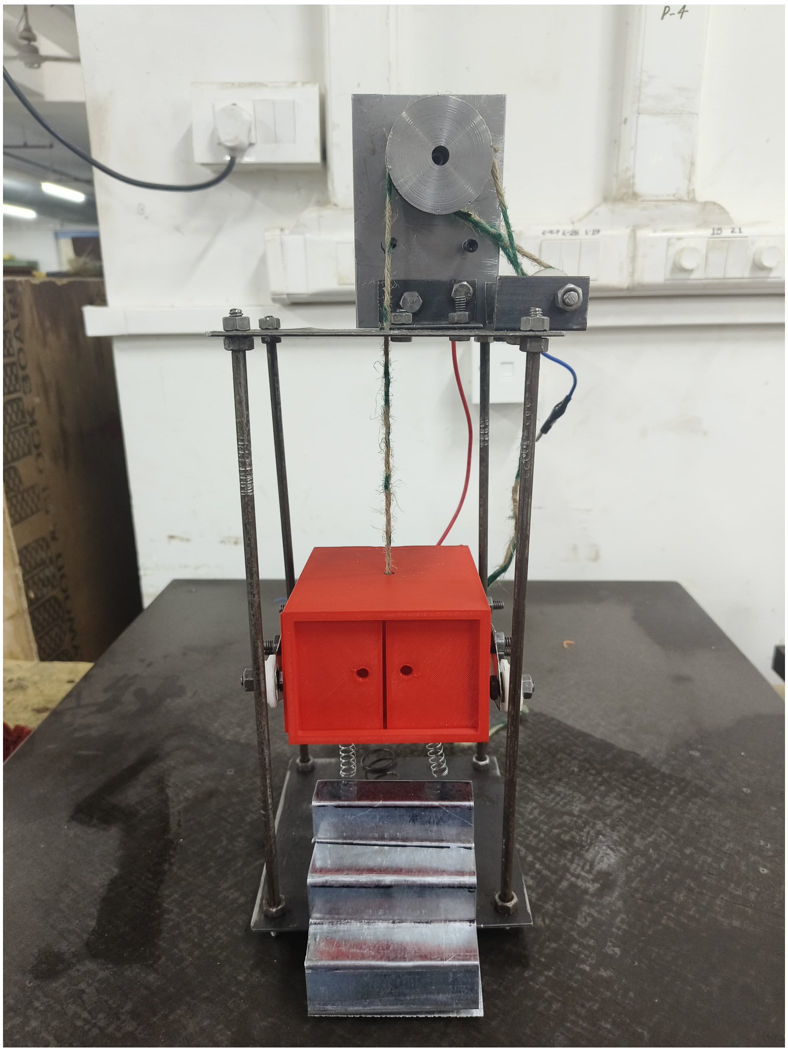
TA212 – Manufacturing Processes–II

2nd Sem 2024-25

Group No. 11

SMART LIFT



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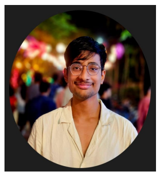

Ayush Rai
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Course Instructor - Dr. Arvind Kumar

Guide - Mr. Greesh Pratap Chaturvedi

Table of Contents

Introduction

In modern infrastructure, elevators or lifts are essential systems for enabling vertical transportation of passengers and goods, especially in multi-storey buildings. With increasing urbanization and the rise of high-rise structures, the demand for reliable, efficient, and safe elevator systems has become paramount.

This project presents the design and development of a scaled working model of a **Smart Lift System**, developed as part of the course *TA212*. The aim is to replicate the functionality of a real elevator using accessible materials and manufacturing techniques, while integrating basic automation and control features.

The system is primarily driven by a DC motor, controlled via an **Arduino-based setup** to simulate automated floor selection. A pulley and counterweight mechanism ensures smooth vertical motion of the cabin, while guide rails provide stability and alignment. Limit switches and programmed logic enhance operational safety, halting the system at defined floor levels. From a manufacturing standpoint, the project makes use of sheet metal fabrication, machining operations, 3D printing of components, and standard fasteners for assembly. Each part of the system has been carefully designed for ease of fabrication and mechanical reliability.

This report details the design considerations, component specifications, manufacturing processes, and testing results of the Smart Lift project. Additionally, challenges encountered during the fabrication and assembly phases are discussed, offering valuable insights into real-world mechanical system development.

Acknowledgement

We would like to express our sincere gratitude to our esteemed project guide, **Mr. Greesh Pratap Chaturvedi**, for his unwavering support, valuable insights, and expert technical guidance throughout the course of this project. His mentorship was instrumental in shaping our ideas and steering us through the challenges encountered during the planning, design, and execution phases. His encouragement and constructive feedback consistently motivated us to strive for excellence.

We are also deeply thankful to our course instructor, **Mr. Arvind Kumar**, for providing us with a strong foundational understanding of manufacturing processes, as well as for his continuous support, valuable lectures, and timely resources that enabled us to approach the project with clarity and confidence.

Our heartfelt appreciation also goes to the lab staff, teaching assistants, and tutors, whose assistance in the workshop and laboratories was crucial in helping us translate theoretical concepts into practical implementation. Their patience, expertise, and hands-on guidance greatly enhanced our learning experience.

Finally, we thank the Department of Mechanical Engineering, IIT Kanpur, for providing us with the facilities and environment necessary for the successful completion of this project.

Abstract

Elevators play a vital role in modern infrastructure, serving as essential systems for efficient vertical transportation in residential, commercial, and industrial buildings. This project delves into the fundamental working principles of elevator lift systems, focusing on the integration of key mechanical components such as motors, cables, pulleys, guide rails, and counterweights. These elements work in harmony to ensure smooth, controlled, and balanced motion between floors.

In addition to mechanical design, the project highlights the importance of safety features—such as limit switches, emergency brakes, and overload protection—which are critical for reliable operation. The incorporation of modern control systems, such as microcontroller-based automation using Arduino, further enhances the functionality and user experience of elevators by allowing precise movement and floor selection.

The primary objective of this project is to provide a comprehensive understanding of elevator mechanics, from structural design to control implementation, while demonstrating the real-world relevance of such systems. Through the design and development of a scaled working model, the project offers valuable insights into the practical applications of mechanical and manufacturing principles in the context of vertical transport solutions.

Motivation

The idea of designing and building a functional lift system was motivated by the widespread presence of elevators in our daily lives and their crucial role in modern architecture. Elevators are not only mechanical systems—they represent a blend of structural design, automation, safety, and user-centric innovation.

We aimed to choose a project that would give us the opportunity to explore multiple facets of engineering: from conceptual design and material selection to fabrication techniques and control systems. A lift project provided the ideal platform to integrate principles from manufacturing processes, power transmission, and electronics.

Furthermore, this project challenged us to think critically about real-world applications, safety concerns, and the need for efficient space utilization in buildings. Building a scaled model also allowed us to experience hands-on problem-solving, teamwork, and creative decision-making—skills that are essential in both academic and professional engineering contexts.

Ultimately, our motivation stems from a desire to understand how everyday systems operate behind the scenes, and to recreate them in a simplified yet functional form that reflects both technical knowledge and practical implementation.

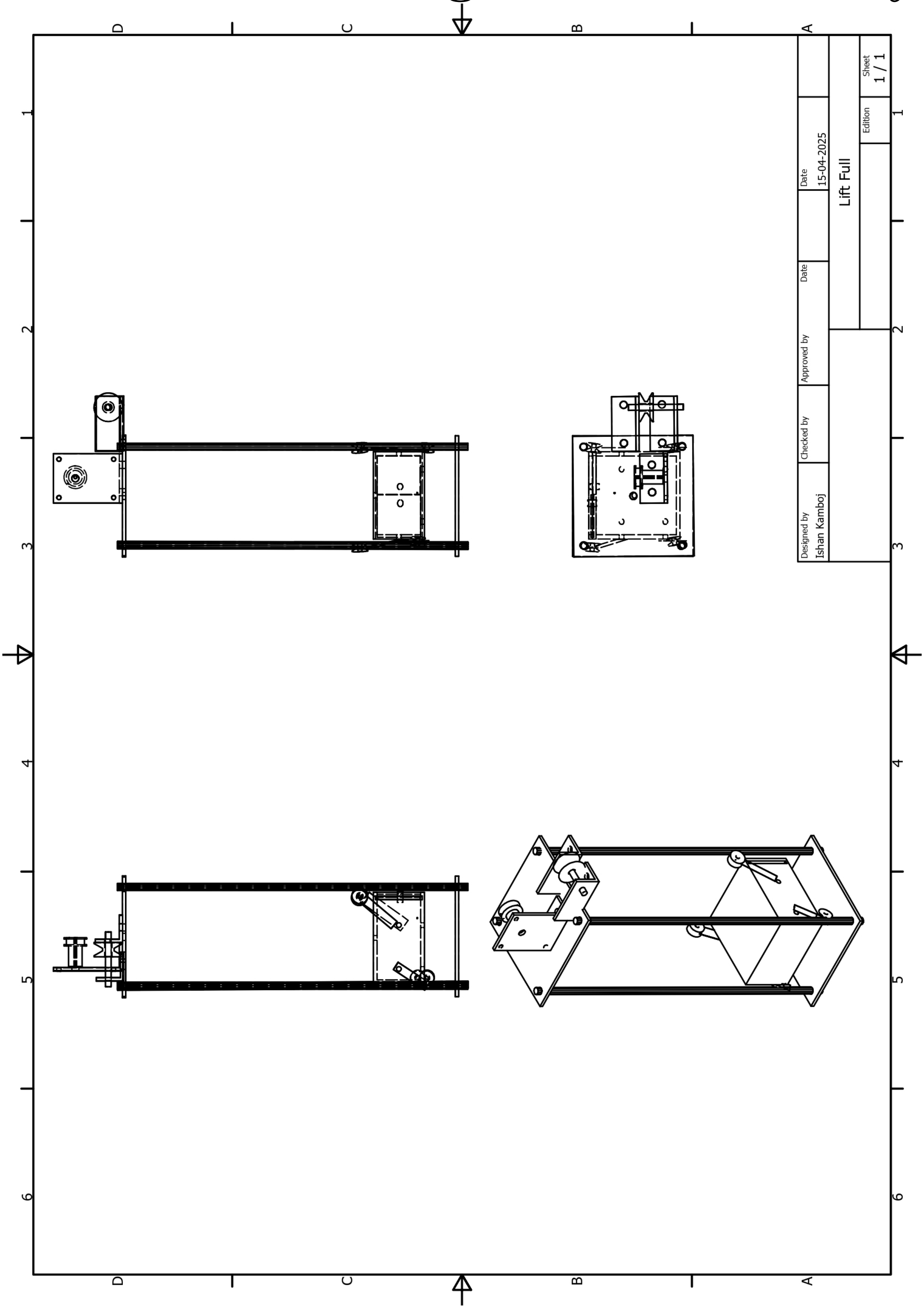
Part List

Part	QTY	Material Type	Dimension	Material	Machining Processes Used	Pg.
Lift Body	1	Thermoplastic Polyester	125mm × 100mm × 70mm	PLA	3D Printing	11
Lift Door	2	Thermoplastic Polyester	3mm × 50mm × 69mm	PLA	3D Printing	12
Exoskeleton Rod	4	Rod	65mm Dia × 320mm	Mild Steel	Hacksawing, Threading	17
Exoskeleton Plate	2	Sheet	110mm × 110mm × 3mm	Mild Steel	Cutting, Drilling	14, 16
Stablising Pulley	5	Thermoplastic Polyester	26mm Dia × 14.4mm Dia with Groove	PLA	3D Printing	19
Stablising Connectors	4	Sheet	40mm × 10mm × 3mm	Mild Steel	Cutting, Drilling	20
Lift Pulley	1	Rod	50mm Dia × 30mm Dia with Groove	Mild Steel	Lathe, Drilling	18
Motor Plate	1	Sheet	60mm × 45mm × 3mm	Mild Steel	Cutting, Drilling	24
Separating L-Clamp	1	Angle	75mm × 25mm × 3mm	Mild Steel	Cutting, Drilling	21
Connecting L-Clamp	3	Angle	50mm × 22mm × 3mm	Mild Steel	Cutting, Drilling	25
Staircase	1	Sheet	80mm × 25mm × 75mm	Galvanised Iron	Cutting, Drilling, Folding	26

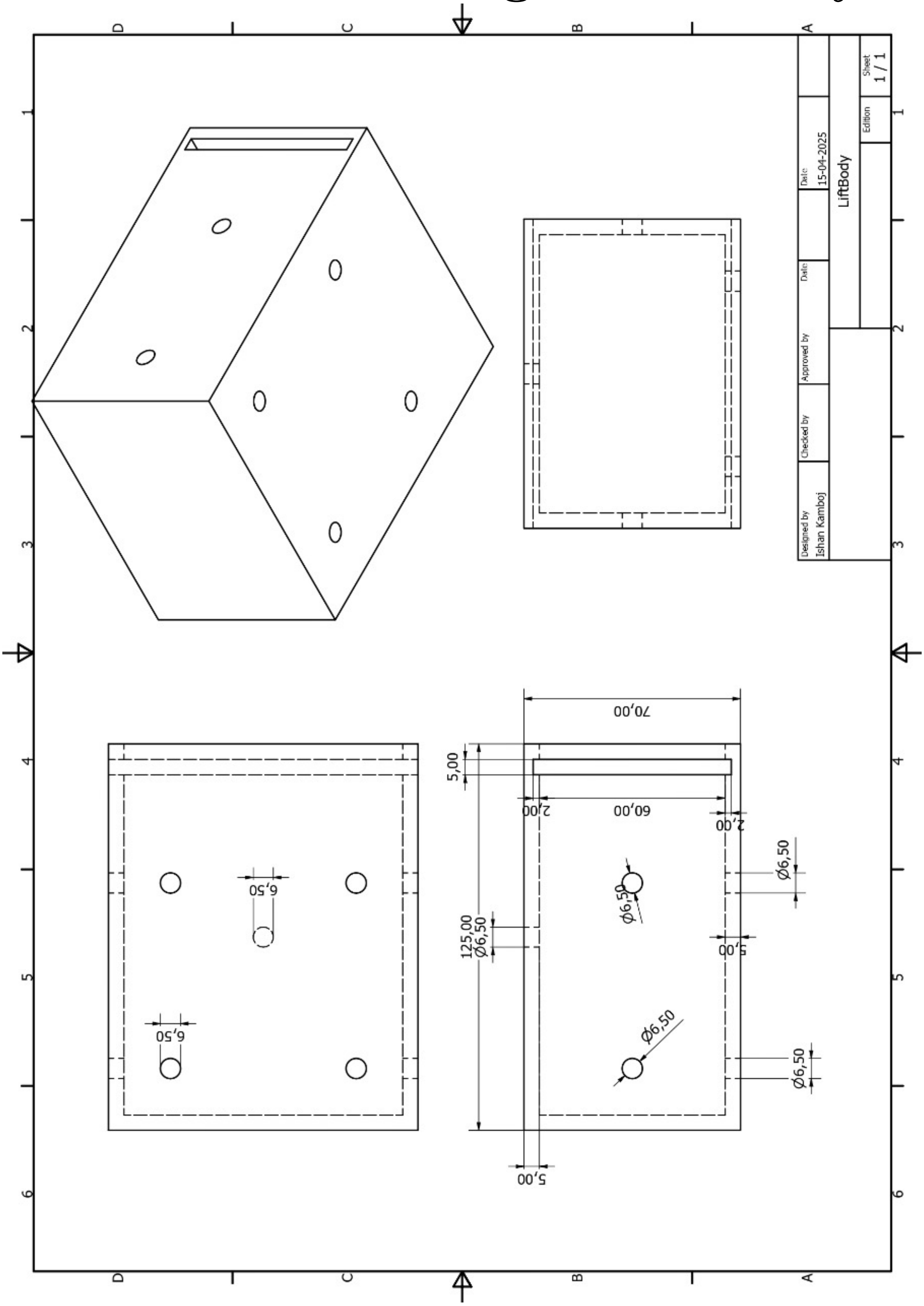
Isometric Drawings

(All Dimensions are in mm.)

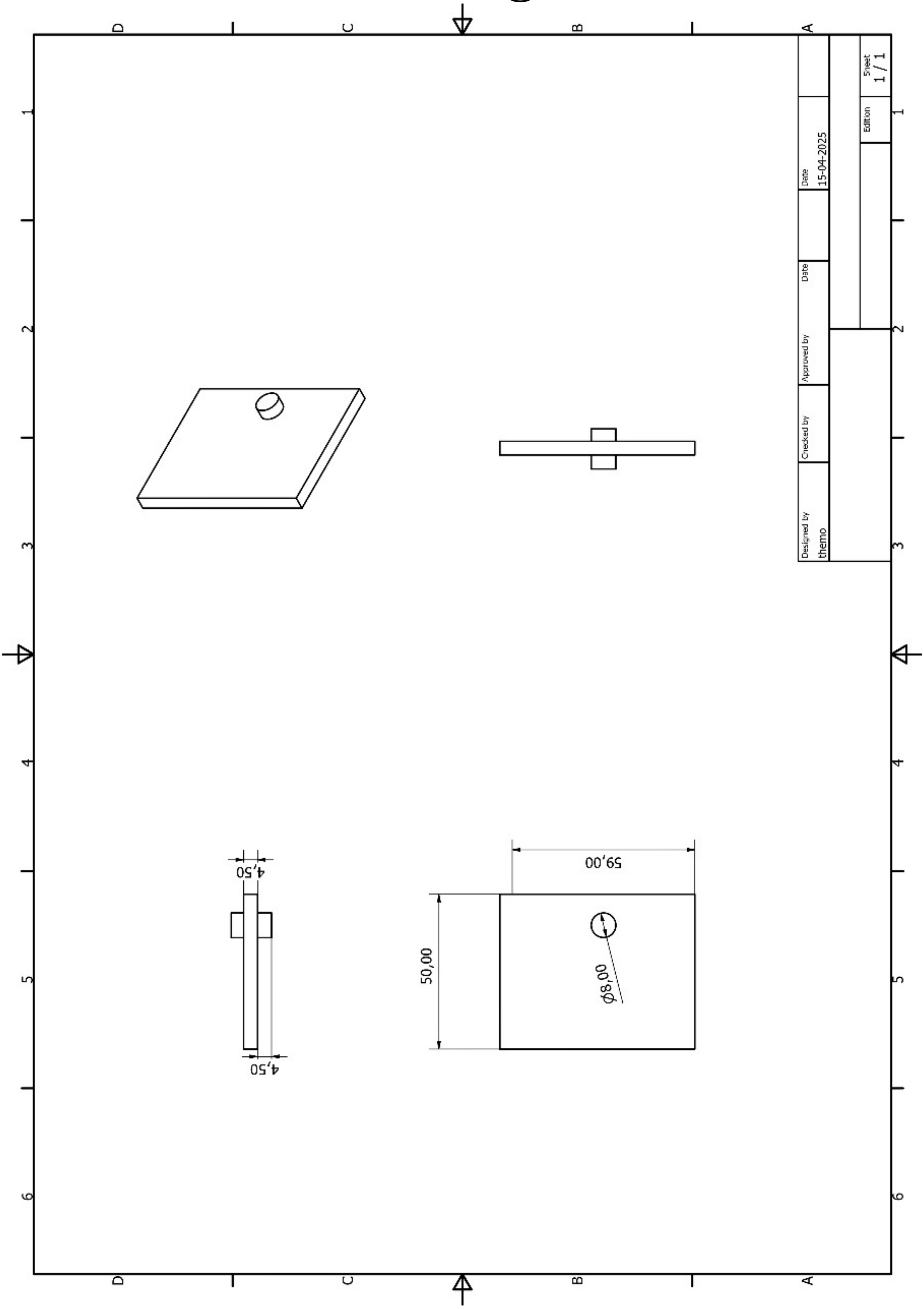
Isometric Drawing of Full Assembly



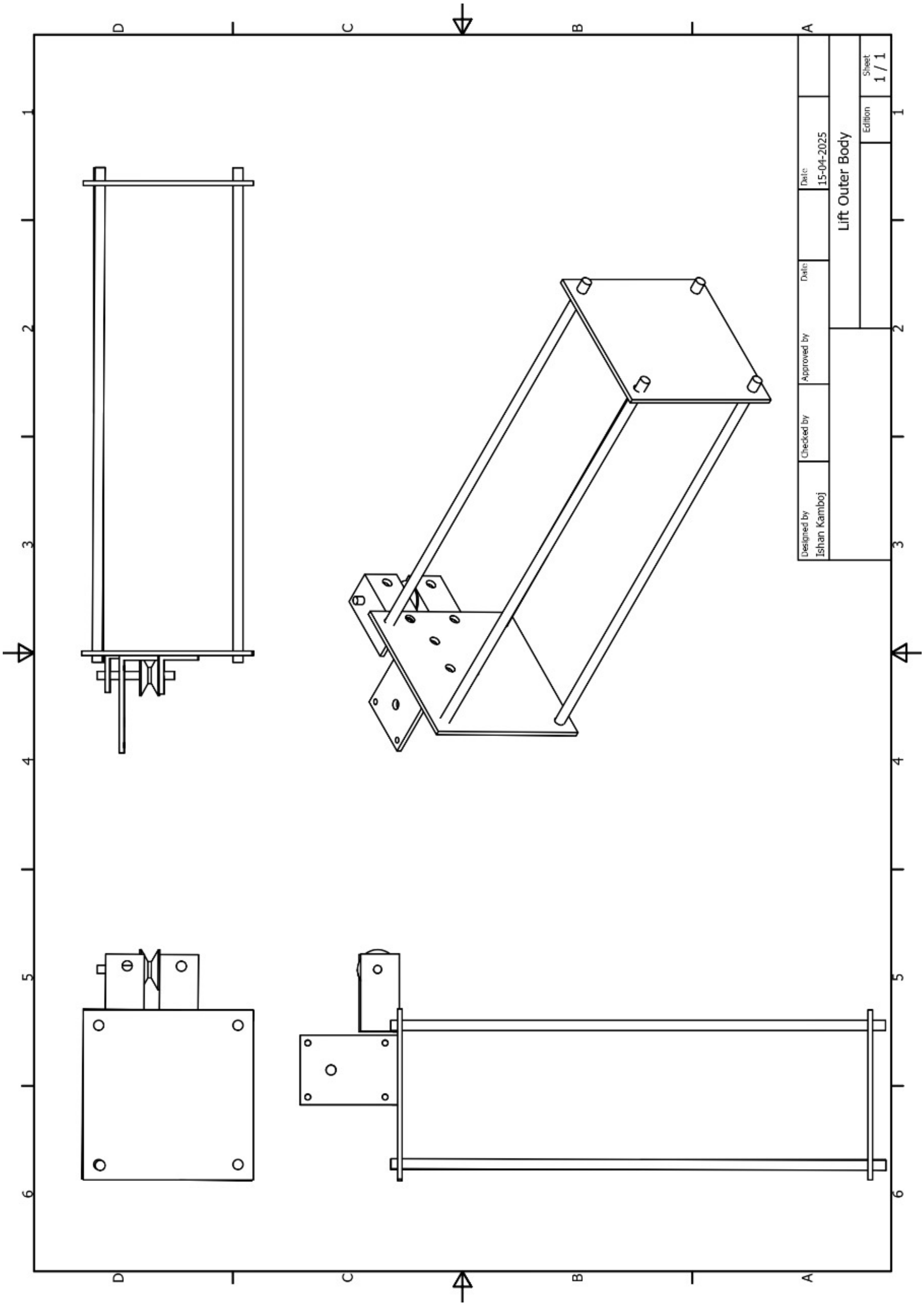
Isometric Drawing of Lift Body

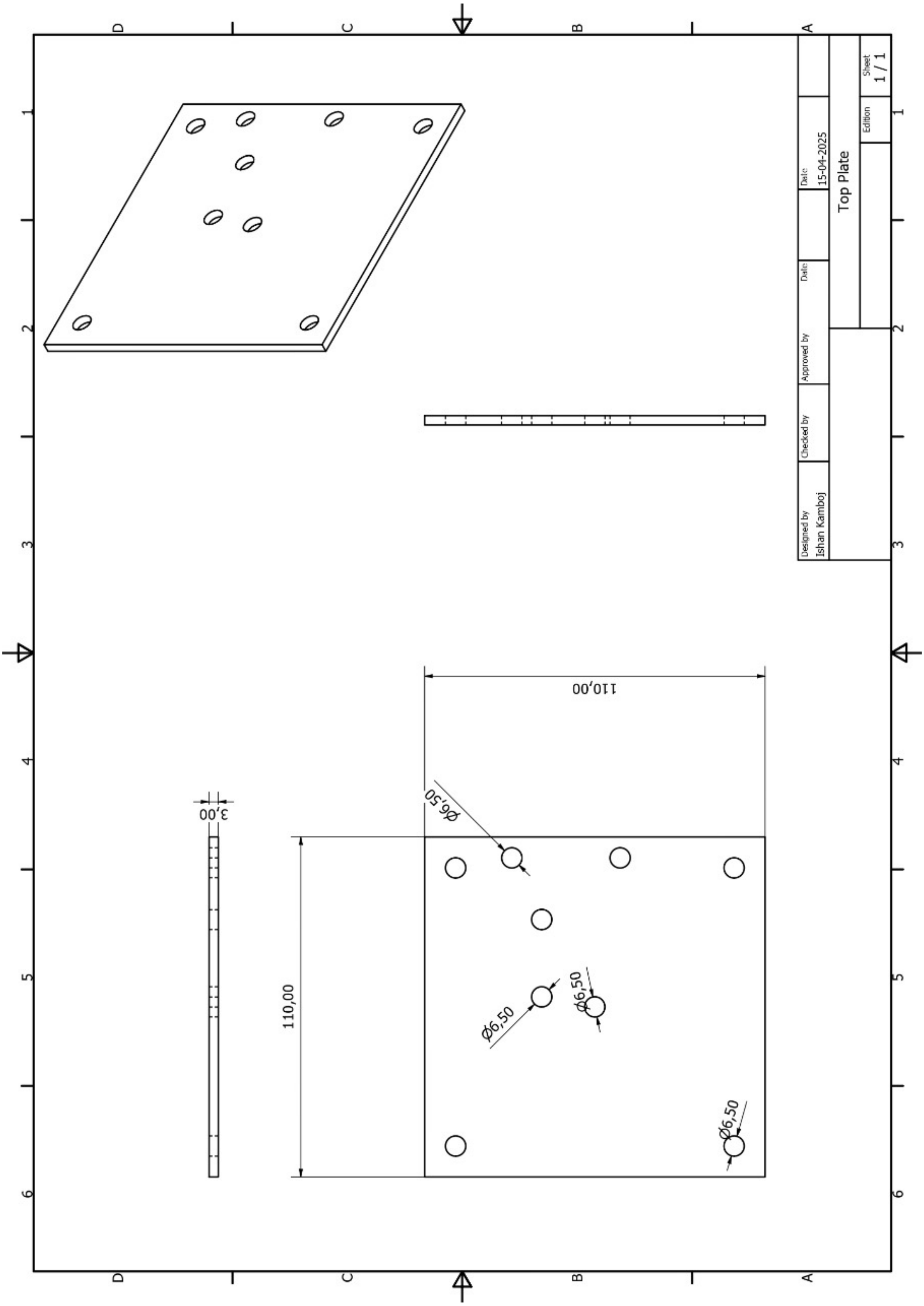


Isometric Drawing of Lift Door



Isometric Drawing of Lift Exoskeleton

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Ishan Kamboj
Checked by
Approved by
Date
Date:
15-04-2025
Top Plate
Edition
Sheet
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110,00
3,00
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Ø6,50
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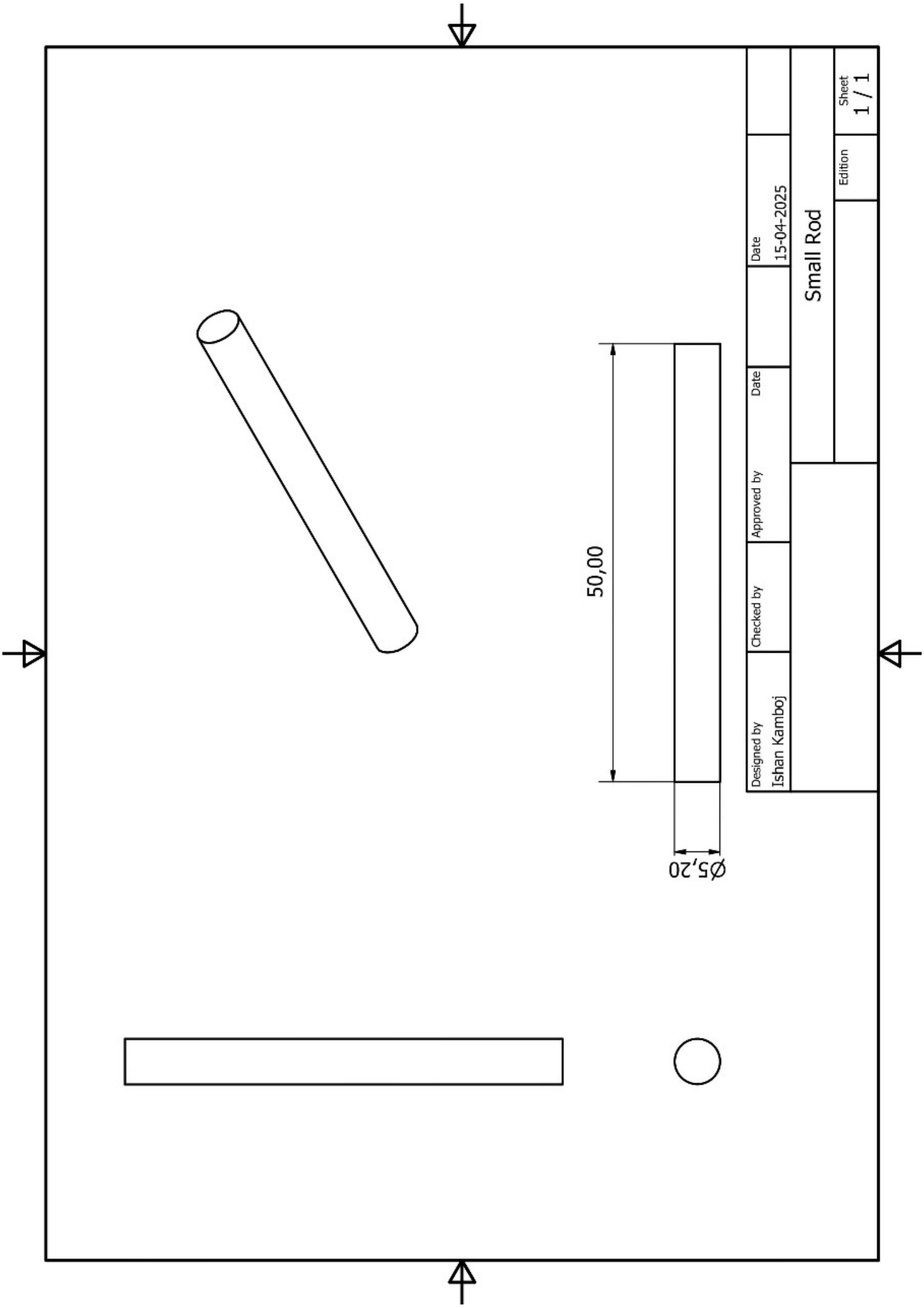

50,00
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Ishan Kamboj
Checked by
Approved by
Date
Date
15-04-2025
Small Rod
Edition
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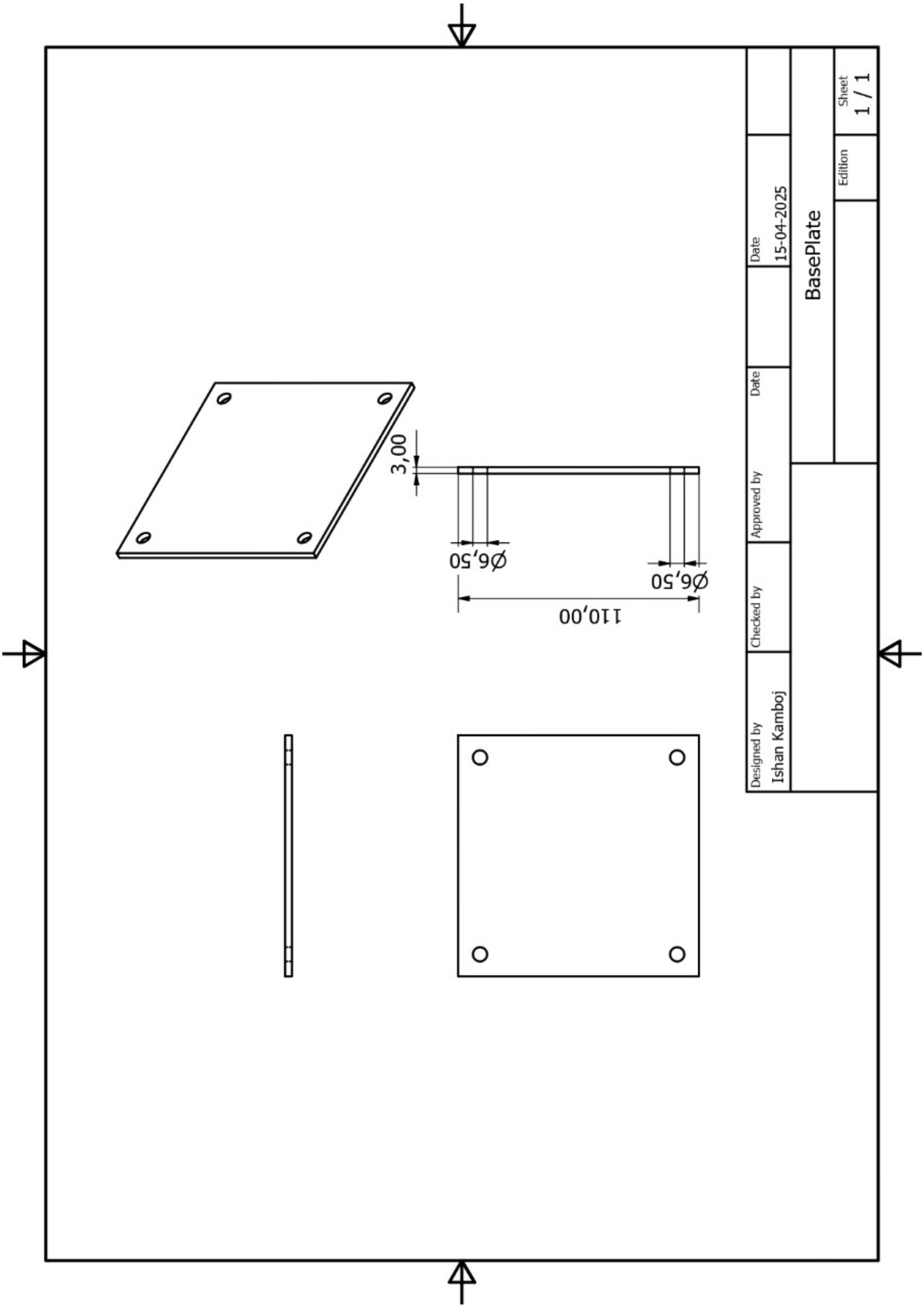
1 / 1



Designed by
Ishan Kamboj
Checked by
Approved by
Date
Date
15-04-2025
BasePlate
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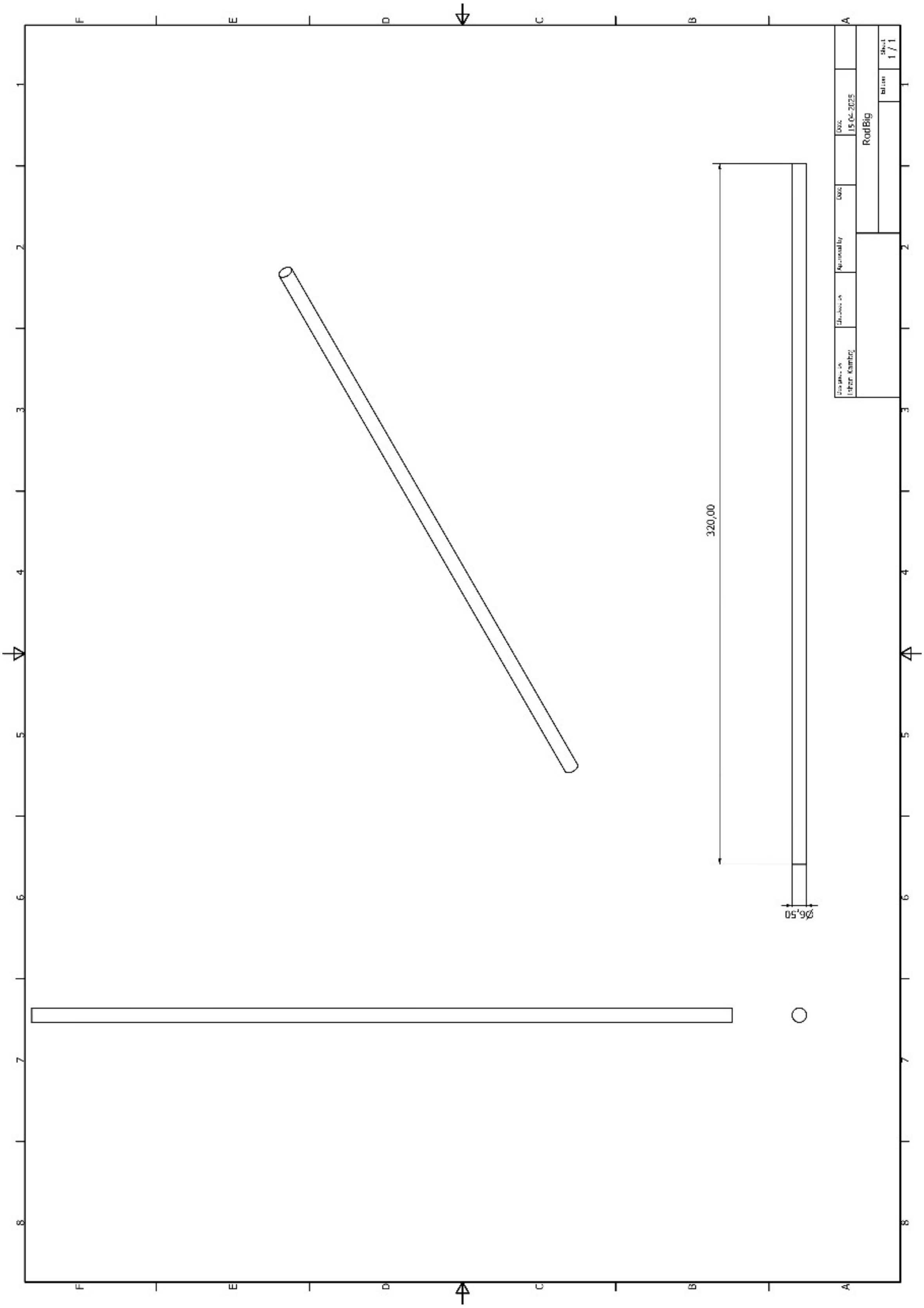

RodBig
15.04.2025
Approved by
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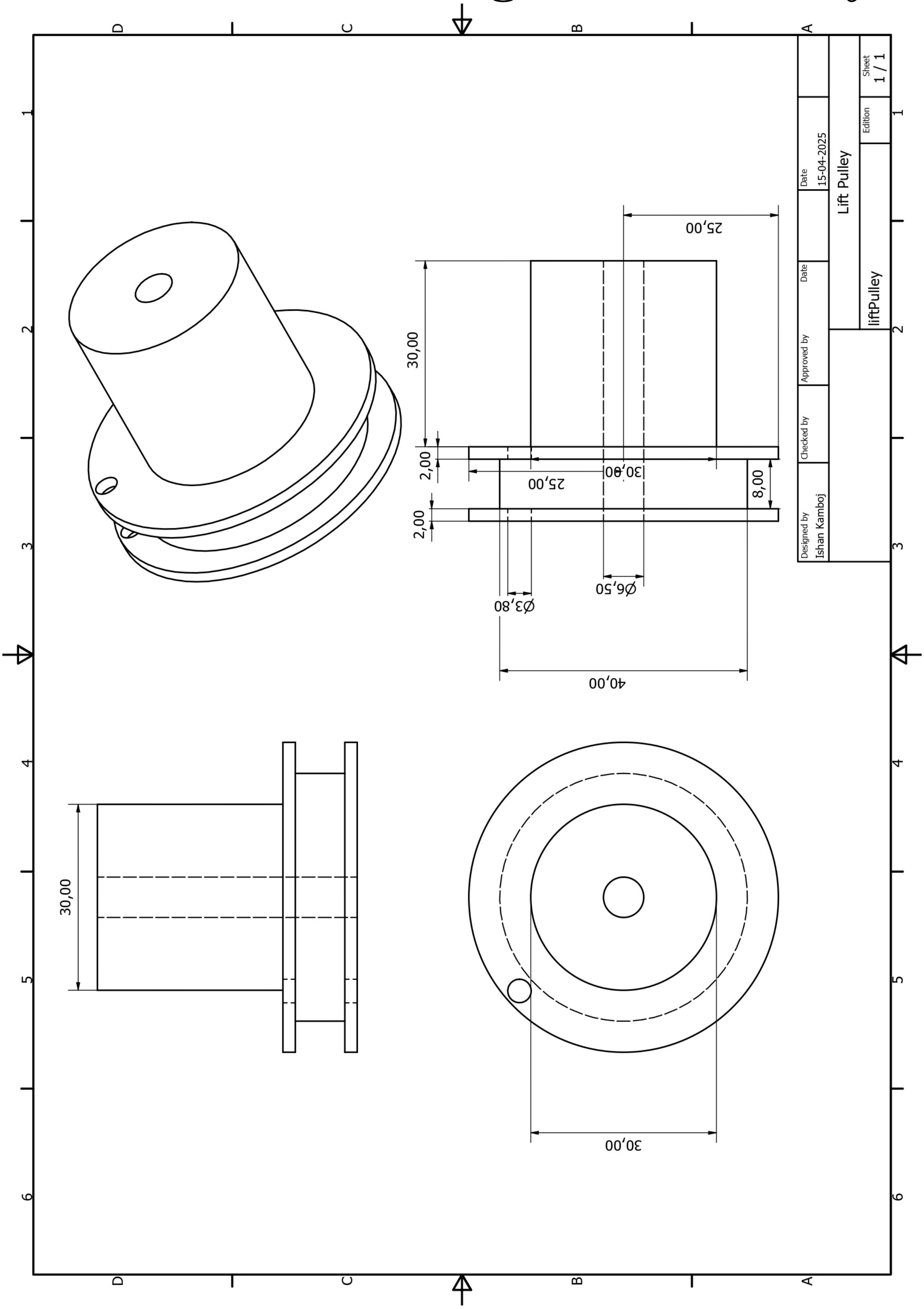
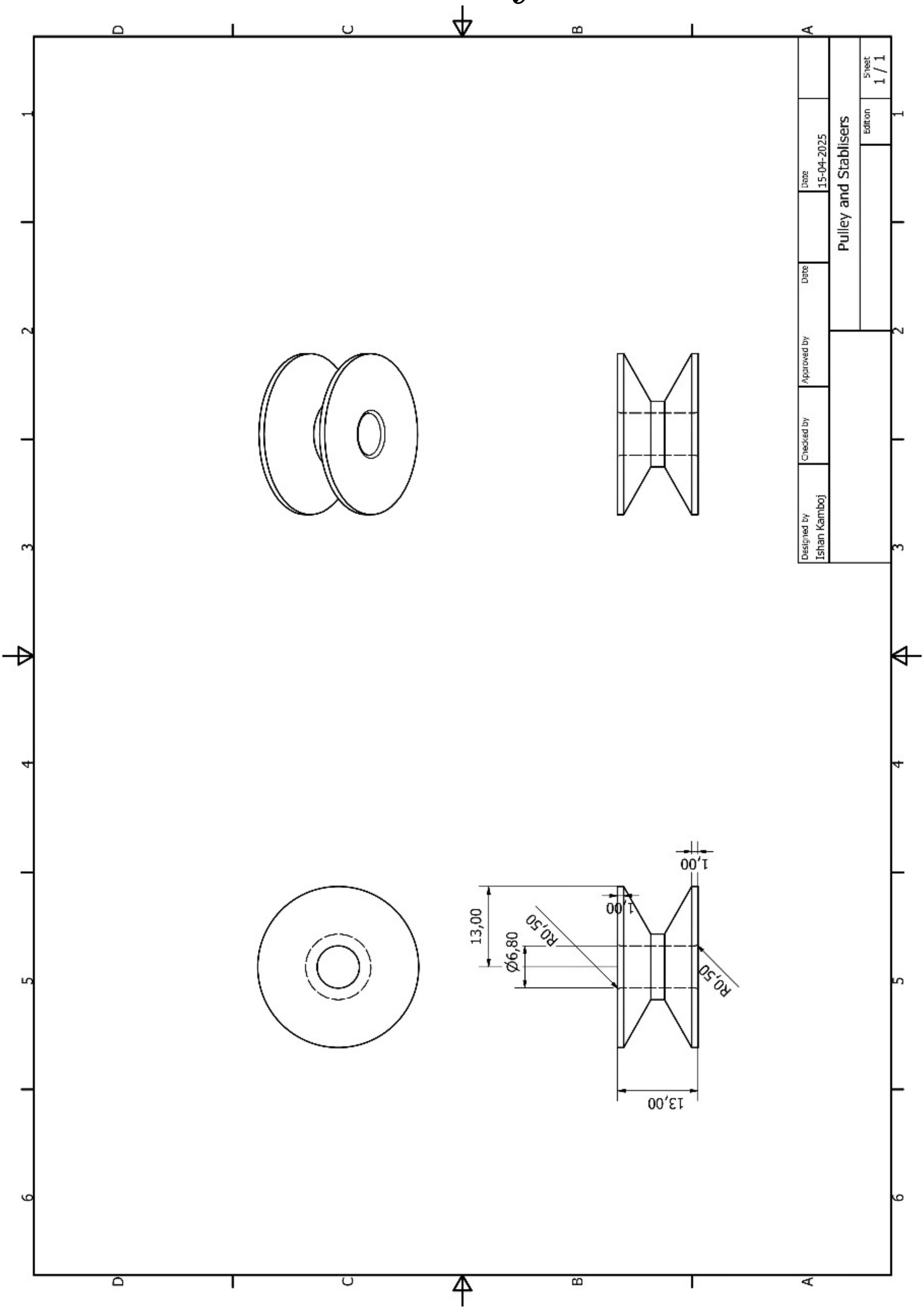
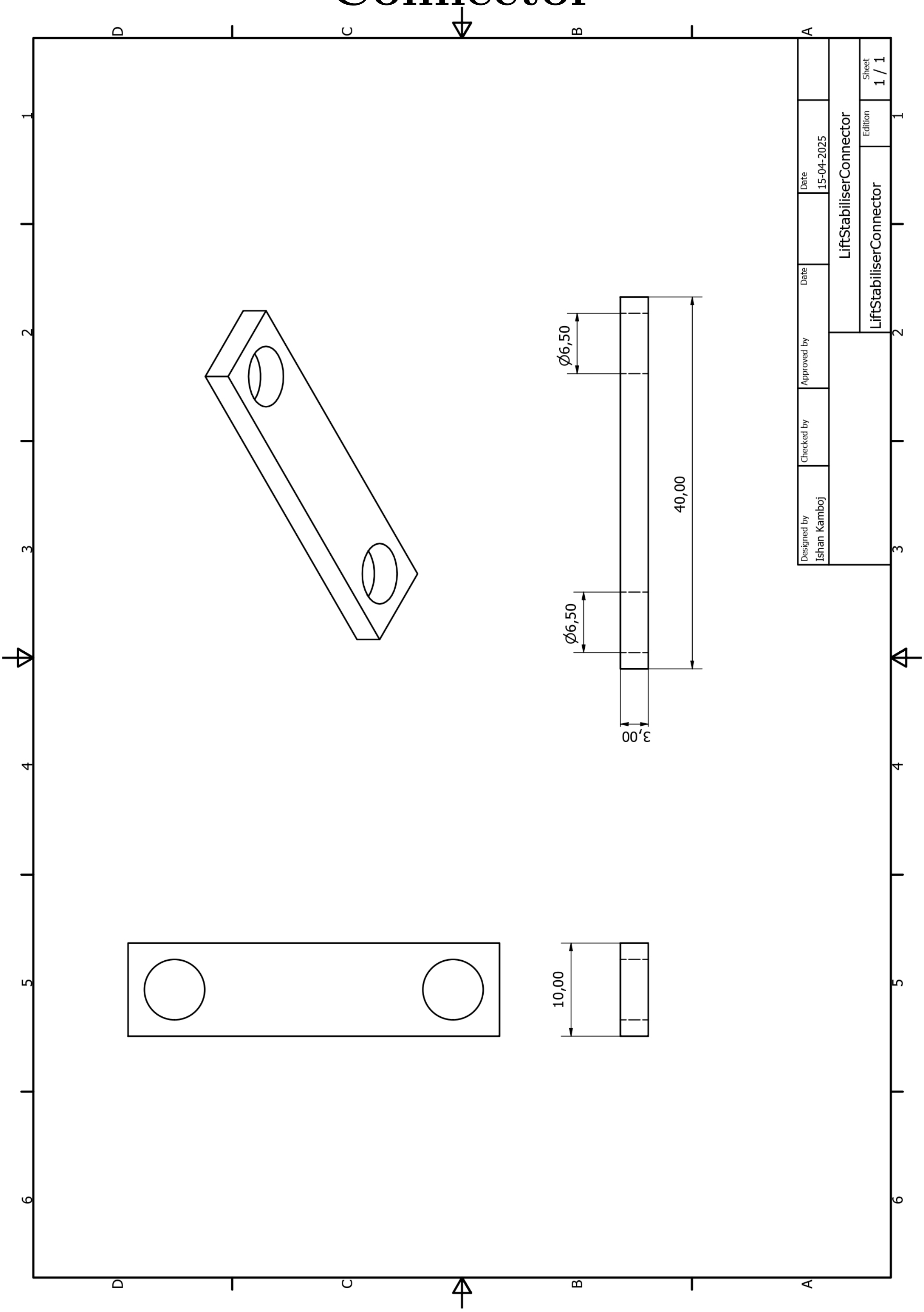
Isometric Drawing of Lift Pulley



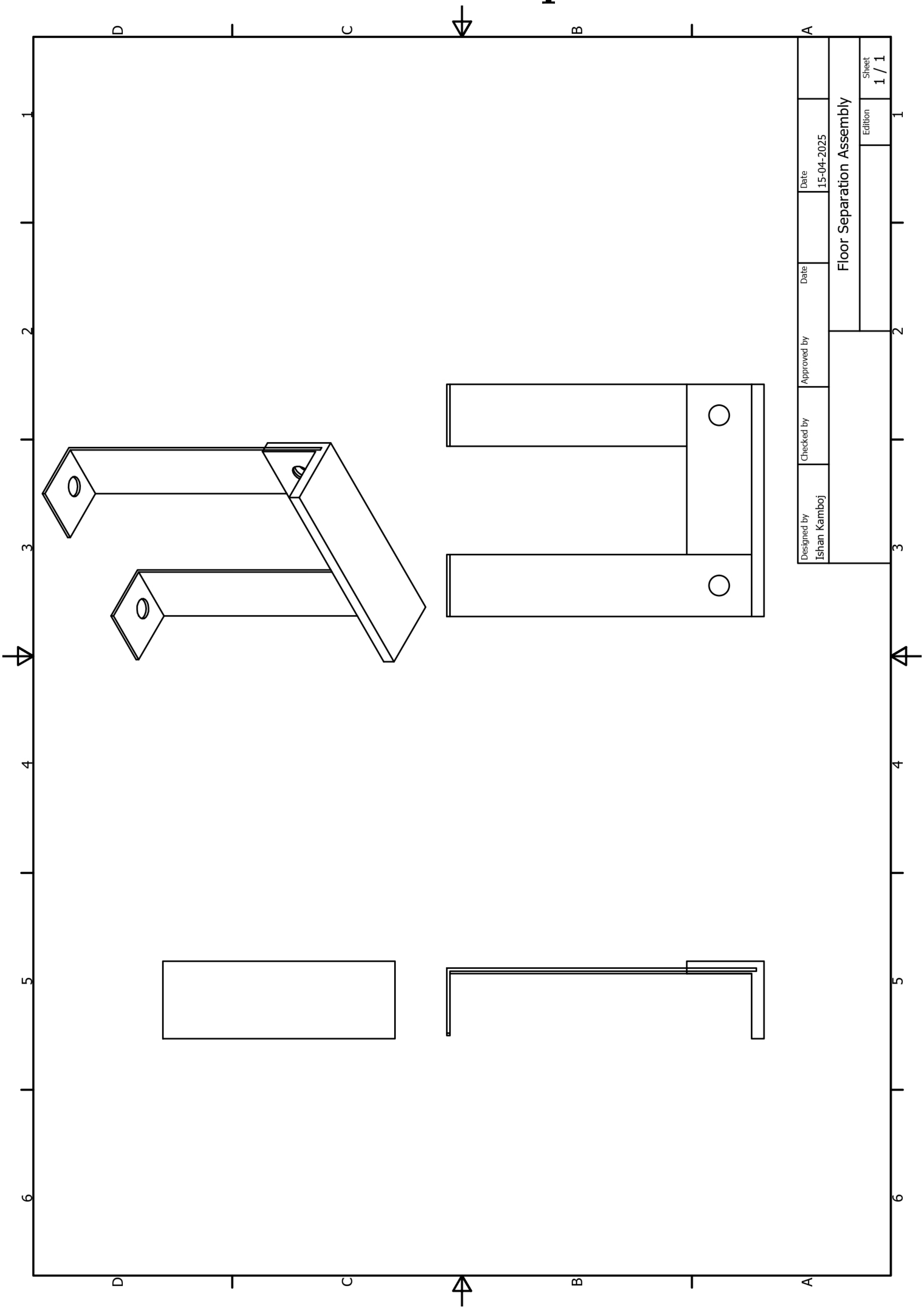
Isometric Drawing of Stabilising Pulley

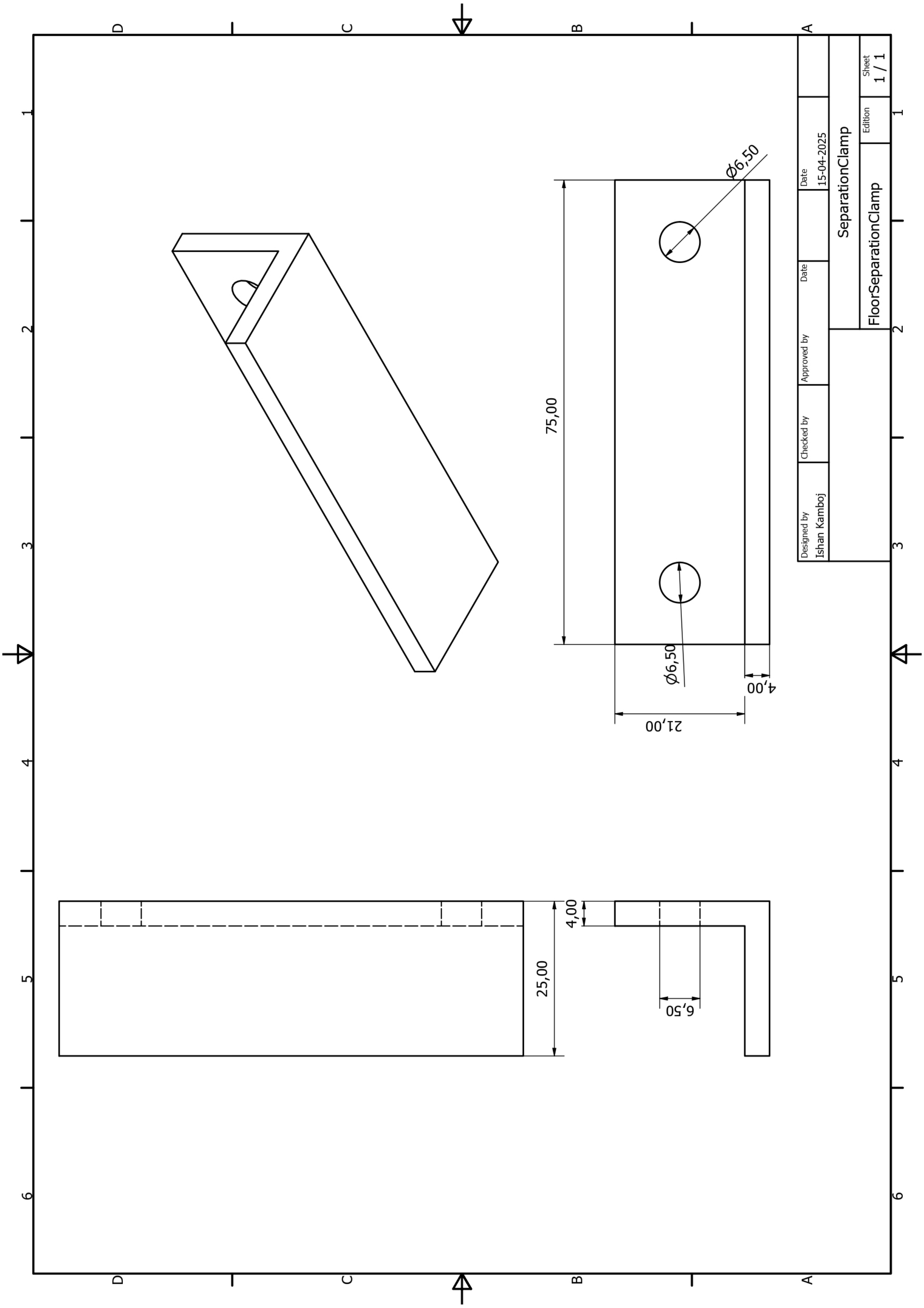


Isometric Drawing of Stabilising Connector



Isometric Drawing of Separating L-Clamp




Designed by
Ishan Kamboj
Checked by
Approved by
Date
Date
15-04-2025
SeparationClamp
FloorSeparationClamp
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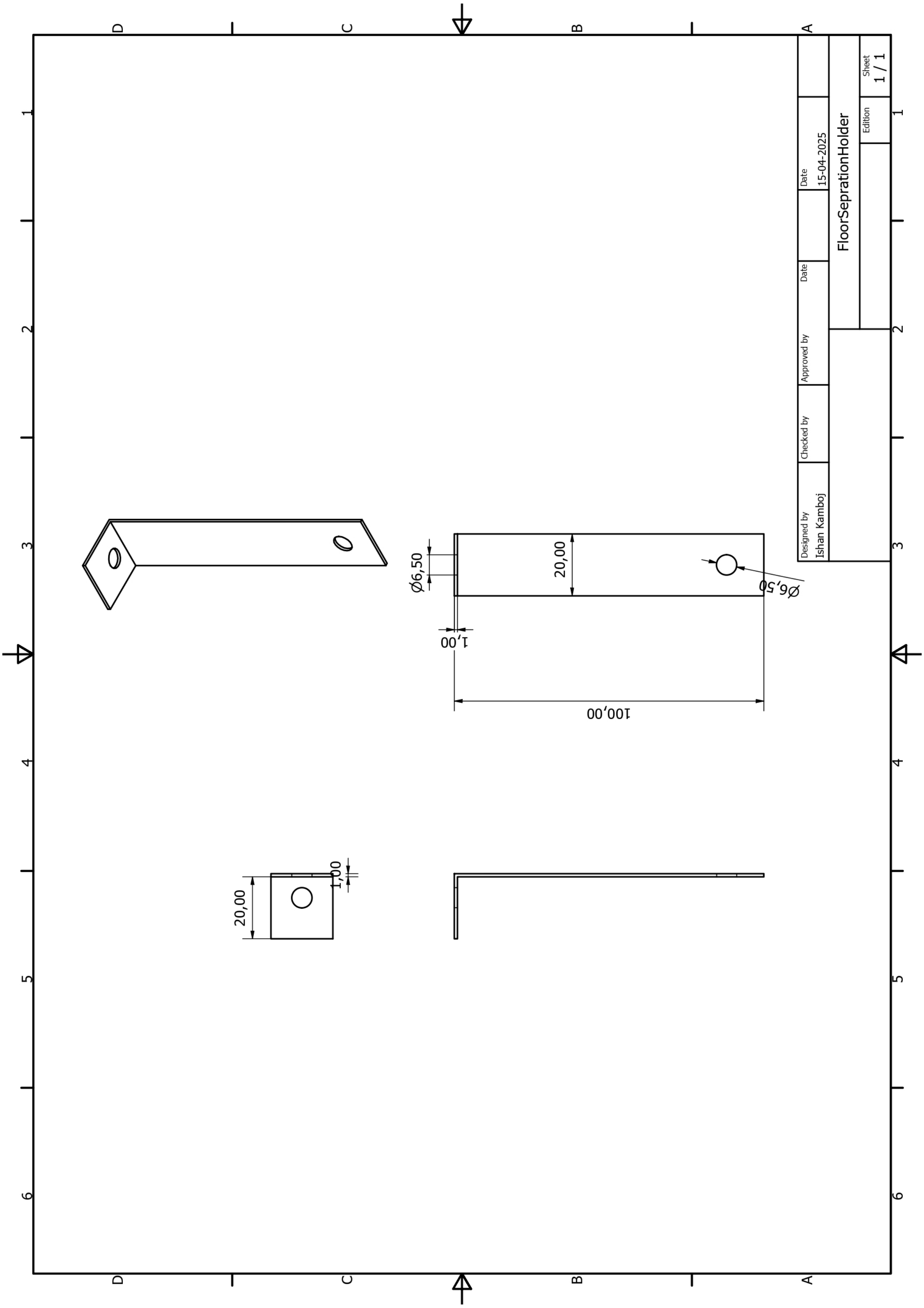
FloorSeprationHolder
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Checked by
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15-04-2025
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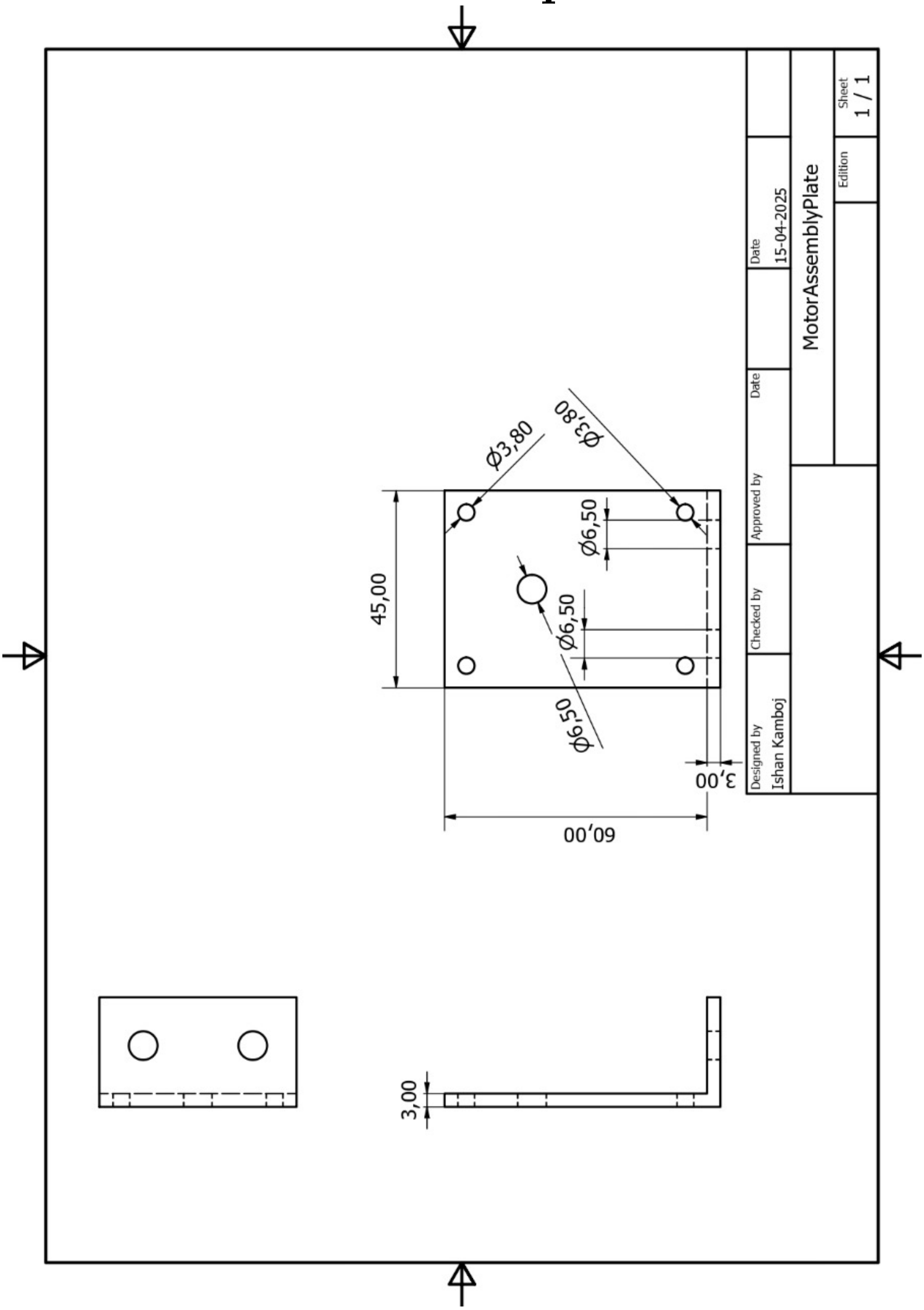
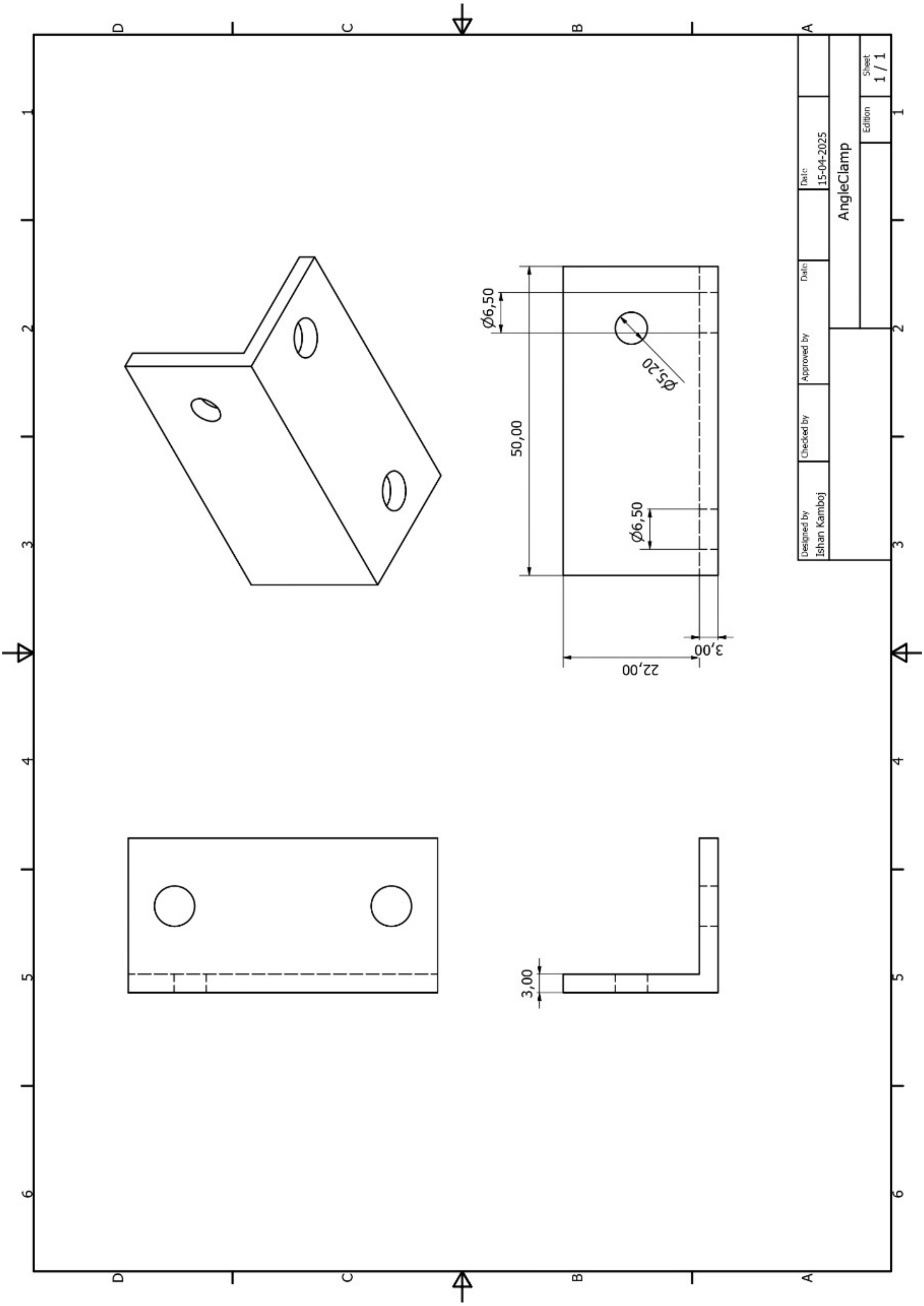
Isometric Drawing of Connecting L-Clamp





AngleClamp
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Ishan Kamboj
Checked by
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Date
Date
15-04-2025
Edition
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Sheet
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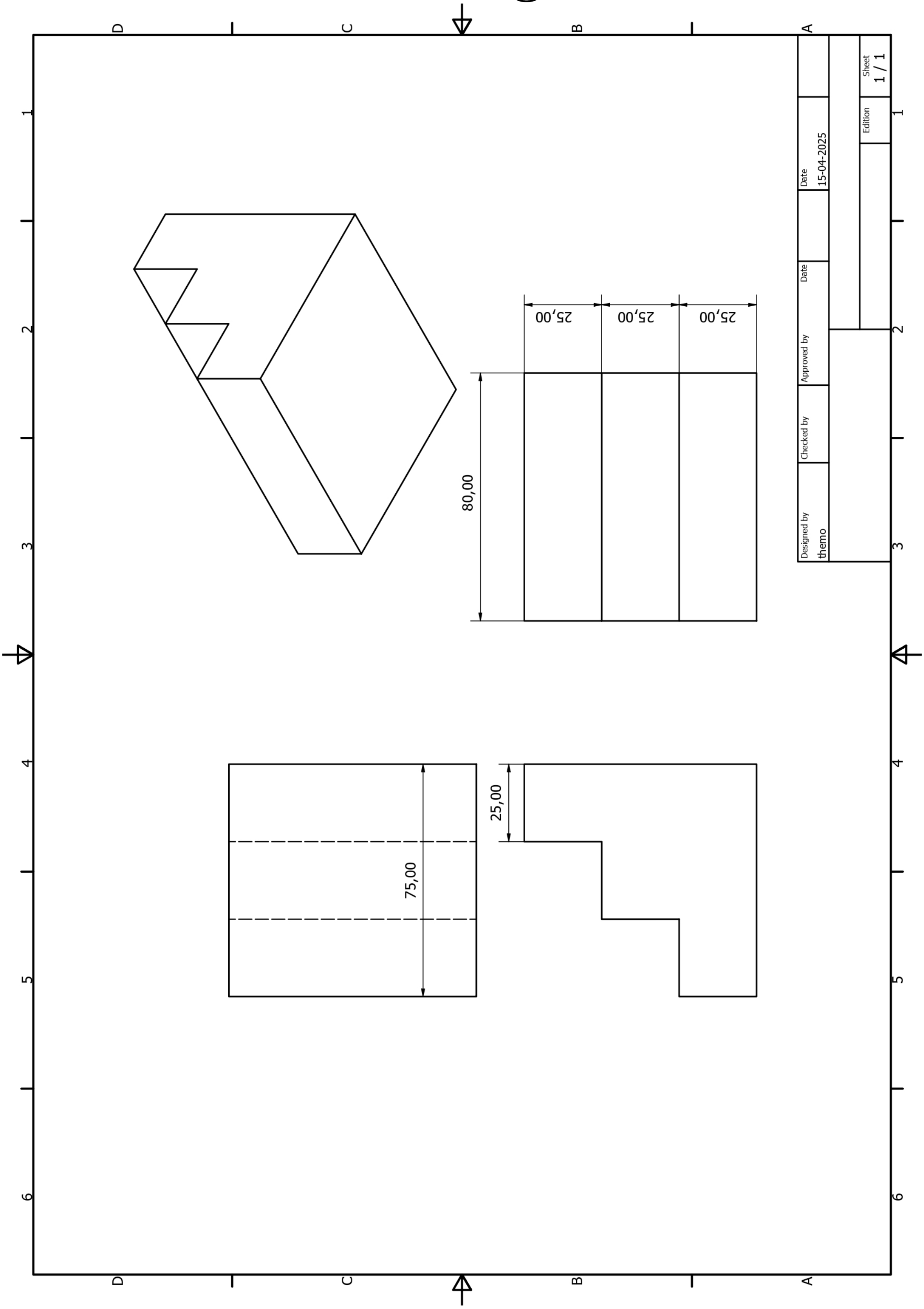
Isometric Drawing of Staircase



Motor Sizing

Motor Torque Requirement and Moment of Inertia Calculation

Specifications

Table:

- Diameter (D) = 20 mm
- Length (L) = 10 mm
- Density (ρ) = 7.85×10^3 kg/m^3

Shaft:

- Diameter (D) = 8 mm
- Length (L) = 15 mm
- Density (ρ) = 7.85×10^3 kg/m^3

Load Dimensions

- $l_o = 125$ mm
- $b = 100$ mm, $b_i = 94$ mm
- $h = 70$ mm, $h_i = 64$ mm
- Distance from load to table center (C) = 200 mm
- Density of Load (ρ) = 1240 kg/m^3

Moment of Inertia Calculations

Table (J_t):

$$J_t = \frac{1}{32}\pi D^4 = \frac{1}{32}\pi(0.02)^4 = 1.97 \times 10^{-5} \text{ m}^4$$

Shaft (J_s):

$$J_s = \frac{1}{32}\pi D^4 = \frac{1}{32}\pi(0.008)^4 = 4.74 \times 10^{-8} \text{ m}^4$$

Load (J_l):

$$J_l = \frac{1}{12}[bh^3 - b_i h_i^3] = \frac{1}{12}[0.1 \times (0.07)^3 - 0.094 \times (0.064)^3]$$

$$= \frac{1}{12}[3.43 \times 10^{-5} - 2.94 \times 10^{-5}] = \frac{1}{12} \times 0.49 \times 10^{-5} = 4.08 \times 10^{-7} \text{ m}^4$$

Adding Parallel Axis Theorem:
A $\times$ d^2 term added
Total $J_l = 5.08 \times 10^{-4}$ m^4

Total J (Final):

$$J = 5.1 \times 10^{-4} \text{ m}^4$$

Torsional Calculations

Angular Velocity Term (α_c, c):

$$\alpha_c,\ c = \frac{J \times V}{t_a} = \frac{9.58 \times t_a}{t_a} = 5.8$$

Torsional Shear Stress from Load:

$$\tau_{\text{load}} = \frac{m \times g \times r}{J} = \frac{1.06}{J}$$

Final Total Shear Stress

$$\text{Total } \tau = \frac{\tau_{\text{load}}}{J} = \frac{1.06}{1.32 \times 10^{-5}} = 1.07$$

Cost Estimation

PROCESS/ MATERIAL	TIME TAKEN/ WEIGHT	OPERATING COST	COST
Mild Steel	1 Kg	Rs. 90/Kg	Rs. 90
Galvanised Iron Sheet	0.2 Kg	Rs. 75/Kg	Rs. 15
Nuts and Bolts	0.3 Kg	Rs. 130/Kg	Rs. 39
Clips and Fold	-	Rs. 120/Kg	-
3D Printing	12 Hrs.	Rs. 300/Hr	Rs. 3600
Lathe	2 Hrs.	Rs. 350/Hr	Rs. 750
Milling	-	Rs. 450/Hr	-
Drilling	2 Hrs.	Rs. 100/Hr	Rs. 200
Cutting	1 Hr	Rs. 60/Hr	Rs. 60
Unskilled Labor	12	Rs. 650/Day/8Hrs.	Rs. 7800
Skilled Labor	8	Rs. 850/Day/8Hrs.	Rs. 6800
Electronics Kit with Single Motor	-	Rs. 2500	Rs. 2500
TOTAL			**Rs. 19354**