FACULTY OF ENGINEERING AND APPLIED SCIENCE

AXELR ∞

DESIGN GROUP C15

GROUP DESIGN TERM PROJECT

ENGR1025U Engineering Design

Winter 2021

Course Instructor:

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Design Team #: C15

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I. Design team identification page

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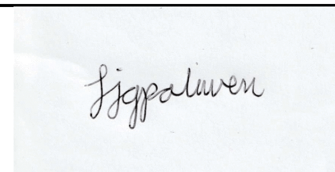
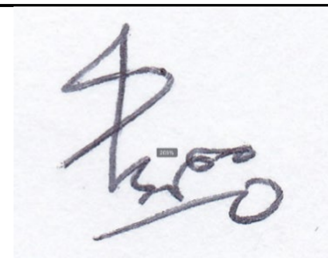
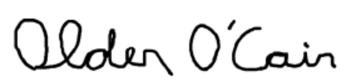
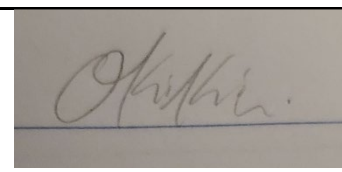
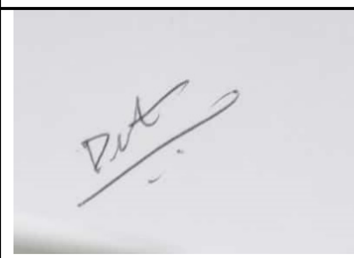
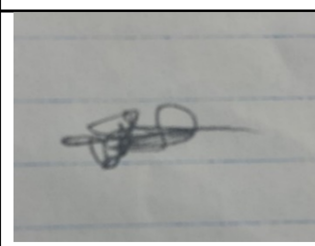
1	Louis Joshua Paliwen	100783561 louisjoshua.paliwen@ontariotechu.net	
2	Israel Ogunmola	100786577 israel.ogunmola@ontariotechu.net	
3	Alden O'Cain	100558599 alden.ocain@ontariotechu.net	
4	Okiki Ojo	100790236 okikioluwa.ojo@ontariotechu.net	
5	Dhrumit Patel	100809140 dhrumitkumar.patel1@ontariotechu.net	
6	Clinton Oyedeji	100791599 clintonoluwadamilare.oyedeji@ontariotechu.net	

II. Executive Summary

We at AXELR ∞ (pronounced 'Accelerate') aim to build a rear-wheel-drive car that uses a pullback engine and a basic linkage steering mechanism. The pullback engine is the source of motion for the rear tires. We also use a steering system as the direction of motion for the car.

Our mission is to produce, refine and bring to market high performance, cheap products aimed at younger children. Our primary target audience is children within the ages of 3 to 10, we aim to build mechanical toys that brings joy to children and deliver educational and inquisitive benefits. Our customers require a product that will captivate children, while still providing a long-lasting fun experience for them. We saw the opportunity to produce a toy that would help develop their problem-solving skills and teach them some basic engineering skills.

Through a rigorous weight-based selection process, the pullback was chosen out of 5 concepts. The pullback is designed to have little impact on the environment, be cost-effective, lightweight, safe, and durable. Using polypropylene, we were able to make the car BPA free and create little transparent views into the inner functions of the car.

The pullback uses a complex system of bevel gears, and shafts, to control the motion of the car. The pullback car uses a spiral torsion spring which stores energy from the user pulling the car backward, and then releases the energy in rotational form when the car is released.

After a rigorous cost analysis, it was concluded that it will cost AXELR ∞ $20.5 to produce a single toy car. We chose a selling price of $30 to ensure that we made back our loses in due time. An initial investment of $862,438.50 would be required to satisfy the costs of the project. The first 10,000 cars will be sold in the second year generating a revenue of $300,000. We will eventually break even between the third and fourth year. From this point on, we see an upward trend in annual unit sales and revenue, we also see AXELR ∞ dominating the toy market in the nearest future.

This project took us a total of one month to complete with meetings every Tuesday, Thursday, and Sunday at 7:30pm – 9:30pm.

Table of Contents

1. Introduction

1.1 Mission & Vision Statements

Our mission is to produce, refine and bring to market high performance, cheap products aimed at younger children. Our primary target audience is children within the ages of 3 to 10, we aim to build mechanical toys that brings joy to children and deliver educational and inquisitive benefits.

We are a young company that use engineering as a tool to drive innovation in fun and intriguing ways. We build toys and devices that are light weight, safe, recyclable, simple, and portable.

Our vision is a world with more inquisitive minds built through innovative toys, driven by curiosity and the willingness to learn more, all built by us at AXELR ∞ (pronounced Accelerate).

Our goal with our current products is to grow till we are larger than our counterparts, we will accomplish this goal through high quality products, great design, good cost, durability, safety, and reliability.

1.2 Customer Needs Assessment

Based on our customer research, we have determined that our clients require our team to conceptualize and design a product that will engage and inspire their children in a captivating way. Our proposed designs are intended to provide a long-lasting and fun experience for children and introduce them to the field of engineering and STEM programs, we will do this through a series of basic engineering concepts built into our products.

As a primary design project requirement, our team must produce a device that consists of a hand-powered mechanism that causes objects to move. We see the opportunity to produce toys that will help develop a child's ability to solve problems and engage their curiosity.
We performed a basic customer research analysis by surveying 10 children within the ages 3 to 10, they were required to fill out an online questionnaire (see appendix II) that inquired about their relationship with toys. We were able gathered sufficient data that will help us a perfect toy that will suit every child's needs.

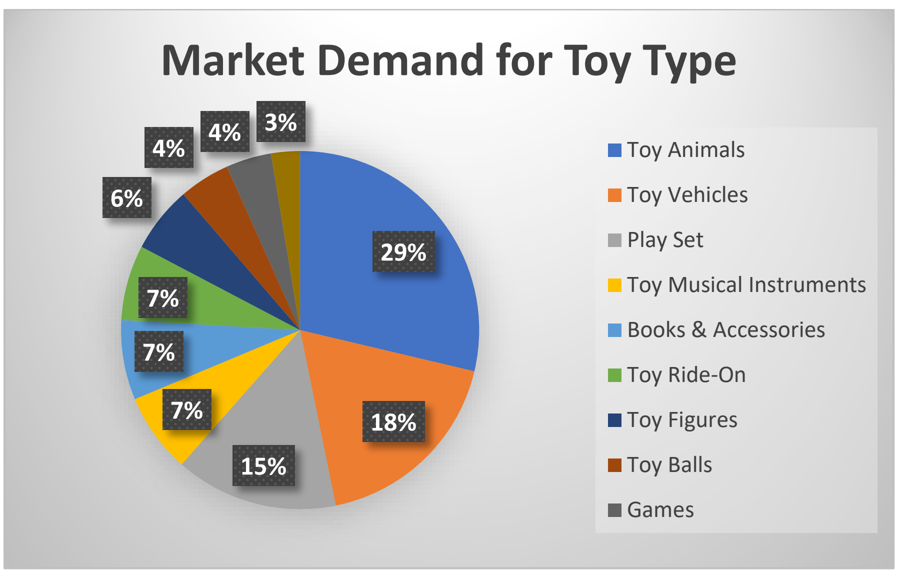


Fig. 1. Pie Chart Describing Children's Preference in Toys [1]

From the pie chart above, we concluded that producing a toy vehicle will favor profits and will enable us to widen our market presence.

1.3 Major Design Specifications

To determine the design of the car, the customer needs were first considered and prioritized. As a reflection from our customer needs assessment, the pullback toy car must meet the following required demands of the customers.

Table 1

Prioritized table of Customer needs

Customer need	Importance (1 low, 5 high)
1. Performance	5
2. Choke hazard free	5
3. Weight	3
4. Cost	2
5. Product Life	4
6. Recyclable	3
7. Portability	4
8. Simple Design	2
9. Aesthetics	4
10. Educative	5
11. Size	4

Down below is a description of the expected requirements the toy car must fulfill:

- Performance: The toy car must keep performing just as brand new for a long period of time, without wear and tear or rusting.
- Choke hazard free: There must be no loose components in the car that may be swallowed by the child [2], [3].
- Weight: 350 grams maximum weight.
- Cost: Inexpensive compared to competitors, $30.
- Product Life: Not less than 7 years.
- Recyclable: Materials used must be biodegradable.
- Portability: Must be easy to move around.

- Simple design: Mechanism used to propel the car must be simple to reduce manufacturing costs as well as selling price.
- Aesthetics: Must be pleasant looking
- Educative: The toy car must provide educational benefits to child
- Size: Big enough to comfortably fit in the child's hand

A further design analysis would be required to fully determine the ergonomics and functionality of the car. The Finite Element Analysis (FEA) as well as engineering quantitative report is not discussed in this document, the design of the car is fully based on the assumption of perfectly designed components.

2. Concept Selection

2.1 Candidate Design Concept Sketches

In total we had eight concept sketches. We used these concepts to display our thought processes on how we came up with the final pullback car concept as our product of choice, we chose five of our best concepts to display in this written report.

<u>The 3D Printing Artist concept</u>

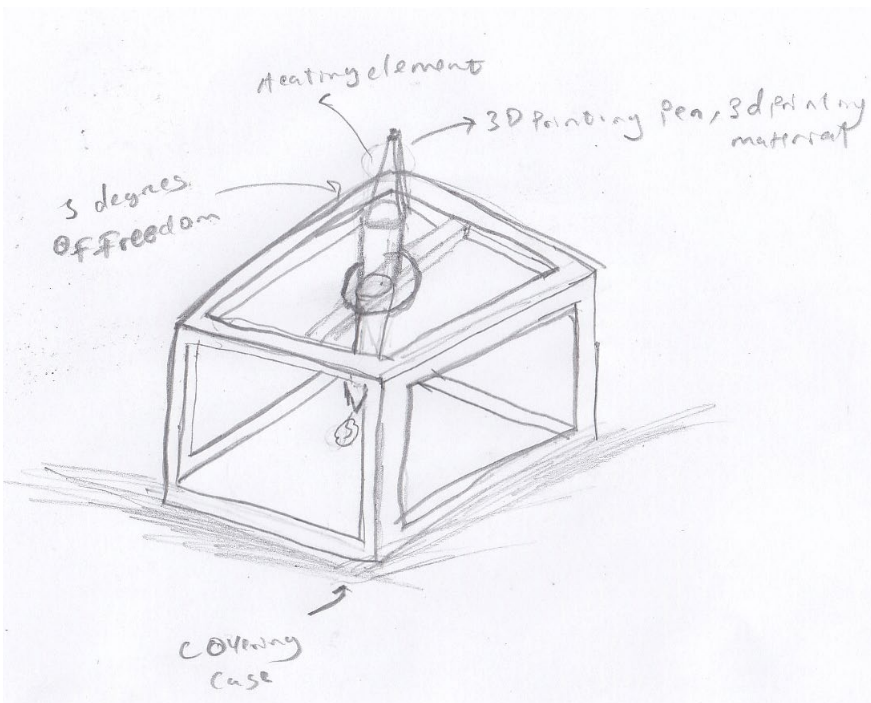


Fig. 2. Sketch of 3D printing artist

The 3D Printing Artist concept is a tool used to create cool unique non-mechanical 3D art. It uses a 3D printing pen and a box for extra precise and granular control. The center shaft moves all along the box axes, it can also change the height of the 3D printing pen. The pen holster can pivot in all directions, allowing for better granular control.

The Pullback Car

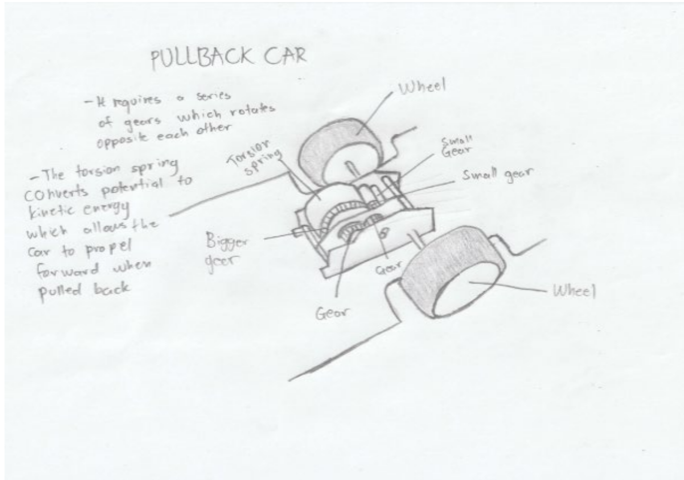


Fig. 3. Concept sketch of pullback car

The Pullback Car is a great automaton for children to play with and enjoy. It has a spiral torsion spring which stores potential energy as the car is pulled back. When the car is released, the potential energy stored is turned into kinetic energy by the multiple moving gears inside, which in turn, propels the car forward [4]. It has multiple moving components (wheels and gears), and it poses as a great toy that will introduce engineering to children in an enjoyable manner.

The Curve Drawing Machine

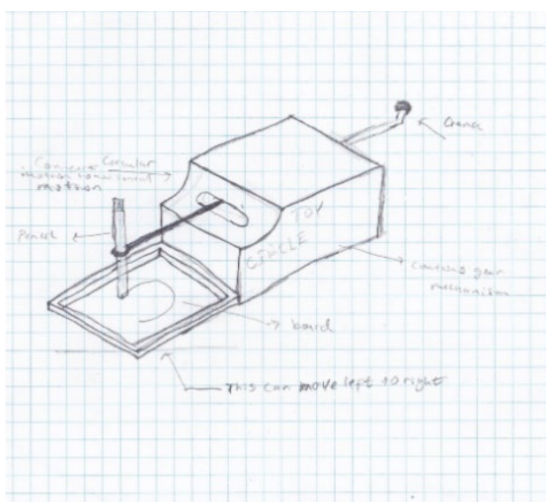


Fig. 4. Concept sketch of curve drawing machine

The Curve Drawing Machine is a device that is intended to produce circular shapes by turning a crank. The automata device consists of gears that convert the users' circular motion into horizontal motion to move the pencil. The device draws shapes such as circles and ovals but also has the ability to draw different mathematical functions. The toy is inspired by parametric equations where the x and y axis in the cartesian coordinate system are independent of each other. This is possible because the board holding the paper moves along the y-axis and the pen moves along the x-axis.

<u>The Hand Mechanics</u>

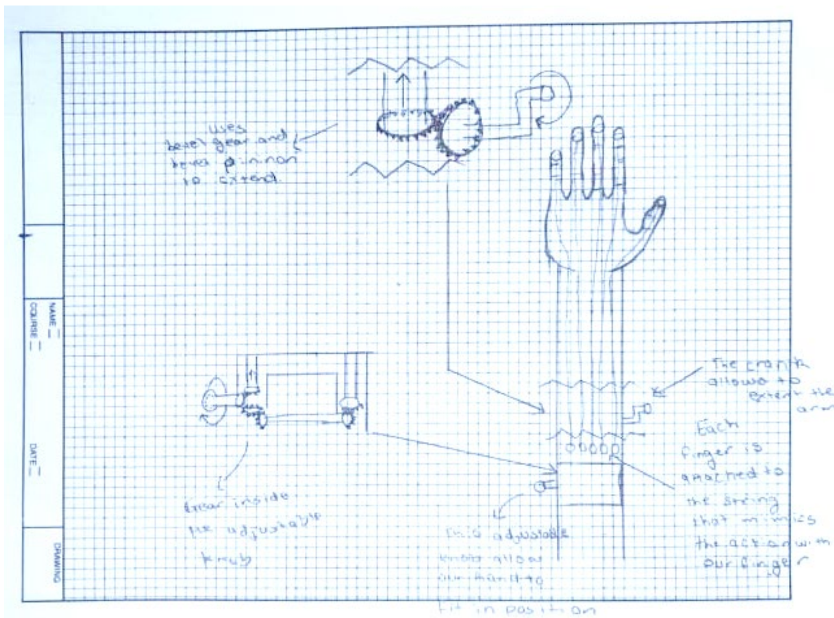


Fig. 5. Idea sketch of the hand mechanics

The Hand Mechanics uses a string attached to the fingers on the hand. There are two cranks that perform two different functions. The first crank uses a spur gear to extend the length of the arm to reach a particular point. The second crank is used for fitting your arm to get a good grip of the hand machine. At last, the string is used to simulate our hand action.

The Circle Drawing Machine

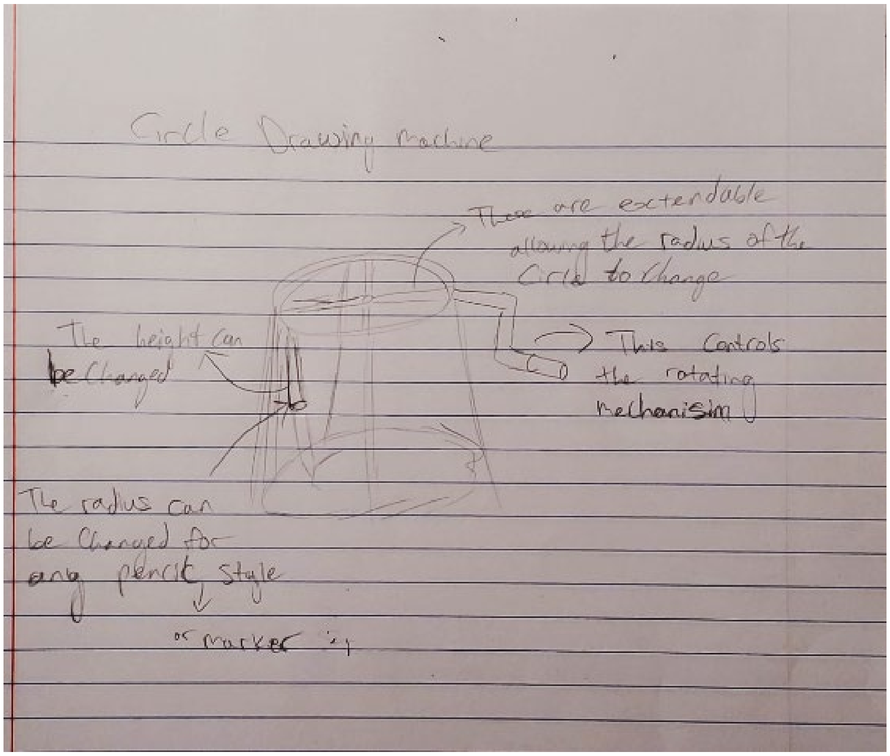


Fig. 6. Concept sketch of cup circle drawing automata

The Circle Drawing Machine follows similar principles as the 3D Printing machine and the curve drawing machine. The circle drawing machine has a pen holder that can change the height of a pencil and change the size to fit pens and markers as well. The circle drawing machine is powered by a rotating wind-up mechanism. The top shell can change the radius of the circle drawing.

2.2 Concept Selection Process

We voted and using weighted values based on the priorities set in the Major Design Specifications, we chose the pullback car as our final product.

Table 2

Concept Selection Diagram

	Concepts (out of 5, negatives are allowed)				
Selection Criteria	**A Manual Automata Hand**	**B Cup Circle Drawing Machine**	**C Pullback car**	**D Box Circle Drawing Machine**	**F 3D Printing Artist**
Kid Friendly & Hazard Free	2	2	5	2	-4
Durability & Weight	1	0	5	3	5
Portability	1	-2	5	-2	-2
Eco-friendly	1	0	3	0	-2
Ease of Manufacturing & Cost	5	-4	3	-5	-5
Net Score	10	-4	21	-2	-8
Rank	2	4	1	3	5
Continue?	Yes	No	Yes	No	No

Using the major design specification priorities, we rated each criterion out of the priority total. E.g., For the Kid Friendly and Hazard Free criteria, we gave each a priority of 5, but together they give a priority of 10, taking that out of the total number of priorities 27, we get a weight of 10/27.

Table 3

Concept Selection Diagram Continued

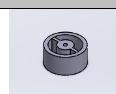
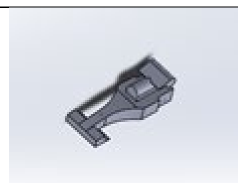
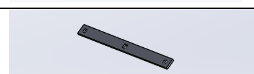
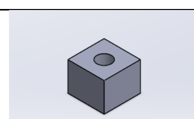
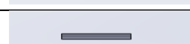
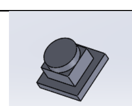
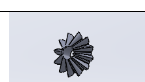
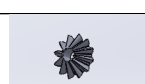
		C Pullback Car		A Manual Automata Hand	
Selection Criteria	**Weight**	**Rating**	**Weighted Score**	**Rating**	**Weighted Score**
Kid Friendly & Hazard Free	10/27	5	1.85	2	0.74
Durability & Weight	6/27	5	1.11	1	0.22
Portability	4/27	5	0.74	1	0.15
Eco-friendly	4/27	3	0.44	1	0.15
Cost & Ease of Manufacturing	3/27	3	0.33	5	0.56
	Total Score	4.47		1.82	
	Rank	1		2	

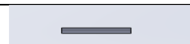
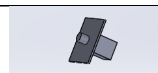
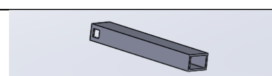
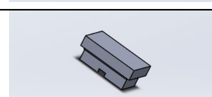
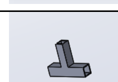
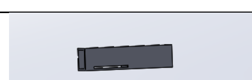
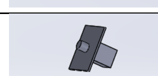
3. Bill of Materials

Here is a table that describes the parts used in the assembly of the pullback car (see appendix II for details).

Table 4

Bill of Materials

Item No.	Part Name	Part	Description	Quantity
1	Wheel		Used For the movement of the car.	4
2	Wheel Axle		Holding and rotating the front wheels of the car	1
3	Wheel Axle Spacer		Keep the wheels in position (I.e., not hit the frame)	4
4	Chassis		Frame of the car	1
5	Steering cross Slide		The slider that assists with turning the wheel axle left or right.	1
6	Steering wheel mount		Holds the cross slide and the axle scalper together.	2
7	Steering Axle		Connect the wheel to the wheel mount.	2
8	Steering Square Bolt		Connects the cross Slide with the one end of the spur gear.	1
9	Metric-Straight bevel Gear 0.25M 12GT 13PT 20PA 12FW		Helps in turning the wheel axle.	3
10	Metric-Straight bevel Pinion 0.25M 12GT		This part come in sync with the bevel Gear to help turn it right or left.	5

	13PT 20PA 12FW			
11	Main Shaft		Shaft for the back wheels	1
12	Windup Vertical Shaft		The shaft that connects to the back gears that helps in rotating the wheels.	1
13	Static Mock Spring [4], [5]		Holds the back gears together.	1
14	Metric-Spur Gear 0.5M 10T 20PA 1FW [5] [6]		Rotates the vertical shafts which then rotates the wheels.	2
15	Metric-Spur Gear 0.25M 10T 20PA 1FW		Rotates the vertical shafts which then rotates the wheels.	1
16	Windup Spring Mount		Holds the spring in place.	1
17	Steering Column Top		Shaft that connects steering wheel to the Column lower	1
18	Steering wheel		Rotating this will rotate everything for the front wheels.	1
19	Steering Column Lower		This shaft connects top column to the lower column.	1
20	Center Shield		The part covers the gear in the middle of the car.	1
21	Gear Shield		This covers the gears for the back portion of the car.	1
22	Rear Shield		Another cover that shields the gears on the bottom of the car	1
23	Center Vertical Shield		Shield the gears located in the front bottom of the car.	1
24	Front Shield		Holds the spring in place.	1
25	Tire Cover		Gives the tires better grip on surfaces.	4

4. Final Design Details

4.1 Detailed description of final design

The pullback car uses a spiral torsion spring [8], [9], which stores energy from the user pulling the car backward. When released the spring drives the rear axle which is attached to the wheels through a system of bevel gears. A steering wheel is included too for changing the steering radius of the car which utilizes bevel gears as well (for controlling the pullback cars steering). The internal moving parts are isolated from the end user by transparent plastic shields that give the children who play with this toy a clear idea of how it functions, while keeping them safe from injury and choking hazards [11], [16].

4.2 Cost Analysis

To estimate the cost of the project, a thorough cost analysis and bill of materials were required. Since there were no strict budget constraints, there were no upper bounds on the cost. However, we still strived to produce a design that is cost efficient and yet still meets the design requirements set forth.

To complete the cost analysis, the manufacturing and development costs have been estimated, as well as the price of polypropylene plastic. We concluded that it would cost $20.5 to make a single toy car.

A request was made for the cost of development of the project but in most cases, responses are still pending, nevertheless an estimate was made based on previous knowledge of the development processes.

It was concluded that to break-even in good time, pricing a single toy car for $30 would be suitable to produce good yearly earnings while still meeting the demands of our customers.

Table 5

Detailed cost analysis for the design

Item	Quantity	Cost/Unit	Total Item Cost
Materials/Components			
Carbon-Steel Alloy for Gears, Shafts.	16	$1.19	$19.04
Rubber to Cover Tire	4	$0.25	$1.00
Torsion Spring	1	$0.08	$0.08
Polypropylene for Car Frame and body *est.*	9.2 kg	$0.022	$0.2024
Bolts for Securing Cross Slide	1	$0.16	$0.16
Total			$20.5
Manufacturing and Development Costs			
Headcount (Engineering Team) *est.*	6	$81,673 ($40.62 / hour)	$490,038
Development *est.*	1	Varied	$372,380
Total Cost			$862,418
Correction Factor of 33% Added On			
Total Projected Cost			$862,438.50

*est. denotes an estimated cost.

4.3 Break Even Analysis

After an in-depth analysis of the costs, it was determined that the cost price for a toy car is $20.5. In this break-even event analysis, we assumed a fixed selling price of $30, which brings our markup to 0.46%. The first year is the investment period, after that, we plan to sell 10,000 units between the first and second year, increasing by 20,000 units each year. We predict that we will break even between the third and fourth year, with a gross profit of 1.2 million dollars for the fourth year.

Table 6

Analysis of Cumulative Cash Inflow/Outflow

Year	0	1	2	3	4	5
Units	0	0	10,000	30,000	50,000	70,000
Cost (Variable)	$862,438.50					
Revenue	$0.00	$0.00	$300,000	$900,000	$1,500,000	$2,100,000
Gross Profit	$0.00	$0.00	$138,000	$552,000	$1,242,000	$2,208,000

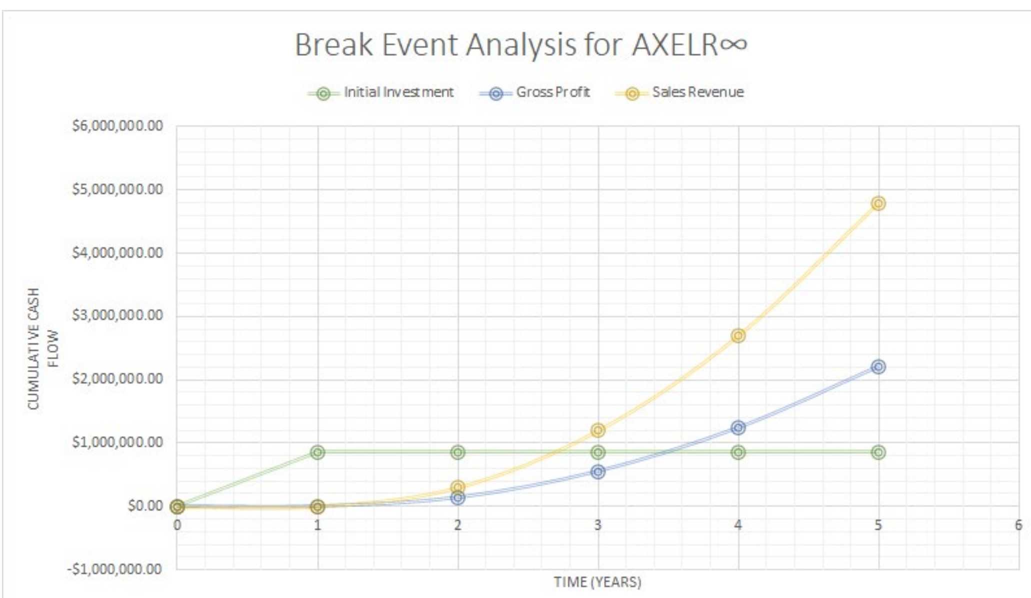


Fig. 7. Break Even Analysis for AXELR ∞

4.4 Environmental Impact

According to a journal from U.K. environmentalists, awareness has been raised around the fact that plastic toys are a big part of the plastic pollute that end up in landfills and oceans which constitute to the ongoing issue of plastic pollution. Corresponding to a survey done by the British Heart Foundation, one in three parents admits to having thrown away toys in working conditions. Considering that, 90 percent of toys are in some way made of plastic, that quickly adds up to a lot of plastic waste [8].

After conducting research, we decided to bring on a product that has little to no harmful impact on the environment. We chose to use PE plastic which is "Propylene Plastic" that is BPA free, meaning that it does not release any toxic substance under normal temperatures, it is also biodegradable and reusable [8]. Additionally, some of the other materials are steel (gears and shafts) and rubber made from the rubber tree (tires) which are nontoxic and 100% recyclable.

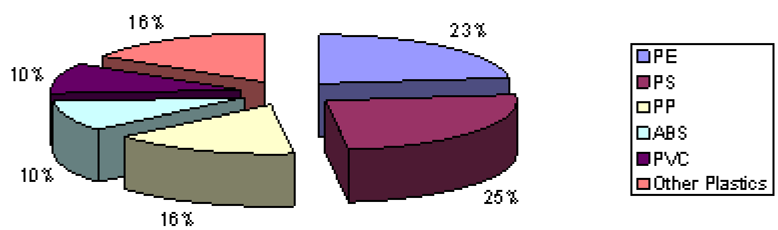


Fig. 8. Chart describing materials used in the pullback car.

From the chart above we saw that PE is the most use plastic when talking about manufacturing in the toy sector. After taking all consideration we decided to use the plastic.

5. Gantt Chart

The Gannt chart is our plan for completing the project in time. During the lifecycle of the project, we met up a minimum of 3 times a week, Tuesday, Thursday, and Sunday at 7:30pm – 9:30pm, to ensure a quality presentation, written report, 3D CAD Design, and brochure. To account for possible delays due to other classes or unexpected events, many tasks were run in parallel, allowing any member who was available to switch tasks quickly and easily.

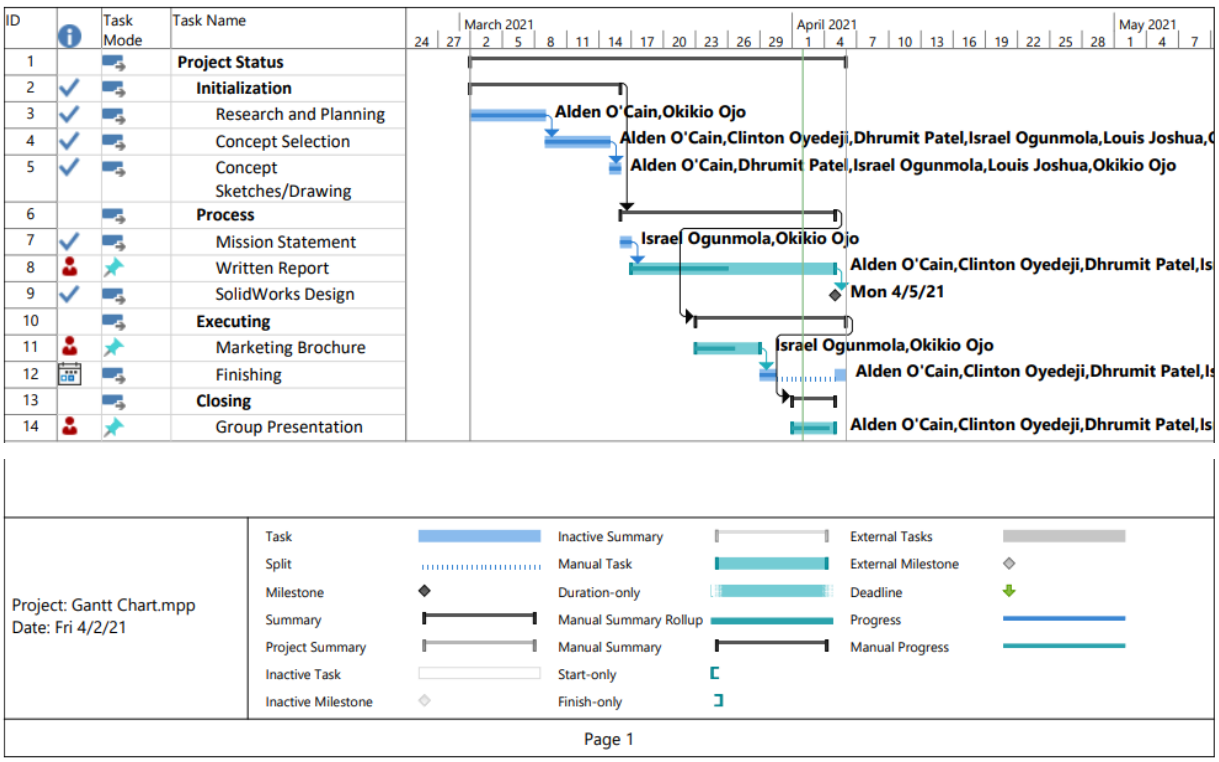


Fig. 9. Gantt Chart for Pullback Car Project

6. Conclusions

We at AXELR ∞ (pronounced Accelerate) believe in engineering and fun, thus we have designed a pullback car that primarily runs on a spiral torsion spring that is fun to play with and that educates on some basics of engineering. Through a rigorous selection process, the pullback was chosen out of five concepts. The pullback uses a torsion spring to store energy and a steering wheel to control direction. Using several complex bevel gear systems, shafts, a transparent cover, and other materials to create an amazing and fun to play with car. We focused on customer needs to ensure the product was easy to use, safe and cost efficient, we also considered the environmental impact of manufacturing the pullback car, so, when selecting materials, we elected to use recyclable and high-quality plastics and metals. The Pullback Car is a product that is fun and engaging for kids, and that comes with great safety measures and peace of mind for parents.

7. Logbook

March 9th

Everyone participated in the meeting.

Notes:

- Hand grab mechanism
- Started logbook.
- Sine wave drawing machine.
- Circle drawing machine (Okikioluwa)
    - Israel will design a free hand sketch.
- 3D Printing Artist (Okikioluwa)
    - Okiki will design a free hand sketch.
- 3D Printing Pen (Israel)
    - Patel will design a free hand sketch.
- Wind Up Toy Mouse Sketch (Alden)
    - Alden will design a final pictorial sketch/already several made in discord #pictures.
- Pull-Back Toy Car (Louis)
    - More info on car
- Max date for the free hand sketch is **March 14, Sunday.**

March 11th

Patel was unavailable.

Notes:

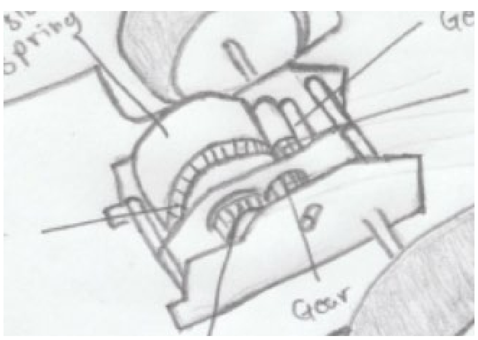
- Israel has finished the concept design for the Box Circle drawing machine.
- Switched to Excel for the Gantt Chart, the Gantt Chart Maker was too complex
- Okiki has finished a cup-based concept design for the Circle Drawing machine
- We Chose the Pull Back Car but the car's staring wheel allows the user to choose a set path before the user lets go of the car
- Wind (TBD) Up Car/Plane,
    - Tires Roll,
    - Door Opening,
    - (TBD) Wheels Changing Directions,
    - (TBD) Lights Turn On [generator; motor running off shaft/otherwise],
    - (If it's a Plane) The Wings Move,
    - (If it's a Plane) The Stairs Move,

    - (If it's a Car) Boot Opening,
    - etc....
- Gantt Chart: https://ontariotechu-my.sharepoint.com/:x:/g/personal/okikioluwa_ojo_ontariotechu_net/ERi7XpAVi3xKp5I8SWLr_HwB4zkaFecxV_i8EdvD-jpEaw?e=4EyXzI
- Questions We Want to Ask the Prof.:
    - Is there only one action that can cause motion?
    - Can the motion be controlled by a single action, and do the following actions need to be distinctly difference types of motion?
- Louis will draw a design concept for a pullback car.
- We need all concept by March 14, Sunday, end of day.
- Okiki will draw the box circle drawing machine Concept.
- The Next Meetings is Sunday, March 14, 7:30pm

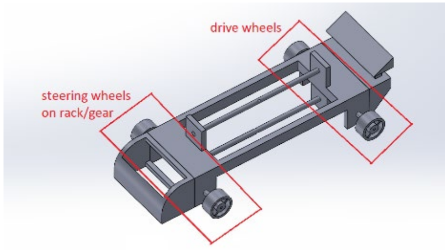
March 14th

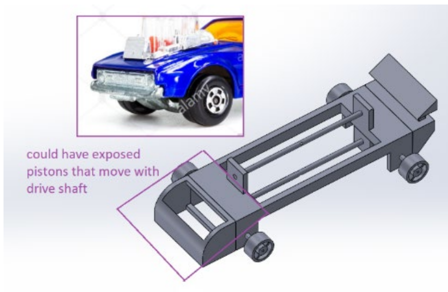
Everyone participated in the meeting.

Notes:

- Louis finished the Pullback car.
- Alden finished a SolidWorks concept.
- Israel finished the Curve Drawing Machine
- Okiki finished the 3D Printing Artist Machine
- The Pullback Car will use springs, gears, and pulleys to create motion that moves the back wheel.
    - 

    - We will use a pulley to then cause the front tire wheels to move, and then we will use oscillatory motion to cause the staring wheel to move, which in turn causes the car to turn.

- 

- 

- that's 1-3 motions
  1) forward motion of car/wheels
  2) steering
  3) 'pistons'
- The Mechanism of the pullback is: How does a Pull-Back Toy Car work?

- We got some of the report done.
- Questions we want to ask the prof:
  - Is opening a door a relevant motion for the project?
  - Can the motion be controlled by a single action, and do the following actions need to be distinctly difference types of motion?

March 16 - 21

Everyone participated in the meeting.

Notes:

- Worked on a prototype for the car steering mechanism Link: [https://drive.google.com/file/d/19axffD4w8gaeXaotKSLPo9lXFUiCMcc0/view?usp=sharing]
- We've started organizing.
- Went through project outline pdf together.
- Established agenda for next meeting and tasks to work on prior to next meeting [21st Mar.]
- Decided on roles for Project [21st Mar.]
  - Presentation is going to be worked on by all group members together later.
  - The written report will be broken up among group members.
  - The 3D design will be taken up by Alden and Patel.

        - Patel will take on the steering mechanism and the bill of materials and engineering drawings.
        - Alden will take on the pullback engine and the car body.
    - Okiki and Israel will take on the Brochure, and the business side of the project.
    - Louis and Clinton will take care of the Conclusions, Acknowledgement, References, and Appendix of the Written report. They will also work on the format of the report and add the final touches to the report.
- Started the presentation.
- Improved Mission statement
- Create a rough copy for the Customer Needs Assessment
- We decided on the basic linkage steering mechanism.
- Created some criteria for the Major Design Specs
- The due date for the individual parts of the project is on the Sunday, March 28, meeting
    - If the written report template is posted on Monday we will meet up on Tuesday March 23, otherwise we are meeting up on Thursday, March 25 with the expectation of some progress being made on the individual parts of the project.

March 23 - 28

<u>Everyone participated in the meeting.</u>

Notes:

- Finalized Brochure design
- Added rough copy content to every section; we will finalize later.
- We received the template reformed our plan and everyone split up on their predefined tasks [Mar. 23]
- 70% done the Written report.
- Started the PowerPoint, but we will really get going when the other tasks are completed.
- The references, and acknowledgements started getting collected.
- Written report is getting some reformatting for better readability [Mar 25, 2021]
- The engine is in progress.
- The gears are calibrated
- The stirring systems are a work in progress
- Gantt chart have been finalized (we may still update it, but we most likely won’t).
- We are done the steering mechanism [Mar. 27] (By Patel)
- (Work In Progress) fitting the steering mechanism in the full Assembly of car (Alden) [Mar. 28]
- (Work In Progress) Appendix (Clinton), References (Louis) [Mar. 28]
- (Update Brochure) with Cost and Features sections (Okiki), and (Israel) [Mar. 28]

- No meeting on Tuesday March 30, but we are meeting on Thursday April 1st (and no it's not an April fool's joke)
- References completed by Louis [Mar. 28]
  - Switched to a proper Gantt Chart by Israel [Mar 28]

April 1 - 4

Everyone participated in the meeting.

Notes:

- Work on the presentation
- Add more content to Written Report.
- So, we need to work on Concept Selection Process, Major Design Specs., Bill of Materials, Environmental Impact, Gantt Chart, Appendix, and CAD Design
- We are meeting on **[April 3] Saturday @6:30pm** and **[April 4] Sunday @7:30pm**
- @Okiki Ojo | okikio will finish the **Concept Selection Process**, **Logbook,** and post CAD component images in the **Appendix.**
- @Israel Ogunmola | Dapo will finish the **Major Design Specs.** and modify the **Gantt Chart.**
- @Dhrumit Patel | HYDRO will finish the **Bill of Materials** and **Environmental Impact**
- @Alden O'Cain | Bath will work on the **CAD Design**
- @Clinton Oyedeji and @Louis Joshua Paliwen will clean up the written report and presentation and make it look fancy and professional
- Presentation Roles in Order:
  - Into Slide [**Okiki**] @okikio,
  - Mission Statement & Customer Needs Assessment [**Okiki**] @okikio,
  - Major Design Specifications & 3D Printing Artist Concept [**Okiki**] @okikio,
  - Circle Drawing Machine (Box Edition) Concept [**Israel**] @israel,
  - Pullback Concept [**Alden**] @alden,
  - Circle Drawing Machine (Cup Concept) Concept [**Okiki**] @okikio,
  - Hand Mechanics Concept [**Patel**] @patel,
  - Concept Selection Process [**Okiki**] @okikio,
  - CAD Photos & CAD Assembly [**Alden**] @alden,
  - Major Design Specs. [**Israel**] @isreal,
  - Bills of Materials [**Patel**] @patel,
  - Cost Analysis [**Israel**] @isreal,
  - Environmental Impact [**Patel**] @patel,
  - Gantt Chart & Conclusion [**Okiki**] @okikio,

8. References

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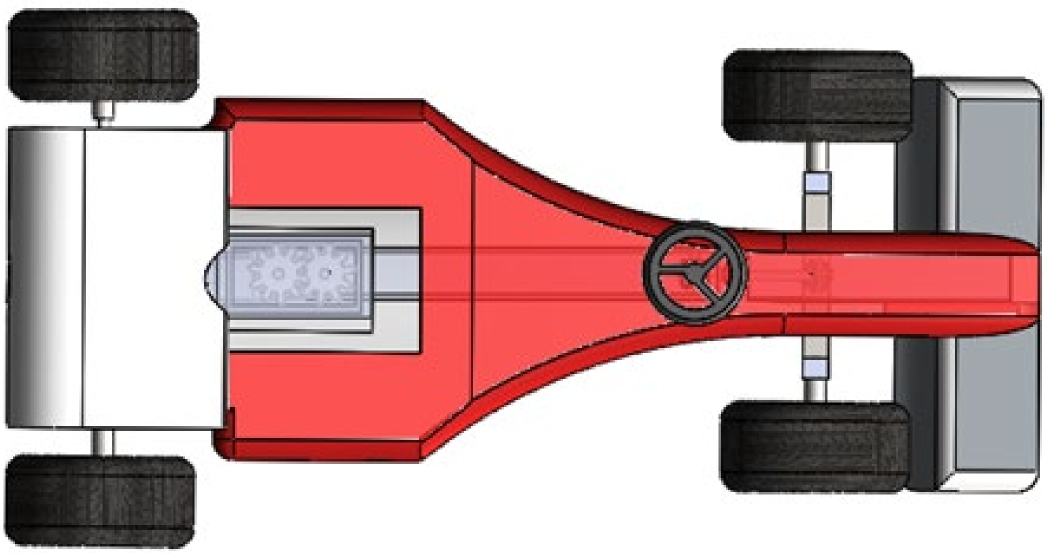
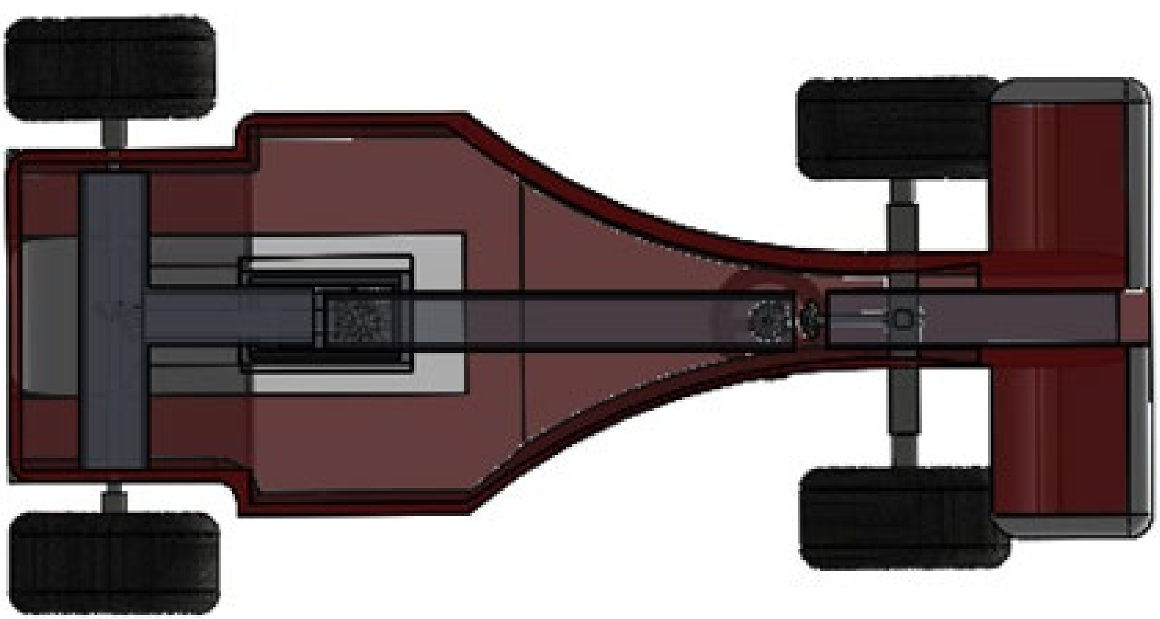
Appendix I

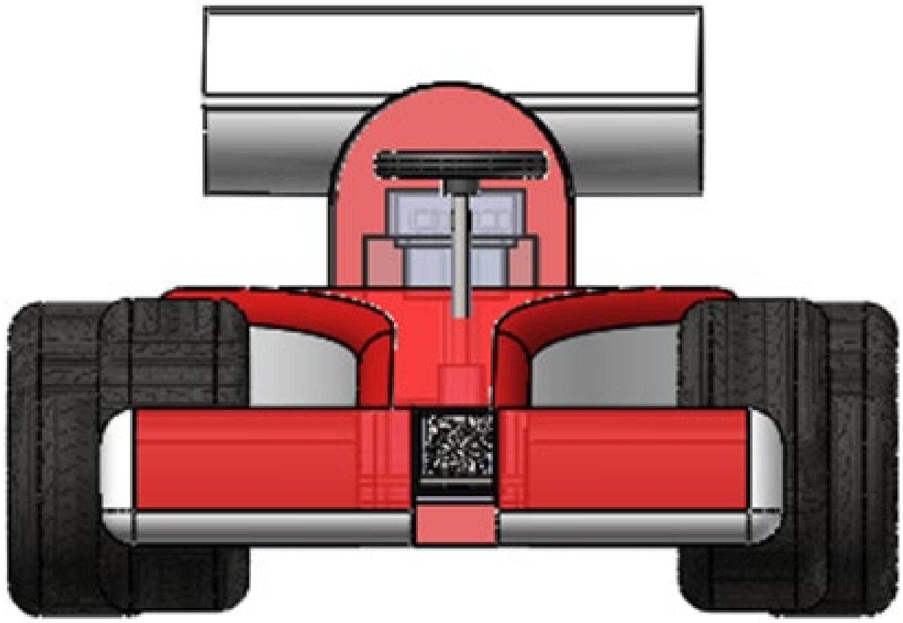
Full Views of Pullback Car



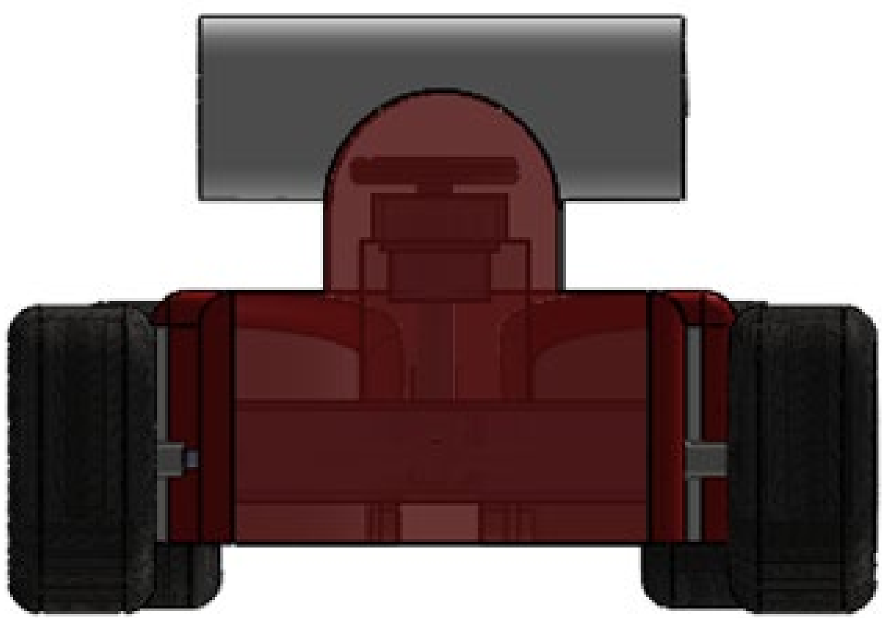
Top View



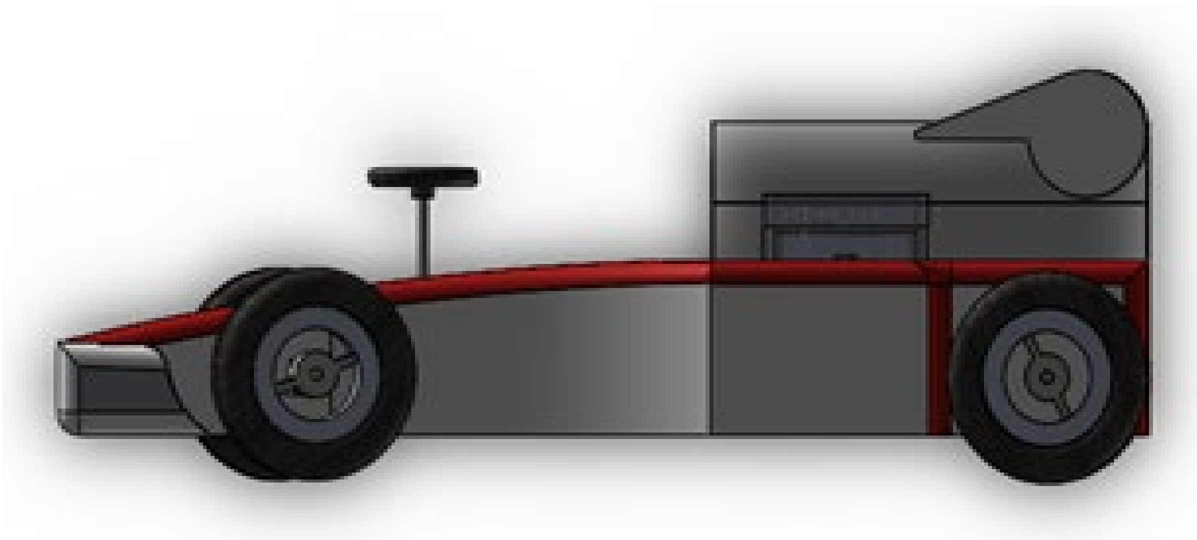
Bottom View



Front View



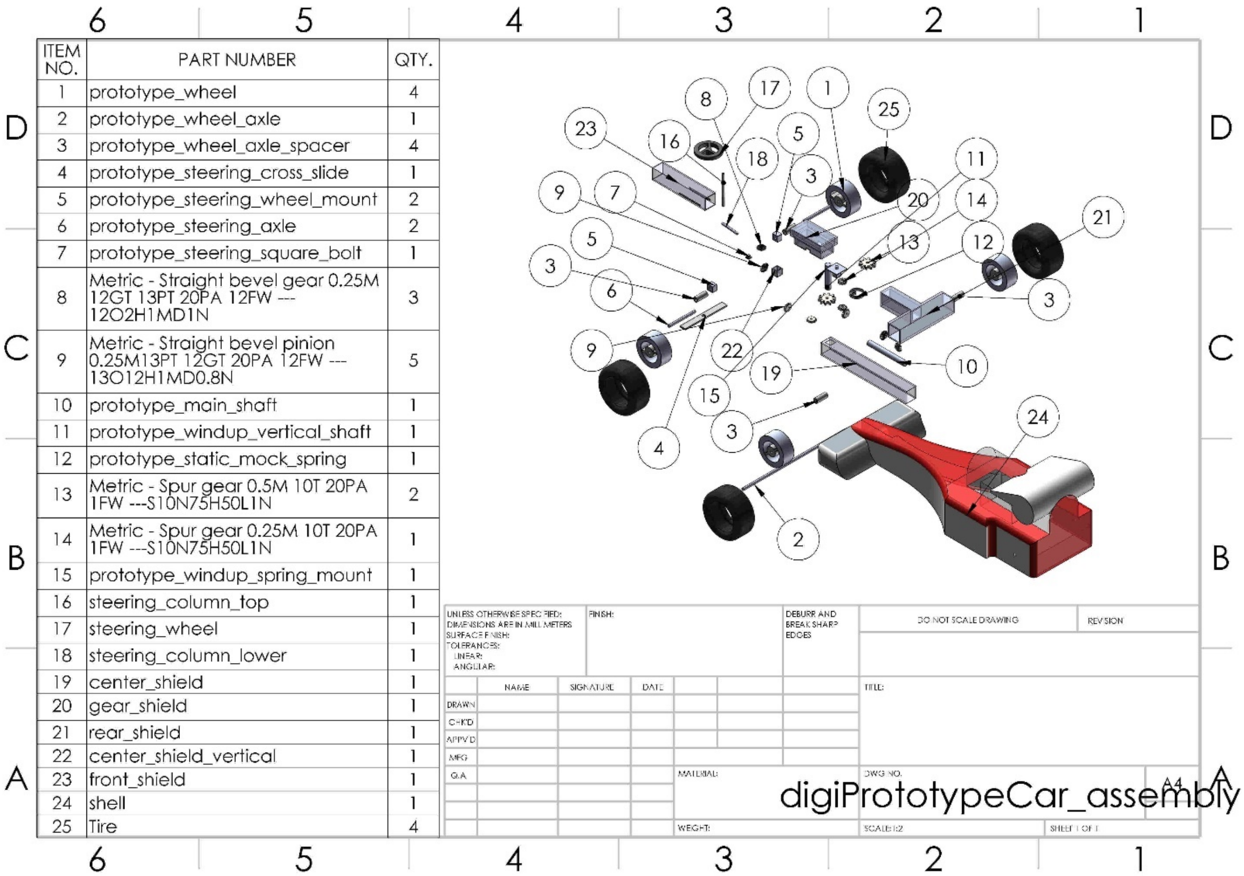
Back View



Side View

Appendix II

Engineering Drawing with Bill of Materials

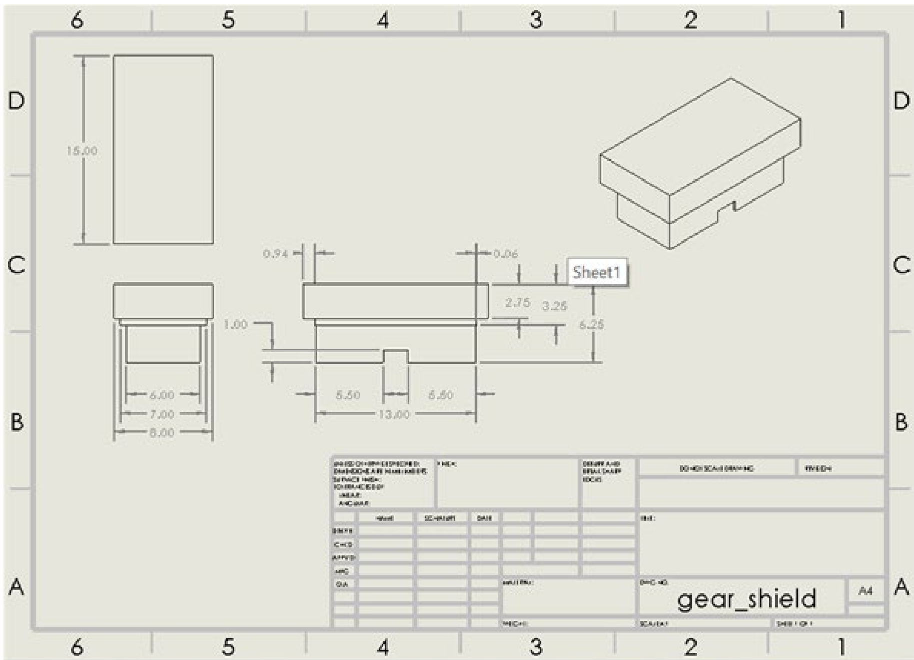


ITEM NO.	PART NUMBER	QTY.
1	prototype_wheel	4
2	prototype_wheel_axle	1
3	prototype_wheel_axle_spacer	4
4	prototype_steering_cross_slide	1
5	prototype_steering_wheel_mount	2
6	prototype_steering_axle	2
7	prototype_steering_square_bolt	1
8	Metric - Straight bevel gear 0.25M 12GT 13PT 20PA 12FW ---12O2H1MD1N	3
9	Metric - Straight bevel pinion 0.25M13PT 12GT 20PA 12FW ---13O12H1MD0.8N	5
10	prototype_main_shaft	1
11	prototype_windup_vertical_shaft	1
12	prototype_static_mock_spring	1
13	Metric - Spur gear 0.5M 10T 20PA 1FW ---S10N75H50L1N	2
14	Metric - Spur gear 0.25M 10T 20PA 1FW ---S10N75H50L1N	1
15	prototype_windup_spring_mount	1
16	steering_column_top	1
17	steering_wheel	1
18	steering_column_lower	1
19	center_shield	1
20	gear_shield	1
21	rear_shield	1
22	center_shield_vertical	1
23	front_shield	1
24	shell	1
25	Tire	4

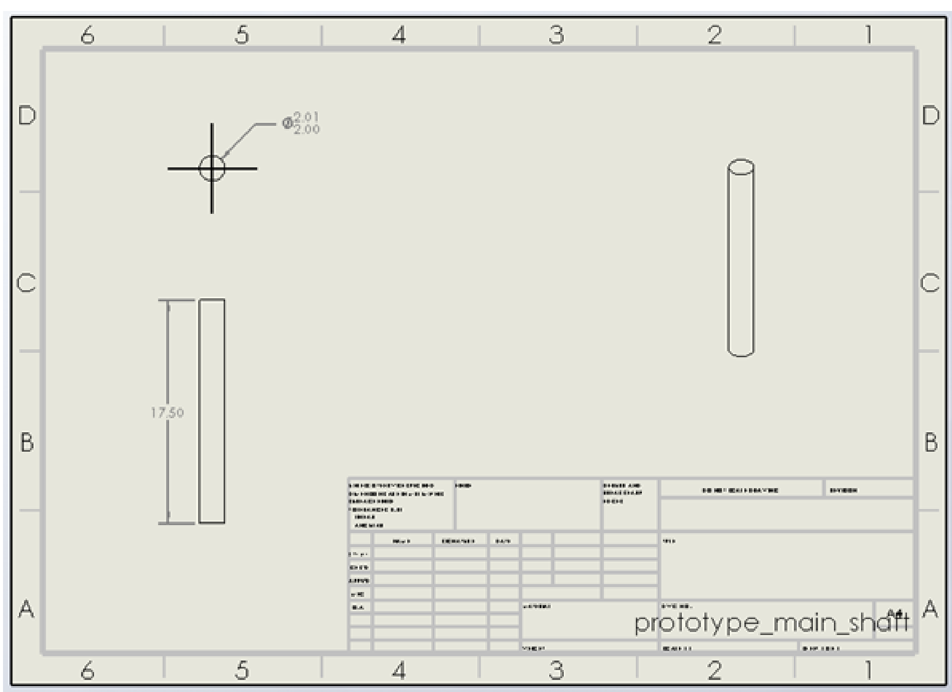
Link to questionnaire to assess customer needs: https://forms.gle/nbZCHuY7uzScJJk2A

Appendix III

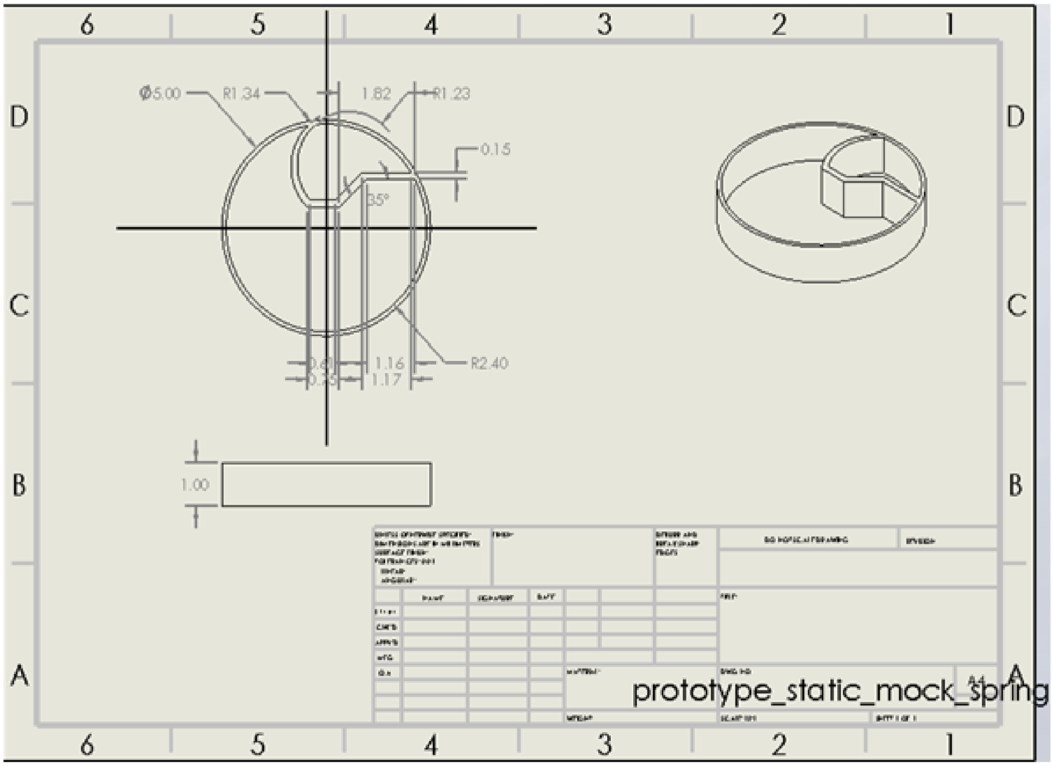
Engineering Drawing of the Pullback Car Parts



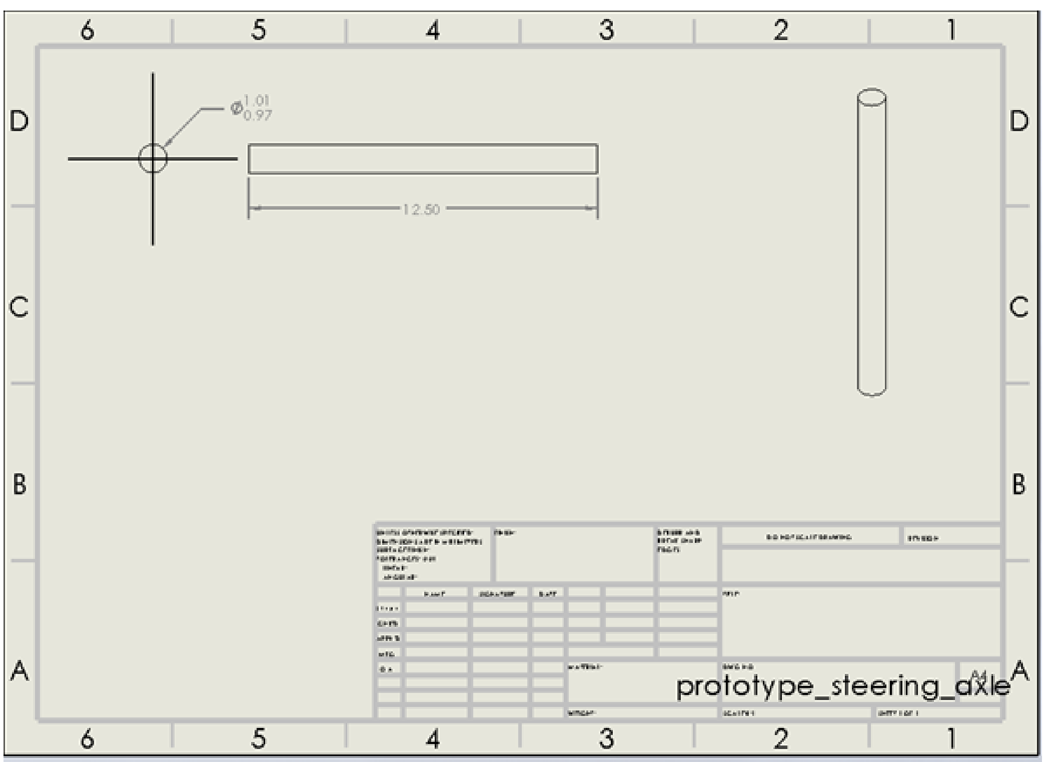
Gear Shield



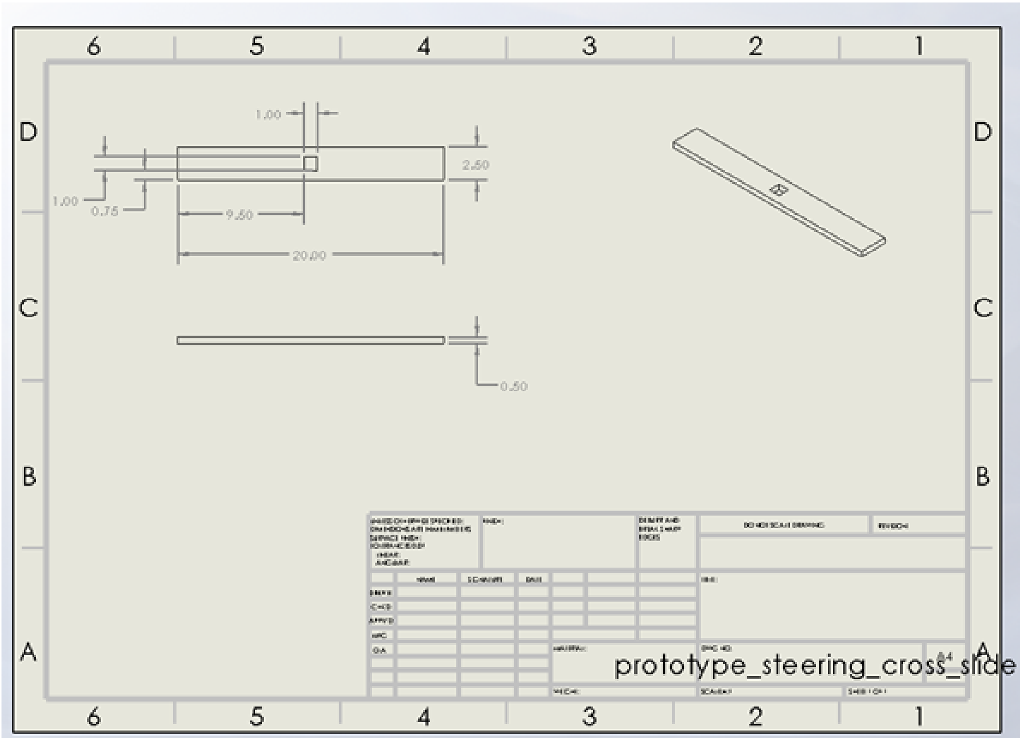
Main Shaft



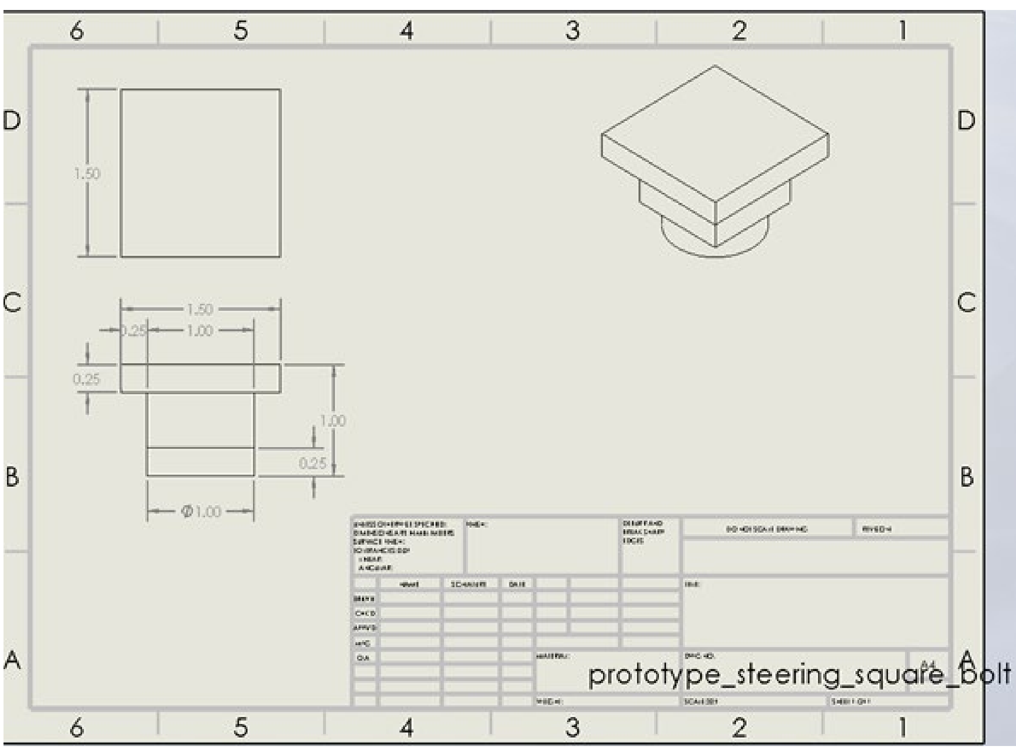
Static Mock Spring



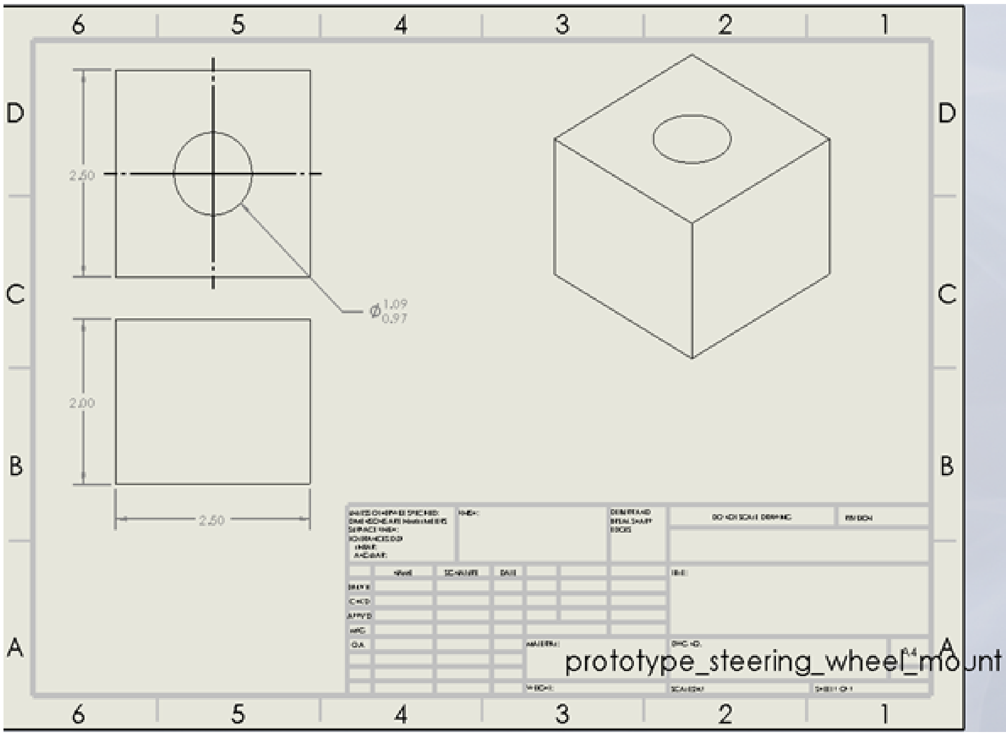
Steering Axel



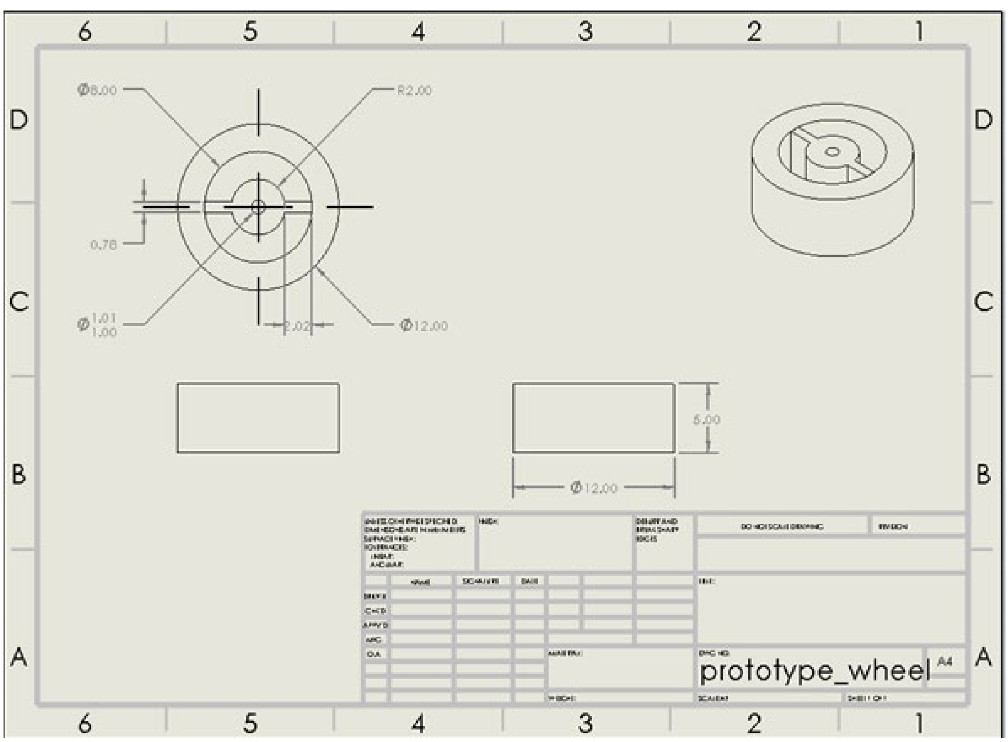
Steering Cross Slide



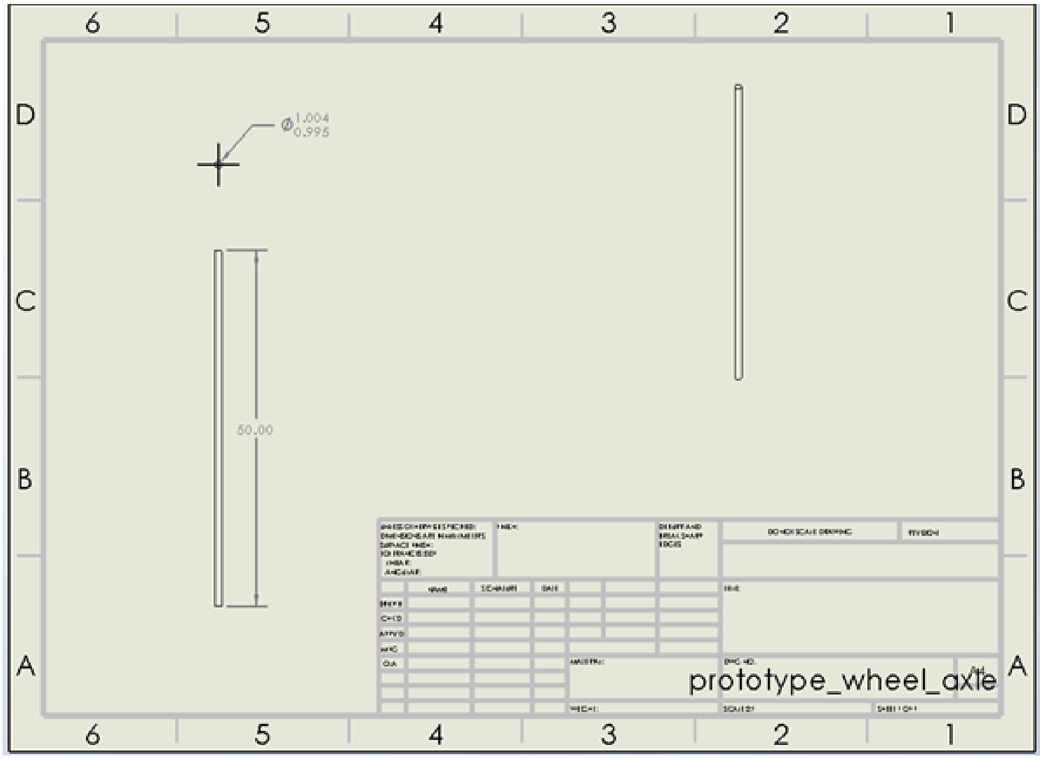
Steering Square Bolt



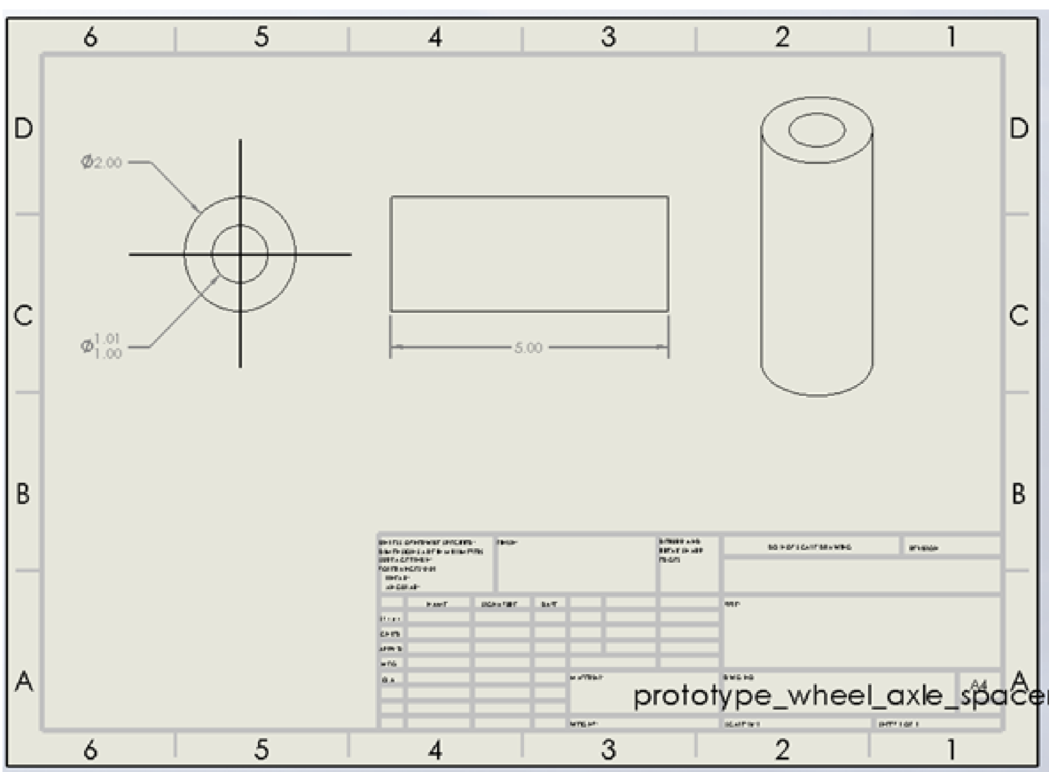
Steering Wheel Mount



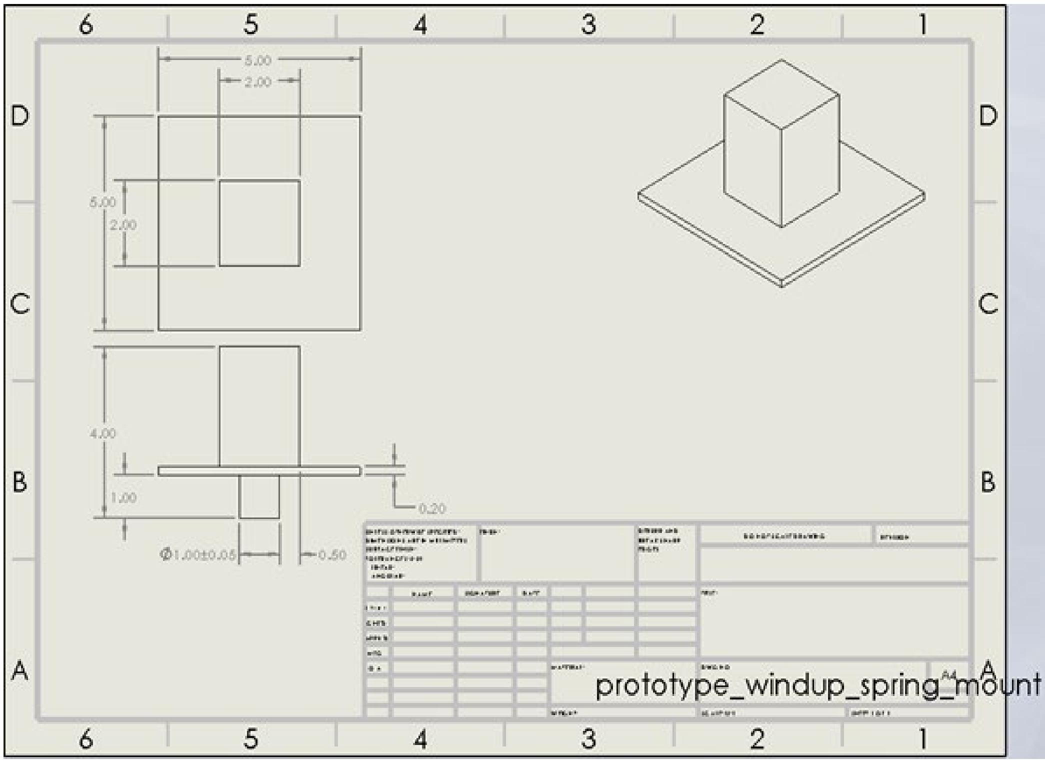
Tire Wheel



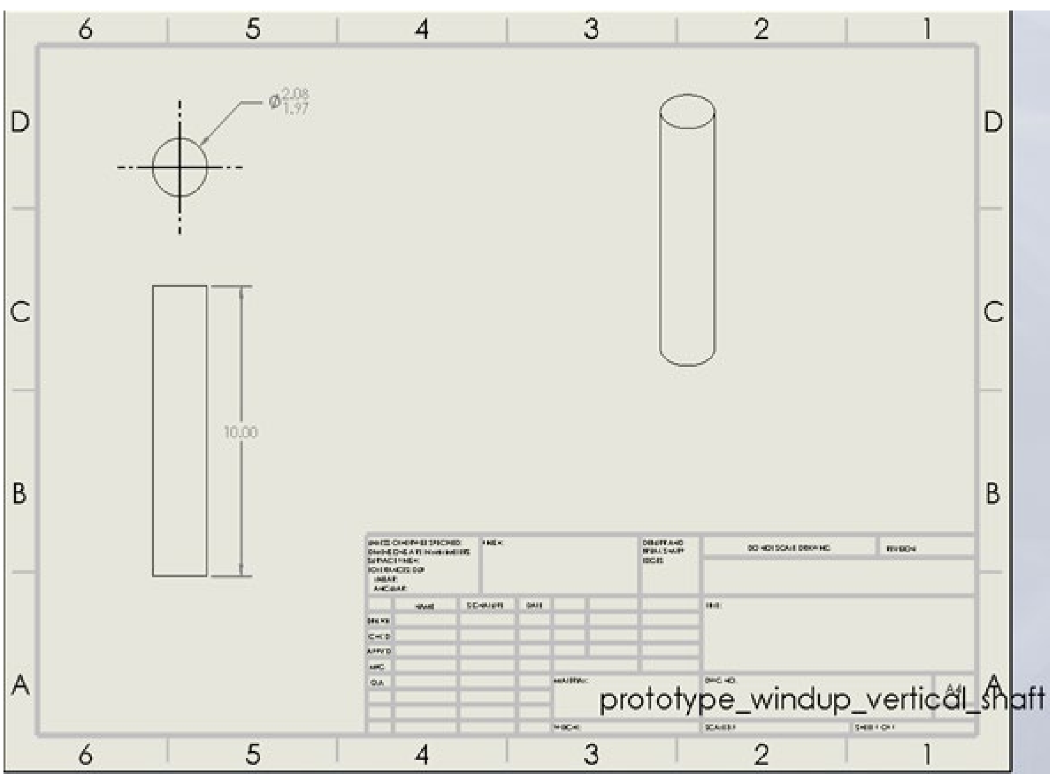
Wheel Axle



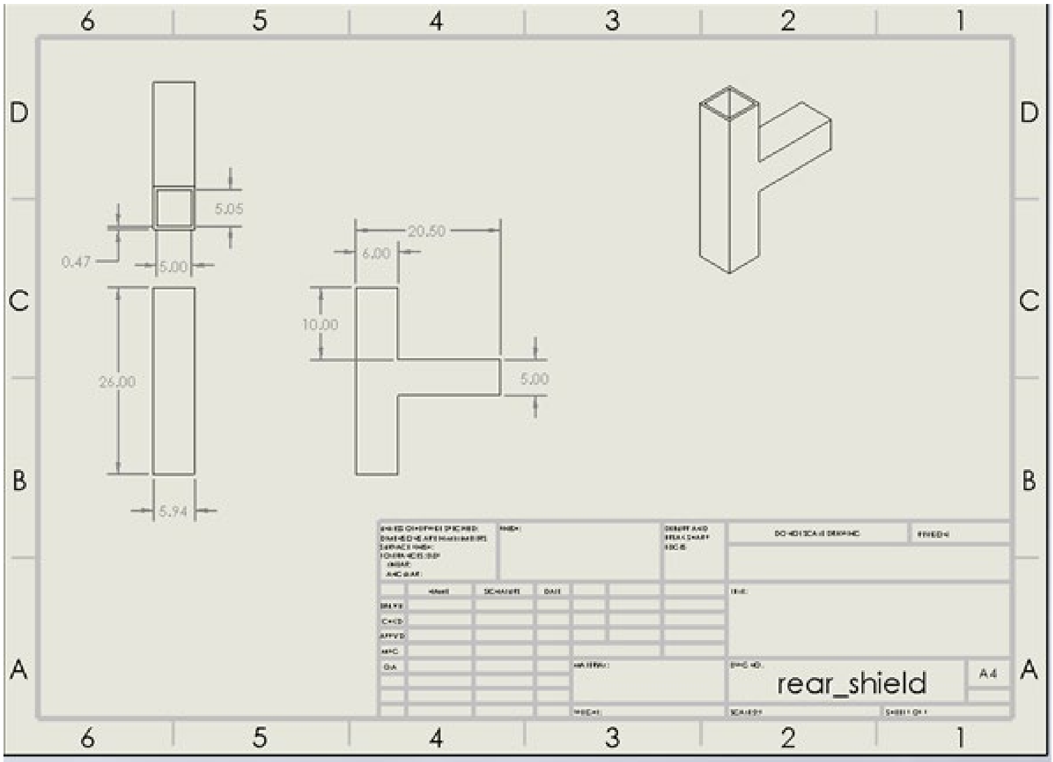
Wheel Axle Spacer



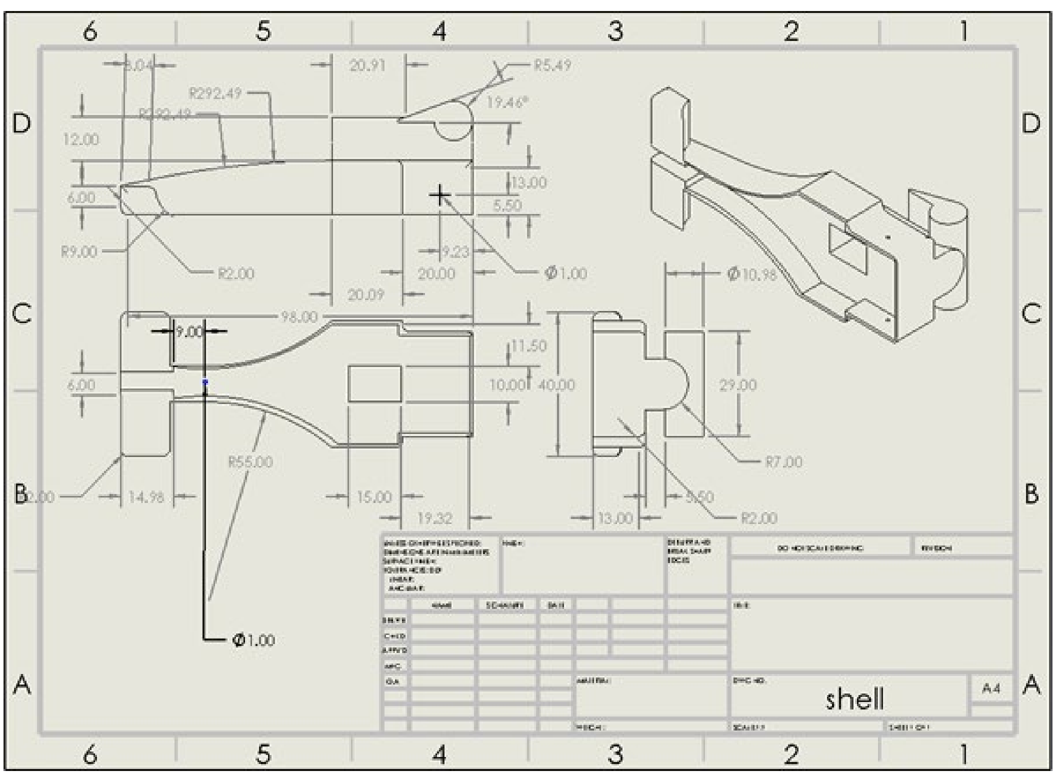
Windup Spring Mount



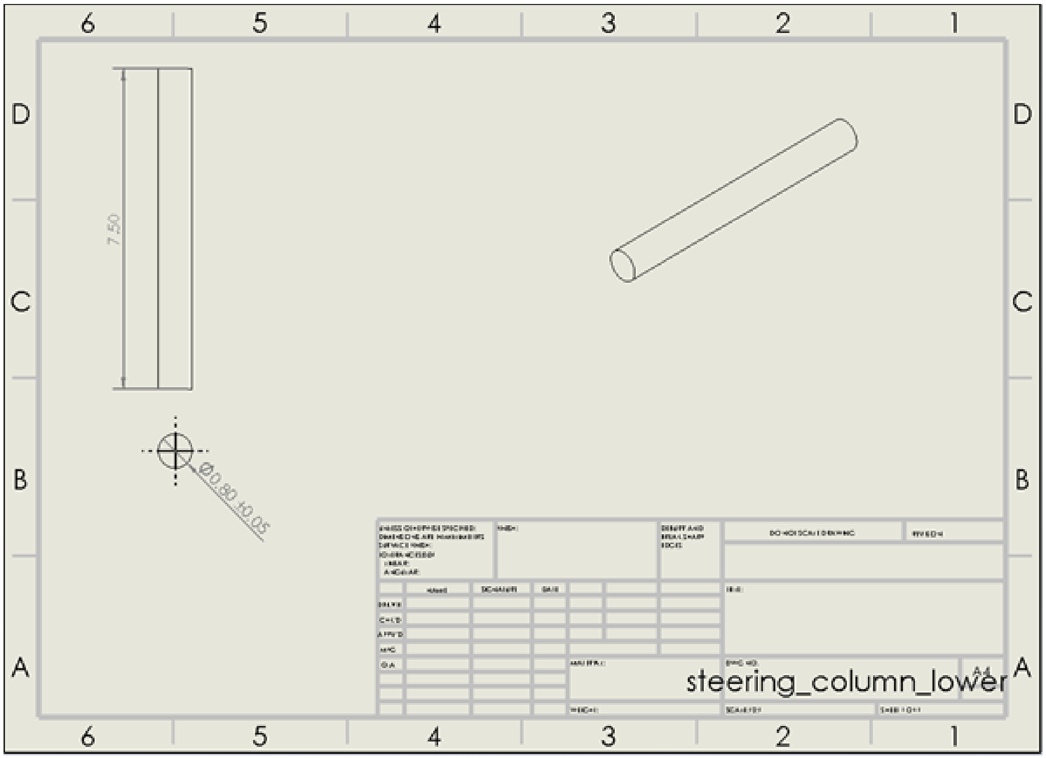
Windup Vertical Shaft



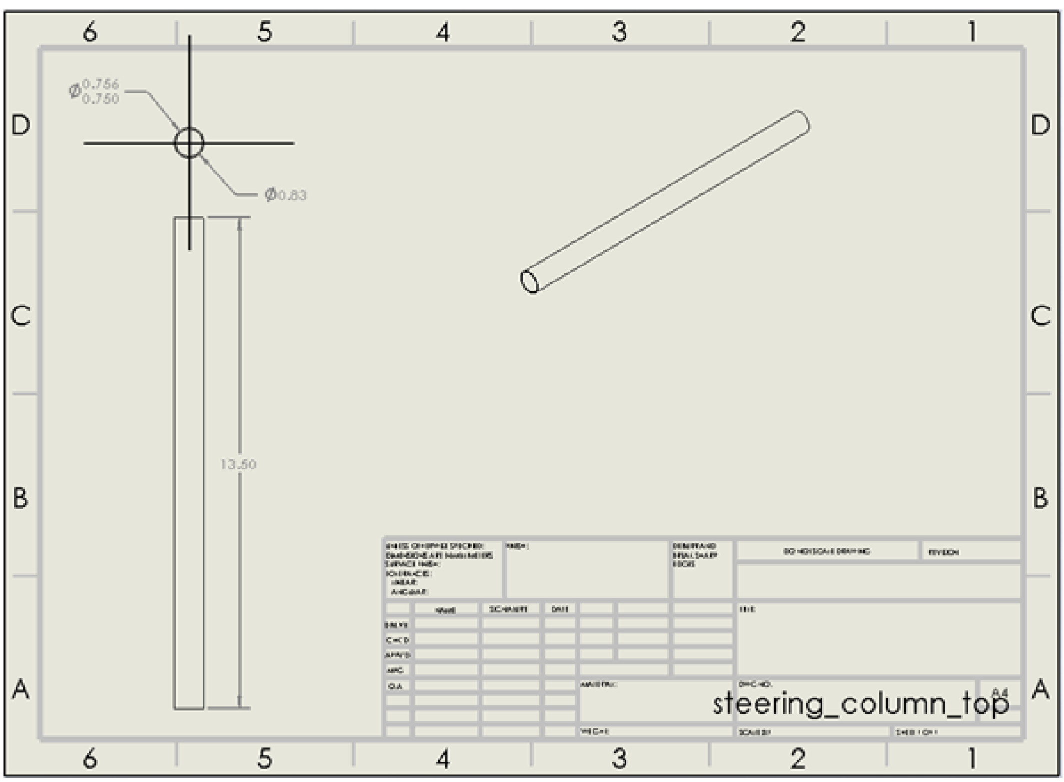
Rear Shield



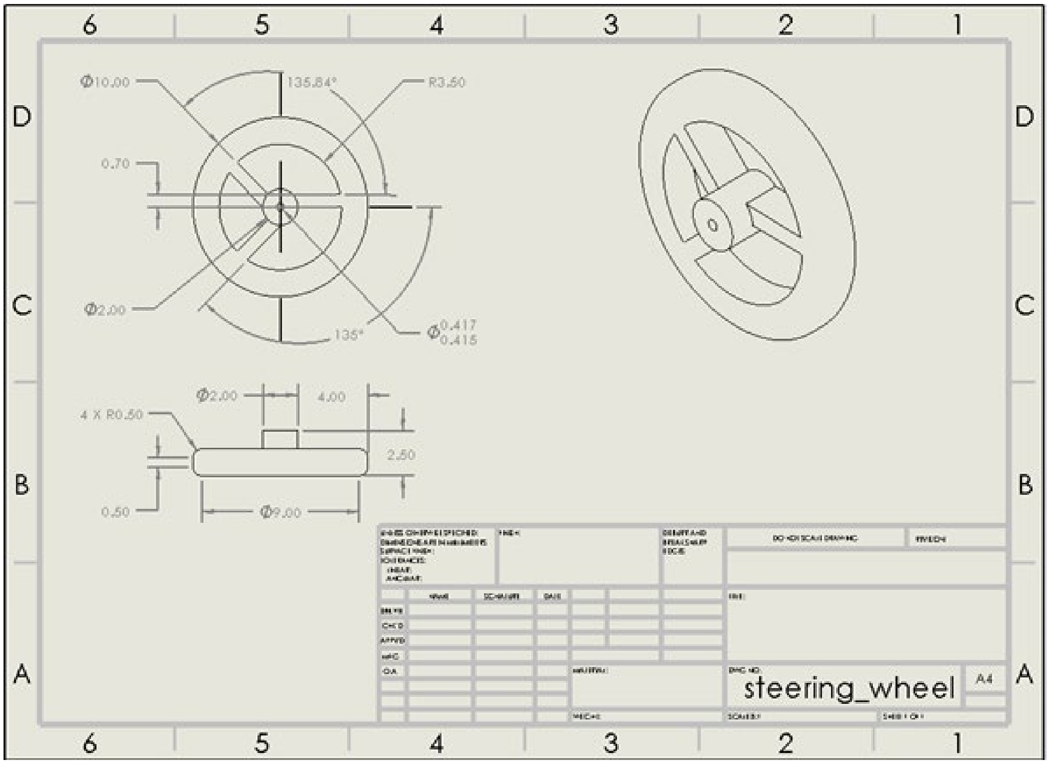
Shell



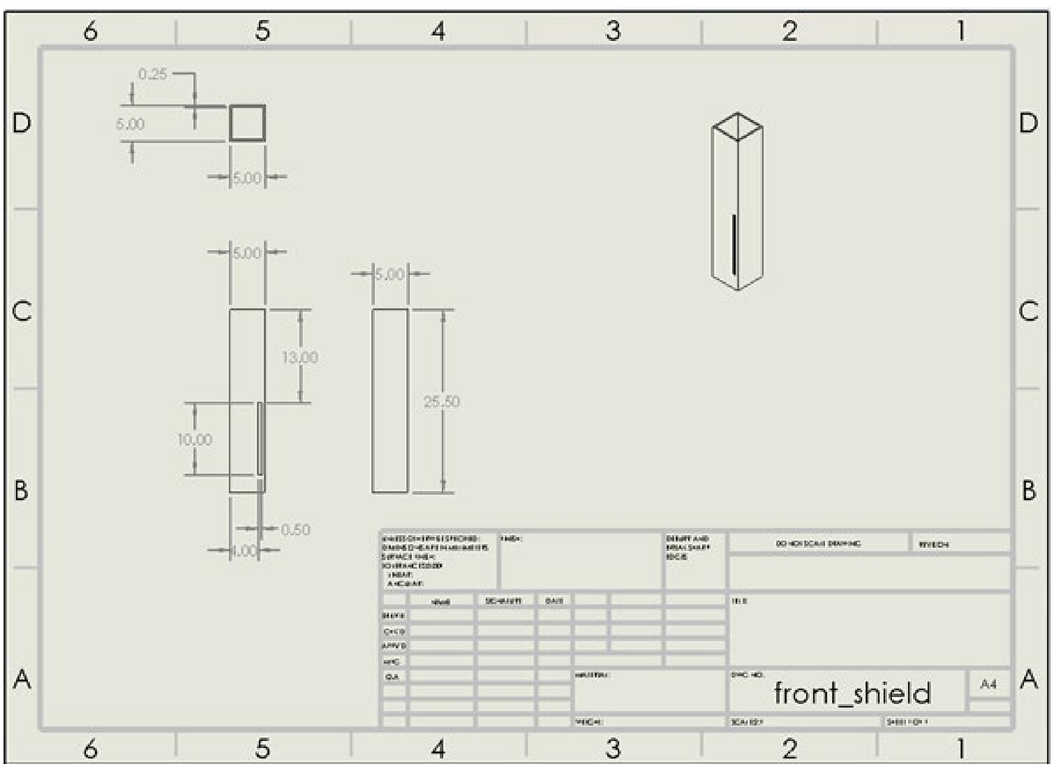
Steering Column Lower



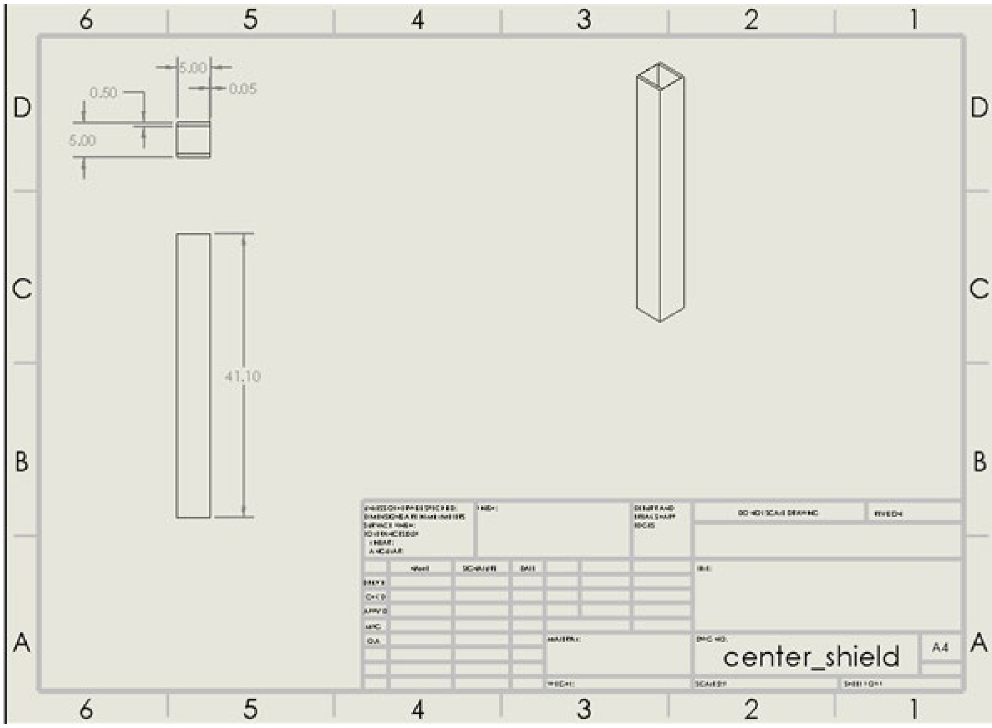
Steering Column Top



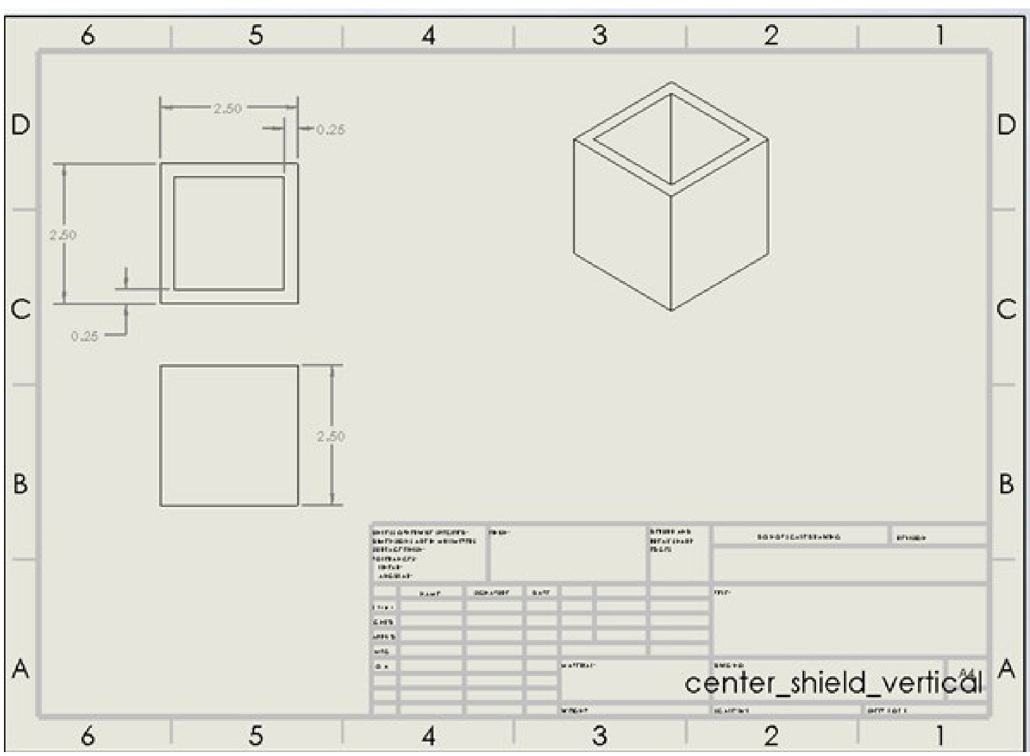
Steering Wheel



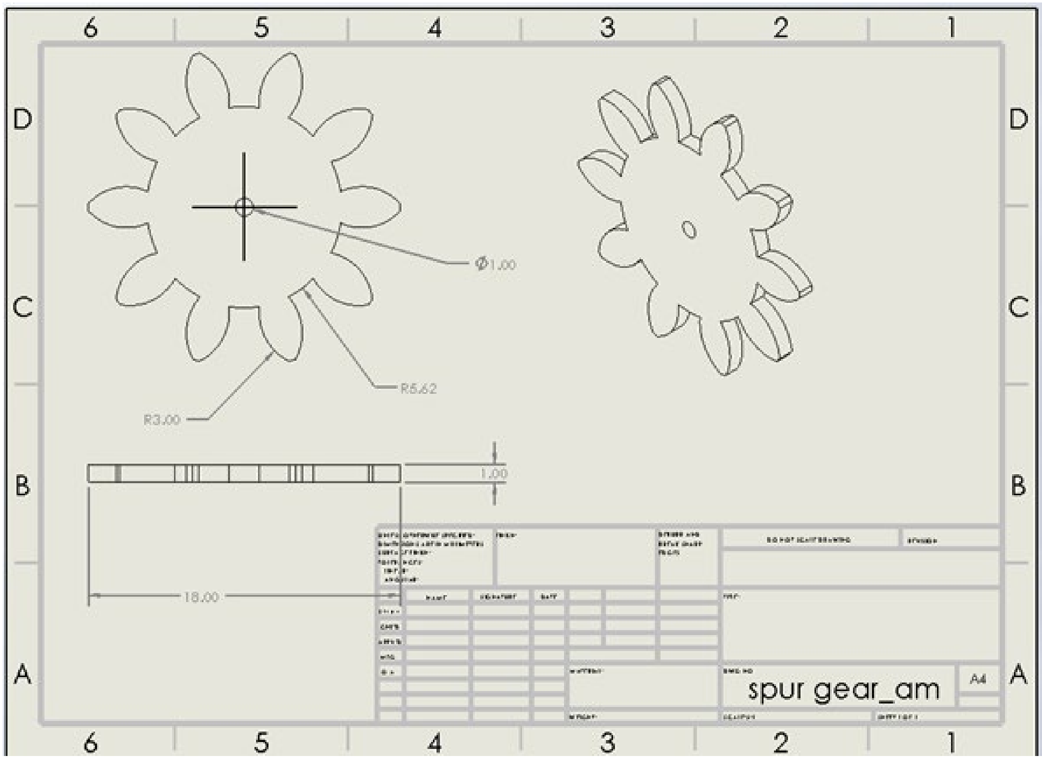
Front Shield



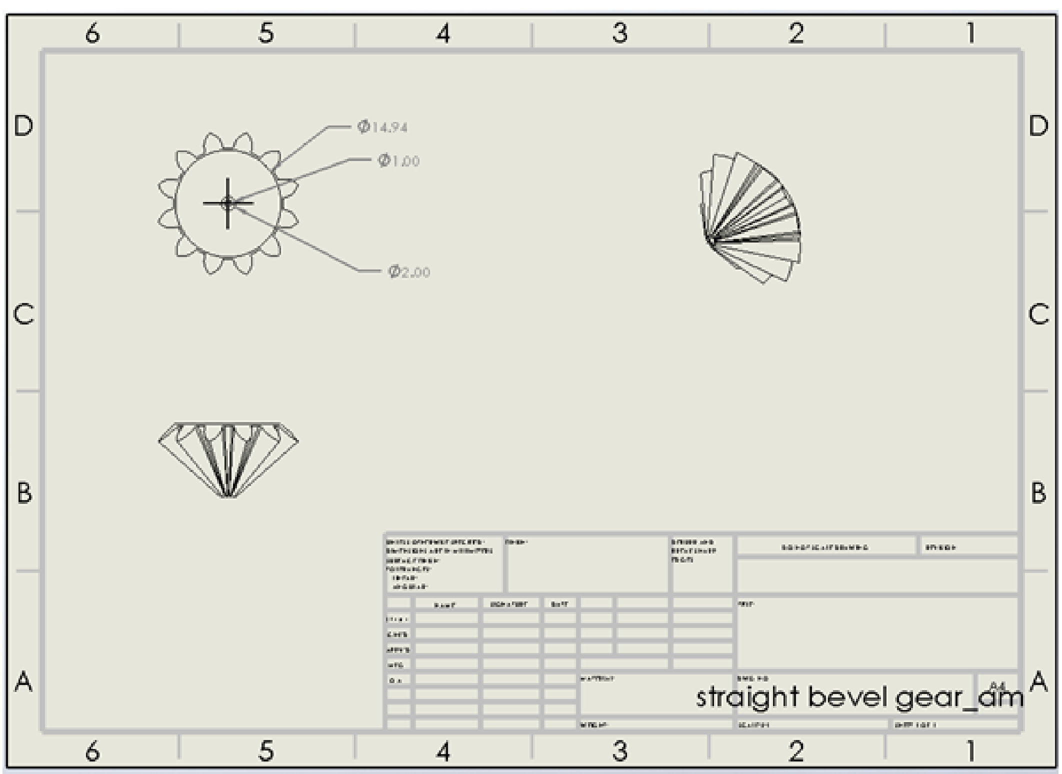
Center Shield



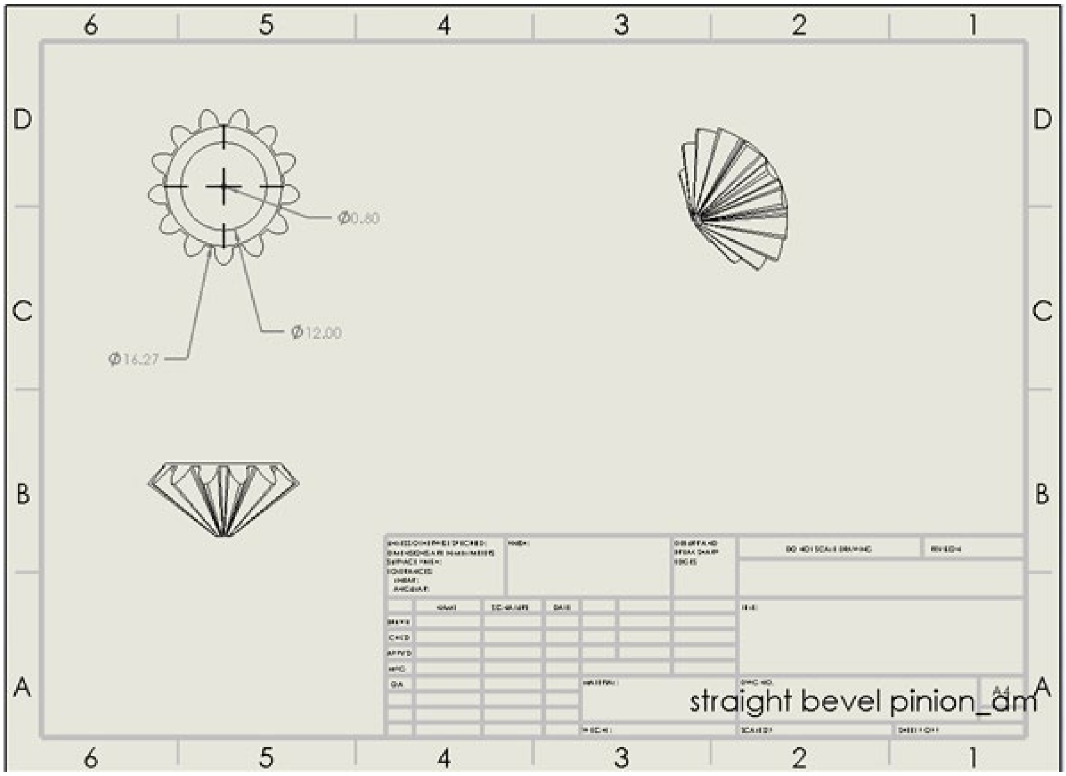
Center Vertical Shield



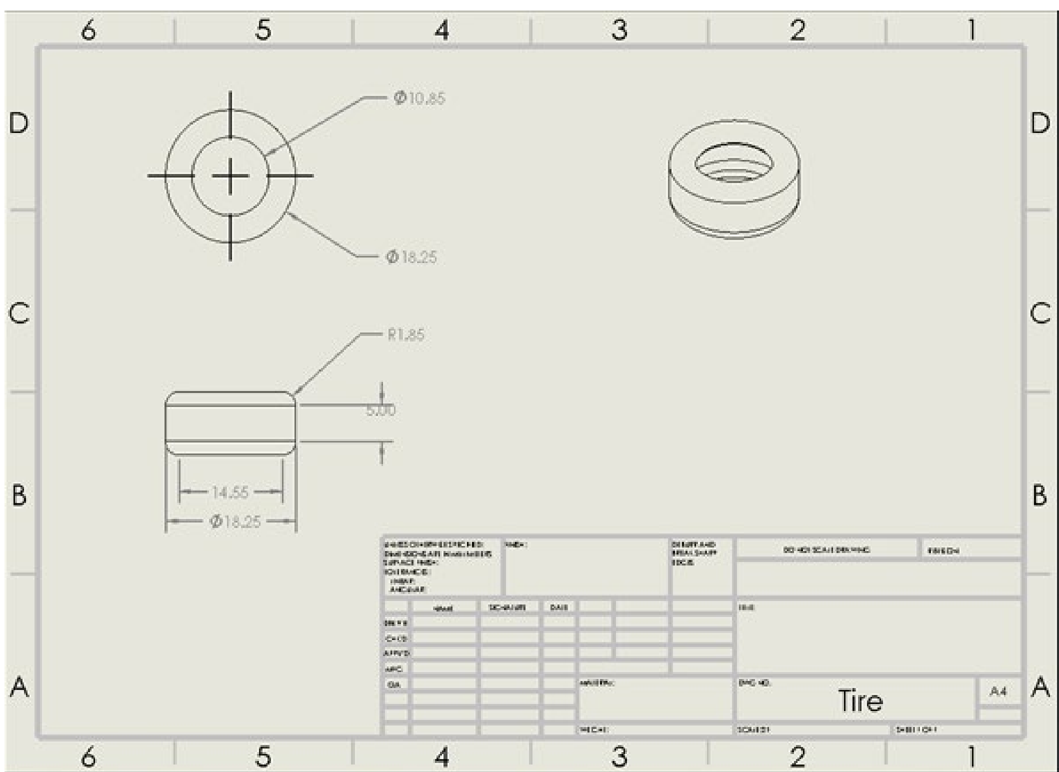
Spur Gear



Straight Bevel Gear



Straight Bevel Pinion



Tire Cover