DESIGN AND DEVELOPMENT OF ORANGE PEELER: AN ERGONOMICS APPROACH

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I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering

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I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicated to my beloved family

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Last but not least, thanks be to God for giving us living in this universe and provide us with all necessary things.

ABSTRACT

This thesis deals with the design and development of an orange peeler with an ergonomics approach. The objectives of this thesis are to design an orange peeler with an ergonomics approach by using SolidWork and simulate by using ALGOR. The purpose for this study is to prevent the musculoskeletal disorder problems when peeling orange. The scope of this project is that the validation of the orange peeler through simulation software is considered precise. As for methodology, the design is based on data from literature review and manual calculation. The design will justify the ergonomics principle and the finite element analysis was performed. The finite element model of design was analyzed using Static Stress with Linear Material Models. Two designs of orange peelers were constructed. The result comes out that peeler A has higher Stress von Misses than peeler B. From the result, it is observed that the designs still lacks in many parts in order to approach the ergonomics criteria. As a conclusion, objectives for the simulation is achieved with comparing the two designs. Thus, the conclusion is based on the literature review, the designed is ergonomics.

ABSTRAK

Tesis ini berkaitan dengan reka bentuk dan penghasilan alat pengupas limau dengan pendekatan ergonomik. Tesis ini bertujuan untuk menghasilkan limau pengupas dengan pendekatan ergonomik dengan menggunakan SolidWork dan mensimulasikan dengan menggunakan ALGOR. Tujuan projek ini adalah untuk mencegah masalah gangguan musculoskeletal ketika mengupas limau. Skop projek ini adalah pengesahan pengupas limau melalui simulasi perisian dianggap tepat. Kaedah yang digunakan adalah mereka bentuk berdasarkan pada data daripada pembacaan dan perhitungan manual. Reka bentuk ini adalah berdasarkan prinsip ergonomik dan analisis elemen hingga dilakukan. Model elemen hingga reka bentuk ini dianalisis menggunakan Statik Stres dengan Linear Model Material. Dua reka bentuk pengupas limau dihasilkan. Keputusan menunjukkan pengupas A mempunyai von Mises Stres yang lebih tinggi dari pengupas B. Dari hasil kajian, diperhatikan bahawa reka bentuk masih kurang di banyak bahagian dalam mengamalkan pendekatan kriteria ergonomik. Kesimpulannya, tujuan simulasi ini berjaya dicapai dengan membuat perbandingan antara dua reka bentuk. Jadi, kesimpulan ini berdasarkan pada hasil pembacaan dan juga reka bentuk ini boleh dianggap ergonomik.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURE

LIST OF SYMBOLS

T	Applied Torque, Nmm
r_o	Major thread radius
h	Thread depth
r_i	Minor thread radius
r_m	Mean thread radius (Pitch Diameter)
r_c	Effective radial area contact surface
f	Coefficient of Friction Screw Thread and Mating (Nut)
f_c	Coefficient of friction at Collar
L	Thread pitch
α	Angle of thread mean radius
θ	Thread angle at bearing surface
θ_n	Angle between Tangent to Tooth profile and a radial line
R_c	Thread constant
W	Load Parallel to screw thread axis
E_{screw}	Efficiency of the Screw Thread Mechanism (ratio of work out
and	work in)
T_{ad}	Torque required to advance the nut

LIST OF ABBREVIATIONS

MSD	Musculoskeletal disorders
SME	Small and medium enteprise
MARDI	Malaysian Agricultural Research and Development Institute
ASTM	American Society for Testing and Materials
AISI	American Iron and Steel Institute

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

An orange is a type of citrus fruit which people often eat. Oranges are a very good source of vitamins, especially vitamin C. Orange juice is an important part of many people's breakfast. The "sweet orange", which is the kind that is most often eaten today, grew first in Asia but now grows in many parts of the world. Oranges are round orange-colored fruit that grow on a tree which can reach 10 meters high. Orange trees have dark green shiny leaves and small white flowers with five petals. The flowers smell very sweet which attracts many bees (Princeton, 2001).

An orange has a tough shiny orange skin. Inside, the fruit is divided into "segments", which have thin tough skins that hold together many little sections with juice inside. There are usually ten segments in an orange, but sometimes there are more. Inside each segment of most types of orange there are seeds called "pips". Orange trees can be grown from pips, but some types of orange trees can only be grown from "cuttings" (a piece cut off a tree and made to grow roots). The segments and the skin are separated by white stringy stuff called "pith". In most types of oranges, the skin can be peeled off the pith, and the segments can be pulled apart with the fingers to be eaten. In some oranges it is hard to take the skin off. With mandarin oranges, the skin, pith and segments can all be pulled apart very easily. Orange skin is often called "orange peel".

Oranges are an important food source in many parts of the world for several reasons. They are a commonly available source of vitamin C. The juice is a refreshing drink. They last longer than many other fruits when they are stored. They are easy to transport because each orange comes in its own tough skin which acts as a container. They can be piled into heaps or carried in bags, lunchboxes and shipping containers without being easily damaged. The color orange takes its name from the fruit. The word "orange" is unusual because it is one of only a few English words that does not rhyme with anything.

Peeling orange is not an easy process. There are several problems that need to be encountered during peeling orange process. First problem is orange has a round shape which tends to rotating. Because of that, orange need to be hold tightly to avoid it rotates while peeling. Second problem is orange has a thick skin. So, it needs to be peeled by sharp tools. The potentially high risks of hand injury due to sharp tools are always present. And the last problem that needs to be encountered is the juicy of the orange while peeling.

Common method of peeling orange is using bare hand and a sharp knife. Peeling orange is not very appropriate due to its high risk of causing injury, many of people start to develop a new technique to peel orange. In 1991, Ban-dak, Joseph try to come out with a simple orange peeler with the design Orange Peeler D320144. Although there are many studies about designing an orange peeler machine, there are still no orange peelers that used ergonomics approach as their core for designing. Most of the designer were focusing on how to minimize the probability of getting hurt and shortens time of operation to peel a orange. An ergonomics study should be put into consideration as it will result bad effect to the operator of the machine for a long term.

Thus, this study is to design and develop orange peeler using ergonomics approach. Generally, ergonomics is a field of study that seeks to design tools, equipment and task to optimize the interface between human and system (Macleod, 1998). This interface can be simple as that between human and a work table such as height of table, sharp edge on table and also foot rest if any (Macleod, 1998).

1.2 OBJECTIVES

The objectives of this study are:

1. To design an orange peeler with ergonomics approach using Solidworks.
2. To simulate the designed orange peeler using Algor.
3. To make comparisons between orange peelers.
4. To justify the design of orange peeler through ergonomics experts.

1.3 SCOPE OF THE STUDY

Without considering unforeseeable problems that might crop up later, these are the exclusions and the things known but not attempted to solve:

1. The validation of the orange peeler through simulation software is considered precise.

1.4 PROJECT BACKGROUND

This project is to solve the musculoskeletal problems among people who manually peel the orange. Currently, there are very studies have been done for such a function. The purpose is to design an orange peeler that will do this by adapting the ergonomics criteria. Doing this can tackle some of the problems associated with the musculoskeletal disorders. Other problems are not tackled in the duration of this project.

1.5 THESIS ORGANIZATION

There are 5 chapters in this thesis and was organized as follow. For each chapter, there are sub-topics in it.

In chapter 1, the introduction consists of describing orange in a scientific way, problem in peeling orange, the studies, the purpose of this study. In addition, this section also includes the objectives of the study, the scope of study, the project assumption and the project background.

Chapter 2 is to gather useful information from journal, book and article that are related to ergonomics study. All of the information gathered from this chapter will be reviewed to design the orange peeler.

Chapter 3 is about methodology of the research design. There are several steps that need to go through in order to achieve the objectives. Justifications about the ergonomics study that related to the orange peelers also noted in this chapter. The software used in this project will also be discussed

Chapter 4 is about analysis of the design based on the previous design in the industry and also ergonomics principles. In this chapter, comparison between designs and also the result of simulation of the design will be discussed.

Chapter 5 will discuss about the achievement of the study and also recommendation regarding the project for the benefits in the future task.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will have all necessary information from journal, book and articles that are related to this project and also about ergonomics study. This chapter is divided into sections. First section of this literature review will cover the history of ergonomics. Second section will discuss about principle of ergonomics that were taken into considerations for this study. Third section will cover on the previous studies on ergonomics design. Fourth section will discuss about anthropometry data used and CAD software will be discussed in general. All of the information gather from this chapter will be reviewed to design an orange peeler. The sources for the literature review are library books, journal from established databases such as Science Direct and Scopus, article and also newspaper article.

2.2 ERGONOMICS

This section will discuss the definition, history and case study about ergonomics and its development.

2.2.1 Ergonomics: Definition

The word "ergonomics" is derived from the Greek Word "ergon" that means work and "nomos" that means law. In the United States, the term ergonomics is also known as "human factor". A direct definition of ergonomics would be that ergonomics aims to design appliance, technical system and task in a way that can improve human safety, health and comfort without sacrifice the performance and efficiency for that particular design.

The formal definition for ergonomics (or human factor) is the field of study that seeks to design tools, equipment, and task to optimize the interface between human and system (Dan Macleod, 2006). Example of the interface is between human and table (sharp edge on table, height of table and also foot rest for the table (Dan Macleod, 2006).

Ergonomics emphasizes on equipment design and workspace design and the relevant subjects are anatomy, physiology, industrial medicine, design, architecture and illumination engineering.

2.2.2 Ergonomics: History

The term ergonomics was invented by Murell in 1949. Ergonomics started to develop and recognize during the Second World War when for the first time human sciences were systematically applied in a co-ordinate manner. At that time, physiologist, psychologist, medical doctor, work scientist, anthropologist and engineer together address the problem arising from the operation of complex military equipment. The result of this inter-disciplinary approach appeared so promising that the cooperation was pursued after the war in industry. In Europe and the United States, the interests in this approach grow rapidly. This lead to the foundation in England of the first ever national ergonomics society in 1949 and starting from that, term "ergonomics" was adopted. After that in 1961, International Ergonomics Association (IEA) was created. At that time IEA was represent ergonomics society which are active at 40 countries or region, with total membership approaching 15000 people (Jan Dul and Bernard Weerdmeester, 2001).

After certain years, modern ergonomics was introduced. Modern ergonomics differ from conventional ergonomics as modern ergonomics only contributed to design and evaluation of work system and product. For conventional ergonomics, engineer designed a whole machine or product. Table 2.1 shows the contribution of modern ergonomics in system design and management.

Table 2.1 Contribution of modern ergonomics in system design and management (Dul and Weerdmeester, 2001)

CONTRIBUTION OF MODERN ERGONOMICS IN SYSTEM DESIGN AND MANAGEMENT
1. A standard format for describing human-machine systems
2. Identification, classification, and resolution of design issues involving the human component
3. Task and human-machine interaction analysis
4. Specification of system design and human behavior. Implementation of controls
5. Identification of core trend in human and biological science and their implications for system design and management
6. Generation of new concepts for the design and analysis of human-machine systems
7. Evaluation of the sociotechnical implication of design option

2.3 ERGONOMICS PRINCIPLES

This section will briefly discuss about the ergonomics principle that were taken into consideration for this study. Ergonomics principle are summarize for the field of ergonomics. There are 10 ergonomics principle is discussed in this section (Mac Leod, 2006).

1. Work in neutral posture

   Work in neutral posture is important as working in awkward position increases fatigue and physically stress in the body. It also reduces strength and dexterity, thereby making task became more difficult to complete. There are several things need to be focused in neutral postures which are:

   i. Maintain the natural curve of the spine
   ii. Keep neck aligned with body
   iii. Keep elbow in and shoulder relax

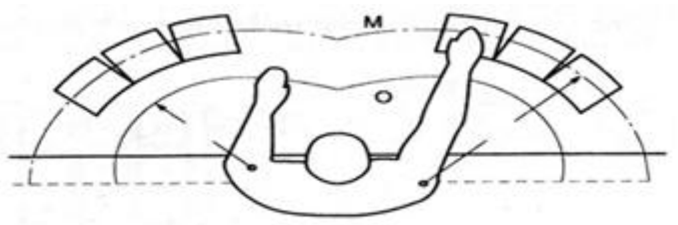
2. Reduce excessive force

   Reduce excessive force is also important in ergonomics. Excessive force can result to creating fatigue, overload muscle and cause injury. There are several ways that can be used in order to reduce force:

   i. Use levers
   ii. Use conveyors
   iii. Improve in grip design
   iv. Change method
   v. Using body position to best advantage
   vi. Fixtures and backstop
   vii. Use Tool and machine

3. Keep everything in easy reach

In order to design a machine that user-friendly, machine part that frequently use need to be in reach envelope. Noted that, rich envelope is semi circle that arms make as it reach. Figure 2.1 show the illustration about reach envelope. There are 2 semi circle lines denoted by M and O in the figure. Capital M is represent by maximum reach envelope that can be achieved and capital O is represent optimum reach that can be achieved without neglecting ergonomics rules.



M = Maximum Reach

O = Optimum Reach

Figure 2.1 Reach envelopes (Bridger, 1995)

4. Work at proper high

Working at wrong high will lead to poor posture and related fatigue, discomfort, and potential damage to soft tissue. Generally, work is best done at about elbow height. However, working high is depending on the nature of work. For example, heavier work requiring upper body strength and it should position slightly lower than elbow height. For works that require high focus, working position should be higher than elbow position. Since people vary in height, the best solution for working height is by design a machine or workstation that can be adjust in height. By doing this, machine or workstation will became more user-friendly and ergonomics.

5. Reduce excessive motion

Number of motion is relatively affected on efficiency and wear and tear on the body. It is important to planned motion in order to reduce excessive force. Excessive force can result injury to sensitive tissue and also joints. Solution for reducing motion is by rearrange layout and organization. Besides that, individual work method also can reduce motion. This is because, if two persons doing the same task, it very common to see that one person will do the task efficiently and the other inefficiently. Repetitions in motion also consider as excessive motion. One of way to overcome this problem is by allow machine or tools to do the repetitions movement. This is possible by redesign that particular machine or tools so it can do the repetitive work. Another possible solution for reducing repetitions in motion is by using mechanical mechanism such as gearing or rack-and-pinion. Figure 2.2 shows the example of tool redesign for screwdriver. There are two pictures in figure 2.2 which are conventional screwdriver and redesigned screwdriver. Conventional screwdriver force user to bend their wrist and will cause excessive motion when us it. This is due to angle of wrist that not perpendicular to the tools holder. Redesigned screwdriver allows user's wrist to be perpendicular to the screwdriver holder. This will result of less motion will be applied while using this tool. Besides of redesigning tool to reduce excessive motion, we also can use motion saving mechanism. Figure 2.3 shows the example of motion saving-mechanism. Instead of using crank to rotate gear, we can use stick with same size of teeth with gear to rotate it.

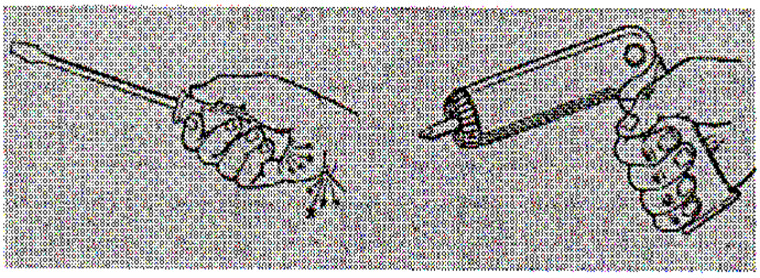


Figure 2.2 Example of tools redesign (Bridger, 1995)

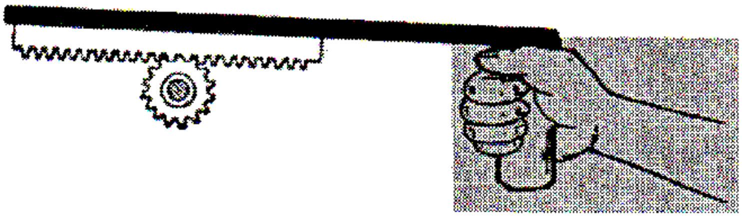


Figure 2.3 Example of using motion-saving mechanism (Bridger, 1995)

6. Minimize fatigue and static load

Fatigue and static load is another challenge in designing. These problems will cause lost production, poor quality accident and wear-and-tear injury to body. Theoretically, fatigue can result from heavy activities (for period of time). Due to fatigue, human will start to sweat and burn calories (metabolic load). Fatigue can be reducing by:

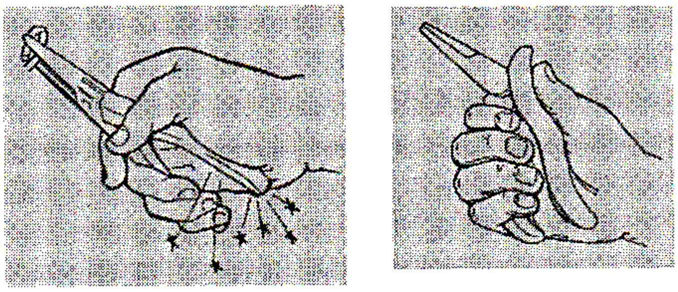
i. Spread peak load over more time
ii. Take frequent, short rest brake
iii. Rotate with less demanding task
iv. Add staffing

Static load can result from holding the same position for period of time. If a person suffered from static load, their muscle will tire and begin to hurt. For long term, this problem will lead to serious damage to that particular tissue or muscle. Static load can be reducing by:

i. Arm rest to support outstretch arms
ii. Fixture, straps or hook to hold item
iii. Shelves or rails on which support a load

7. Minimize pressure point

Pressure point can lead to uncomfortable feeling and can cause restrain in nerve function as well as blood flow. There are four common pressure points which are while gripping, working using table, standing and also while sitting. Pressure point for gripping can be reduced by changing the shape, contour, size and also provide padding for hand grip. Figure 2.4 shows two picture of the same hand held tools. Figure 2.4(a) shows hand held tools that is not provided by padding for hand grip and figure 2.4(b) shows hand held that is equiped by padding for hand grip. By providing padding for hand held tools, pressure point can be minimized.



(a) (b)

Figure 2.4 Provide padding for hand grip (Bridger, 1995)

Working using table also can create pressure point, several solution for that problem are:

i. Padding the edge
ii. Rounding the edge
iii. Providing arm rest
iv. Redesign the task
v. Changing layout to avoid leaning

Standing for a long time on hard surface can lead to tissue damage and also fatigue. Pressure point while standing can be reduces by using anti-fatigue mats and wearing proper shoe (cushion insoles). Figure 2.5 shows the using of anti-fatigue maps to minimize pressure point. Anti-fatigue maps were placed on floor which operator standing to perform their task.

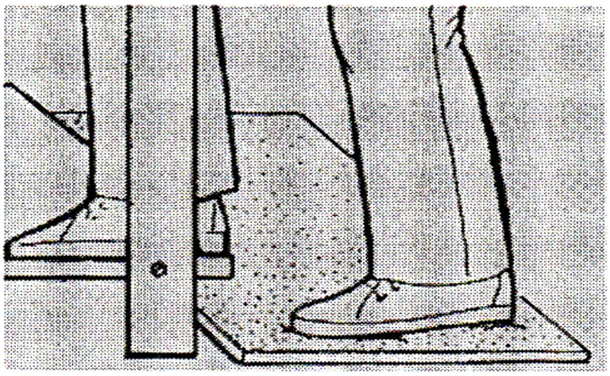


Figure 2.5 Provide cushioning for feet (Bridger, 1995)

8. Provide clearance

Clearance is important in design as it can create bumping hazards or force people to work in controlled posture. Good design should have enough work space and easy access to everything that is needed. Workspace clearance can be improved by:

i. Reorganize equipment, shelves, etc.
ii. Increase size of opening
iii. Eliminate obstruction

9. Move, exercise, and stretch

All of the above ergonomic principle should not conclude that the best ergonomics design is work by pushing button only. Healthy life requires body activities. However, in working movement or exertion were often too much. To reduce effect of too much movement or exertion, warm-ups body is a one way. Another way is by allow for alternate posture.

10. Maintain a comfortable environment

For the last ergonomics principle is by maintaining a comfortable environment. Comfortable environment related with lighting, working temperature, surrounding air, level of noise and other factor that contributed to uncomfortable feeling.

2.4 PREVIOUS STUDIES ON ERGONOMICS DESIGN

Table 2.2 shows the previous finding on ergonomics studies. This table consists of 7 topics which are designing work surface, designing work station, design and selection guide of hand held tools, basic posture, maximum height for control for standing position, adjustable workstation and crank design. Information gathered from this section will be used to design a preliminary design for durian peeler.

Table 2.2 Finding on ergonomics design

No	Topic	Journal/book	Author	Year	Findings
1	Designing work surface	Introduction to Ergonomics	R.S. Bridger	1995	People are varying in height. The workstation should be designed with the consideration of height and also type of work.
2	Designing workstation	Ergonomics in Manufacturing	Waldemar Kaewowski and Gavriel Salvendy	1998	Height of the working surface should maintain a definite relationship with the operator elbow height, depending on the type of work The maximum reach can be considered as the boundary on the work surface in front of an operator that he/she can reach without flexing his own/her torso The minimum lateral clearance at waist level is determined by adding 5 cm

Table 2.2 Finding on ergonomics design continue

					on both side or 10 cm to hip breadth(standing position)
3	Design and selection guide for hand held tools	Ergonomics in Manufacturing	Waldemar Kaewowski and Gavriel Salvendy	1998	Principles of hand tools designed: ▪ Should effective perform the function of which it was intended ▪ Properly proportional with operator body dimension ▪ Suitable adjusted to the strength and work capacity of the operator ▪ Not cause premature fatigue ▪ Inexpensive and easy to maintain For grip material, Konz(1990) recommended to use the compressible grip material that dampens vibration and allows better distribution of pressure across the palm/grip contact area Wu(1975) and Mital(1991) indicated that grip material should not absorb liquid and not permit conduction of heat or electricity Sharp indentation or grooves should be avoided For grip shape, grip shape should maximize the area contact between the palm and the grip to provide better pressure distribution and reduce change of forming pressure ridges or pressure concentration point Handle diameter should be 41 to 86 mm for power grip

Table 2.2 Finding on ergonomics design continue

					Grip length should be at least 102 mm
	Basic Posture	Ergonomics for beginner	Jan Dul and Bernard Weerdmeester	2001	Activities where considerable force has to be exerted or where the work place has to be frequently changed should be carried out in standing position Guideline for work carried in standing position ▪ Alternate standing with sitting and walking ▪ Work height depend on the task ▪ Height of the work table must be adjustable ▪ Avoid using platform ▪ Provide sufficient room for legs and feet
5	Maximum height for control : standi[illegible] positi[illegible]	Kodak's Ergonomics Design for [illegible]	Eastman Kodak Company	2004	Any control manipulations that required not a light effort, control should be [illegible] oulder [illegible] than knuckle height
6	Adjustable workstation	Kodak's Ergonomics Design for People at Work	Eastman Kodak Company	2004	Adjustable workplace is needed as people vary in size and strength. Most of workplace require attention more than one anthropometry data
7	Crank design	Kodak's Ergonomics Design for People at Work	Eastman Kodak Company	2004	Crank design must be suitable to force applied

Table 2.2 Finding on ergonomics design continue

Table 2.3 Recommended work surface height for standing workers (Bridger, 1995)

RECOMMENDED WORK SURFACE HEIGHTS FOR STANDING WORKERS(in cm)		
Task Requirement	Male	Female
Precision work	109-119	103-113
Light assembly work	99-109	87-98
Heavy work	85-101	78-94

2.4.1 Previous Orange Peeler Design

There are varieties of orange peeler machines have been developed nowadays. However, many of these orange peelers were not ready to be commercialized and only be used for personal purpose only. This section only discusses about orange peeler that is ready to be commercialized. Table 2.4 shows the previous design on orange peeler.

Table 2.4 Previous design of Orange Peeler

Year	Title	Designer	About Design
1991	Orange peeler (United States Patent D320144)	Ban-dak, Joseph (POB 14, Kiryat Atta 28000, IL)	Design peeler that operate using fingers
2010	Citro Orange Peeler	Markus Brodmerkel	Design a peeler for right-handed use
1992	Fruit peeling machine United States Patent 5133250	Del Ser, Gonzalez Clemente (Paseo de Talleres, No. 36, 28021 Madrid, ES)	Design a peeler that use a motor

2.5 ANTHROPOMETRY DATA

Due to the limited source on Malaysian anthropometry data, anthropometry data of the southern Thai population is used in this study. This research is done by Jaruwan Klamklay, Angoon Sungkhapong, Nantakrit Yodpijit and Patrick E. Patterson on 2006.

	Dimension[a]	Mean	S.D.	1st percentile	5th percentile	50th percentile	95th percentile	99th percentile
1	Weight (kg)	61.85	8.57	46.00	49.95	60.42	75.42	86.06
2	Stature	171.94	5.15	161.99	164.60	170.92	181.25	184.60
3	Eye height	160.21	5.01	151.73	153.60	159.28	169.07	172.35
4	Shoulder height	140.67	11.74	99.14	135.56	141.30	149.44	154.06
5	Elbow height	109.18	8.75	98.83	102.40	107.78	119.54	151.03
6	Hip height	84.96	4.09	76.03	77.88	84.55	91.25	95.61
7	Knuckle height	74.19	10.13	64.79	69.00	73.07	79.23	83.86
8	Fingertip height	63.21	4.87	55.44	59.17	63.18	69.06	71.08
9	Sitting height	90.16	3.41	83.01	85.30	89.95	95.30	100.90
10	Sitting eye height	78.01	3.37	70.69	72.69	78.13	83.04	84.57
11	Sitting shoulder height	60.63	2.68	53.66	56.16	60.82	65.31	66.52
12	Sitting elbow height	25.11	2.58	19.05	21.47	25.05	28.85	30.84
13	Thigh thickness	14.21	1.46	11.10	11.90	14.18	17.10	17.40
14	Buttock–knee length	58.52	2.45	53.43	54.95	58.40	61.91	64.25
15	Buttock–popliteal length	48.23	3.95	43.85	45.02	48.42	51.78	54.02
16	Knee height	52.81	2.29	47.86	48.62	52.85	56.07	59.11
17	Popliteal height	43.04	1.56	39.66	40.64	43.02	45.51	46.18
18	Shoulder breadth (bideltoid)	43.24	2.26	38.10	39.63	43.12	46.94	49.27
19	Shoulder breadth (biacromial)	40.45	1.99	35.96	37.28	40.25	43.85	44.77
20	Hip breadth	34.34	5.48	29.80	30.82	33.77	36.89	39.52
21	Chest (bust) depth	19.85	1.92	14.73	16.68	19.90	22.59	25.63
22	Abdominal depth	20.90	2.43	16.00	17.52	20.98	24.45	26.97
23	Shoulder–elbow length	35.97	1.46	32.70	33.46	35.93	38.21	39.47
24	Elbow–fingertip length	47.12	1.63	44.00	44.70	47.00	50.24	50.64
25	Upper limb length	77.12	4.12	70.16	72.92	77.02	82.57	83.54
26	Shoulder–grip length	66.55	2.73	61.52	62.65	66.47	71.44	72.05
27	Head length	18.99	0.73	17.59	17.93	18.92	20.04	20.70
28	Head breadth	15.78	0.56	14.60	14.86	15.80	16.70	17.03
29	Hand length	19.11	7.16	16.80	17.13	18.40	20.30	21.49
30	Hand breadth	8.22	0.35	7.40	7.66	8.25	8.87	8.90
31	Foot length	25.35	0.99	23.29	23.63	25.42	26.90	27.20
32	Foot breadth	9.80	0.54	8.73	8.97	9.75	10.67	11.07
33	Span	174.28	13.88	107.32	166.35	175.15	187.73	190.85
34	Elbow span	90.07	3.14	84.43	85.72	89.90	95.71	96.51
35	Vertical grip reach (standing)	204.73	12.51	170.51	195.95	204.65	217.17	220.61
36	Vertical grip reach (sitting)	124.78	14.51	115.42	117.63	124.02	132.92	177.06
37	Forward grip reach	73.66	4.70	64.41	68.00	73.78	80.34	81.63

Figure 2.6 Anthropometry data of the male southern Thai population, aged 18–25 years (*n*= 100) (Source: Jaruwan et al., 2006)

	Dimension[a]	Mean	S.D.	1st percentile	5th percentile	50th percentile	95th percentile	99th percentile
1	Weight (kg)	49.90	7.59	38.00	40.95	48.07	64.22	72.11
2	Stature	157.94	5.32	146.36	149.44	157.98	167.18	169.48
3	Eye height	146.29	5.15	135.73	137.41	146.03	155.09	158.57
4	Shoulder height	129.71	4.94	119.91	122.73	129.43	139.19	142.30
5	Elbow height	99.02	6.15	90.63	92.25	98.65	105.19	117.82
6	Hip height	78.36	4.08	69.76	72.62	77.90	85.67	87.27
7	Knuckle height	68.26	3.03	61.99	63.55	68.40	73.00	74.20
8	Fingertip height	59.08	2.89	51.97	54.56	59.22	63.11	65.38
9	Sitting height	83.70	5.00	77.22	79.39	84.00	88.43	91.01
10	Sitting eye height	72.97	2.93	66.12	68.76	73.27	76.75	80.55
11	Sitting shoulder height	56.50	4.35	47.13	52.33	56.25	61.24	66.83
12	Sitting elbow height	23.12	2.06	18.96	20.02	23.07	26.04	27.21
13	Thigh thickness	12.01	1.03	10.27	10.62	11.87	13.84	14.90
14	Buttock–knee length	54.54	2.51	49.87	50.96	54.30	59.38	60.37
15	Buttock–popliteal length	46.43	2.22	42.73	43.39	46.12	50.69	52.07
16	Knee height	48.13	2.16	43.96	44.70	47.77	51.77	53.74
17	Popliteal height	40.17	1.41	36.66	38.13	40.08	42.90	43.24
18	Shoulder breadth (bideltoid)	38.75	1.96	35.24	35.83	38.57	41.88	44.67
19	Shoulder breadth (biacromial)	35.19	1.59	31.76	32.60	35.22	37.74	38.64
20	Hip breadth	36.15	2.18	32.36	33.18	35.65	39.91	41.15
21	Chest (bust) depth	19.95	1.67	17.52	17.83	19.70	23.35	24.22
22	Abdominal depth	18.45	1.70	15.23	16.20	18.30	21.76	23.34
23	Shoulder–elbow length	33.36	1.64	30.03	30.80	33.17	36.24	37.12
24	Elbow–fingertip length	42.57	3.52	38.93	39.36	41.92	45.77	47.31
25	Upper limb length	69.71	3.18	63.26	64.72	69.30	75.24	76.35
26	Shoulder–grip length	59.56	2.78	53.83	55.53	59.53	64.54	66.57
27	Head length	17.97	0.64	16.57	16.96	17.93	18.97	19.20
28	Head breadth	14.95	0.58	13.70	14.00	14.95	15.87	16.20
29	Hand length	16.61	0.73	15.20	15.46	16.57	17.84	18.10
30	Hand breadth	7.26	0.34	6.50	6.57	7.30	7.77	7.87
31	Foot length	22.68	0.94	20.50	21.05	22.78	24.00	24.57
32	Foot breadth	8.63	0.47	7.46	7.93	8.63	9.47	9.63
33	Span	157.41	6.86	143.96	146.97	155.60	169.46	172.50
34	Elbow span	81.17	3.35	74.97	76.02	80.55	87.31	88.24
35	Vertical grip reach (standing)	187.12	9.56	170.96	176.16	187.53	201.47	208.29
36	Vertical grip reach (sitting)	114.81	10.86	101.75	106.76	113.38	122.63	153.57
37	Forward grip reach	68.45	3.28	62.91	63.60	67.77	74.13	78.37

Figure 2.7 Anthropometry data of the female southern Thai population, aged 18–25 years (*n*= 100) (Source: Jaruwan et al., 2006)

2.6 CAD SOFTWARE

CAD is an acronym for Computer Aided Design which means the usage of computer technology to aid in the design and any particularly drafting of a part or product, including entire buildings .Drafting can be done in two dimensional (2D) or three dimensional (3D). There are plenty of CAD software available in the market. Each of that has its own advantages and disadvantages. For this section, two CADs software will be discussed and compared. CAD software that will be discussed is SolidWorks and AutoCAD.

2.6.1 SolidWorks

SolidWorks is a parasolid-based solid modeler, and utilizes a parametric feature-based approach to create models and assemblies. SolidWorks was developed by Solid Work Cooperation and now a subsidiary of Dassault Systèmes, S. A. (Vélizy, France).Core product for this software includes tools for 3D modeling, assembly, drawing, sheetmetal, weldments, and freeform surfacing. By using SolidWork, 2D drawing can be easily converted to 3D drawing and vice versa. SolidWork also support numerous of extension file such as IGS file, DWG file etc.

2.6.2 ALGOR

Same with SolidWork software ALGOR is CAD software application for designing and stimulating. ALGOR is a general-purpose multiphysics finite element analysis software package developed by ALGOR Incorporated for use on the Microsoft Windows computer operating systems. It is distributed in a number of different core packages to cater to specifics applications, such as mechanical event simulation and computational fluid dynamics. ALGOR is used by many scientists and engineers worldwide. It has found application in aerospace, and it has received many favorable reviews

2.6.3 Comparison for CAD Software

Each of the CAD software has its own advantage and disadvantages. Table 2.5 shows the comparison for the selected CAD software. The comparison will be based on certain criteria which are availability of the software, function of the software, supported import and export file type and knowledge on that particular software.

Table 2.5 Comparison for the selected CAD software

CAD software	**Benefits**	**Disadvantages**
SolidWorks	Can easily convert 3D to 2D and vice versa. Can easily modify the drawing. Can create simulation on design (how its work). Support IGS file which is file that export to finite Element Analysis software. Support assembling drawing which means, design can be draw separately for each part.	High performance computer needs to run this software. Previous version of SolidWorks file not compatible with newer version of SolidWorks file.
ALGOR	ALGOR is a complete FEA solution that offers a good combination of cost-effectiveness, quality and features within ALGOR FEMPRO, an easy-to-use interface. it provides all the necessary features for directly capturing 3-D solid geometry from, generating a high-quality solid FEA mesh, easily setting up loads and constraints, performing analyses quickly, evaluating results and presenting a final design.	Whole must be drawn in as it not support assembling drawing function. Limited materials can be use and it has its own properties of materials.

2.7 CONCLUSION

Ergonomics design is related to the principle of ergonomics. To design an ergonomics tools, principle of ergonomics need to be followed. Besides relying on literature review to get data for ergonomics design, conducting a survey is also a proper way to get the data. Next chapter will discuss on the methodology of this project.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter is about the method that is used to collect data in completing this study. Explanations for this chapter will be based on several elements that contains in the flow chart of the study. This methodology includes the step to design the product until the steps to develop the simulation using the finite element analysis software.

3.2 FLOW CHART OF THE STUDY

Figure 3.1 shows overall flow chart of this project. This flow chart is the simplification of the methodology for this project and showing the steps to complete the project.

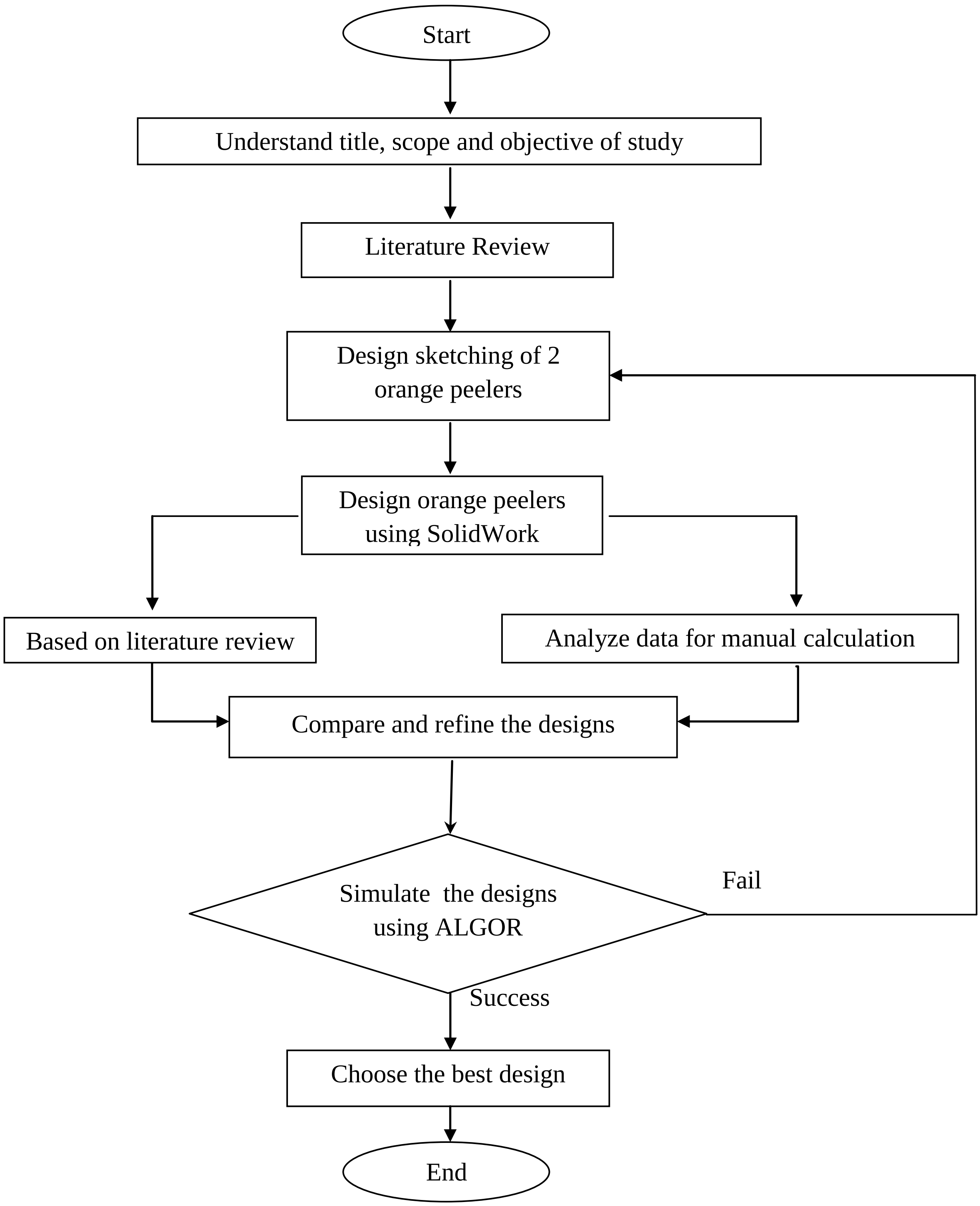


Figure 3.1 Flow chart of the study

3.3 LITERATURE REVIEW

Literature review is one of the methods to collect data for this study. Literature review is only being done on reliable sources such as journal from established databases such as Science Direct and Scopus, book from library and also articles. There are four steps in doing a literature review which is scanning, marking, reading and review. Scanning is also can be defined as surveying. Second step is marking the important or useful topic and information found on step 1. Third step is further reading on that particular topic or content. At this step, understand the reading is a main objective that needs to be achieved. Last but not least is to review back the reading. This step required skill to extract data from the readings and explain it using own word.

3.4 DESIGN THE ORANGE PEELERS

Designing an orange peeler is the main objective for this study. These orange peelers are design to solve mass production to peel the oranges. There are several stages in designing the orange peeler. First stage is to design based on the literature review. The design is focus on the information about ergonomics study the previous design.

The second stage is to choose the suitable materials. Each part in orange peeler has its own use. So, the material needed might be different due to the materials properties itself.

The last stage is to develop a design that satisfied both ergonomics principle and also the needs of people. The design will be drawn using Solidwork software and below are the steps that have been taken in order to design orange peelers:

1. This design has many parts in it. It required to be design part by part, so choose 3D representation of a single design component like in Figure 3.2.

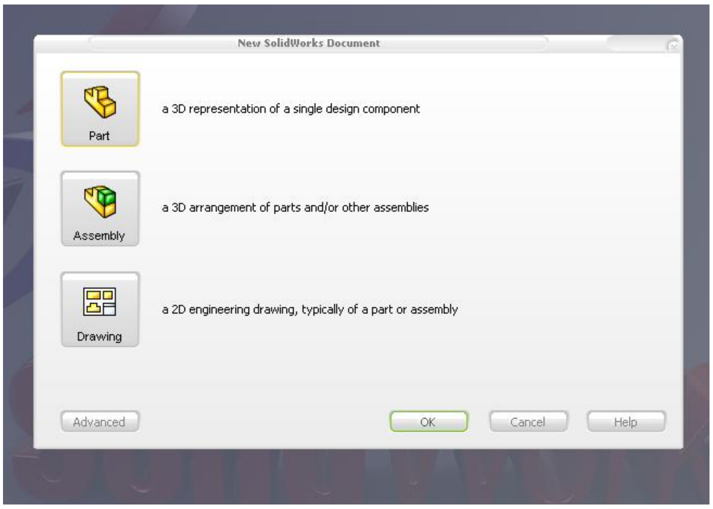


Figure 3.2 Select SolidWork Document for Part

Draw all the parts that are needed for an orange peeler by using the same step.

2. After all parts are drawn, assemble all the parts together. Choose the button 'Assembly' like in Figure 3.3.

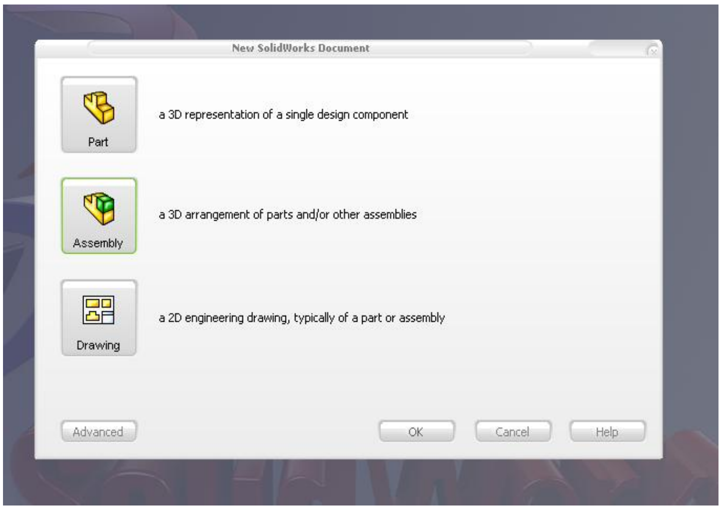


Figure 3.3 Select SolidWork Document for Assembly

The result for the assembly should be like Figure 3.4.

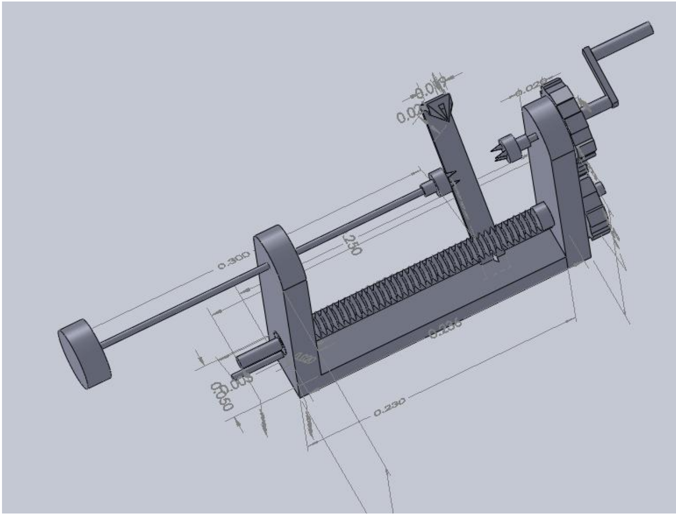


Figure 3.4 Result after the Assembly

3. Design another orange peeler with the same steps. The design should also base on the literature reviews.

3.5 DEVELOPING THE SIMULATION

The test should be done to the designs to identify the strength and ability of the design to support any force or rotation. In this project, finite element analysis method is used. The software used is ALGOR because it can validate and optimize the design quickly before moving to the manufacturing process.

In this analysis, the simulation is to compare which design can provide better quality and can handle the force better. So, the materials of the orange peelers are constant, which for most part that can be attached to an orange is Stainless Steels (AISI 430), and the body part is Steels (ASTM-A36).

Below are the steps that have been taken in order to develop the simulation by using ALGOR:

1. The type of analysis that will be used in this analysis is Static Stress with Linear Material Models. It is because the model cam be analyzed with multiple loads.

2. Since this orange peeler is fully solid, so the suitable element type that can be used is tetrahedral. This type of element can easily detect all the nodes in every single part of the design.

3. Define the materials used for each part of the design. Figure 3.5 and Figure 3.6 shows the properties of material used, which are Stainless Steels (AISI 430) and Steels (ASTM-A36).

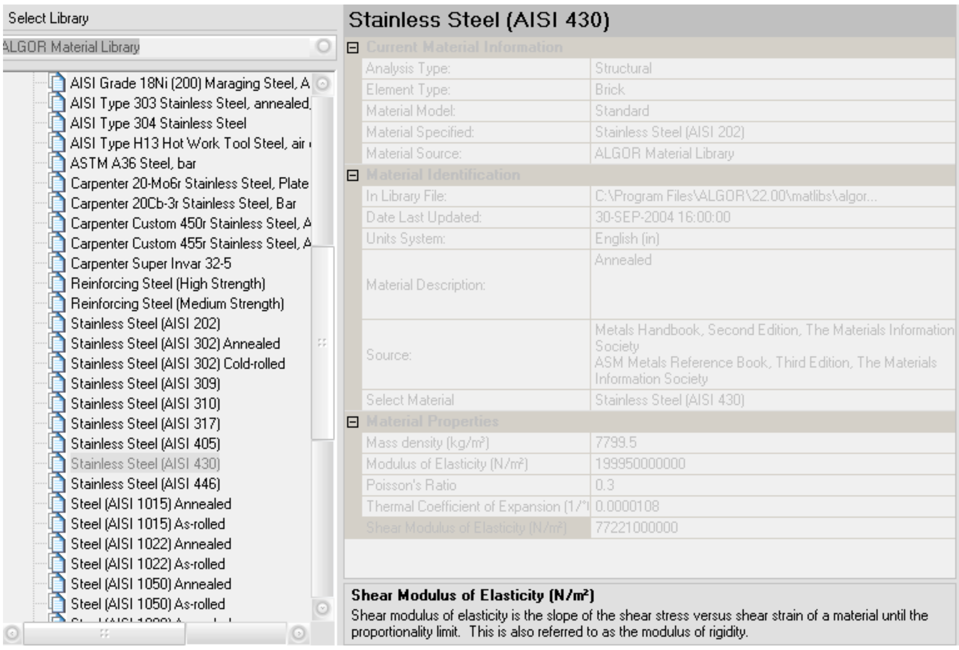


Figure 3.5 Properties of Stainless Steel (AISI 430)

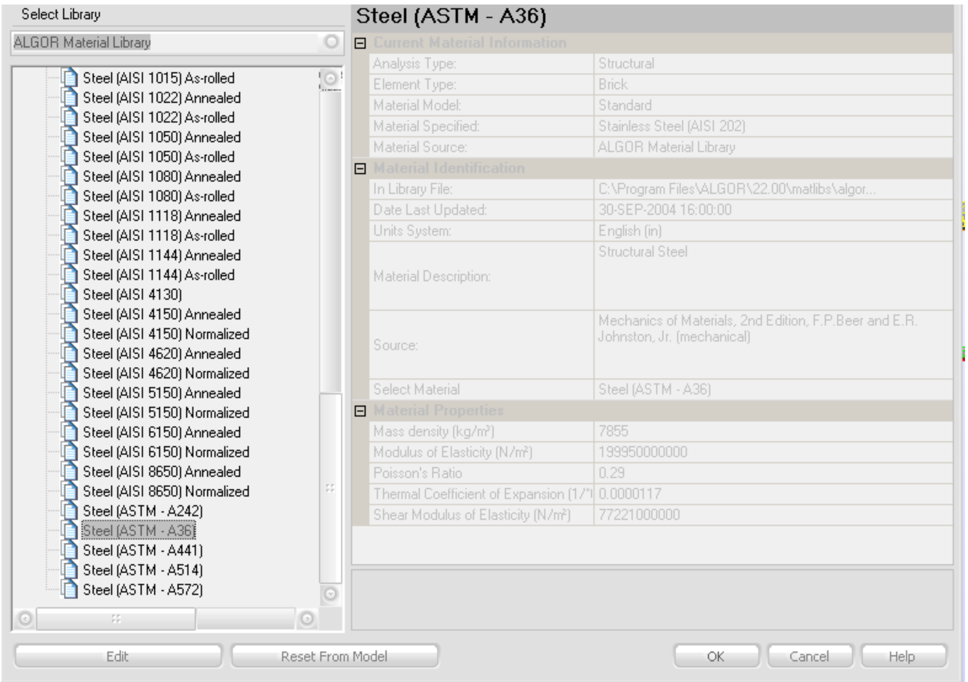


Figure 3.6 Properties of Steel (ASTM-A36)

4. The design from SolidWork software is transferred to ALGOR by converting it to *.igs* file. Then, the design is meshed like Figure 3.8 before the analysis start.

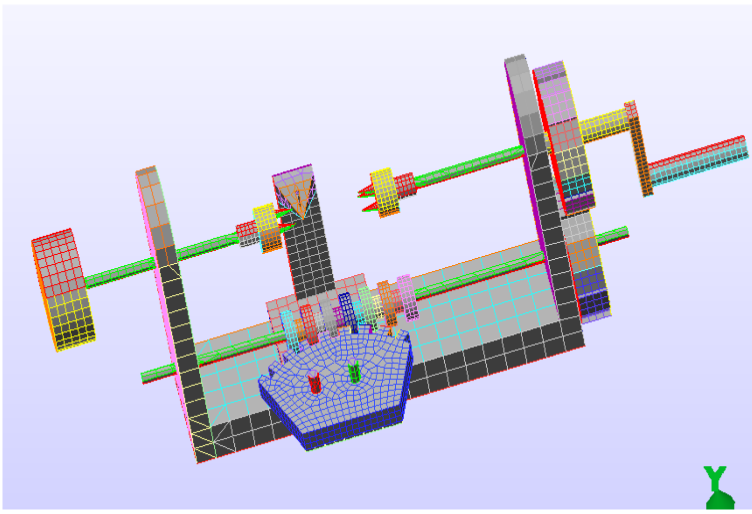


Figure 3.7 Design after mesh

5. Then, the loads that need to be considered can be add like in Figure 3.9. Every forces and rotation need to be considered.

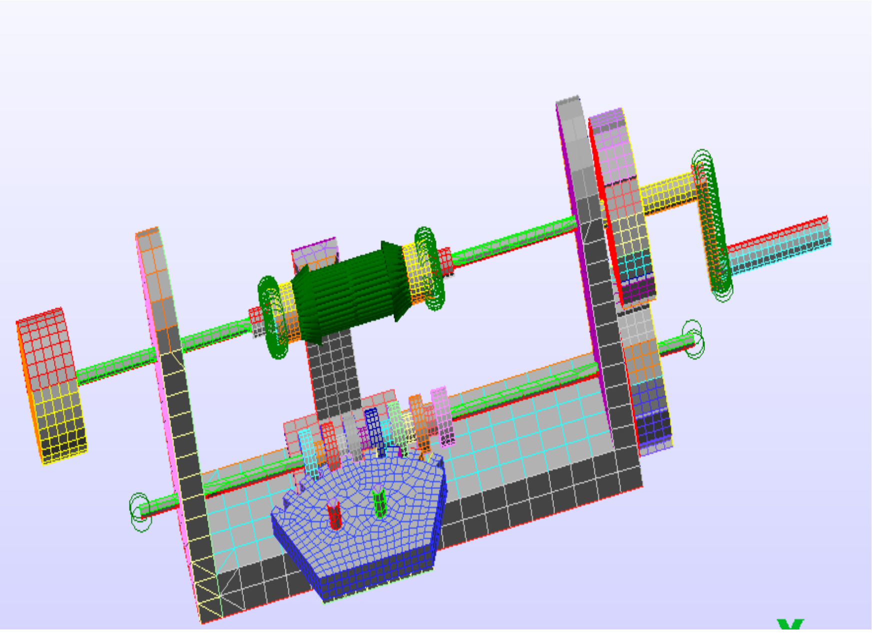


Figure 3.8 Setting the Loads and Boundary conditions

6. Analyzing the model after it is ready. Repeat the steps to analyze the second design. Finally the result for both analyses can be compared and the best design is choose.

3.6 MATERIAL SELECTION

There are several parts that need to be design for an orange peeler such as blade, rod, gear, handle, shaft and also the base.

The material selection for blade, rod and shaft is martensitic stainless steel. Martensitic stainless steels are essentially alloys of chromium and carbon that possess a martensitic crystal structure in the hardened condition. They are ferromagnetic, hardenable by heat treatments, and are usually less resistant to corrosion than some other grades of stainless steel. Chromium content usually does not exceed 18%, while carbon content may exceed 1.0 %. The chromium and carbon contents are adjusted to ensure a martensitic structure after hardening. The high carbon enables the material to be hardened by heating to a high temperature, followed by rapid cooling (quenching). Martensitic types offer a good combination of corrosion resistance and superior mechanical properties, as produced by heat treatment to develop maximum hardness, strength and resistance to abrasion and erosion. The martensitic grades are usually sold in the soft state. This allows the customers to cut or form the parts before they are thermally hardened. Excess carbides may be present to enhance wear resistance or as in the case of knife blades, to maintain cutting edges. The selection material for gear is based on the Table 3.1.

Table 3.1 Material for gears

Material	**Outstanding features**	**Applications**	**Precision Rating**
Ferrous:			
Cast Iron	Low cost, good machining, high internal damping	Big size, moderate power rating, Commercial gears	Commercial quality
Cast Steel	Low cost, high strength	Power Gears, medium rating	Commercial quality
Plain Carbon Steel	Good machining, Heat treated	Power Gears, medium rating	Commercial to medium precision
Alloy Steels	Heat treated, high strength and durability	Strict power requirements	High precision
Stainless Steel	High corrosion resistance, nonmagnetic	Low power rating	Good Precision
Non Ferrous:			
Aluminium alloys	Light weight, noncorrosive, good machinability	Very light duty instrument gears	High precision
Brass alloys	Low cost, noncorrosive, good machinability	Low cost commercial equipment	Medium precision
Die cast alloys	Low cost, low strength	High production, low quality, commercial	Low grade commercial
Non Metallic:			
Nylon	No friction or lubricant, high water absorption	Long life, low nose, low loads	Commercial quality
Delrin	Wear resistant, long life	Low loads	Commercial quality

From the table, the material that suitable for the orange peeler is Aluminum Alloy. It is because, since the orange peeler that we want need to be very light. Aluminum Alloy is also noncorrosive and has high precision.

For the handle, the material that has been select is silicon rubber since it has flexibility, low chemical reactivity and the ability to repel water and form water tight seals. So this is easy for cleaning the orange peeler. Silicon rubber is also has excellent resistance to oxygen, ozone and sunlight.

Since the orange peeler need to be stable, the material than can be use for the base is steel. Usually, Steel A36 can be use since it is easy to fine and has high stability.

3.7 JUSTIFICATION OF DESIGN

The design that is already completed will be justified. This justification is based on the ergonomics aspect. The purpose of this justification is to make sure the design followed the ergonomic principles.

3.8 CONCLUSION

The methodology of this study has been discussed in this chapter. Chapter 4 will be discussed on design dimension and also from the analysis using Finite Element Technique.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter will be focused on analyzing and compare between previous and new design. Data obtain from the simulation will be use to obtain a better design in the future. Designing the orange peeler by using SolidWork 2009 and is stimulate by ALGOR.

4.2 NEW DESIGN BASED ON LITERATURE REVIEW

Two new designs of orange peeler are made. Figure 4.1 shows the front view of a new designed orange peeler, which is conducted as Design A, while Figure 4.12 showed Design B. There are some modifications done at an old designed machine to make sure the machine fulfill ergonomics criteria without sacrificing user’s comfort. Table 4.1 show the major dimension for orange peeler. The detail drawing will be attached on the appendix.

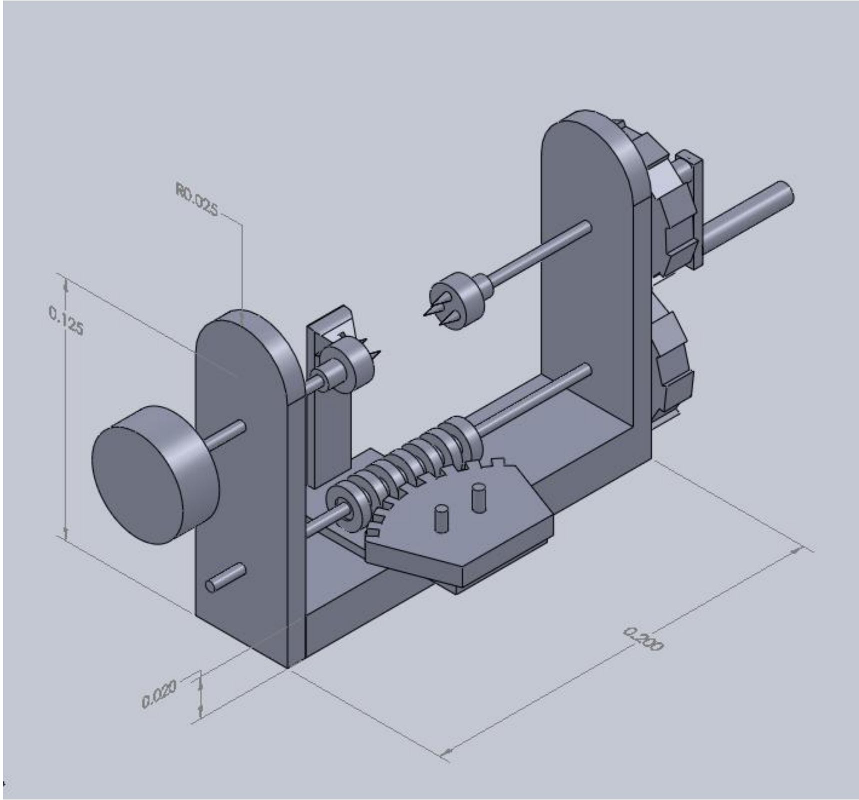
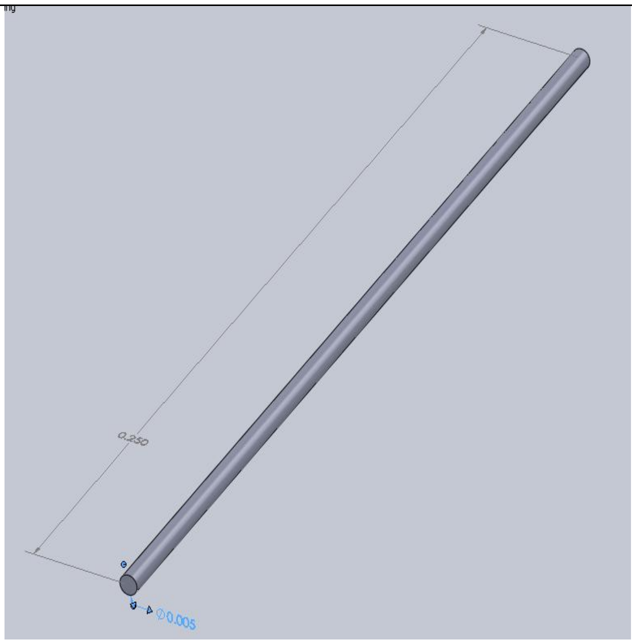
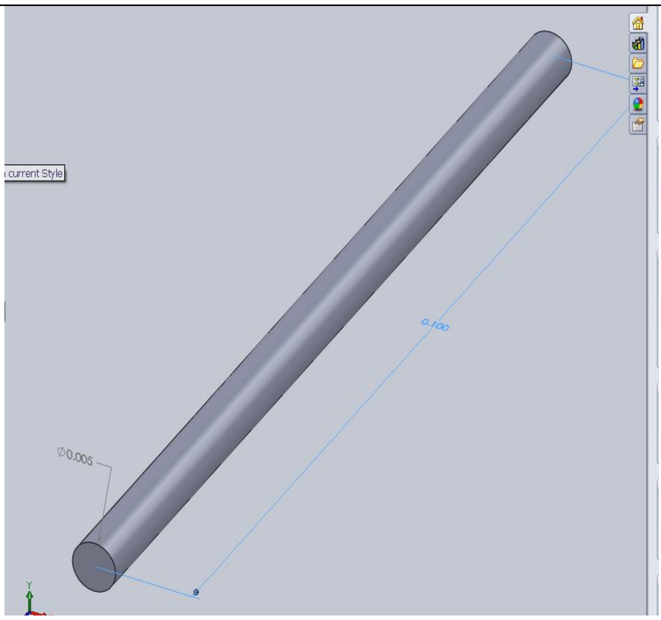


Figure 4. 1 The isometric view of Design A

Table 4.1 Major dimension for Design A

Parameters	Dimension (mm)
Total Height	150
Width	200
Base widht	20

Table 4.2 Parts dimension for Design A

Parameters	Dimension (mm)
 **Figure 4. 2** Longest rod	Long = 250 Diameter = 5
 **Figure 4. 3** Shortest rod	Long = 100 Diameter = 5

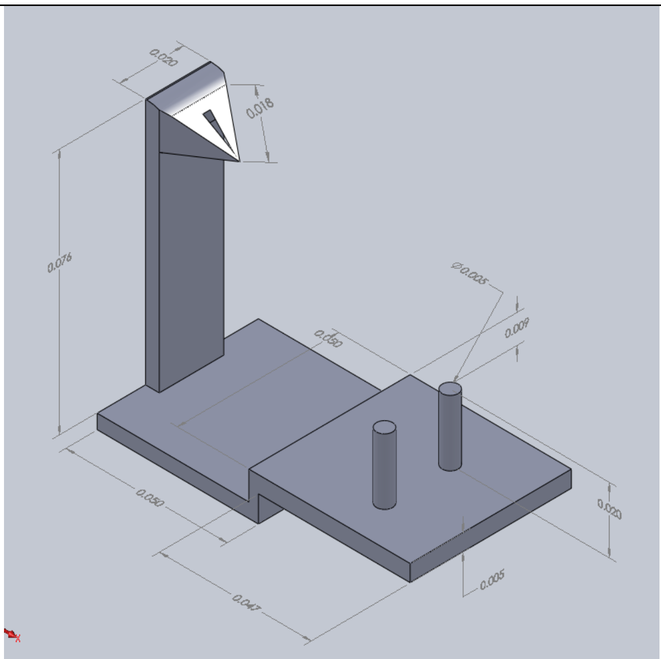


Figure 4. 4 Blade

Whole part

Height = 80

Width = 50

Long = 97

Blade Support

Height = 76

Width = 20

Long = 4

Blade

Long = 18

Width = 20

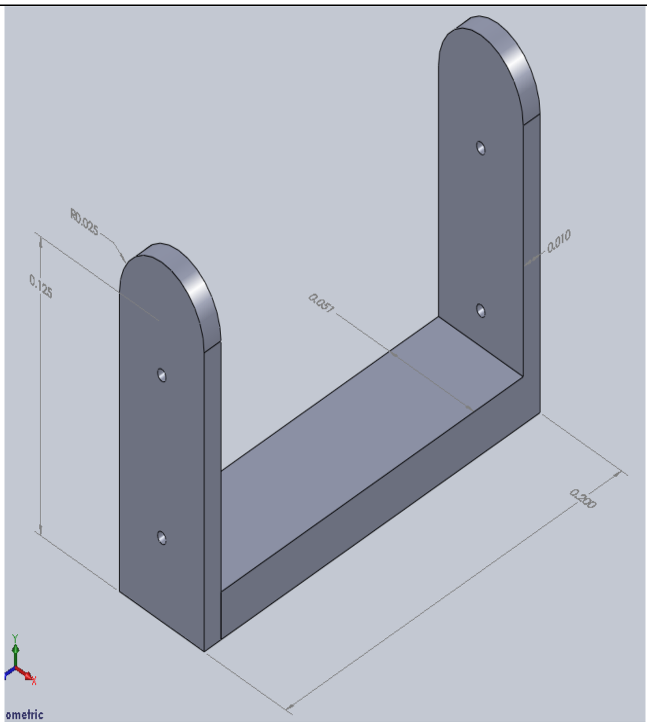


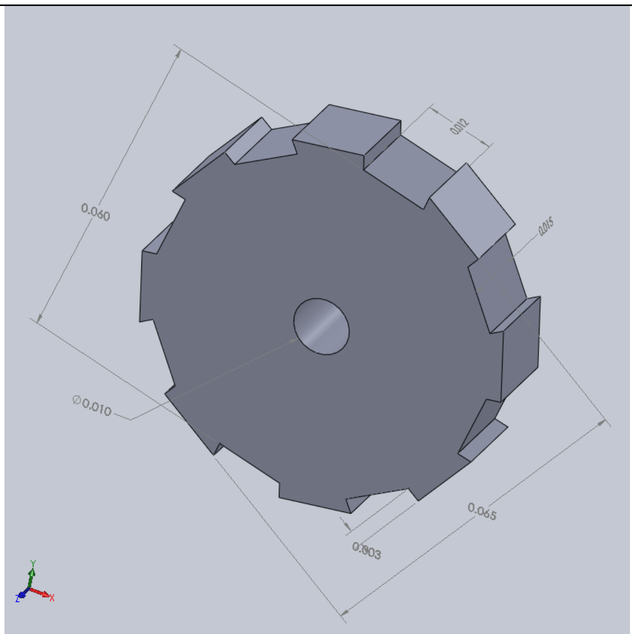
Figure 4. 5 Body

Height = 150

Long = 200

Widht = 50

Thickness = 10



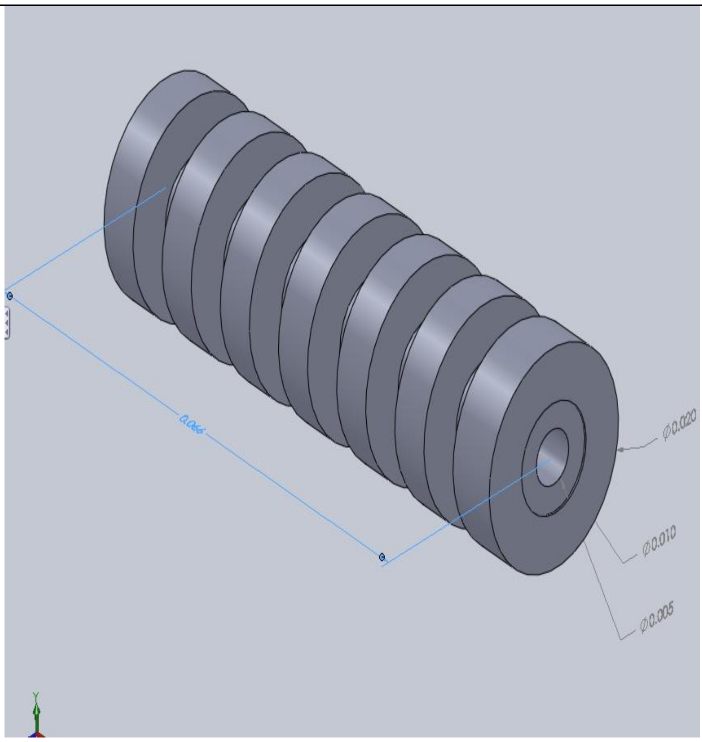
Hole diameter = 10

Minor diameter = 60

Major diameter = 65

Thickness = 1.5

Figure 4. 6 Gear



Hole diameter = 5

Inner diameter = 10

Outer diameter = 20

Figure 4. 7 Movable Thread

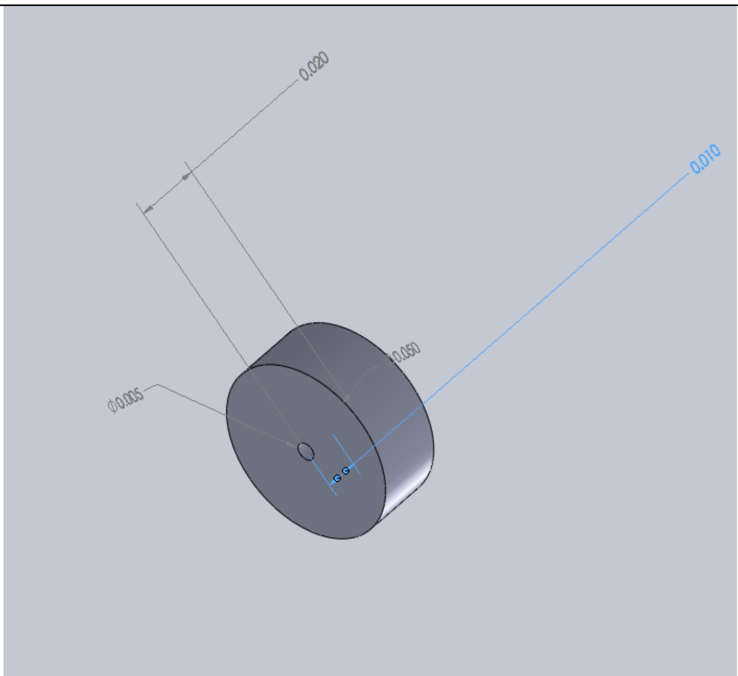


Figure 4. 8 Rod Lock

Inner diameter = 5

Outer diameter = 50

Thickness = 20

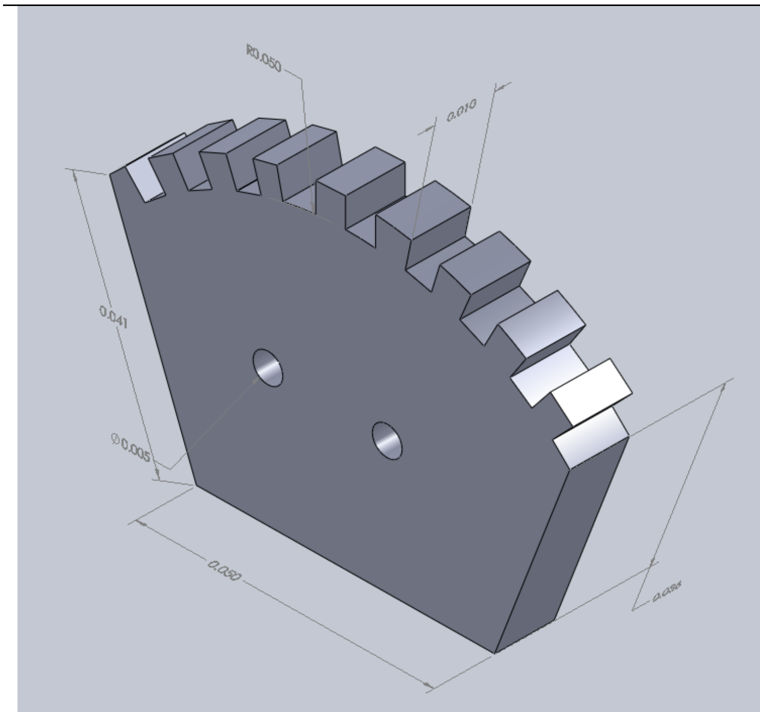


Figure 4. 9 Tooth Plate

Long = 50 – 70

Hole diameter = 5

Thickness = 10

Height = 36 - 55

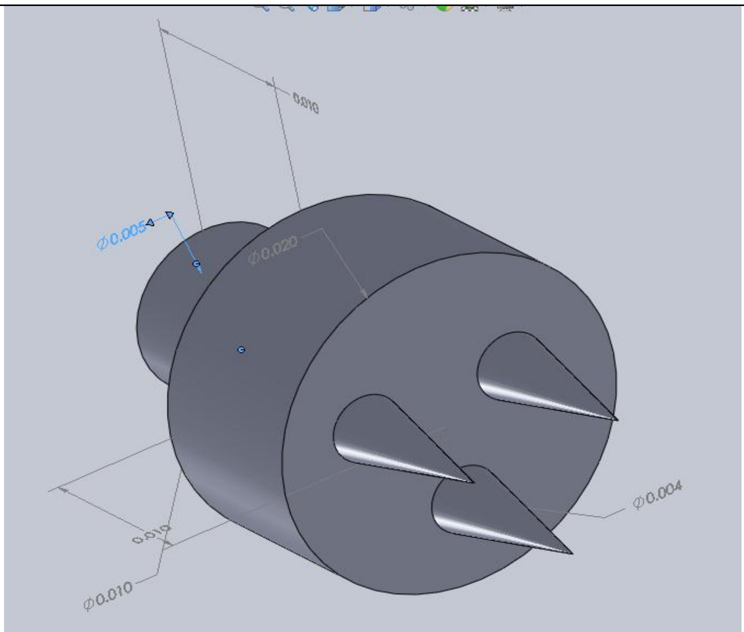


Figure 4. 10 Vise

Hole diameter = 5

Small part diameter = 10

Small-part thickness = 10

Large part diameter = 20

Large-part thickness = 10

Thorn diameter =4

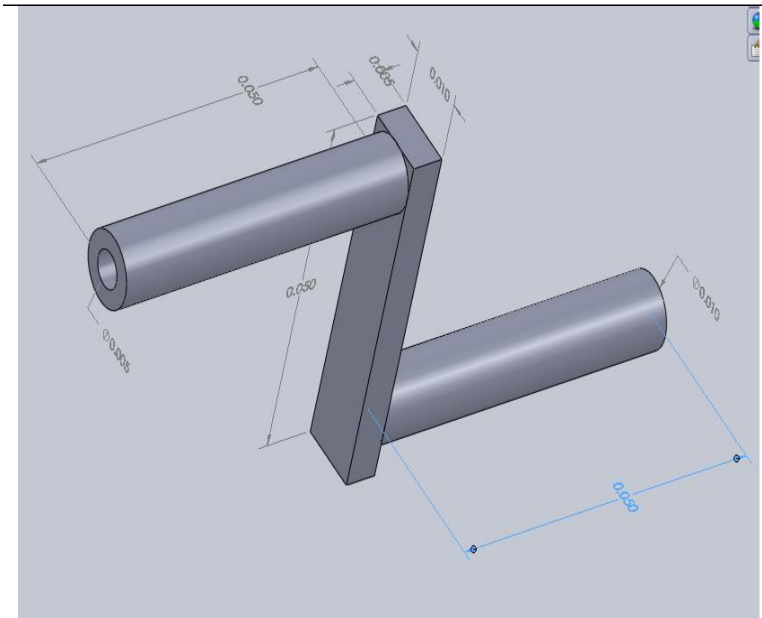


Figure 4. 11 Handle

Hole diameter = 5

Outer diameter = 10

Handle supporter long = 50

Handle supporter width = 10

Handle supporter thickness = 5

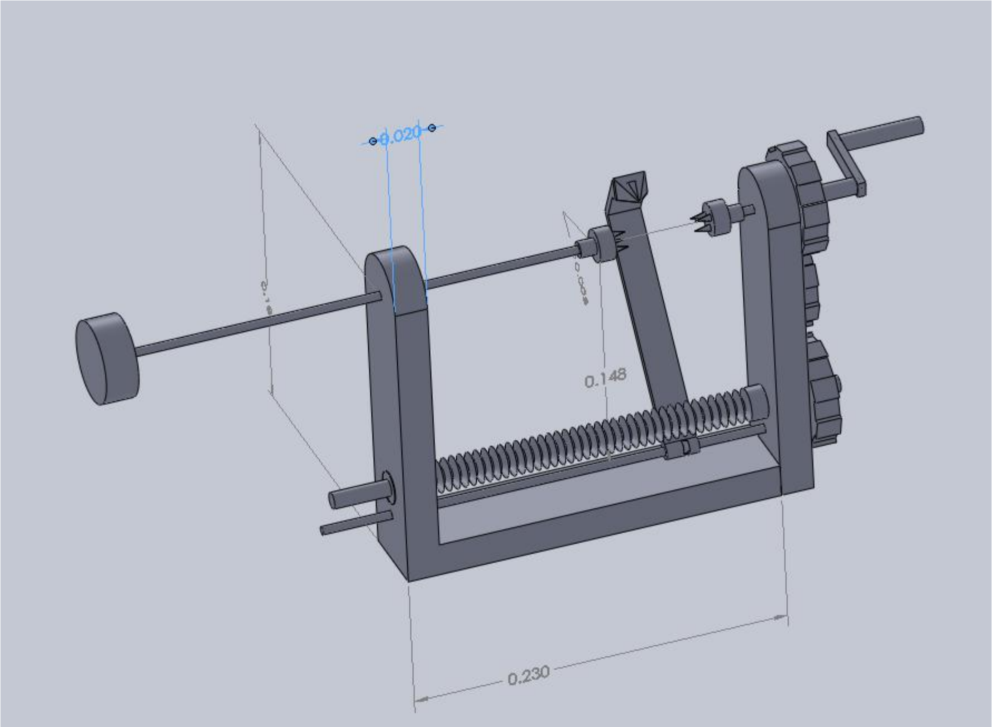
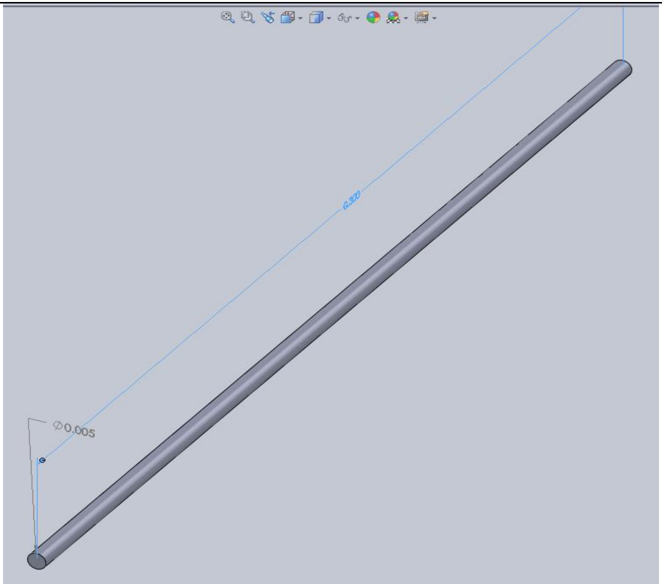
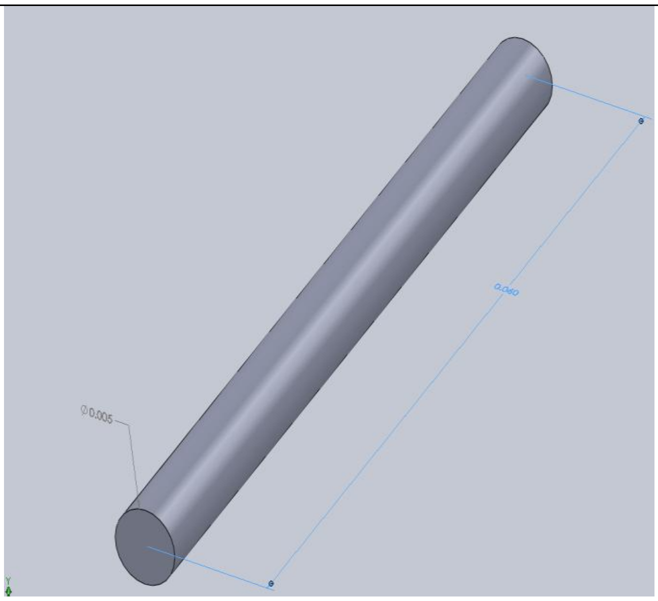


Figure 4. 12 The isometric view of Design B

Table 4.3 Major dimension for Design B

Parameters	**Dimension (mm)**
Total Height	180
Width	230
Thickness	20

Table 4.4 Parts dimension for Design B

Parameters	**Dimension (mm)**
 **Figure 4. 13** Long rod	Diameter = 5 Length = 300
 **Figure 4. 14** Short rod	Diameter = 5 Length = 50

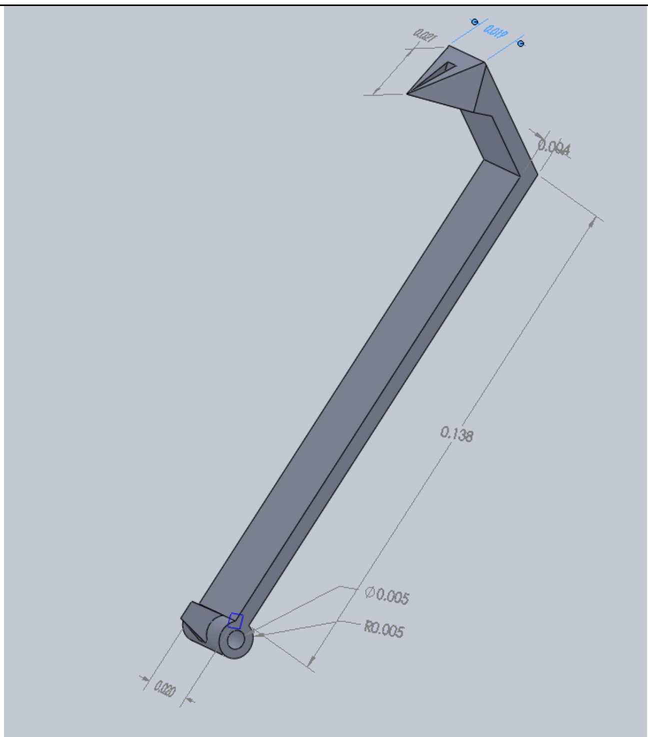


Figure 4. 15 Blade

Inner diameter = 5

Outer diameter = 10

Thickness = 4

Width = 20

Length = 138

Blade width = 19

Blade Length = 21

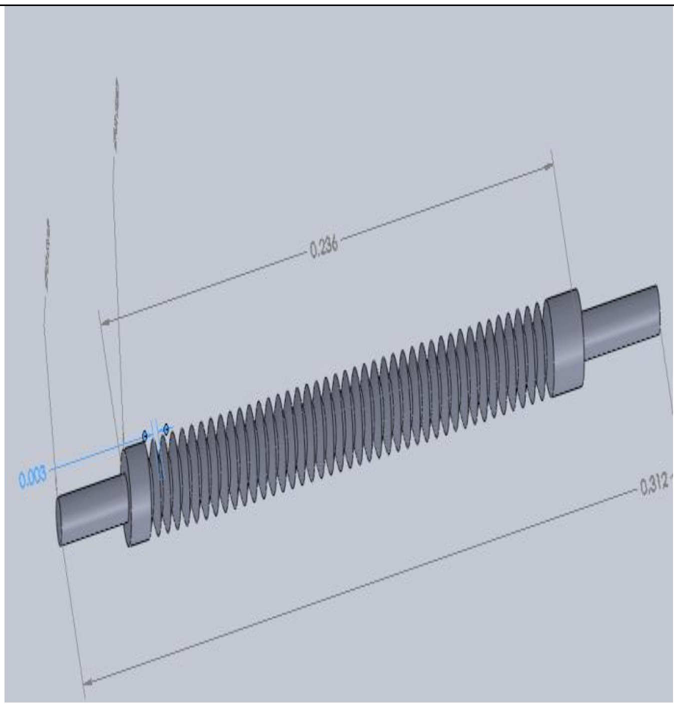
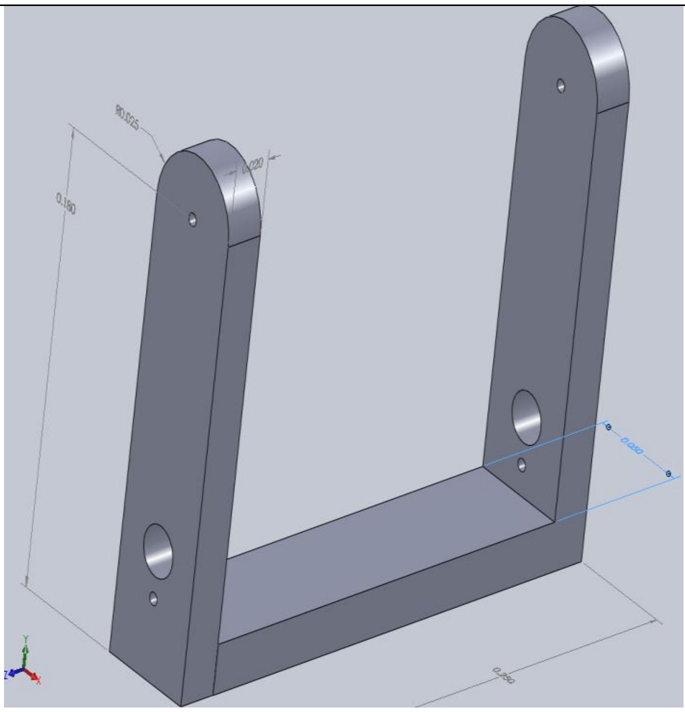


Figure 4. 16 Thread

Small diameter = 10

Large diameter = 20

Length = 312

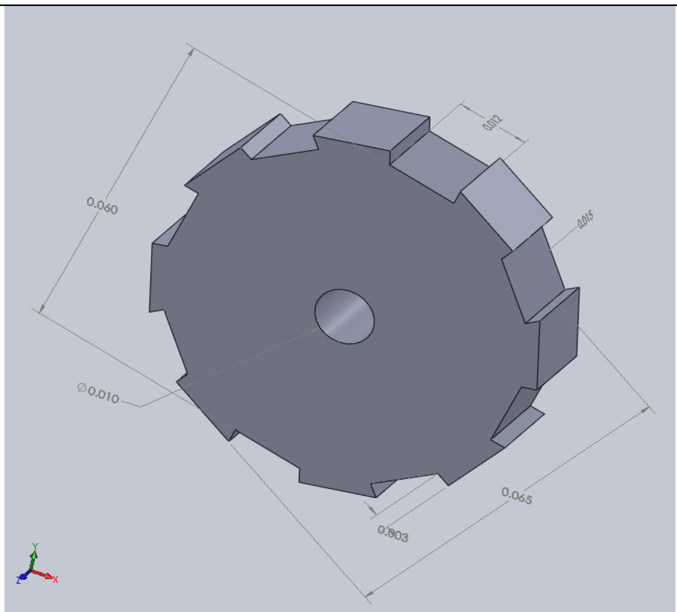


Height = 205

Width = 50

Thickness = 20

Figure 4. 17 Body



Hole diameter = 10

Minor diameter = 60

Major diameter = 65

Thickness = 1.5

Figure 4. 18 Gear

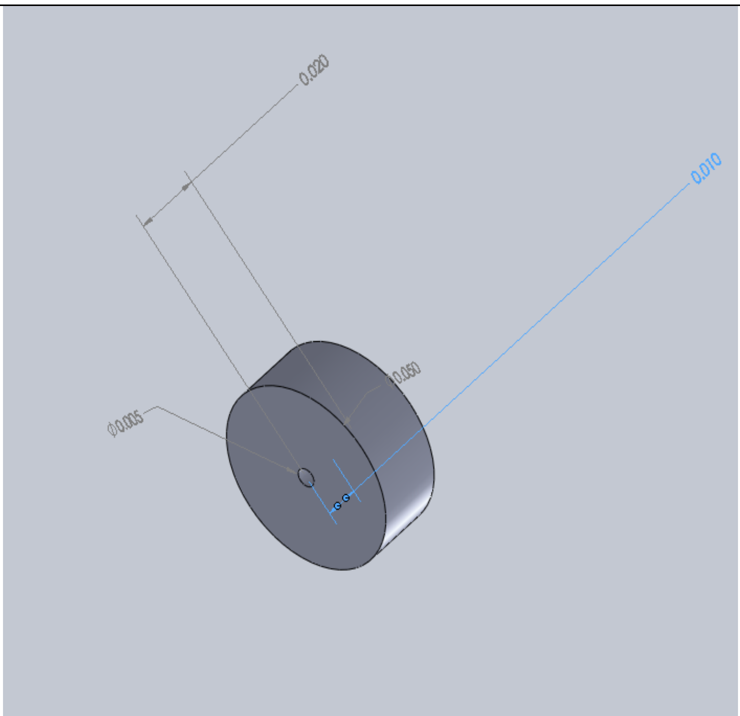


Figure 4. 19 Rod Lock

Inner diameter = 5

Outer diameter = 50

Thickness = 20

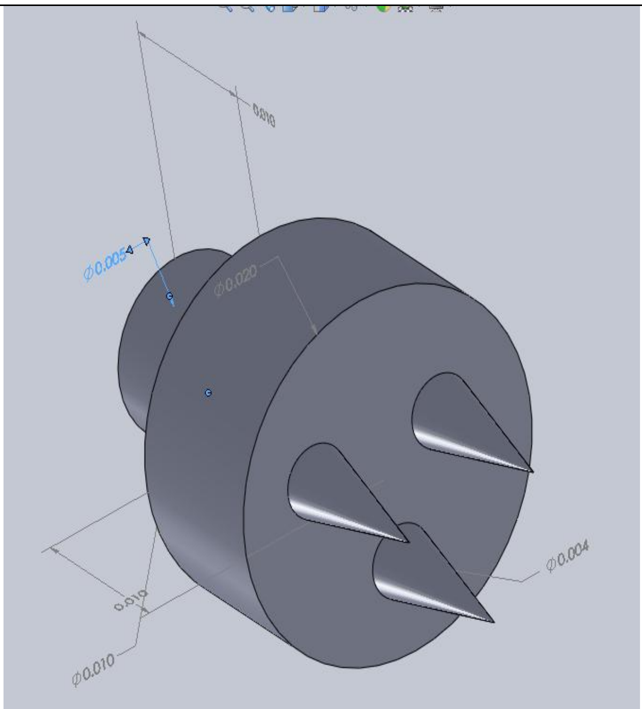


Figure 4. 20 Vise

Hole diameter = 5

Small part diameter = 10

Small-part thickness = 10

Large part diameter = 20

Large-part thickness = 10

Thorn diameter =4

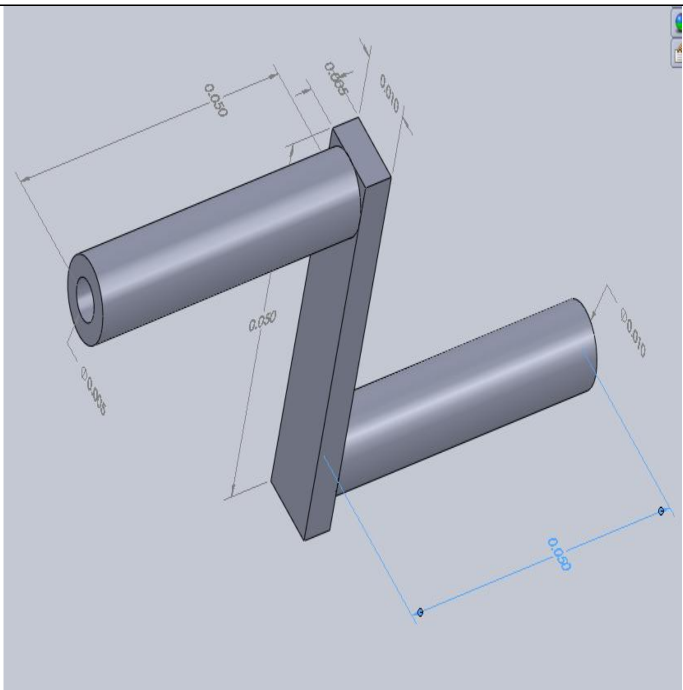
	Hole diameter = 5 Outer diameter = 10 Handle supporter long = 50 Handle supporter width = 10 Handle supporter thickness = 5

Figure 4. 21 Handle

4.3 JUSTIFICATION OF THE DESIGN

This section provides the specific reason of the designed peeler. For the working position, the peeler need operator to operate it in standing position. This is because activities where considerable force has to be exerted or where the work place has to be frequently changed should be carried out in standing position based on Ergonomics for Beginner, 1998. Table 4.10 shows the summary of the justification part for the machine. The justification is based on the dimension of the machine parts. Most of the Ergonomics principles (Mac Leod, 2006) are applied to these design.

Principle 1 : Work in neutral posture.

Both of these orange peelers are easy to carry. By just putting it on the suitable height, the operator can maintain the natural curve of the spine, keep neck aligned with the body and also keep the elbows in and relax the shoulder.

Principle 2 : Reduce Excessive force.

Excessive force can result to creating fatigue, overload muscle and cause injury. The handle for these two designs is covers with the Silicon Rubber, which gives extra grip to the operator. The use of gears also is one of the way toward ergonomics approaches too.

Principle 5 : Reduce excessive motion.

Current orange peelers required lots of motion. By using gearing and also rack-and-pinion, it will reduce the repetition of the movements. Besides of reducing the motion in operation, we also use the motion saving mechanisms.

Principle 7 : Minimize pressure point.

These designs provide padding for hand grip. Padding is one of the way to minimize the pressure point that can cause restrain in nerve function as well as blood flow.

Principle 9 : Move, exercise and stretch.

Ergonomics doesn't mean that the operator need to only push button. Healthy life requires body activities. These designs are not using any button so that the operator can move a little, but not over move.

4.4 MACHINE MANUAL

Generally, these peelers are use for a mass production of oranges and its main focuses are the blade, vise and also the handle. Firstly, the operator needs to put then an orange between the vices. Both up part and end part of the orange will meet the vices. Adjust the blade so that the height is parallel to the orange's centre. Push the blade toward the orange's skin. The thickness is up to the operator. After that, move the handle clockwise until all the orange's skin is peeled. Figure 4.22 show all the 3 elements that need to be adjust before operating the peeler.

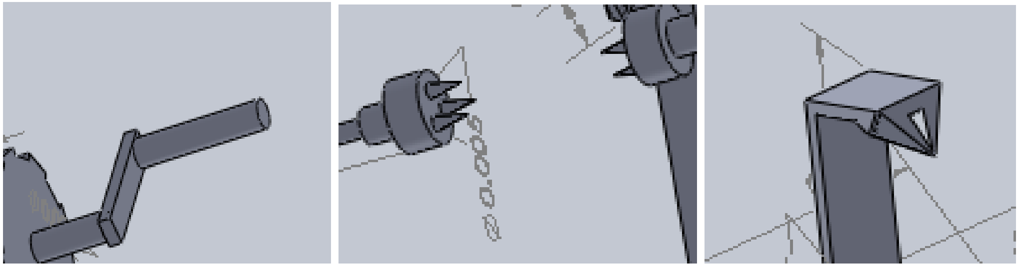


Figure 4. 22 Three important elements in operating the peeler

4.5 RESULTS FOR SIMULATION

After designing, stimulation was conducted by using ALGOR. The force applied on both of the vises' face as a pressure of the orange. While a torque applied on the handle as the rotation the operator applied. Both designs are applied with the same amount of pressure. Figure 4.23 and Figure 4.24 is the result for Design A while Figure 4.25 and Figure 4.26 is the result for Design B. The result will be used in order to improve the design for avoiding the musculoskeletal disorder (MSD) using the ergonomics approach.

The purpose of the analysis is to analyzing whether the vice can support the orange or not. It is common that people have different force in grabbing the orange by pushing the vice. So, maximum load is used in order to analyze the strength of the vice. The Rotation movement is also required in operating this peeler. So, maximum torque is used to the handle and the rod that connect the handle to the vice.

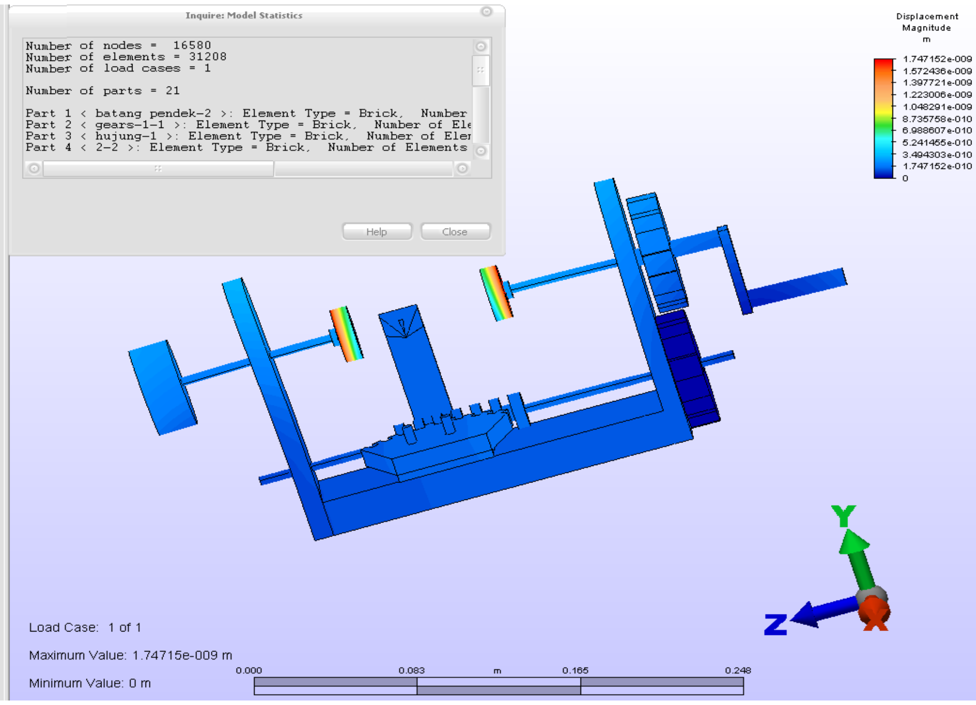


Figure 4. 23 Displacement result for Design A

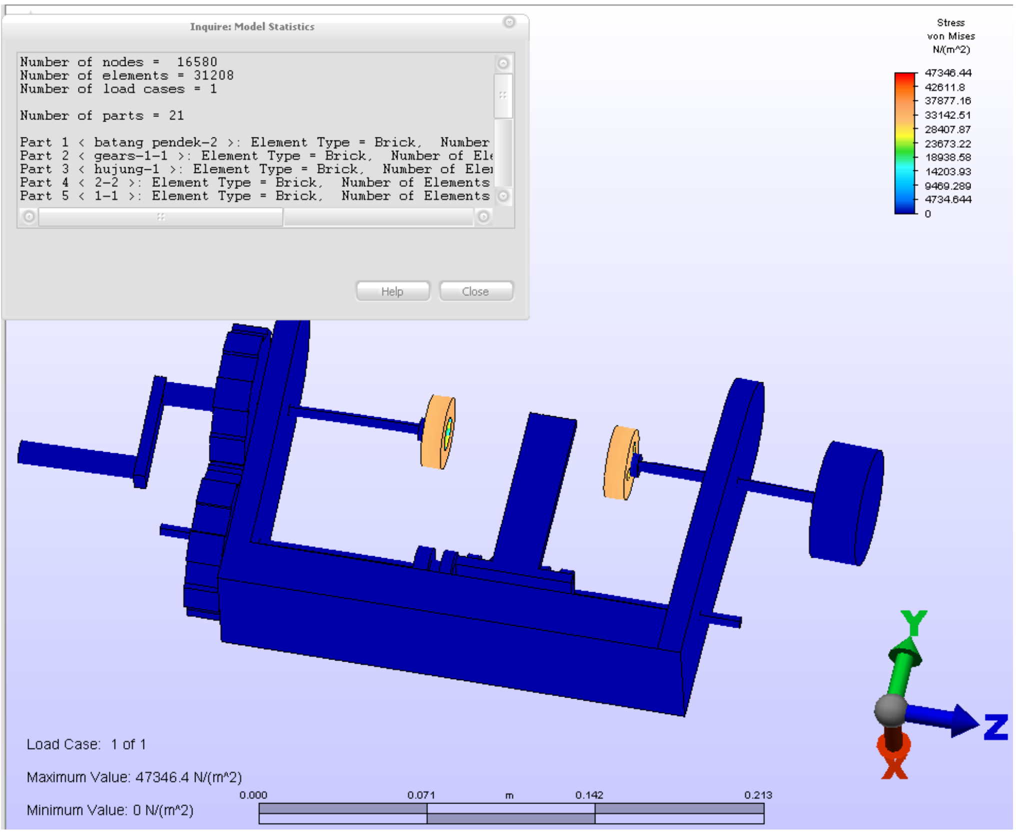


Figure 4. 24 Stress von Mises result for Design A

The result shows that there is not major displacement and stress damage but since the main use is at the vise, it is more affected than other parts.

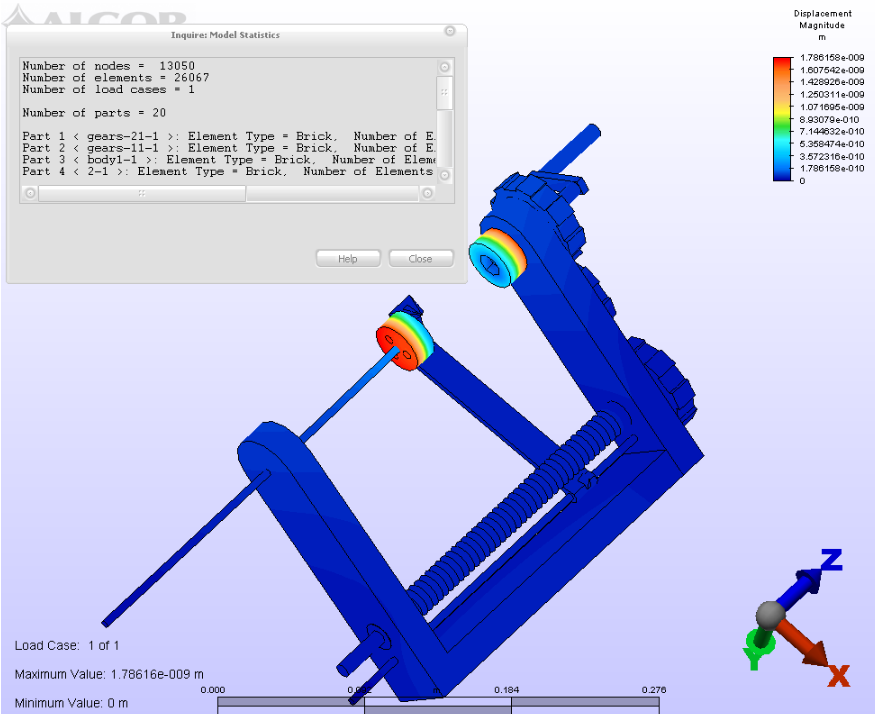


Figure 4. 25 Displacement result for Design B

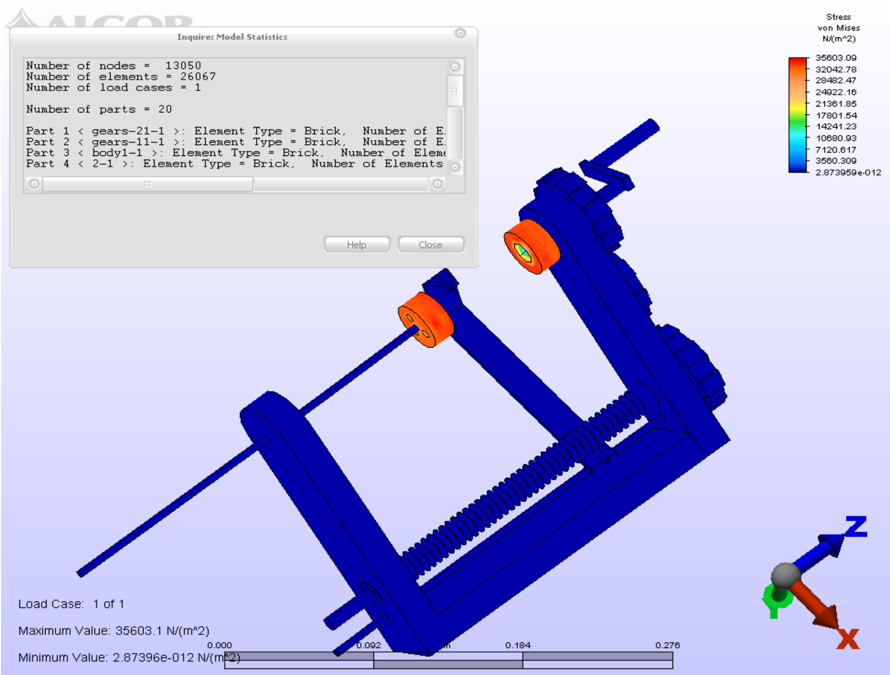


Figure 4. 26 Stress von Mises result for Design B

4.5.1 Results Analysis and Discussion

After constructing the analysis, the result than can be compared are the von Mises Stress and the displacement analysis. It is to avoid the fatigue failure to happen and see the strength of the peeler. Table 4.5 show the results of each designs.

Table 4. 5 The Analysis Result Different Designs

Design	Displacement (m)		Stress von Mises (N/m^2)	
	Maximum	**Minimum**	**Maximum**	**Minimum**
Design A	$1.74715x10-^{9}$	0	47346.5	0
Design B	$1.78616x10-^{9}$	0	35603.1	$2.87396x10^{-12}$

From the results above, design A give higher Stress von Misses value and lower displacement value than design B. The highest minimum value of Stress von Mises achieved by design B.

Von Mises stress is used to estimate yield criteria for ductile materials. It is calculated by combining stresses in two or three dimensions, with the result compared to the tensile strength of the material loaded in one dimension. Von Mises stress is also useful for calculating thefatigue strength. Stress is a complicated six dimensional tensor quantity, Von Mises stress boils it down to one scaler number for the purposes of caluclating yield criteria. Finite element analysis results are typically presented as Von Mises stress. Von Mises stress theory is also known as the *Maximum Distortion Energy Theory* and the *Maxwell-Huber-Hencky-von Mises theory*.

In this analysis, a conclusion can be made that both design gives almost the same result. The maximum value showed at the vice since it is the part where loads exist in grabbing the orange. Therefore, the vice need to handle both force and rotation in the same time.

For the body part, it is not affected by any load since it is static. The body only need to support the weight of the peeler and the orange. This is why, the minimum value fot both displacement and Stress von Mises occur at the body parts.

4.6 MANUAL CALCULATION

The manual calculation for this design is concentrated on the axial thrust or load applied on a worm gear thread.

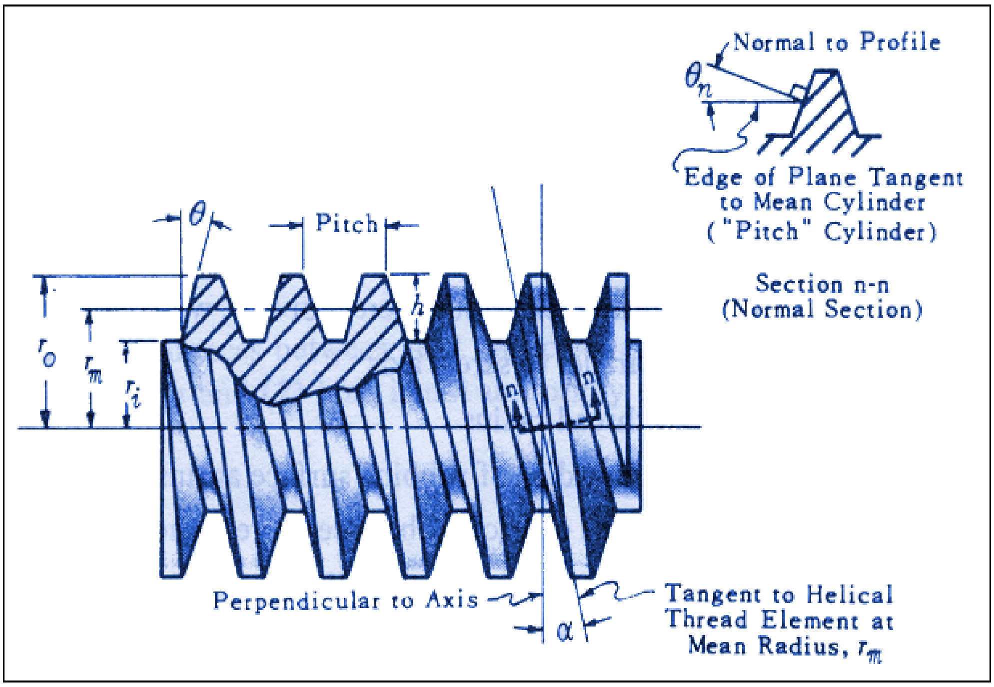


Figure 4. 27 Worm Gear Thread Analysis

Source : Schaum's Outline Machine Design (2010)

T = 35000 Nmm (Assumption)

$$r_i = r_o - h \quad (4.1)$$

$$r_m = r_c = \frac{r_o + r_i}{2} \quad (4.2)$$

$$\alpha = \operatorname{atan}\left(\frac{L}{2\pi r_m}\right) \tag{4.3}$$

$$\theta = \tan \theta_n \cos \alpha \tag{4.4}$$

$$R_c = \left(\frac{\tan\alpha + \frac{f}{\cos\theta_n}}{1 - \frac{f\tan\alpha}{\cos\theta_n}}\right) r_m + f_c r_c \tag{4.5}$$

$$W = \frac{T}{r_c} \tag{4.6}$$

$$E_{screw} = \frac{WL}{2\pi T} \tag{4.7}$$

$$T_{ad} = W\left(\left[\frac{-\tan\alpha + \frac{f}{\cos\theta_n}}{1 + \frac{f\tan\alpha}{\cos\theta_n}}\right] r_m + f_c r_c\right) \tag{4.8}$$

Where;

T	=	Applied Torque, Nmm
r_o	=	Major thread radius
h	=	Thread depth
r_i	=	Minor thread radius
r_m	=	Mean thread radius (Pitch Diameter)
r_c	=	Effective radial area contact surface
f	=	Coefficient of Friction Screw Thread and Mating (Nut)

f_c	=	Coefficient of friction at Collar
L	=	Thread pitch
α	=	Angle of thread mean radius
θ	=	Thread angle at bearing surface
θ_n	=	Angle between Tangent to Tooth profile and a radial line
R_c	=	Thread constant
W	=	Load Parallel to screw thread axis
E_{screw}	=	Efficiency of the Screw Thread Mechanism (ratio of work out and work in)
T_{ad}	=	Torque required to advance the nut

By substituting all the values in the equations above, the result that we can get are:

r_o	=	10mm
h	=	5mm
r_i	=	5mm
r_m	=	7.5mm
r_c	=	7.5 mm
f	=	0.15
f_c	=	0.15
L	=	4mm
α	=	4.85°
	=	0.08468 rad
θ	=	0.26180 rad
θ_n	=	0.27 rad
R_c	=	2.95206 mm

$W = 3387.4645\ N$

$E_{screw} = 21.57\%$

$T_{ad} = 5581.8725\ Nmm$

Based on the results, it shows that the maximum torque that can be use on the design is 5581.8725 Nmm. So, to handle the bigger torque, the dimension or the design's size need to be increase. However, due to the ergonomics condition, the heavier the peeler is, the higher force that we need to rotate the handle.

4.7 CONCLUSION

Both designs have been analyzed in this chapter. The data obtain from the simulation is used as a guideline to modify the previous design. The justification and the comparison between the two designs is also been discussed in this chapter. The next chapter will be on the overall conclusion of this study.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

Generally this chapter concludes the study. Besides that, the objective is also be reviewed in this chapter to determine if it is achieved or not. The contribution of this study, the limitation are also been discussed in this chapter.

5.2 CONTRIBUTION OF THE STUDY

The main contribution of this study is the designation of the orange peeler machine that does not neglecting the ergonomic principles and also sacrificing customers comfort. This can be achieve since the previous design has modified and by compraing the two designs, we can see a lot of room for improvements in the design.

The other contribution of this study is the specific literature review on the ergonomics design on hand. This study can be used as a guideline to design another type of hand held tools.

5.3 LIMITATIONS

There are several limitions while compeleting this study. The first limitation is the usage of the antrophometry data from other country which is Thailand. This is due to the limited source on the Malaysian data. Since Thailand is the most nearest antrophometry data with Malaysian data, the antrophometry data from Thailand is used.

The second limitation is on the ergonomics software. Since there is no available ergonomics software, the analysis on the product which is based on ergonomics view can't be done.

The third limitation is on the fabrication process. Since there a facilities problem occur in the middle of the project, the fabrication seems to be impossible to carry out.

The fourth limitations is on the software used for stimulation. For a smaller design, there is a software which is more suitable for the design.

The last limitation is on the getting validation via ergonomics experts. The purpose of the validation is to verify the study contents. Since there is no fabrication is made, the validation becomes impossible. However, based on the theorytical view, the study contents is relevent.

5.4 RECOMMENDATIONS

For the improvement of the study, there are several matters can be done:

i. The other stumulation software can be used to see the more precise and uccurate results.
ii. Fabrication is important to ergonomics design as it can give a real experience when people use it.
iii. Instead of focusing on design mechanism, ergonomics raw material also need to be studied.
iv. Do a survey to see if people approve with the design and it is really needed.
v. Using ergonomics software to analysis the design.

5.5 CONCLUSION

The objective for this study is to design an orange peeler with an ergonomics approachs using Solidworks. Based on chapter 4, this objective has been achieved since the preliminary design has been designed and redesigned to meet the ergonomics principles. The designation of the machine is based on the literature review. The objectives for the simulation is also achieved with comparing the two designs. Thus, the conclusion is based on the literature review, the designed is ergonomics.

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APPENDIX A

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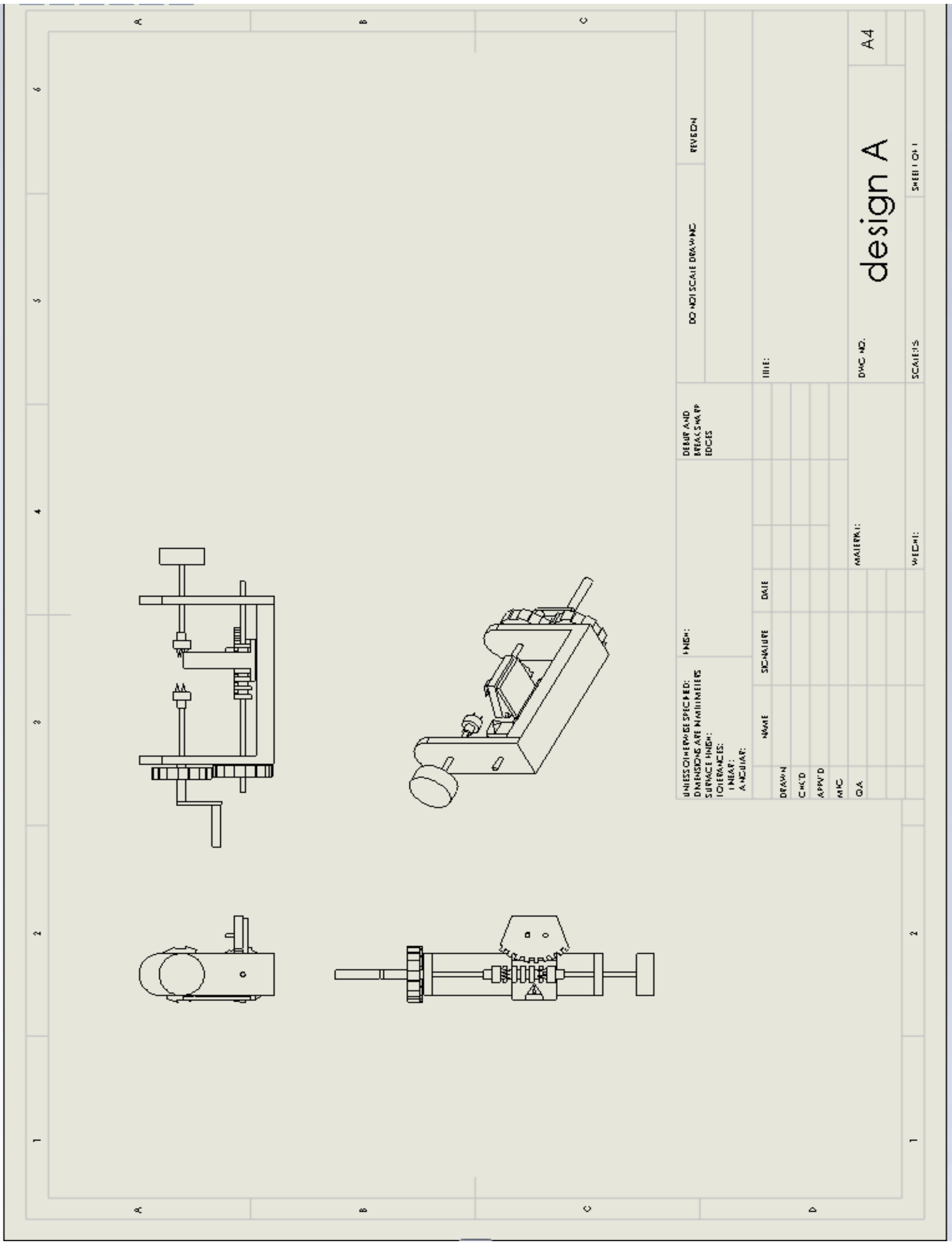

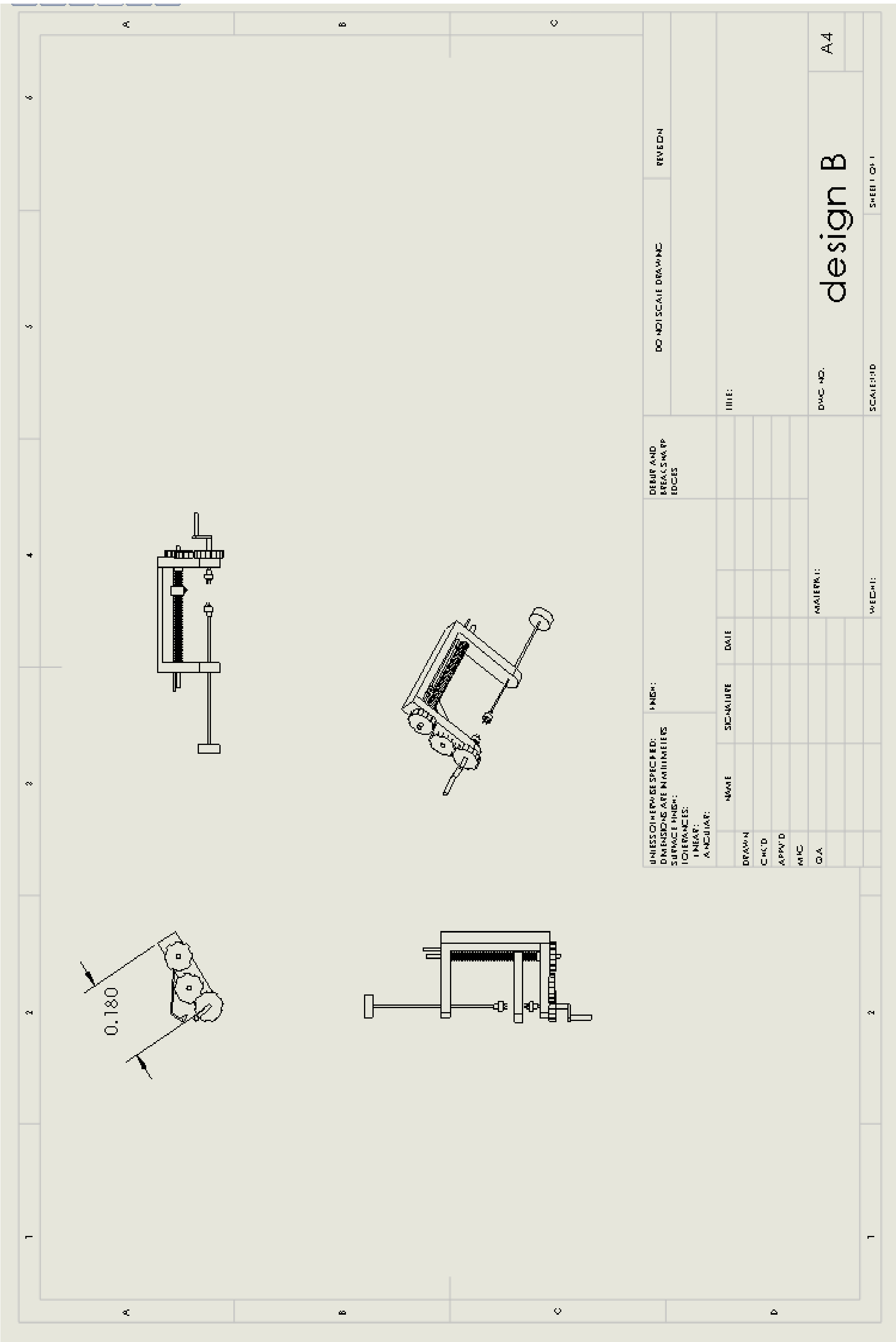
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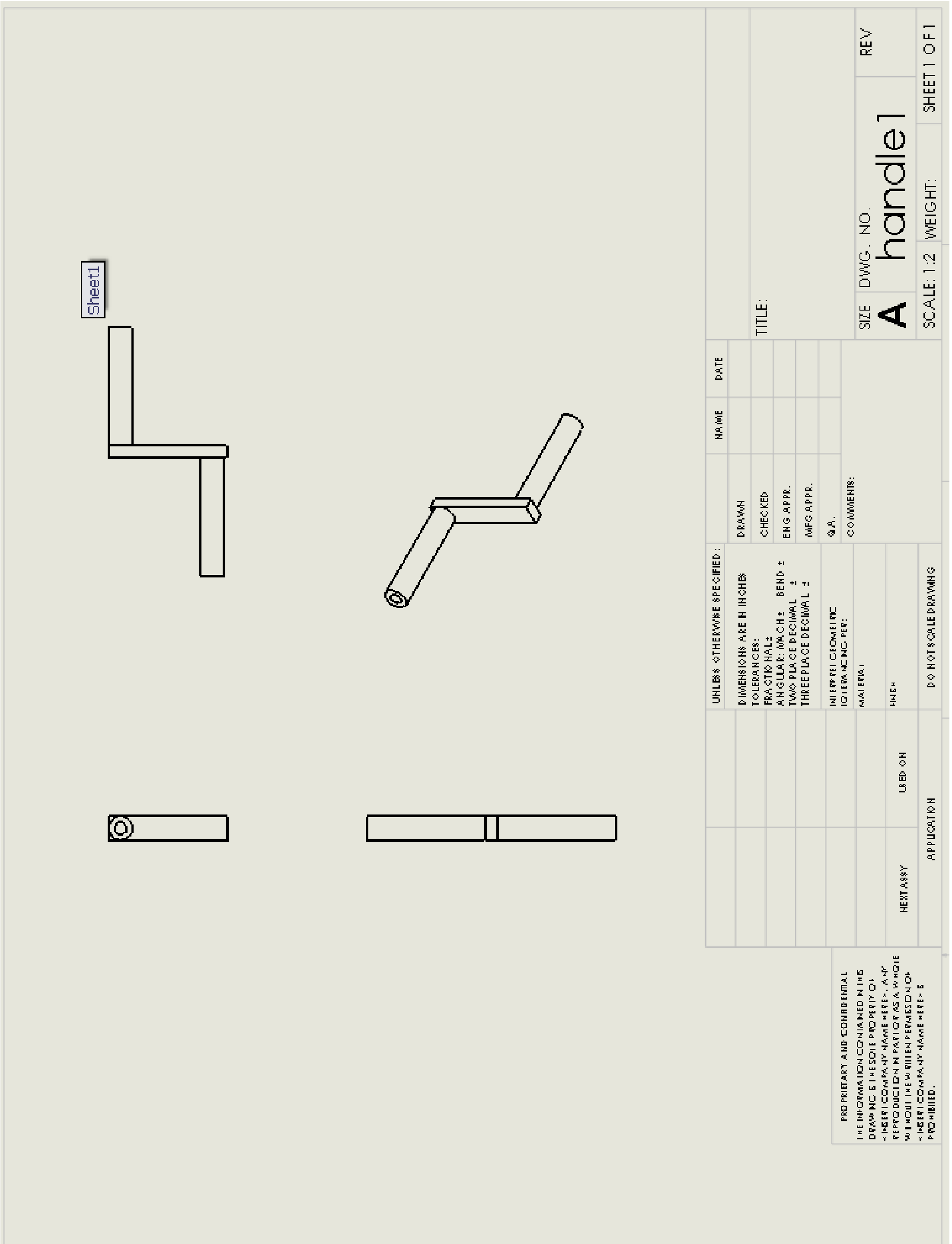
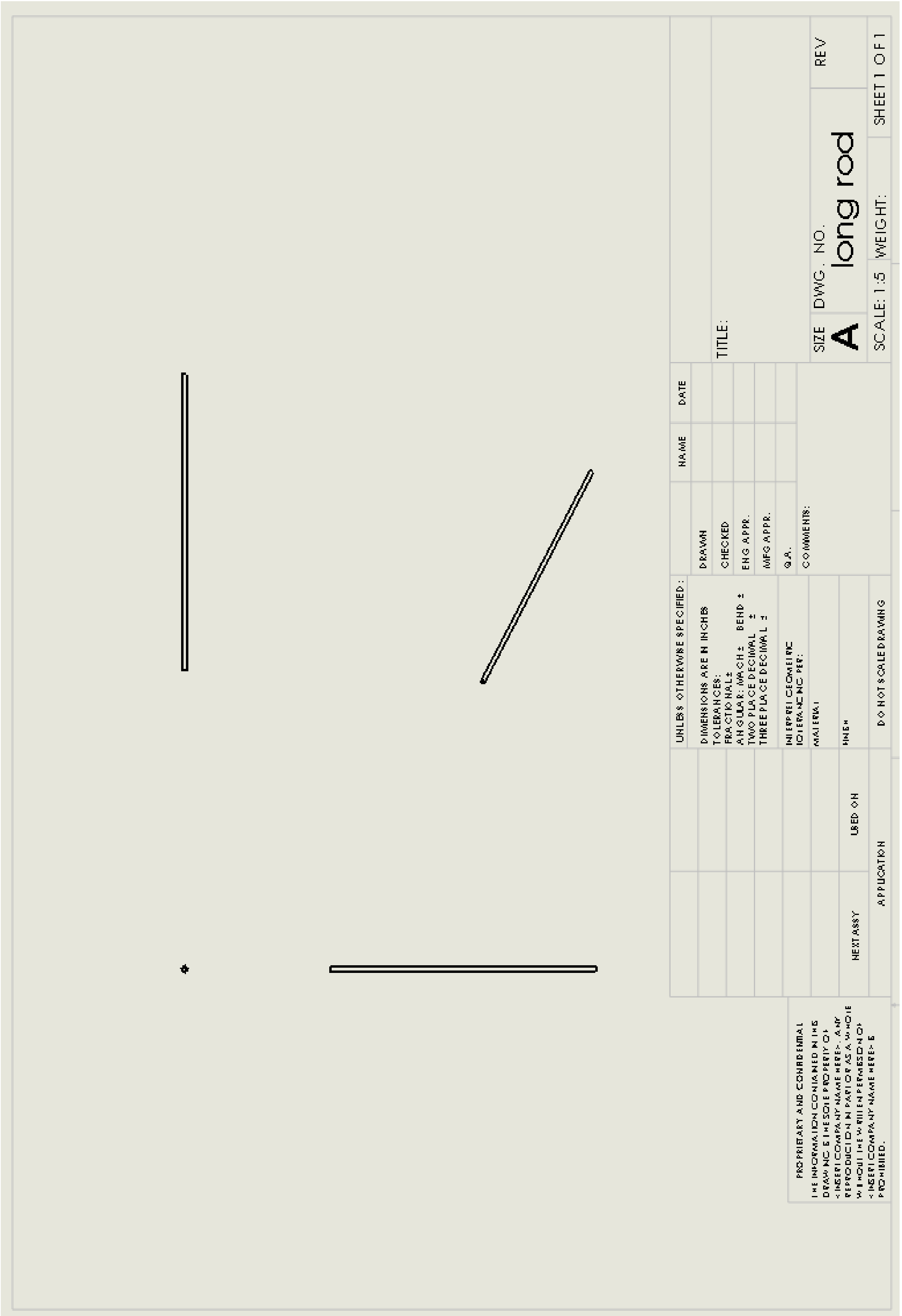
APPENDIX B

DRAWING FOR PARTS

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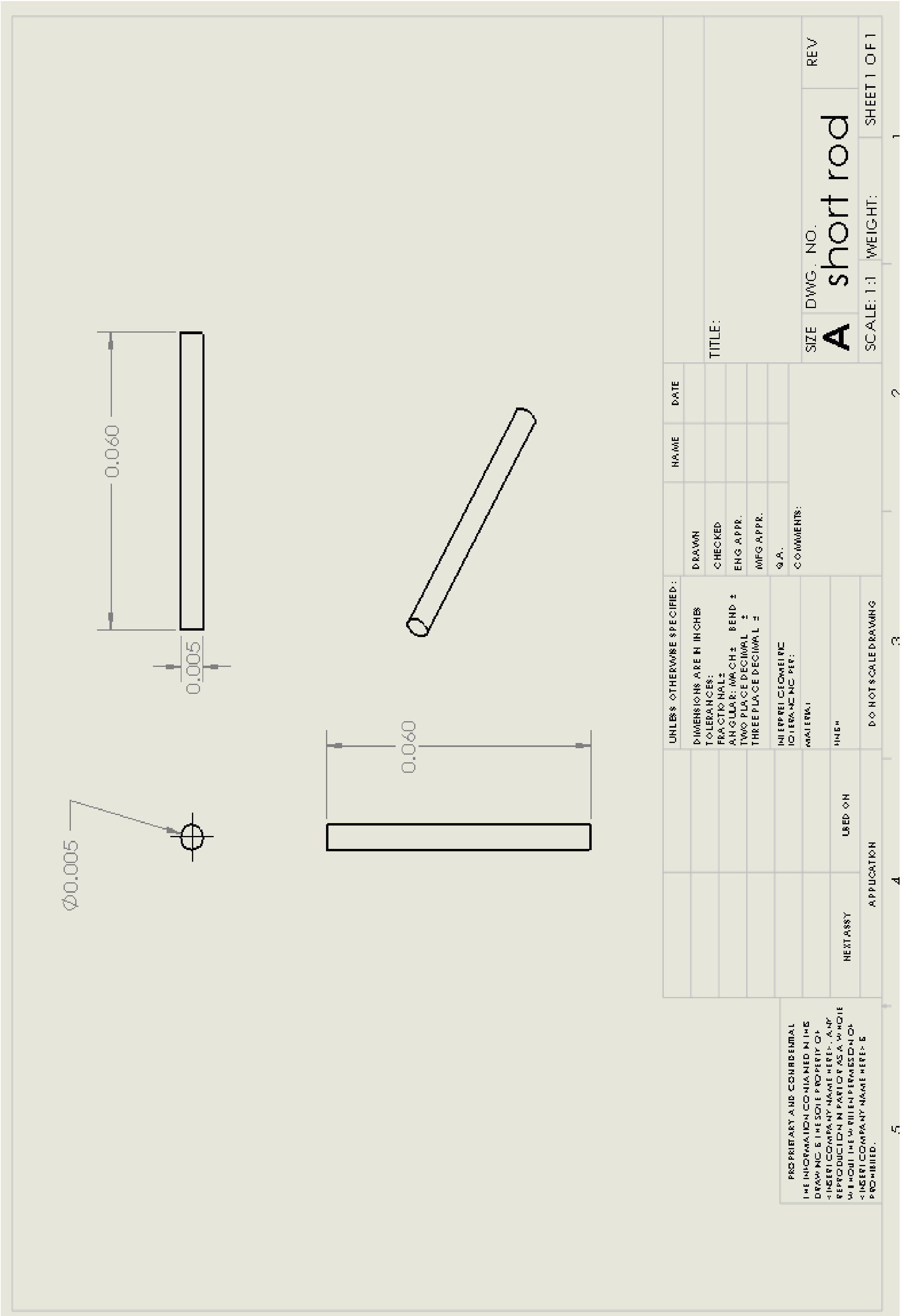
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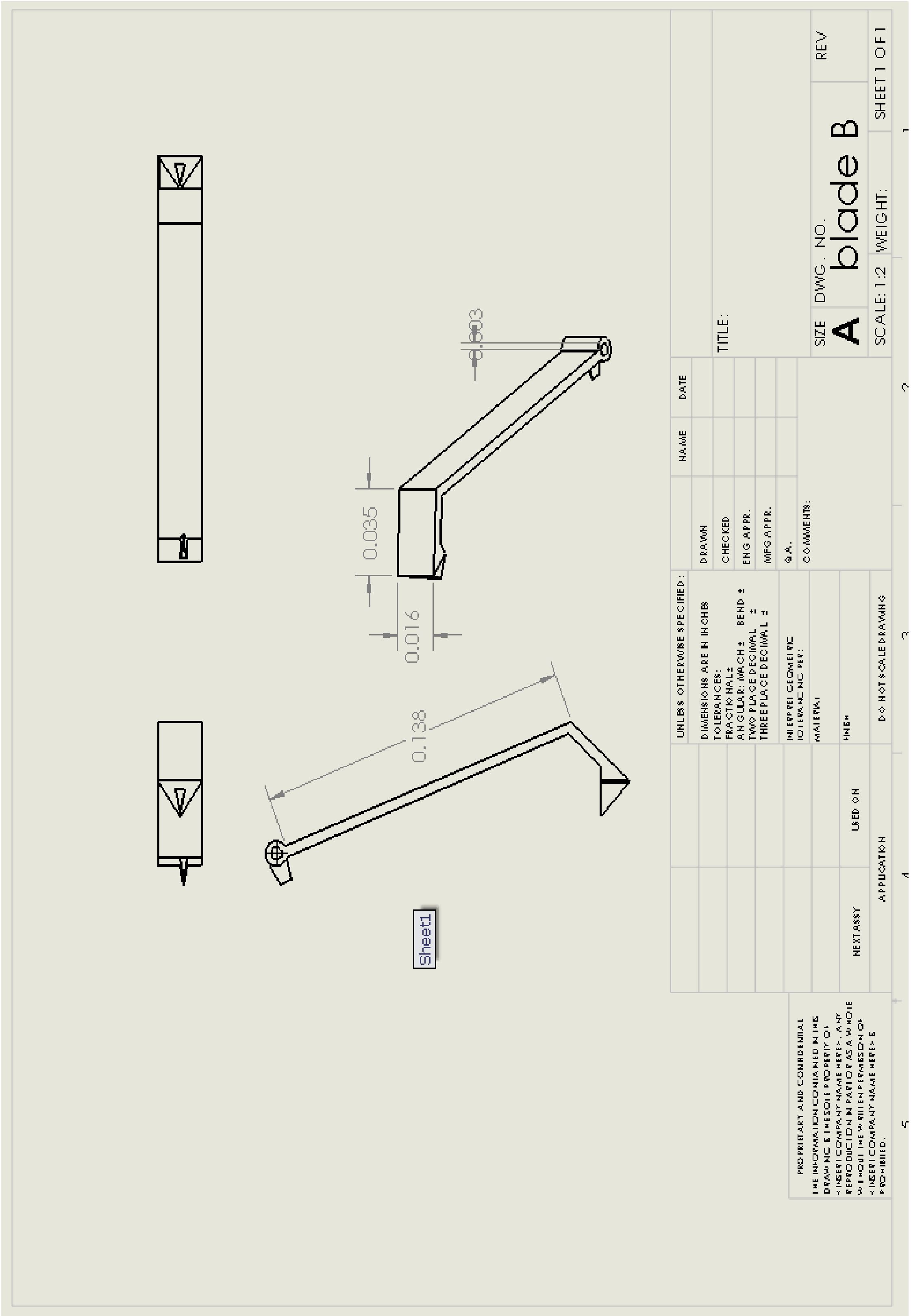
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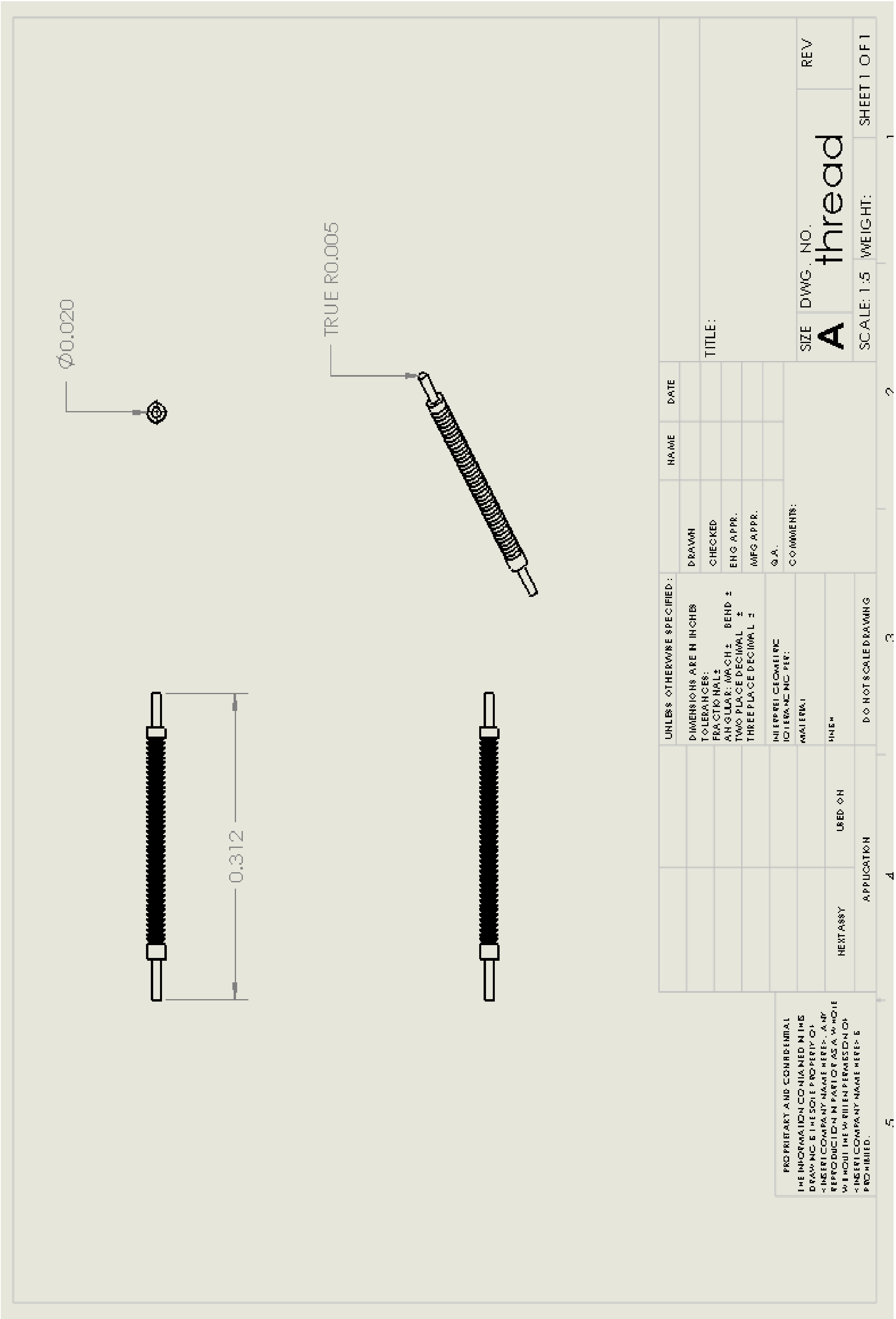
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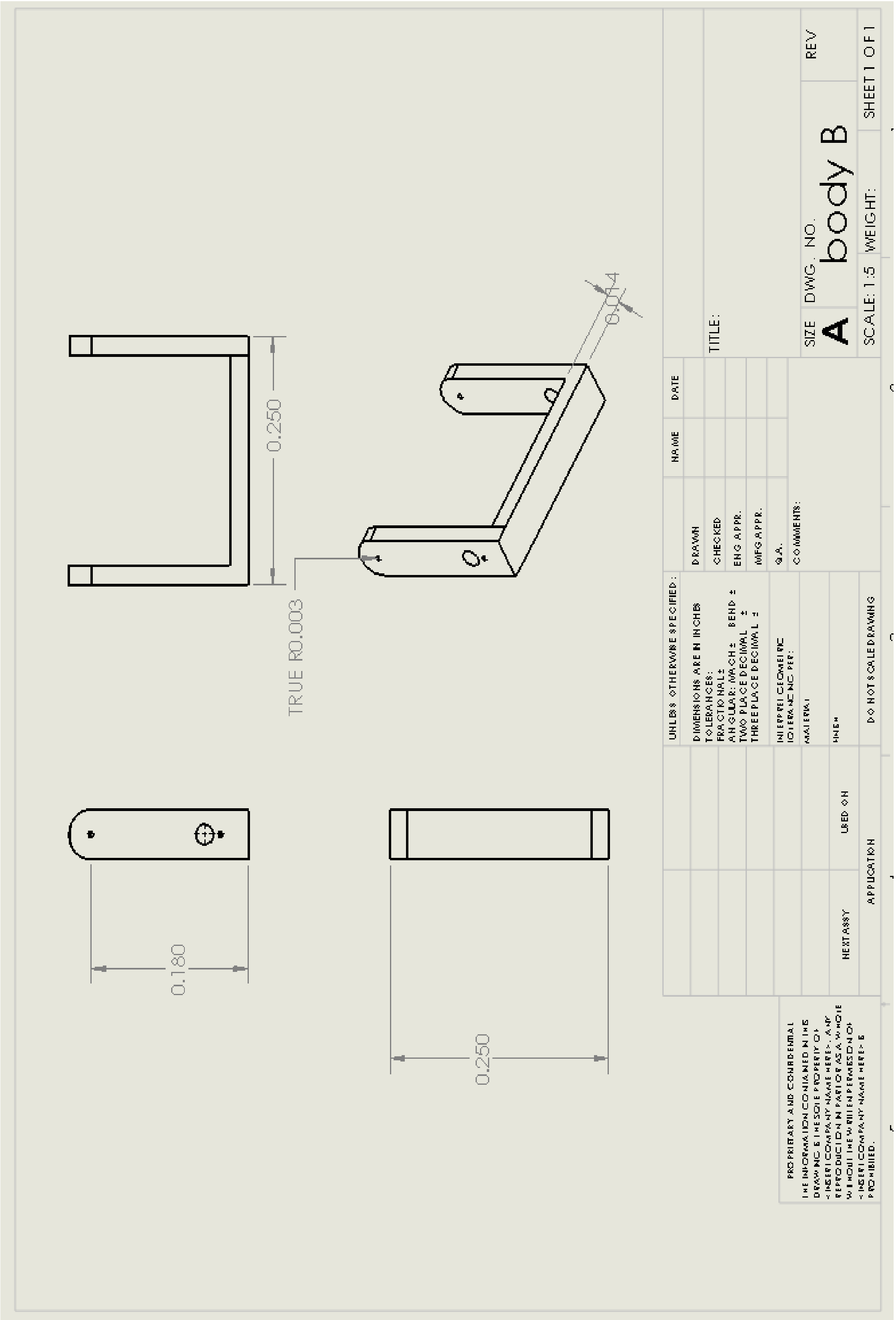
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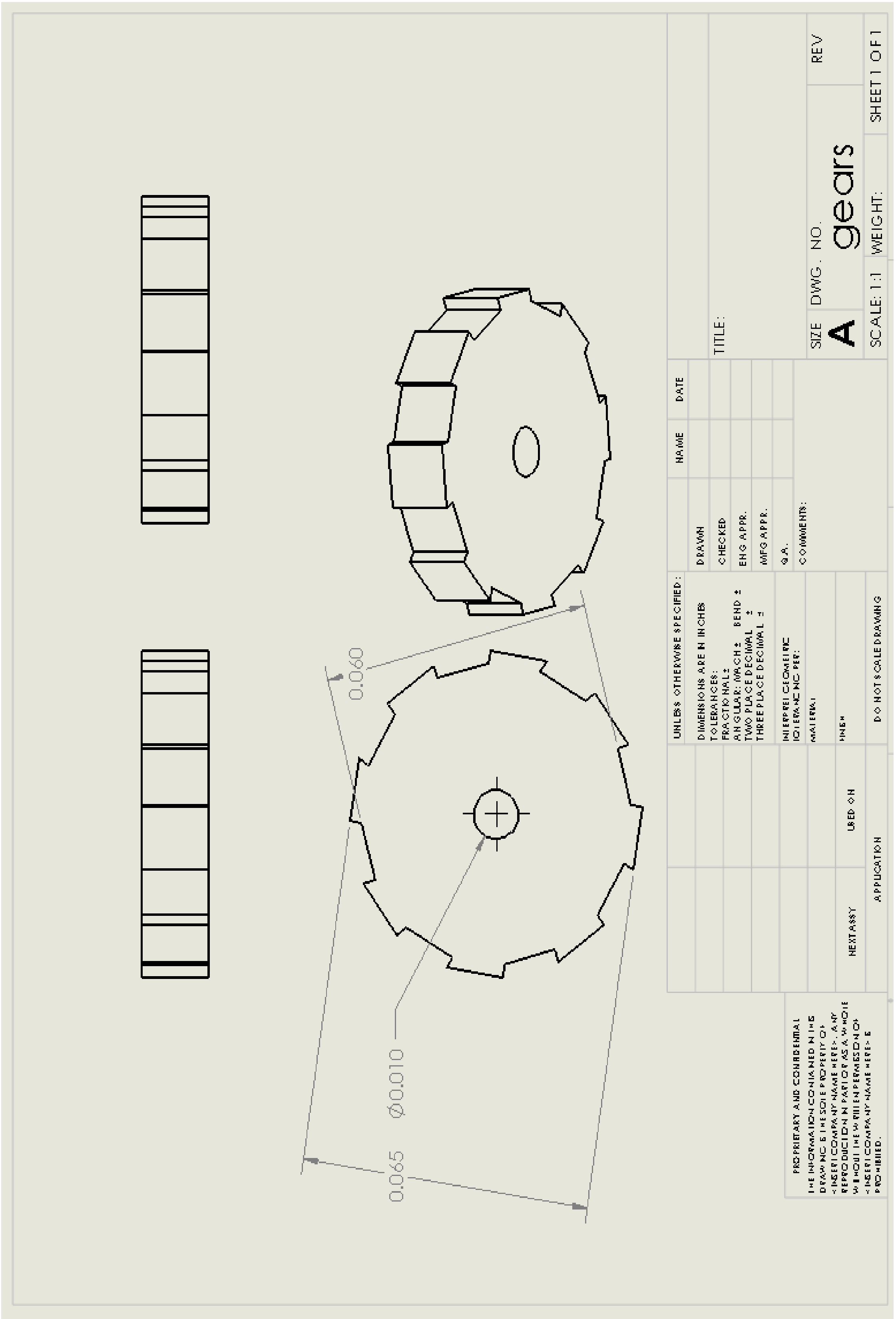
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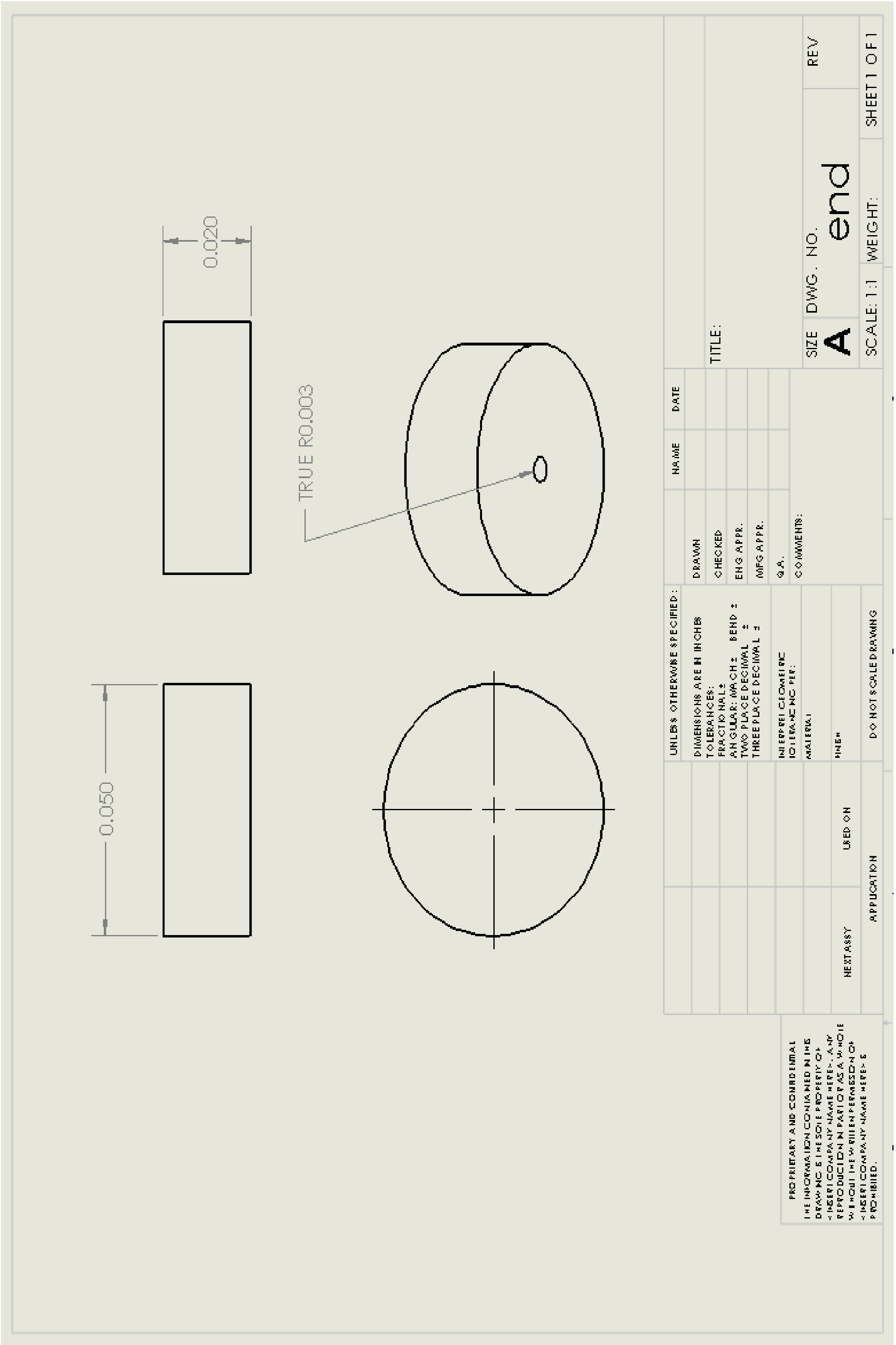
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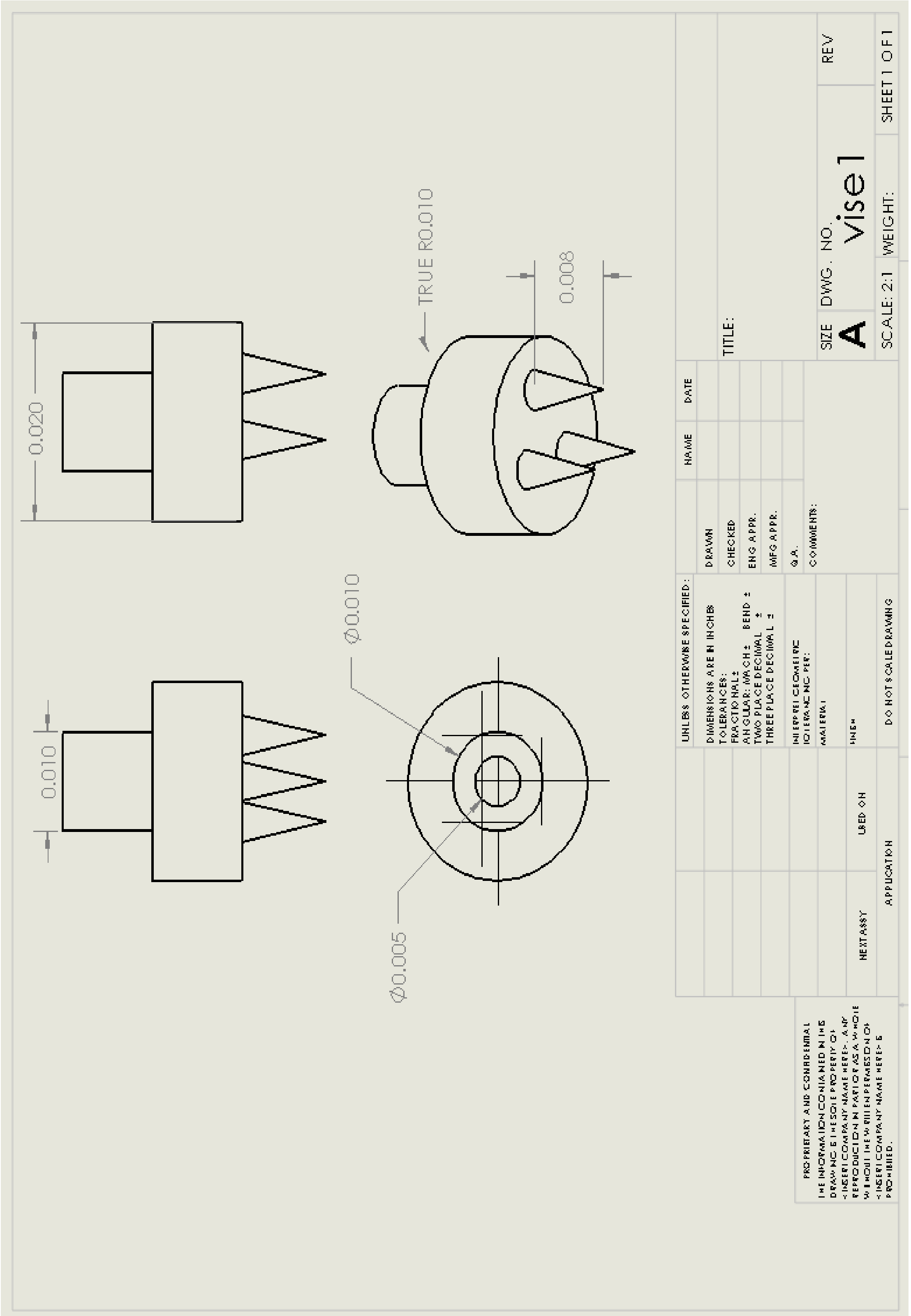
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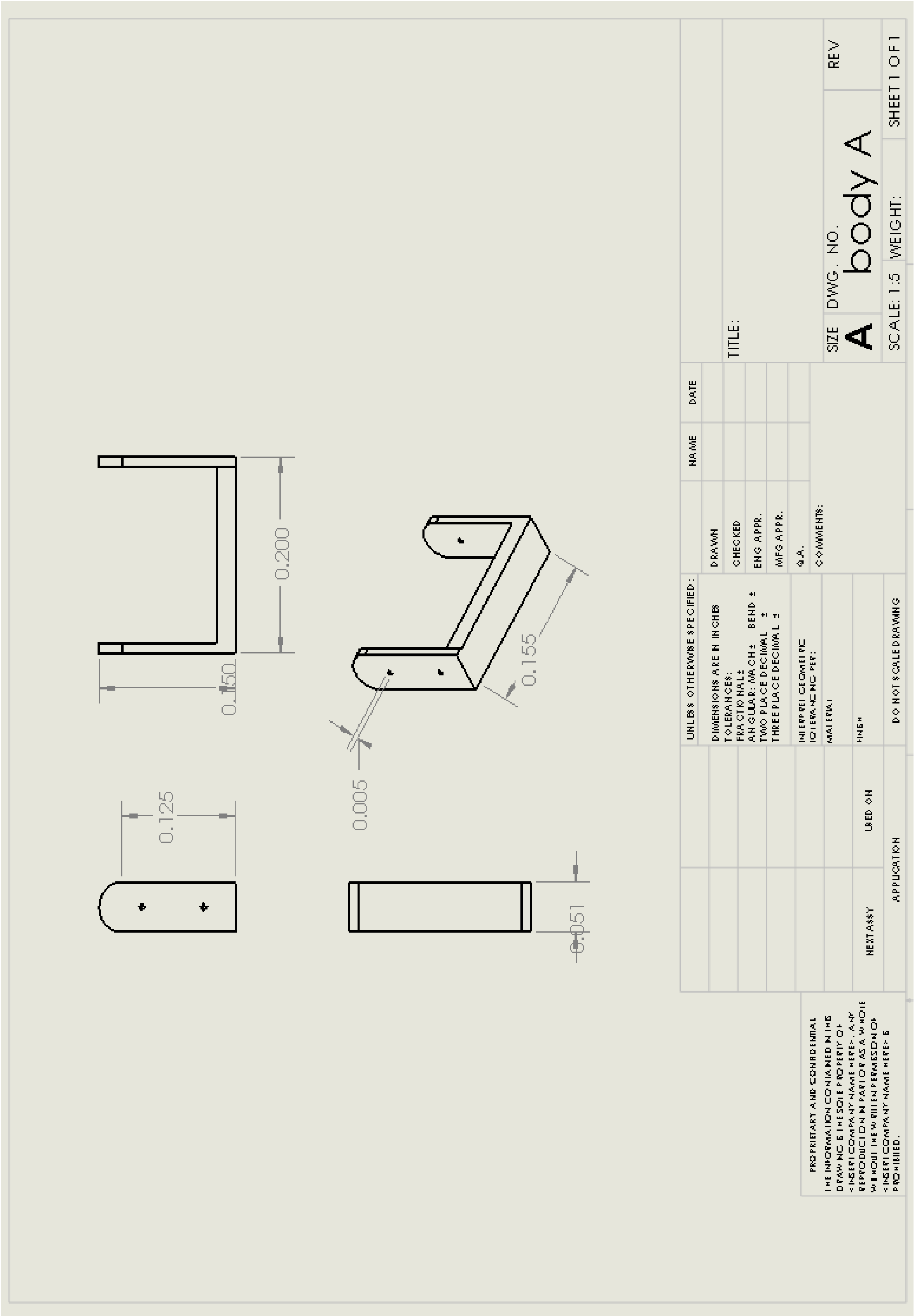
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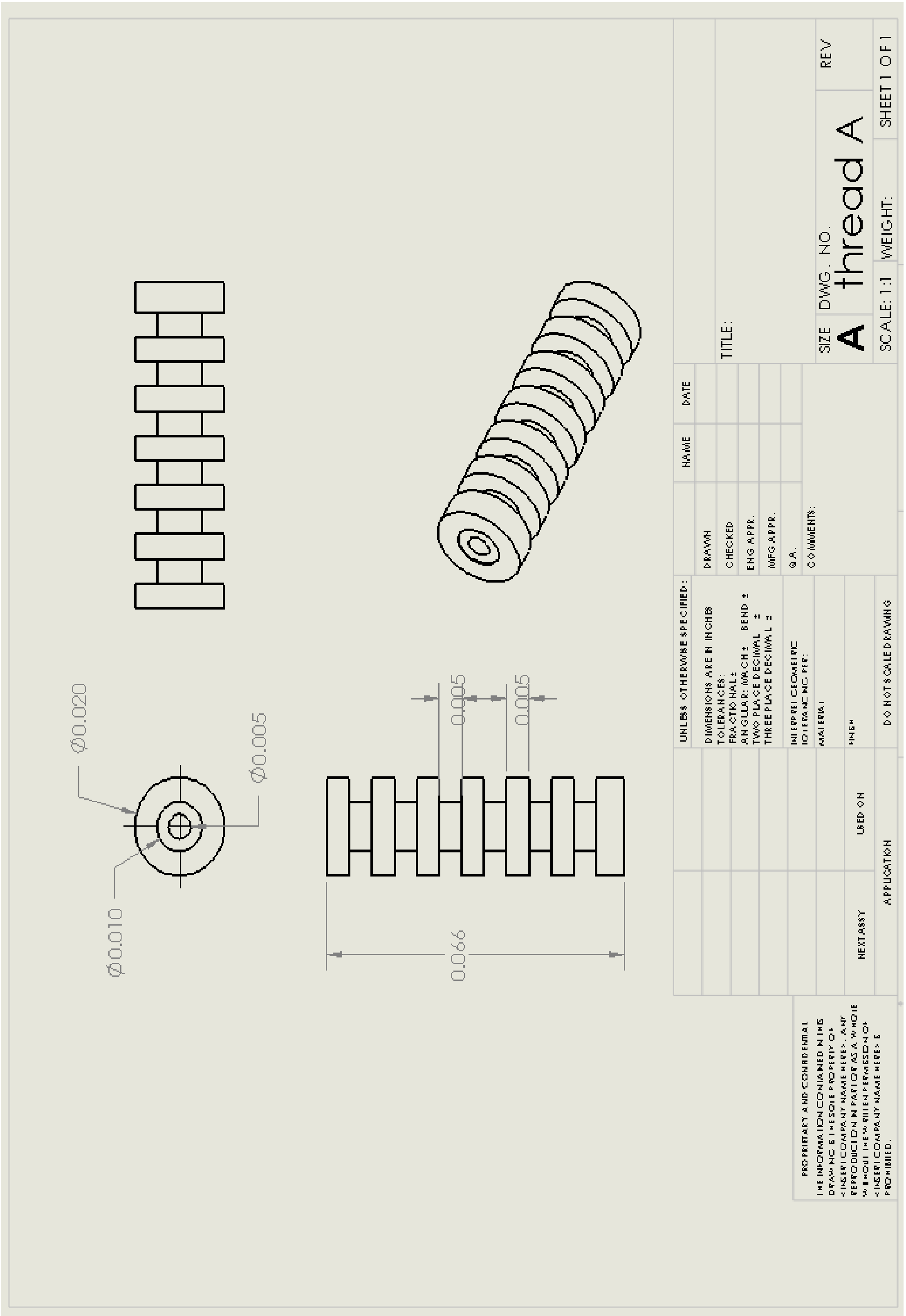
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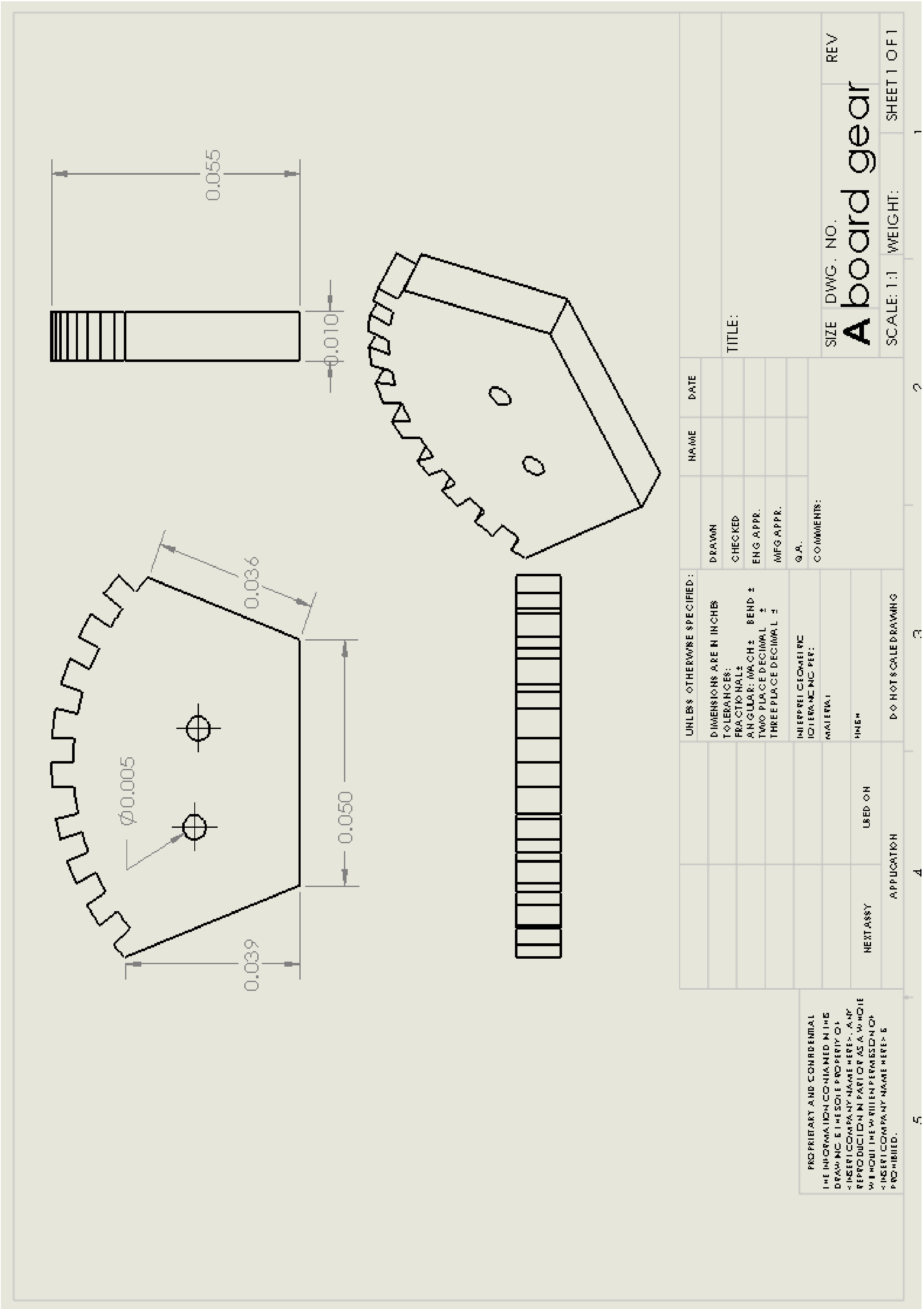
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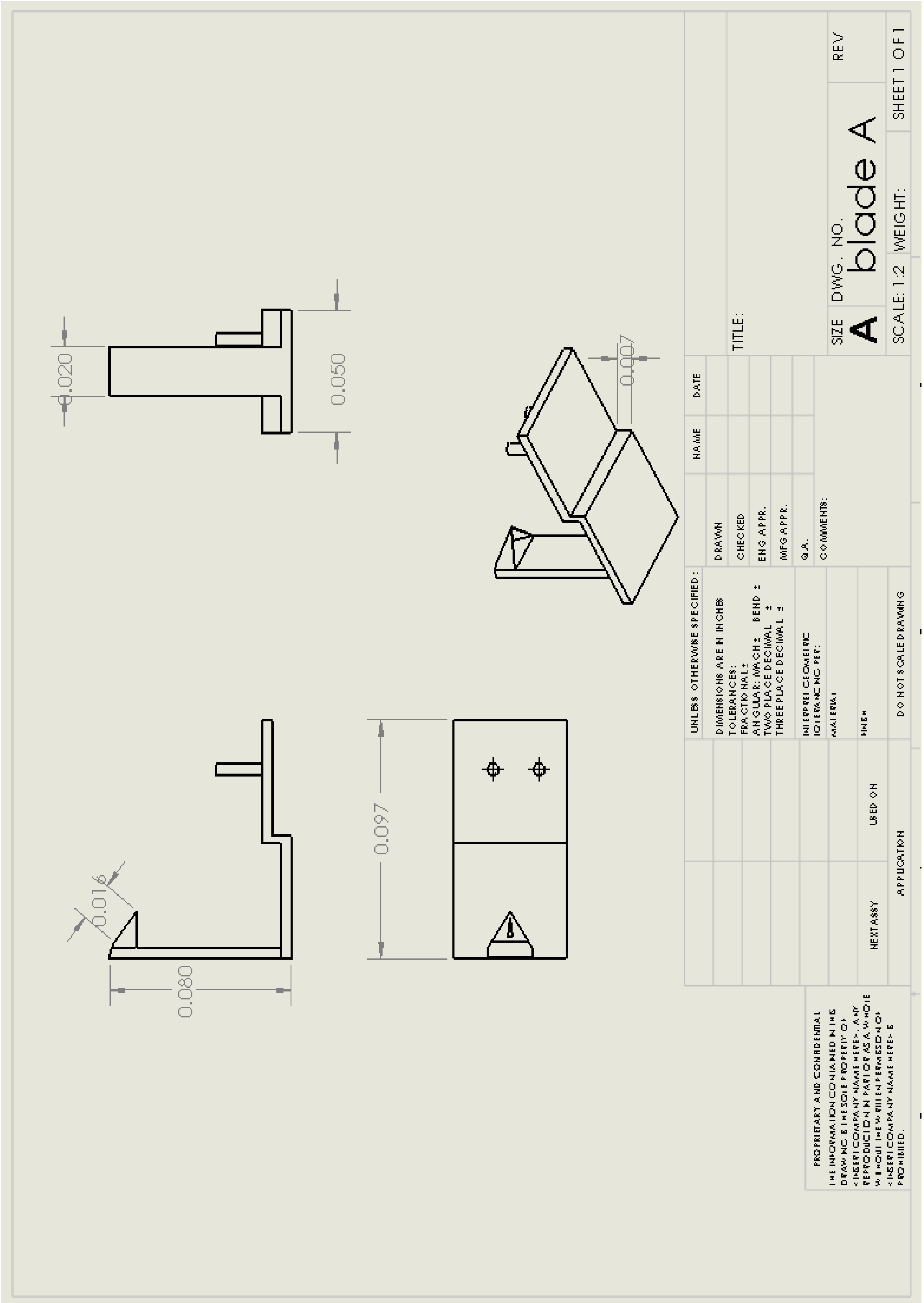
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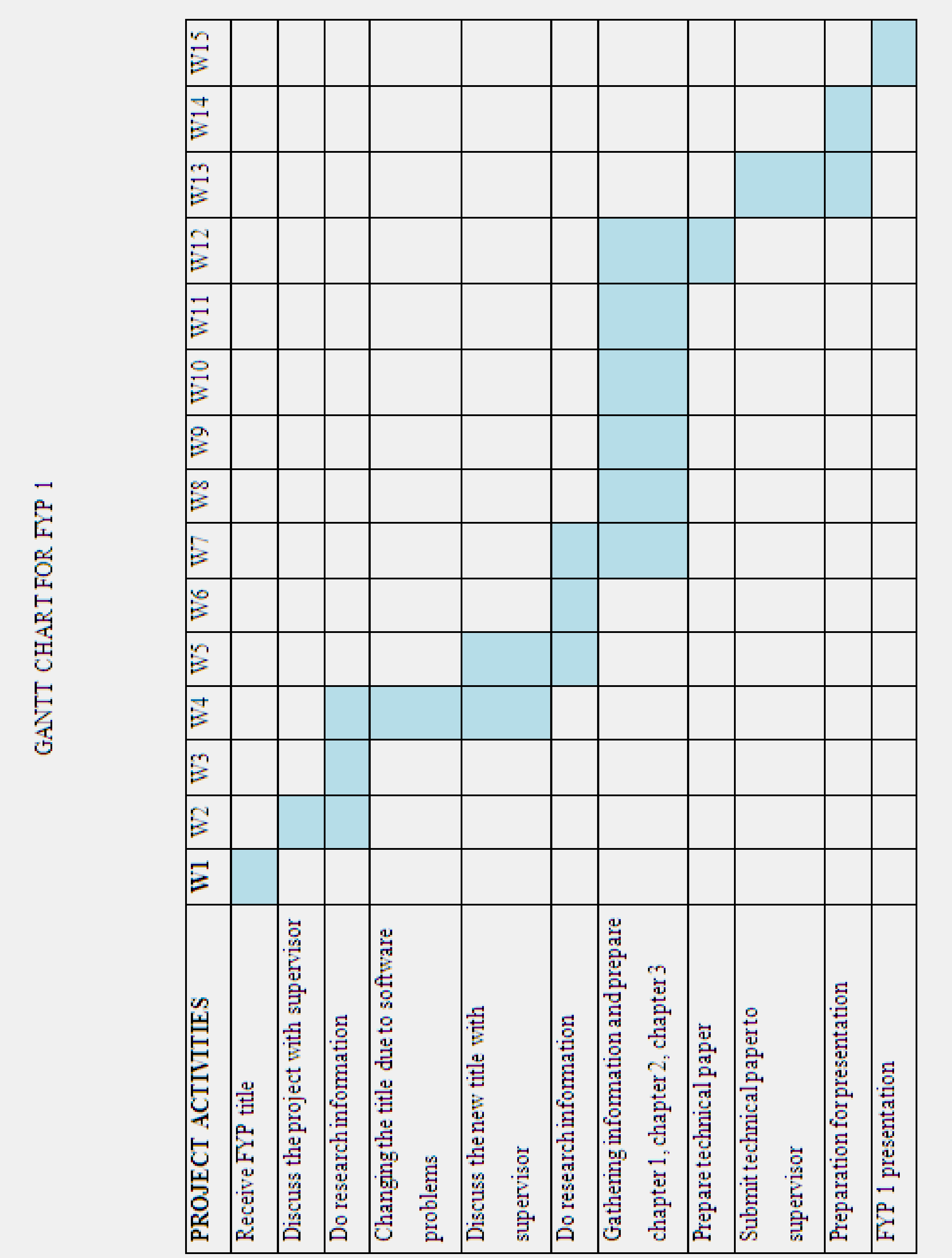
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
SIZE
A
DWG. NO.
blade A
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL

APPENDIX C

GANTT CHARTS FOR FINAL YEAR PROJECT



GANTT CHART FOR FYP 2

PROJECT ACTIVITIES	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15
Supervisor gave comment for previous presentation															
Correction of the previous project															
Discuss the tasks for FYP 2															
Finding suitable software															
Do the designs															
Do the simulation															
Gathering information and prepare for thesis															
Prepare technical paper															
Submit technical paper to supervisor															
Preparation for presentation															
FYP 2 presentation															