDE module is used.

2.3 Schematic diagram

The Arduino UNO development board is sued to control this firefighting robotic system, which is made up of HC-SR04 sensors. A gas sensor (MQ2) for sensing hazardous smoke, a temperature sensor (LM35) for more precise temperature measurement, and a fire flame sensor (IR) for detecting and sensing the approaching fire are all mounted on a servo-motor for obstacle detection and free path navigation. In addition, for extinguishing the flames, it also makes use of a water tank and a spray gun mechanism.With the aid of a 12V pump, water is pumped from the main water tank to the water nozzle.

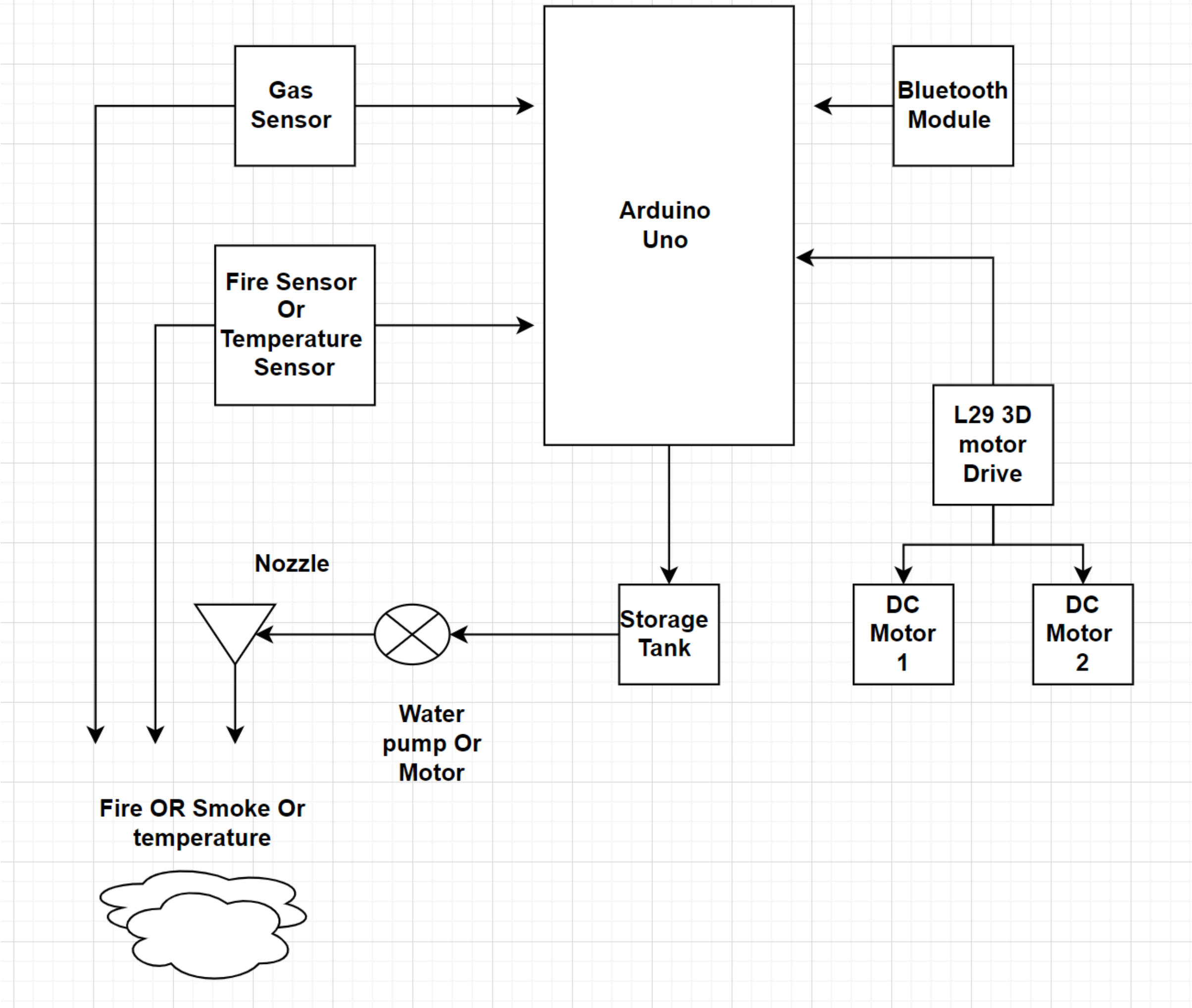


Fig.No. 2.3.1 Schematic diagram

3. COMPONENT DESCRIPTION & IT'S USES

3.1 Arduino Board

In this Project Arduino is used as Main Controller, in simple Arduino is an open-source electronics platform based on easy-to-use hardware and software to Control And manipulate the date Received with internal components like sensors and motors.

Arduino Board are able to read inputs Like- light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board.Following slides gives a brief description of Arduino and its Pin configuration.

Table3.1.1 Specification of Arduino Board

Board	Name	Arduino UNO R3
	SKU	A000066
Microcontroller	ATmega328P	
USB connector	USB-B	
Pins	Built-in LED Pin	13
	Digital I/O Pins	14

	Analog input pins	6
	PWM pins	6
Communication	UART	Yes
	I2C	Yes
	SPI	Yes
Power	I/O Voltage	5V
	Input voltage (nominal)	7-12V
	DC Current per I/O Pin	20 mA
	Power Supply Connector	Barrel Plug
Memory	ATmega328P	2KB SRAM, 32KB FLASH, 1KB EEPROM

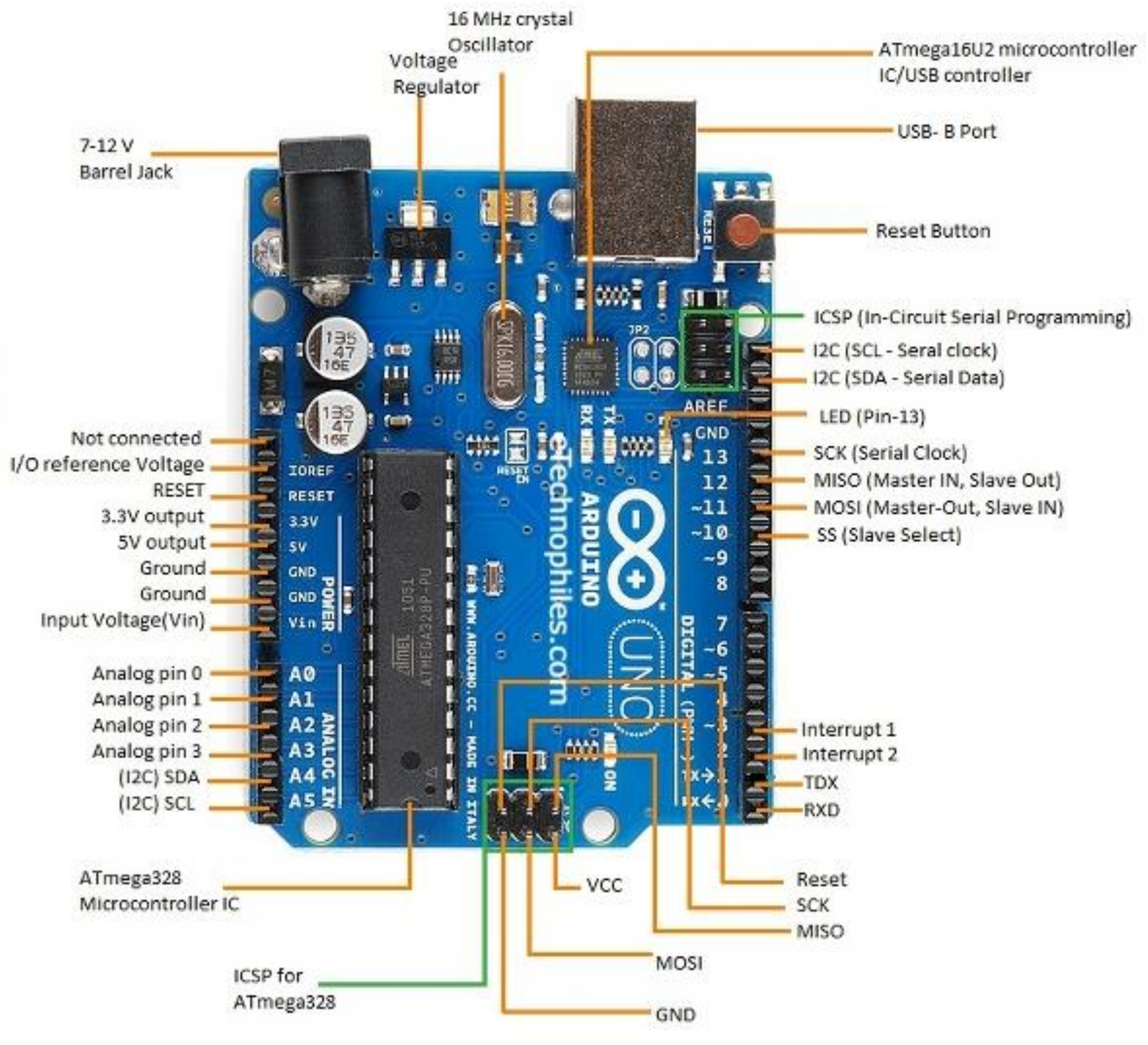


Figure3.1.1 Arduino Pin Description

3.2 MQ-135 gas or smoke sensor

The MQ-135 Gas sensor can detect gases like Ammonia (NH3), sulfur (S), Benzene (C6H6), CO2, and other harmful gases and smoke. Similar to other MQ series gas sensor, this sensor also has a digital and analog output pin. When the level of these gases go beyond a threshold limit in the air the digital pin goes high. This threshold value can be set by using the on-board potentiometer. The analog output pin, outputs an analog voltage which can be used to approximate the level of these gases in the atmosphere.

3.2.1 Technical Specifications of MQ135 Gas Sensor

- Operating Voltage: 2.5V to 5.0V
- Power consumption: 150mA
- Detect/Measure: NH3, Nox, CO2, Alcohol, Benzene, Smoke
- Typical operating Voltage: 5V
- Digital Output: 0V to 5V (TTL Logic) @ 5V Vcc
- Analog Output: 0-5V @ 5V Vcc

3.2.2 Pin diagram of mq-135 & IDE design

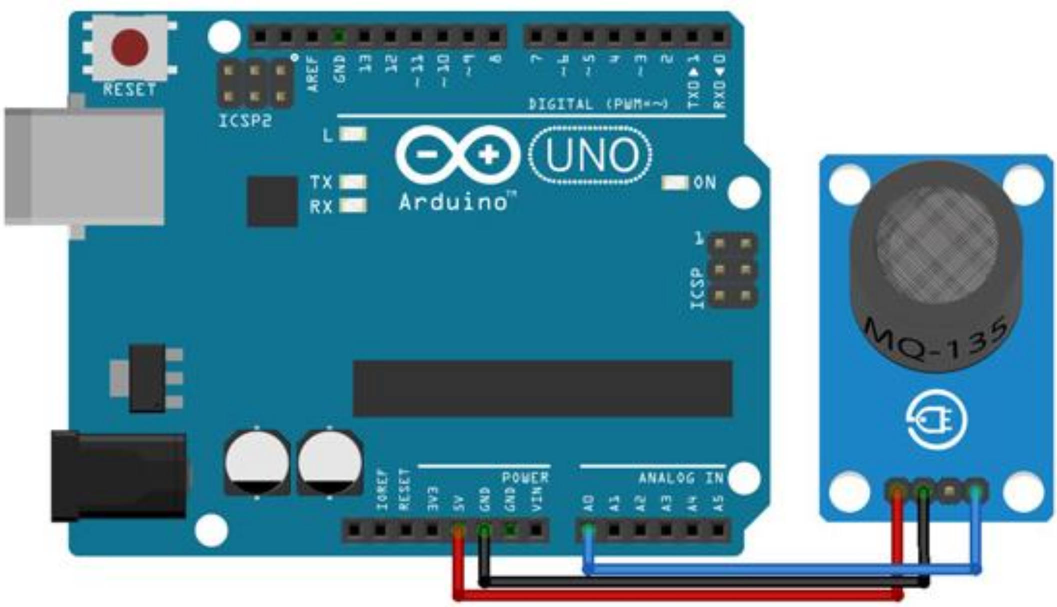


Figure3.2.1 Pin Description of Arduino with MQ 135 Sensor

Pin No.	Pin Name
1	Vcc(+5V)
2	Ground
3	Digital Out
4	Analog out

Figure 3.2.2 Pin Diagram

3.3 NTC Thermistor Temperature Sensor Module & IDE design

It is very sensitive to ambient temperature. It is generally used to detect the temperature of the surrounding environment. Through potentiometer adjustment, it is possible to change the temperature detection threshold. DO output can be directly connected to the micro controller to detect high and low, by detecting temperature changes in the environment.

3.3.1 Specification

Working voltage: 3.3V-5V

Output form: DO digital switching outputs (0 and 1) and AO analog voltage output

Fixed bolt hole for easy installation

Small PCB board size: 3.2cm x 1.4cm

uses a wide voltage comparator LM393

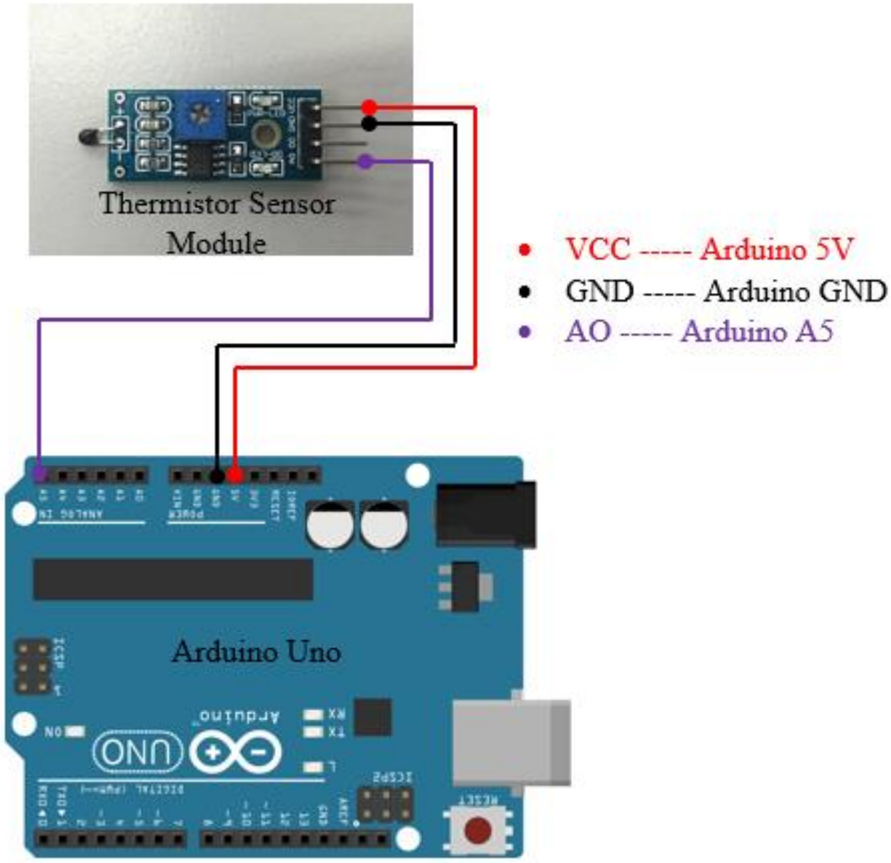


Figure 3.3.1 pin diagram of temperature sensor

3.3.2 Battery Description

- 12 Volts 1.3 Amp Sealed Lead Acid Rechargeable Battery
- Maintenance-Free Operation
- Position-Free and Leakage-Free
- **Clamps** are used to hold components like batteries, motors and other elements rigidly. Hear we had taken a standard available L-clamp in market of thickness 3mm.Material =Aluminium (here we have considered weight optimization, as we can also adopt steel material but its mass density is more compared)

4. DESIGN/ ANALYSIS / ACTUAL WORK CARRIED OUT FOR THE SAME

4.1 Water motor power.

- Pump power P(kW) in kilowatts is equal to the product of the rate of flow q(m3/hr) in cubic meter per hour, fluid density ρ(kg/m3) in kilogram per cubic meter, gravity g in m2/s, pump differential h(m) head in meter and the differential pressure p(Pa) in Pascal or N/m2 divided by 36,00,000.

Pump Power $P_{(\mathrm{kW})} = q_{(\mathrm{m^3/hr})} \times \rho_{(\mathrm{kg/m^3})} \times \mathrm{g}_{(\mathrm{m^2/s})} \times \mathrm{h}_{(\mathrm{m})} \times \mathrm{p}_{(\mathrm{Pa})}/3600000$ (4.1)

- Let's assume Q= 2.5 liters/ min = 0.6 m^3/hr
- Water Density = 997 kg/m³
- Spraying Arm length = 0.5 m
- Assume Head = 1 m from tank to nozzle.

4.2 Design/ Analysis / Actual work carried out for the same

Circumferential = πr^2 (4.2)

G = 9.81 gravity

H = 1m

Assume Pressure required to supply water from inlet to outlet = 2.5 - 3 pascal

Power $=\frac{0.6*997*1*9.81*2.5}{3600000}$ =4.0752^-3 kw (4.3)

- Power = 4.0752 watts required to deliver the water from tank to nozzle.
- According to availability we will select 4 watts water pump from market

4.3 Submersible Pump

Standard available motor in market

Specifications and Features of R385 6-12V DC Diaphragm Based Mini Aquarium Water Pump: -

- Model : R385
- Rated Voltage : DC 6V to 12V (1 amps)
- Working current: 0.5A to 0.7A (Max)
- Power: 4W-7W
- Max Lift: 3m

Figure 1.4DC Diaphragm

- Max Suction: 2m
- Max Water Temp: 80 °C
- Pump Size: 90mm * 40mm * 35mm approx
- Fluid: 0-100 ° C
- Input/output tube diameter: outer 8.5mm, inner 6mm approx.
- Max Current: Up to 2 Amps while starting up
- Life: up to 2500 Hours
- The maximum flow rate of up to 1 – 5L/min.

5. ANALYTICAL CALCULATION

5.1 Design of Support or frame

5.1.1 Area of rectangular

- We had taken a teak wood frame which is available in the market of thickness 4 mm and length, width according to requirement.

Thickness = 5 MM

W = 300 MM

L = 400 MM

The total surface area of the rectangular prism is given by:

A = 2(lb + bh + lh) (5.1)

= 2((400 x 300) + (300 x 5) + (400 x 5))

= 247000 MM2

Mass of frame wit Material Ply-wood = 0.385 Kg

= 0.127 x 9.81

= 3.776 N

From CATIA v5 software @ Area = 247000 mm2 = 0.247m2

Moment of Inertia ICM = 1/12 x M (w2 + l2) (5.2)

= 1/12 x 3.776(400^2 + 300^2)

= 78666.6 Nmm2

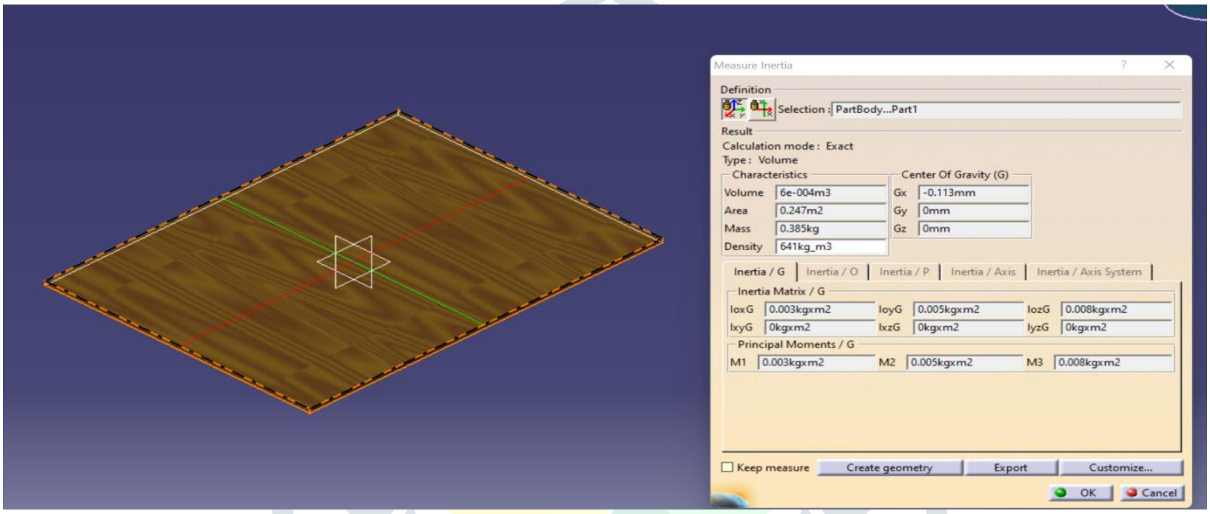


Figure5.1 properties of plywood from Catia v5

Assume load on the frame including all components = 5Kg

Mass of water storage = 2.5-3 litters

= 3kg

Total mass on frame = 5+3

= 8Kg

= 8*9.81

= 78.48 N

FOS = 1.5

= 78.48 X 1.5

= 117.72 N

= 120 N

Perpendicular distance = 400 / 2

= 200 mm

M = 120 X 200

= 24000 Nmm2

M = 24000 Nmm2

I = 78666.6 Nmm2

Y = Distance of the layer at which the bending stress is consider

=5/2 = 2.5 mm

Sigma b= M X Y / (I) (5.3)

= 24000 X 2.5 / (78666.6)

= 0.762 Mpa

0.127 MPa <Plywood 13.8 MPa Ultimate Yield strength Hence Design is safe.

5.1.2 Motor selection on total pay load of component

Hence total weight on the frame is taken in frame calculation = 120 N

No Motors required = 2 at back side wheels

Load is distributed into 4 wheels = 120/4 =30N

Actual load = total load / no. of Motors

= 120/2

= 60N

Diameter of inside hole of a wheel 10mm

Torque = ½ Force X Diameter

=½ X 60 X 10mm

=300 N.mm

=0.3 Nm.

=3.059 Kg-cm torque

Note

Diameter =diameter of wheel (d= 90 mm) standard available in market, internal diameter (d 10mm).

Force =total force including all components (30N) at each wheel

5.1.3 Motor selection from market

- Johnson Geared Motor (B Grade) 12 V DC 200 RPM – 100 Rpm are available with same torque.
- It is a simple DC motor featuring metal gearbox for driving the shaft of the motor, so it is a mechanically commutated electric motor which is powered from DC supply.
- The Johnson Geared Motors are known for their compact size and massive torque-speed characteristic.
- The motor will run smoothly between the voltage range 6 to 18 V DC and give you 200 RPM at 12V supply. It provides the torque of 3.9 kg-cm at 200 RPM.

Figure 5.2 DC Motored

5.1.4 Specification of motor

Table 5.1 Specification of motor

Rated Base Motor RPM	18000
Gear Material	Metal
Rated Speed (RPM)	200
Operating Voltage (VDC)	6 ~ 18
Nominal Voltage (V)	12
Rated Torque(kg-cm)	3.9
Stall Torque(Kg-Cm)	15.6
No-Load Current (mA)	300
Load Current Max (mA)	900
Shaft Diameter (mm)	6
Shaft Length (mm)	30
Gearbox Diameter (mm)	37
Motor Diameter(mm)	27
Motor Length (mm)	62
Weight (gm)	162
Shipment Weight	0.18 kg
Shipment Dimensions	10 × 4 × 4 cm

5.1.5 Clamp For Holding Motor Rigidly

- Clamps are used to hold components like batteries, motors and other elements rigidly. Hear we had taken a standard available L-clamp in market of thickness 3mm.
- Material =Aluminium (here we have considered weight optimization, as we can also adopt steel material but its mass density is more compared).

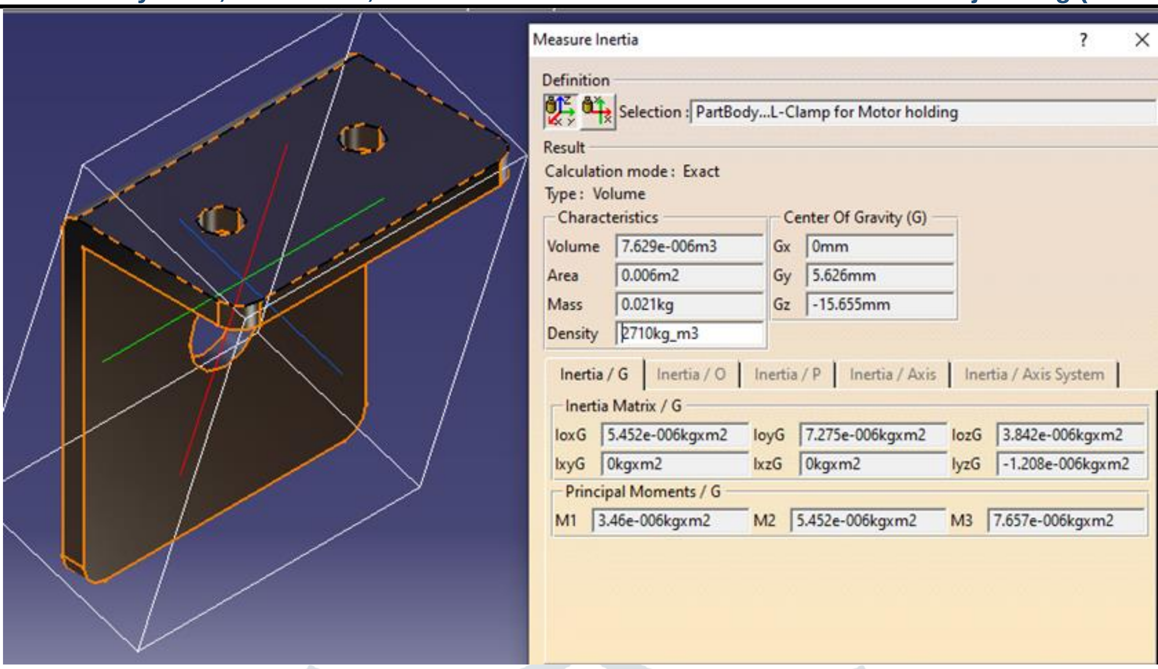


Figure 5.3 Clamps for Motor properties

- Clamps for holding motors rigidly during motion
- Material = Aluminium
- Properties or specification
- Volume = 7.629x106 m2
- Area = 0.006 m2
- Mass = 0.021 Kg
- I = 3.842 gcm2

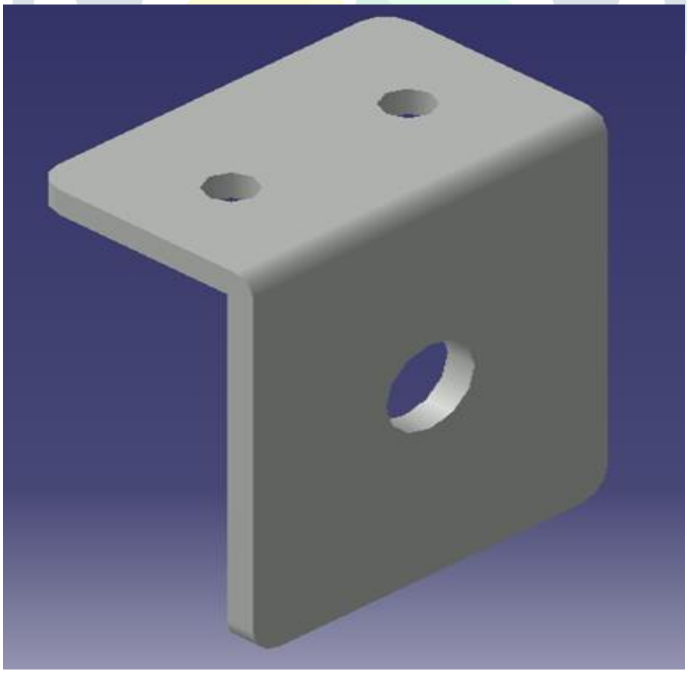


Figure 5.4 Clamps for Motor

5.1.6 Discussion

- Hence selection of frame material and its dimension
- Clamp for holding motors and its material,
- Wheels

- DC Motors
- Water Pump
- Dimensions and calculations are done and standard component has been selected up on the market survey as given in above presentation data.
- Hence design and preparation of " Fire Fighting Robot is successfully Completed as per the standard.

6. DESIGN

- Design has been done using CATIA v5 CAD Software
- First all the sub parts are Designed using part design module.
- Then all the sub parts are assembled using product module in the CATIA software.
- Finally assembled part drafting has been done using draft module and saved as a pdf.

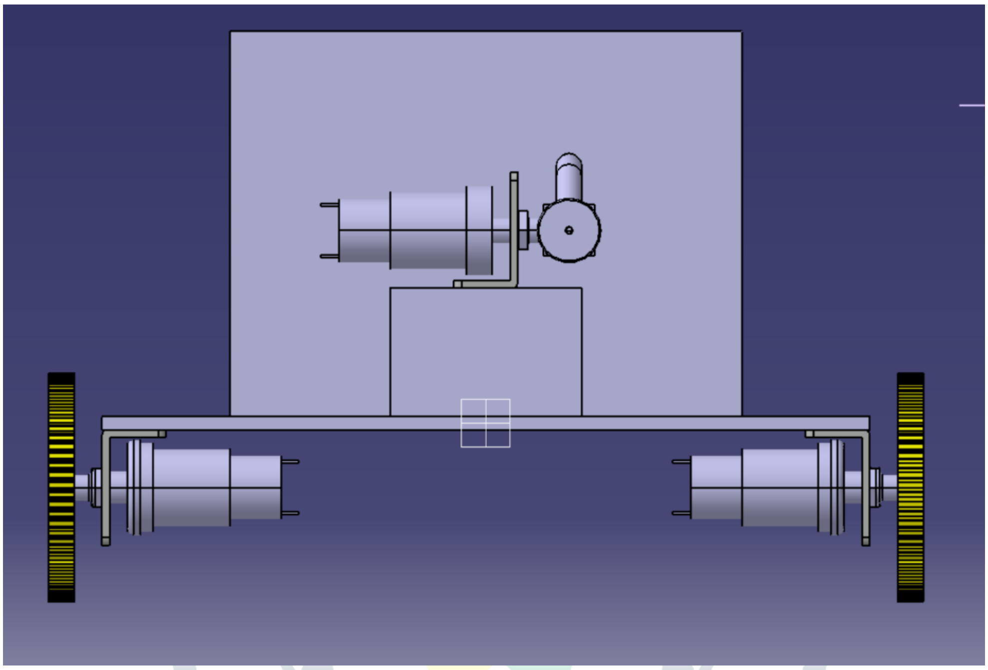


Figure 6.1 Front view

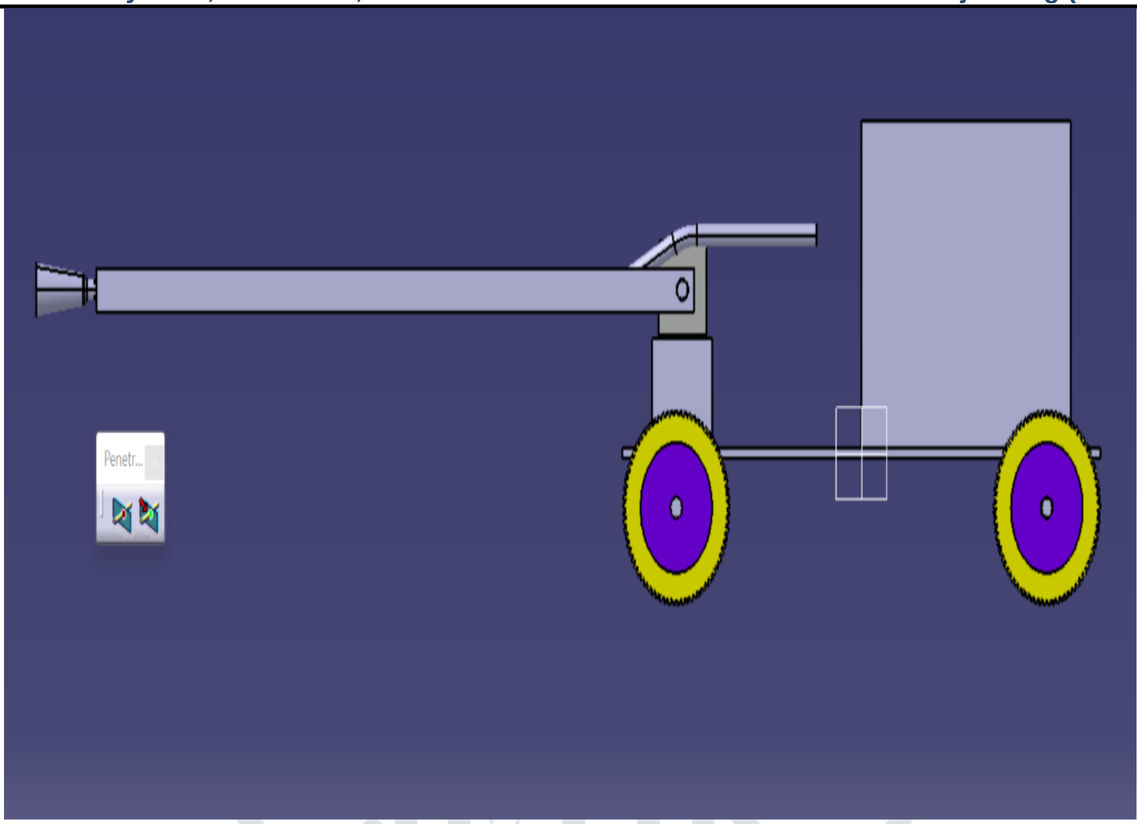


Figure 6.2 Side View

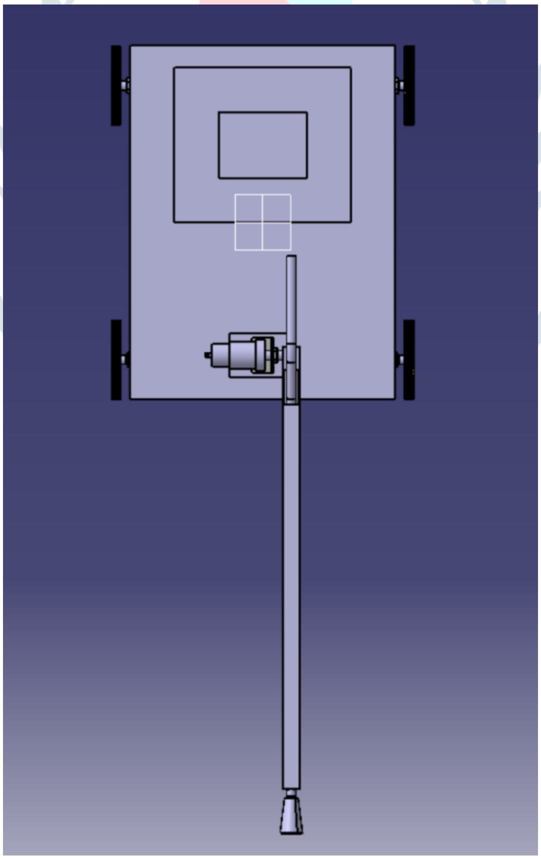


Figure 6.3 Top View

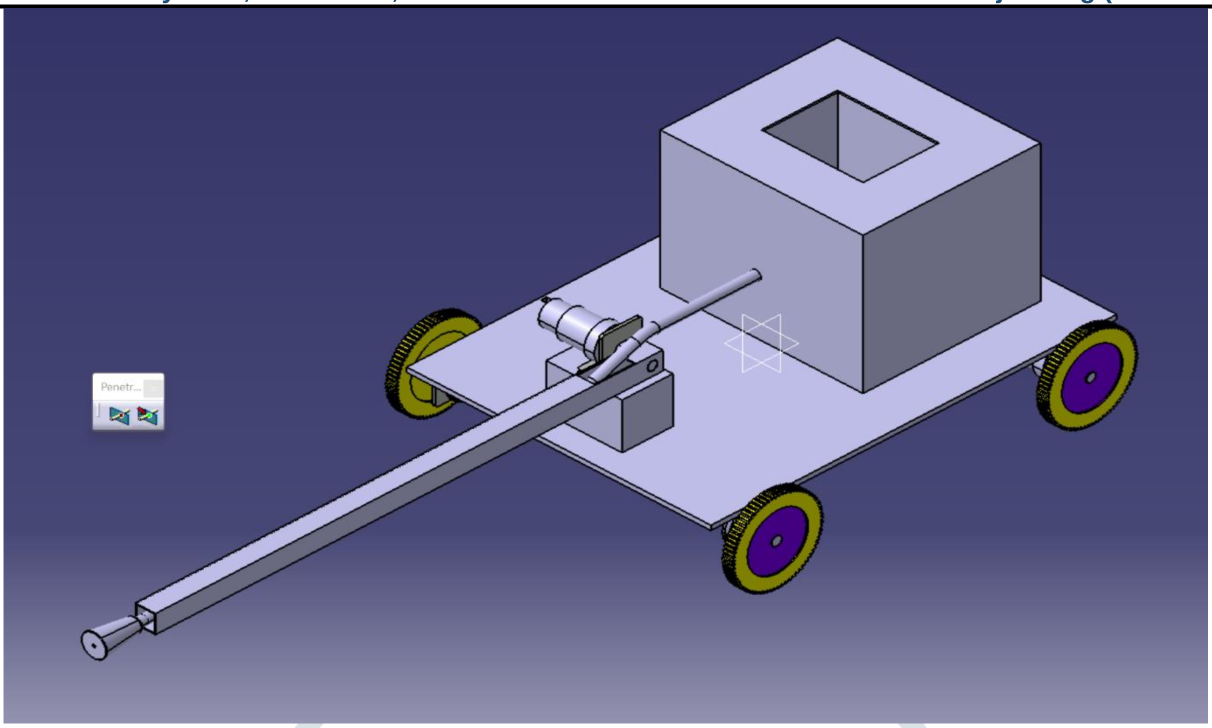


Figure 6. 4 ISO View

7.Drafting

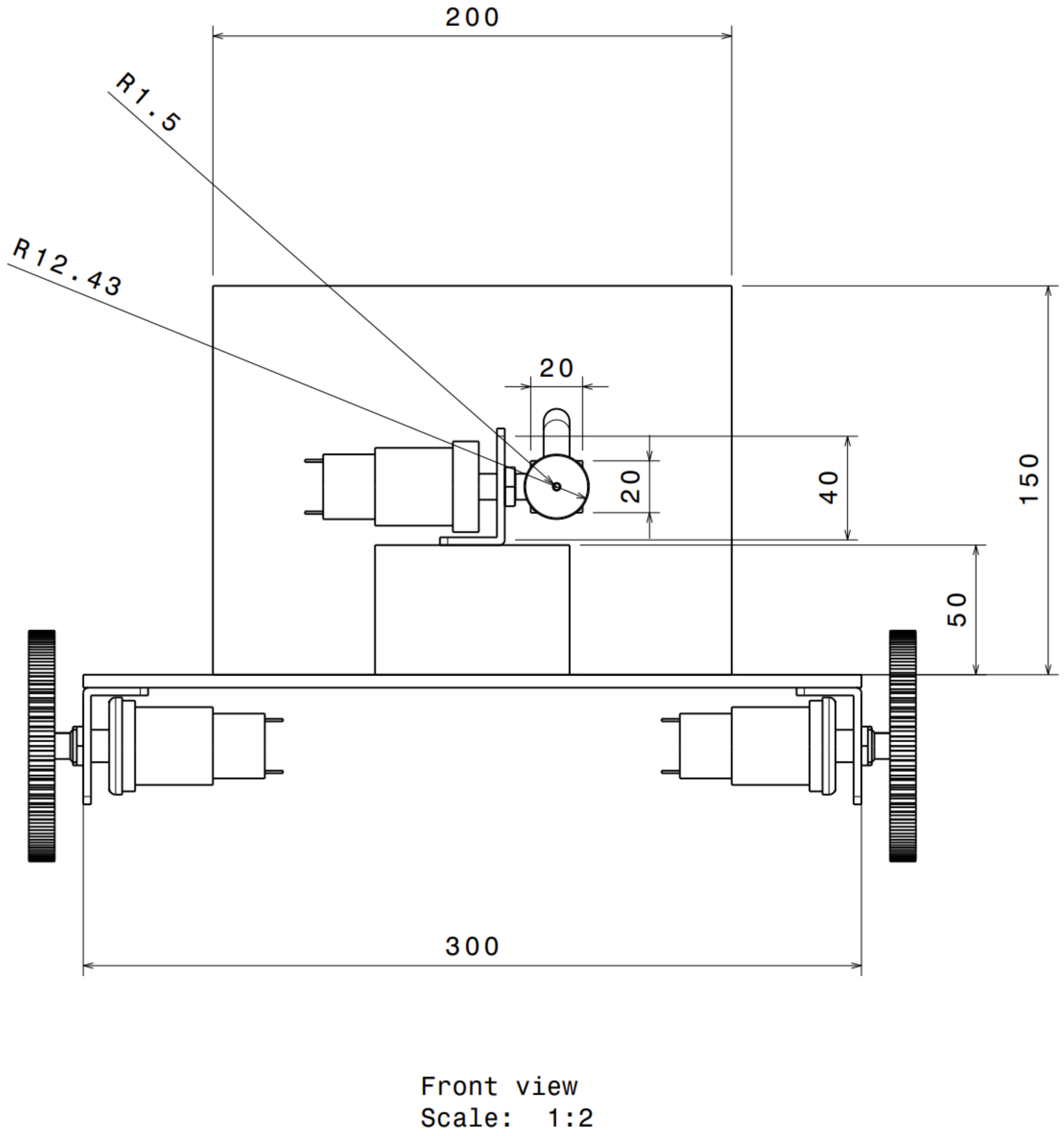


Figure 7.1front view

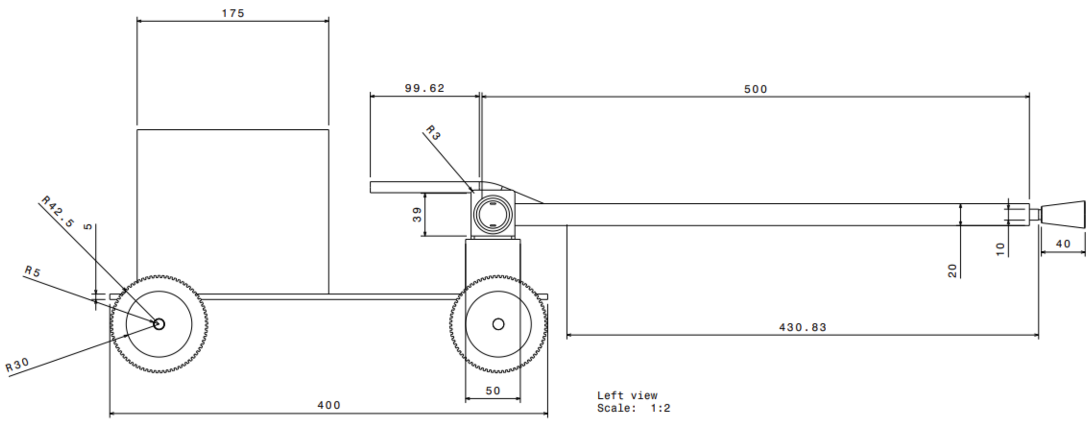


Figure 7.2 Side view

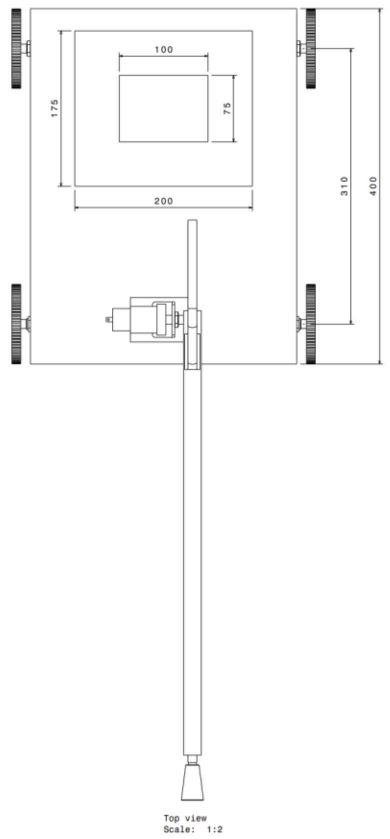


Figure 7.3 Top view

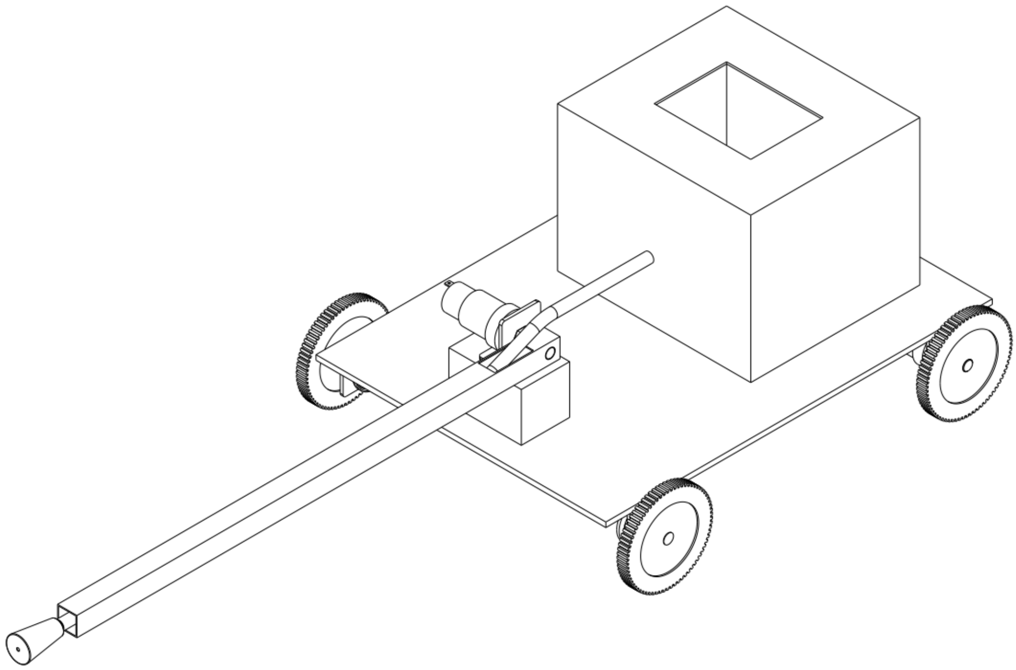


Figure 7.4 ISO view

8. Results

- Autonomous searching, detecting and extinguish burnt area.
- Extinguish fire on the in rural area using wireless connection
- The robot can be moved in any direction required using MC Arduino Uno.

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