Design & Development of a Multi-Functional Adjustable Work Desk

by Kyle Flanegan

Supervised by Patricia Khwambala

- The adjustable desk integrates electromechanical systems, allowing users to adjust height and tilt precisely, improving ergonomic flexibility in workspace design.
- The adjustable work desk successfully meets ergonomic and user-specific requirements through linear and rotational motion control, supported by an Arduino-based system, enhancing functionality and user comfort.
- This project primarily targets office and home workspaces. It aims to provide an adjustable desk solution that supports both seated and standing positions, reducing sedentary health risks.
- By enabling real-time positional adjustments with user-friendly controls, the desk design addresses modern ergonomic standards, improving user posture and comfort in a versatile work environment.
- Incorporating limit switches, an emergency stop, and momentary switches, the design prioritises functionality and safety, showcasing the effective combination of mechanical and electrical engineering in a single adjustable desk prototype.

DECLARATION OF ACADEMIC INTEGRITY

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Module Code: EMPV400

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Table 1: Self-Assessment

Questions		Included in Part A?	Comment
1	Is the problem statement and summary clear and appropriate?	√	The problem statement and project scope are well-defined and clearly communicated in the introduction section.
2	Is the quality and sufficiency of the literature study and referencing satisfactory?	√	The literature review is thorough, with sources referenced appropriately to support the theoretical foundation of the project.
3	Have alternative solutions been investigated? Are they clearly described?	√	Various alternative solutions have been explored and justified in the problem analysis and design description.
4	Has the fundamental and engineering sciences theory been applied correctly to develop the design concepts?	√	Mechanical, Electrical and Programming Engineering principles have been correctly applied to develop design concepts, as demonstrated in the theoretical background section.
5	Are engineering tools and methods applied correctly to achieve design concepts?	√	Engineering tools such as CAD and FEA software have been effectively used to design and analyse design concepts.
6	Does the document flow well and be laid out? Is the document logical and clear? Is there a satisfactory use of language and technical care throughout the document?	√	The report is well-organised, with clear headings, logical flow, and appropriate technical language and formatting.

Table 2: GA Self-Assessment

ECSA Graduate Attribute		Evidence in Report	Explanation
GA 1	Problem-Solving	Problem Analysis and System Requirements Design Description	The Introduction outlines the specific problem of sedentary work behaviour, leading to the development of an ergonomic adjustable desk. The design description applies detailed engineering methods, including structural calculations and FEA, to ensure functionality. Testing and validation in Part B confirm the desk's stability and adaptability under varying load conditions.
GA 2	Application of Scientific and Engineering Knowledge	Design Description Performance Evaluation, Experiments, and Data Analysis	Scientific and engineering knowledge is used throughout the design, including motor torque calculations, gear ratios, and FEA to validate material choices and structural integrity. Actuator selection and control algorithms were refined in Part B to enhance precision and responsiveness, showcasing a comprehensive application of engineering principles.
GA 3	Engineering Design	System Requirements Design Specification and Operation Description	The design process encompassed constraints like load-bearing capacity and mobility, which were addressed in the final design. Part B reflects an iterative approach, testing data-informed design refinements, such as tuning the control system and enhancing structural stability. The desk now meets all specified ergonomic and operational requirements.
GA 4	Investigations, Experiments and Data Analysis	Performance Evaluation, Experiments, and Data Analysis	In Part B, investigations included voltage stability testing, repeatability tests, and load performance evaluations. Detailed analysis validated the design choices, showing a robust application of experimental methods and data interpretation to support the project's conclusions.
GA 5	Use of Engineering Tools	Design Description Performance Evaluation	Engineering tools, including CAD for structural modelling and FEA for stress testing, were critical in the design phase. Part B demonstrates the practical application of programming tools for the control system and oscilloscope readings for electrical testing, ensuring that all components function as intended.
GA 6	Professional and technical communication	The entire report is written to communicate technical information clearly and effectively.	The report integrates figures, schematics, tables, and testing data, facilitating clear communication of technical aspects. Each section is organised to enhance readability, meeting academic and professional standards for engineering documentation.
GA 7	The Engineer and the World	The Introduction and Conclusion discuss the project's impact on society and the environment.	The project addresses the need for flexible, ergonomic furniture to improve health in the workplace, with environmental considerations in materials and design. This demonstrates awareness of the project's societal and environmental impact, providing a sustainable solution that promotes well-being.
GA 8	Individual & Collaborative Teamwork	The entire report highlights practical individual work and collaborative teamwork.	Collaborative feedback informed design adjustments throughout the project, ensuring that the desk met technical and user requirements. Regular consultations and adherence to feedback demonstrate effective teamwork and alignment with project goals.
GA 9	Independent learning Ability	Literature Review Performance Evaluation	Research into adjustable desks, actuator selection, and control systems reflects a robust independent learning ability. Testing in Part B involved adapting new analytical techniques and demonstrating an ongoing commitment to learning and applying relevant information.
GA 10	Engineering Professionalism	Introduction Design Specification and Operation Description	The project prioritises user safety, with features like limit switches, an emergency stop, and reliable locking mechanisms. Engineering professionalism is evident in the rigorous testing and ethical responsibility to create a safe and functional product.
GA 11	Project Management and Finance	Appendix F – Cost Breakdown Design Specification and Operation Description	Effective project management ensured timely completion within budget constraints, with adjustments based on testing outcomes. The project's structured approach to managing resources, tasks, and timelines underscores a solid grasp of engineering project management.

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Design & Development of a Multi-Functional Adjustable Work Desk

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Nomenclature

DC	Direct Current
FEA	Finite Element Analysis
HAD	Height Adjustable Desk
SSD	Sit-Stand Desk
TPM	Technical Performance Measure
OHSA	Occupational Health and Safety Act
PWM	Pulse Width Modulation

Design & Development of a Multi-Functional Adjustable Work Desk

by Kyle Flanegan

Abstract – This report details the mechanical, electrical, and programming efforts behind a multi-functional adjustable desk with automated height and tabletop tilting capabilities. Critical mechanical tasks included manufacturing telescopic legs from aluminium, supported by custom 3D-printed spacers for stability and precision. The electrical system, featuring an Arduino Mega microcontroller, reads inputs from a control panel to precisely control the linear actuators for height adjustment and a stepper motor for the unique tilting feature. This tilting capability marks an evolutionary advancement in adjustable desk design, providing users with greater versatility and customisation options over traditional models. Through rigorous testing, the desk was shown to meet all design requirements, achieving smooth, synchronised movements and reliable positioning at any height or angle. The result is a high-quality, robust solution that integrates seamlessly into diverse working environments.

***Keywords* — Linear Actuator, DC Motor, Rotational Motion, Arduino Microcontroller, Worm Gearbox**

I. Introduction

Ssedentary behaviour has become a significant public health concern in contemporary society [1]. Being inactive for long periods leads to cardiovascular diseases and mortality, especially for people who don't take part in physical activities often [1].

Adjustable work desks, also known as sit-stand desks (SSDs) or height adjustable desks (HADs), are ergonomic inventions that promote standing and working. Their defining feature is the ability to change the height of the desk surface to accommodate both sitting and standing positions.

Given the increasing trend towards remote work and the growing emphasis on office ergonomics, the need for desks that can accommodate various working positions has become obvious [2]. Manufacturers continuously introduce new models to meet different user preferences and requirements.

This project aims to combine mechatronic principles and knowledge from previous years of study to design and develop a height-adjustable work desk that enhances user comfort and productivity.

The project integrates engineering aspects to create a multifunctional adjustable desk that can switch between sitting and standing heights. Furthermore, the desk features tabletop rotation, providing different angles to work.

This report comprehensively evaluates the completed adjustable work desk, focusing on its design, construction, and performance testing. It details the mechanical, electrical, and programming elements integrated to achieve precise height adjustment and tabletop rotation, meeting the ergonomic and functional requirements. The report also reviews the testing results, demonstrating the desk's structural stability under load and its responsive control system. By examining each component and its role in the final assembly, this report illustrates how the desk meets modern ergonomic standards and offers a reliable solution for flexible and user-friendly workspaces.

II. Literature Review

Research indicates that office workers are among the most sedentary groups, spending approximately 73% of their workday sitting down [3]. This highlights the need for height-adjustable desks to reduce sedentary behaviour and promote healthier working environments.

A crucial aspect that sets HADs apart from traditional office desks is the height displacement they can achieve. Traditional office desks, however, offer no height adjustments of the surface, forcing the user to work in a sitting position.

A. Existing Adjustable Work Desks

Adjustable desk configurations vary, including L-shapes, U-shapes, and traditional rectangular shapes. While similar in form, they perform differently, using different control mechanisms to achieve their adjustments.

In a previous analysis and design of a drafting table, nine anthropometric measurements were examined [4]. The 5^{th} and 95^{th} percentile of the minimum and maximum measurements for both men and women were considered. Table 3 indicates the recommended dimensions for drafting tables with larger surfaces to accommodate architectural work.

Table 3: Standard Desk Surface Dimensions

Parameter	Measurement
Drafting Table Length	1200 mm
Drafting Table Width	800 mm

The above measurements outline the standard surface dimensions referenced in the adjustable desk design.

B. Adjustable Work Desk Control Mechanisms

Linear motion, also known as one-dimensional motion, is characterised by movement along a single spatial dimension [5]. This type of motion control enables seamless modifications to the desk's height. The two ways this motion can be achieved is by using brushed DC motors or linear actuators, both widely used in existing HADs.

1) Electric Motors and Lead Screw

The use of a lead screw mechanism driven by a DC motor provides highly efficient linear movement, essential for adjustable desk applications [6]. The lead screw translates the rotational motion of the motor into linear displacement, ensuring smooth and accurate height adjustments. This setup is effective in achieving the desired height range with minimal noise and wear, as the lead screw distributes load evenly along its threads [6]. The study highlights the robustness of this mechanism, capable of handling substantial loads while maintaining stability and precision, making it a good choice for modern desk designs [6].

Further research demonstrates the effective use of lead screw mechanisms driven by stepper motors in automated systems, similar to those required for adjustable desks. This study, focusing on a smart forklift mechanism, highlights the precision and load-bearing capacity of lead screw systems [7]. The stepper motor provides torque and fine control, accurately converting rotational motion into linear movement. The lead screw's ability to handle significant loads and the stepper motor's high precision and low maintenance requirements make this combination ideal for ergonomic applications. [7].

2) Linear Actuators

Commonly integrated into robotic systems, actuators enable a robot to react with its surroundings by converting energy into physical motion [8]. Ongoing research and development in actuators have led to enhanced control strategies and designs, resulting in their increased accuracy, durability, and energy efficiency [8].

Hydraulic Actuators use fluids to generate mechanical forces and movements. They can produce linear, rotary, or oscillatory motion [9]. Hydraulic actuators are popular in the industrial and automotive industries due to their accurate motion control and high force and speed capabilities [8]. With the unbelievable strength of fluids, these actuators can provide incredible forces, which means they tend to move at a slower speed.

Pneumatic Actuators rely on compressed air to generate linear motion. Their compact bodies include compressors as power sources, valves for airflow control, sensors, and a controller to regulate and monitor the system [9]. Pneumatic actuators are popular in the industrial automation industry as they are reliable, flexible in application, and cost-effective [8].

Electromagnetic actuators transform electrical energy into mechanical motion. They offer advantages such as quick response times, affordability, and ease of control and maintenance. They are popular in the robotics industry because of their ability to operate with high efficiency, precision, and scalability [8].

Powered by hydraulic fluid, pneumatic pressure, or electric current, linear actuators are versatile and widely used to enable controlled linear movement in adjustable work desks.

C. Rotational Control

Rotational control mechanisms in drafting tables provide a foundational comparison for enhancing the functionality of adjustable work desks. Traditionally, these tables feature a lever-locking mechanism below the tabletop, facilitating manual angular adjustments that allow architects to set a comfortable angle for drawing and reviewing plans. This manual system, while functional, reveals a market gap for further automation and improvement.

Such advancements can be achieved by integrating mechatronic principles that combine mechanical and electrical components, enabling automatic tilting of the desk surface through either incremental or sequential motion.

The application of solar panel tilting mechanisms provides an appropriate analogy. A control system for solar panels was showcased, which utilised 180-degree servo motors controlled by an Arduino microcontroller, which dynamically adjusted the panel’s positioning based on programmed algorithms [10]. The microcontroller could command the motors to rotate in both directions at varying speeds, modelling similar technology that could be applied to adjustable work desks.

Controversially, stepper motors are used in precision control and positioning applications due to their step angles [11]. Their application in solar tracking systems reveals their potential for enhancing the functionality of adjustable work desks. Stepper motors are more powerful, more controllable, and more energy-intensive than any other electrical motor [11].

This review of rotational control mechanisms showcases the potential for adopting principles and applications from various sectors. These control mechanisms in adjustable work desks will improve functionality and user satisfaction.

D. Control Schemes

Actuators are frequently driven by software, with the control signal originating from a microcontroller [12]. The critical element for reliability and performance is their control system. Due to various applications, limitations of standard control methods have been noted. Hence, new control techniques are being developed to reduce the uncertainties and non-linear dynamics usually found in actuators [12].

Control schemes are the methods used to regulate and adjust a system's behaviour to minimise overshoot and steady-state error, thereby driving the output toward the desired setpoint [12]. Digital controllers offer accuracy and versatility in control due to their ability to handle complex algorithms [12].

A study [11] models the precise horizontal tilting of a solar panel, demonstrating the effective control of a stepper motor using an Arduino microcontroller paired with a motor driver. A software algorithm controls the angular rotation of the stepper motor with high precision, which is relevant to the adjustable work desk's screening feature that requires precise adjustments. Moreover, the Arduino UNO efficiently handles tasks such as data reading, performing calculations, and managing control systems [11]. These applications highlight the microcontroller's capabilities of performing the operations of the adjustable work desk, making it an excellent choice for integrating into the design.

A Raspberry Pi's capability to control stepper motors was demonstrated in a smart forklift mechanism [7]. The 40 pins on the Raspberry Pi provide sufficient connectivity for multiple motors, sensors, and control panel components, which may be necessary for the adjustable work desk design. The Raspberry Pi's higher processing power and RAM, compared to the Arduino Mega, allow the handling of complex control algorithms and real-time processing [7].

III. Problem Analysis and System Requirements

The following section addresses the need for this desk by outlining the functional objectives and requirements.

A. Project Rationale

Traditional desks do not offer automatic tilt adjustments, restricting users from achieving optimal postures for various tasks. This project seeks to overcome these limitations by creating a desk capable of reliable height adjustments and a full 90-degree tabletop tilt. This will allow for sitting, standing, and specialised functions like presentation mode addressing the need for ergonomic solutions in modern workspaces.

B. System Requirements

The adjustable work desk is designed to meet three functional modes, ensuring comfort, accessibility, and usability across various tasks. Table 4 summarises the top-level requirements that the system must fulfil.

Table 4: System Requirements

System Requirements	Description
Sitting Mode	Provides a comfortable seated workspace
Standing Mode	Allows a smooth transition to a standing position
Screening Mode	Tilts the tabletop to a 90-degree angle

To meet these requirements, specific design concepts were integrated to ensure functionality, ergonomics, and safety. The most suitable and feasible approach involved using actuators or a lead screw mechanism for height adjustment, coupled with a worm gearbox driven by a NEMA 23 stepper motor. This design choice effectively addressed all the project requirements while staying within the budget. The overall design incorporates essential mechatronic principles and technical reliability, making it a robust solution with operational consistency.

C. Technical Performance Measures

The project requirements were carefully analysed to ensure that the desk met all necessary criteria. Table 5 outlines the TPMs for the desk, illustrating the importance of the factors considered during the design process.

Table 5: Technical Performance Measures

TPM	Requirement	Importance
Height Adjustment	Automated height adjustment for both sitting and standing modes	20%
Screen Mode	Tilting tabletop from horizontal to vertical for versatile use	20%
Safety	Integrated locking, alarm, and sensors for user protection	15%
Load Capacity	Supports 70 kg seated, 30 kg standing	10%
Stability	Ensures structural integrity under maximum load	10%
Surface Dimensions	Standard desk dimensions (1200 mm x 600 mm)	5%
Surface Finish	Whiteboard-compatible surface	5%
Mobility	Equipped with lockable castors	5%
User-Friendliness	Simple, intuitive control panel	5%
Minimalistic Design	Integrated components and uncluttered leg space	3%
Overall Appearance	Modern, black aesthetic	2%

This section accurately defines the system requirements for the adjustable work desk. By providing precise height adjustments, large load capacities, and tilting functions, the desk exceeds the needs of modern office environments.

IV. Design Description

This section outlines the development of the final adjustable desk design and details the reasoning behind specific design choices.

A. Description of the Design Development

As mentioned in the previous section, the final design was developed to support two primary modes of operation: height adjustment and tabletop tilting. As detailed below, achieving these functions required thorough research and deliberate design decisions.

1) Mechanical Aspects of the Design

The desk structure is predominantly made from steel and aluminium to ensure stability and meet the "robust" design requirement. The Finite Element Analysis (FEA), illustrated in Figure 1, shows that the horizontal legs experience the highest stress points, guiding the material choice and design. FEA Results can be found in_Appendix A – FEA Forces on Base Legs.

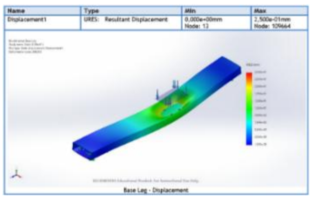

Figure 1: FEA Resultant Displacement on Base Legs

The 1.6mm thick steel tubes proved adequate to support the maximum load, while the telescopic legs relied on aluminium tubing that slotted into a channel and stabilised by spacers. This setup, shown in Figure 2, was chosen for its effectiveness in achieving smooth linear motion.

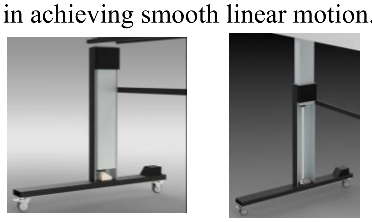

Figure 2: Telescopic Leg Assembly

The actuators in the above figure were mounted upside down, with the DC motor at the top of the legs to prevent cables from obstructing the linear motion. This arrangement also reduces the risk of injury, as the actuators face away from any moving parts during adjustments.

The above image shows the actuator shaft exposed when the desk raises, creating a safety hazard. To solve this, a 3D-printed housing assembly, Figure 3, was designed to enclose all moving parts of the desk completely. This addition to the desk was motivated by the Guidelines for Driven Machinery Regulations of 2015, from the OHSA 85 of 1993. This document mentions that all shafts and similar components must be protected [13].

Figure 3: Telescopic Leg Housing

Figure 4: Safety Housing Attached to Legs

The housing above protects all moving parts, eliminates any risk of injury, and satisfies all safety requirements for this project.

The linear actuators have built-in limit switches, preventing them from overextending and retracting and ensuring the height adjustment's safety. They do not draw any current while stationary and can withstand a load of 1200N, proving suitable for this application.

The initial concept of using a single long shaft proved impractical for the tabletop's rotational mechanism due to alignment issues. A revised design, depicted in Figure 5, utilises three shafts to tilt the surface. A flexible spider coupling links the gearbox output to the rotational arm, allowing minor misalignments between shafts. This coupling ensures smooth and stable rotation, accommodating slight variances in alignment without impacting functionality.

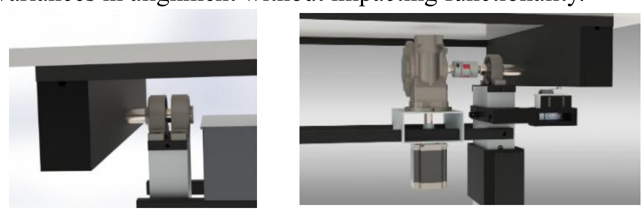

Figure 5: Worm Gearbox Rotational System

The rotating assembly has a total weight of 15 kg. Considering the width of the tabletop while neglecting friction and inertia:

$$T_{total} = T_{load} + T_{dynamic}$$
$$F = ma = (12)(9.81) = 117.72\,N$$
$$T_{load} = F\ x\ d = (117.72)\left(\frac{0.6}{2}\right) = 35.16\ N \cdot m$$

Considering the inertia of the desk surface when it stops and starts rotating, the dynamic torque needs to be calculated. The table rotates around the x-axis, and the centre of mass:

$$I_x = \frac{1}{12}ma^2 = \frac{(12)(0.6)^2}{12} = 0.36 kg \cdot m^2$$

The angular acceleration, the speed at which the surface will rotate, is required to calculate the dynamic torque. Rotational motion kinetic equation:

$$\Delta\theta = \omega_o t + \frac{1}{2}\alpha t^2$$

To achieve a rotation of 30° in 2 sec:

$$\alpha = \frac{2\Delta\theta}{t^2} = \frac{2\left(\frac{\pi}{6}\right)}{2^2} = \ 0.262\ rad/sec^2$$

Therefore, the dynamic torque and total torque are as follows:

$$T_{dynamic} = I_x \cdot \alpha = 0.36 \cdot 0.262 = \ 0.622 N \cdot m$$
$$T_{total} = 35.16 + 0.622 = 35.78\ N \cdot m$$

The above calculations indicate the output torque that the motor and gear system must produce to achieve the rotation of the surface. Together with the stepper motor, the rotational system produces a total output torque of:

$$T_{output} = T_{motor} \text{ x } T_{gearbox} = 1.26 \text{ x } 41 = 51.66\ Nm$$

The above calculation confirms the reliability of this rotational concept as it can produce approximately 15.88 Nm additional torque.

2) *Electrical Aspects of the Design*

The electrical system was designed to deliver stable power to the motors and ensure safe operations. Power is sourced from a 12V, 8.5A power supply, which steps down from the standard 230V AC to 12V DC, suitable for the linear actuators and stepper motor.

A fuse must be integrated with the emergency stop button to protect the system from overload. If the motors get overloaded, the fuse cuts the power for the entire system. This is a safety feature for the user and all the electrical components in the 3D-printed control box below.

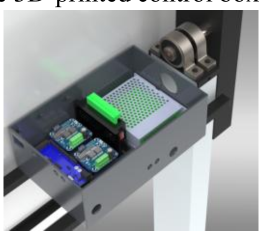

Figure 6: Control Box Housing all Electrical Components

An additional safety feature was an alarm system that notified the user of any mode changes. A piezo buzzer sounds if a motor is running, enhancing operational awareness and safety.

Figure 7 illustrates the precise placement of the limit switches, which halt the motor as the tabletop approaches its endpoints at 0 degrees (horizontal) and 90 degrees (vertical).

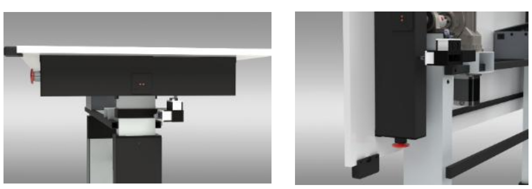

Figure 7: Limit Switch Trigger Positions

This arrangement was essential for maintaining the desk's safety standards by ensuring precise and repeatable stopping points. The accuracy and reliability of the limit switches were further validated through a repeatability test, the results of which are documented in the following section, "Performance Evaluation and Data Analysis."

3) *IT Aspects of the Design*

The adjustable desk's control panel, shown in Appendix I – Adjustable Desk User Guide integrates four button functions: Raise, Lower, Tilt Forward, and Tilt Backward.

When pressed, an emergency stop button, clearly visible beneath the control panel, immediately cuts power to the system. Once the E-Stop is acknowledged, by twisting it, the controls will be functional again.

Throughout the planning and design phases, several concepts for the rotational control system were evaluated, as illustrated in Figure 8. Various tilting configurations were considered in consultation with project supervisors to provide the desired functionality for the screening mode.

Figure 8: Rotating Motion of Screening Mode

Ultimately, momentary switches proved most effective as they allow the user to adjust the tilt continuously rather than being limited to set increments. Alternative designs with step increments of 15 or 30 degrees were discussed, which would have limited the tilting function to only a few pre-set positions, as shown in Figure 8 above.

Appendix F – Programming Sequence Flow Chart illustrates the simplified logic for the adjustable work desk's control system. It outlines the primary decision-making steps and actions for adjusting the desk's height and angle.

The software code also includes logic to manage tilting limits using sensor feedback, preventing the tabletop from colliding with the desk frame while tilting. With these measures in place, the control system delivers functional versatility and adheres to essential safety standards, making it a reliable solution for ergonomic adjustment in modern workspaces.

4) *Integration of Mechanical, Electrical and IT Aspects*

The functional flow chart in Figure 9 illustrates the integration of the adjustable work desk's mechanical, electrical, and IT aspects. The diagram details the structure of the desk's control system, illustrating the distinct modes of operation.

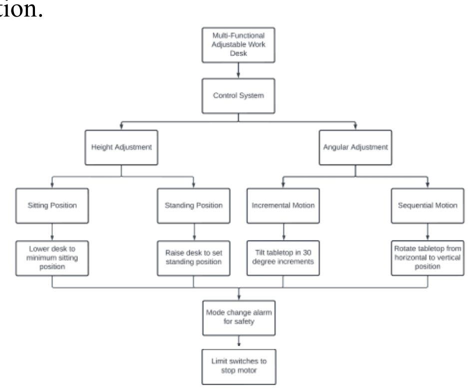

Figure 9: Functional Flow Chart

The flow chart also includes safety features, such as the mode change alarm and limit switches, which stop the motors and ensure accurate positioning. This comprehensive integration supports seamless functionality while prioritising user safety and control.

B. Design Specification and Operation Description

The following section provides a comprehensive specification of the final design of the built adjustable work desk in Figure 10.

Figure 10: Sitting and Standing Screening Mode of the Build and Tested Adjustable Desk

The complete design achieves structural stability, user control, and reliability in its intended functionalities. The following subsections detail the developed desk's mechanical, electrical, and IT aspects.

1) Mechanical Design Description

The desk's mechanical design is engineered to ensure durability, stability, and precise functionality. The structure utilises robust materials to meet load-bearing requirements and support the desk's full range of motion.

FEA results from the previous section indicate that the highest stress points are located on the horizontal legs, where steel tubing has been applied to prevent bending or deformation.

Figure 11 shows the final leg assembly, emphasising the ball-bearing guide rails, which ensured balanced vertical motion and prevented lateral wobbling.

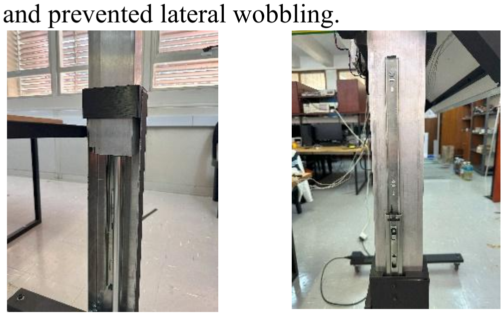

Figure 11: Telescopic Legs

As illustrated above, 3D-printed spacers and rails attached to each leg guided the inner leg to produce smooth height adjustments. The actuators are enclosed within the leg structure, providing a clean, uncluttered appearance.

The rotational mechanism shown in Figure 12 has a NEMA 23 stepper motor driving a worm gearbox. The motor, rated at 1.26 Nm torque, drives a worm gearbox with a 60:1 gear reduction to achieve a controlled tilt range from 0° to 90°. The figure below shows the spider coupling, allowing minor alignment adjustments.

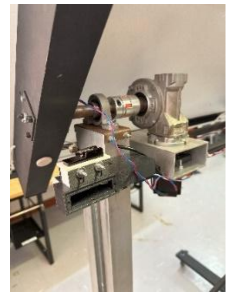

Figure 12: Worm Gearbox and Stepper Motor Assembly

The rotational motion is fed through the tabletop, causing the left shaft to rotate in the two pillow block bearings. This configuration enables the tabletop to tilt smoothly and securely while maintaining its position when the motor is off.

Worm gears are self-locking, which satisfies the locking for this mode. Having the table locked in position without the stepper motor enabled is essential when the desk is not powered on.

Lockable castors attached to each side of the horizontal legs allow for mobility and stability when the desk is stationary.

2) Electrical Design Specification

The electrical system has been designed to distribute power effectively to the actuators, motors, and control panel while integrating safety features and user warnings.

Figure 13 shows the full wiring schematic, detailing the connections between the power supply, Arduino Mega microcontroller, motor drivers, and peripheral components.

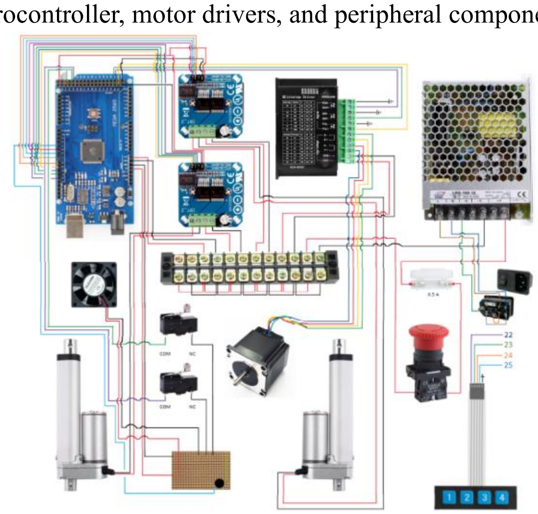

Figure 13: Electrical Circuit Diagram

The power circuit is protected by a 6.5A fuse installed in series with the emergency stop (E-stop) button in the wiring diagram below. In case of an overload or emergency, the E-stop button cuts off all power to the system, preventing further operation.

The control panel includes four momentary switches for height adjustments (raise and lower) and tilt adjustments (tilt forward and backward). These switches provide intuitive operation by allowing users to control each movement in real-time. The choice of momentary switches provides more flexible positioning than preset steps, giving the user complete control over tilt angle and height. Additionally, an audible alarm sounds during mode changes, alerting the user to any movement for enhanced safety.

A 3D-printed bracket, shown below, was designed to prevent physical interference between desk components. It was specifically designed to mount the limit switches on the adjustable right leg of the desk.

Figure 14: 3D Printed Limit Switch Bracket

The bracket moves with the leg, ensuring the switches are functional across both sitting and standing modes. The stepper motor is cut out when they are triggered at each end of the tilting range.

3) *IT and Programming Aspects*

The desk's programming is managed by an Arduino Mega microcontroller, which coordinates the movements of the actuators and motors according to user inputs from the control panel. The Arduino is programmed to interpret the inputs from the control panel and power the motors accordingly.

The control algorithm features safety checks to prevent undesired movements. The limit switches stop the motor as the desk approaches the horizontal and vertical limits, ensuring that the desk remains within its intended range of motion.

The system includes an audible feedback mechanism that activates during any adjustment to height or tilt. This alarm ensures that users know movements, minimising the risk of accidental adjustments. The program also includes a failsafe that immediately stops any ongoing motion if a limit switch is triggered, or the E-stop button is pressed.

4) *Operation of the Desk*

The operation of the adjustable desk is straightforward and designed with user safety and ease of control in mind. The following is a summary of the operation process:

Once powered on, the control panel becomes active, and the desk is ready for operation. The user can adjust the desk's height by pressing the UP or DOWN buttons, indicated with arrows.

To tilt, the user must press and hold the FORWARD or BACKWARD button to achieve the desired angle. Releasing the buttons stops the motors, and the desk locks into that position.

In an emergency or overload, pressing the E-stop button cuts power, instantly halting any ongoing movement.

The adjustable desk's design integrates robust mechanical structures, a safe and efficient electrical system, and an intelligent control algorithm. The engineering drawings, schematics, and specifications ensure that this design can be manufactured and assembled while maintaining clarity and ease of understanding for both evaluators and potential manufacturers.

V. Performance Evaluation, Experiments and Data Analysis

This section outlines the testing procedures conducted to evaluate the functionality and performance of the adjustable work desk in a laboratory where it is desired to be placed. The two crucial aspects of the system, height adjustment, and tabletop tilting, were tested to certify the system's structural integrity, accuracy, and safety. The data acquisition process included three recordings of each operation under evaluation to ensure accuracy in results.

A. *Signal Testing*

This test evaluates the electrical behaviour of the DC motor drivers, particularly aspects such as voltage stability and noise, as the system operates in real-time. Measurements were recorded using a PicoScope 2000 Series Kit with probes attached to the motor drivers. PicoScope 7, the data acquisition software, was utilised for signal conditioning and detailed waveform analysis.

1) *Experiment 1: DC Motor Output Voltage*

This experiment is essential to assess the stability and consistency of the power supplied to the linear actuators, which are critical for the adjustable desk's functionality. By monitoring voltage output during raising and lowering operations, we can identify any fluctuations that may impact the actuators' performance, especially under conditions of uneven weight distribution on the desk.

Probe A was connected to the left actuator's 12V and ground pins, while Probe B was connected to the right actuator. Voltage levels were recorded for both actuators during the raising and lowering operations with minimal load applied.

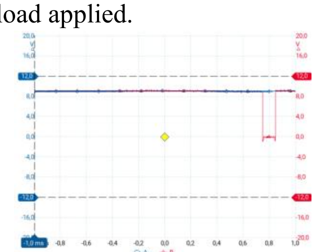

Figure 15: Extending Voltage Output

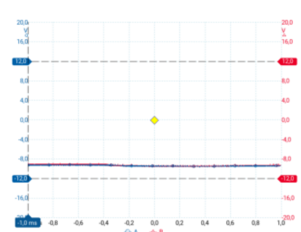

Figure 16: Retracting Voltage Output

The graphs above illustrate that both motor drivers output approximately ±9V to the linear actuators, indicating that each actuator receives an equal power supply during operations. However, the output voltage waveform for the right actuator (represented in red) displays noticeable fluctuations. This is likely due to the additional weight from the rotational system above the right actuator, which exerts variable effort to compensate for this load imbalance.

Although these fluctuations suggest a slight increase in operational strain, they remain within the functional limits, demonstrating that the actuator can still handle the load effectively. A higher-quality actuator could reduce these fluctuations, however the current setup adequately meets the project's requirements.

Table 6 provides essential measurement values captured while the desk was raising, highlighting the performance of each actuator under an upward load.

Table 6: DC Voltage Readings During Extending the Actuators

Measurement	$\bar{x}_{\text{Left}}$	$\bar{x}_{\text{Right}}$	Difference
Frequency (kHz)	114.3	149.4	35.1
Negative DC (%)	10.29	80.26	69.97
Positive DC (%)	89.71	19.74	69.97
Cycle Time (μs)	296.6	7.273	289.327

During the raising operation, the right actuator shows a higher frequency (149.4 kHz) than the left (114.3 kHz), indicating it's working harder due to the additional load on that side.

Table 7 summarises critical measurement values observed during the desk's lowering operation, illustrating the behaviour of each actuator while lowering the desk.

Table 7: DC Voltage Readings During Retracting Actuators

Measurement	$\bar{x}_{\text{Left}}$	$\bar{x}_{\text{Right}}$	Difference
Frequency (kHz)	890.6	731	159.6
Negative DC (%)	48.4	26.35	22.05
Positive DC (%)	51.6	26.35	25.25
Cycle Time (μs)	153.4	283.6	130.2

The left actuator shows a higher frequency (890.6 kHz) than the right (731 kHz), indicating it's compensating slightly during descent.

Overall, the DC motor output voltage experiment confirms that while each actuator responds to the desk's weight distribution, both actuators perform within acceptable limits. These findings validate the system's capacity to effectively manage the added load on the right side, ensuring reliable operation of the desk's height adjustment functions.

B. *Performance Optimisation Testing*

This test established the adjustable desk's performance and functional characteristics. The results obtained from the performance experiments verify the requirement satisfaction. Excel's Data Analysis ToolPak was utilised to achieve the descriptive statistics of the experiment shown in Table 9 and Table 10 in Appendix E. The results from this experiment can be found in Appendix C – Height Adjustment Repeatability Test Results.

1) Experiment 1: Repeatability on Height Adjustment

The linear actuators integrated into the telescopic operate using direct current and do not have positional feedback. This means there is no way of knowing the position of the shaft inside the actuators.

This experiment aimed to determine the optimal PWM speed for each actuator to synchronise their movements and enhance the accuracy of the desk's height adjustment function. Table 8 lists the variables this experiment considered to achieve synchronisation in the desk's height adjustment system.

Table 8: Variable Classification for Synchronising Experiment

Independent	Dependent	Controlled
Table Height	Extending Time	PWM Speed
	Retracting Time	

Appendix E – PWM Speed Adjustment Test Results contains the descriptive statistics of the error in raising and lowering times between the two actuators before adjusting the PWM speed.

The statistics in Table 9 show a mean time difference of 1.441 seconds, indicating variability in synchronisation, with a maximum observed difference of 2.32 seconds. Meanwhile, retracting statistics show a mean difference of 0.77 seconds, with a maximum difference of 1.01 seconds.

These values highlight the need to adjust the PWM speed to reduce discrepancies and improve synchronisation between the actuators.

The results of this test show that the optimisation significantly improved consistency and speed. The mean extending time was reduced to 0.174 seconds, with a low standard error of 0.025, indicating increased uniformity in extending actions. Similarly, the mean retracting time decreased to 0.358 seconds, with a standard error of 0.036. Figure 17 illustrates the waveforms of the error in time between the two actuators before and after speed adjustment.

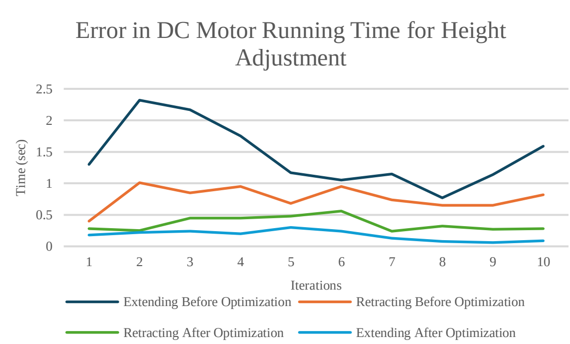

Figure 17: Raising and lowering time error waveforms

Post-optimisation, the green and blue lines representing extending and retracting times exhibit a much flatter trend, with minimal fluctuations across iterations. These results confirm the effectiveness of PWM optimisation in aligning actuator speeds, which is essential for maintaining accuracy in the desk's height adjustment functionality.

This consistency ensures reliable performance in the desk's height adjustment functionality, meeting the system's operational requirements.

2) Experiment 2: Tilting Repeatability

This experiment aimed to assess the accuracy and repeatability of the rotational mechanism in the adjustable desk's tabletop positioning. The objective was to verify if the desk could achieve precise horizontal (0 degrees) and vertical (90 degrees) positions, controlled by limit switches at each endpoint. Accurate positioning is crucial for the desk's functionality and safety, especially when switching between different user-defined positions.

The tabletop was rotated back and forth across its full range, from horizontal to vertical, for 20 repetitions to evaluate this. A smartphone with a precision-level app was mounted on the rotating arm to measure each endpoint with decimal-place accuracy. During each repetition, the angle was recorded at both the horizontal and vertical endpoints to determine any deviation from the ideal 0 and 90 degrees.

This test aimed to identify minor errors in the system's ability to return consistently to the desired endpoints, thus assessing the accuracy of the limit switches. The results are presented in Appendix D – Limit Switch Repeatability Test Results. The graph below visually represents the error for each rotation endpoint over the 20 repetitions.

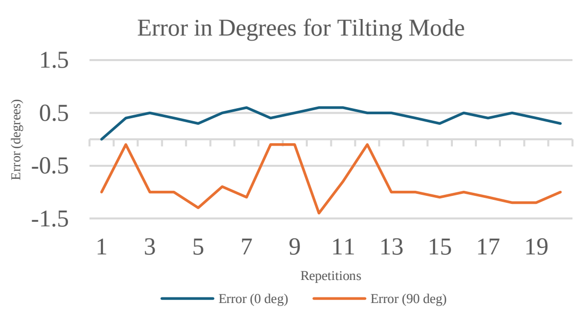

Figure 18: Error Waveforms for Tabletop Tilting Range

The findings indicate that the system generally maintains accuracy in reaching both horizontal and vertical endpoints. Notably, the vertical position (90 degrees) fluctuates slightly more than the horizontal one. The readings and statistical results confirm the reliability of the limit switches, demonstrating accurate repeatability across the test cycles.

VII. Conclusion

In conclusion, this project successfully developed a multi-functional adjustable desk that meets the outlined requirements for structural stability, ergonomic design, and user-friendly operation. The final design integrates mechanical, electrical, and software components to provide three modes, enhancing user comfort and versatility in a modern workspace.

The project validated the desk's capability to withstand loads up to 70 kg in the horizontal position and implemented a compact control panel for seamless mode transitions. Integrating safety features, such as the mode-change alarm and limit switches, ensured controlled and safe operation. Additionally, the iterative design and testing phases allowed for optimisations, such as adjusting the PWM settings to synchronise actuator movement, improving the overall functionality of the desk.

However, several improvements could be considered for future iterations. Utilising higher-quality actuators with built-in positional feedback could enhance accuracy and further reduce the fluctuations observed under load conditions. Additionally, implementing a Bluetooth module to control the desk via a smartphone application could increase its adaptability in various environments.

Overall, this project has provided a solid foundation for an adjustable desk design that combines practical functionality with structural and ergonomic standards. Further development and refinement could expand its applications, potentially making it an asset in both office and educational settings.

VIII. REFERENCES

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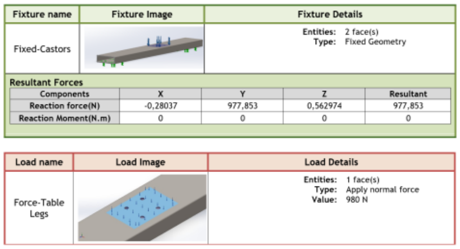
IX APPENDIX

A. *Appendix A – FEA Forces on Base Legs*



Fixture name	Fixture Image	Fixture Details
Fixed-Castors		Entities: 2 face(s) Type: Fixed Geometry

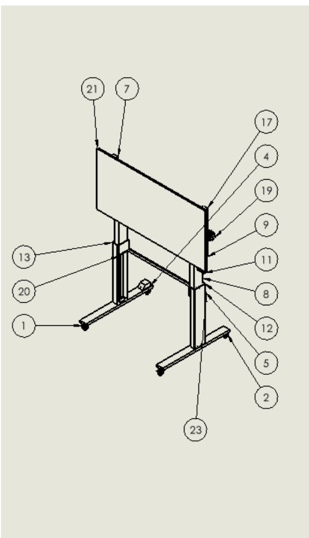
Resultant Forces

Components	X	Y	Z	Resultant
Reaction force(N)	-0,28037	977,853	0,562974	977,853
Reaction Moment(N.m)	0	0	0	0

Load name	Load Image	Load Details
Force-Table Legs		Entities: 1 face(s) Type: Apply normal force Value: 980 N

Figure 19: Loads and Fixtures Simulated in the FEA

B. *Appendix B – Technical Drawings*



ITEM NO.	PART NUMBER	QTY.
1	Castor	1
2	Castor	1
3	Leg Cap	2
4	Plug insert	1
5	Plug Insert	1
6	Connector with switch and fuse	1
7	Rotational Assembly New Shafts	1
8	Rectangular Tube	2
9	E-Stop Bracket	2
10	E Stop Button	1
11	Control Panel	1
12	Spacer Left	1
13	Spacer Right	1
14	Top Crossbar	2
15	Control Box Assebbly	1
16	Gearbox Bracket Plate	1
17	Arm Plugs	3
18	Tabletop crossbars	2
19	Limit Switch Holder Assembly	1
20	Actuator	2
21	Tabletop	1
22	Top Crossbar Plug	4
23	Rect Crossbar Plug	2

Figure 20: Desk Assembly Bill of Materials

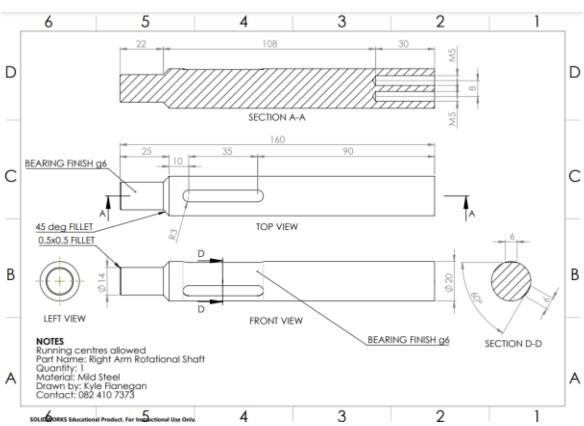


Figure 21: Right Arm Rotational Shaft

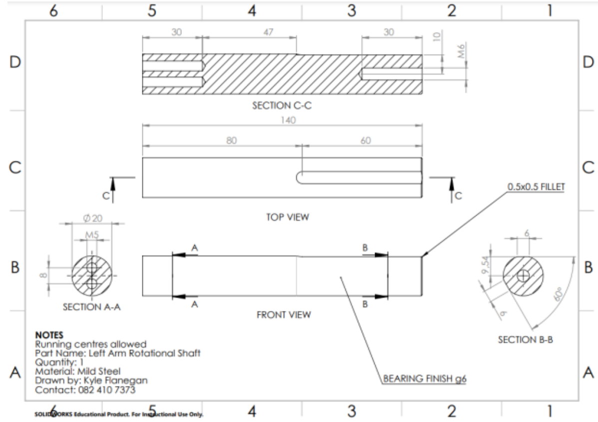


Figure 22: Left Arm Rotational Shaft

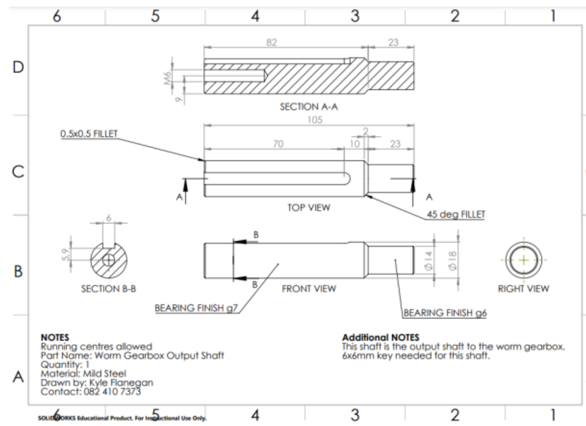


Figure 23: Worm Gearbox Output Shaft

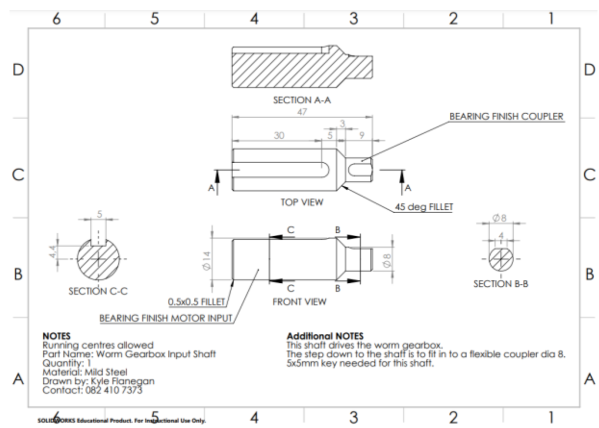


Figure 24: Worm Gearbox Input Shaft

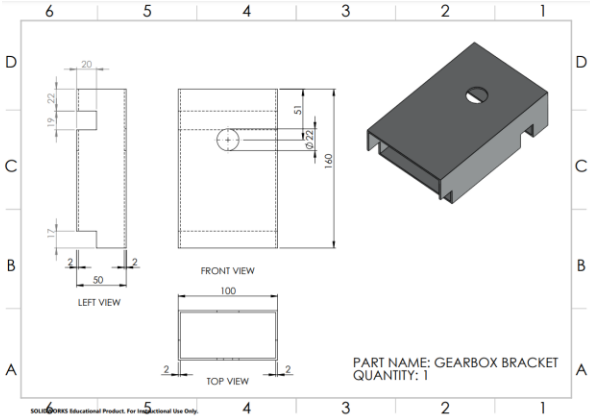


Figure 25: Gearbox Mounting Bracket

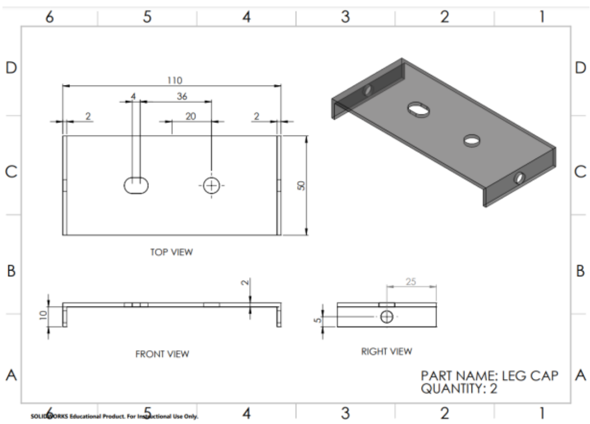


Figure 26: Leg Cap

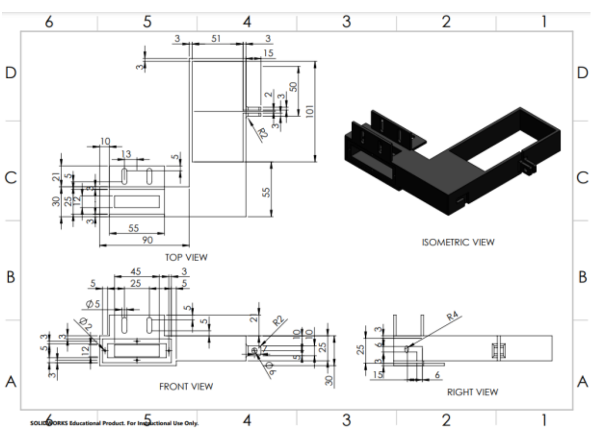


Figure 27: Limit Switch Bracket

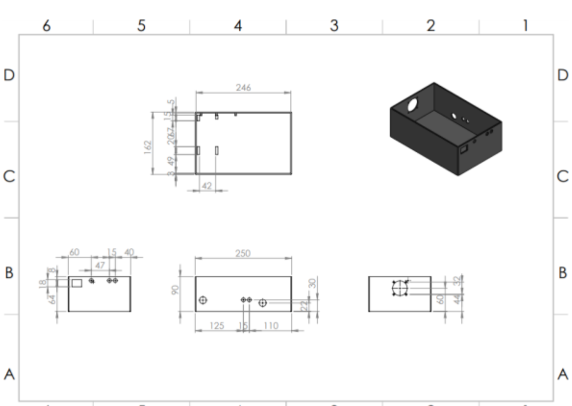


Figure 28: Control Box

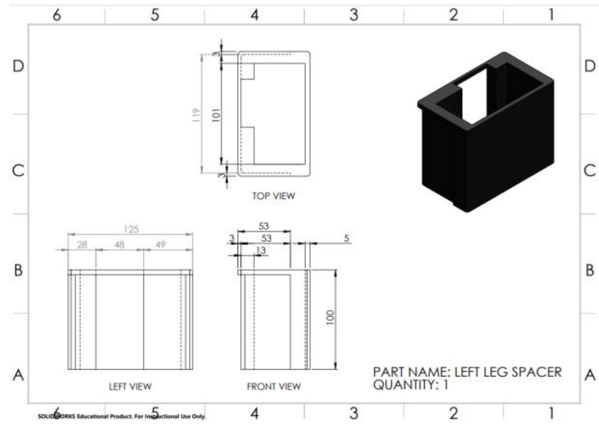


Figure 29: Left Leg Spacer

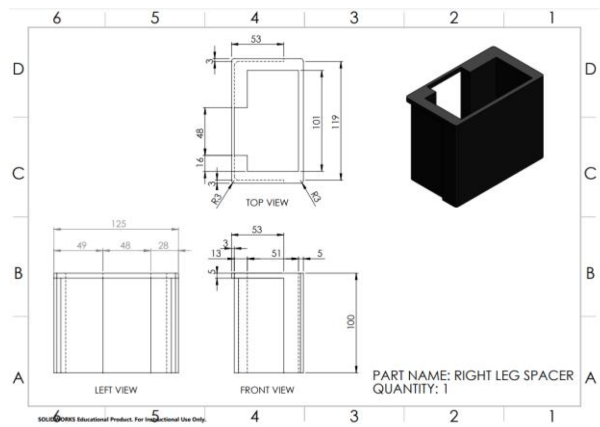


Figure 30: Right Leg Spacer

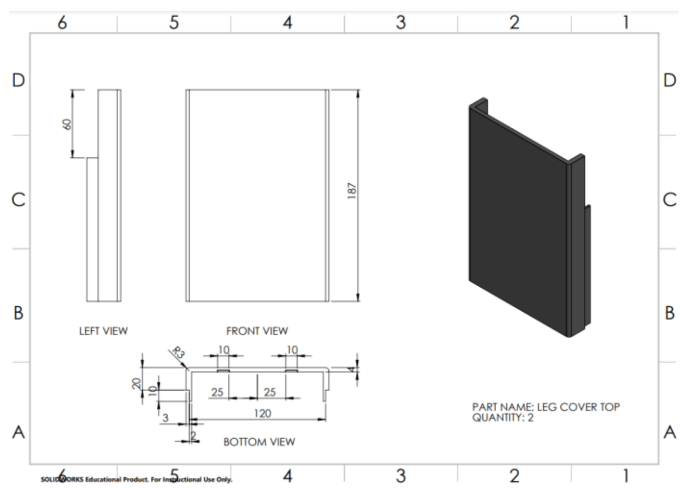


Figure 31: Leg Cover Top

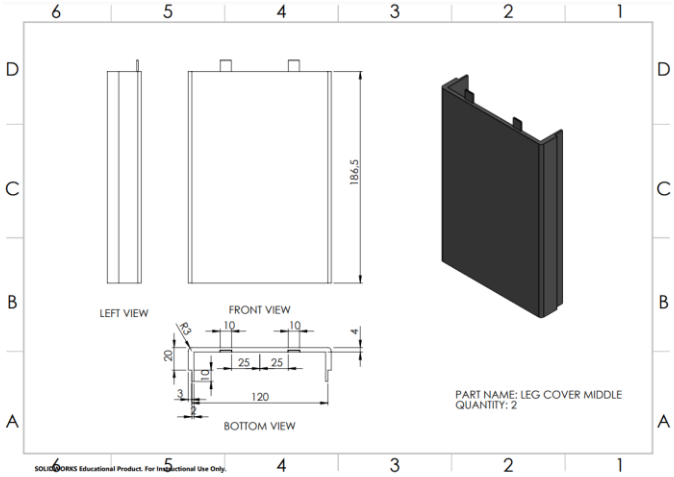


Figure 32: Leg Cover Middle

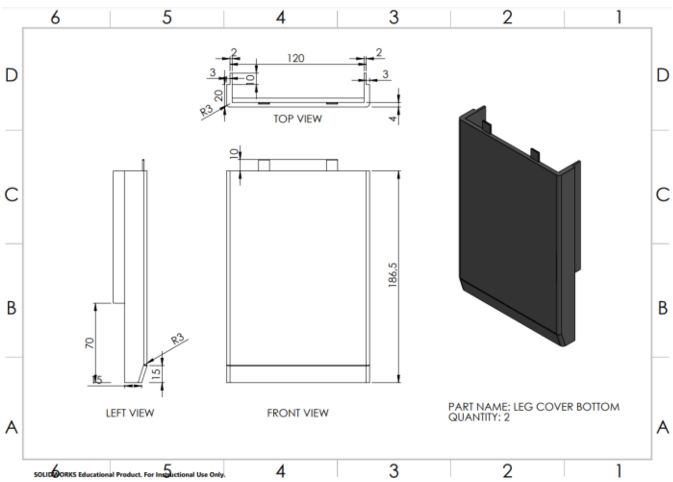


Figure 33: Leg cover Bottom

C. *Appendix C – Height Adjustment Repeatability Test Results*

Extending Before Optimisation	Retracting Before Optimisation	Retracting After Optimisation	Extending After Optimisation
1.3	0.4	0.28	0.18
2.32	1.01	0.25	0.22
2.17	0.85	0.45	0.24
1.75	0.95	0.45	0.2
1.17	0.68	0.48	0.3
1.05	0.95	0.56	0.24
1.15	0.74	0.24	0.13
0.77	0.65	0.32	0.08
1.14	0.65	0.27	0.06
1.59	0.82	0.28	0.09

D. *Appendix D – Limit Switch Repeatability Test Results*

Limit Switch Repeatability Test

Iterations	Horizontal Position	Error (0°)	Screening Position	Error (90°)
0	0.0	0.0	89.0	1.0
1	0.4	0.4	89.9	0.1
2	0.5	0.5	89.0	1.0
3	0.4	0.4	89.0	1.0
4	0.3	0.3	88.7	1.3
5	0.5	0.5	89.1	0.9
6	0.6	0.6	88.9	1.1
7	0.4	0.4	89.9	0.1
8	0.5	0.5	89.9	0.1
9	0.6	0.6	88.6	1.4
10	0.6	0.6	89.2	0.8
11	0.5	0.5	89.9	0.1
12	0.5	0.5	89.0	1.0
13	0.4	0.4	89.0	1.0
14	0.3	0.3	88.9	1.1
15	0.5	0.5	89.0	1.0
16	0.4	0.4	88.9	1.1
17	0.5	0.5	88.8	1.2
18	0.4	0.4	88.8	1.2
19	0.3	0.3	89.0	1.0

Measurement	*Value*
Mean	0.43
Standard Error	0.03086473
Median	0.45
Mode	0.5
Standard Deviation	0.13803127
Range	0.6
Minimum	0
Maximum	0.6
Count	20

Measurement	*Value*
Mean	0.875
Standard Error	0.09371709
Median	1
Mode	1
Standard Deviation	0.41911561
Range	1.3
Minimum	0.1
Maximum	1.4
Count	20

E. *Appendix E – PWM Speed Adjustment Test Results*

Table 9: Speed Error Statistics Before PWM Adjustment

Difference in Extending Times Before Optimisation	
Mean	1.441
Standard Error	0.159634652
Median	1.235
Minimum	0.77
Maximum	2.32
Sum	14.41
Count	10
Confidence Level(95.0%)	0.361118672

Difference in Retracting Times Before Optimisation	
Mean	0.77
Standard Error	0.058309519
Median	0.78
Minimum	0.4

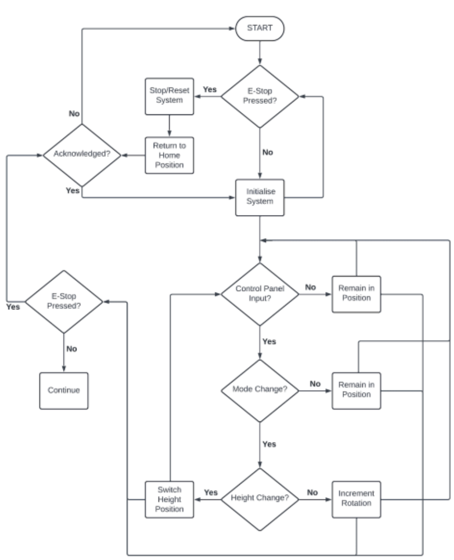
Maximum	1.01
Sum	7.7
Count	10
Confidence Level(95.0%)	0.131905296

Table 10: Speed Error Statistics After PWM Adjustment

Difference in Extending Times After Optimisation	
Mean	0.174
Standard Error	0.025438379
Median	0.19
Minimum	0.06
Maximum	0.3
Sum	1.74
Count	10
Confidence Level(95.0%)	0.057545611

Difference in Retracting Times After Optimisation	
Mean	0.358
Standard Error	0.036447832
Median	0.3
Minimum	0.24
Maximum	0.56
Sum	3.58
Count	10
Confidence Level(95.0%)	0.082450724

F. Appendix F – Programming Sequence Flow Chart



G. Appendix G – Cost Breakdown

Table 11: Full Cost Breakdown

STORE	DATE	COMPONENT DESCRIPTION	PRICE
Builders Warehouse	21 September 2024	Brackets	R103.00
	22 September 2024	Nuts & Bolts	R162.00
	25 September 2024	Ball Bearing Sliders	R218.00
	26 September 2024	Nuts & Bolts	R34.00
	09 October 2024	Spray Paint	R215.00
		TOTAL	**R732.00**
Hardware Store	25 September 2024	Heat Shrink 10mm	R29.90
		Control Panel Cable	R120.00
	26 September 2024	Fuse 6.3A	R10.00
	27 September 2024	Nuts & Bolts	R80.00
		Heat Shrink 10mm	R29.90
		Heat shrink 5mm	R24.90
		Terminal Red Female	R25.90
		Terminal Red Male	R19.90
		Terminal Red Ring	R25.90
		Inline Fuse Holder	R39.90
	14 October 2024	Cutting disk	R25.00
		Bolts	R20.00
		Nuts & Bolts	R29.00
		TOTAL	**R480.30**
Communica	18 September 2024	12 V Linear Actuator 500mm 1200N	R1 087.00
		12V Linear Actuator 500mm 1200N	R1 087.00
		12V Linear Actuator bracket set	R56.52
		12V Linear Actuator bracket set	R56.52
		National Courier (delivery fee)	R153.50
		VAT	R366.08
		TOTAL	**R2 806.62**
Steel Pipes & Fittings	11 September 2024	Rectangular Tube 76x25x2 + cut	R130.19
		Rectangular Tube 25x12x1.6 + cut	R51.20
		Flat Bar + cut	R86.48
	25 September 2024	Leg Caps 50x3mm flat bar bending	R245.33
	02 October 2024	510mm Steel Shaft	R74.75
		TOTAL	**R587.95**
Micro Robotics	07 September 2024	Membrane Keypad	R116.00
		TOTAL	**R116.00**
Mantech	19 September 2024	Panel Mount Plug with fuse holder & switch	R60.00
		Terminal pre-ins 6.35mm	R15.00
		VAT	R11.25
	23 September 2024	High Power Motor	R128.00
		High Power Motor	R128.00
		Strip Board	R103.00
		VAT	R53.85

		TOTAL	**R499.10**
Euro Steel	09 September 2024	100x50 Aluminium Tubing + Cut	R460.00
		TOTAL	**R460.00**
Stone-Stamcor	05 September 2024	Gearbox	R2 566.00
		VAT	R384.90
		TOTAL	**R2 950.90**
H1 Engineering	18 September 2024	2 x Aluminium Channel 3mm	R350.00
		VAT	R52.50
		TOTAL	**R402.50**
3D Printing Store	20 August 2024	Pillow Block Bearings x 2	R339.45
	01 October 2024	12V 40x40mm Fan	R19.95
		40mm Flexible Couplings	R199.95
		Pillow Block Bearing	R69.95
		5PK 4-Way Connector with pins	R25.90
		TOTAL	**R655.20**
BobShop	21 August 2024	White Board Sticker	R80.00
		TOTAL	**R80.00**
		TOTAL AMOUNT TO BE REIMBURSED	R9 770.57

H. *Appendix H - Program Code*

```
const int buttonPins[] =
const int numButtons = sizeof(buttonPins) /
sizeof(buttonPins[0]);
const int enaPin = 50;
const int dirPin = 51;
const int stepPin = 52;
const int RPWM_Left = 5;
const int LPWM_Left = 6;
const int R_EN_Left = 7;
const int L_EN_Left = 8;
const int RPWM_Right = 9;
const int LPWM_Right = 10;
const int R_EN_Right = 11;
const int L_EN_Right = 12;
const int limitSwitchPinForward =
const int limitSwitchPinBackward = 29;
const int trigPinL = 30;
const int echoPinL = 31;
const int trigPinR = 32;
const int echoPinR = 33;
const int buzzerPin = 4;
bool isRaising = false;
bool isLowering = false;
bool isTilting = false;
const int stepsPerRevolution =
long durationL;
int distanceL;
long durationR;
int distanceR;
const int buzzerVolume = 200;
const float strokeLength = 500.0;
const float speed = 12.0;
const int actuatorMovementTime = (int)(strokeLength / speed *
1000);

void setup()
{
  Serial.begin(9600);
  for (int i = 0; i < numButtons; i++)
  {
    pinMode(buttonPins[i], INPUT_PULLUP);
  }
  pinMode(RPWM_Left, OUTPUT);
  pinMode(LPWM_Left, OUTPUT);
  pinMode(R_EN_Left, OUTPUT);
  pinMode(L_EN_Left, OUTPUT);
  pinMode(RPWM_Right, OUTPUT);
  pinMode(LPWM_Right, OUTPUT);
  pinMode(R_EN_Right, OUTPUT);
  pinMode(L_EN_Right, OUTPUT);
  pinMode(enaPin, OUTPUT);
  pinMode(dirPin, OUTPUT);
  pinMode(stepPin, OUTPUT);
  pinMode(limitSwitchPinForward, INPUT_PULLUP);
  pinMode(limitSwitchPinBackward, INPUT_PULLUP);
  pinMode(buzzerPin, OUTPUT);
  pinMode(trigPinL, OUTPUT);
  pinMode(echoPinL, INPUT);
  pinMode(trigPinR, OUTPUT);
  pinMode(echoPinR, INPUT);
  digitalWrite(enaPin, LOW);
  digitalWrite(R_EN_Left, HIGH);
  digitalWrite(L_EN_Left, HIGH);
  digitalWrite(R_EN_Right, HIGH);
  digitalWrite(L_EN_Right, HIGH);
  digitalWrite(buzzerPin, LOW);
}
void loop()
{
  if (digitalRead(buttonPins[0]) == LOW) {
    raiseDesk();
  }
  else if (digitalRead(buttonPins[1]) == LOW) {
    lowerDesk();
  }
  else {
    stopActuators();
    digitalWrite(buzzerPin, LOW);
  }
  if (digitalRead(buttonPins[2]) == LOW) {
    decrementTilt();
  }
  else if (digitalRead(buttonPins[3]) == LOW) {
    incrementTilt();
  }
  else {
    stopStepperMotor();
  }
}

const int leftActuatorSpeed = 255;
const int rightAactuatorSpeed = 255;
void raiseDesk()
{
  analogWrite(buzzerPin, buzzerVolume);
  digitalWrite(R_EN_Right, HIGH);
  digitalWrite(L_EN_Right, HIGH);
  analogWrite(RPWM_Right, 0);
  analogWrite(LPWM_Right, rightAactuatorSpeed);

  digitalWrite(R_EN_Left, HIGH);
  digitalWrite(L_EN_Left, HIGH);
  analogWrite(RPWM_Left, 0);
  analogWrite(LPWM_Left, leftActuatorSpeed);
void lowerDesk()
{
  analogWrite(buzzerPin, buzzerVolume);
  digitalWrite(R_EN_Right, HIGH);
  digitalWrite(L_EN_Right, HIGH);
  analogWrite(LPWM_Right, 0);
  analogWrite(RPWM_Right, rightAactuatorSpeed);
  digitalWrite(R_EN_Left, HIGH);
  digitalWrite(L_EN_Left, HIGH);
  analogWrite(LPWM_Left, 0);
  analogWrite(RPWM_Left, leftActuatorSpeed);
}
void stopActuators()
{
  analogWrite(RPWM_Right, 0);
  analogWrite(LPWM_Right, 0);
  analogWrite(RPWM_Left, 0);
  analogWrite(LPWM_Left, 0);
  digitalWrite(R_EN_Right, HIGH);
  digitalWrite(L_EN_Right, HIGH);
  digitalWrite(R_EN_Left, HIGH);
  digitalWrite(L_EN_Left, HIGH);
  digitalWrite(buzzerPin, LOW);
```

I. *Appendix I – Adjustable Desk User Guide*

Safety & Info

- Make sure no obstacles are in the desk's path.
  Make sure the desktop is not touching any walls.
- Keep children away from electric height - adjustable desks, control units and handsets. There is a risk of injury and electric shock.
- Keep all electrical components away from liquids.
- Do not sit or stand on the desk frame. Do not crawl or lie under the desk frame.
- Do not place any objects taller than 20" underneath the desk.
- Do not open any of the components - the Legs, Control Box, or Switch. There is a danger of electric shock.
- In the event of an emergency, push the e-stop button to force stop all functions. (See User Guide)

This height adjustable desk has electric motors and is designed for use in dry work areas only. The desk height is adjustable so that it can be positioned at the most ergonomically suitable height. Any other use is at user's risk.

User Guide

POWER

1.) Plug the desk into a wall socket closest to the space you will be working.

2.) Switch the Main Plug on to turn the desk on and enable it's control panel functionality.

CONTROLS

Here's a quick guide to the buttons on the desk's control panel

Remote Control

Control	Action
↑	Up Arrow: Press and hold to raise the desk
↓	Down Arrow: Press and hold to lower the desk
←	Left Arrow: Press and hold to tilt the tabletop backward (away from you)
→	Right Arrow: Press and hold to tilt the tabletop forward (towards you)

RELEASE BUTTON TO STOP THE DESK

Emergency Stop

E-Stop button: Push incase of an emergency or if you would like to immediately stop all desk functions.

TWIST TO RELEASE THE BUTTON AND ACKNOWLEDGE THE FAULT

Fully developed Adjustable Work Desk Images