Course: Minor Project
Course Code: 17EARW302

Minor Project Report on

Two Wheel Balancing Bot

Team Members

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2021-2022

CERTIFICATE

This is to certify that the project entitled "Two Wheel Balancing Bot" is carried out by below mentioned students have satisfactorily completed the project as part of Minor Project-17EARW302, Department of Automation and Robotics, KLE Technological University, Hubballi,during 6th Semester of B.E program for the academic year 2021-22. The project report fulfills the requirements prescribed.

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INTRODUCTION

The goal is to build a robot that can maintain its balance on two wheels. With only one axle connecting the two wheels, and a platform mounted on top of it, the vehicle will be extremely compact. There will be a second platform above it as well. The platform will not be able to maintain its stability on its own. Our job will be to balance the platform with the help of distance sensors and to keep it horizontal at all times. At first, we decided to simply balance the robot on its two wheels to see how it would perform. Depending on the direction and extent of inclination, the microcontroller (in this case, Arduino) will send signals to the motors, which will cause the motors to move forward or backward depending on their position on the platform. Consequently, if the platform tilts forward, then the motors will run forward and vice versa to keep the platform level. In order to accomplish this, we will need to program the Arduino in order for it to perform the desired task. It is the same principle that is used to balance the Inverted Pendulum, and the same technique is used to create the self-balancing robot.

1. STAKEHOLDERS

- Team members
- Teachers
- Students
- Manufacturers
- Project manager
- Product testers
- Consultants
- Investors
- Advertisers
- Sponsors
- Suppliers
- Vendors
- Sellers
- Buyers
- Customers
- End users

Stakeholder Needs

1. The bot should to carry a small payload.
2. The bot should move at least 2m stably carrying the load.
3. The Load on the bot has be stable.
4. The bot has to take the main power input from a battery.
5. The bot should run continuously for at least for 60 minutes once completely charged.
6. The battery should last at least for 2 years.
7. Should indicate when battery charge is low.
8. The bot has to give indication of other parameters.
9. It Should be modular.
10. It should be safe to use by the students and teachers.
11. The bot should be durable.

12. The bot should be cost-effective.
13. There should be ease in assembly and disassembly of the bot.
14. The parts should be easily replaceable and repairable.
15. It should be safe to use.

2. Stakeholder Requirements

1. Should be able to balance by itself
2. Should travel in both forward and reverse
3. Detect the obstacles
4. Avoid Obstacle
5. good battery life
6. Simple UI/UX
7. Should be compact
8. Mobile app support
9. should have an interactive display
10. Low power consumption
11. Easy to assemble and disassemble
12. Easy to repair
13. Faster time response
14. Lightweight
15. Easy to clean
16. Good aesthetic design
17. Fast charging
18. Work within the motor capacity
19. Easily swappable parts
20. It should have wireless connectivity
21. It should have a higher load capacity
22. Sound Indicators

3. Conversion of Stakeholder Requirements into Technical Requirements

Technical Requirements	Operational Values/Devices
Obstacle Avoidance	Ultrasound Sensor
Mobile app support	Android App
Measure the load	Load Sensor
Balancing	Gyroscope
User alarms	Buzzer
Wheels	2
Battery	6s LiPo
Controller	Arduino
Motors	DC Motors
Drivers	Dual Motor Drivers L2982A

Table 3.1 Technical Requirements

4. Need Statement

To build a two wheeled balancing robot to sustain and carry the payload. To maintain the balance by itself using movement of the wheels and body.
An effective way to sustain the weight and move from one place to another.

Black Box

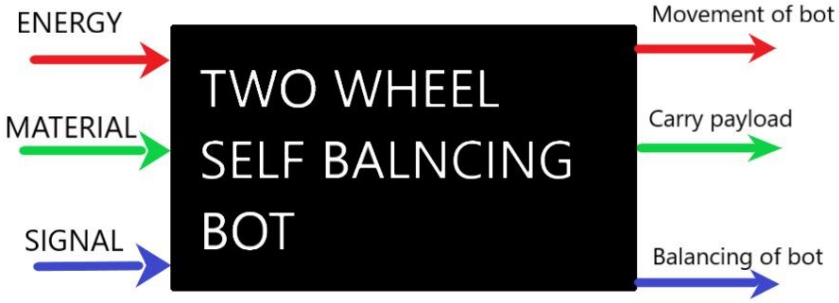


Fig 4.1 Black box

5. UML Diagram

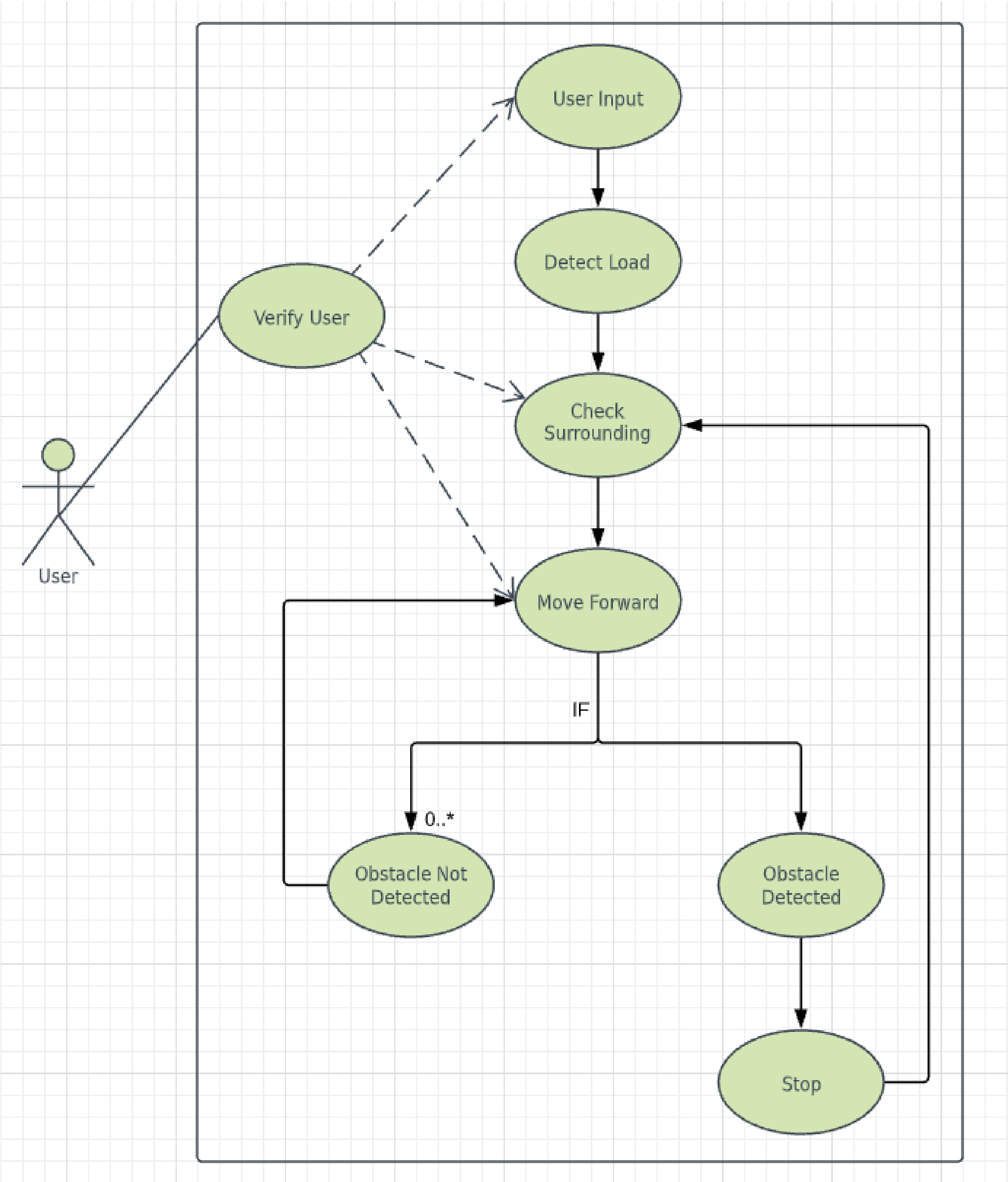


Fig 5.1 UML Diagram

6. Sequence Diagram

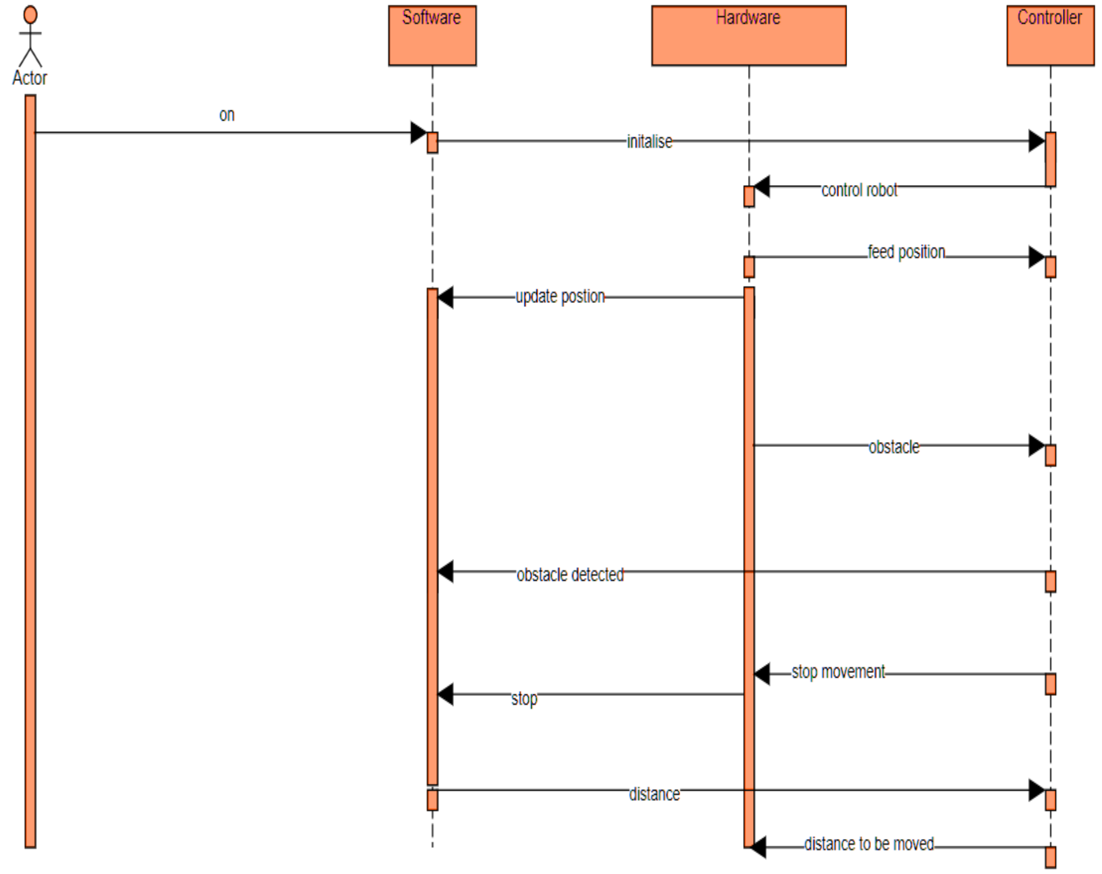
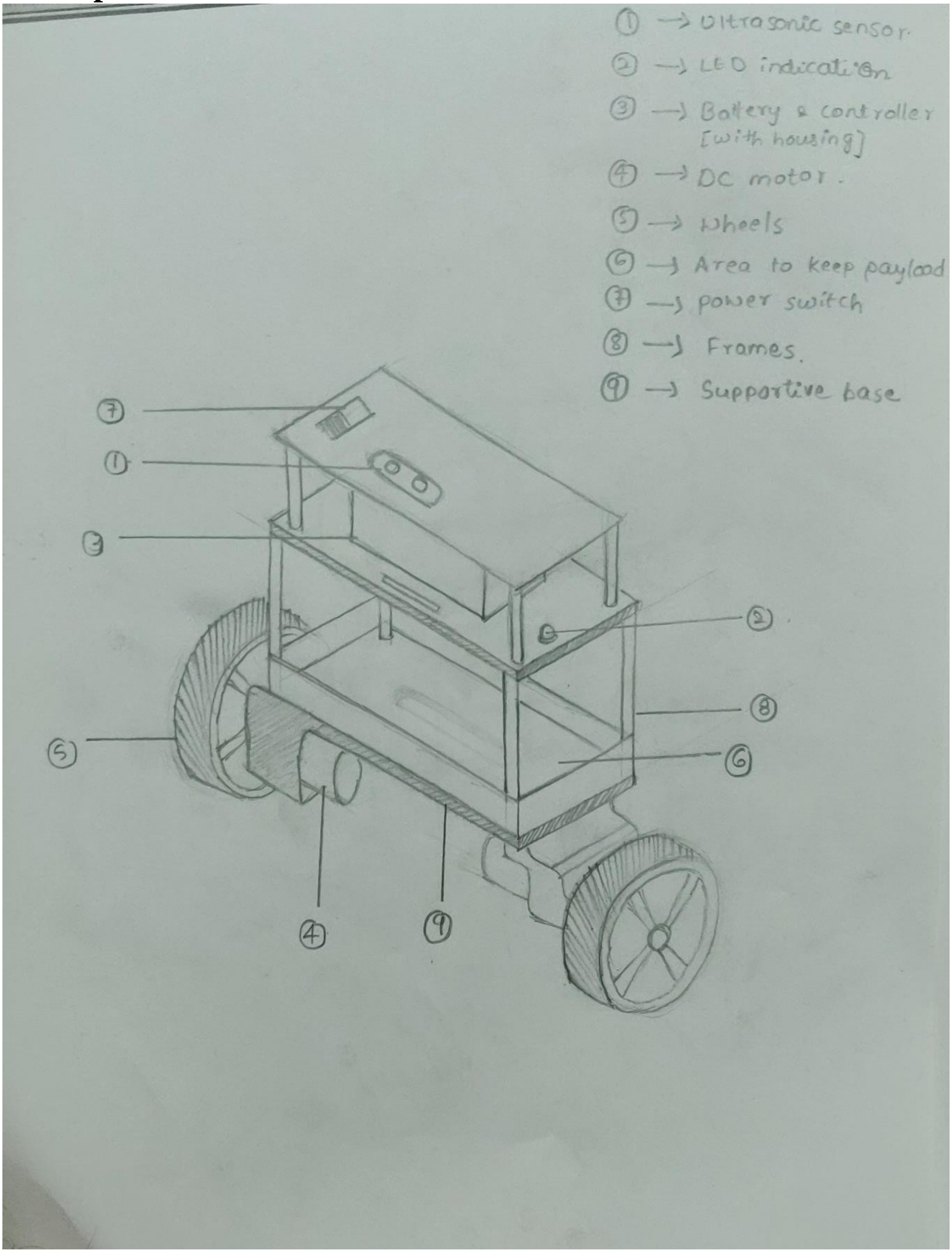


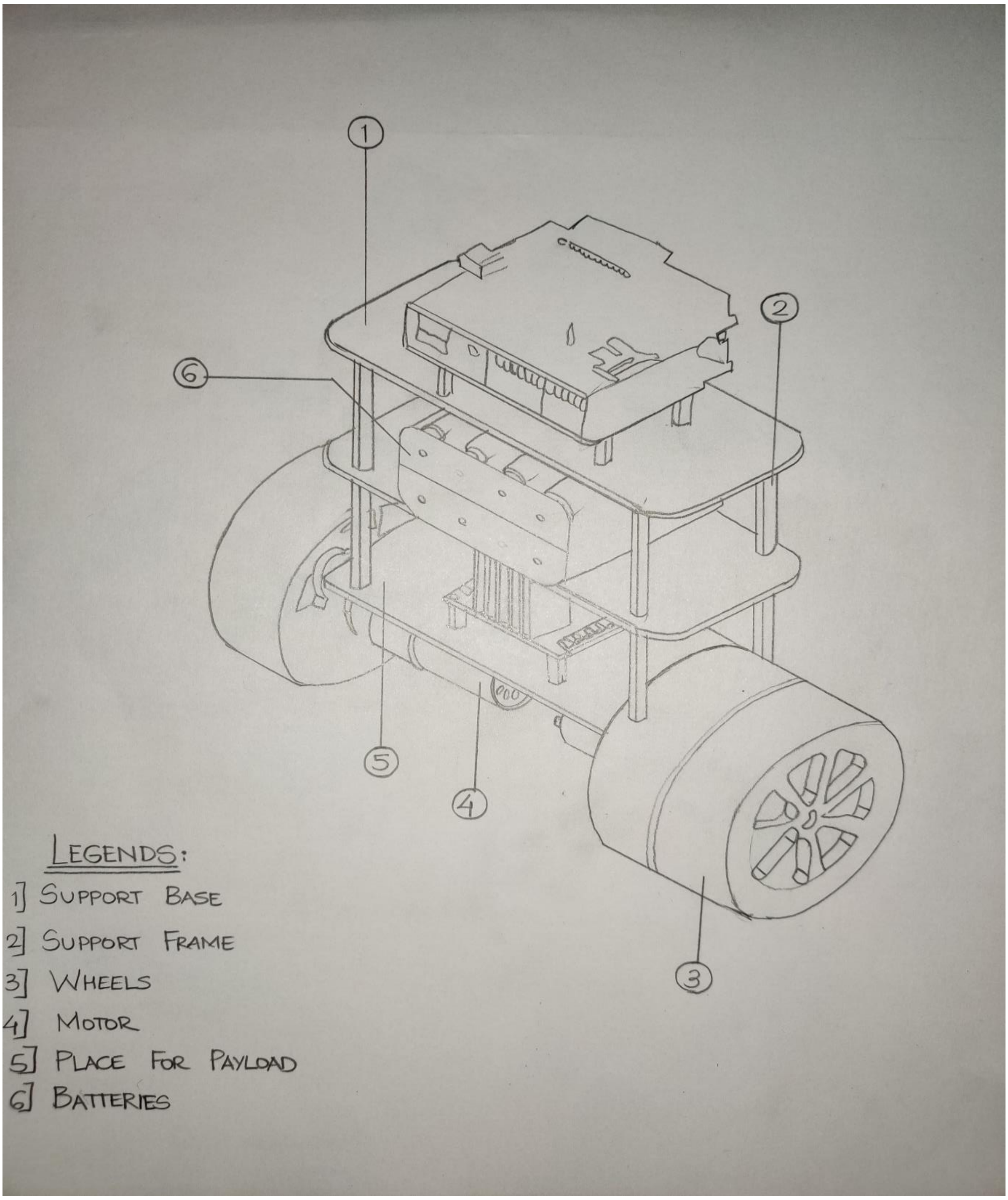
Fig 6.1 Sequence Diagarm

7. Conceptual Sketches

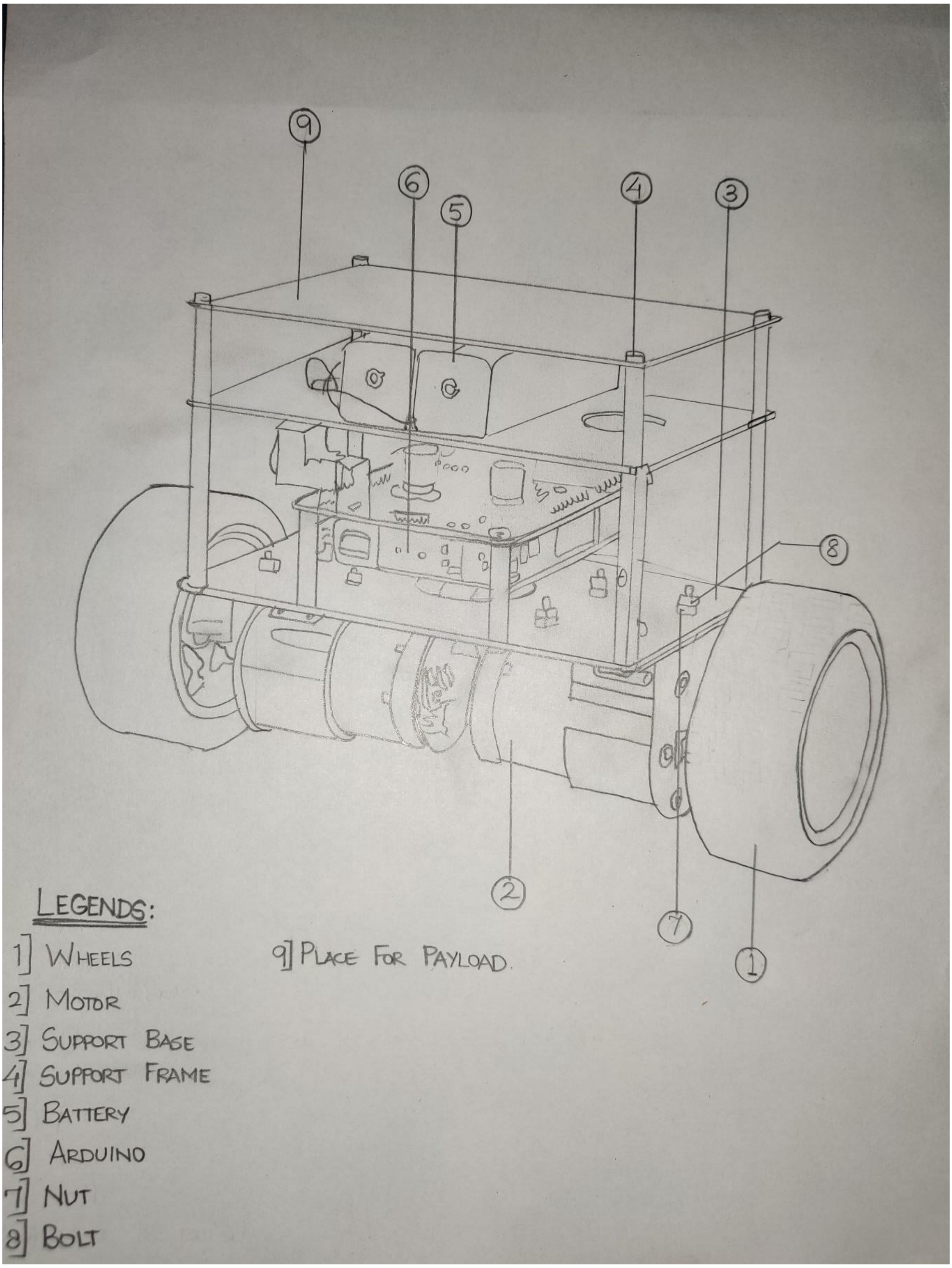
Concept A



Concept B

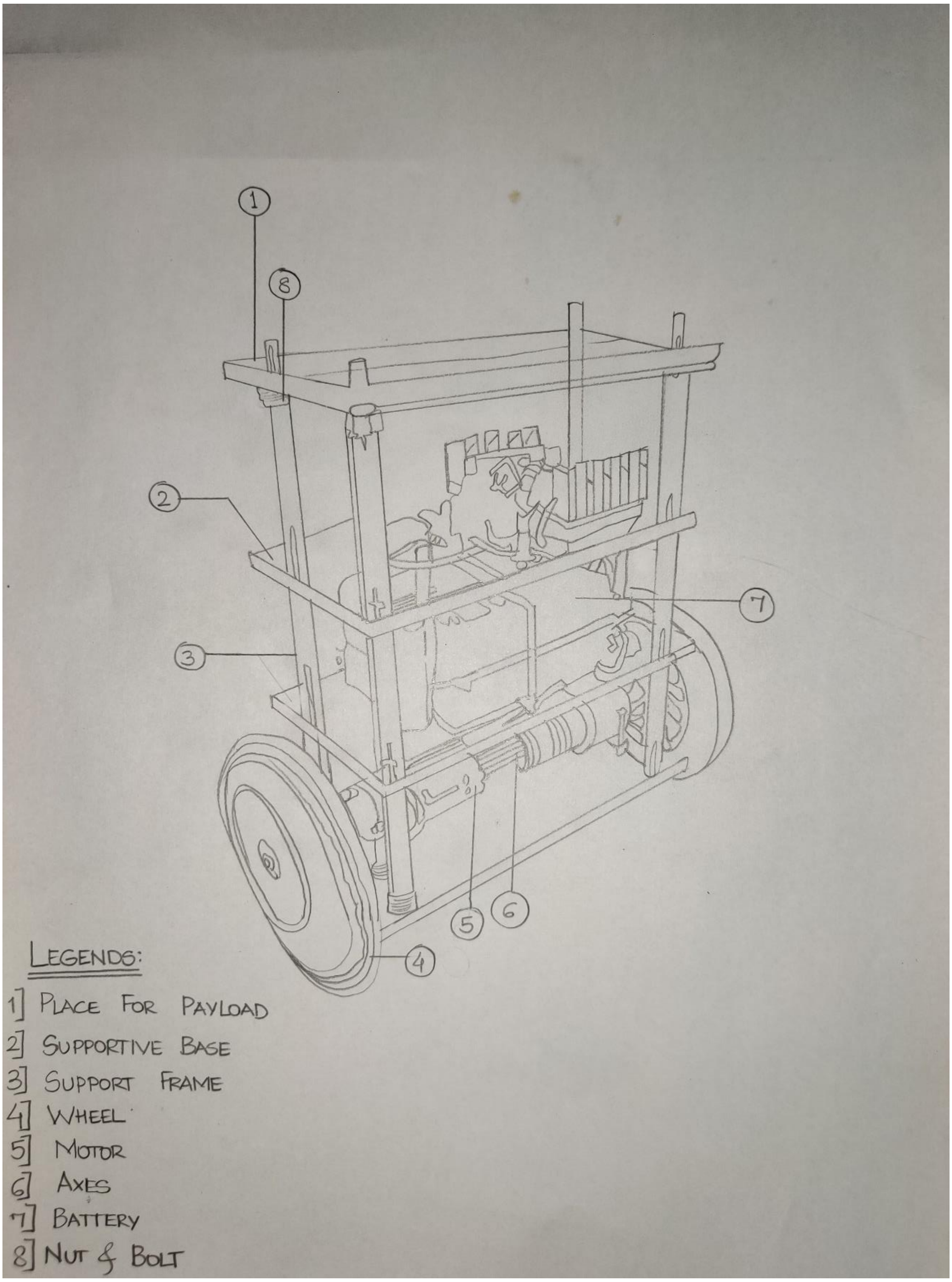

1
2
6
5
4
3
LEGENDS:
1] SUPPORT BASE
2] SUPPORT FRAME
3] WHEELS
4] MOTOR
5] PLACE FOR PAYLOAD
6] BATTERIES

Concept C

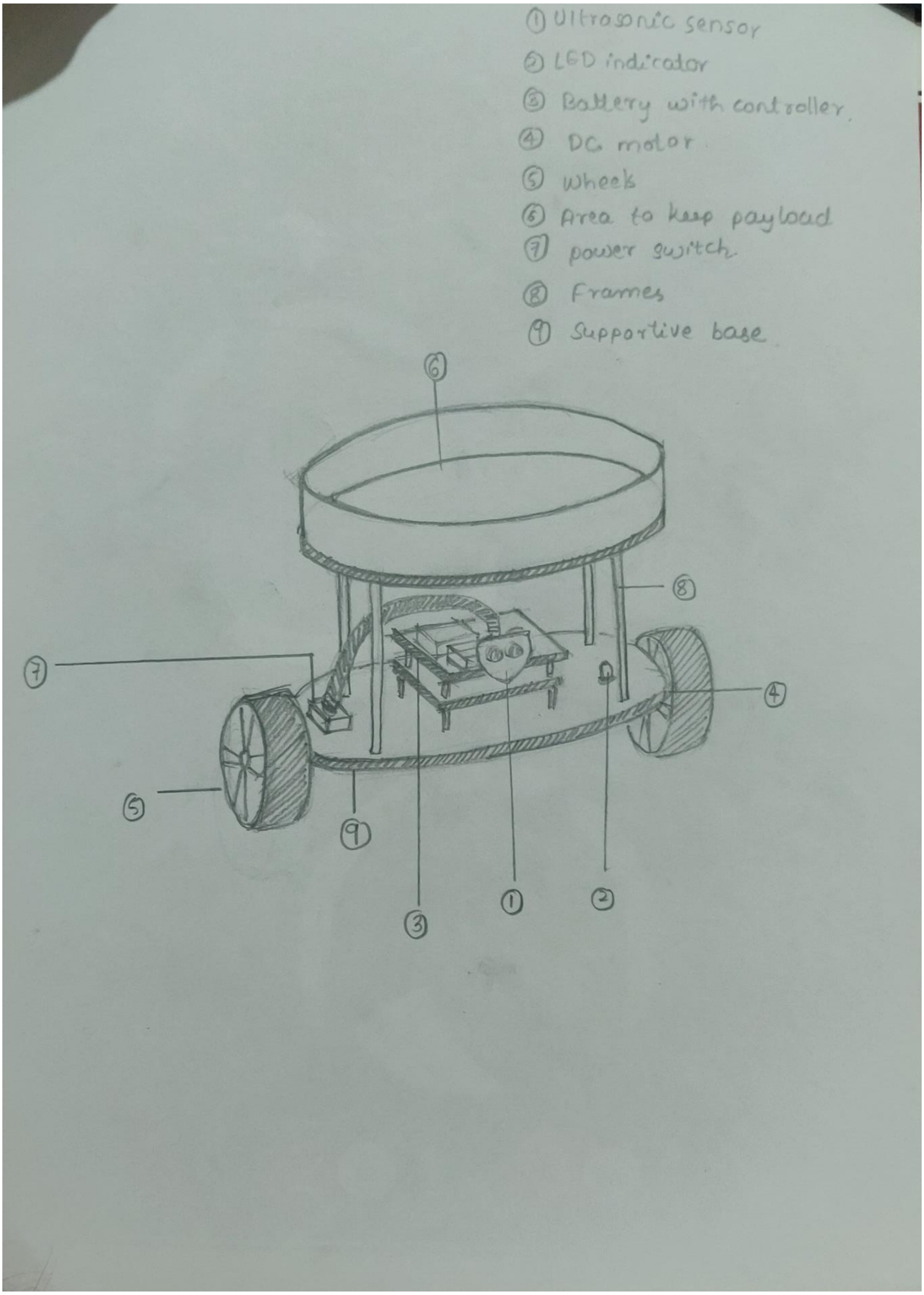


9
6
5
4
3
8
2
7
1
LEGENDS:
1] WHEELS
2] MOTOR
3] SUPPORT BASE
4] SUPPORT FRAME
5] BATTERY
6] ARDUINO
7] NUT
8] BOLT
9] PLACE FOR PAYLOAD.

Concept D


1
8
2
3
7
5
6
4
LEGENDS:
1] PLACE FOR PAYLOAD
2] SUPPORTIVE BASE
3] SUPPORT FRAME
4] WHEEL
5] MOTOR
6] AXES
7] BATTERY
8] NUT & BOLT

Concept E


1 Ultrasonic sensor
2 LED indicator
3 Battery with controller.
4 DC motor
5 Wheels
6 Area to keep payload
7 power switch
8 Frames
9 Supportive base
6
8
7
4
5
9
3
1
2

8. Morphological Chart

	Concept 1	Concept 2	Concept 3	Concept 5
Microcontroller	STEM 32	Arduino UNO	Raspberry Pie	ESP8266
Battery	Li-ion	LiPo	Lead Acid	
Motor	BLDC	High Torque Geared Motor	NEMA 17	
Input Commands	Joystick	HC-05	WI-FI Module	Wired
Sensor	Laser	Ultrasound	IR	Motion Sensor
Balancing Sensor	Gyro	Accelerometer		
Frame	Steel	Acrylic	3D Printed	Wood

Table 8.1 Morphological Chart

9.Configuration Design

1.	Motor	Geared DC Motor
	Power Supply	15.6W
	RPM	154
	Shaft diameter	3.5mm
	Shaft length	50mm
	Weight	280 grams
2.	Chassis	Acrylic
	Thickness	3mm
	Side length	130mm
	Weight	1800 grams
3.	Wheel	Fiber
	Dimensions	130mm
	Weight	50 grams
4.	Spacers	Metal
	Dimensions	4mm
	Weight	120mm
5.	Weight of the payload	500 grams

Table 9.1 Configuration design

10.Product Architecture

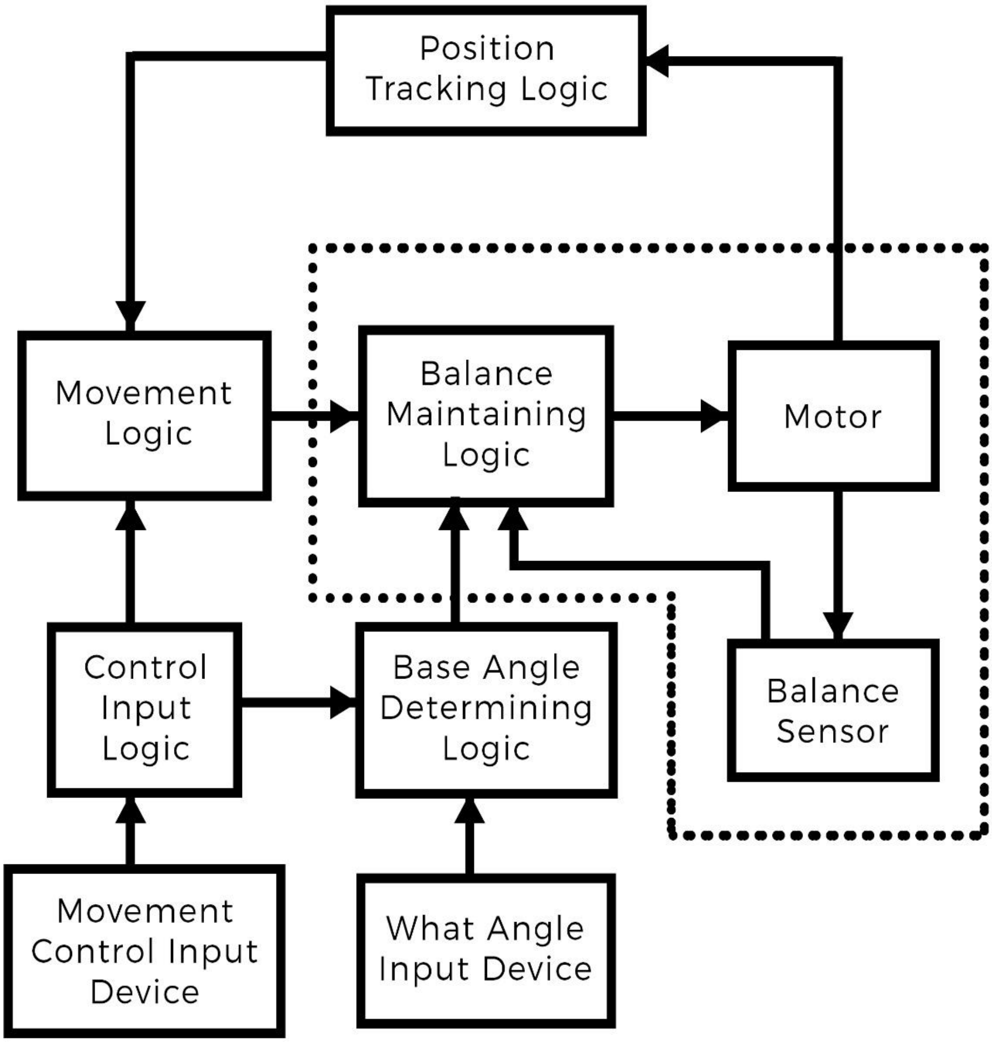


Fig 10.1 Product Architecture

11.Bill of Materials

Sl No.	Part Name	Specification	Quantity	Price
1	Arduino Uno	Development Board	1	1000/-
2	Wheels	Movement	2	-
3	Tetrix 154 RPM Geared DC Motor	Actuation	2	-
4	Motor Driver L298N	Maintaining Balance	1	180
5	Metal Spacers (4mm)	Mounting	24	600
6	Acrylic Sheet 3mm	Chassis	1	300
7	Lithium Polymer Battery 2200 mah	Power	1	1600/-
8	Wires	Connections	3m (Approx.)	50/-
9	Gyroscope MPU6050	Maintaining Balance	1	220/-
10	Lipo Battery Connector	Connection	1	60/-
11	16X1 LCD Display	Signaling	1	199/-
Total				4209/-

Table 11.1 Bill off materials

12.Concept Screening

Selection criteria	Concept A	Concept B	Concept C	Concept D	Concept E	Reference
Ease of operation	+	+	+	+	+	0
Ease of manufacturing	-	-	-	0	-	0
Self-balance	+	+	-	-	0	0
Battery capacity	0	0	0	0	0	0
Payload capacity	-	+	+	-	-	0
Modularity	-	0	-	+	+	0
Human interaction	+	+	-	-	0	0
/Safety	0	+	+	-	-	0
Durability	0	-	-	0	+	0
Portability	-	0	0	+	0	0
Cost efficiency	0	-	-	0	0	0

PLUS	3	5	3	3	3
SAME	3	3	2	3	4
MINUS	4	3	6	4	3
NET	-1	2	-3	-1	0
RANK	2	1	5	3	4
CONTINUE?	NO	YES	NO	NO	YES

Table 12.1 Concept Screening

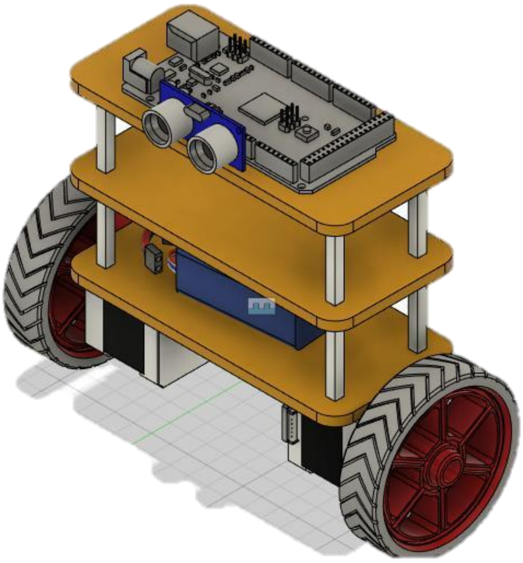
13.Concept Scoring

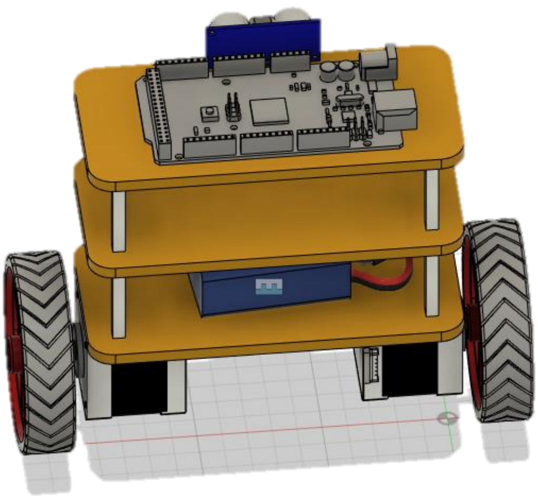
		Concept B+		Concept AC		Concept E	
Selection Criteria	Weights	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Ease of operation	20%	3	0.60	3	0.60	2	0.40
Ease of manufacturing	18%	4	0.72	2	0.36	3	0.54
Self-balance	15%	3	0.45	3	0.45	4	0.60
Battery capacity	10%	4	0.40	3	0.30	3	0.30
Modularity	10%	2	0.20	3	0.30	2	0.20
Human interaction	8%	3	0.24	3	0.24	3	0.24
Safety	6%	3	0.18	4	0.24	2	0.12
Durability	6%	2	0.12	2	0.12	2	0.12
Portability	5%	2	0.10	3	0.10	3	0.15
Cost efficiency	2%	3	0.06	2	0.04	2	0.04
Total Score		3.07		2.75		2.71	
Rank		1		2		3	
Continue?		Develop		No		No	

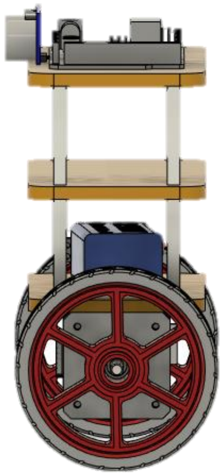
Table 13.1 Concept scoring

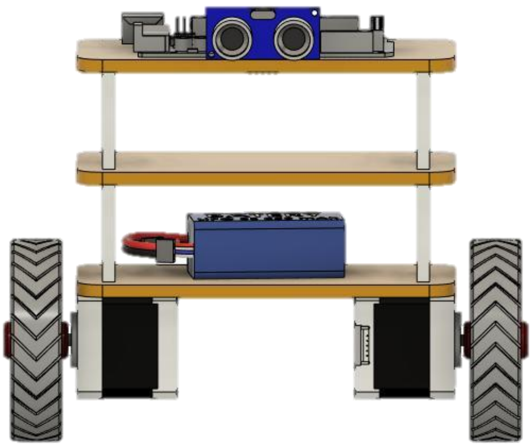
13.Modeling

3D Model

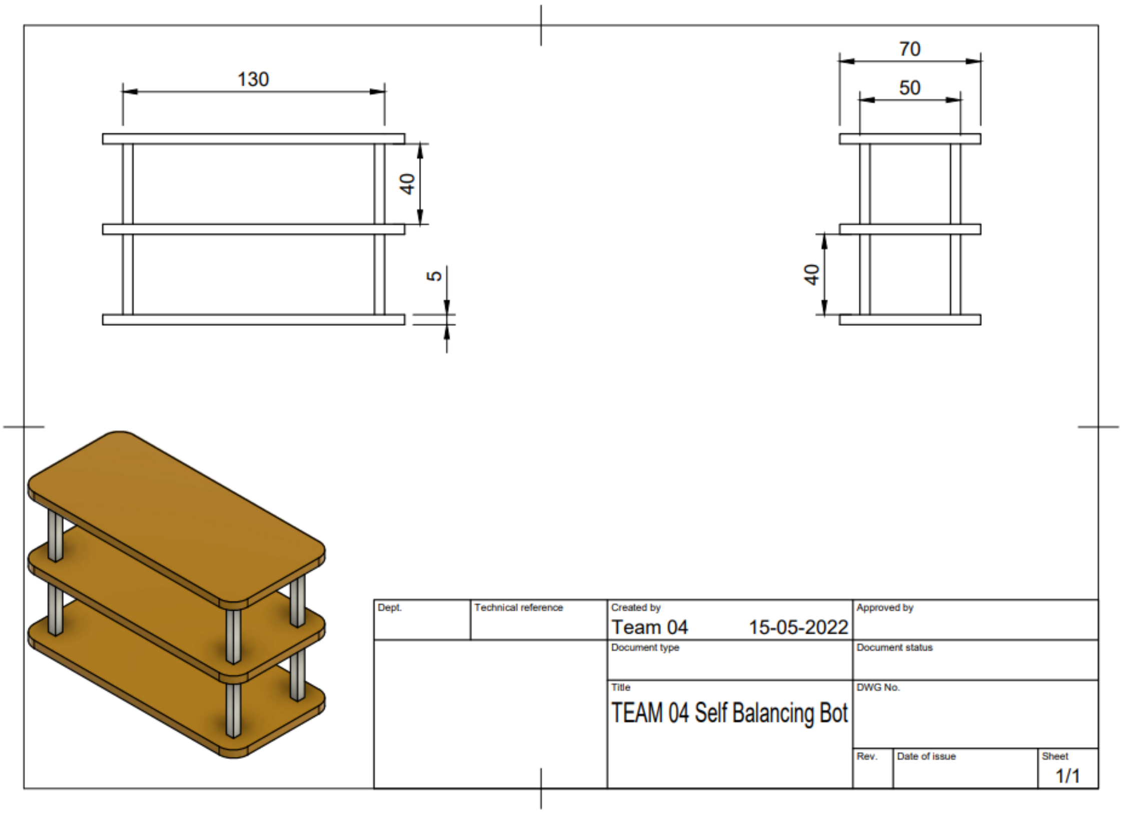


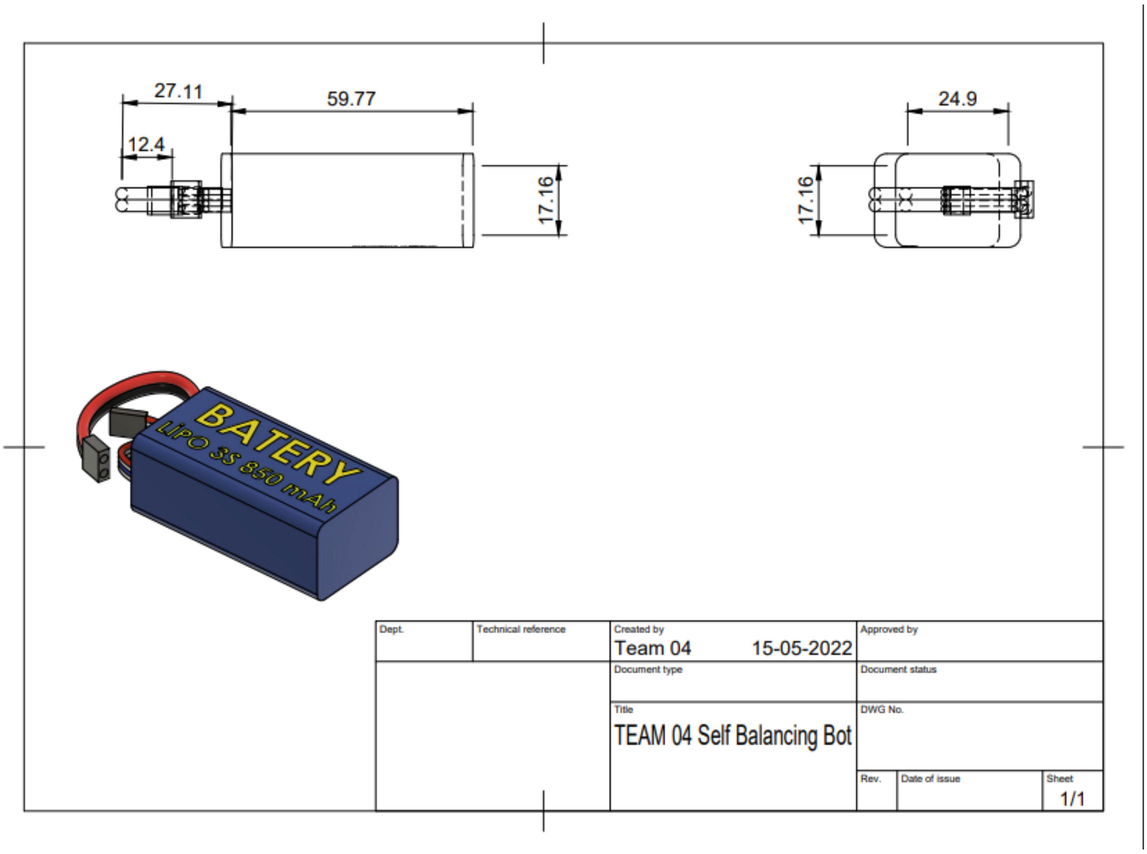






14.Part Drawings:

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59.77
12.4
17.16
24.9
17.16
BATERY
LIPO 3S 850 mAh
Dept.
Technical reference
Created by
Team 04
15-05-2022
Approved by
Document type
Document status
Title
TEAM 04 Self Balancing Bot
DWG No.
Rev.
Date of issue
Sheet
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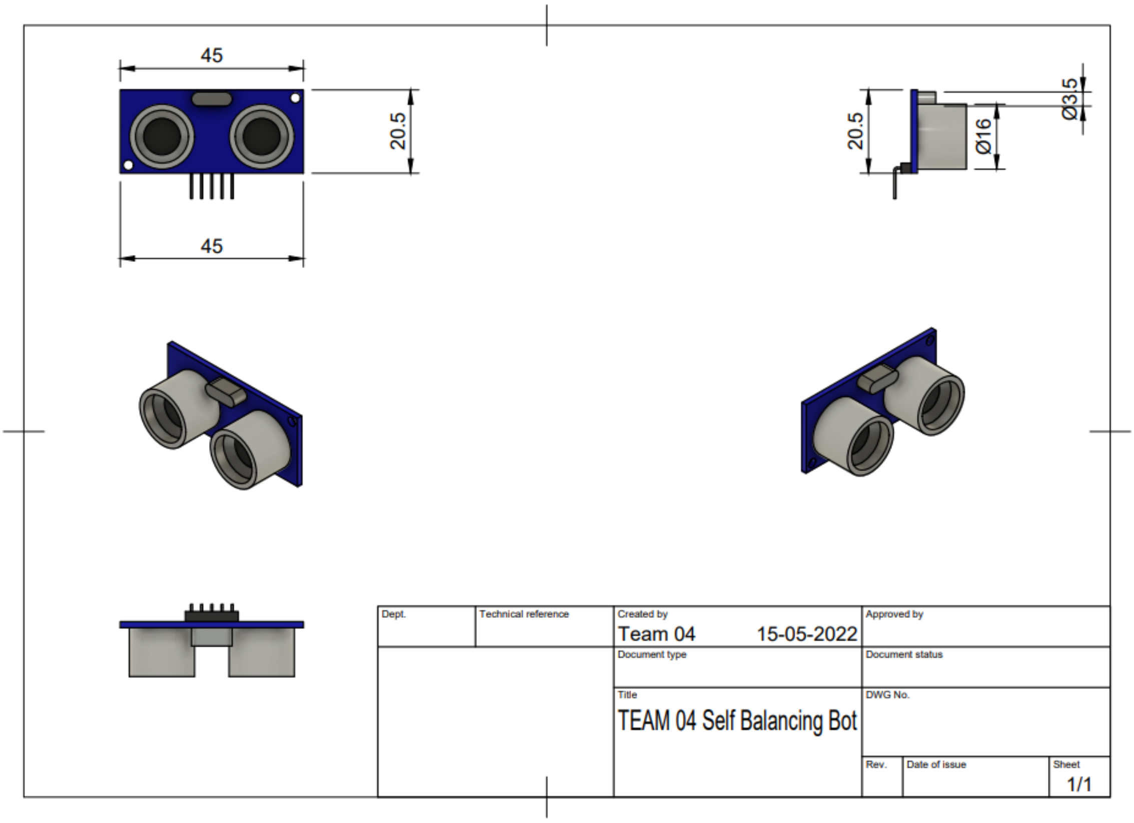
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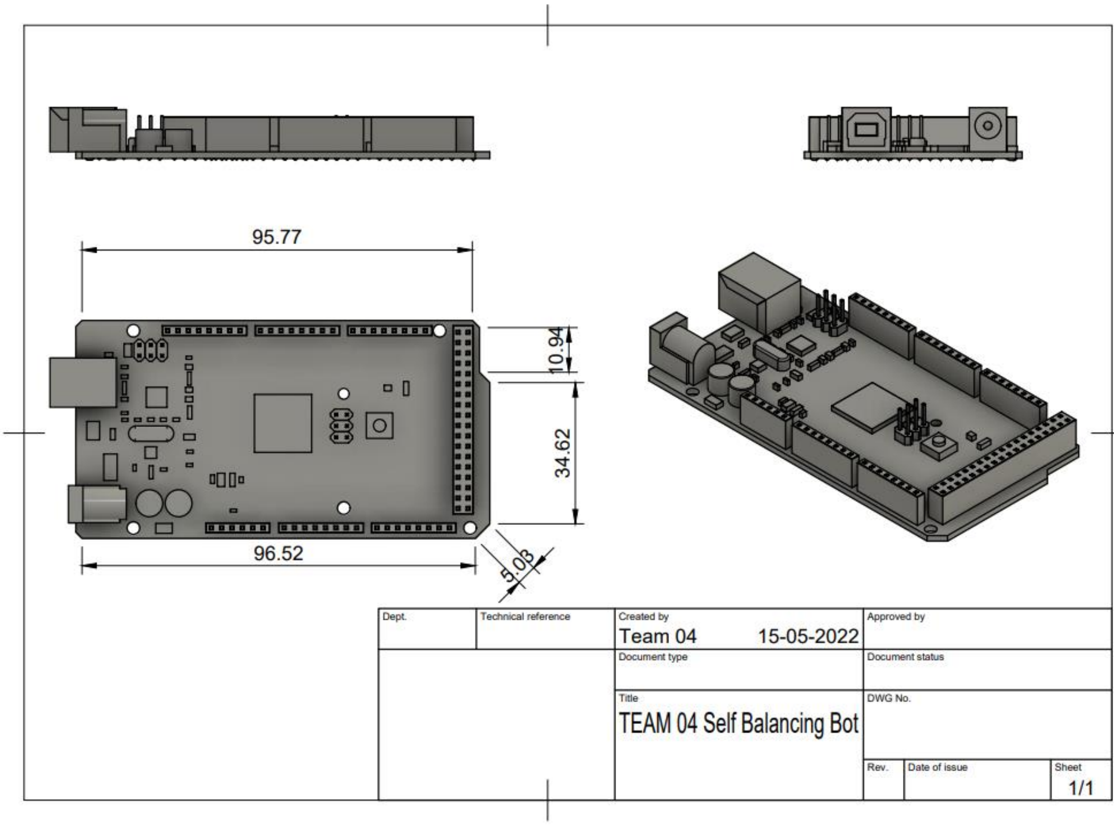
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DWG No.
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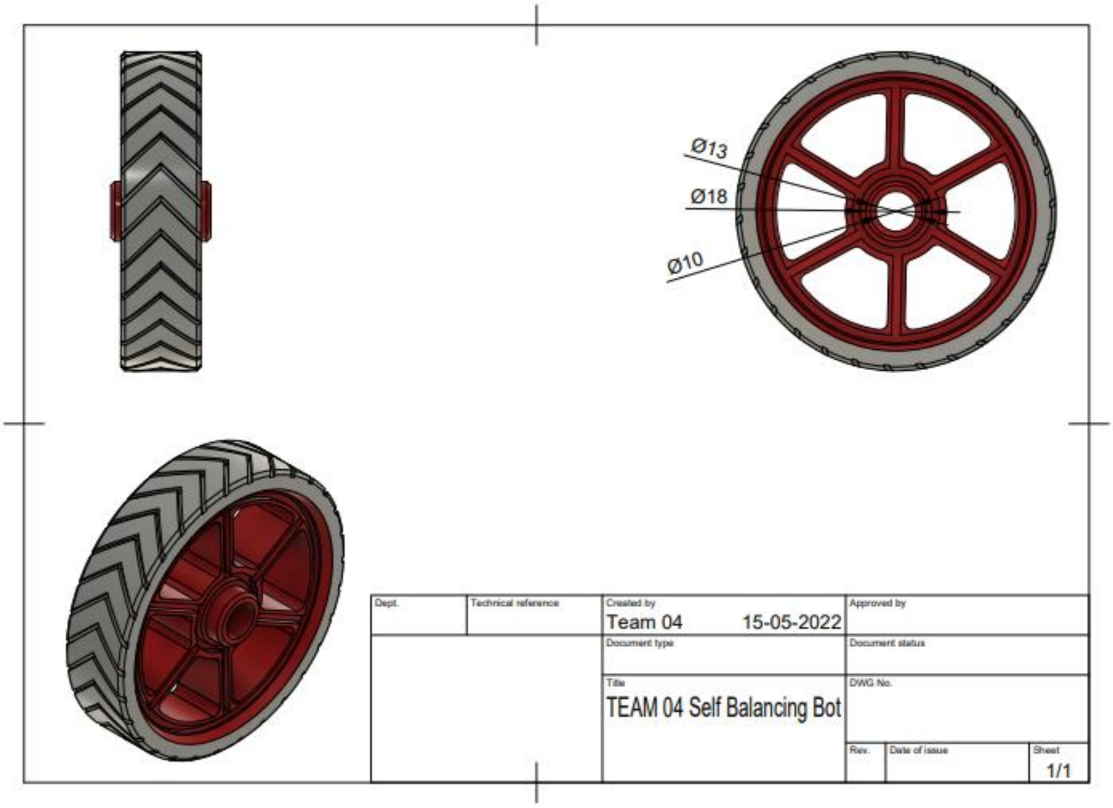
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Team 04
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DWG No.
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Date of issue
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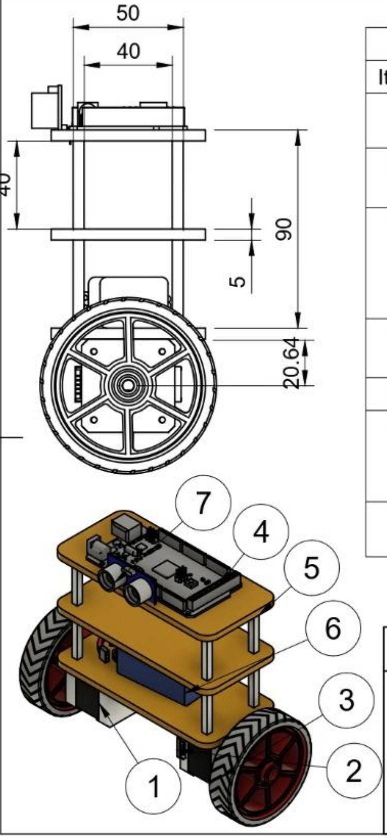
1/1

Assembly Part Drawing



Parts List				
Item	Qty	Part	Description	Material
1	1	Tetrix 154rpm geared DC motor	Motors for movement	Steel
2	1	Tetrix 154rpm geared DC motor	Motors for movement	Steel
3	2	Wheel1 v1	Wheels of the robot	SOLIDWORKS Materials|Alloy Steel
4	1	Arduino UNO	Controller for the robot	Steel
5	1	Chassis	Chassis of the robot	Steel
6	1	LIPO Battery	For power supply	Lithium Polymer
7	1	ULTRASONIC SENSOR	To detect obstacle	Steel

Dept.	Technical reference	Created by	Approved by
		Team 04 15-05-2022	
		Document type	Document status
		Title: TEAM 04 Self Balancing Bot	DWG No.
			Rev. / Date of issue / Sheet 1/1

15.MATLAB Simulation

Circuit Diagram

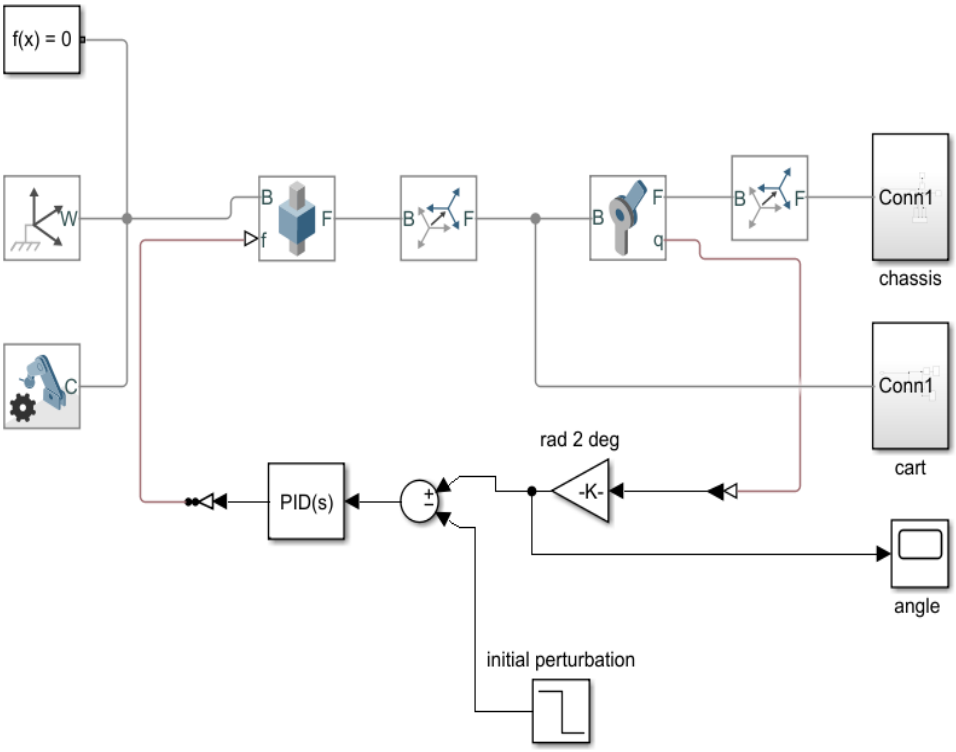


Fig 15.1 Circuit diagram

Mechanical Explorer

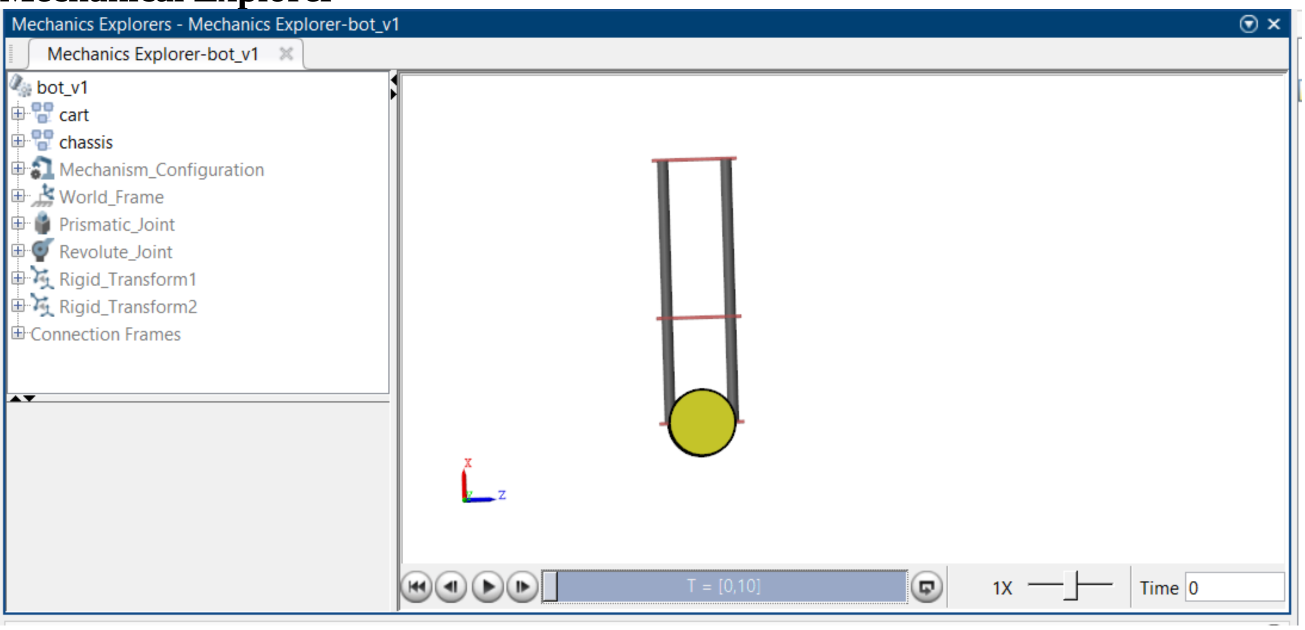


Fig 15.2 Mechanical Explorer

PID Parameters

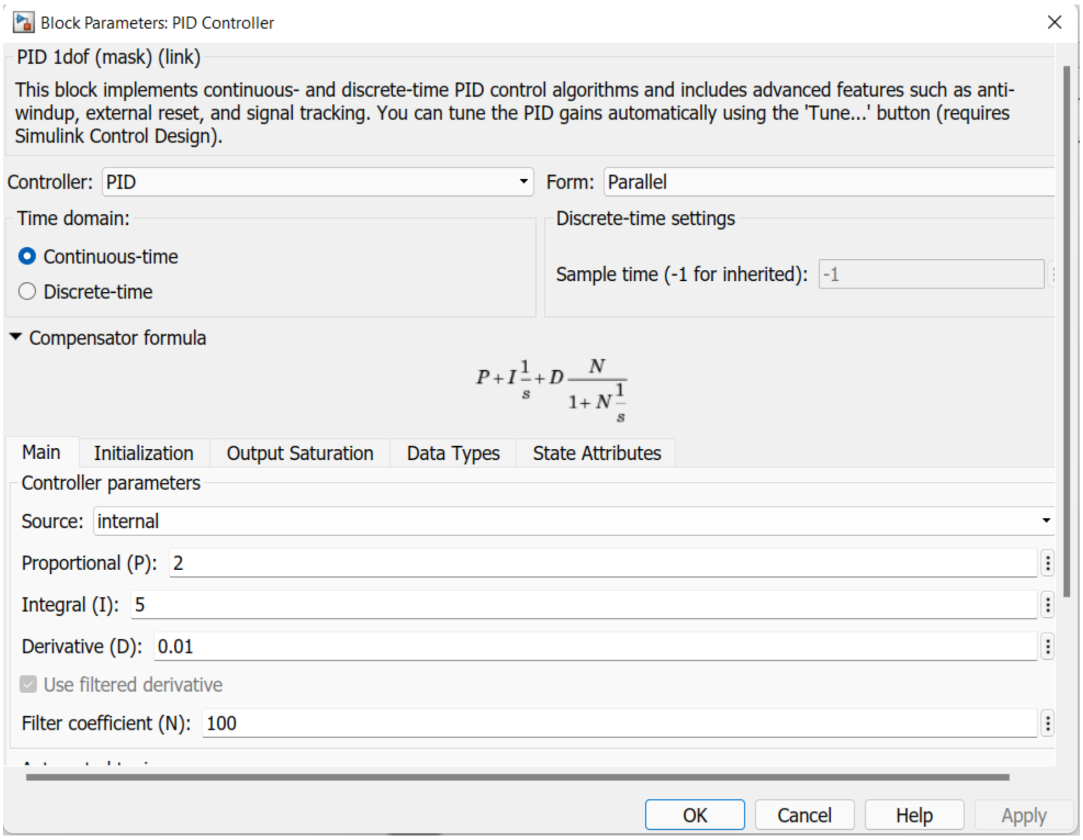


Fig 15.3 PID Parameters

Angle Scope

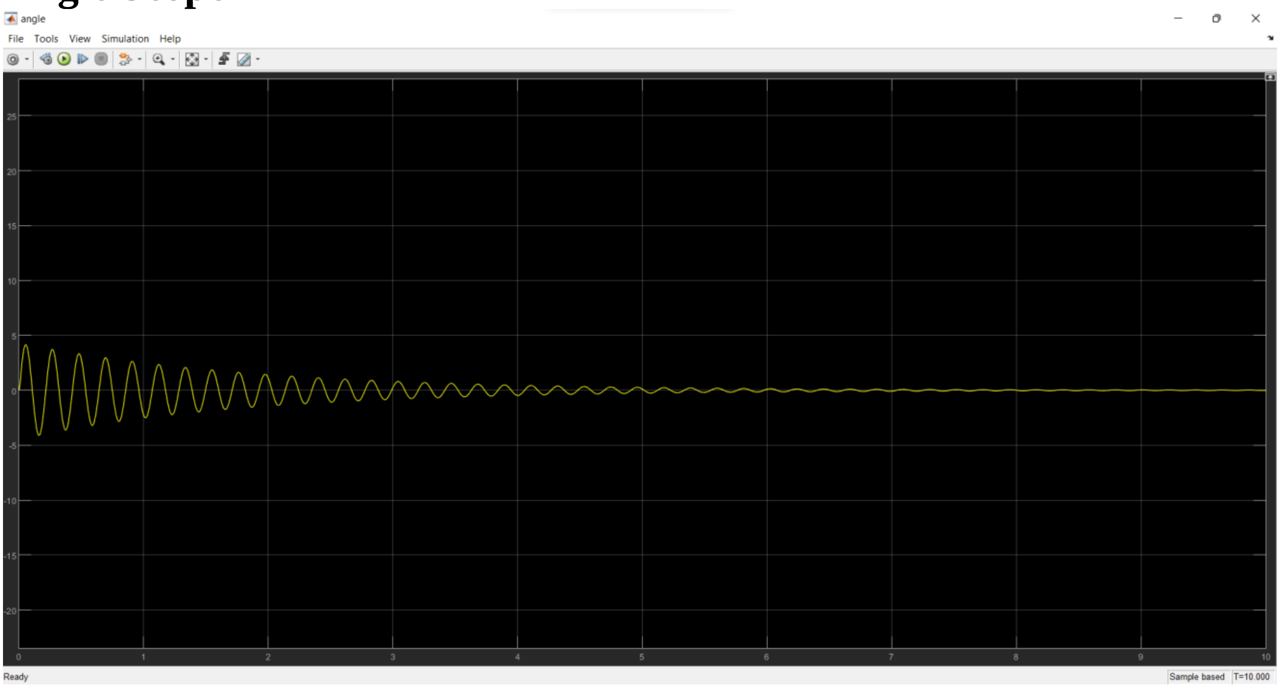


Fig 15.4 Angle scope

PID Values chosen

$K_p = 25$
$K_d = 0.9$
$K_i = 110$

16. ALGORITHM USED:

When it came to maintaining balance on the autonomous self-balancing two-wheel robot, the PID controller was the algorithm that was employed to do this. The proportional, integral, and derivative (PID) controller is a three-term controller that is well-known in the industry.

The error from the system is used as the controller's input signal. The proportional, integral, and derivative constants are denoted by the letters Kp, Ki, and Kd, respectively (the three terms get multiplied by these constants respectively). The closed loop control system, often known as a negative feedback system, is a type of automatic control system. The basic concept of a negative feedback system is that it detects the process output y from a sensor and provides feedback to the system. An error is produced when the measured process output is deducted from the reference set-point value, which is known as the error. The fault is then passed into the PID controller, where it is dealt with in three different ways depending on the situation. The error will be employed on the PID controller to execute the proportional term, the integral term for the reduction of steady state errors, and the derivative term for the handling of overshoots and overshoot reduction. After the PID algorithm analyses the error, the controller provides a control signal u. The PID control signal is then delivered into the process that is being monitored and controlled. The two-wheeled robot is the process that is being controlled by PID. The PID control signal will attempt to steer the process to the specified reference setpoint value by adjusting the PID control signal. In the case of the two-wheel robot, the required set-point value is the vertical position at 0 degrees (zero degrees).

Using a mathematical form, the PID control method may be represented. PID is used to compute the 'correction' term, which is as follows

Correction = Kp*error + Ki* error + Kd* d/dt(error); Correction = Kp*error + Ki* error + Kd* d/dt(error);

Kp, Ki, and Kd are constants that are determined by experimentation.

Using only the first term to determine the correction, the robot would have behaved in the same way as it would have in the standard line following method, resulting in the identical result. The second term drives the robot to move more quickly towards the mean location in order to reach it. The third term may withstand a quick shift in the deviation value.

The integral term is just the total of all of the preceding variations in the equation. This is referred to as the 'total mistake'. The derivative is defined as the difference between the present deviation and the preceding deviation in a certain period of time. The following is the code that will be used to evaluate the adjustment.

Each iteration should have the following lines:

correction = Kp*deviation + Ki*totalerror + Kd*(deviation - previousdeviation); totalerror += correction; deviation += correction; totalerror += correction;

previousdeviation = departure from the mean

17.Motor Power Requirements

- Motor specification: Tetrix 154 RPM geared DC MOTOR
    - Full load current consumption=0.65A
    - Rated voltage of the motor =9.12 v
- Power consumption= 7.8 W
    - Total power consumption=7.8 x 2 = 15.6W (For two motors)

Battery requirement

- Voltage = 12v Wattage = 16W Ampere =W/V=16/12=1.34A=1.5A
- Number of hours = 0.75 hour (45 mins) The battery required is 1125 mah @ 12V
- Let us consider safety factor as 2
- Therefore, battery required = 2250 mah @ 12V
- So we have selected Xrace LIPO battery (2200 mah @ 12v) because this battery almost meets the requirement and it is of light weight.

18.Manufacturing Cost

Sl No.	Part Name	Quantity	Price
1	Arduino Uno	1	1000/-
2	Wheels	2	-
3	Tetrix 154 RPM Geared DC Motor	2	-
4	Motor Driver L298N	1	180
5	Metal Spacers (4mm)	24	600
6	Acrylic Sheet 3mm	1	300
7	Lithium Polymer Battery 2200 mah	1	1600/-
8	Wires	3m (Approx.)	50/-
9	Gyroscope MPU6050	1	220/-
10	Lipo Battery Connector	1	60/-
11	16X1 LCD Display	1	199/-
Total			4209/-

Table 18.1 Manufacturing cost

19. Manufacturing Process Sheet

Part Name	Manufacturing Process	Quantity	Material
Chassis Frame	Laser Cutting	3	Acrylic Sheet (3mm)
Spacers, Screws	Lathe	28	Steel

Table 19.1 Manufacturing Process sheet

20. List of Vendors

- Shree Marketing
- Siddharodha Electronics
- Eleczone
- Core Electronics

21.Testing and Evaluation Report

	Specification	Evaluation
1	Ease of use	Yes
2	Balancing the bot	Yes
3	Portable	Yes
4	Durable	Yes
5	Ease to Maintain	Yes
6	Carry Load	Yes
7	Obstacle Avoiding	Yes
8	DIY Kit	Yes
9	RF Communication	Yes
10	Easy to start	Yes
11	Minimal Human Intervention	No

Table 21.1 Testing and evaluation

22.Prototype

24.Conclusion

Our main goal is to build a two wheeled balancing robot to sustain and carry the payload, to maintain the balance by itself using movement of the wheels and body.

What worked?

We could demonstrate the process that the bot is able to balance by it self when the payload is placed on the bot and even when there is no payload placed.

What didn’t Work?