TA201A: Manufacturing Processes I

Engineering Metallurgy Laboratory

Semester III, 2021-22

The Extendable Staircase

…based on the Scissors Mechanism

Group Members

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Course Faculty

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Acknowledgements

We would like to express our sincere gratitude to our Course Tutor, Dr. Niraj Chawake and lab in-charge Mr. Indra Pal Singh for their guidance and support throughout the execution of the project. We also extend our gratitude to the Teaching Assistants, Mr. Sandeep Sahni and Mr. Ankush Ghosh for providing valuable inputs. Finally, we would like to thank our Course Instructor, Dr. Shashank Shekhar for providing us with the opportunity to work as a team in designing a unique product by using the theoretical concepts learnt in class.

Introduction and Motivation

The Extendable Staircase is a project motivated by the requirement to save the space used by staircases in homes and offices. The Extendable Staircase has been designed such that its steps will extend out of the floor to appropriate heights using the scissors mechanism, which is driven by gear chain mechanism, operated by a motor. Also, we might not need any power to lower staircase. We just need to switch off our motor and gravity will do rest of the job. A safe and better method is explained in working mechanism.

Working principle

First, a motor attached to the main gear rotates the gear at a speed controlled by the operator. Then, this rotation is transferred to 3 different shafts through a gear chain assembly. The rotation is then transferred to the main threaded shaft at the center of the contraption with the help of 3 sets of 90^0 bevel gears. Now, the threaded shaft, which is screwed into the sliding rods, starts to rotate, and in turn pulling the sliding rod causing scissor legs to be pulled towards each other, which raises the platform. The motor can be stopped at any time, maintaining the platform at a constant height.

The lowering of the platform is executed by reversing the direction of the rotation of the motor which will push the arms away from each other. Furthermore, it will not rotate until its electric solenoid is activated, which prevents the sudden descent that can result from a power failure.

Timeline

Turn 1	Initial Ideation: Shortlisting three ideas from which we chose one to work with.
Turn 2	Solidification of Project Idea and further planning.
Turn 3 and 4	Division of work between team members. Designing individual parts and creating their isometric drawings.
Turn 5	Compilation of contents and drawings in a PowerPoint presentation.

Work Distribution

NAME	Turn 1	Turn 2	Turn 3	Turn 4	Turn 5	Turn 6
Granth Choudhary	Ideation (staircase)	Finalizing Working mechanism	Designing Gears and Chains	Finalized the design and Made drawings of gears	Compilation and Cost Analysis	Final Project Report and Presentation
Jatin Chauhan	Ideation (Bicycle Cleaner)	Finalizing Materials required	Designing Platform	Finalized the design and Made the Draft presentation	Cost Analysis and PPT Design	Final Project Report and Presentation
Daksh Shrivastava	Ideation (Robotic Arm)	Finalizing Materials required	Designing Gears and Chains	Finalized the design and Made drawings of chains	Cost Analysis and PPT Design	Final Project Report and Presentation
Garvit Arora	Ideation (Staircase)	Finalizing Working mechanism	Designing Shafts	Finalized the design and Made drawings of shafts and Draft presentation	Compilation and overall PPT Design	Final Project Report and Presentation
Karan Jeyasankar	Ideation (Bicycle Cleaner)	Finalizing Working mechanism	Designing Scissors	Finalized the design and Made drawings of scissors	Compilation and Sustainability analysis	Final Project Report and Presentation

NAME	Turn 1	Turn 2	Turn 3	Turn 4	Turn 5	Turn 6
Apurb Agarwal	Ideation (Staircase)	Finalizing Working mechanism	Designing Base	Finalized the design and Made drawing of base	Compilation and Draft Report	Final Project Report and Presentation
Ananya Mehrotra	Ideation (Robotic Arm)	Finalizing Working mechanism	Designing Platform	Finalized the design and Made drawing of platform	Compilation and Process Description	Final Project Report and Presentation
Muhammad Farhan	Ideation (Bicycle Cleaner)	Finalizing Materials required	Designing Scissors	Finalized the design and Made the Draft presentation	Sustainability analysis and Process Description	Final Project Report and Presentation

Components and Materials Required

Component	Materials Required
Scissor Arms	Mild steel flat
Platform	Mild Steel Flat
Gears and Chain	Cast Iron
Shafts	Mild Steel Round rod (10 mm)
Motor	Pre-Fabricated
Base Frame	Mild Steel Flat
Nuts and Bolts	Pre-Fabricated
Joints (bearings and pins for scissors)	Aluminum and Cast Iron
Joints (brackets and pins for base and platform)	Aluminum and Cast Iron

Materials Required

Mild Steel Flat:

Mild steel flat will be used for scissors because of its composition which gives it high strength.

Galvanized Iron Sheet:

These are rust-resistant structural iron sheets which will be used to make the platforms and the base for our staircase.

Aluminum and Cast Iron:

Bearings, pins and brackets will be casted using Aluminum and Cast Iron.

Iron:

Iron will be used to cast gears and shafts as iron can be casted easily in any form.

Mild Steel Rods:

Shafts are made using mild steel rods. The shafts should be of high strength so as to prevent scissors from falling apart due to which we used mild steel rods.

Processes Involved

Sand Mold Casting:

Sand-mold casting is a metal casting process characterized by using sand as the mold material. The term "sand casting" can also refer to an object produced via the process. A major amount of metal castings are produced using this process.
Molds are made of sand and in addition, a suitable bonding agent (usually clay) is mixed. The mixture is moistened, typically with water, but sometimes with other substances, to develop the strength and plasticity of the clay. The sand is contained in a system of frames known as a flask. The mold cavities and gate system are created by compacting the sand around models called patterns, by carving directly into the sand.
Molten metal is then poured into the mold cavity and we get the required product upon cooling and some additional finishing.

> **Use:** Sand mold casting has been used to fabricate parts like nuts, bolts, chains and gears.

Sheet Metal Bending:

Bending is a manufacturing process that is used to produce a U-shaped, V-shaped or channel shape along a straight axis in ductile materials, most commonly sheet metals. Sheet metal bending can be done with help of the metal bending machine, which has box, pan brakes and brake presses and other specialized machine presses. It will be used for making the platforms and the base for our staircase.

> **Use:** Metal sheets will be bent to make the platform and the base frame.

Cutting:

Cutting has been at the core of manufacturing throughout history. Different methods are used for cutting metals which can be grouped by the physical phenomena used. The process involves removing unwanted material from a block of metal in the form of chips to get our desired product. This will be used for different parts including scissors, base and platform.

> **Use:** Cutting was used in the manufacturing process of platform, base and scissors from thick metal sheets.

Welding:

Welding is a fabrication process that joins materials, usually metal and thermoplastics. It is done by heating the parts to a high temperature and allowing them to cool while in contact, causing fusion. In this process, the base metal is melted to form a strong joint between parts, unlike in the brazing and soldering processes in which the base metal is not melted.

> **Use:** Welding has been used for different static joints in platform, base and sliding rod.

Riveting:

A rivet is a permanent mechanical fastener which is used to join two parts which can freely rotate about the rivet. It consists of a smooth cylindrical shaft with a head on one end. The end opposite to head is called tail. The rivet is placed in a punched or drilled hole, and the tail is bucked so that it expands to about 1.5 times the shaft diameter holding the rivet in place.

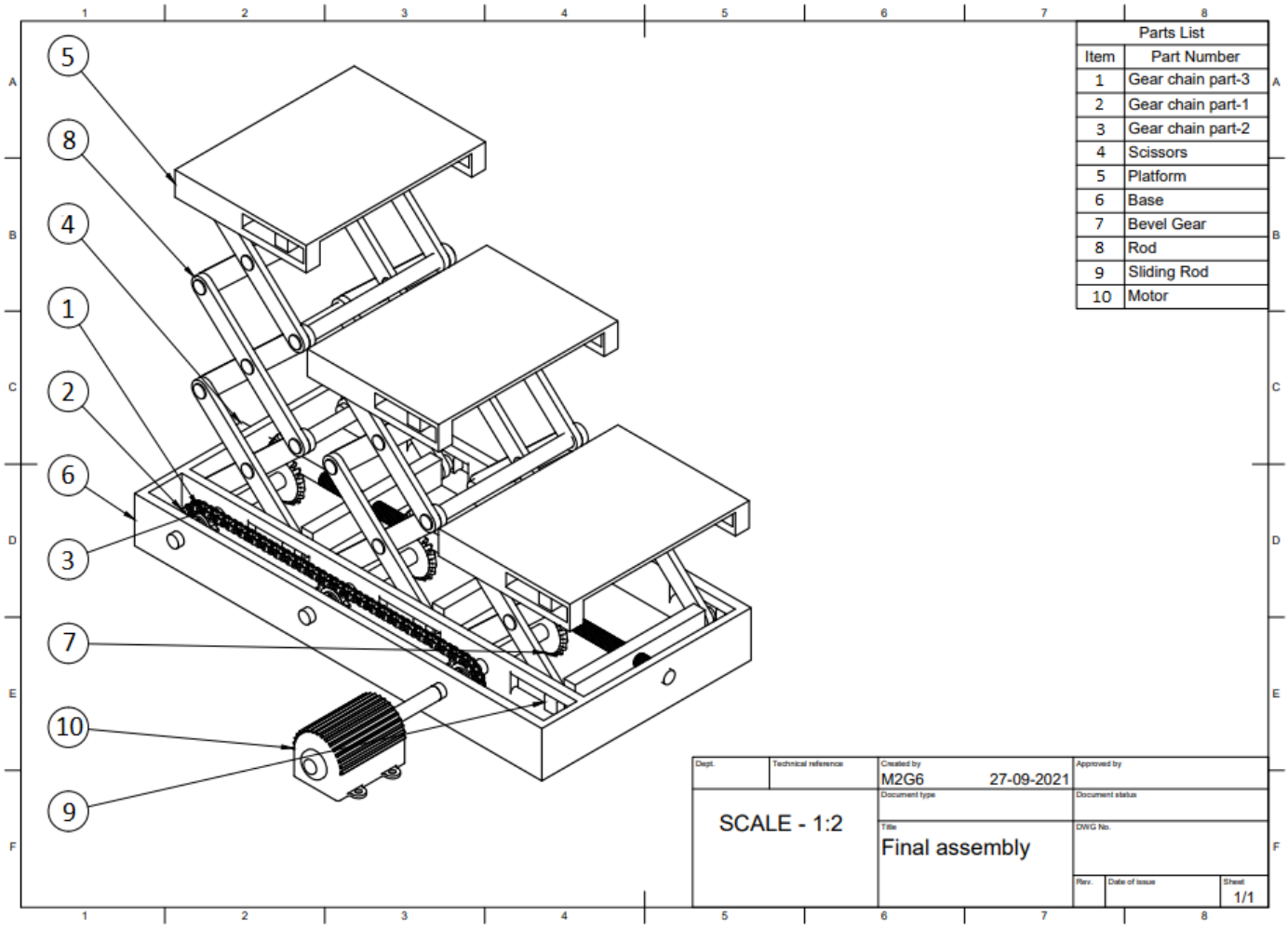
Use: Riveting has been used to join the scissors so that they can freely rotate about the pivot.

Galvanization:

It is the process of coating the surface of the parts made up of iron or steel with a protective layer of zinc in order to prevent the part from rusting and increase its durability. The method to be used is hot dip galvanization, in which the parts are dipped in the hot molten zinc and upon cooling, the protective layer of zinc is formed on it.

Use: Our casted products have been galvanized to protect them from rusting.

Isometric Drawing of Assembly



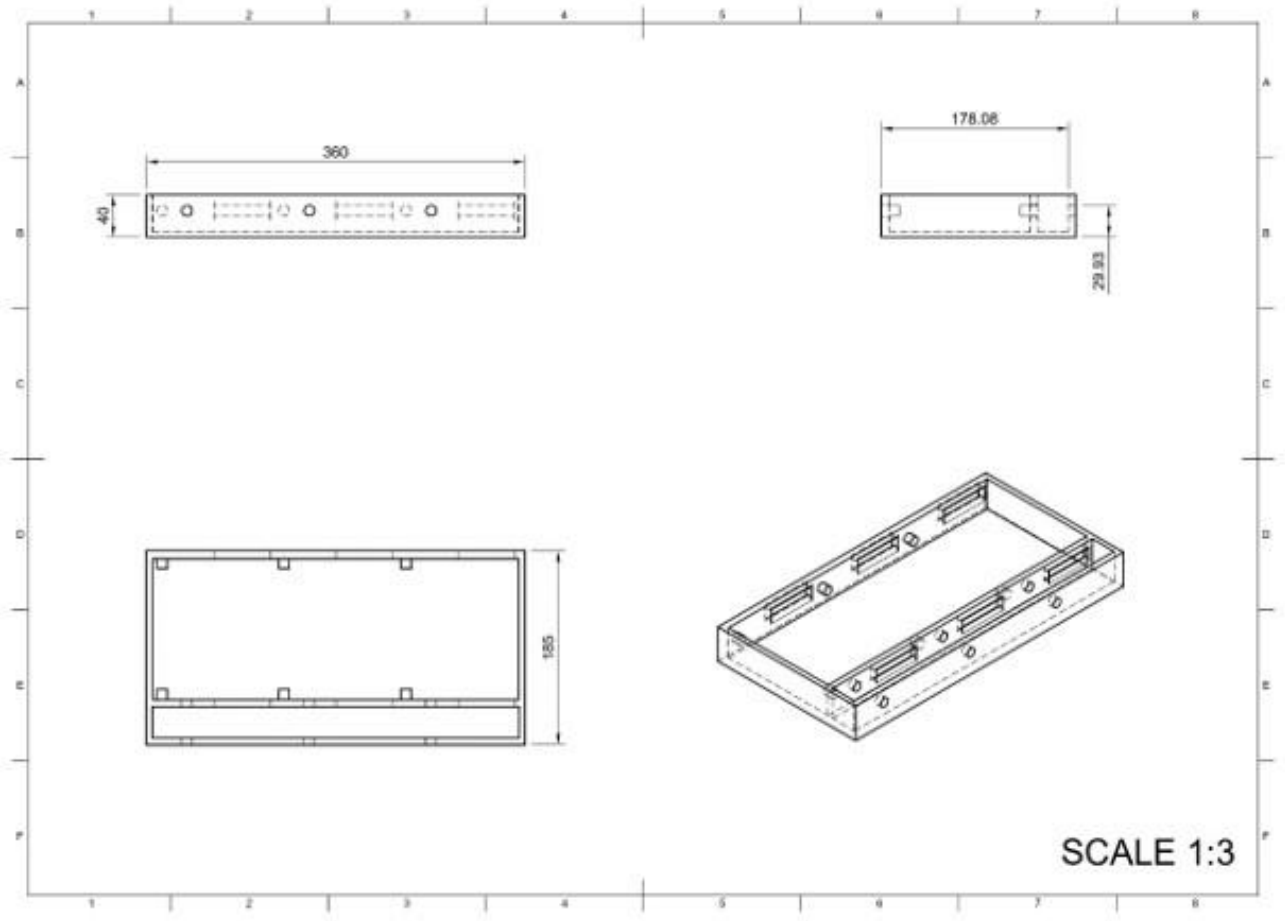
Parts List	
Item	Part Number
1	Gear chain part-3
2	Gear chain part-1
3	Gear chain part-2
4	Scissors
5	Platform
6	Base
7	Bevel Gear
8	Rod
9	Sliding Rod
10	Motor

Dept.	Technical reference	Created by M2G6 27-09-2021	Approved by
SCALE - 1:2		Document type	Document status
		Title: Final assembly	DWG No.
			Rev. / Date of issue / Sheet 1/1

NOTE: All the dimensions are in mm

Individual Components

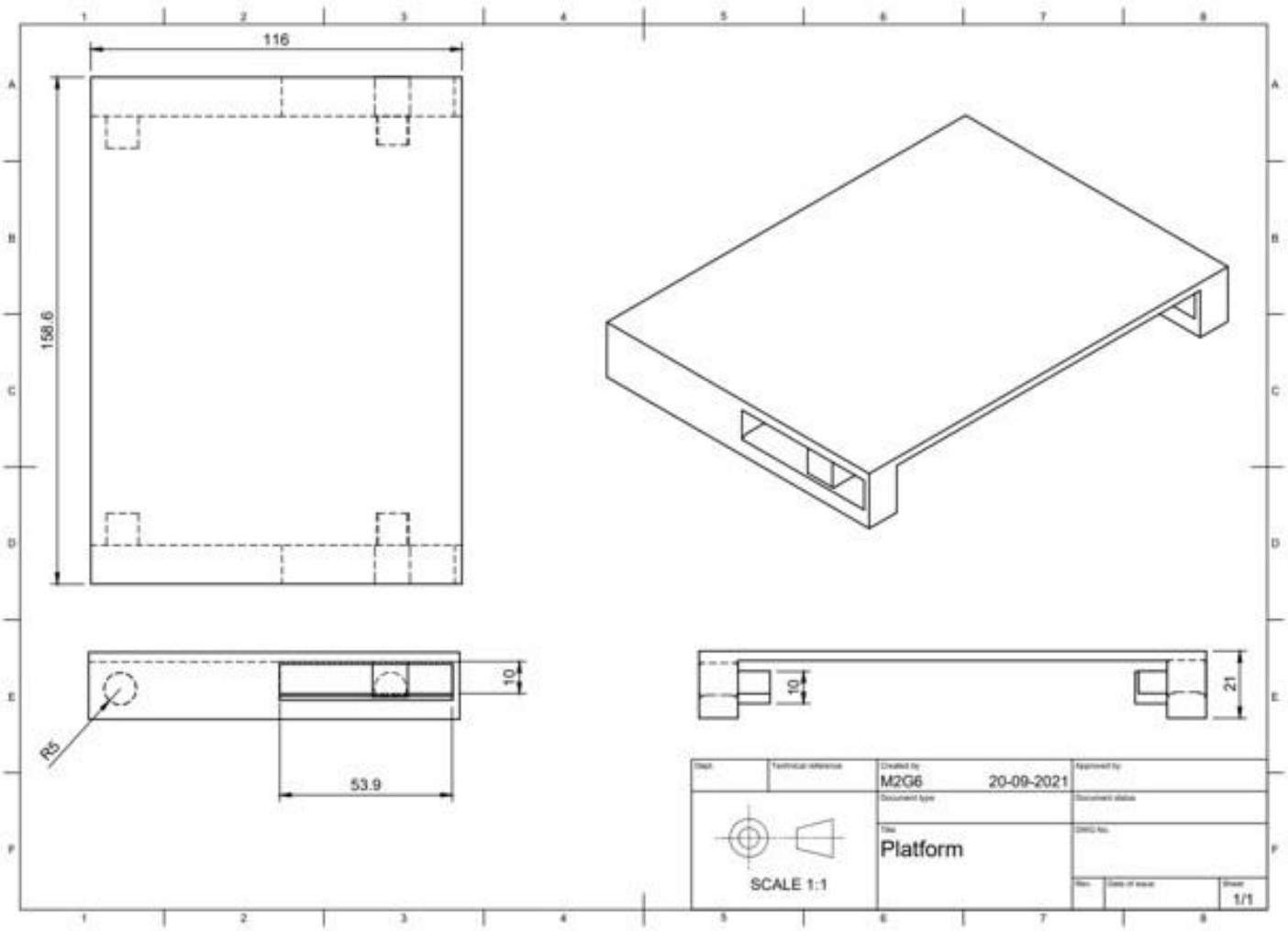
Base:



Processes Involved: Sheet Metal Bending, Welding and Cutting.

Material Required: Mild Steel Flat

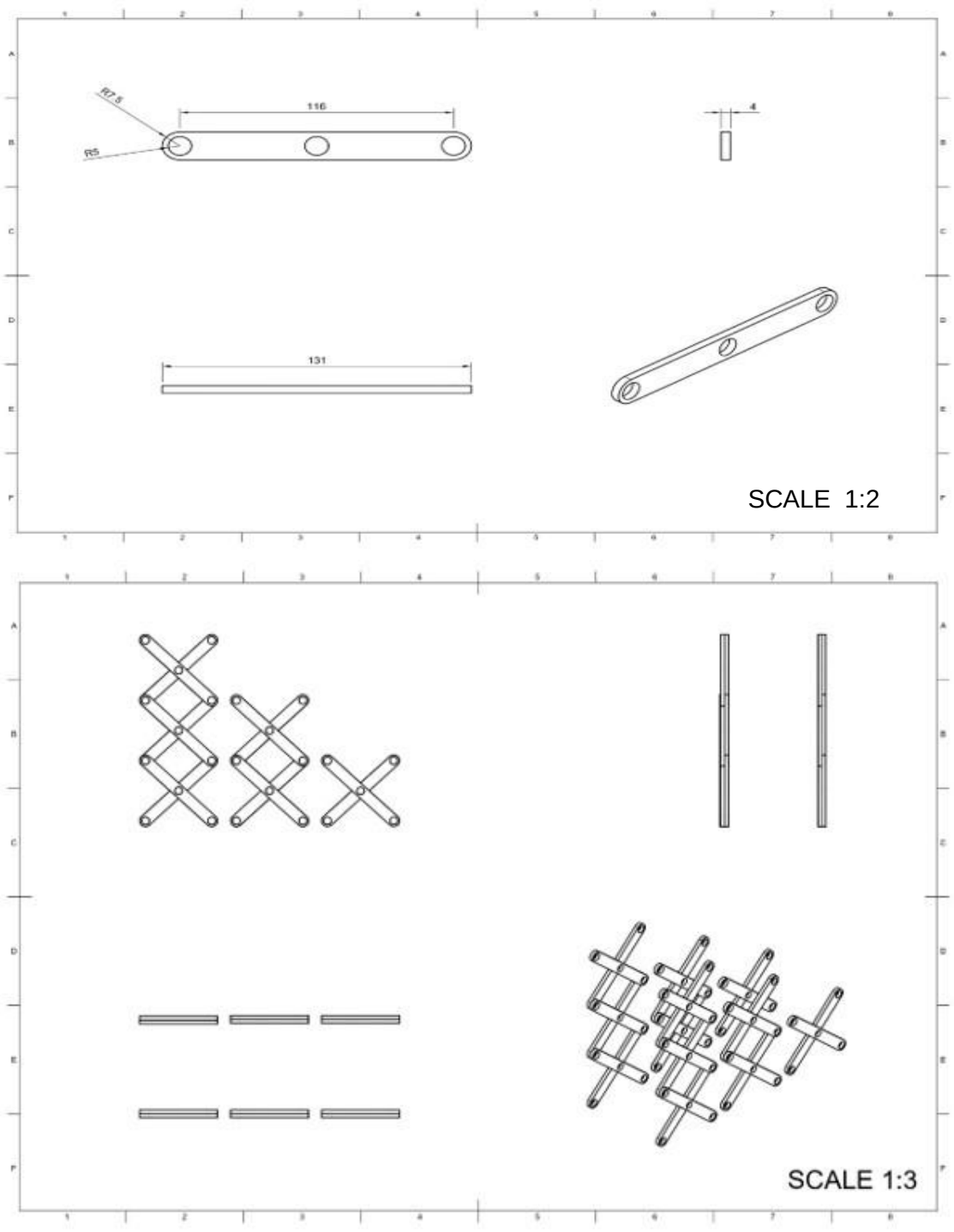
Platform:



Processes Involved: Sheet Metal Bending, Welding and Cutting.

Material Required: Mild Steel Flat

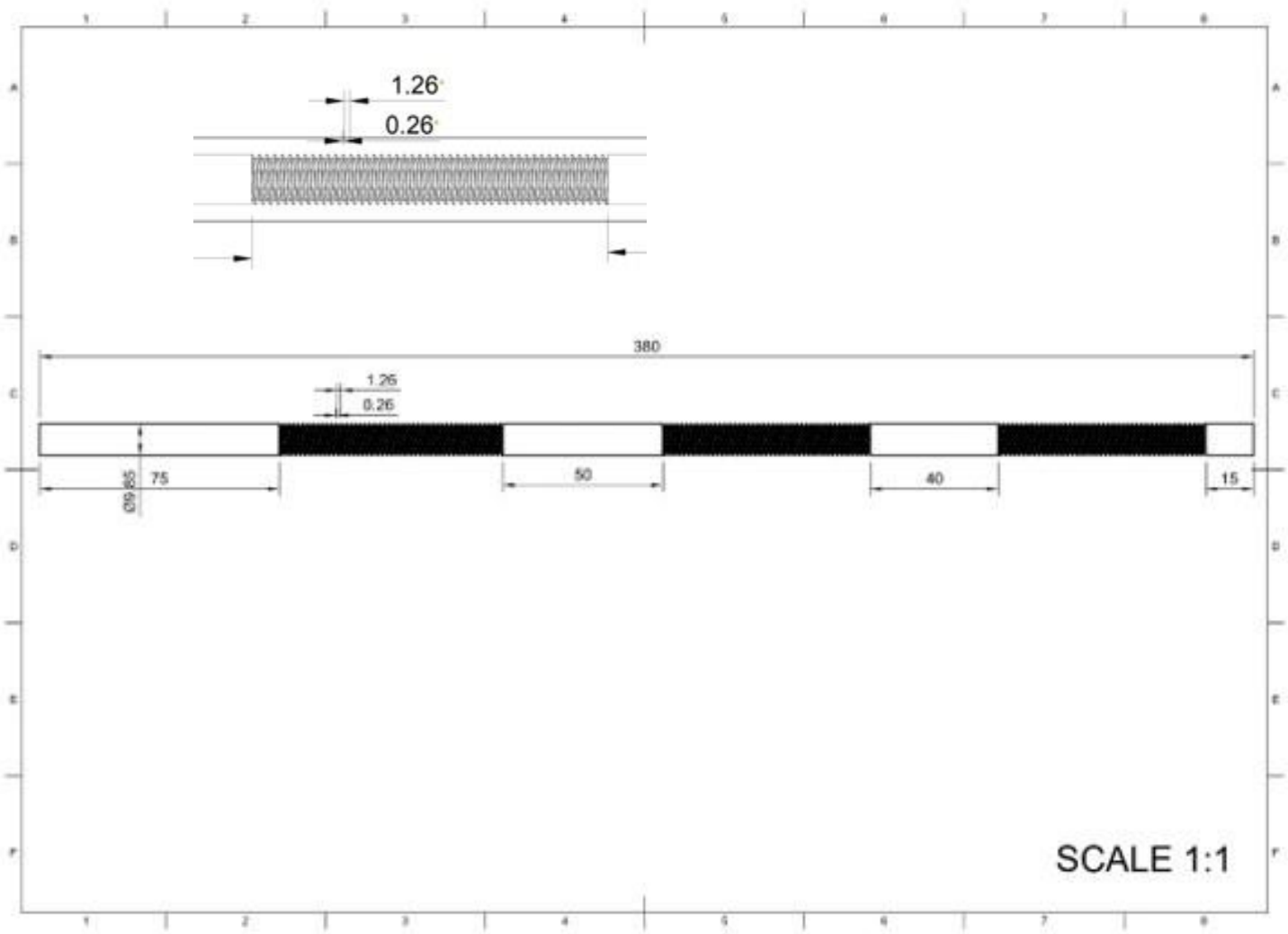
Scissors:



Processes involved: Cutting and Riveting

Material required: Mild Sheet Flat

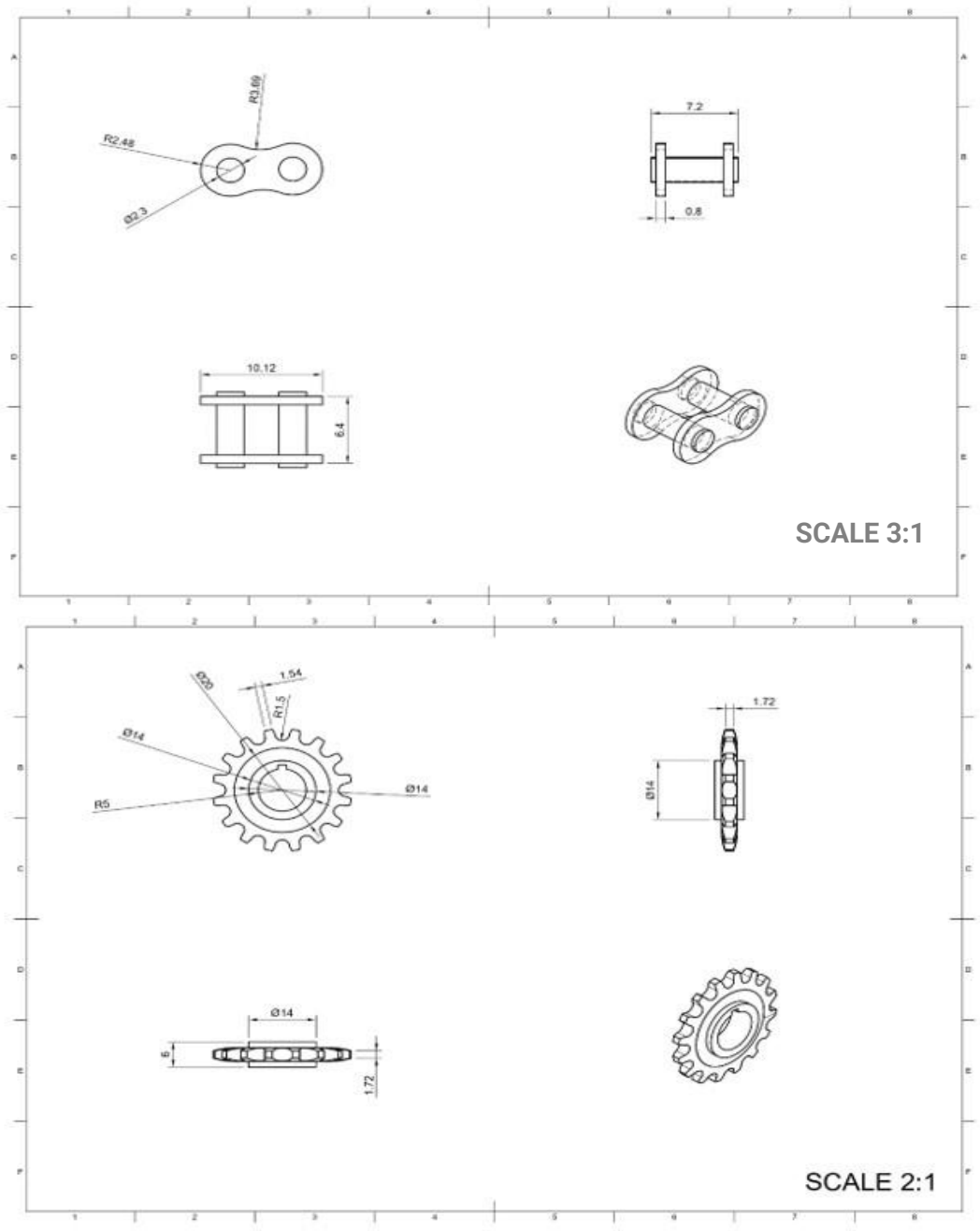
Shaft:



Processes involved: Threading, Extrusion

Material required: Mild Steel Round Rod

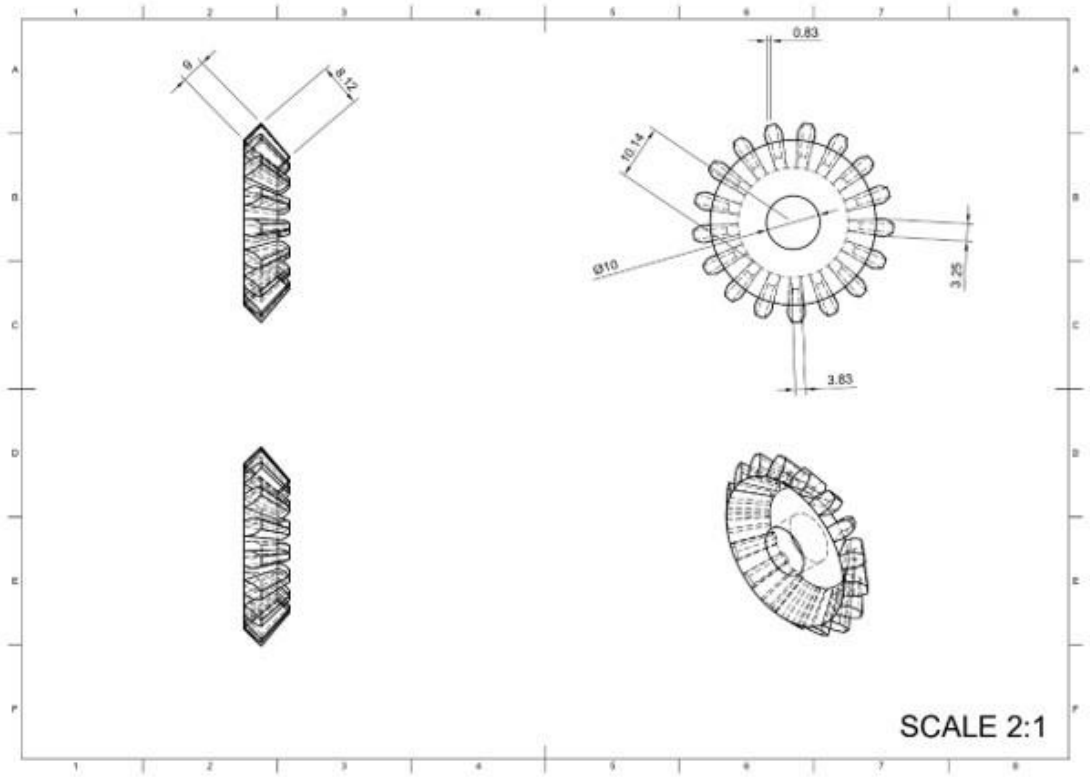
Gears and chain:



Processes Involved: Sand Mold Casting, Galvanization

Material Required: Cast Iron

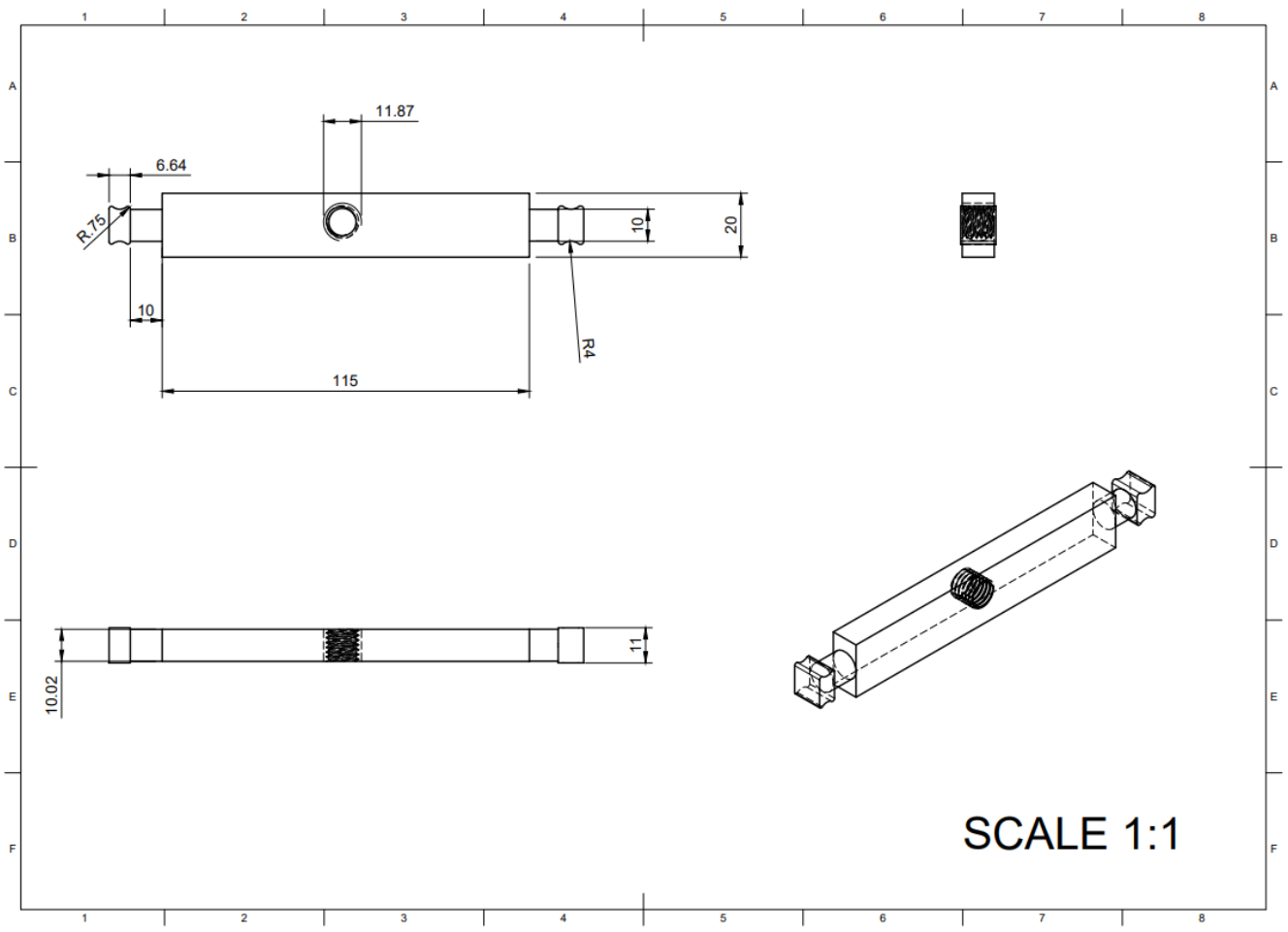
Bevel Gear:



Processes involved: Investment Casting, Galvanization

Material required: Cast Iron

Sliding Rod



Processes involved: Sand Mold Casting, welding

Material required: Cast Iron, Mild Steel Square Rods

Cost Analysis

Parts	Qty.	Material	Total Cost (₹)
Platform	3	Mild Steel Flat	150.15
Scissor Arm	24	Mild Steel Flat	102.96
Long shaft	1	Mild Steel round Rods	14.07
Base	1	Mild Steel Flat	319.41
Sprocket	3	Cast Iron	2.6
Chain Links	62	Mild Steel Flat	3.5
Chain Links (inner)	62	Mild Steel Flat	2.34
Bevel Gear	6	Cast Iron	13.5
Sliding rods	3	Mild Steel square rods	39
Small rods	6	Mild Steel round Rods	23.86

Total: ₹671.37

Rounding off cost considering wastage (10%): ₹740

Sustainability

Social:

The whole idea behind this project is to save space.

Durability:

The parts which could rust, have been galvanized, giving strength and durability to the product.

Recyclable:

All the parts used are easily recyclable and can be used again.

Portability:

The product is fully portable and can be easily installed anywhere.

Economical:

Economic cost has been kept in mind while designing the model. It is relatively cheap compared to its utility and quality.

References

- Scissor Mechanism (Concept)
- Scissor Mechanism (Fusion 360)
- Bevel Gears Plugin
- Sand Casting process
- Sheet Metal Bending process
- Riveting process
- Galvanization process
- Welding process