Divik Bhargava – Project Portfolio

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Welcome to My Project Portfolio!

This portfolio highlights a diverse range of engineering and robotics projects that showcase my expertise in mechanical design, control systems, and dynamic simulations. Each project integrates theoretical knowledge with practical applications to solve real-world challenges. For more information, please feel free to visit my GitHub Profile.

Design and Development Contributions at Becton Dickinson (BD)

NRFit™ filter needle NRFit™ spinal needle

Product Development Role & Responsibilities:

- Part Design in SolidWorks: Developed detailed 3D models of components, including needle body, hub and syringe ensuring high volume manufacturing for injection molded components
- Functional Verification: Performed CAE simulations to evaluate key functional characteristics such as needle shield pull-out force, syringe leakage, and syringe-needle fit. These simulations helped assess product performance and optimize sample size for DV tests.
- Risk Analysis, FMEA, & Design Verification: Conducted Risk Analysis and FMEA to address potential failure points, optimizing designs for safety and reliability. Planned Design Verification activities such as test method developments, test sampling plans, and measurement system analysis, ensuring prototypes met product specifications and manufacturing standards.
- GD&T & Tolerance Stack-Up: Applied Geometric Dimensioning and Tolerancing (GD&T) principles to ensure tight tolerances and compatibility with assembly processes for spinal needle and spinal syringe.
- Injection Molding & Sample Bracketing: Focused on injection molding design for manufacturability and performed sample bracketing to validate quality standards across a range of conditions, ensuring the product met real-world performance criteria.

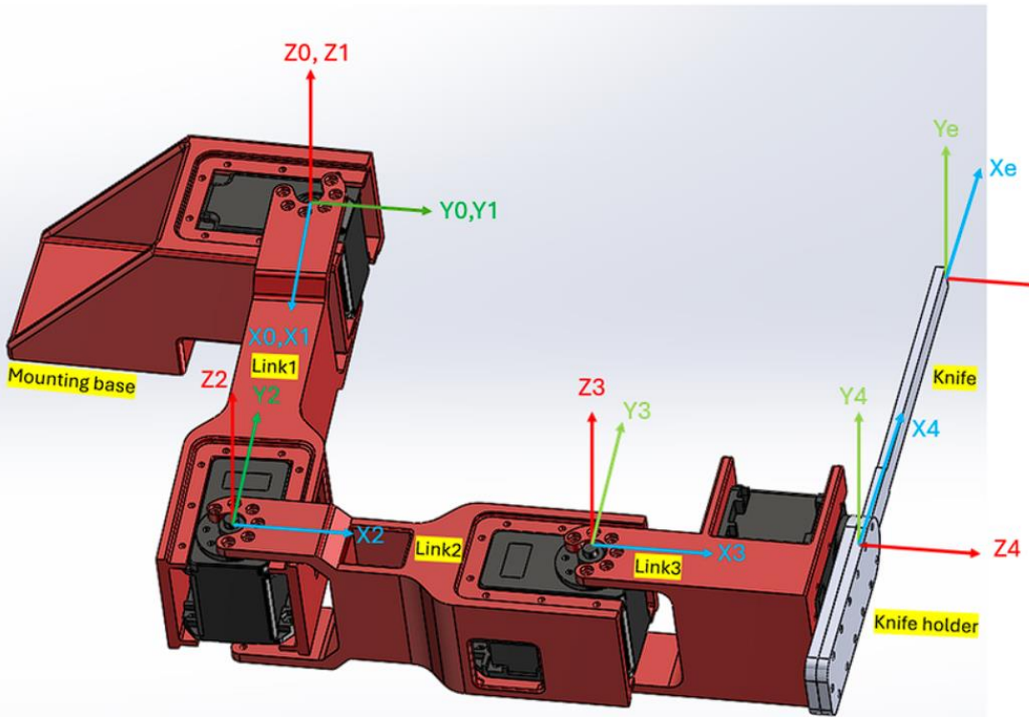
BD Disinfecting Cap

Dual Chamber syringe Utility Patent

Innovation Contributions & Patents

- Patent Filing: Filed 9 US patents for innovations in medical devices focusing on multi-chamber syringes, disinfection caps, and needle safety devices**.**
- Product Concept Generation & Prototyping: Developed initial product concepts for various medical devices, including multi-chamber syringe designs, dual disinfection caps and catheter securement device, and prototyped them using 3D printing. This allowed for rapid iteration and physical testing, enabling effective evaluation of design feasibility and functionality.
- Electromechanical Device Development: Designed an electromechanical device using a piezoelectric actuator to transfer vibrational energy through a catheter, optimized via DOE for improved performance. Developed 20+ enclosure concepts and optimized their placement for maximum energy transfer to disrupt biofilm formation

CHOPP: Vegetable Chopping Robot



Overview

The Chopping Robot (CHOPP) is a four-degree-of-freedom (DOF) robotic manipulator designed to assist in food preparation, specifically chopping produce like hard-boiled eggs and bananas. The project demonstrates decentralized PID control and trajectory generation, allowing the robot to handle complex food-cutting tasks autonomously. This system was designed to showcase real-world applications of robotic manipulation and control.

Key Objectives:

- Design and control a robotic manipulator that can safely and effectively cut food items.
- Implement decentralized PID control to manage the robot's trajectory and motion.
- Optimize the system to handle different types of food items with precision and reliability.

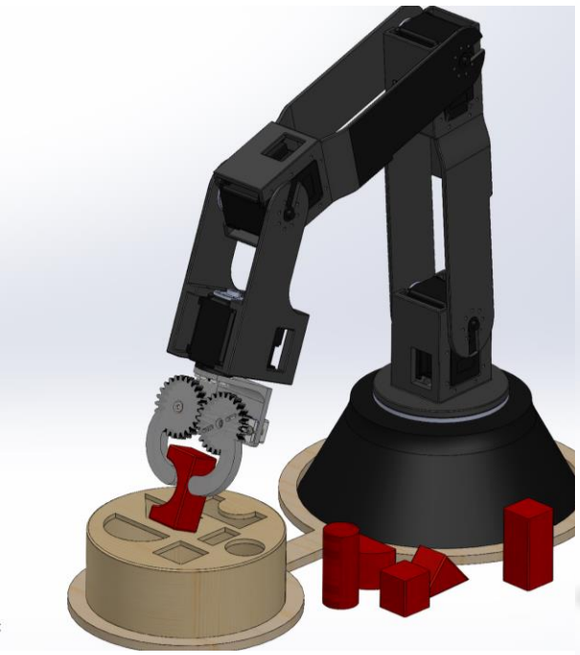
My Role:

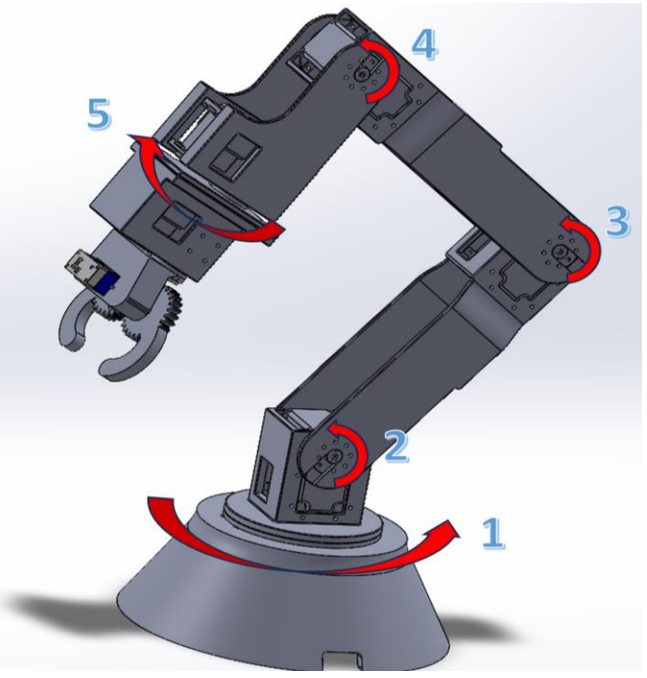
- Conceptualized and designed the Robot using SolidWorks
- Developed the overall control system for the robot.
- Implemented decentralized PID controllers to ensure smooth and accurate motion.
- Conducted testing and calibration to ensure safe operation during food cutting.

Results/Impact:

- Successfully designed a system that could chop and organize food autonomously.
- The project demonstrated the potential for robots to assist in food preparation in domestic or commercial environments.

SQUARE: 5DOF Robotic arm





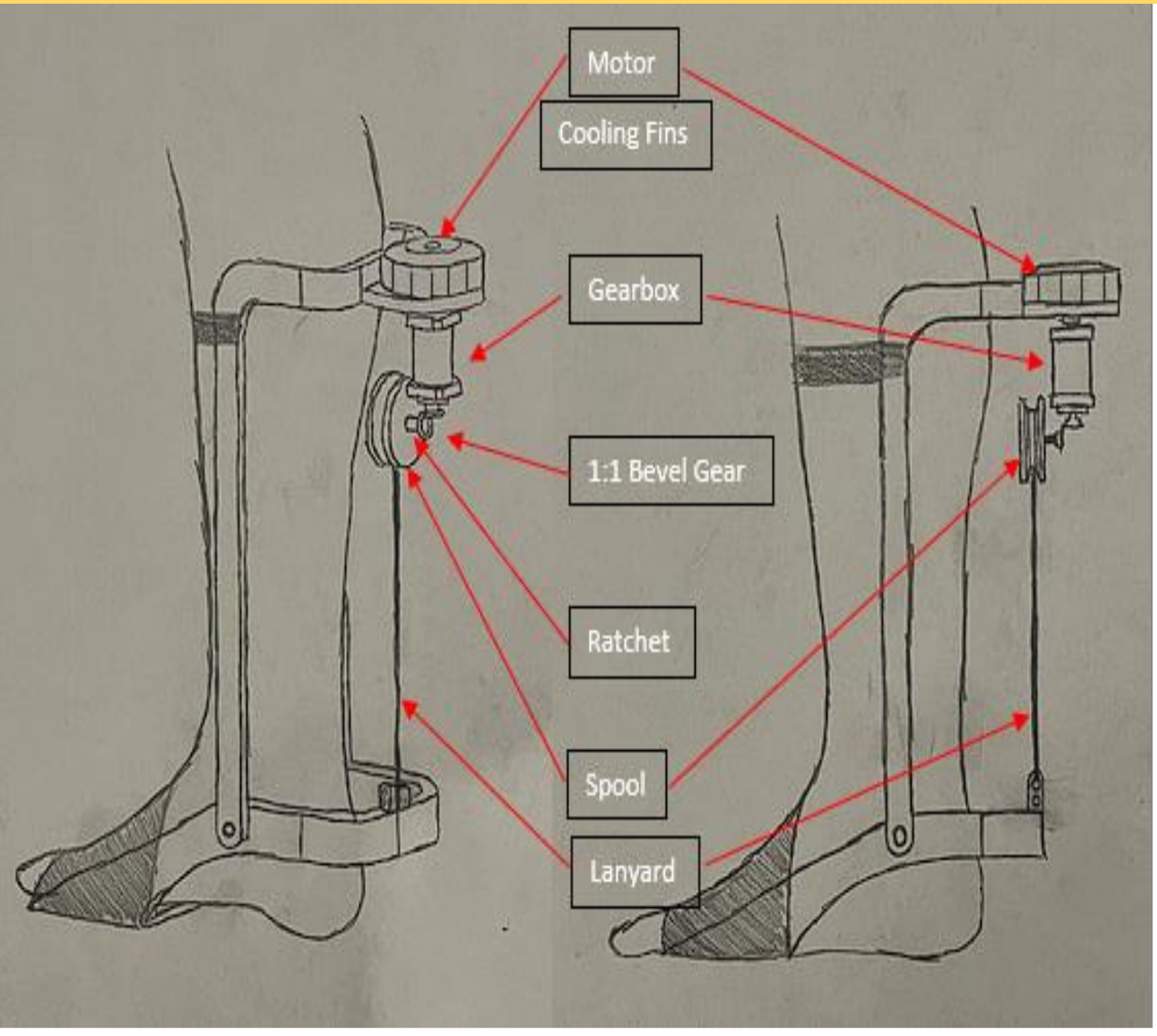
Overview:
Designed and built a 5-degree-of-freedom (DOF) robotic manipulator to precisely place blocks into a square hole, inspired by the viral “It Goes in the Square Hole!” video. The project showcased kinematic control, motion algorithms, and a custom gripper system for accurate object manipulation.

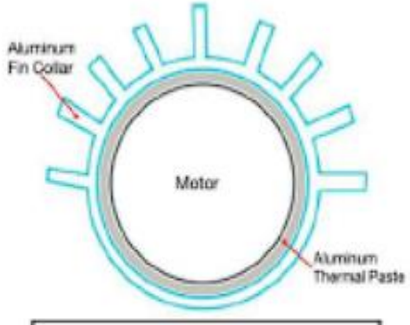
Key Objectives:
- Develop a robotic arm capable of precise object placement.
- Implement kinematic control and motion planning for smooth operation.
- Design a custom gripper for secure handling of objects.

My Role:
- Designed and modeled the robotic arm in SolidWorks.
- Fabricated using 3D printing, and assembled into functional prototype
- Developed control algorithms to ensure precise block placement using MATLAB

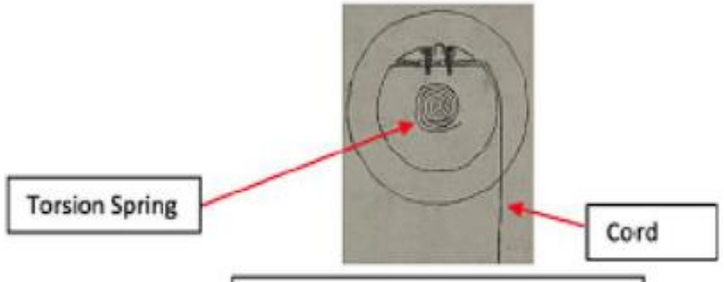
Results:
- Achieved high-accuracy object placement using optimized motion control.
- Successfully integrated custom gripping mechanisms for secure handling.
- Demonstrated real-world application of robotic kinematics and automation.

Bionic Foot Prosthesis





Cooling System



Spool Cross Section

Overview:

Designed an assistive bionic foot prosthesis to aid individuals with Achilles stiffness and weakened calf muscles. The system supplements plantarflexion, reduces muscle force requirements, and enhances gait efficiency using biomechanical modeling and motorized assistance.

Key Objectives:

- Develop a biomechanical model to simulate Achilles tendon pathology.
- Design an energy-efficient actuator system to support plantarflexion.
- Optimize motor selection, transmission, and control system for seamless integration.

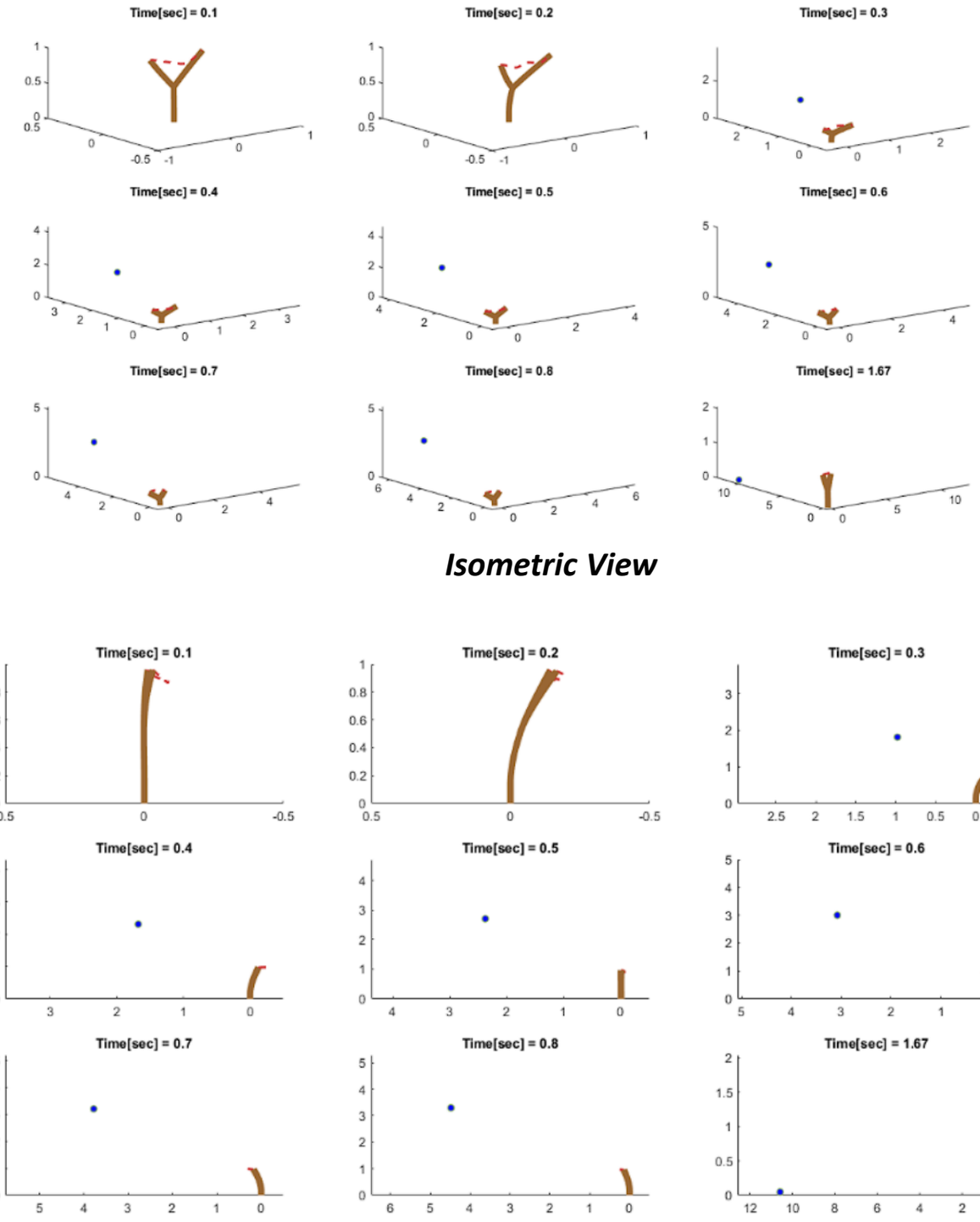
My Role:

- Modeled tendon stiffness and calf muscle weakness in OpenSim and define torque requirement for each gait instance.
- Conceptualized bionic system design, defined motor characteristics and optimized transmission system
- Optimized actuator placement and force for load reduction.

Results:

- Reduced peak Soleus muscle force by 82%, minimizing discomfort.
- Maintained metabolic cost efficiency while integrating the bionic system.
- Achieved a lightweight, compact design (4 kg) with torque-efficient transmission.

Angry Bird Catapult Simulator



Isometric View

Side View

Project Overview

Developed a physics-based simulation inspired by Angry Birds, focusing on modeling bending and stretching energy in materials. The project aimed to create a realistic deformation response in objects upon impact by applying principles of continuum mechanics and structural deformation

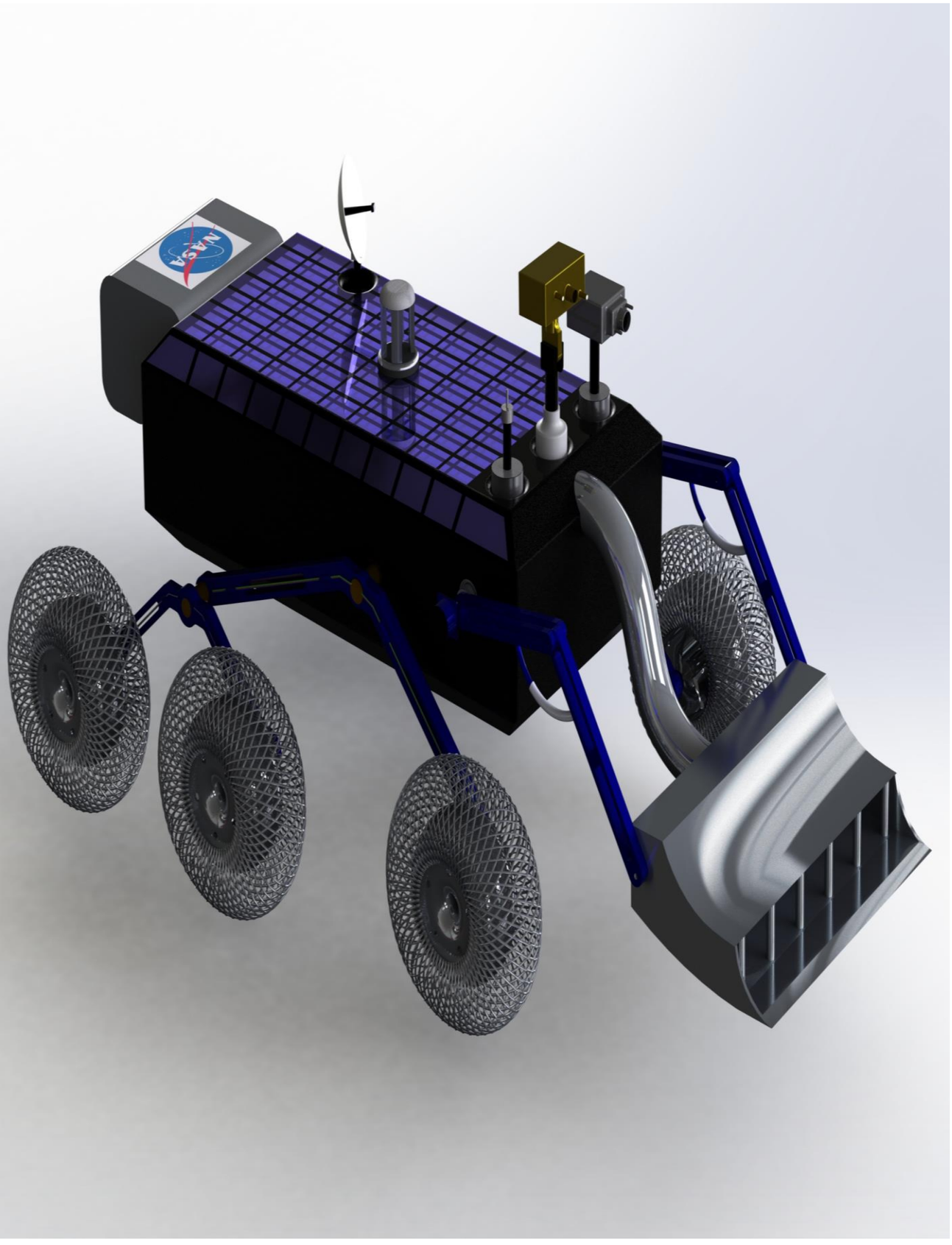
Key Responsibilities & Contributions

- Elastic Deformation Modeling: Implemented a system to simulate bending and stretching of materials upon impact using Hooke's Law and beam bending equations.
- Finite Element Approximation: Modeled structures as discretized beam elements, calculating strain and stress distribution across the material when forces were applied.
- Energy Conservation Principles: Integrated strain energy density functions to track how energy was stored and dissipated during deformation.
- Material Behavior Analysis: Applied different material properties (elastic modulus, yield strength) to simulate the deformation of soft and rigid bodies.
- Numerical Methods & Simulation Performance: Used Euler for dynamic calculations, ensuring accurate time-stepping for deformation evolution.

Results

- Successfully modeled bending and stretching energy in materials, demonstrating realistic deformation under applied forces.
- Verified simulation accuracy by comparing results with analytical beam bending equations and strain energy density functions.

NASA Lunar Sampling System Design Challenge



Project Overview

Designed a lunar sampling system for a NASA challenge, aimed at efficiently collecting lunar surface regolith within a specific size range and quantity. The system was developed to function in the extreme lunar environment, ensuring precision, reliability, and operational feasibility for future planetary exploration missions.

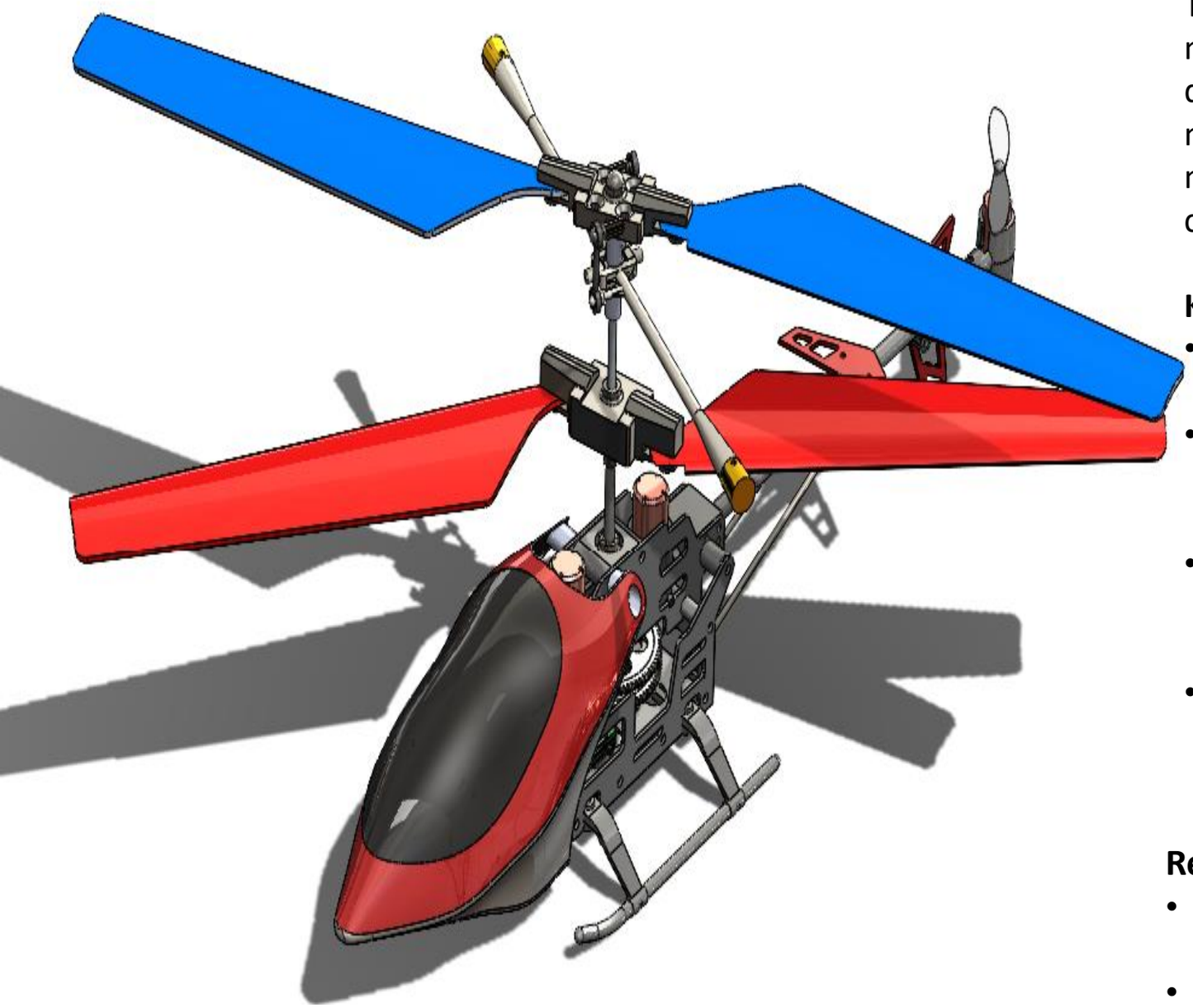
Key Responsibilities & Contributions

- Rover & Mechanism Design: Engineered a mechanical system capable of acquiring and filtering regolith within defined size constraints.
- SolidWorks 3D Modeling: Created a detailed CAD model of the rover and its sampling components, ensuring accurate assembly and motion constraints.
- Regolith Collection System: Developed a scoop and sorting mechanism to capture, sieve, and store lunar material efficiently.
- Structural Integrity & Weight Optimization: Designed for lightweight durability, considering the low-gravity lunar environment.

Results & Outcomes

- Successfully designed a fully functional lunar sampling system, meeting NASA challenge criteria.
- Improved mechanical design skills, particularly in planetary rover development and mechanism integration.
- Developed an efficient regolith collection and filtering system, ensuring precise material acquisition.
- Strengthened CAD proficiency by designing a complex, multi-component assembly in SolidWorks.

Toy Helicopter Modeling in SolidWorks



Project Overview

This personal project focused on enhancing CAD skills by modeling a Toy Helicopter in SolidWorks, translating 2D drawings into a fully detailed 3D model. The goal was to refine mechanical design proficiency, improve surface and part modeling techniques, and develop a structured approach to complex geometry creation.

Key Responsibilities & Contributions

- 2D to 3D Conversion: Interpreted technical drawings and accurately reconstructed them into a parametric 3D model.
- Part & Surface Modeling: Applied solid and surface modeling techniques to create smooth and accurate shapes.
- Assembly & Constraints: Modeled individual helicopter components and assembled them using SolidWorks mates to ensure realistic movement.
- Detailing & Rendering: Enhanced model aesthetics using material properties, decals, and rendering techniques for a realistic appearance.

Results & Outcomes

- Successfully developed a detailed and accurate Toy Helicopter model using best CAD practices.
- Improved mechanical design skills, particularly in complex geometry handling and parametric modeling.
- Strengthened ability to interpret 2D drawings and reconstruct realistic 3D components.
- Gained hands-on experience in surface modeling techniques, essential for aerodynamic and aesthetic designs.