Design and Fabrication of a Biomimetic Robot

Semester 6 CEP

Mechanics of Machines

DHA Suffa University

Department of Mechanical Engineering

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Introduction

Biomimetic robots are robots that use principles learned from nature replacing more classical engineering solutions. For example, the use of legs instead of wheels or tracks makes these robots more versatile allowing movement of complex terrains. However, inspiration from the biological systems usually comes at a cost of increased complexity and power requirement of the robot.

Problem Statement

In this project, you are required to design a robot that moves in a straight line from the start point to point 1 meter away using a mechanism inspired by nature. This means that robot should either walk, crawl, hop, or slither to its destination.

Constraints

- The size of the robot should not exceed 210 mm × 297 mm (the size of an A4 paper)
- The height of the robot should not exceed 200 mm
- The robot should not have any wheels or tracks touching the ground
- At the start point, the robot must be released with zero velocity

Working Principle of the Project

The design and fabrication of the biomimetic spider robot is a remarkable project that draws inspiration from the natural world to create a robot capable of emulating the locomotion and behavior of spiders. This article explores the working principle of the biomimetic spider robot, shedding light on its unique features and functionalities.

Spider-Inspired Locomotion: The core of the biomimetic spider robot's working principle lies in its spider-inspired locomotion. Careful study and analysis of spider movement have enabled the robot's creators to replicate the spider's agile and versatile walking capabilities. By mimicking the biomechanics of spider legs, the robot achieves superior adaptability, allowing it to traverse diverse terrains with ease.

Leg Mechanism: A key component of the robot's working principle is its intricate leg mechanism. Each leg is designed to flex and extend independently, mirroring the natural movement of a spider's legs. This modular leg structure provides the robot with a high degree of mobility and stability, enabling it to navigate through confined spaces and challenging environments.

Parts List

1. Motor with Gears

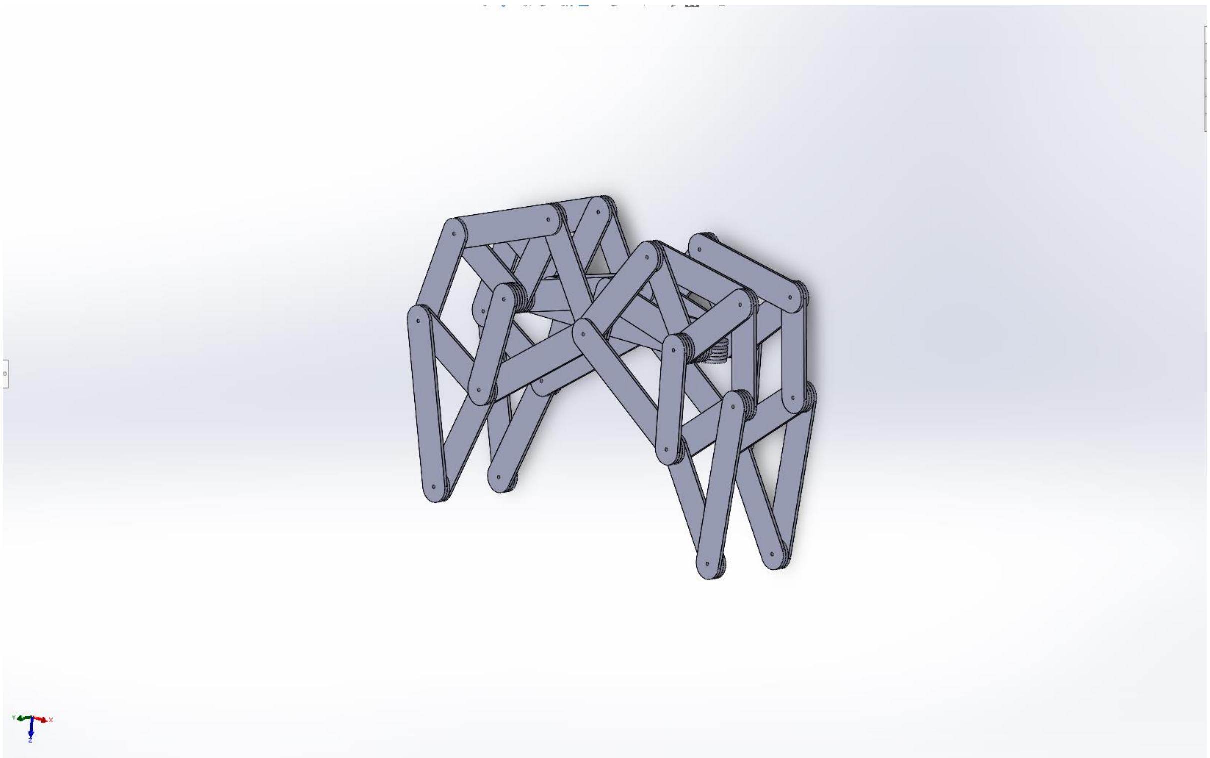
2. Batteries

3. 2 Cell Holder

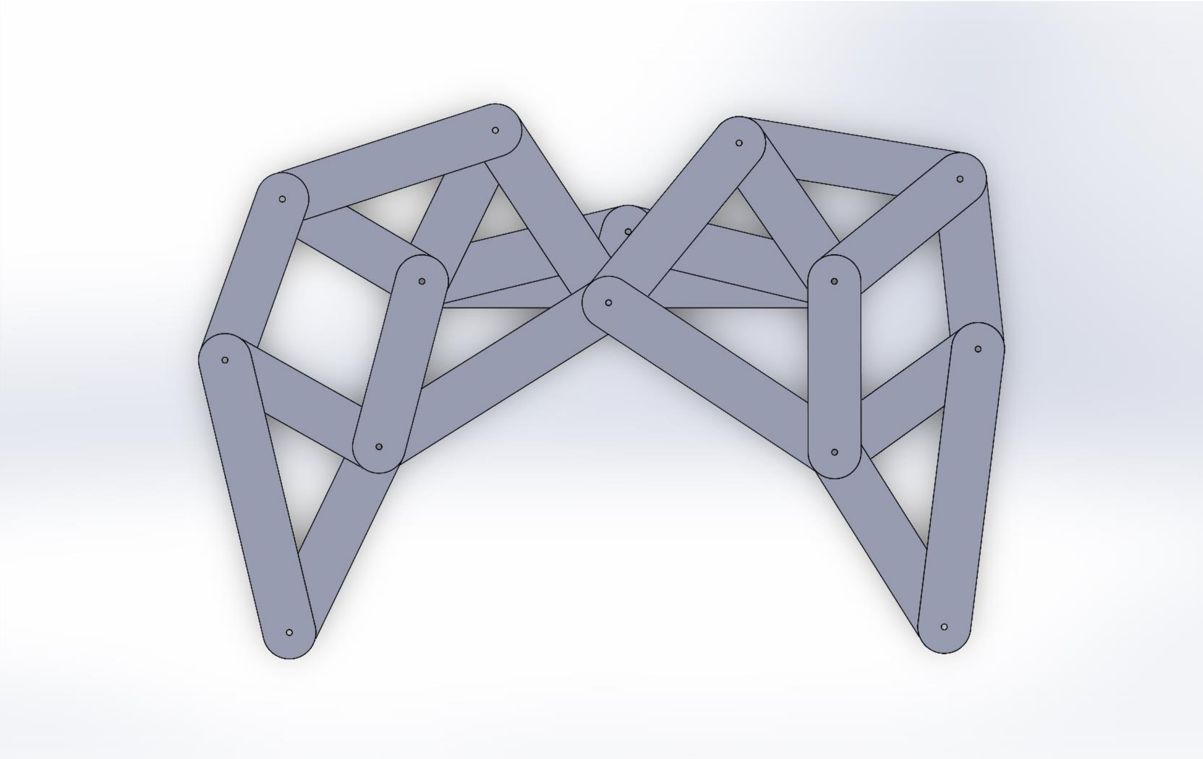
4. Ice Cream Sticks

5. Screws

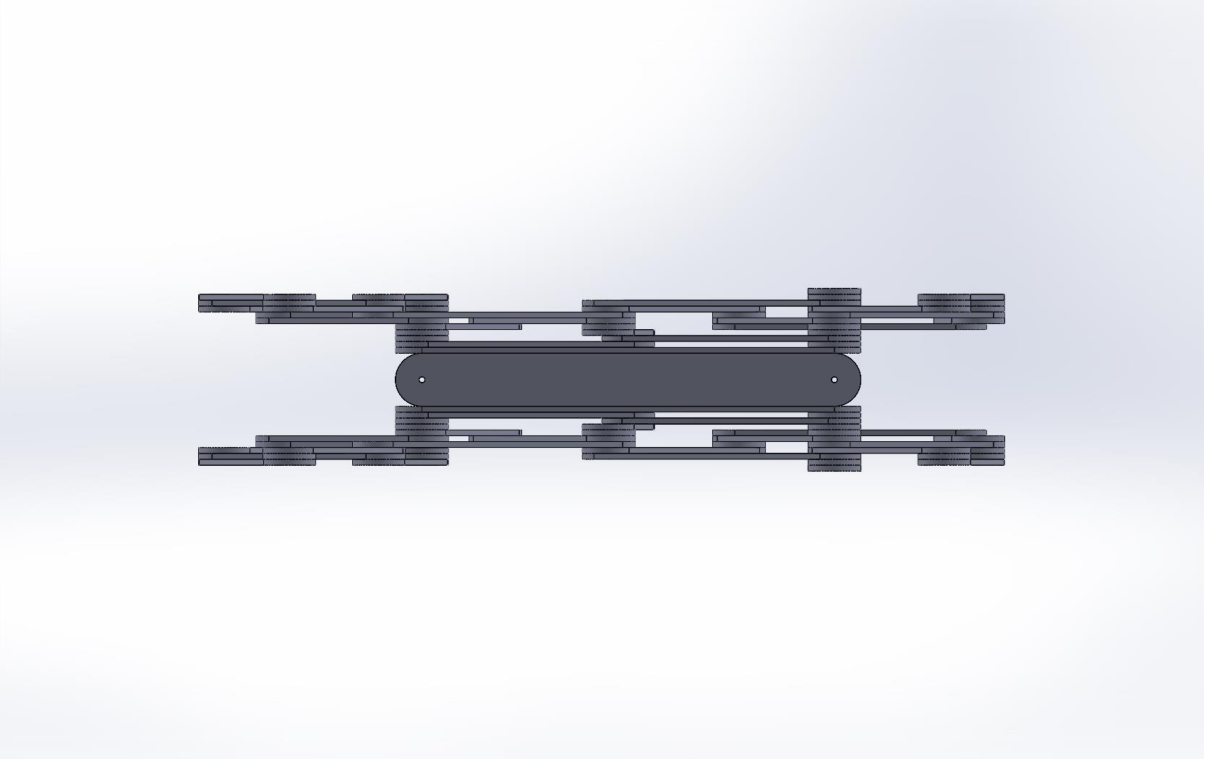
CAD Model of the Mechanism



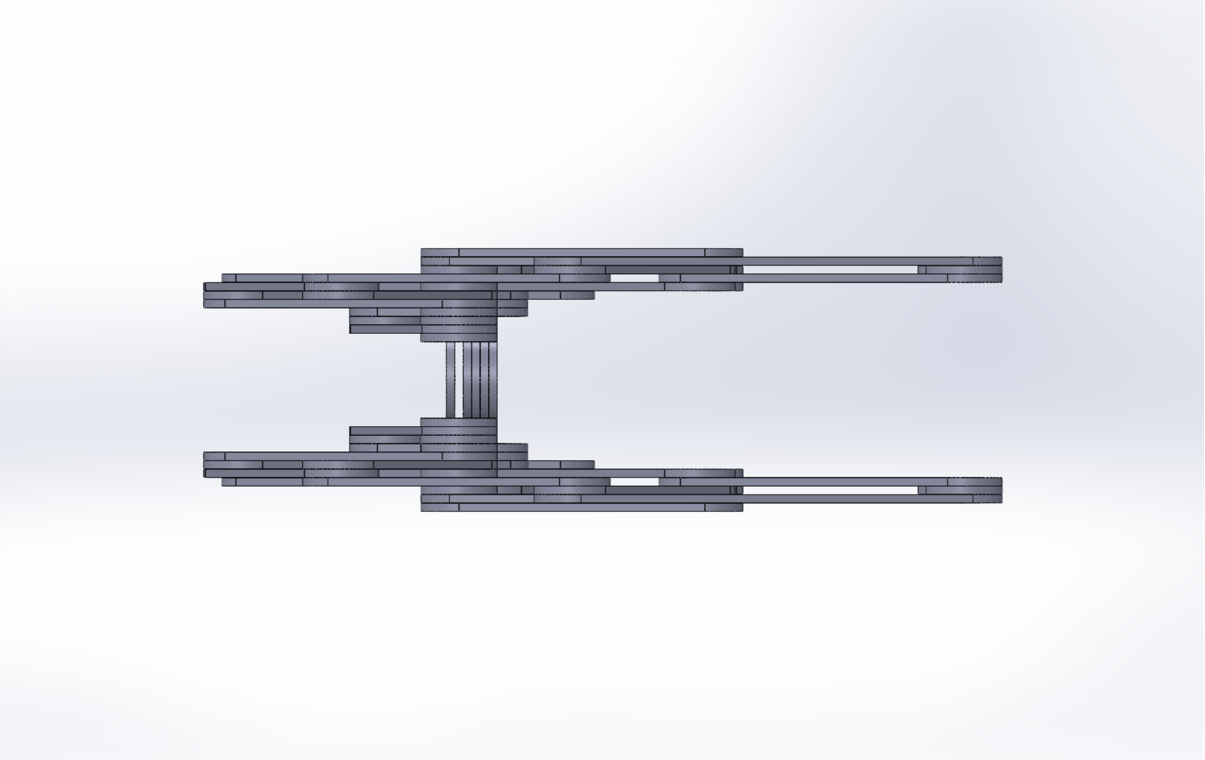
Top View



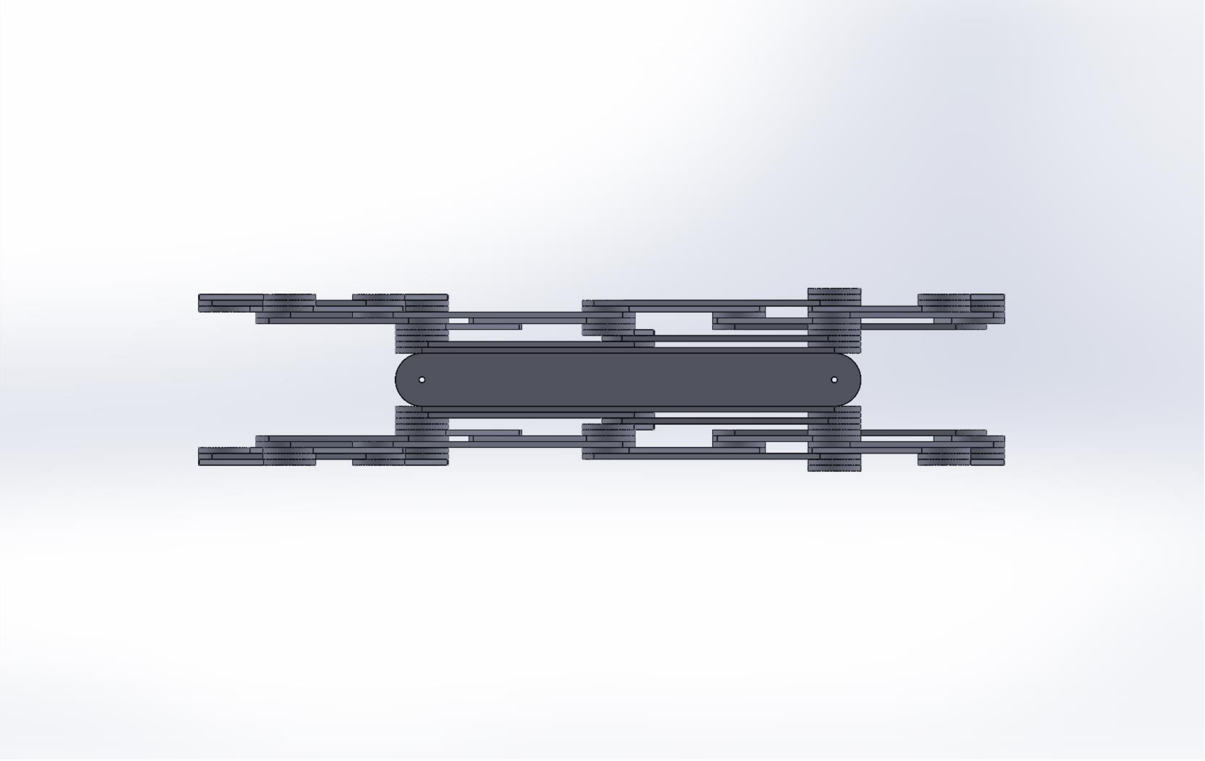
Front View



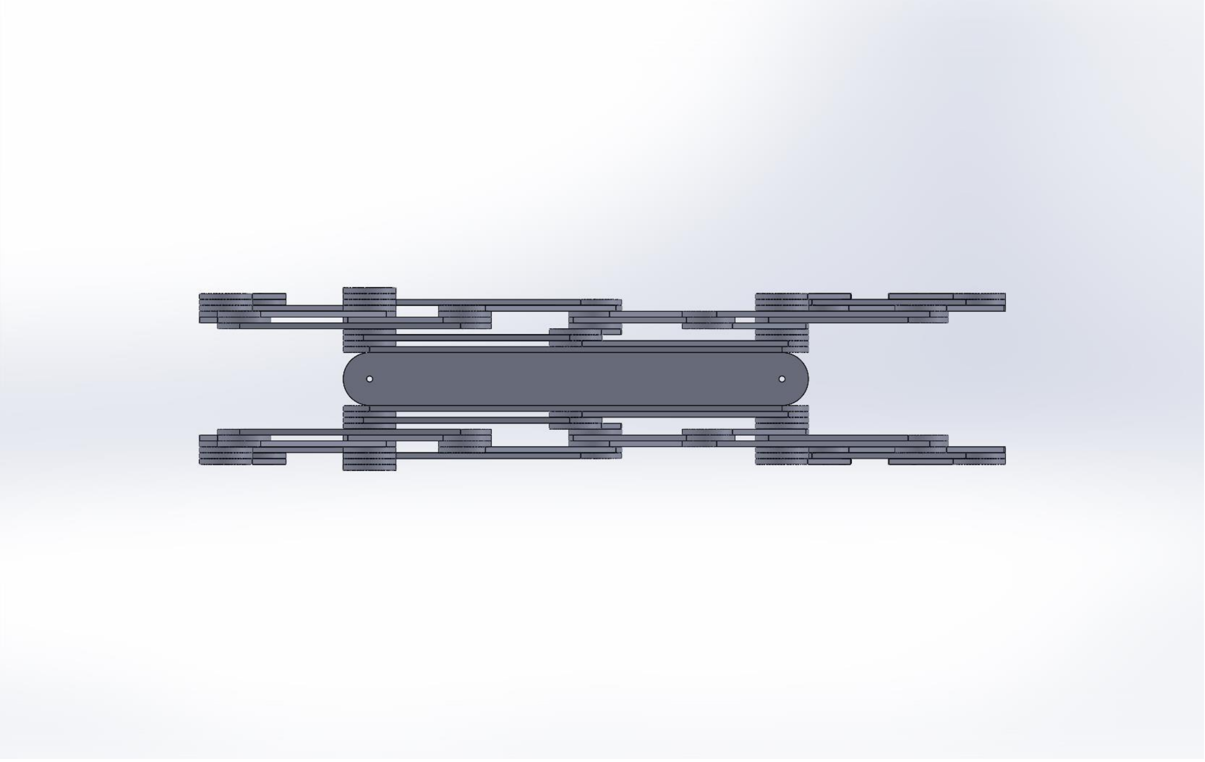
Left Side View



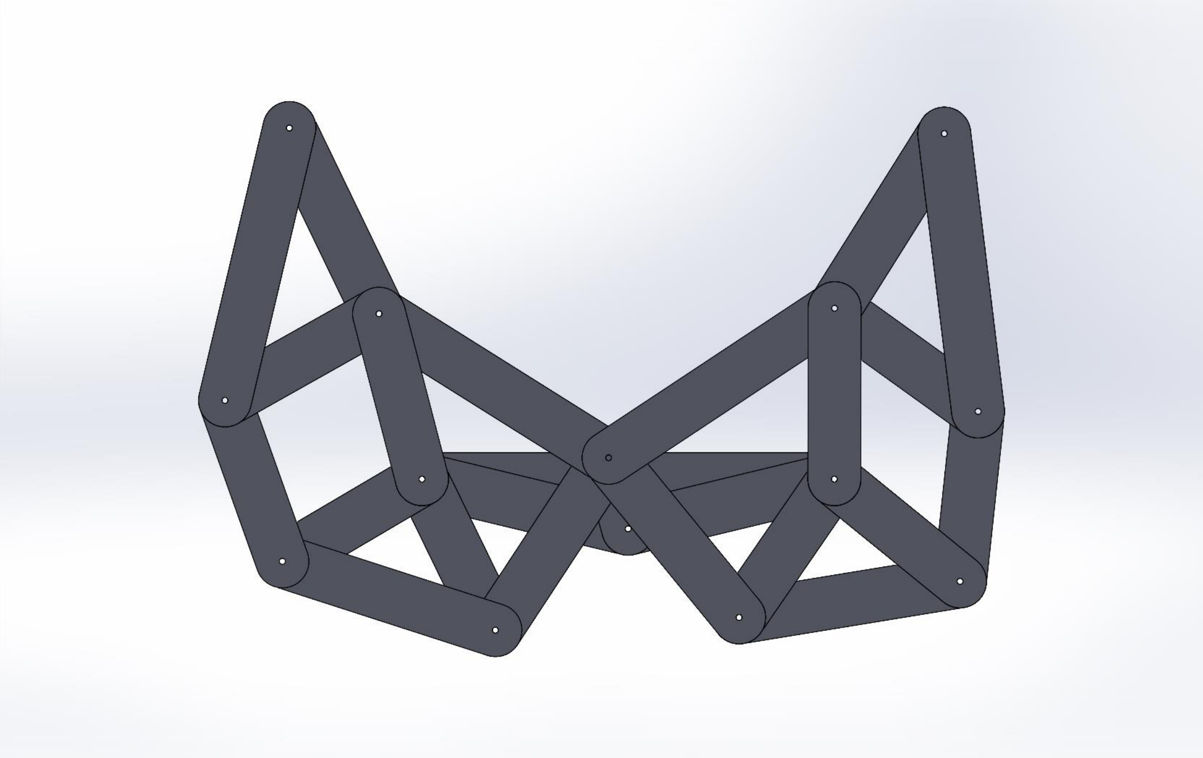
Right Side View



Back View



Bottom View



Application of Course Knowledge to the Project

Crank Mechanism Design and Implementation:

We effectively applied our course knowledge to design and implement a crank mechanism capable of converting rotational motion into reciprocating and oscillating motion, simulating the crawling movement of a spider.

Linkage Mechanism and Coordinated Movement:

To achieve coordinated movement, we connected the driving leg of the robot spider to the other legs using linkage mechanisms. This realistic crawling motion was achieved by adjusting wooden slat lengths and attachment points.

Gearing for Speed Adjustment and Power Optimization:

Our gear knowledge played a crucial role in designing the robot. Implementing an appropriate gear system between the motor and crank allowed for speed adjustment and power optimization.

Ensuring Mechanical Stability:

We ensured mechanical stability by applying principles of weight distribution, component placement, and structural design. This prevented tipping during movement, enhancing performance and safety.

Optimizing Design through Kinematics and Motion Analysis:

An in-depth analysis of kinematics and motion patterns improved design and control parameters. Studying the spider's leg movements and making necessary adjustments significantly enhanced overall performance and efficiency.

Materials Selection for Robustness:

Knowledge of materials science helped us select suitable materials for the robot's construction, considering factors like strength, lightweight properties, and durability. This ensured the robot could withstand movement forces while remaining robust.

Computer-Aided Design (CAD) for Precision:

We utilized CAD knowledge to accurately and intricately model the robot's components. This allowed for precise design specifications and streamlined the fabrication process through virtual visualization and iteration.

Appropriate Manufacturing Methods:

Our course knowledge in manufacturing guided the selection of appropriate methods for producing high-quality parts. Adhering to manufacturing standards ensured the robot's components were accurately and efficiently produced.

Testing Results

Walking Motion: During testing, we observe the robot spider's walking motion to ensure that the reciprocating and oscillating motion of the driving leg effectively translates to the other legs, creating a realistic crawling movement. The robot should move forward, backward, and turn smoothly.

Stability and Balance:

Testing assesses stability and balance, ensuring the robot maintains its equilibrium and avoids tipping over during motion. If stability issues arise, we may need to adjust the design or weight distribution.

Battery Life:

Monitoring the battery life helps determine how long the robot can operate on a single charge. If the battery drains quickly, we consider optimizing power consumption or upgrading to a higher-capacity battery.

Mechanical Wear and Tear:

We check for mechanical wear and tear during testing, ensuring all components are securely fastened. Any parts showing signs of wear will be reinforced or replaced.

Static Testing:

Static testing measures the robot's weight, center of mass, and moments of inertia to ensure stability. The robot demonstrated stability and resistance to tipping in these tests.

Dynamic Testing:

Dynamic testing involves measuring the robot's speed, acceleration, and range of motion to assess its efficiency and realistic movement. The robot exhibited smooth and efficient crawling motion during these tests.

Performance Testing:

We compare the robot's performance to other biomimetic robots to evaluate project success and identify areas for improvement, enhancing overall performance.

Safety Testing:

Safety testing ensures the robot complies with relevant safety standards, guaranteeing safe operation without posing hazards to users.

Durability Testing:

The robot undergoes durability testing to evaluate its ability to withstand various stresses and loads, demonstrating sufficient durability for everyday use.

Environmental Testing:

Environmental testing exposes the robot to different conditions, including extreme temperatures and humidity levels, to assess its adaptability and operability in diverse environments.

The testing results provide valuable insights for identifying areas that require improvement and making necessary adjustments to enhance the performance, stability, and learning capabilities of the robot. Iterative testing and refinement play a crucial role in attaining the desired outcomes for the DIY robot spider project.

June 12, 2023							June 19, 2023							June 26, 2023							July 03, 2023						
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9
M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S

TASK	START	END
Project Initiation		
Define project objectives and scope	Jun 12, 2023	Jun 12, 2023
Requirements Gathering		
Determine functional and performance requirements	Jun 12, 2023	Jun 13, 2023
Identify biomimetic features	Jun 13, 2023	Jun 14, 2023
Concept Design		
Generate conceptual designs	Jun 14, 2023	Jun 16, 2023
Evaluate design options	Jun 16, 2023	Jun 18, 2023
Create visual representations	Jun 18, 2023	Jun 19, 2023
Detailed Design		
Develop mechanical design	Jun 19, 2023	Jun 22, 2023
Develop electrical design	Jun 22, 2023	Jun 24, 2023
Conduct simulations and analysis	Jun 24, 2023	Jun 26, 2023
Material Procurement		
Identify required materials and components	Jun 26, 2023	Jun 27, 2023
Research suppliers	Jun 26, 2023	Jun 27, 2023
Purchase materials	Jun 27, 2023	Jun 28, 2023
Prototype Development		
Assemble mechanical structure	Jun 28, 2023	Jun 29, 2023

Integrate electrical components	Jun 29, 2023	Jun 30, 2023
Test and iterate on the prototype	Jun 30, 2023	Jul 02, 2023
Testing and Validation		
Perform functional and performance testing	Jul 02, 2023	Jul 03, 2023
Validate biomimetic capabilities	Jul 03, 2023	Jul 04, 2023
Address any issues or improvements	Jul 03, 2023	Jul 04, 2023
Documentation and Reporting		
Document design process	Jul 04, 2023	Jul 05, 2023
Prepare project report	Jul 04, 2023	Jul 05, 2023
Create user manuals or guidelines	Jul 04, 2023	Jul 05, 2023
Final Presentation and Review		
Present completed robot	Jul 05, 2023	Jul 06, 2023
Gather feedback and incorporate revisions	Jul 05, 2023	Jul 06, 2023
Conduct final project review	Jul 06, 2023	Jul 07, 2023
Project Closure		
Complete documentation and administrative tasks	Jul 07, 2023	Jul 07, 2023
Handover deliverables to stakeholders	Jul 07, 2023	Jul 07, 2023
Conduct project review	Jul 07, 2023	Jul 07, 2023