INTRODUCTION TO ROBOTICS
(MTS -417)
DE-44 Mechatronics
Syndicate– C

Project Proposal

Title: Development and Kinematic Analysis of a Mechanism Used for a Four-Legged Robot

Name of members:

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1. Problem Description

The project focuses on developing and analyzing the kinematic mechanism of a **four-legged robot**, specifically the **leg mechanism** that defines its motion and stability. In quadruped robots, the leg is the core mechanical element that determines how the robot moves, balances, and interacts with its environment. Unlike wheeled robots, a four-legged system requires precise control of multiple degrees of freedom in each leg to achieve natural and stable walking patterns.

Importance

Four-legged robots are crucial in applications where wheeled or tracked robots fail—such as uneven terrain, disaster response, exploration, or surveillance. A properly designed leg mechanism with accurate kinematic modeling allows for smooth, adaptive, and energy-efficient motion. Understanding and implementing inverse and forward kinematics for such mechanisms is essential to create motion control algorithms that can move the robot's foot (end-effector) to desired positions precisely.

Proposed Solution

The project will begin with the **design and development** of a **single leg mechanism** of a four-legged robot. This leg will include all the necessary joints, links, and actuators that define its degrees of freedom.

- The **mechanical design** will be modeled and built using hardware components such as servo motors or stepper motors.
- **Kinematic analysis** will be carried out mathematically to derive the relationships between joint angles and the position of the foot.
- Both **forward and inverse kinematics** will be implemented to compute joint parameters for a given desired foot position.
- These equations will then be **coded into a microcontroller**, allowing the leg to respond to commands like "move the foot to a specific point in space."
- Once the inverse kinematics are correctly implemented, **control algorithms (such as PID)** will be tuned so the leg can move smoothly.
- If time allows, the same mechanism will be replicated to assemble a complete four-legged robot capable of performing walking motions.

2. Work Distribution

Task	Assigned Member	Description
Mechanical Design & Hardware Development	M. Saqib & Ahmed	Design the 3-DOF leg mechanism, fabricate the prototype, and assemble hardware components (motors, linkages, joints).
Kinematic Analysis	Ahmed Hussain	Perform detailed inverse kinematics derivations; compute all joint angle equations and develop mathematical models.
Software & Control Implementation	Abdul Haseeb	Develop the control logic using the derived equations, write embedded code (Arduino or similar), and tune PID/other controllers.
Integration & Testing	ALL	Integrate mechanical and software components, perform testing, and document the system behavior.

3. Key Deliverables

1. **Mechanical Prototype:**
    - A working **hardware leg mechanism** capable of motion in multiple degrees of freedom.
2. **Kinematic Model:**
    - Complete **inverse kinematic equations** of the leg mechanism.
3. **Software Implementation:**
    - Code implementing inverse kinematics and control algorithms to move the leg's end-effector (foot) to desired positions.
4. **Demonstration:**
    - A **controlled leg motion** that responds to positional commands.
    - (Bonus: If time permits, integration into a full four-legged walking prototype.)

5. **Documentation & Report:**
    - Mathematical derivations, circuit diagrams, control flow, and testing results compiled into a final report.

4. Expected Outcome

By the end of the project, a **single-leg prototype** will be developed that can move its foot to any specified position in 3D space through inverse kinematics and coded control. This will serve as a foundation for a complete four-legged robot capable of walking and maneuvering on different terrains.