

Conveyor 3D Printer

Motion and design analysis of conveyor 3D printer

Submitted to the Department of Mechanical Engineering in partial fulfillment of the requirements for the degree of Bachelor of Science in Engineering at the University of New Brunswick

Callum Ewen - 3780460

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ABSTRACT

The goal of this project was to design a conveyor belt 3D printer that could print continuously while being constructed with simple tools and materials. The main objectives were to keep the design low-cost and easy to manufacture without access to a full machine shop. The conveyor belt parts are to be constructed using aluminum extrusion and 3D printed.

The printer was split into two main assemblies the upper frame and the base.

Parts were modeled in SolidWorks using in-context design to speed up the process. The z-axis uses a T8 threaded rod to convert rotational motion into vertical movement, and a rack and pinion system which controls the x-axis. Stepper motors were used for all motion.

A motion study was done to compare angular velocity to linear velocity. The z-axis showed a ratio of 14.32 mm/s per rad/s, and the x-axis showed 13.9 mm/s per deg/s. Most parts were printed or made with basic tools, except the rack gear and backplate, which would need to be machined with tighter tolerances.

Overall, the design met the goal of making a simple and functional conveyor belt 3D printer.

TABLE OF CONTENTS

Abstract	2
List of Figures	4
Introduction.....	6
Design Methodology.....	8
Design Analysis	11
Conclusion	14
References	15
Appendix.....	17
.....	17
.....	18
.....	19
.....	23

List of Figures

Figure 1 mechanism.....	6
Figure 2 x axis mechanism	7
Figure 3 3d printer final assembly	8
Figure 4 z axis Linear velocity vs angular velocity graph	12
Figure 5 x axis Linear velocity vs angular velocity graph.....	13
Figure 6 orginal drawing for extruder assembly	17
Figure 7orginal drawing for upper assembly	18
Figure 8 orginal drawing for base assembly	19
Figure 9 finalized model of base assembly	20
Figure 10 upper frame fully assembled exploded view	21
Figure 11 assembly used for motion study	22
Figure 12 parts deisgned spread out.....	23
Figure 13 280 by 20 by 20 aluminum extruion drawing	24
Figure 14 stepper mount axel plate	25
Figure 15 axel for belt roller	26
Figure 16 bearing plate	27
Figure 17 belt roller	28
Figure 18 buildplate belt tensioner	29
Figure 19 spring washer.....	30
Figure 20 threaded insert	31
Figure 21 T8 support.....	32
Figure 22 joint and stepper support	33
Figure 23spring stopper for extruder	34
Figure 24 adapter and spacer for roller bearings	35
Figure 25 back side x-y axis mount	36
Figure 26 front side x-y mount	37
Figure 27 offset heat sink mount	38
Figure 28 Heat block.....	39
Figure 29 filament tensioner arm.....	40
Figure 30 extrusion fill.....	41

Figure 31 bowden adapter filament	42
Figure 32 extruder housing	43
Figure 33 extruder backplate	44
Figure 34 215 by 20 by 20 aluminum extrusion	45
Figure 35 215 by 20 by 20 slotted aluminum extrusion	46
Figure 36 extrusion L plate	47
Figure 37 4*5 bearing spacer	48
Figure 38 exploded view	49
Figure 39 rack gear drawing	50

INTRODUCTION

The conveyor 3D printer was inspired by the Creality CR-30[2] and was selected due to an interest in automation in machines. The idea of a conveyor 3D printer allows for continuous printing and can be used for mass production of 3D printed parts. The two main mechanism that will be studied are the z-axis translation between a treaded rod and a bolt which converts rotational movement in linear. The other motion that will be studied is the rack a pinion which controls the x-axis by matching contact though the teeth of the gears the extruder assembly will be propelled forward.

Figure 1 mechanism

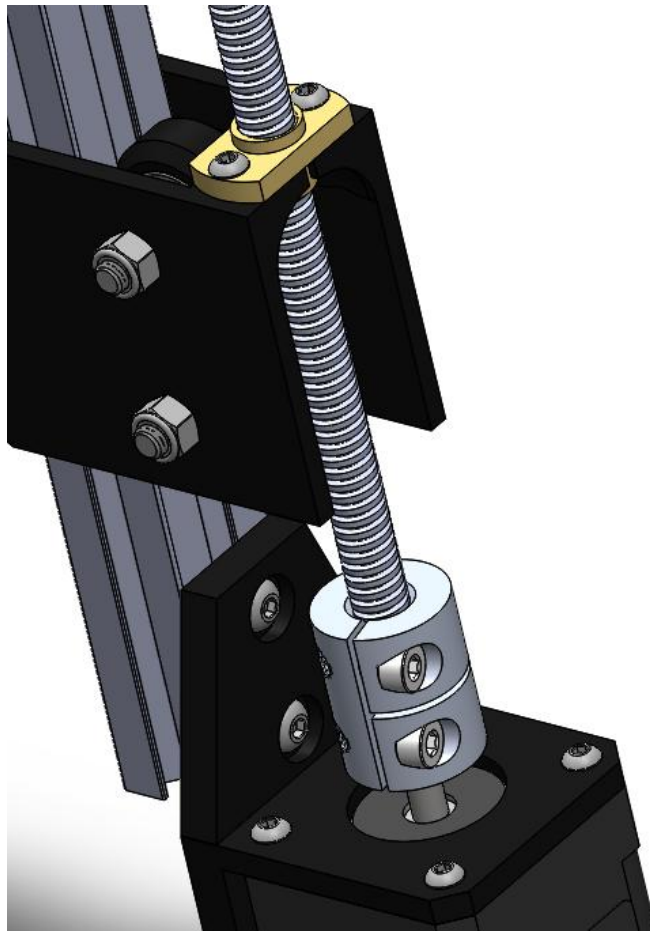
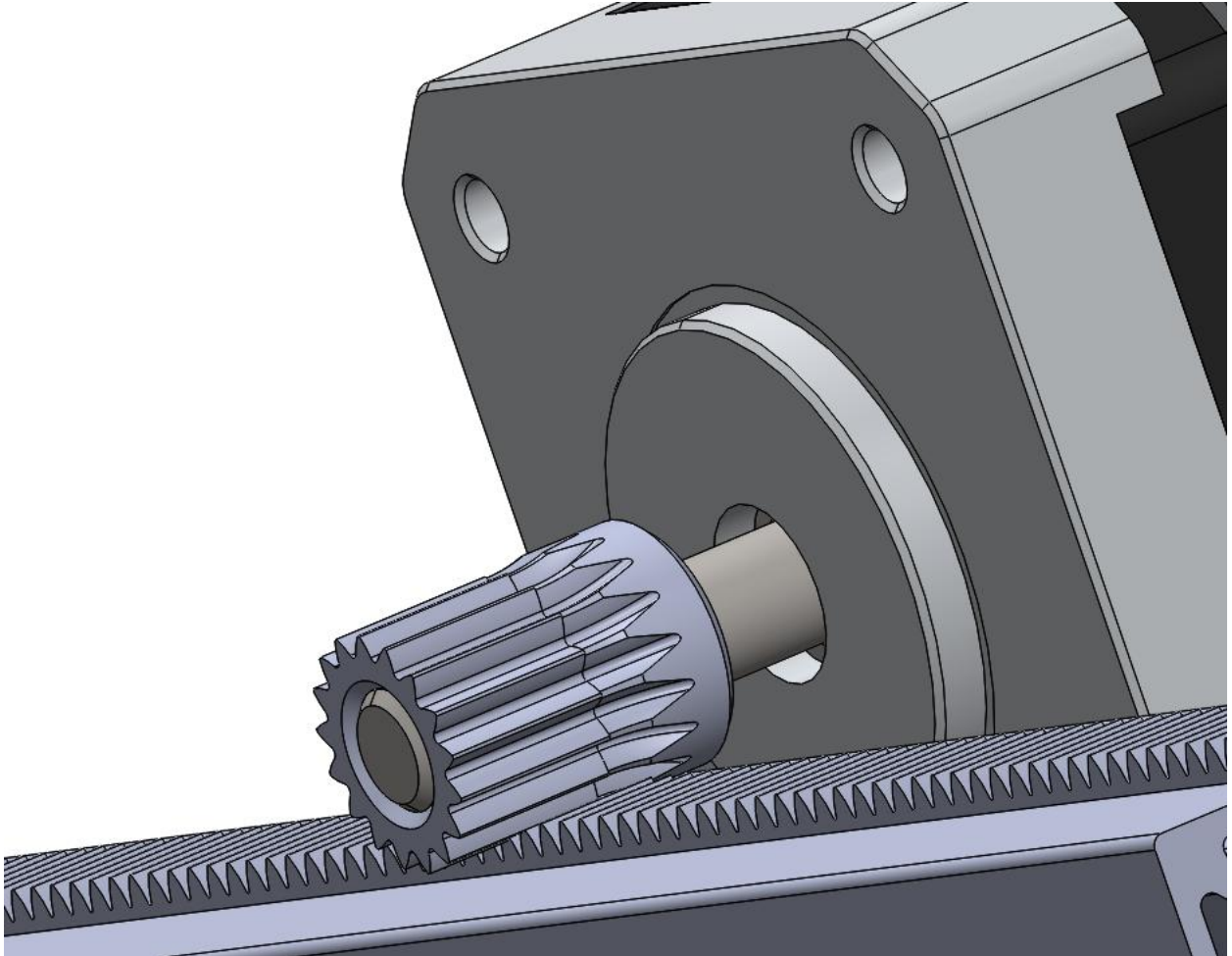
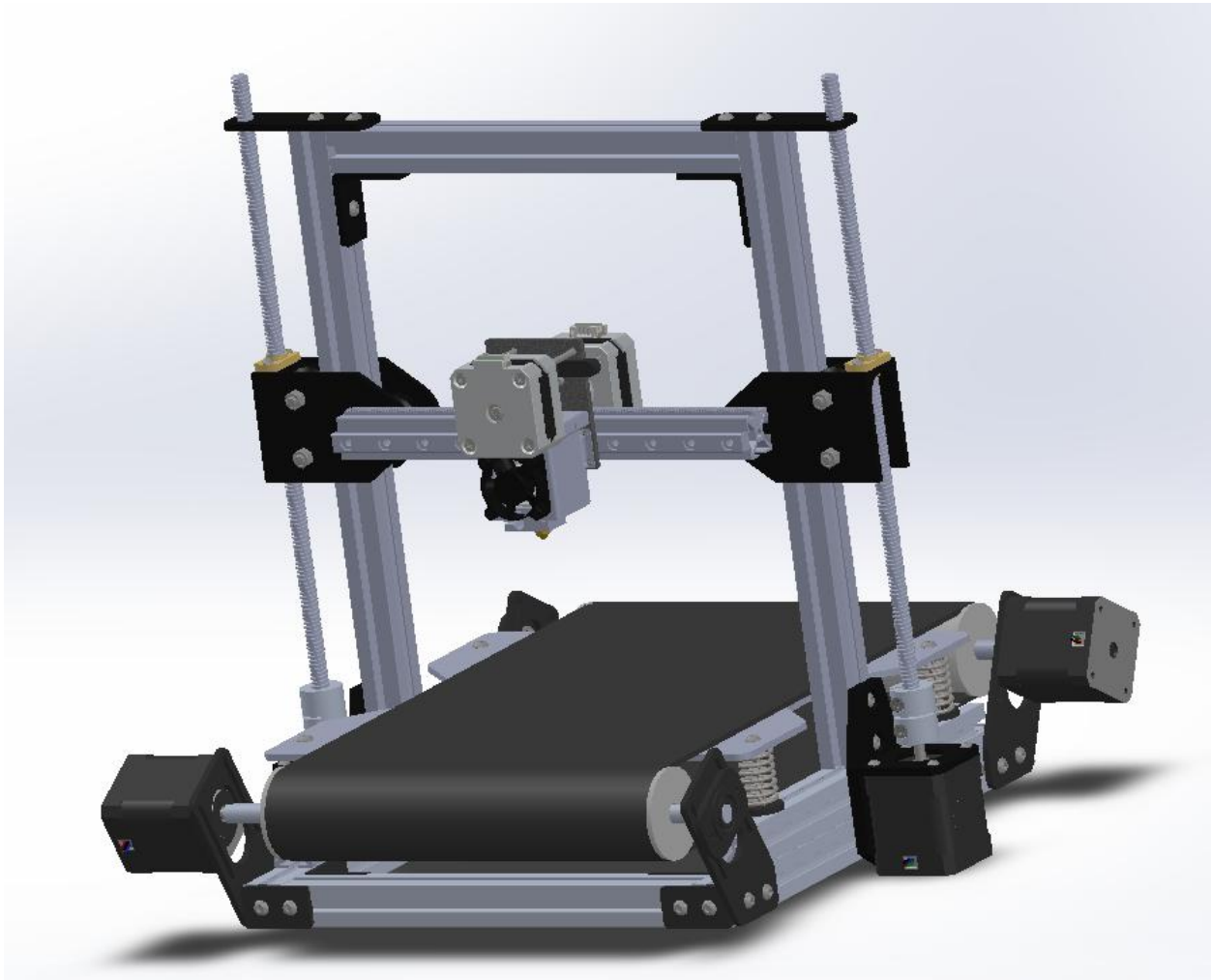


Figure 2 x axis mechanism



DESIGN METHODOLOGY

Figure 3 3d printer final assembly



The original idea for the conveyor 3D printer was to design a basic, simple 3D printer which has infinite travel in the y-axis, originally inspired by the Creality CR-30. An initial rough sketch was made for three different assemblies including the upper frame, the base, and the extruder. Each sketch covered the estimated number of parts and design guidelines (Figure 6). Sketches sped up the design process by making it easy to reference components since most brainstorming and layout planning happens quick on paper and any small adjustments can be made.

The base assembly was planned to be mostly constructed from aluminum extrusion, which was chosen for its large availability and easy workability, allowing for quick adjustments. The plan initially was for the aluminum extrusion to be drilled out and tapped for the assembly of the frame, which was later changed to 3D-printed joints, M4 screws, and specialized T4 Nuts commonly used in aluminum extrusion assembly. The stepper motors control the y-axis belt, which is mounted using a 3d printed bracket, the bracket also supports the bearing and bearing mounts. The stepper brackets were made adjustable so that the height and tension of the belt could be altered easily, allowing for quick and simple adjustments. The bracket for the bearings was made to fit the same screw spacing as the stepper motors, allowing for the stepper mount to be reused for mounting the bearings.

A surface is needed for parts that could be printed against, a build plate was designed as a build surface/tensioner. The build surface is fully adjustable in height and uses adjustable springs in the assembly. which was made by relating a sketch constraint to an assembly constrain and allows for an interesting spring effect in SolidWorks.

In the upper assembly the same sized aluminum extrusion as the base frame was used, and the same 3D-printed joints were used in junction with T4 slot nuts to reduce the number of designed parts. To drive the z-axis, stepper motors were chosen as they are standard in most 3D printers. A custom 3d printed bracket had to be made for the attachment of the stepper motors, which also works as a connector between the upper assembly and the lower assembly using the same M4 screws and T4 slot nuts. Cutouts for the bolt heads were made in the stepper mount to ensure that the steppers would be flush with the mount. To translate the rotational energy from the stepper motor to the T8 threaded rod, a coupler is used (**Error! Reference source not found.**). These couplers dimensions were taken from a previously designed file and recreated in SolidWorks [19]. To translate the rotational motion to a vertical motion, a brass flanged T8 nut is used dimensions for the a brass flanged T8 nut were proved online and recreated in solid works[8] was used and attached to the X-axis support (Figure 25). The x-axis support is used to support the central aluminum extrusion, which is the structure for the extruder and the linear guide rail. A linear guide rail was used in place of the typical roller bearings for its compact profile, in addition to the fact that no adjustments must be made to ensure that the tension between the extruder and the aluminum extrusion is maintained, the dimensions for the linear guide rail were found on grab cad and

recreated in SolidWorks[12]. The extruder sub-assembly was removed and combined with the upper assembly due to the convenience of the design, since most parts were made in assembly using in-context references.

To attach all major parts of the extruder a backplate was designed in order to mount the x-axis stepper, and the main extruder assembly. The backplate is without a doubt the most important and complex part designed in the 3D printer, as six different parts or features of the extruder must be mounted to it. To accommodate all the attached components, many holes had to be carefully placed in a small, compact surface. Designing in context was essential for the design of the extruder backplate due to the complexity of the hole placements.

After the design was complete, there were many thoughts about future changes or re-designs. The idea of placing the stepper motor that controls the x-axis with the extruder assembly is a flawed idea with many faults, including the fact that it will be harder to manufacture parts for, require more expensive parts, be harder to repair, have larger interferences, and add extra weight, which leads to more momentum on the x-axis causing larger printing errors and slower movement.

Majority of the parts designed for the 3D printer were designed in context to an assembly, which allowed the design process to be quick and efficient. However, this design strategy also led to many errors. Because the parts were made in context to each other, if a small change was made to one part in the assembly, updates would be made throughout the assembly, leading to many errors. After each part was designed, all in-context references were deleted, then fully defined without the in-context reference.

Another issue encountered in the assembly was with the motion study, where the x-axis would not move due to the large number of parts connected to the x-axis stepper motor. To resolve the problems in the motion study all parts connected to the x-axis stepper were deleted which allowed for the rack and pinion motion to be analyzed.

Overall, planning throughout the design process was helpful in the creation of the assembly.

DESIGN ANALYSIS

For the motion study, two mechanisms were analyzed, one converting rotational velocity into vertical motion, and the other rotational velocity into horizontal motion. Velocity was chosen as the primary metric because it offered the most consistent and meaningful data. Other measurements, like rotational displacement and acceleration, produced noisy graphs or significantly lower values, making them less suitable for comparison. For each motion study, the difference between the angular and linear velocity was studied. For the vertical z-axis, the rotation of the coupler was measured and compared to the vertical displacement of the x-axis supports (Figure 25). There is a clear relationship between the angular velocity of the coupler and the linear velocity of the x-axis support. The linear velocity is far less than the angular velocity due to the coarse thread of the T8 threaded rod a reaction ship of 14.32 Was found between the angular velocity and the linear velocity.

The motion that was transferred in the rack and pinion gear, shows a similar result where the rotational movement from the pinion gear was compared to the linear velocity of the stepper motor. There is a relationship in the rack and pinion gear as seen in (Figure 5), where for every rotation of the pinion gear, there is a scale factor where every deg/s there is 13.9 mm/sec translated linearly.

Most parts can either be bought off the shelf or 3D printed, except for the rack gear, which would have to be custom made as it fits with the teeth of a standard extruder gear. The rack gear would require incredibly precise manufacturing processes. The best fit would likely be wire EDM manufacturing, as the rack gear consists of a flat face to be cut out and is a relatively thin feature. EDM manufacturing has incredible tolerance of ± 0.0001 in [1].

The other machined part, also not a part of a mechanism, would be the back plate for the extruder and the heat sink mount, which will both have to be milled likely using a CNC mill with fine tolerances of ± 0.0025 for both, as the orientation and position of the heat block (Figure 28) rely on proper placement.

For 3D printed parts, which have a relatively high tolerance, are used in areas where tolerances are not extremely important or are made adjustable, such as basic joints, washers, spacers, stepper mounts, and the x-axis supports. The holes and cuts that can be made into the aluminum extrusion can be done mostly by hand. Using hacksaws, band saws, or any other cutting method that would be available, tolerance of $\pm 0.1\text{mm}$ would be necessary for the extrusion. All modifications made to the extrusion should be achievable using manual cutting methods. It is important that the cut surfaces of the aluminum extrusion are flat, any angular misalignment could compromise the accuracy of the 3D printer. Holes for the extrusion will be made using a drill press with the addition of a tap corresponding to the desired thread size. The main idea for the manufacturing process was to keep it as simple as possible and make it possible for the design to be done with minimal resources.

Figure 4 z axis Linear velocity vs angular velocity graph

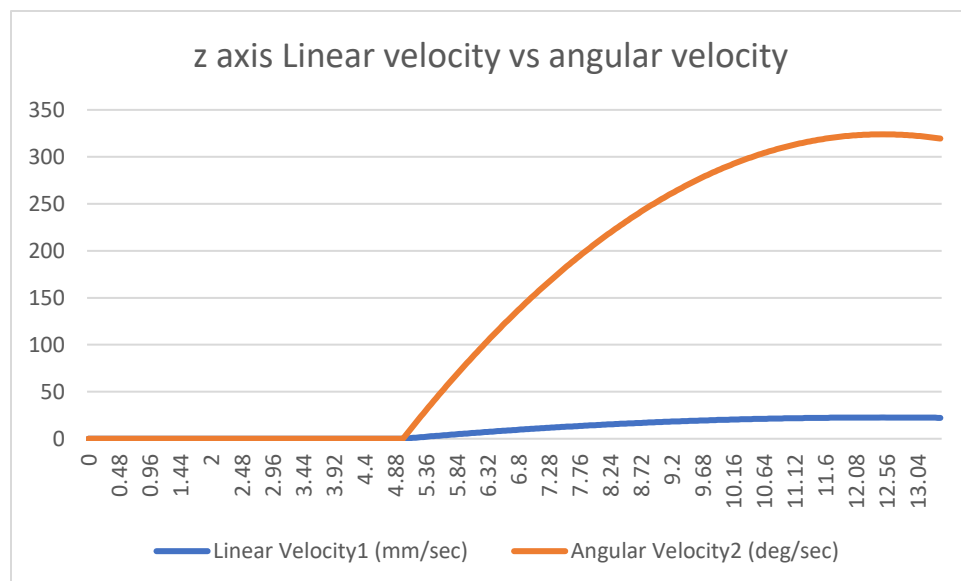
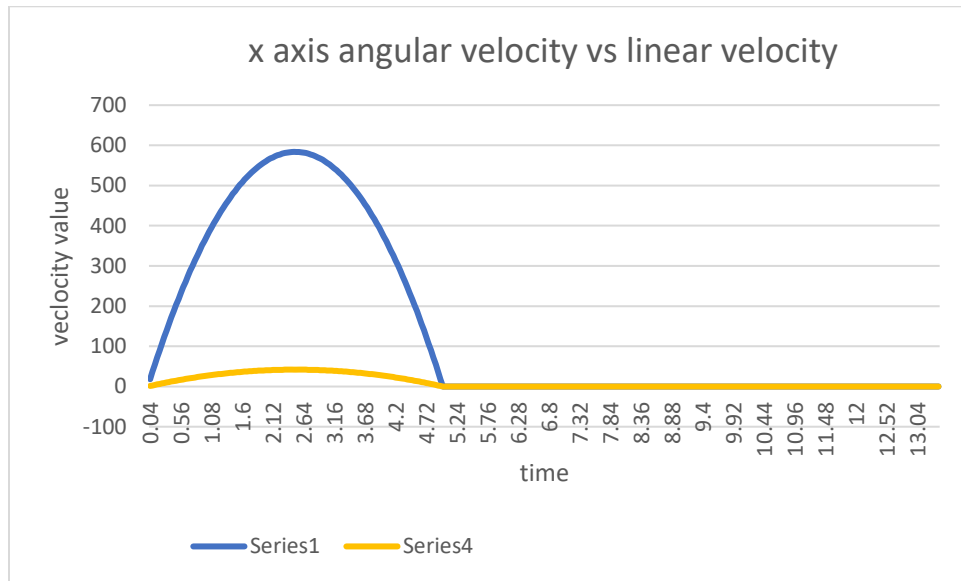


Figure 5 x axis Linear velocity vs angular velocity graph



CONCLUSION

The idea of creating the 3D printer was a challenge and the project involved problem-solving, planning, experimentation, and frustration. The original goal was to build a simple 3D printer with infinite travel in the y-axis, inspired by the Reality CR-30 [2]. The design was broken into subassemblies and created in context. By starting with quick sketches they helped get ideas down quickly and saved time throughout the design process. Aluminum extrusion was chosen for its ease of manufacturing and accessibility. While the original plan was to drill and tap the extrusion, 3D-printed joints and standard hardware such as M4 screws and T4 Nut R were chosen, which allowed for minimal machining. Many mounting parts, especially for the stepper motors and bearings, were designed to use the same screw spacing, which reduced the number of custom parts needed which kept the assembly simpler and will result in a simpler manufacturing process.

The motion studies gave a clear look into how the mechanical systems would perform. For both the z-axis and the rack and pinion system, a clear relationship was seen between rotation and movement. This confirmed that the mechanical setup would work as expected. While some components like the rack gear and extruder backplate will need to be precisely machined, most other parts can be 3D printed or made with basic tools, keeping the manufacturing process simple.

There's still room to improve. By mounting the x-axis stepper motor directly onto the extruder added weight and complexity, which hurt the printer's performance and made it harder to maintain. However, the overall design met its main goals. It was kept simple, modular, and easy to build and adjust without needing a full machine shop.

Ultimately, this project wasn't just about creating a 3D printer. It was about working through real design problems, using CAD hands-on, and learning through the process. The design may not have been perfect, but it's a solid starting point for future improvements and further iterations.

REFERENCES

- [1] EDM Department Inc., “Wire EDM Capabilities,” EDM Department, [Online]. Available: <https://www.edmdept.com/manufacturing-services/wire-edm/#:~:text=Wire%20EDM%20Capabilities,array%20of%20industries%20and%20application> [Accessed: Apr. 9, 2025].
- [2] Creality, “CR-30 3D Printer,” Creality Official Store, [Online]. Available: <https://store.creality.com/ca/products/cr-30-3d-printer> [Accessed: Apr. 9, 2025].
- [3] GrabCAD, “Stepper Motor 42mm,” GrabCAD, [Online]. Available: <https://grabcad.com/library/stepper-motor-42mm-2> [Accessed: Apr. 9, 2025].
- [4] PCBoard.ca, “T-Slot Nut 30T-M5,” PCBoard.ca, [Online]. Available: <https://www.pcboard.ca/t-slot-nut-30t-m5> [Accessed: Apr. 9, 2025].
- [5] GrabCAD, “M4 T-Slot Nut 2020,” GrabCAD, [Online]. Available: <https://grabcad.com/library/m4-t-slot-nut-2020-1> [Accessed: Apr. 9, 2025].
- [6] McMaster-Carr, “Metric 18-8 Stainless Steel Button Head Hex Drive Screws, M4,” McMaster-Carr, [Online]. Available: <https://www.mcmaster.com/products/screws/thread-size~m4/rounded-head-screws~metric-18-8-stainless-steel-button-head-hex-drive-screws/> [Accessed: Apr. 9, 2025].
- [7] McMaster-Carr, “M4 Washers,” McMaster-Carr, [Online]. Available: <https://www.mcmaster.com/products/washers/washers-2~/?s=m4+washers> [Accessed: Apr. 9, 2025].
- [8] 3Duino, “T8 Lead Screw + H Nut Flange Brass Nut (Pitch 2mm),” 3Duino, [Online]. Available: <https://www.3duino.com/product/t8-lead-screw-h-nut-flange-brass-nut-pitch-2mm/> [Accessed: Apr. 9, 2025].
- [9] GrabCAD, “Plastic Pulley Wheels,” GrabCAD, [Online]. Available: <https://grabcad.com/library/plastic-pulley-wheels-1> [Accessed: Apr. 9, 2025].
- [10] GrabCAD, “Bondtech Motor Gear for BMG SingleDirect and DualDirect Extruders,” GrabCAD, [Online]. Available: <https://grabcad.com/library/bondtech-motor-gear-for-bmg-singledirect-and-dualdirect-extruders-1> [Accessed: Apr. 9, 2025].

- [11] GrabCAD, "NEMA 17 25/26mm Stepper Motor," GrabCAD, [Online]. Available: https://grabcad.com/library/nema-17-25-26mm-stepper-motor-1/details?folder_id=2746995 [Accessed: Apr. 9, 2025].
- [12] GrabCAD, "Linear Rail and Block LML9B," GrabCAD, [Online]. Available: https://grabcad.com/library/linear-rail-and-block-lml9b-1/details?folder_id=7175865 [Accessed: Apr. 9, 2025].
- [13] Creativity 3D Printer, "V6 PT100 Heater Block – Brass Copper Plated," Creativity 3D Printer, [Online]. Available: https://www.creativity3dprinter.com/V6PT100HeaterBlock_BrassCopperPlatedHeatingBlocks_HeatingBlocks [Accessed: Apr. 9, 2025].
- [14] Ooznest, "E3D v6 Hotend Heatsink 1.75 – Drawing," Ooznest, [Online]. Available: <https://ooznest.co.uk/wp-content/uploads/2018/06/E3D-v6-Hotend-Heatsink-175-Drawing.jpg> [Accessed: Apr. 9, 2025].
- [15] McMaster-Carr, "Ball Bearings – Shaft Diameter 4mm / 1/8in," McMaster-Carr, [Online]. Available: <https://www.mcmaster.com/products/rotary-bearings/ball-bearings-1~/ball-bearings-8/shaft-diameter~4-mm/shaft-diameter~1-8/> [Accessed: Apr. 9, 2025].
- [16] 3D Print Creativity Pty Ltd, "Jaw Shaft Coupler 5x8x26mm - Flexible Rigid Coupling," [Online]. Available: <https://www.3dprintcreativity.com.au/products/jaw-shaft-coupler-5x8x26mm-flexible-rigid-coupling>. [Accessed: 10-Apr-2025].

APPENDIX

Figure 6 original drawing for extruder assembly

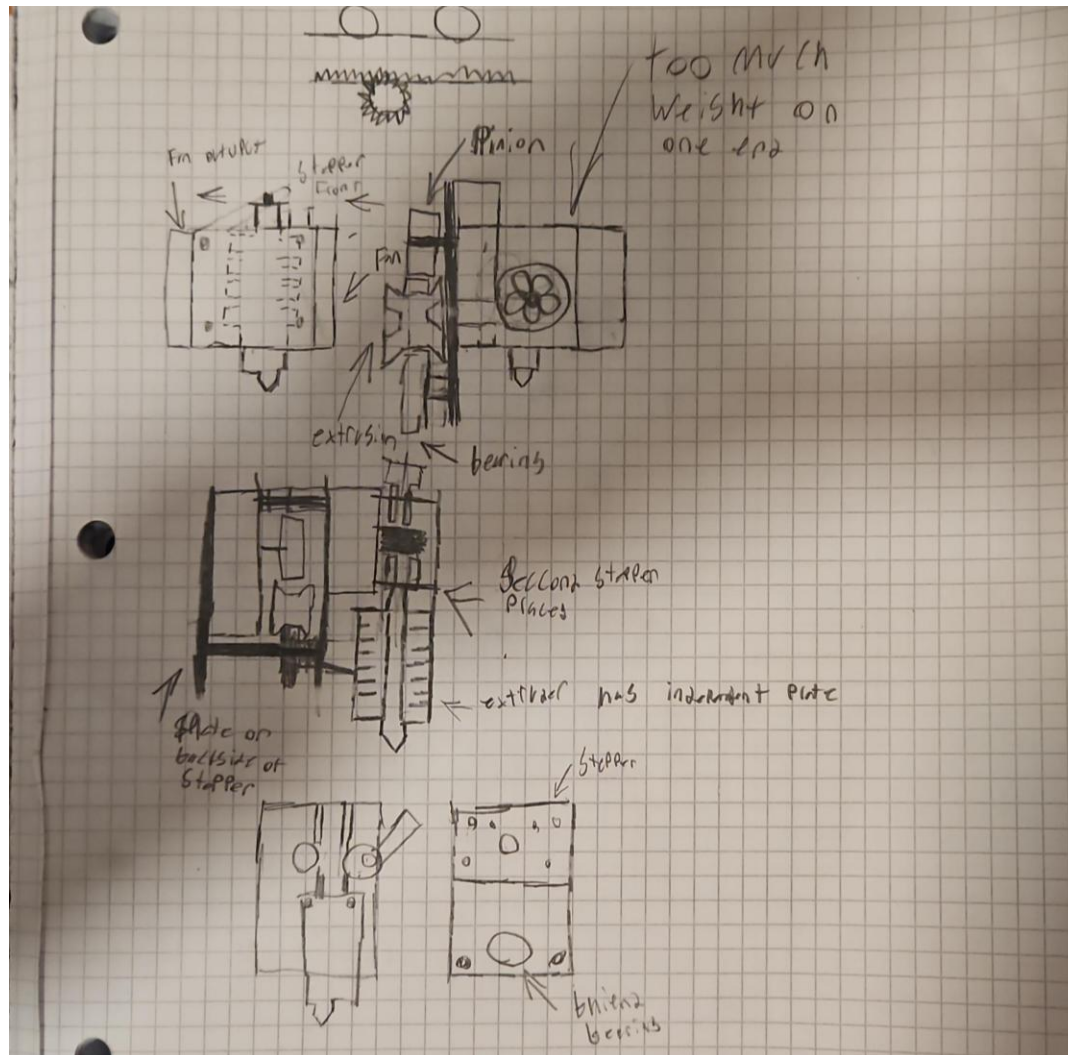
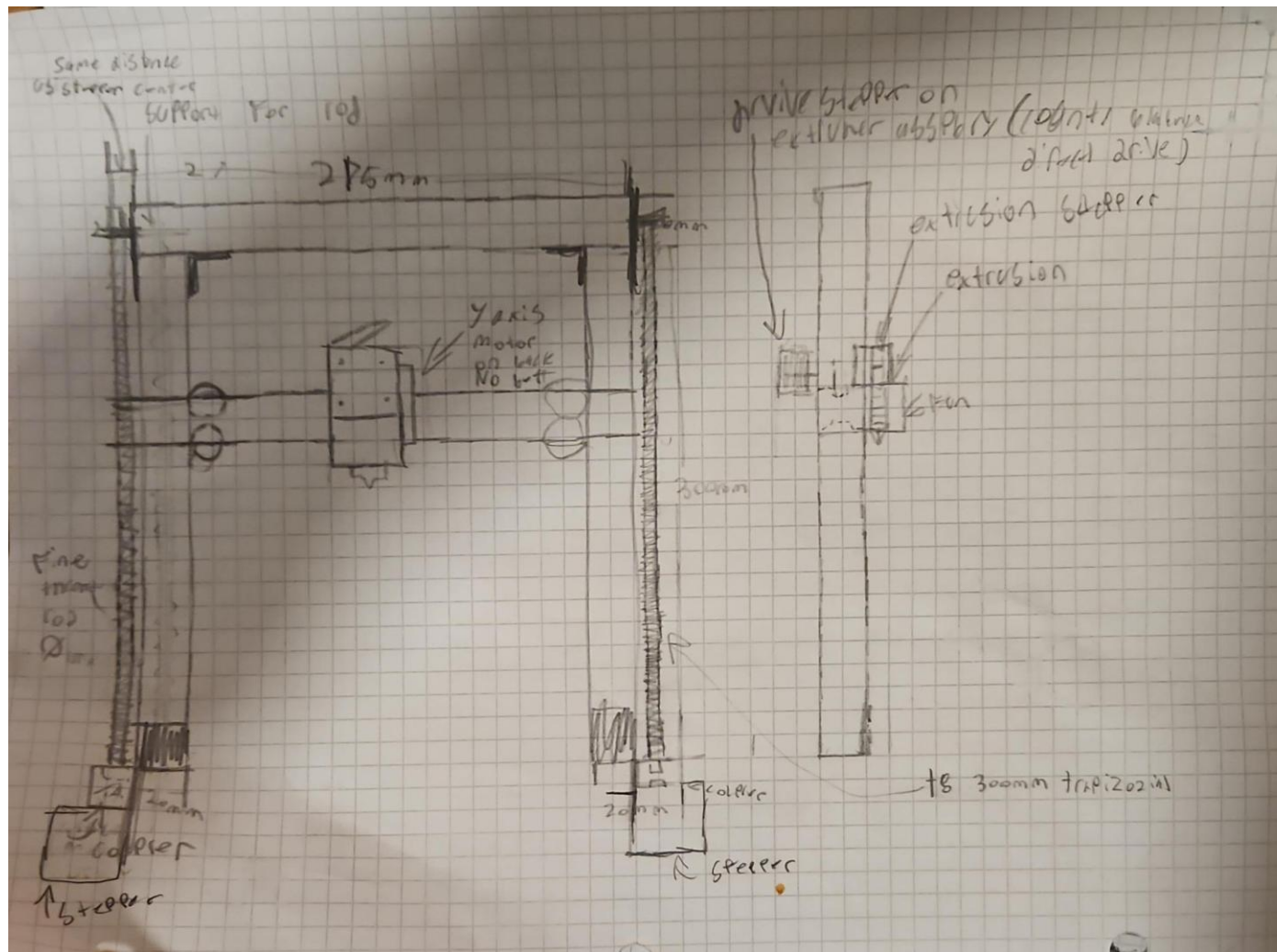


Figure 7 original drawing for upper assembly



[illegible]

- 1 belt / solid Surface
- 2 350mm x 20mm aluminium extension
- 4 215mm x 20mm aluminium extension
- 2 stepper gears 1 size
- 4 x 0.5" stepper roller mounting euros
- 2 roller pins
- 1 carbon 02154 ball race
- 4 balls 25mm dia
- 2 axes for bot
- 2 rollers for belt
- 16 m5 screws

Figure 9 finalized model of base assembly

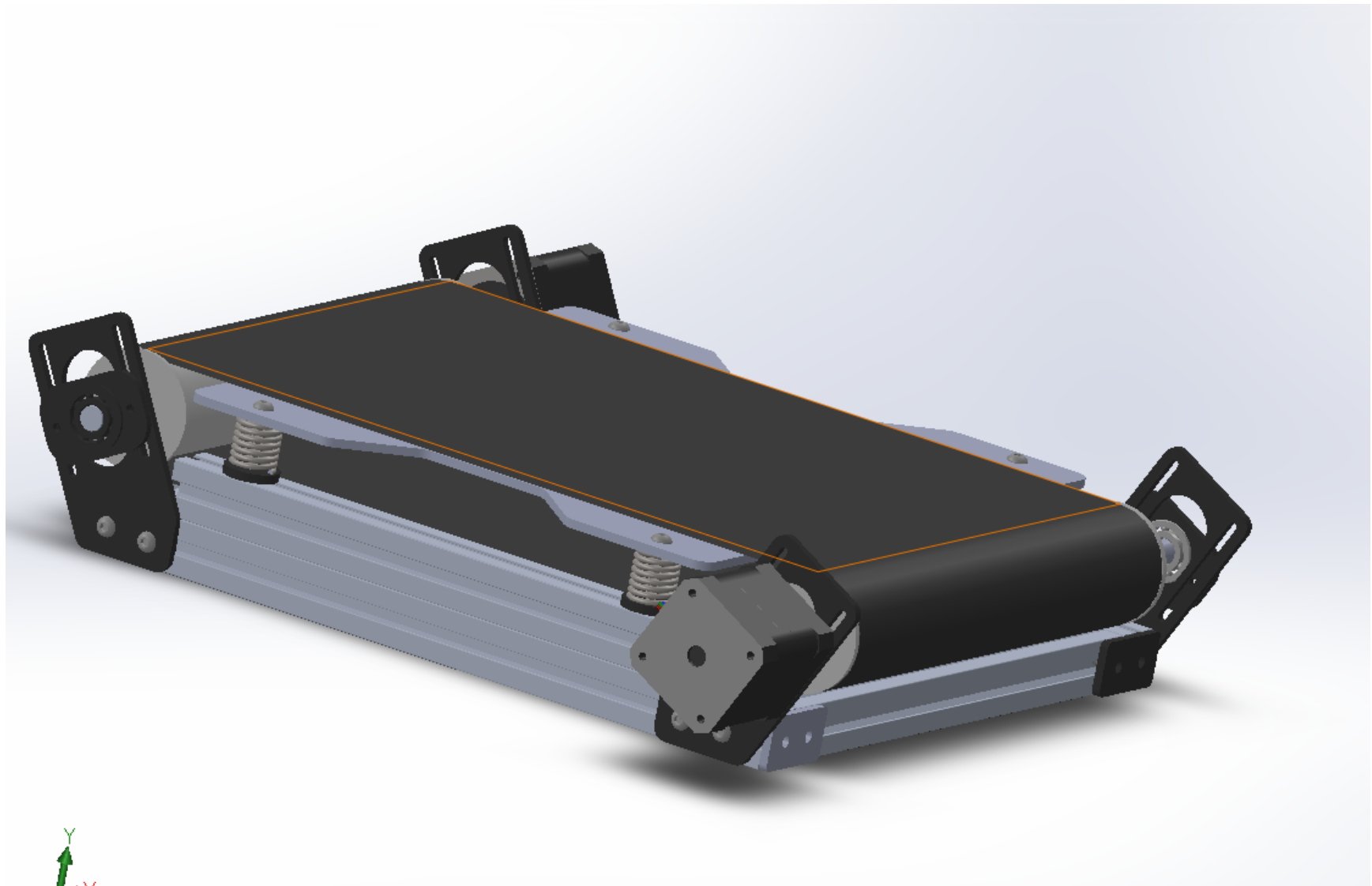


Figure 10 upper frame fully assembled exploded view

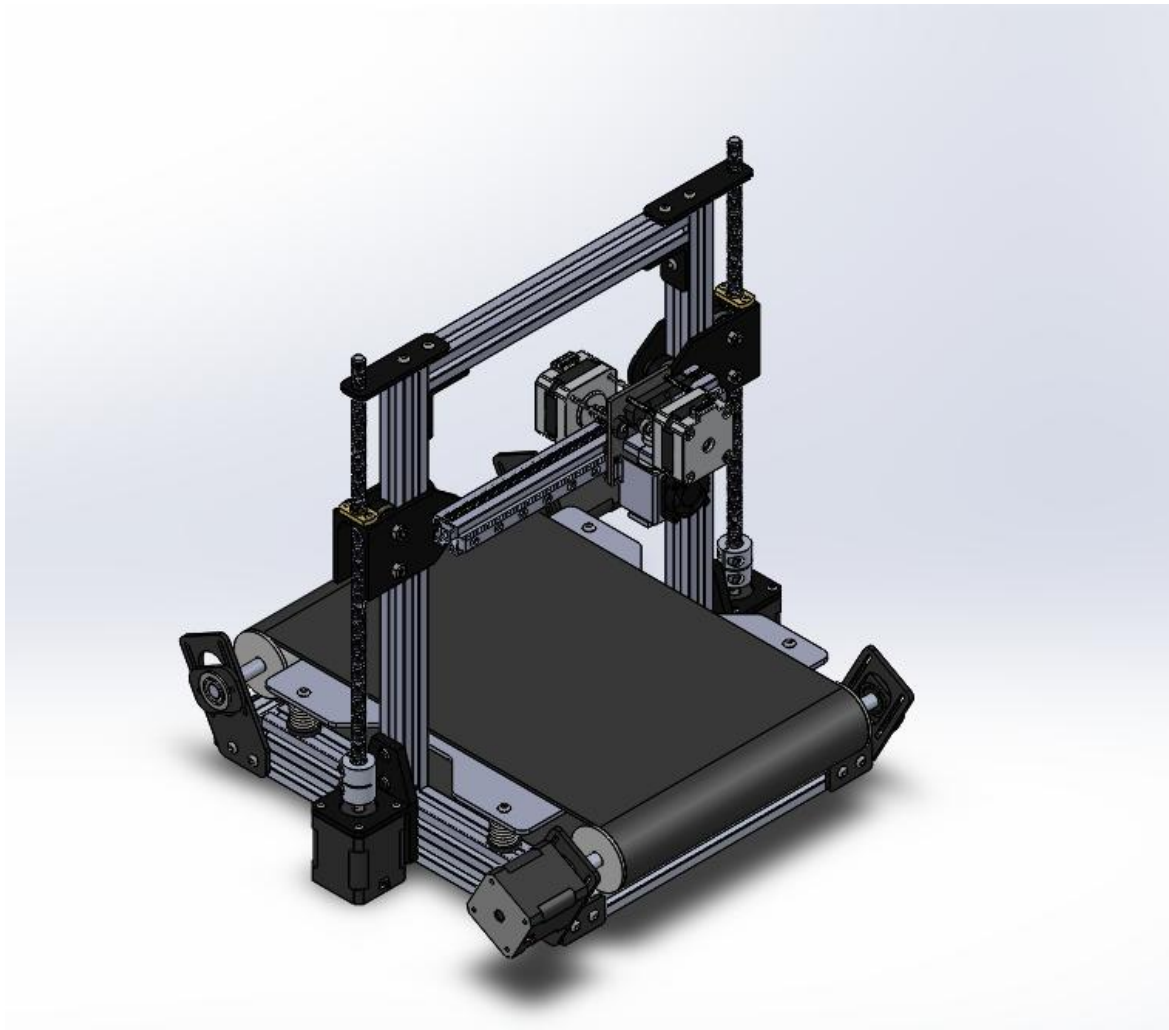


Figure 11 assembly used for motion study

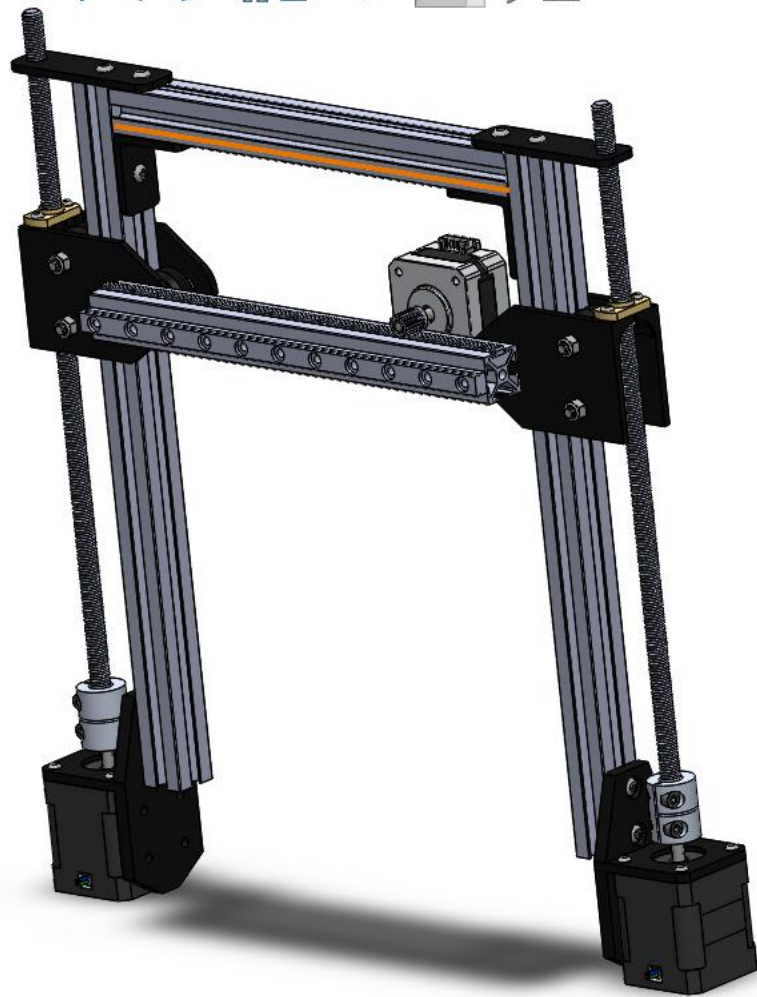


Figure 12 parts deisgned spread out

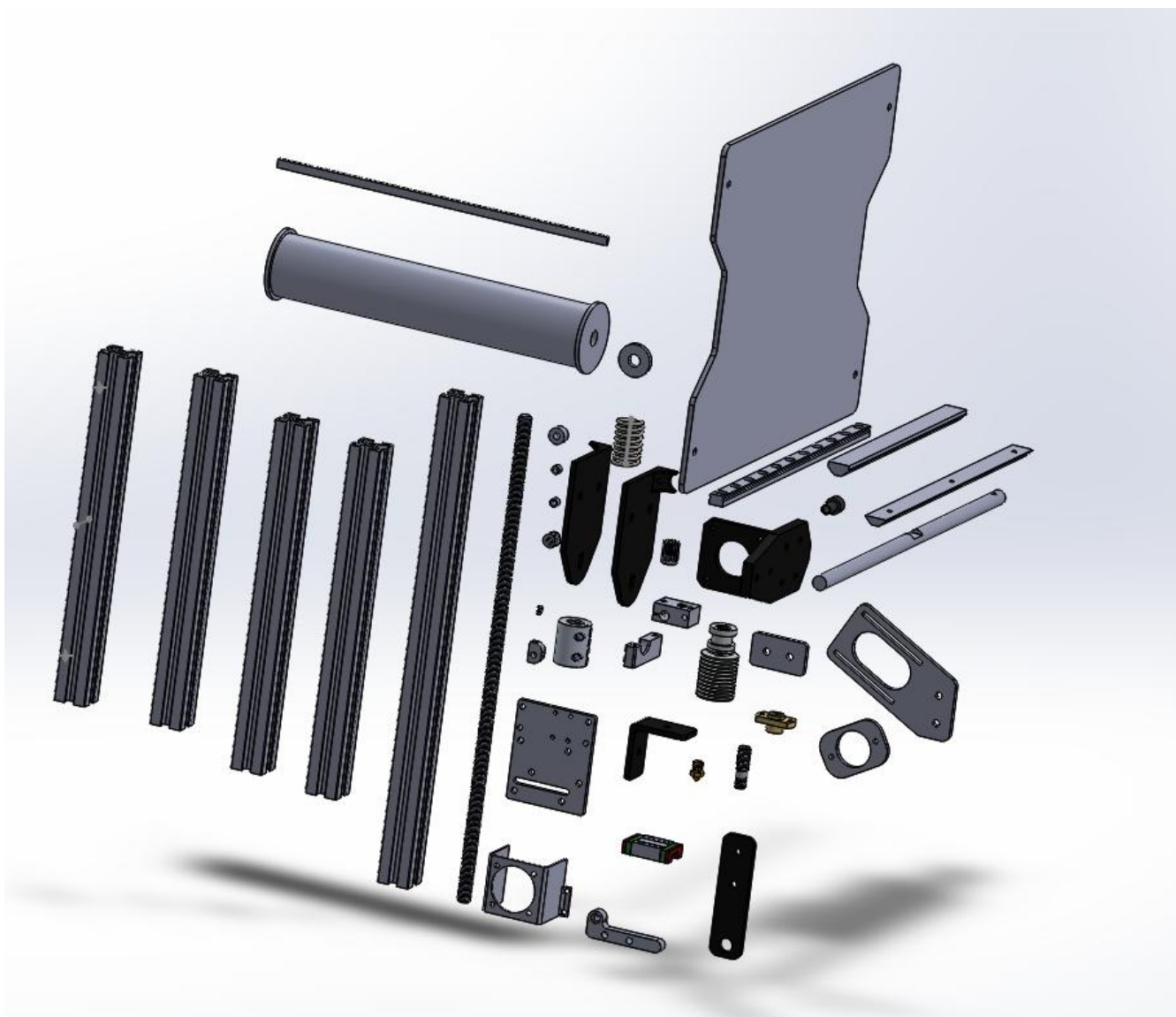


Figure 13 280 by 20 by 20 aluminum extruion drawing

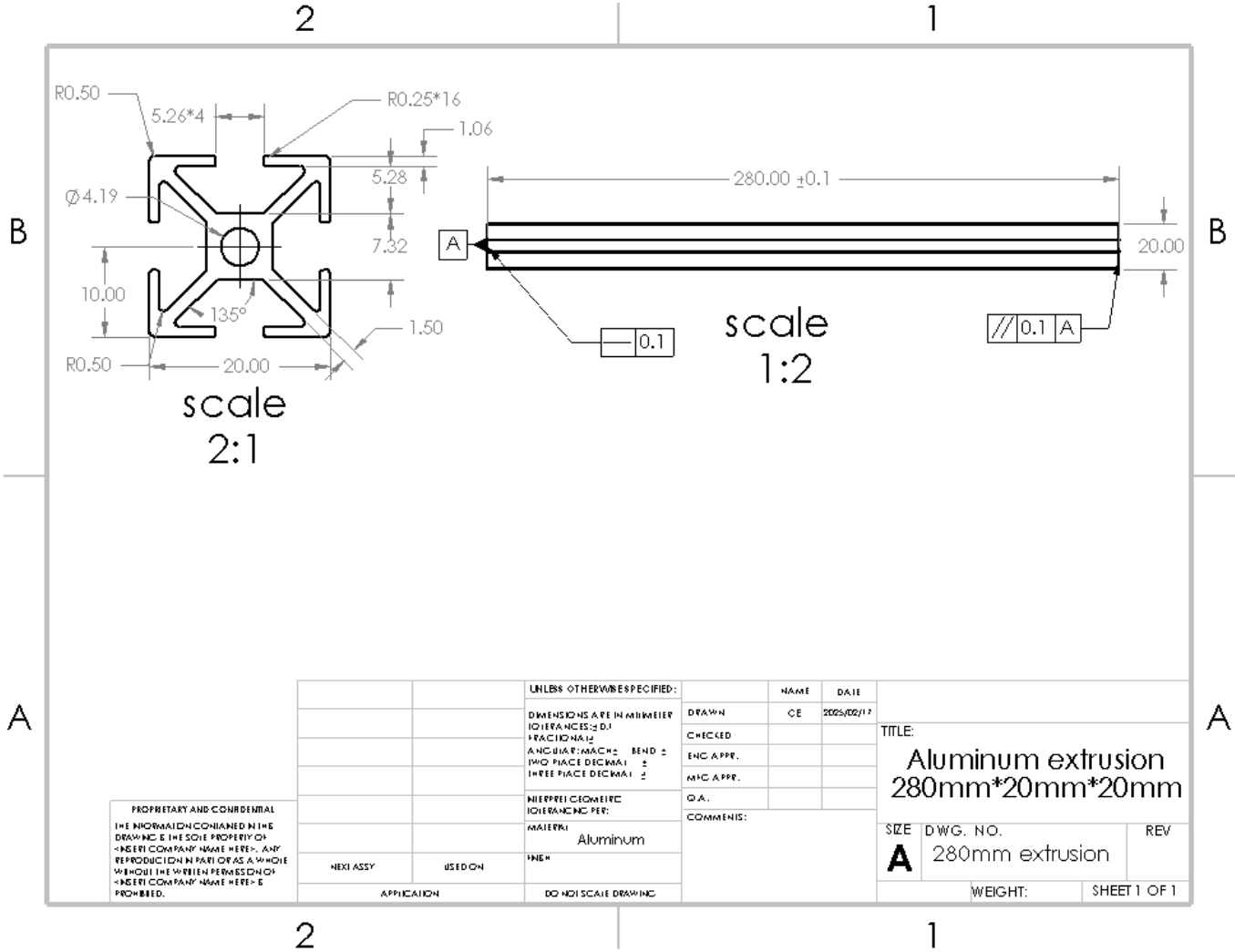


Figure 14 stepper mount axel plate

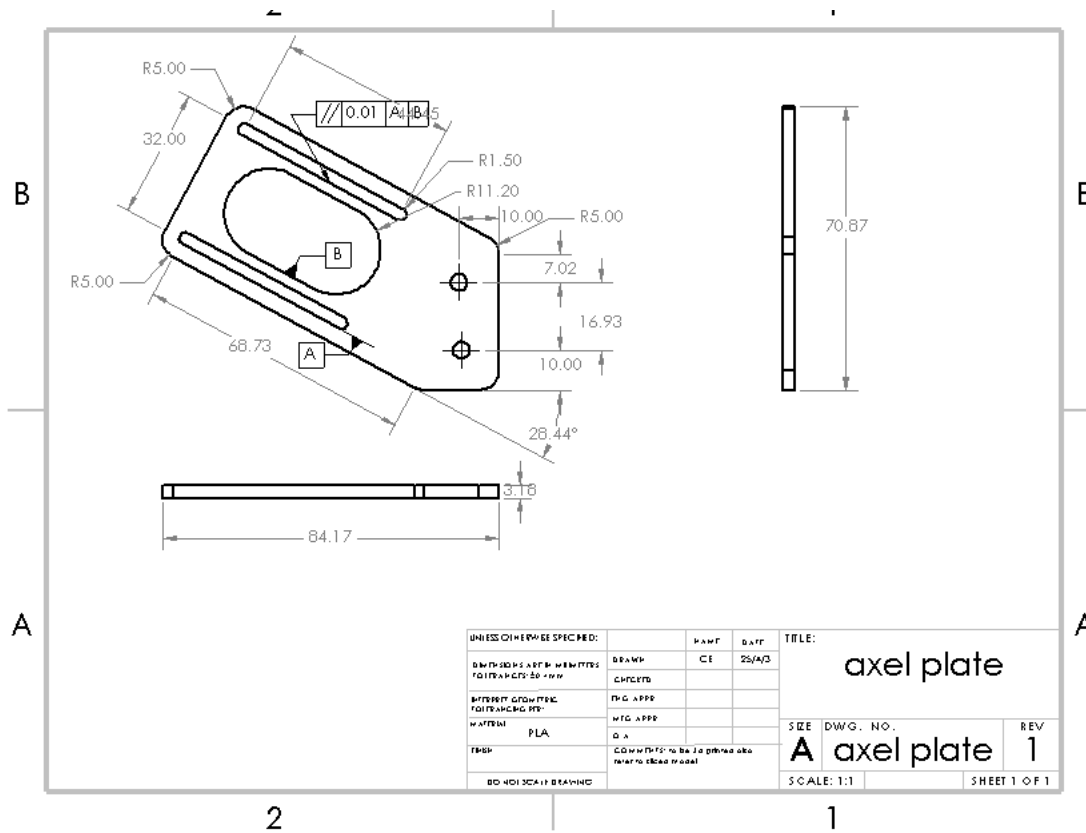


Figure 15 axel for belt roller

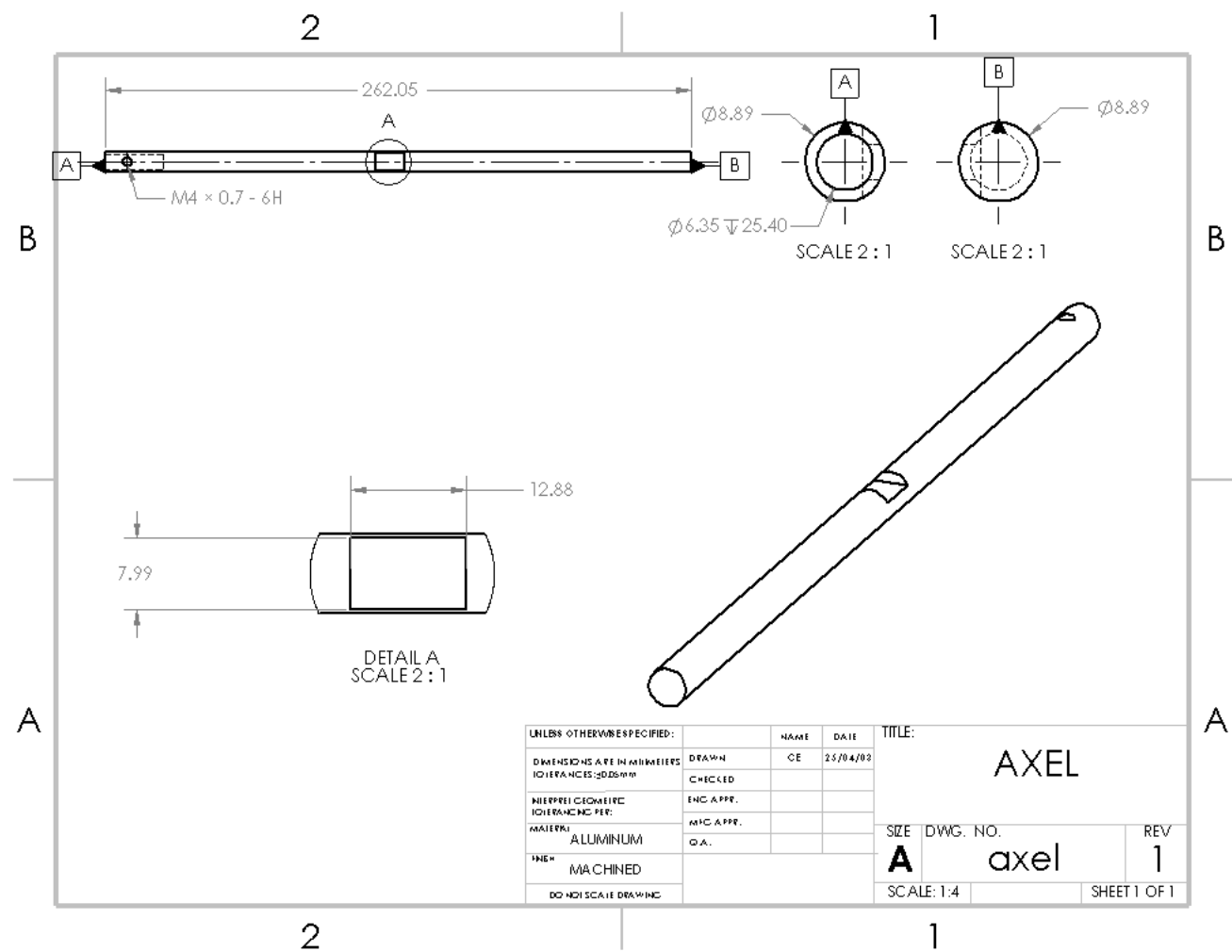


Figure 16 bearing plate

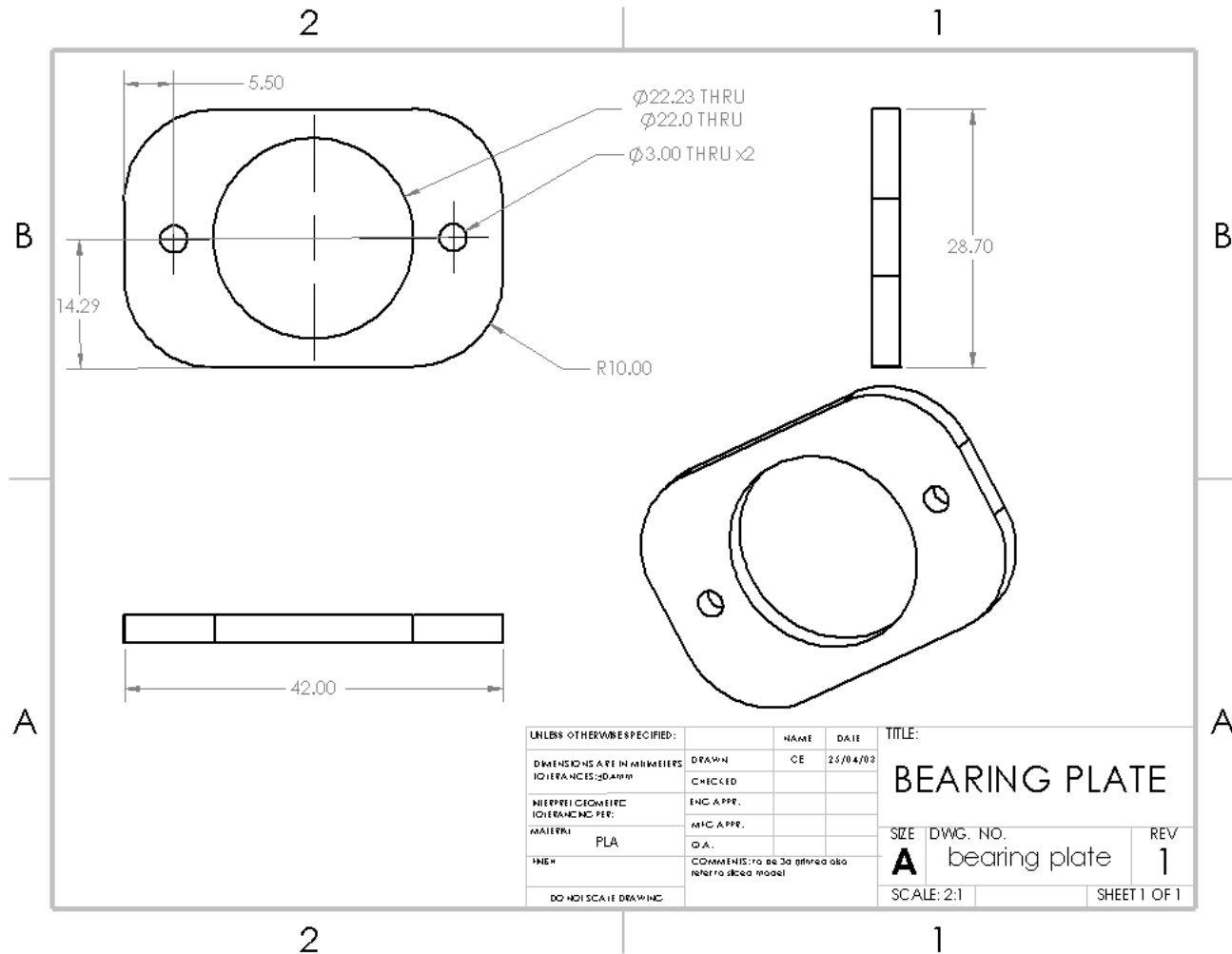


Figure 17 belt roller

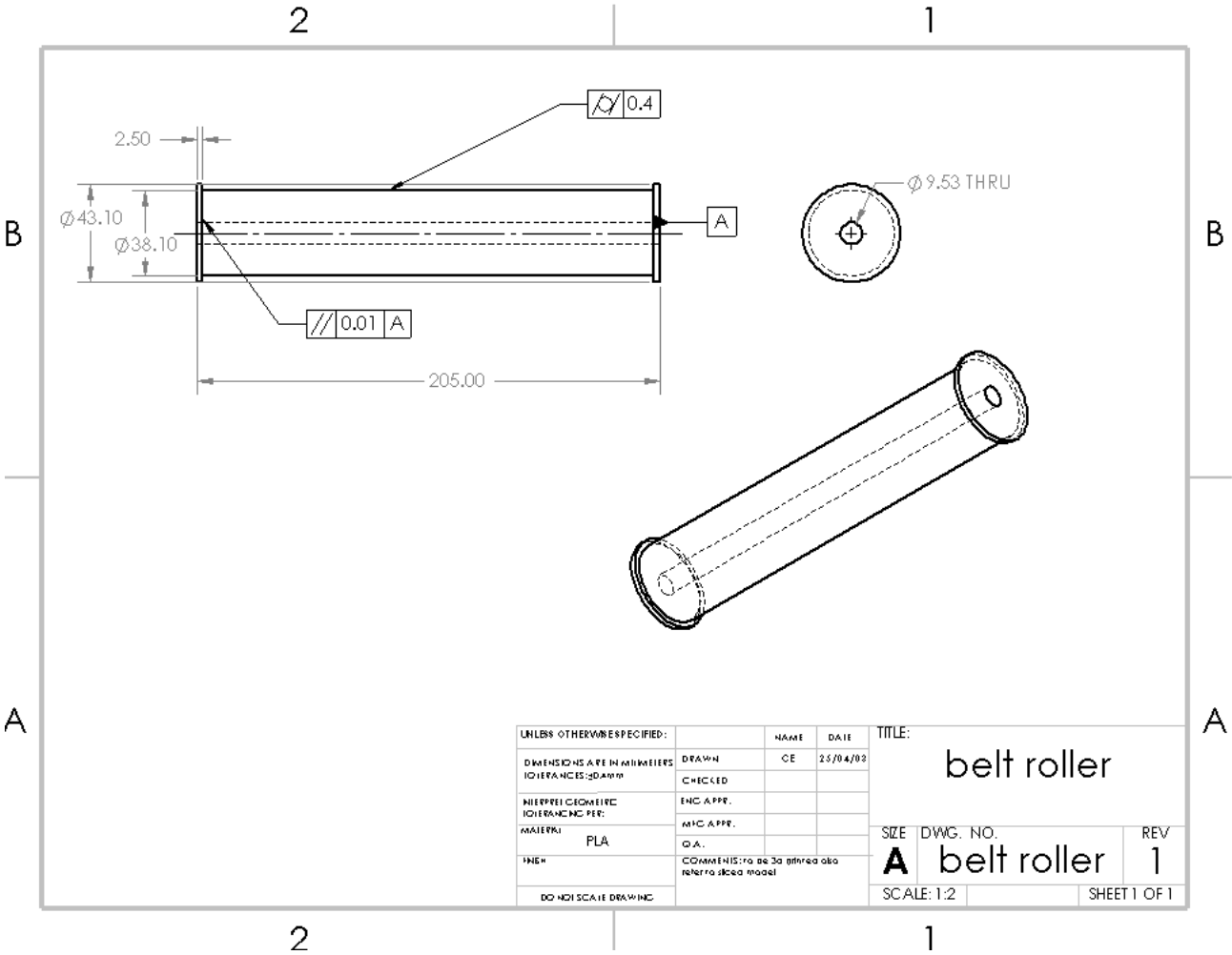


Figure 18 buildplate belt tensioner

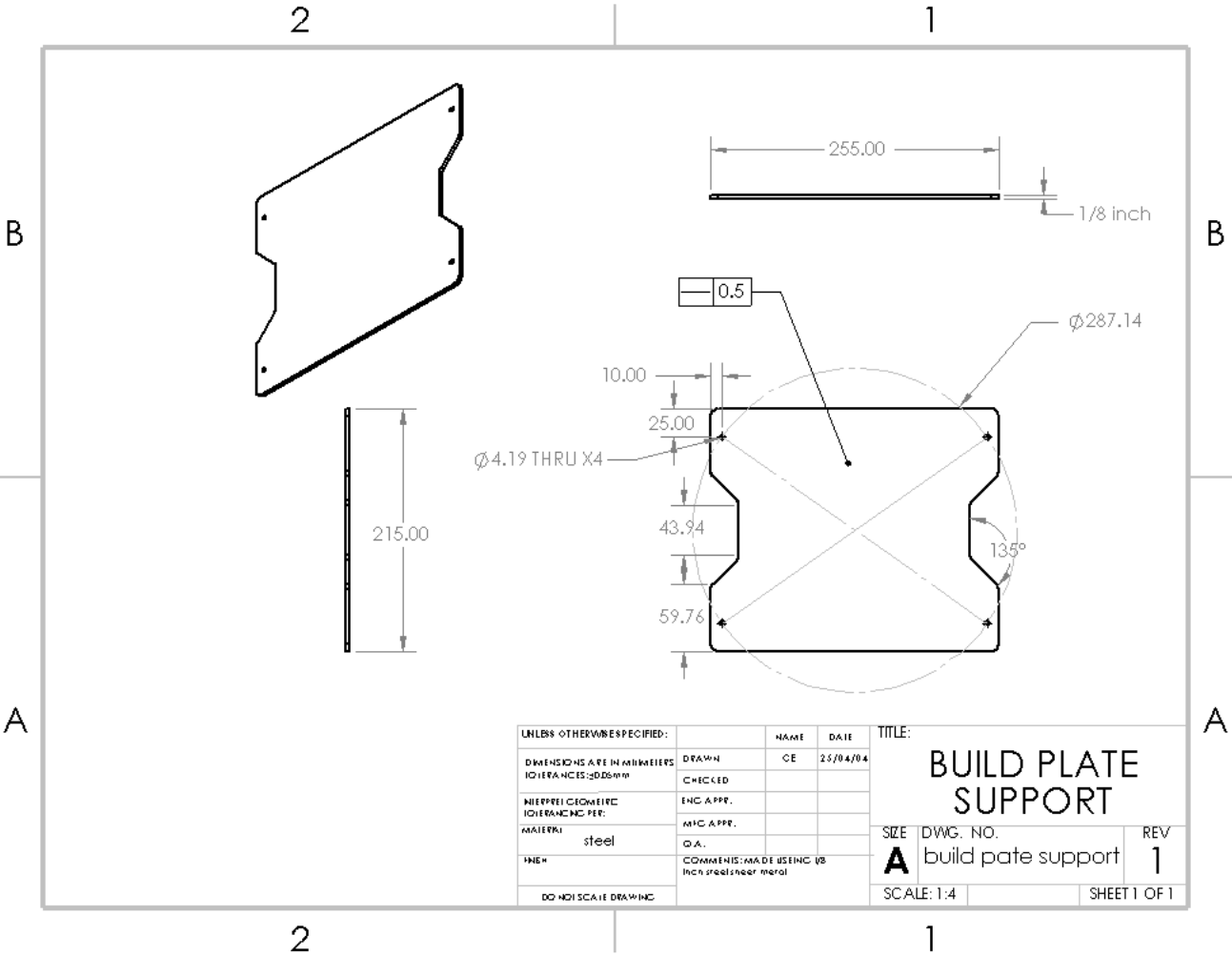


Figure 19 spring washer

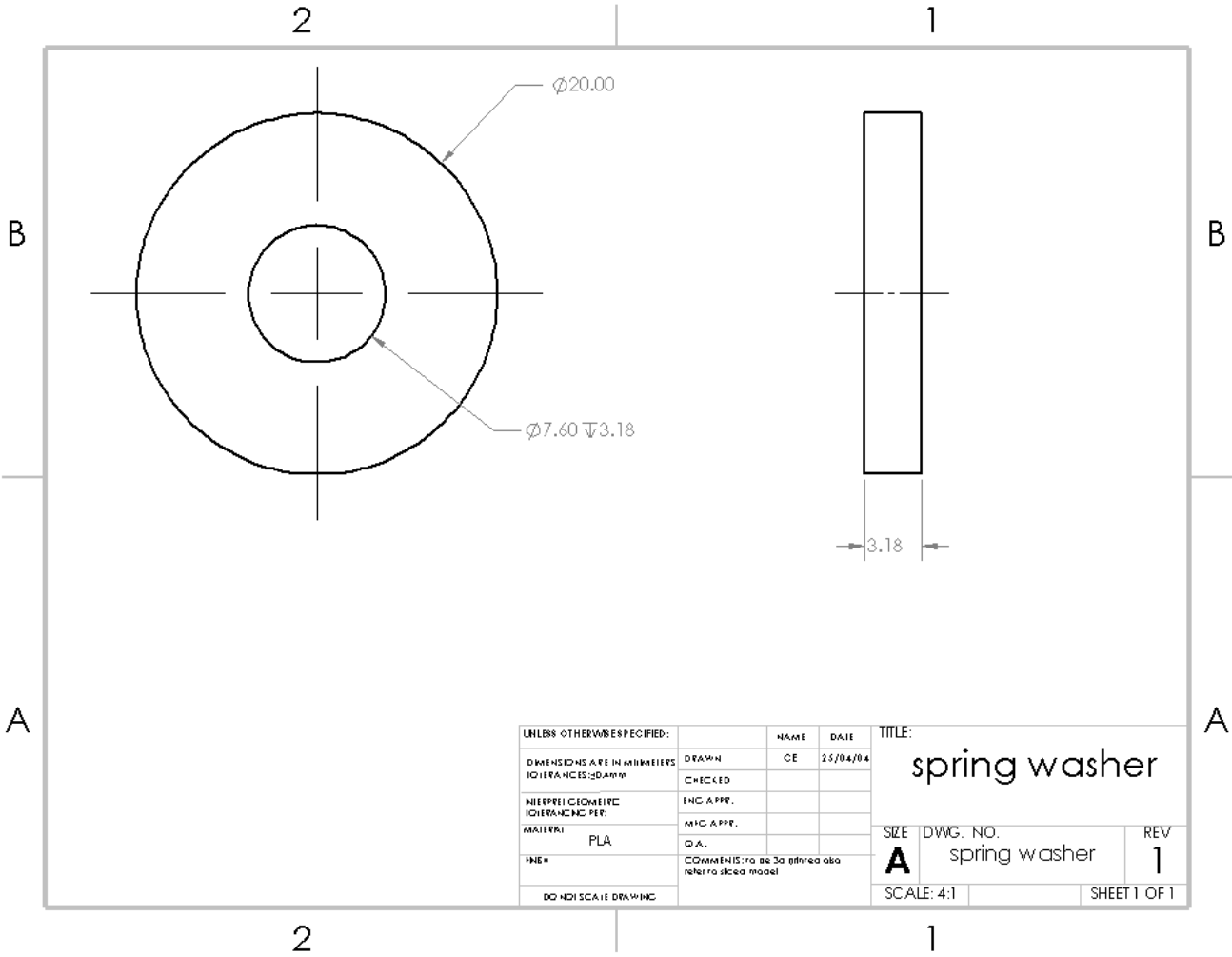


Figure 20 threaded insert

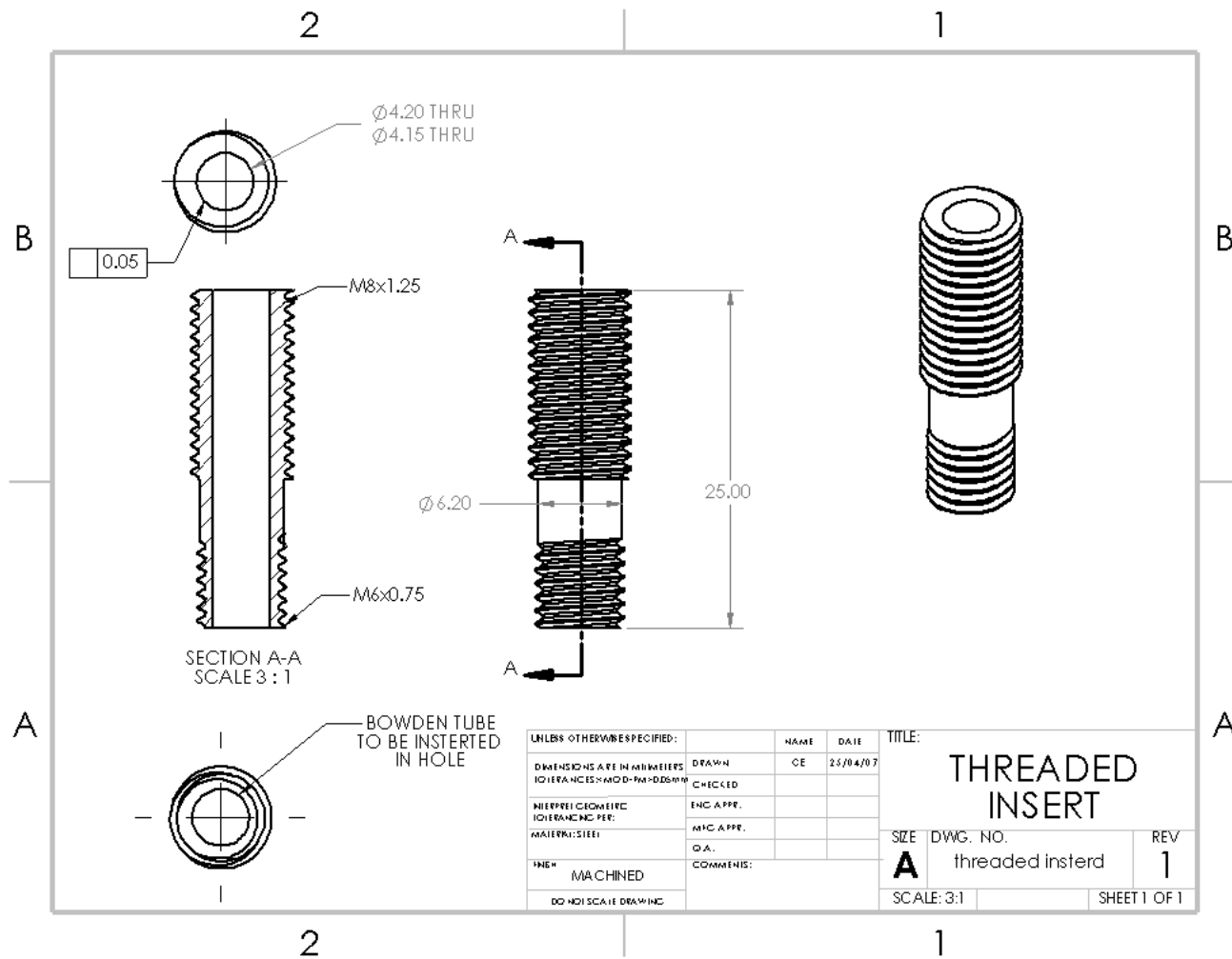


Figure 21 T8 support

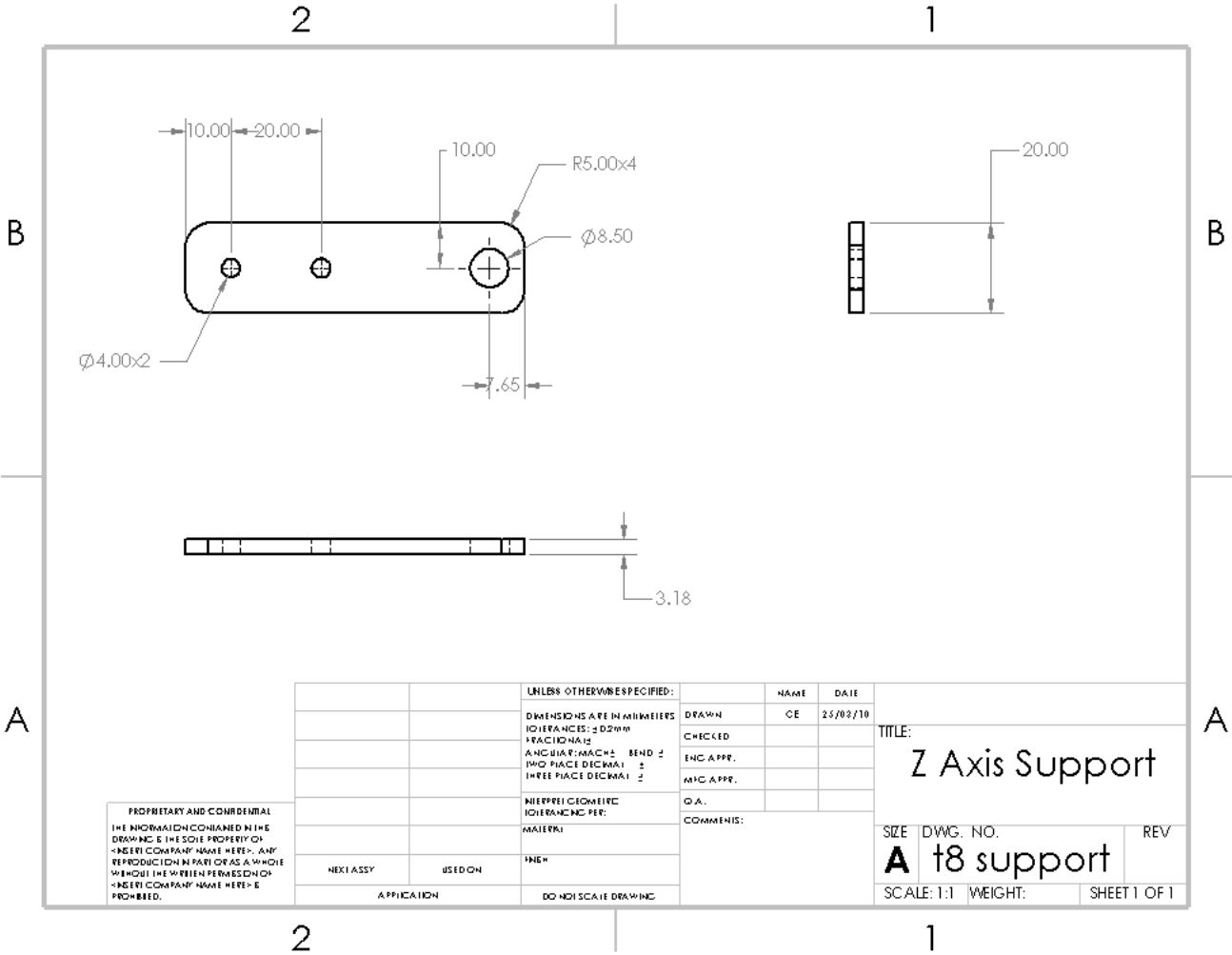


Figure 22 joint and stepper support

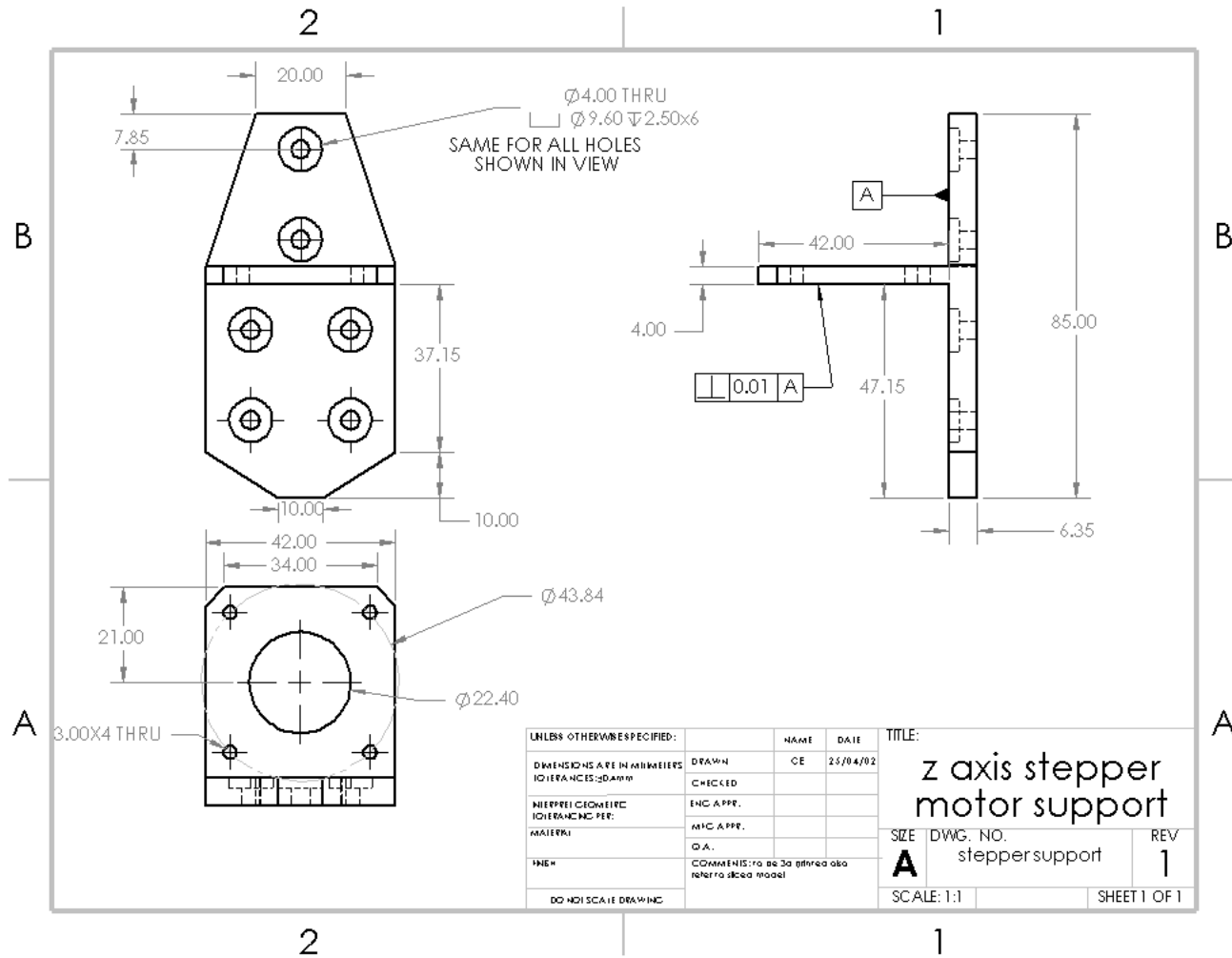


Figure 23spring stopper for extruder

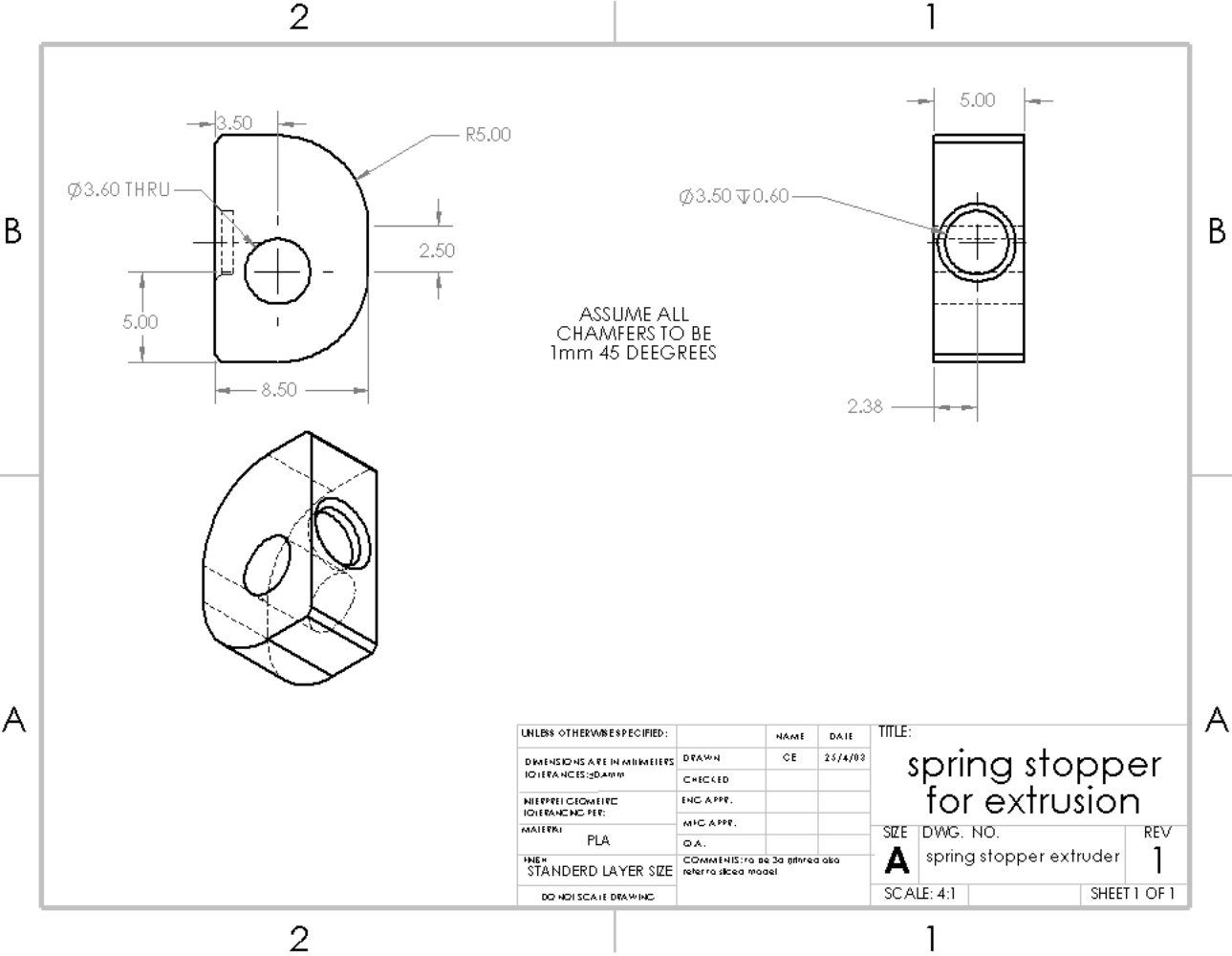


Figure 24 adapter and spacer for roller bearings

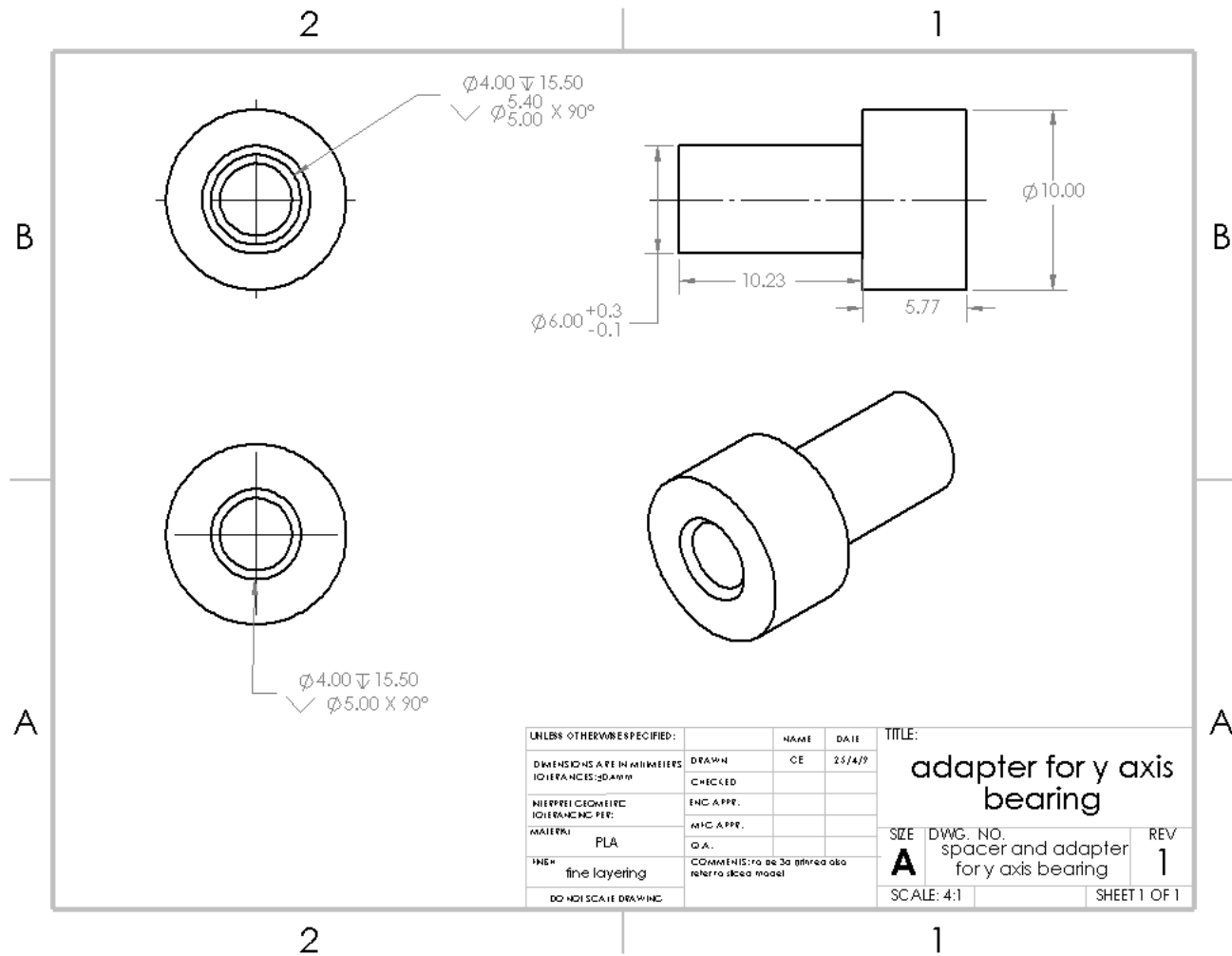


Figure 25 back side x-y axis mount

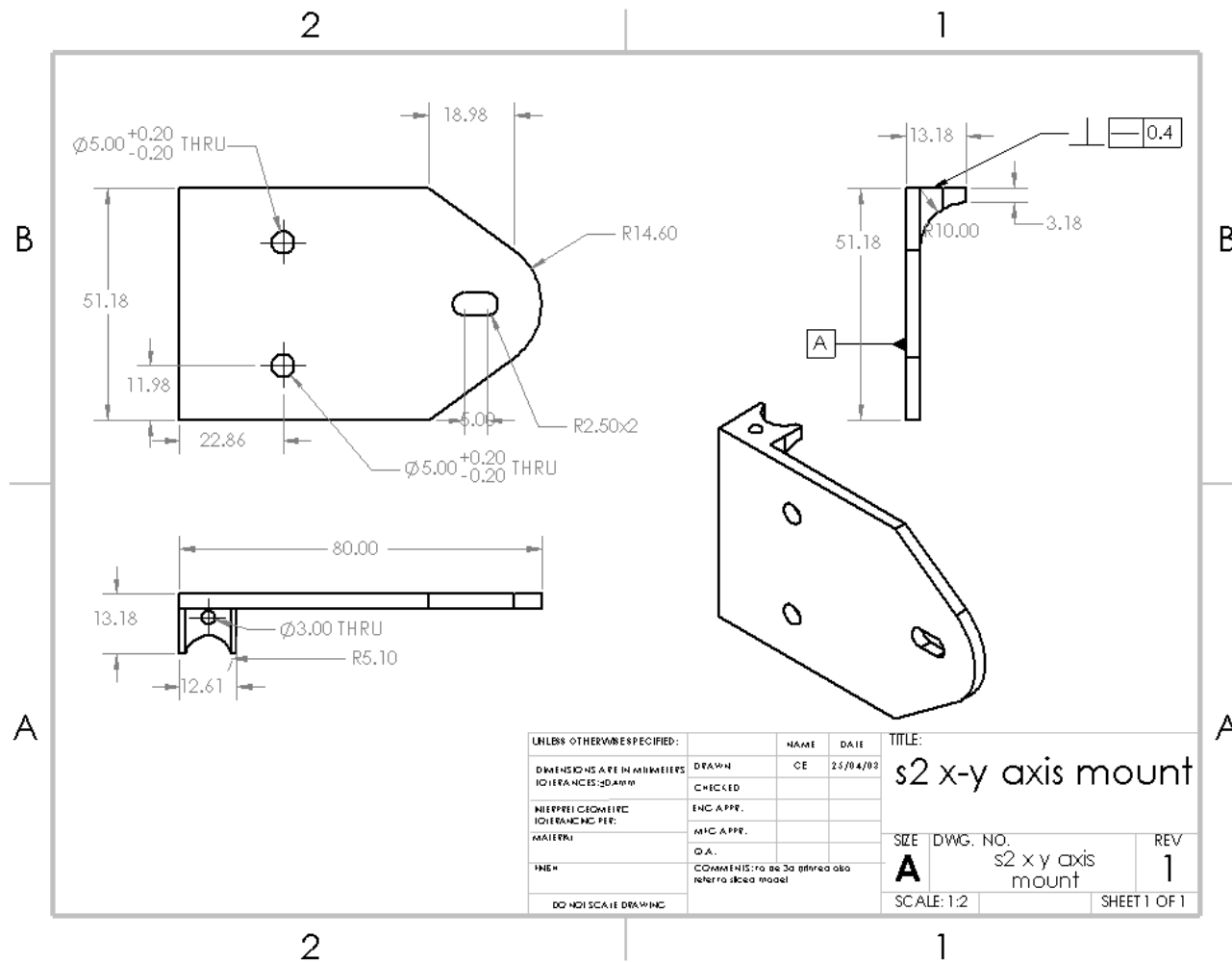


Figure 26 front side x-y mount

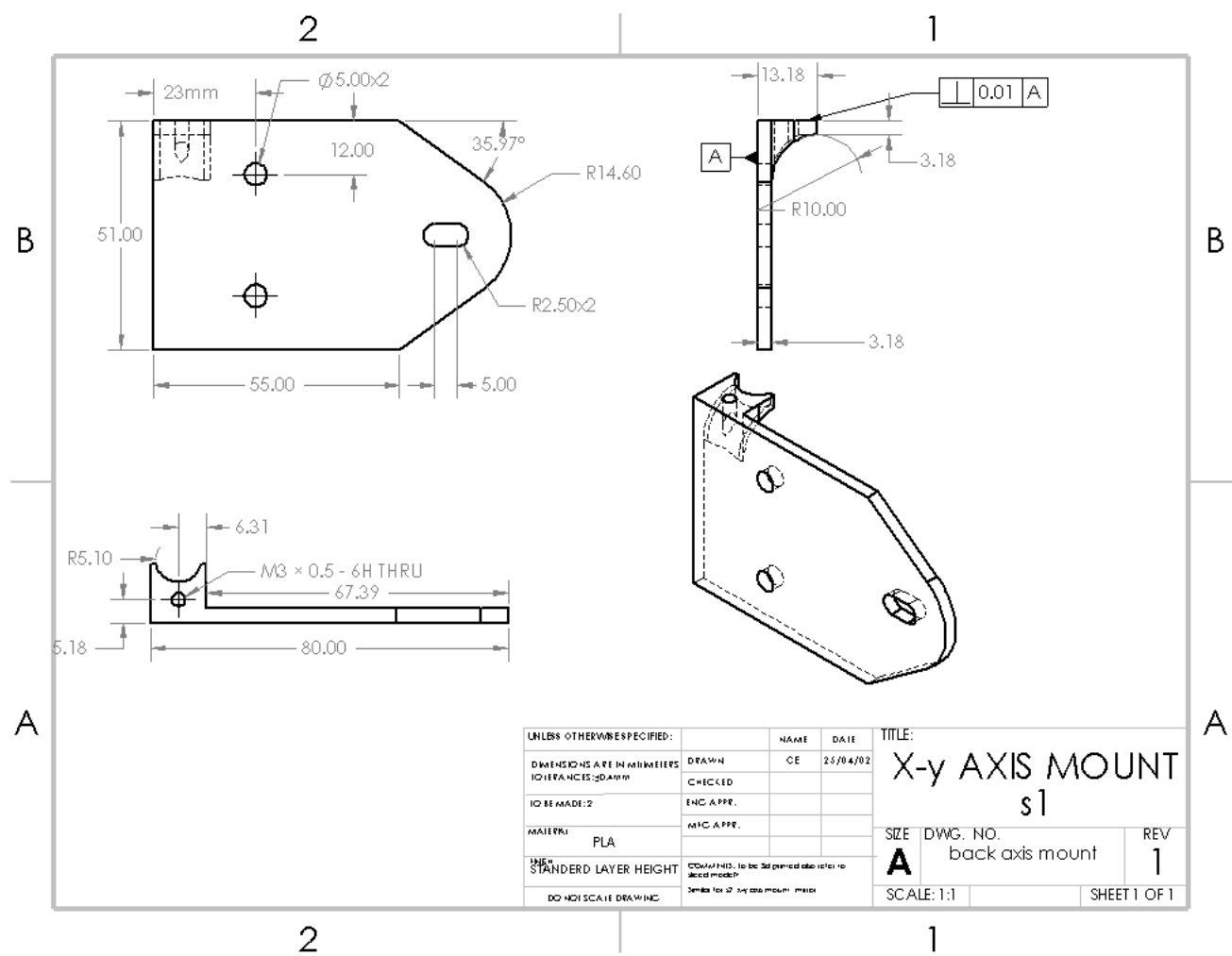


Figure 27 offset heat sink mount

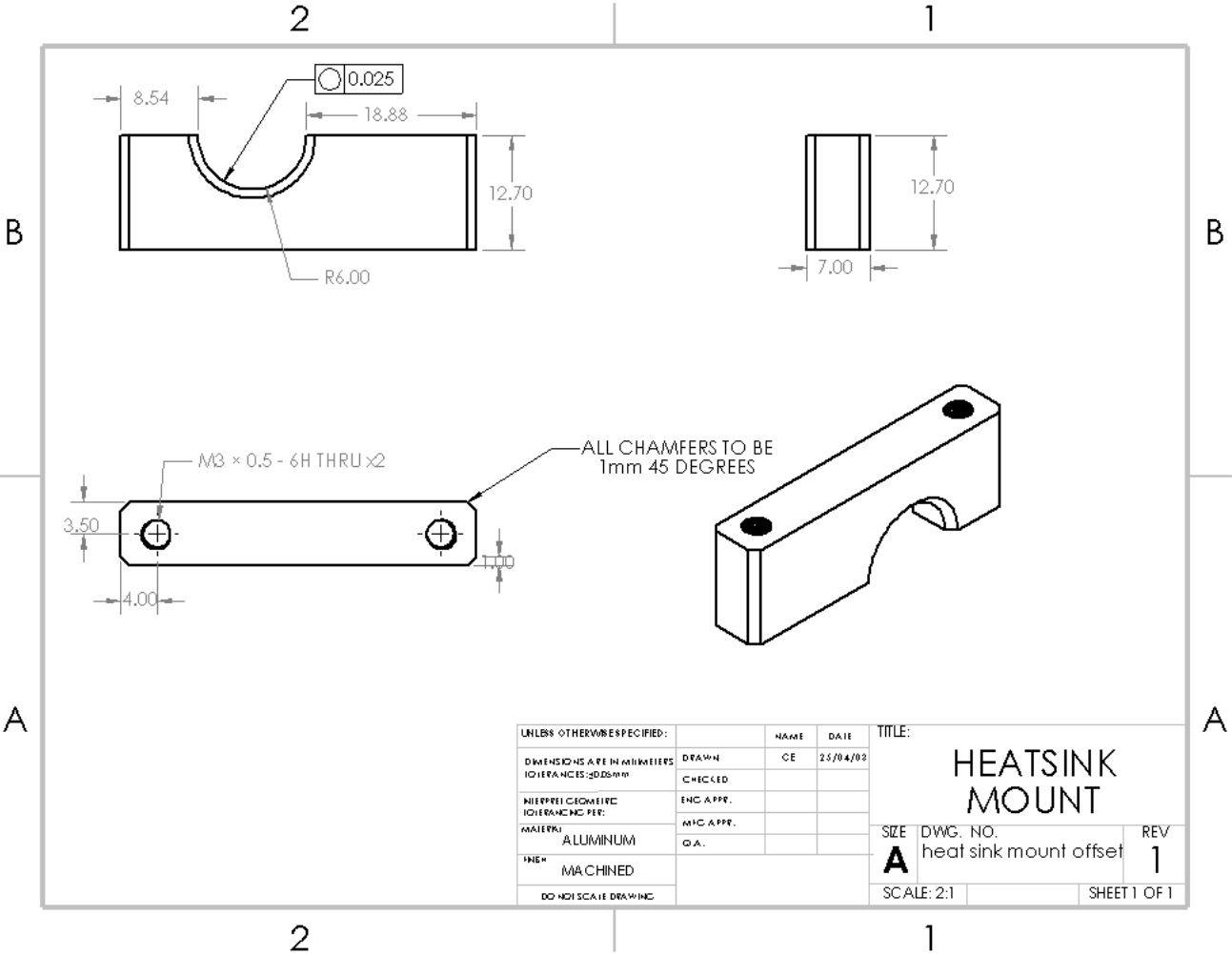


Figure 28 Heat block

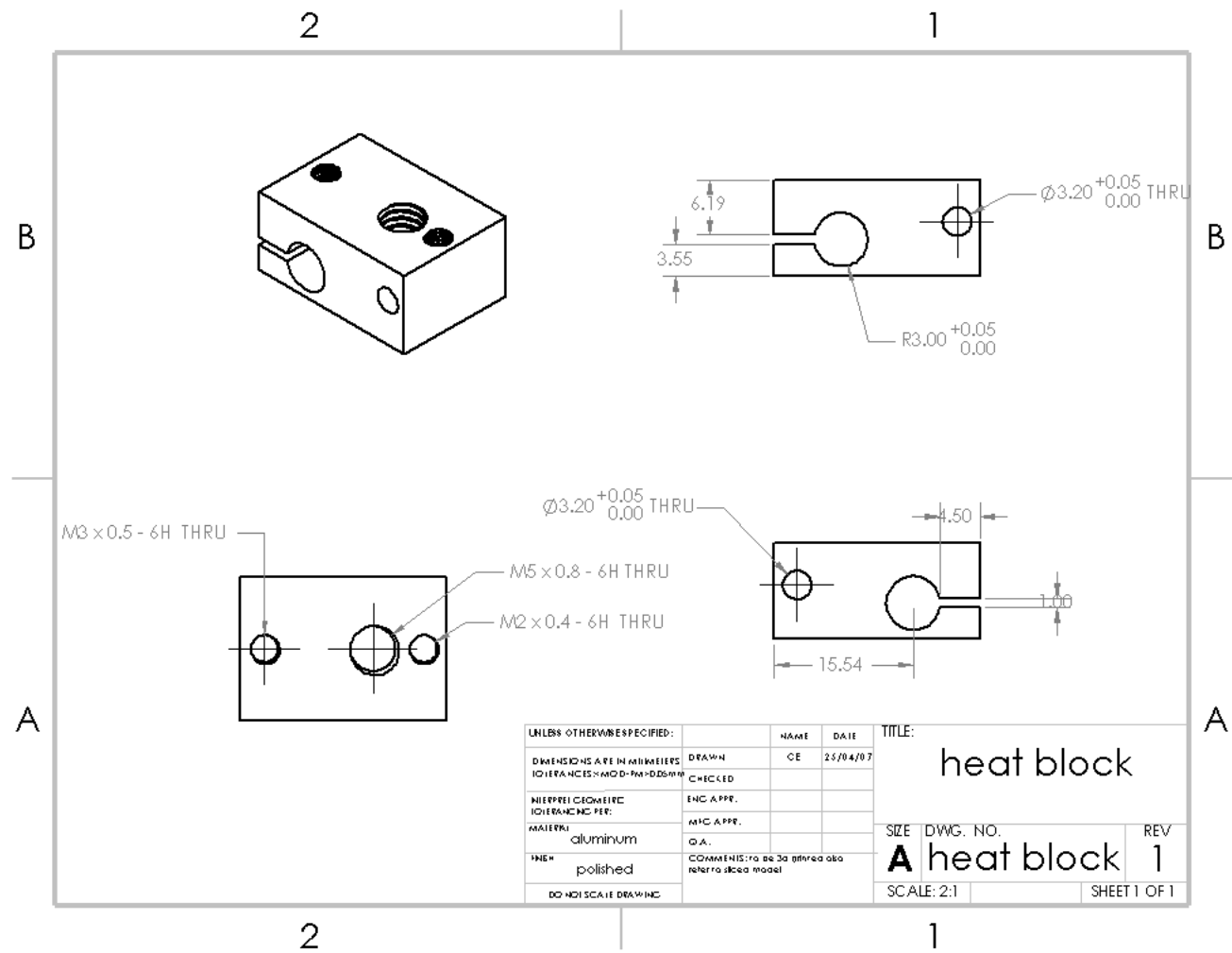


Figure 29 filament tensioner arm

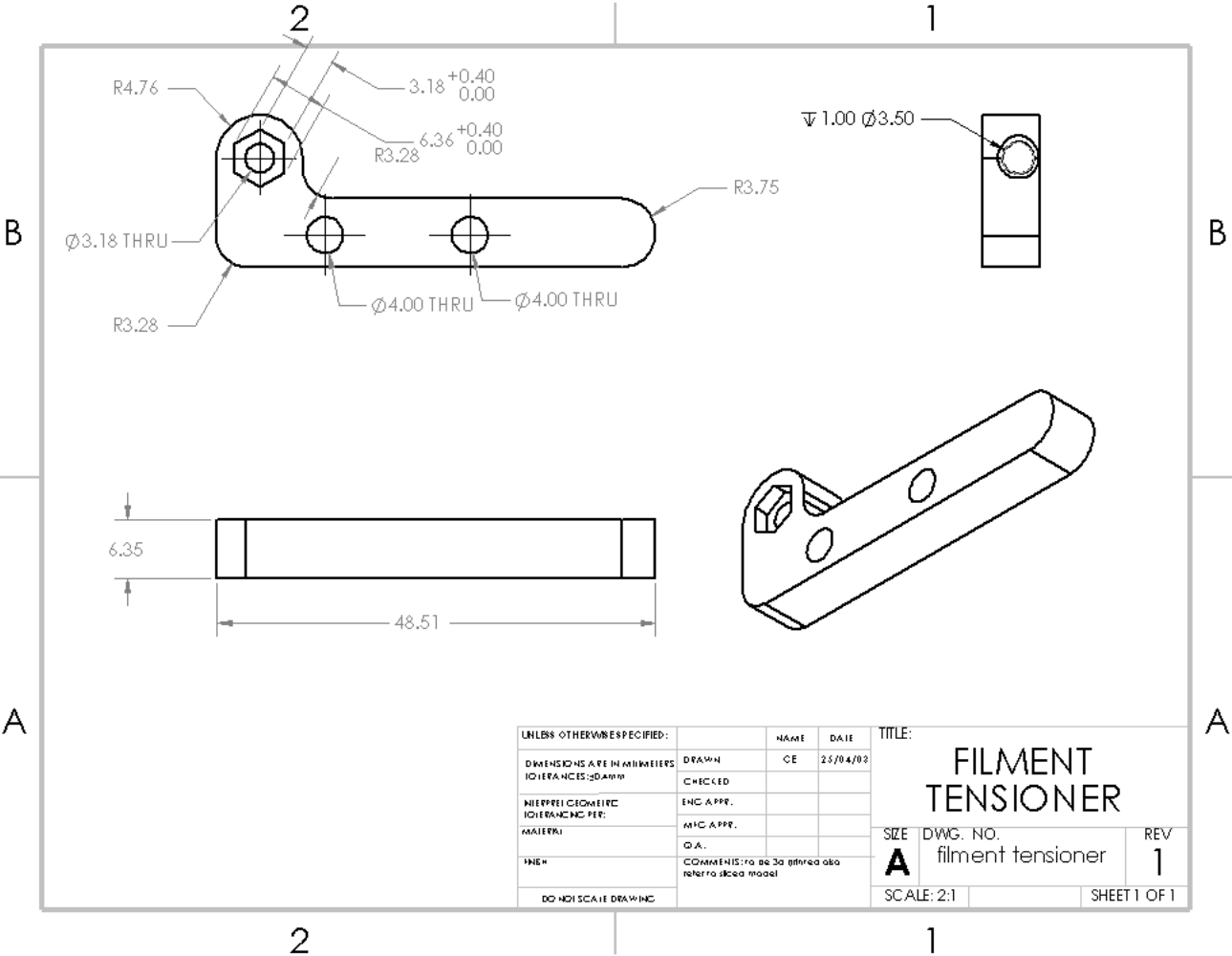


Figure 30 extrusion fill

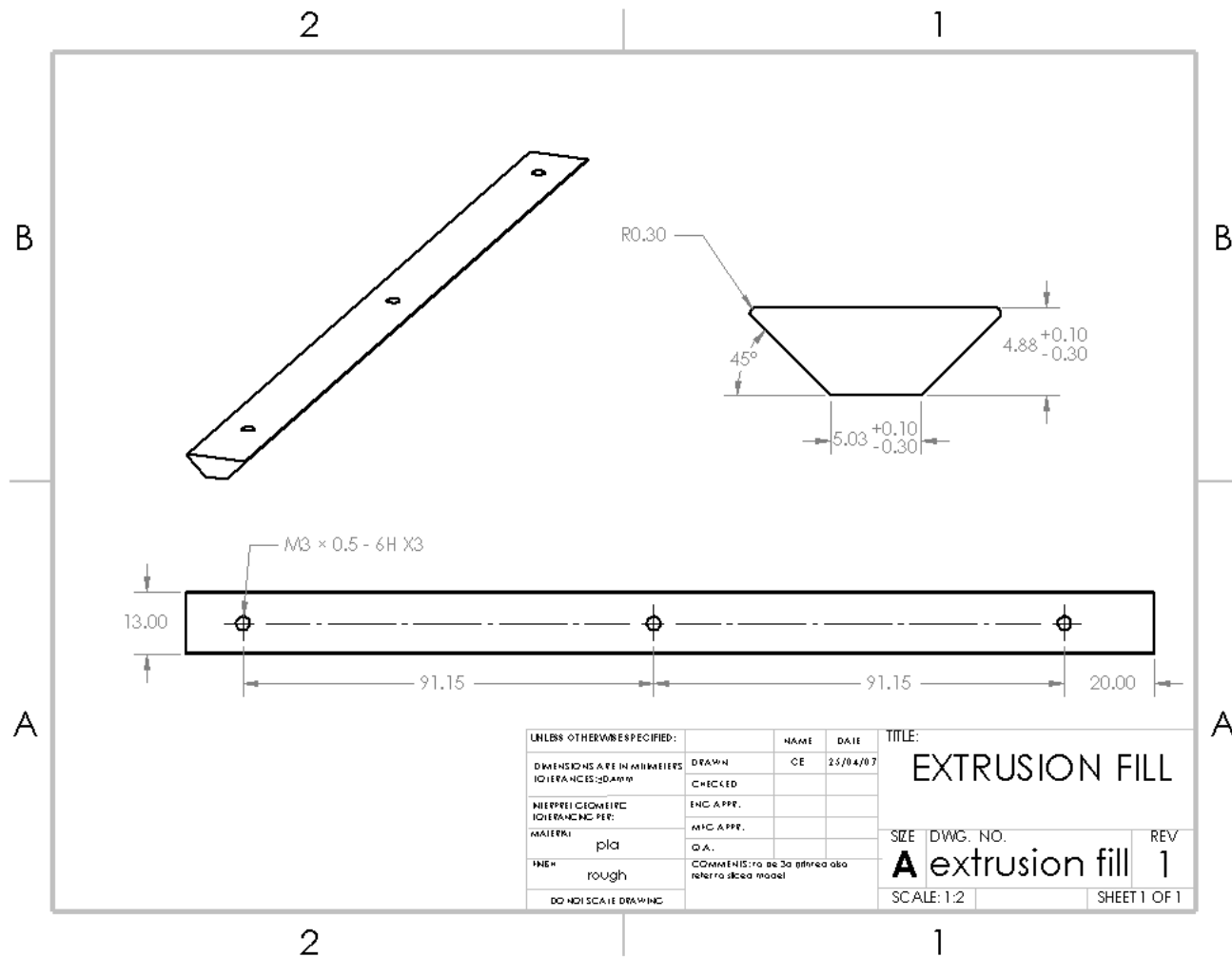


Figure 31 bowden adapter filament

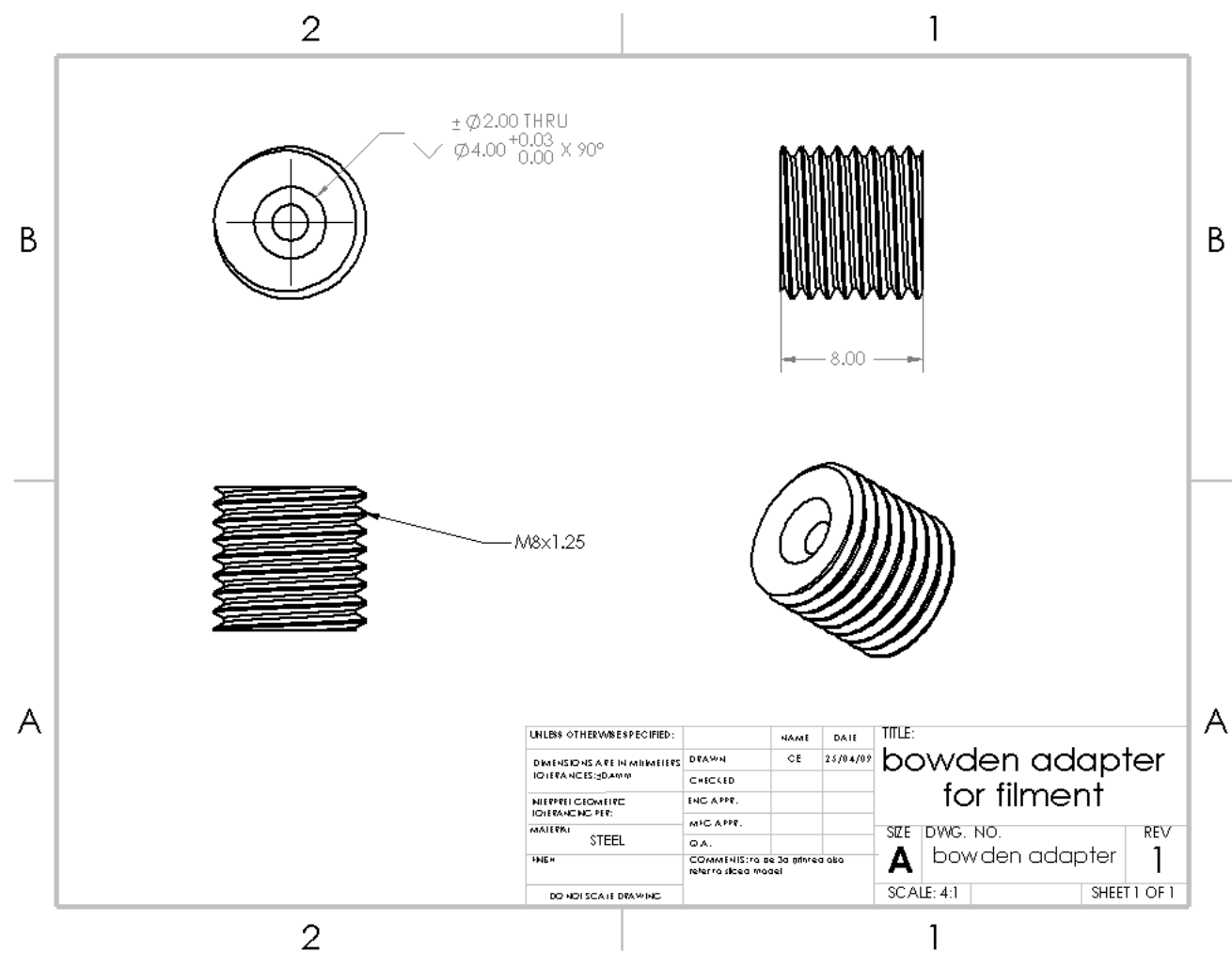
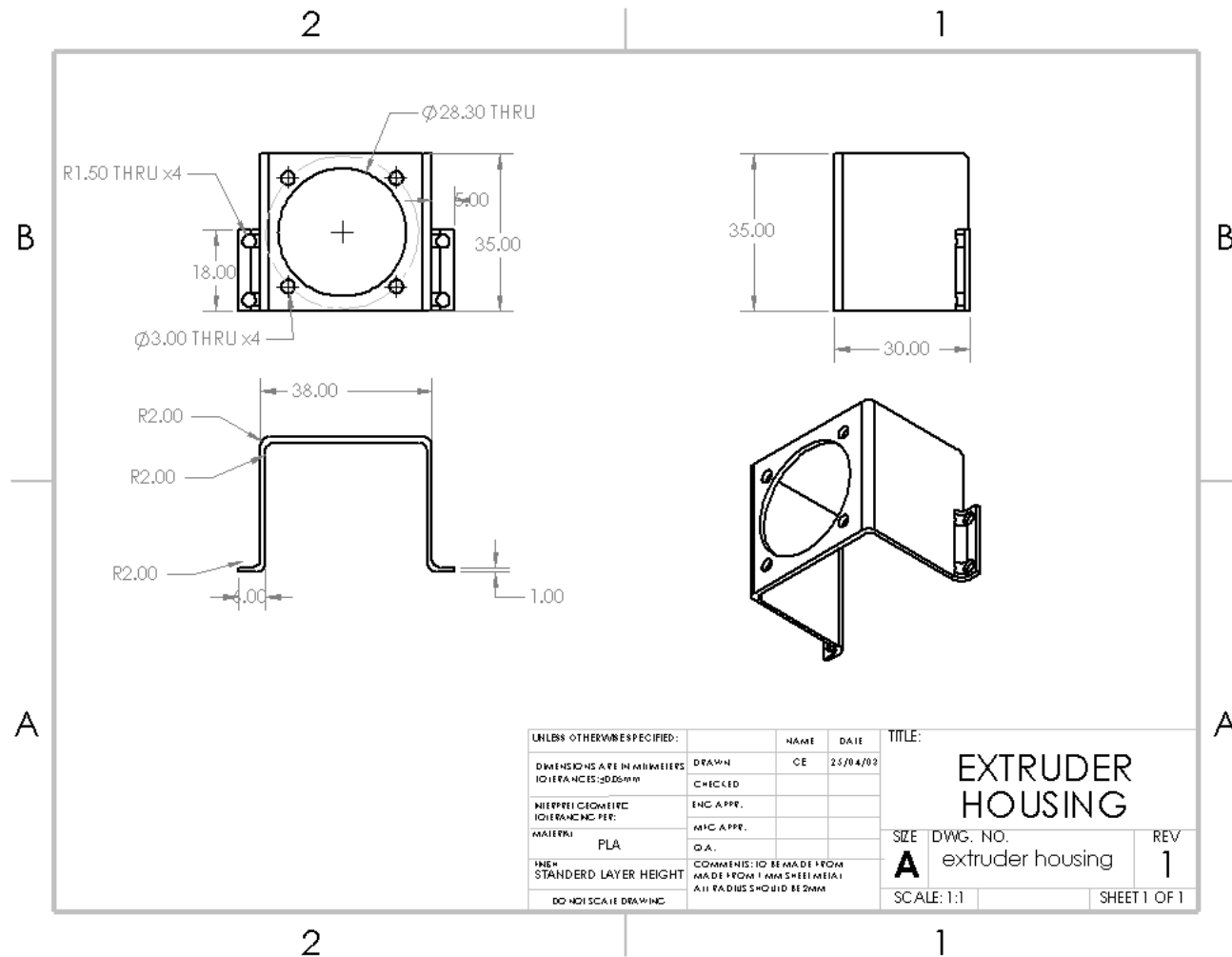


Figure 32 extruder housing



Technical drawing of an extruder backplate. The drawing includes a front view, a side view, and a detail view of a corner.

Front View Dimensions:

- Overall width: 50.00
- Overall height: 61.00
- Top edge features: 32.00, 31.00, 4.50, 5.66, $\varnothing 3.60^{+0.05}_{0.00}$ THRU x2
- Left edge features: 5.66, 13.34, $\varnothing 3.60^{+0.05}_{0.00}$ THRU x4, 5.00, 7.50, 13.00, M3 x 0.5 - 6H THRU x4, 15.50
- Right edge features: 14.00, 15.00, 4.00
- Internal features: R2.00, 21.50, $\varnothing 2.50^{+0.05}_{0.00}$ THRU x4
- Surface finish: $\sqrt{0.01}$ A

Side View: Shows the profile of the backplate with a height of 61.00.

Detail View: Shows a corner detail with a surface finish of $\sqrt{0.01}$ A.

Table:

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	TITLE:
DIMENSIONS ARE IN MILLIMETERS TOLERANCES: 0.025mm	DRAWN	CE	25/04/02	extruder backplate DWG. NO. A extruder backplate SCALE: 1:1
INTERPRET GEOMETRIC TOLERANCE PER:	CHECKED			
MATERIAL: ALUMINUM	ENG APPR.			
FINISH: MACHINED	MTC APPR.			
DO NOT SCALE DRAWING	COMMENTS: TO BE MADE ON CNC MILL			REV 1 SHEET 1 OF 1

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	TITLE:	
DIMENSIONS ARE IN MILLIMETERS TOLERANCES: ±0.05mm	DRAWN	CE	25/04/02	extruder backplate	
	CHECKED				
INTERPRET GEOMETRIC TOLERANCES PER:	ENG APPR.				
MATERIAL:	MTC APPR.				
ALUMINUM				SIZE	DWG. NO.
FINISH				A	extruder backplate
MACHINED					REV
DO NOT SCALE DRAWING				SCALE: 1:1	SHEET 1 OF 1

Figure 34 215 by 20 by 20 aluminum extrusion

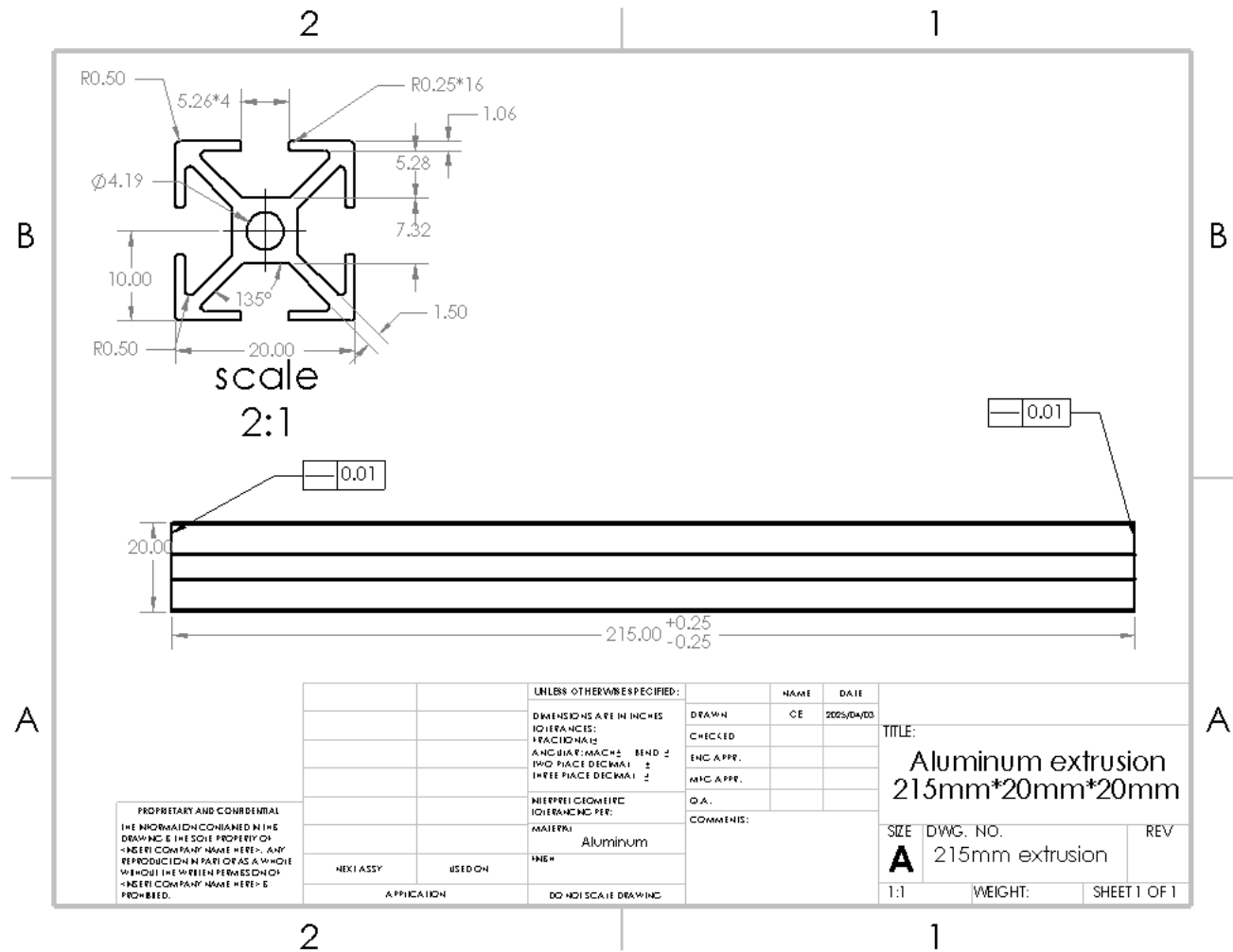
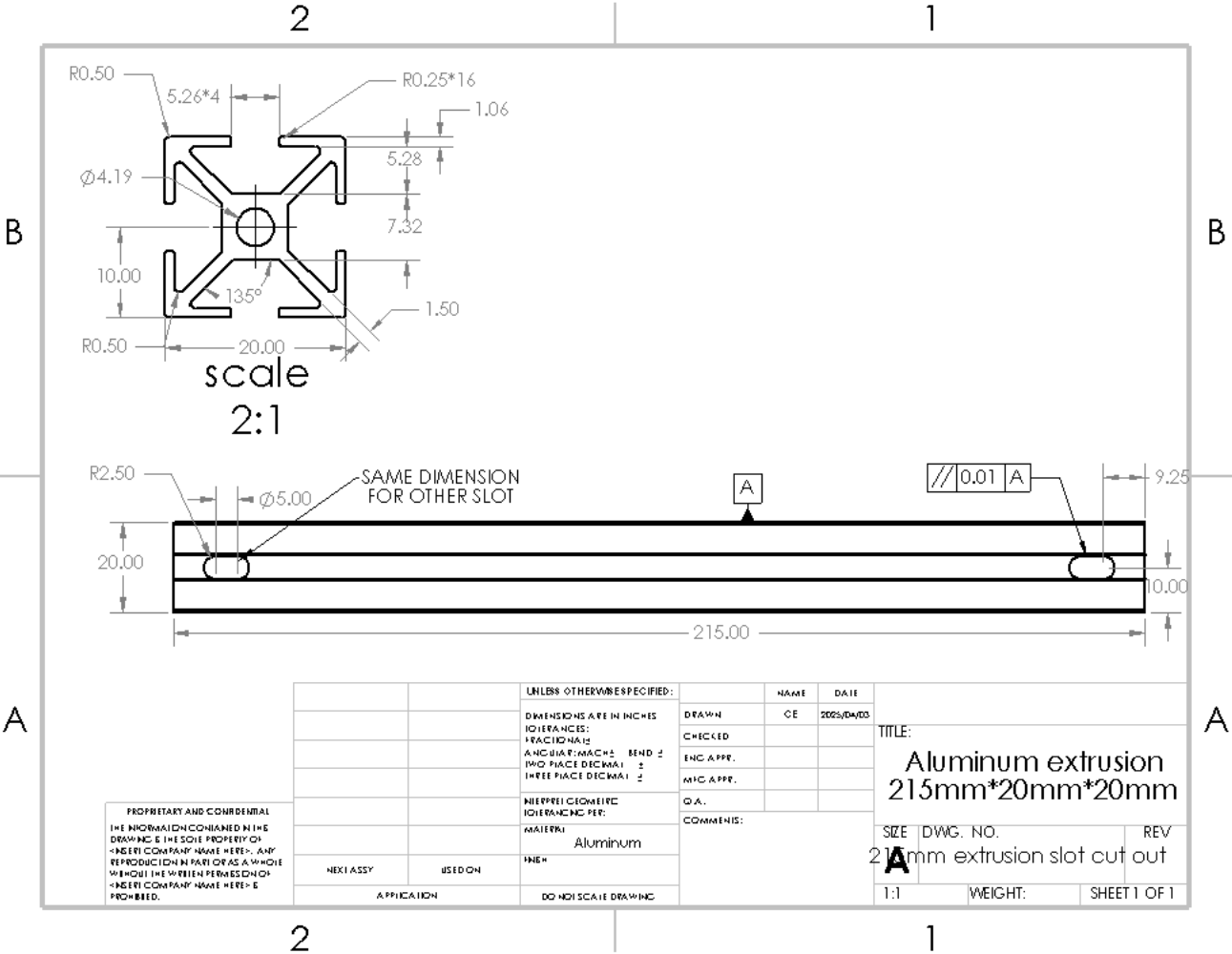


Figure 35 215 by 20 by 20 slotted aluminum extrusion



[illegible]

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN MILLIMETERS
TOLERANCES: DIMS
FRACTIONS ±
DECIMALS: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC
TOLERANCES PER:
MATERIAL PLA
FINISH
DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	C.E	25/2/4
ENC APP.		
MIC APP.		
QA.		
COMMENTS:		

SIZE	DWG. NO.	REV
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A		
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SCALE: 1:1	WEIGHT:	SHEET 1 OF 1
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Figure 37 4*5 bearing spacer

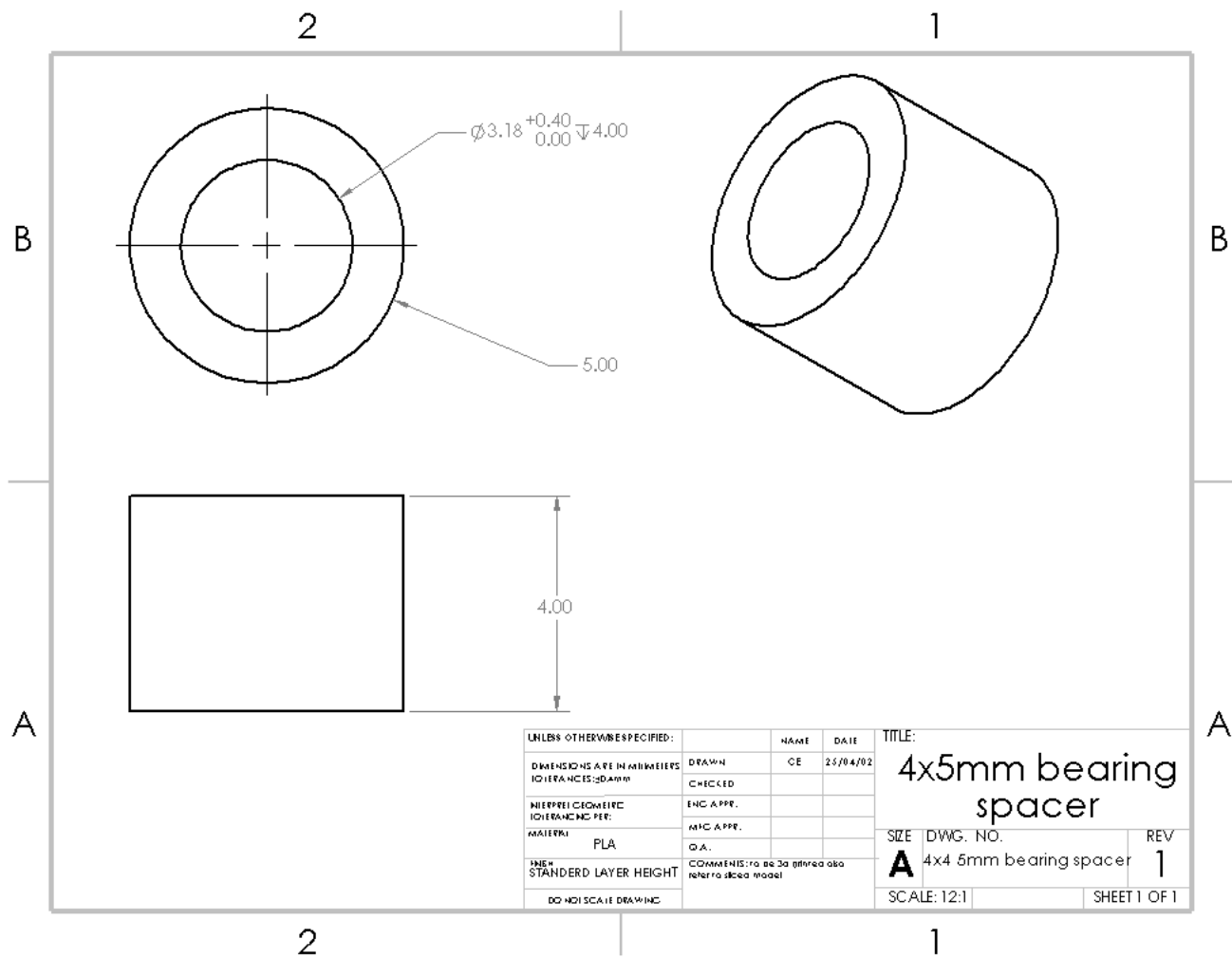


Figure 38 exploded view

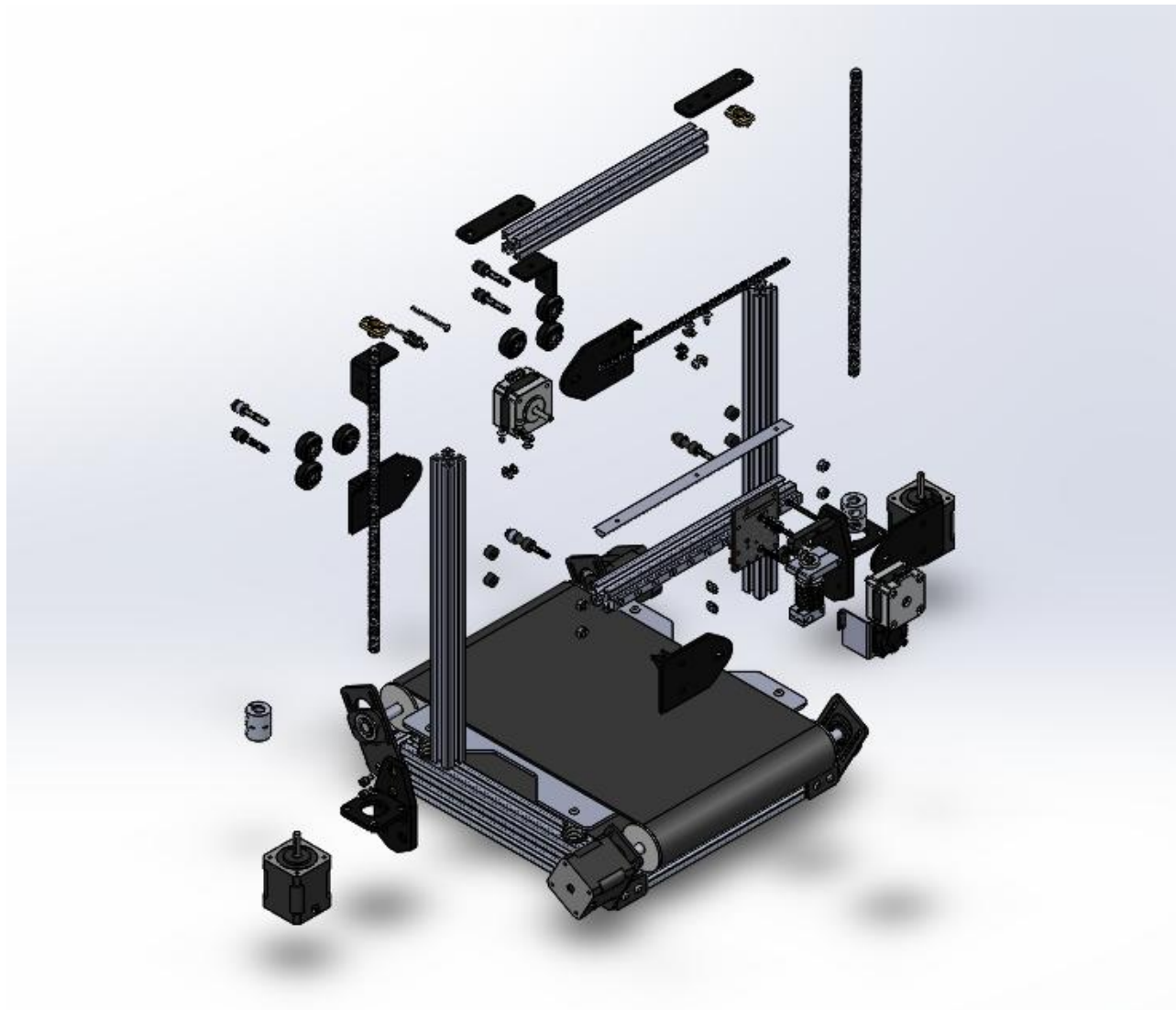


Figure 39 rack gear drawing

