UNIVERSITI MALAYSIA PAHANG

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BORANG PENGESAHAN STATUS TESIS

JUDUL: DESIGN AND FABRICATION OF TANDEM REAR PART

SESI PENGAJIAN: 2012/2013

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DESIGN AND FABRICATION OF TANDEM REAR PART

AMIRUL IZWAN BIN ABDULLAH

Thesis submitted fulfillment of the requirements for the award of

Diploma of Mechanical Engineering

Faculty of Mechanical Engineering

UNIVERSITI MALAYSIA PAHANG

JANUARY 2013

SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion this project is satisfactory in terms of scope and quality for the award of the Diploma of Mechanical Engineering

Signature :

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Date : 18 JANUARY 2013

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotation and summary which have been duly acknowledged. The thesis has not been accepted for any diploma and is not concurrently submitted for award of other diploma.

Signature :

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ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor Mr. Rosmazi bin Rosli for his invaluable guidance, continuous encouragement and constant support in making this project possible. I really appreciate his guidance from the initial to the final level that enabled me to develop an understanding of this research thoroughly. Without his advice and assistance it would be a lot tougher to completion. I also sincerely thank for the time him spending for proofreading and correctly my mistakes.

I also would like to express very special thanks to my project partner Izzatzikri bin Musa in the effort for completing this project together and also to all my lectures and members of the staff of the Mechanical Engineering Department of University Malaysia Pahang(UMP) who helped me in many ways and made my journey at UMP pleasant and unforgettable. Also many thanked to the member of Diploma of Mechanical Engineering M01 for their excellent co-operation, inspirations and supports during this study. This three year experience with all you guys will be remembered as important memory for me to face the new chapter of life as an engineer.

I also acknowledge my sincere thankful and gratitude to my parents for their love, dream and sacrifice throughout of my life. I am really thankful for their sacrifice; patience and understanding that were inevitable to make this work possible. Their sacrifice had inspired me from the day I learned how to read and write until what I have become now. Their devotion, support and faith in my ability to achieve my dreams is the most valuable gift for myself.

ABSTRACT

These thesis give a detail explanation about the final year project fabrication of a tandem rear part. The purpose for this project is to fabricate a new tandem that is suitable for the child and also the elder compare to the tandem nowadays. There are many steps has been taken to design and fabricate this tandem. The modeling for this project has been made using Solidwork software. The fabrication process also undergoes many processes like cutting, welding, grinding, bending, sanding and also coating for the finalization of the project. Next, also being provided is a result of a simulation analysis for the product testing. Finally, the conclusion and the recommendation for the future plan of the project also being attached together with this thesis.

ABSTRAK

Tesis membentangkan penerangan secara terperinci tentang penghasilan bahagian belakang sebuah tandem sebagai projek tahun akhir. Tujuan utama projek ini adalah untuk menghasilkan sebuah tandem yang bersesuaian untuk kanak-kanak dan orang tua berbanding dengna tandem yang sedia ada pada masa kini. Terdapat banyak langkah-langkah yang telah diambil dalam proses mereka bentuk dan juga sepanjang penghasilan tandem ini. Proses permodelan atau penstrukturan projek ini telah dilaksanakan dengan menggunakan aplikasi computer Solidwork. Penghasilan projek ini telah melalui banyak prosess seperti pemotongan, kimpalan, pengikiran, pembengkokan, pengempelasan dan juga prosess mengecat turut dilakukan sebagai langkah kemas kini untuk projek ini. Seterusnya, keputusan analisis simulasi sebagai ujian bagi projek ini juga turut disediakan. Akhir sekali, kesimpulan dan bererapa perkara yang boleh dibaiki untuk projek ini juga turut disertakan di dalam tesis ini.

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N	Newton
mm	Millimetres

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

This chapter will be review about the project background, problem statement, objectives and the project scope. Gantt chart for the project flow is also been included in this chapter.

1.1 PROJECT BACKGROUND

A tandem bicycle is designed for two riders and colloquially referred to as a "bicycle built for two". Interest in tandems has generated enough business to attract a number of reputable manufacturers, according to many tandems manufacturing centre. Many tandem bike riders are looking for companionship on a cross-country sightseeing trip, spending more time with their spouse or children or are looking at more of a sports activity. Tandem bikes come in a wide range of styles and models to suit touring, road racing, leisure rides or mountain biking. Tandem bicycle adds a whole new dimension to cycling. A tandem allows two cyclists of differing strength and ability to ride together, pleasurably. The front rider named as Captain and Stoker

for the rear rider. The faster rider doesn't need to wait for the slower one besides the slower rider doesn't need to struggle to try to keep up with the faster rider. A tandem also turns the basically solitary, individualistic activity of cycling into an mutual experience that may be shared by a couple besides allows handicapped people who couldn't otherwise ride a bicycle to share in the joy of cycling.

1.2 PROBLEM STATEMENT

In manufacturing of the tandem industries, manufactures focused on the quality and productivity of the tandem. But most of the tandem product nowadays got a few minor problems. Like nowadays, the tandem bicycle team needs to coordinate their cadence like the speed at which the pedals are turned for makes that both cyclists are comfortable. The Captain will choose the pace by the gear speed she/he chooses to use. A faster cadence is on the whole a better, more effective technique and kinder on the old knee joints, however it is no good if they other rider is uncomfortable and unhappy. The partner must do it simultaneously. Often the weaker or less experienced rider will want to coast more to start. Besides if the second riders feel tired to make a stroke for the second pedal, there will be no place to rest their feet while the other one keep stroke the first pedal and vice versa. Second problem for the tandem nowadays is it’s contained no family characteristics. Many tandems has been designed for sport, pair and other than family activities. The third and the last problem is tandem is one of the rare item sold in our country as the price of a tandem is very expensive.

1.3 OBJECTIVES

The objectives of this project are to design and fabricate a tandem bike: rear part.

1.4 PROJECT SCOPES

The scope that has been decided for this project is to create a bicycle that can be used for the child and also the older besides being used for a recreation with the family members. For the older this product also must be comfortable enough to be use.

1.5 GANT CHART

Gantt chart shows a full planning for my project flow. The planning is made as a guide for me so my project can be completed according to the time given. There is much a waste of time for me during the designing process because of lack of idea for a new design of a tandem that is different from the other tandem in the market nowadays. The Gantt chart can be referring to the appendix B.

1.6 THESIS ORGANIZATION

Chapter 1 will be review about the project background, problem statement, objectives and the project scope. Gantt chart for the project flow is also been included as a direction guide for my final year project.

Chapter 2 will go through about the background study and the research that has been made related to my final year project. This chapter will review about the products in market that are related to my project.

Chapter 3 will go through about the flow chart for this project from the starting until the end process of the project and also included with the concept design generated for this project.

Chapter 4 will explain about the fabrication process that is carried out to complete this project in properly. The material selection for the rear part of the tandem are also been provided in the end of this chapter.

Chapter 5 will be focused on the final product that has been fabricated include with some simple stress simulation analysis to know for sure about the firmness and durability of the product with depends on the material usage and the structure of the project design before proceed to the fabricating process.

Chapter 6 is the conclusion of the project. This chapter would conclude the project and give some recommendation on future similar projects.

CHAPTER 2

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter will provide a background study and some review about the research that has been made related to my final year project. Most of my review is focused on the rear part since my task is only for designing and fabricate the rear part of the tandem. There are many products that are related to my project since my project is a common product that has been used by the community which is a tandem.

2.1 BACKGROUND STUDY

A tandem allows two cyclists of differing strength and ability to ride together, pleasurably. The faster rider doesn't need to wait for the slower one; the slower rider doesn't need to struggle to try to keep up with the faster rider. A tandem turns the basically solitary, individualistic activity of cycling into a mutual experience that may be shared by a couple. A tandem allows handicapped people who couldn't otherwise ride a bicycle to share in the joy of cycling. A tandem can allow a parent to share cycling at an adult level of speed and distance with a child.

The front rider is commonly known as the "captain." Other names for the front rider include "pilot" and "steersman" but for my background study I will just focused on the rear part of the tandem refer to my objective.

The rear rider is commonly known as the "stoker." Other names for the rear rider include "navigator", "tail gunner" and "rear admiral" or "R.A." The rear rider is not a "passenger", but is an equal participant. The stoker serves mainly as a motor. Since the stoker is not called upon to control the bike, this rider should be able to actually generate more power than the same rider would on a single bike. Depending on the strength and endurance of the stoker, this may take the form of a steady output or may be held in reserve. If the stoker is acting as a "reserve," it is OK to take it easy for general cruising, so long as the stoker can help out with a burst of power for the climbs. Since starting up on a tandem is a bit trickier than on a single, the stoker should apply as much smooth power as possible when starting up, to get the bike up to maneuvering speed quickly.

The stoker's other major responsibility is a negative one: The stoker must not attempt to steer. Unpredictable weight shifts on the part of the stoker can make the captain's job much harder, and can lead to crashes, in extreme cases. The stoker should keep in line with the centerline of the bicycle, and lean with it as it leans through corners. A stoker must shift position on the saddle, or adjust a toe strap, or take a drink without disturbing the equilibrium of the bicycle. These activities should not be attempted at all while the captain is dealing with tricky traffic situations or narrow spaces

2.2 PRODUCT REVIEW

Figure 2.1: Bike Friday

Figure 2.1 shows a tandem named as a Bike Friday and being introduced since 1992. This tandem has being designed indeed for the family usage refers to the height. This tandem rear part has a low center-of-mass and classic touring geometry to provide steady climbing and descending. Their also got a low stand over height compared to conventional tandems. This means an ability to not only be built for large riders but for smaller riders. The rear of the bike can also be ride by 4 year old stoker so it is easy be used as a platform teach them cycling and keep them safe from falling. Apart from the physical of the tandem it's also provided a bottle holder made it easier for the rider to keep their water bottle for a long cycling distance.

Figure 2.2: Screamer Recumbent

Figure 2.2 shows a tandem named as a Screamer Recumbent. The lateral of the frame gives very predictable handling, a real asset at high speeds and mostly being used for climbing activity. They allow much recline adjustment and have probably the best lower back support available. On the Screamer the stoker and the rider are close together, making conversation a bit easier in traffic. There is a down side to this. When the front is adjusted (6'3" & full recline) a stoker may hit their toes or shins on the captain's seat. Water bottles or a seat bag on the front seat would interfere with the stokers pedaling. Couples with a shorter captain won't have to worry about this and may even have room to mount bottles and/or a seat bag on the back of the captain's seat. The lack of space makes it a bit tight getting on and off the back though. This tandem use a car seat as their concept seat makes people feel more comfortable and relax in cycling. They also put a chain pressure that connects between the middle chain ring and the flywheel to avoid the chain sag.

Figure 2.3: Kids Tandem

Figure 2.3 shows a tandem named as a Kids Tandem. As it's named, this tandem has definitely being designed by the Brown Cycles company of the Grand Junction in Colorado for the kid's usage. This tandem is exactly different from the others since this tandem is fully controlled by the stoker. All the steering, braking and gearing system are in the back, allowing the child to pedal and enjoy viewing for everything that's coming up. The front of the bike can take a toddler seat for the very young. This toddler seat can be easily replaced with a saddle for older children.

CHAPTER 3

METHODOLOGY

3.0 INTRODUCTION

This chapter will review the flow chart for this project from the starting until the end process of the project included with the concept design generated for this project. Three concept designs has been generated and all the advantages and the disadvantages of the designs are explained in order to regenerate the final design that included all the advantages from the other's designed. From the final design the bill of the material use are generated.

3.1 FLOW CHART

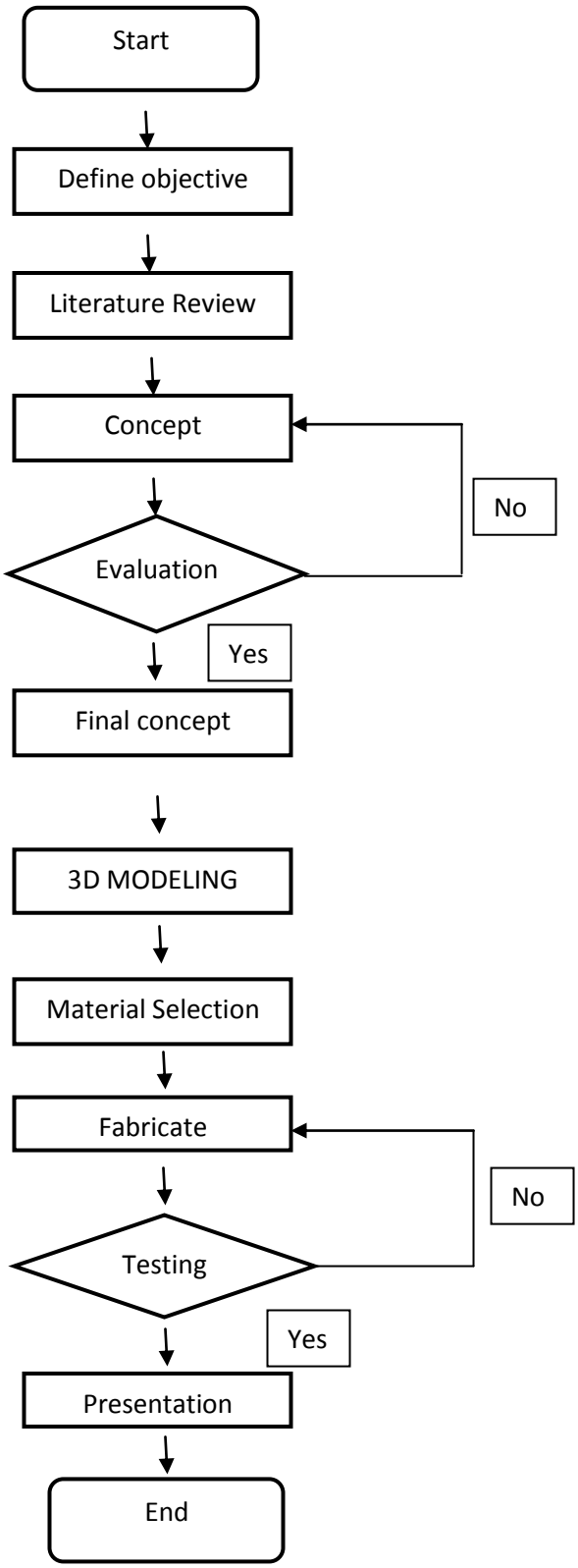


Figure 3.1: Flow chart of the project

3.2 CONCEPT DESIGN

The design needed for this project must be compliance with the objective and the scope of this project where it must be suitable for the recreation, child or older usage with a comfortable condition.

3.2.1 DESIGN 1

Figure 3.2 shows the isometric view of design no 1. This design is a bit attractive compared to the other tandem nowadays because it is a side-by-side tandem where the first and the second rider will seat next to each other to fully control this tandem. This design is also definitely stable compared to the other tandem since it does create a largest space area. Item box is also included in this design make it easier for the users to bring their item or supply together during their journey. The disadvantages of this design is it will cause a high maintenance cost because it is easy to break down depends on the brake system of the design. The left side of the tandem brake will be controlled by the left rider while the right side of the tandem brake will be controlled by the right rider. If the rider needs to slower or stop the tandem they need to push the brake together. Otherwise the left or right side of the tandem will slower while the other will not. From that there will be a higher force occur in the middle connection of the tandem make it easier to break apart with each other side.

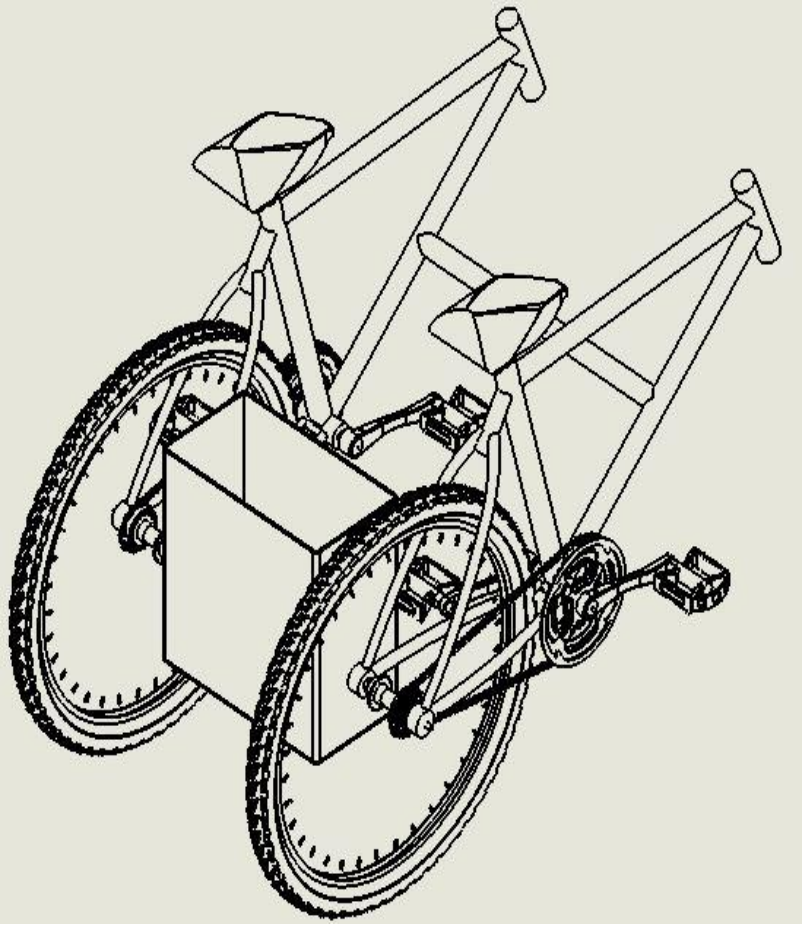


Figure 3.2: Isometric view of design 1

3.2.2 DESIGN 2

Figure 3.3 shows the isometric view of the design 2. Same as design 1 this design is also attractive compared to the tandem nowadays because it's also a side-by-side sitting position for the first and the second rider but the concept is fully like a normal bicycle. The only different is the sits will be doubled to make it possible to be ride like a tandem. The left driver will be controlled the left pedal while the right driver will be controlled the right pedals means a half cadence for each side of the driver. This will affect the space used for this tandem. The disadvantage for this design is it has low stability condition depends on the sits condition design but the

major disadvantages for this design is it is not suitable to be used by the older and the child besides the comfortable aspect for this design is definitely not satisfactory for the elder.

Figure 3.3: Isometric view of design 2

3.2.3 DESIGN 3

Figure 3.4 shows the isometric view of the design 3 which the last design before proceeding to the final design. For the third design I prefer to make an improvement from the second design where I dispose the side-by-side concept of tandem and make it becomes a single ride for the rear driver. The advantages of this design are I have made an addition for the features with the bottle holder and the handle bar for the rear driver. This will give an advantage for the rear driver which is the child where he or she can be in a proper condition of a normal cycler make it easier for them to learn cycling. The disadvantages of this design it has a low stability condition compared to the first design because of the base area. Furthermore this design will be used only one long bicycle chain that will connect the chain wheel for the stoker and the captain. If the chain broken off during the cycling the bicycle can’t be move either by the stoker or the captain.

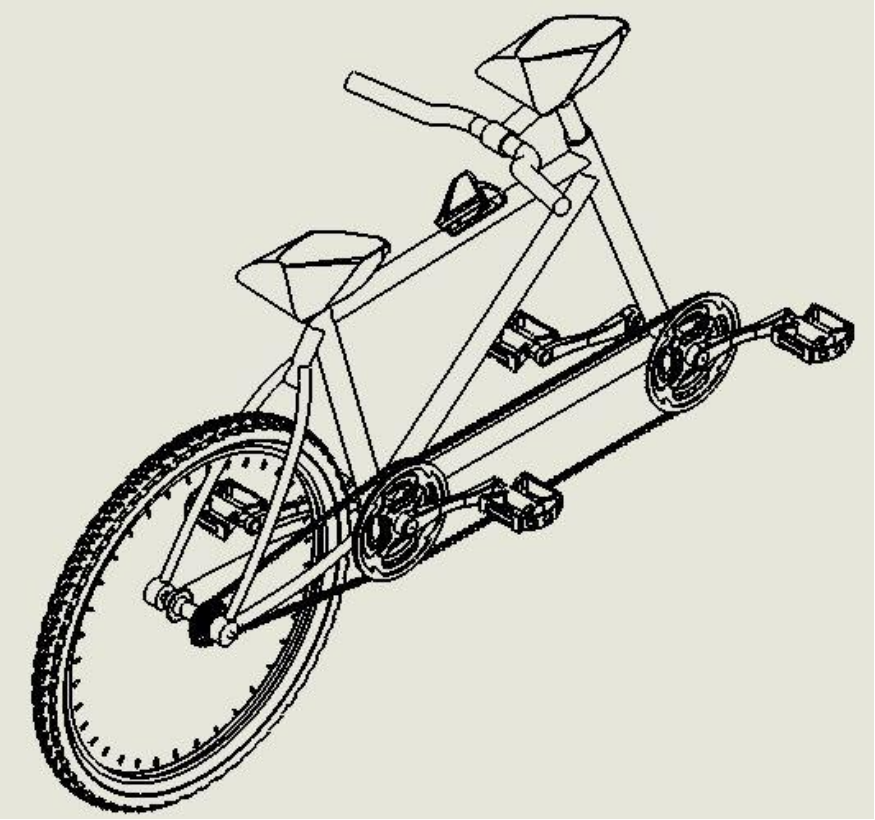


Figure 3.4: Isometric view of design 3

3.3 DESIGN COMPARISON

Table 3.1: Design Comparison for Three Proposed Design

	Concept 1	**Concept 2**	**Concept 3**
Attractive	/	/	/
Safety	/		/
Affordable		/	/
Child and elder user friendly		/	/
Durable			/
Features	/		/

From table 3.1 it was shown that the concept 3 scores the highest mark in the design comparison. It is attractive, safety, affordable, durable and the main subject is it is a user friendly for the child and the elder because it has a suitable features designed indeed for them.

3.4 FINAL CONCEPT

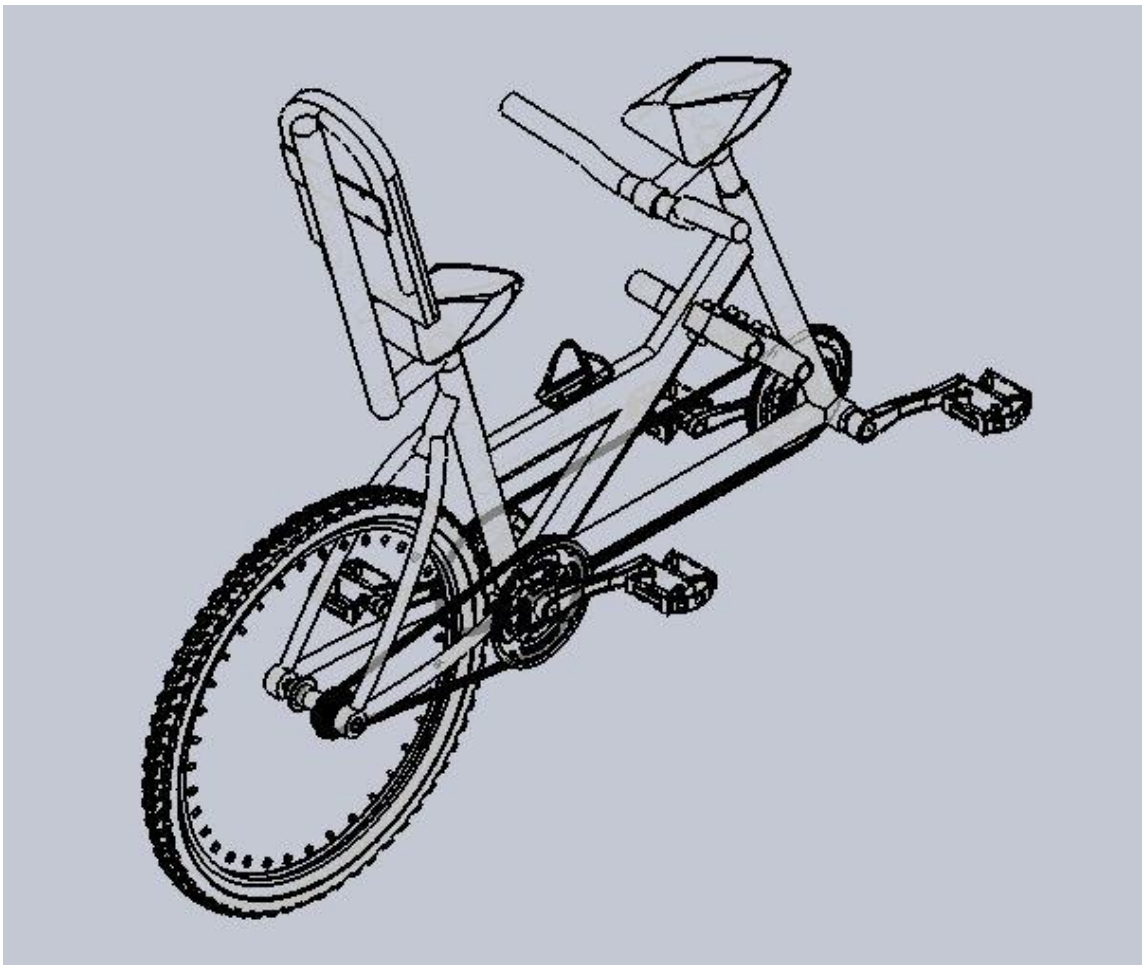


Figure 3.5: Isometric view of final design

Figure 3.5 shows the isometric view of the final design for the project. From three of the concept designed that has been generated before I've combine the entire concept to generate the final concept for this project to achieve the main objective and scope of the project. This concept is really suitable for the child and the elder because it has enough features that is suitable for their usage that will be explain in part design description. The 2D full drawing would be shown in appendix.

3.5 PART DESIGN DESCRIPTION

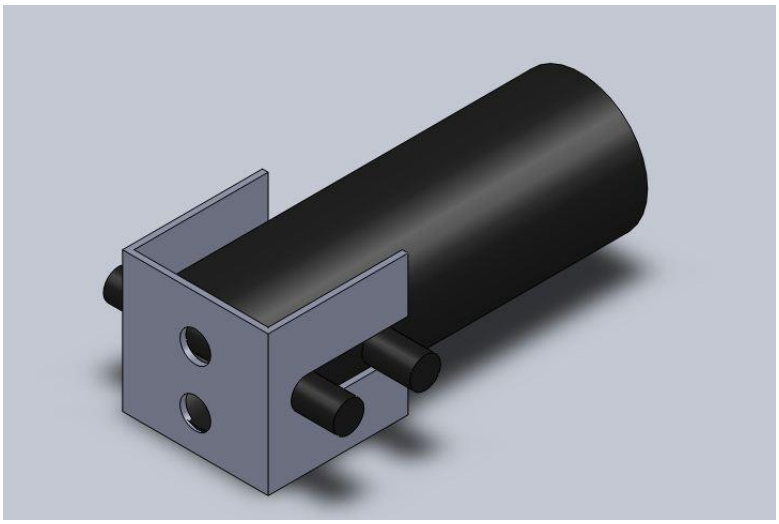


Figure 3.6: Isometric view of the foot rest part

Figure 3.6 shows the isometric view of the foot rest part. This is the part where the child or the elder can put their foot at the rest condition. These parts are being attached to the frame of the tandem by using a screw with a diameter of 8mm. This part are being place in two different places in each side of the tandem and it is adjustable depends on the stoker requisite.

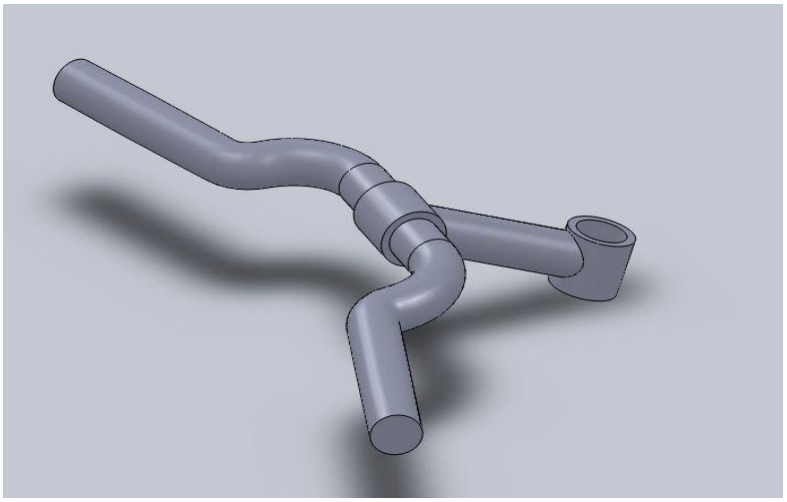


Figure 3.7: Isometric view for the handle part

Figure 3.7 shows the handle part for the stoker. This handle part are weld together with the seat of the captain make it fix together with the tandem. The height of this part are being measured depends on the normal height of the child and the elder.

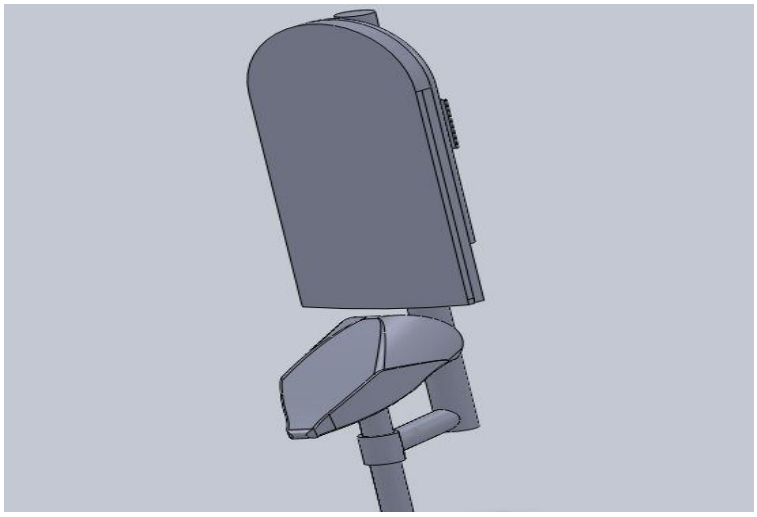


Figure 3.8: Isometric view of the seat rest part

Figure 3.8 shows the seat part of the tandem for the stoker. Seems the rear part is being design correspond to the elder, I've decide to place a rest place for supporting the back of the elder so the elder can be in a comfortable condition. These part are being attached with the seat of the stoker by using a screw with a diameter of 8mm but these part are not adjustable but can be detached if the stoker do not want to use these part.

3.6 SELECTED MATERIALS

For this project, the material use for joining the rear part and the front part of the tandem 1" mild steel and also used for the handle part. Next, also 1" cast iron hollow bar has been decided to be use for the foot rest part.

CHAPTER 4

FABRICATION PROCESS

4.0 INTRODUCTION

This chapter will be explained about the fabrication process that is carried out to complete this project in properly. Cutting, welding, drilling, sanding, coating and finally assembling process would be explained thoroughly to show the steps of the fabrication for this project. Moreover, a material selection for the rear part of the tandem are also been provided in the end of this chapter.

4.1 FABRICATION PROCEDURE

4.1.1 MEASURING

Figure 4.1 shows the measuring tape used to measure the material used for the project. The fabrication process starts with measuring and marking the materials

into the dimension needed according to the design. The measuring and marking process is done by measuring tape, L-shape ruler and steel marker.

Figure 4.1: Measuring process

4.1.2 CUTTING

I’ve basically just cut the head tube open straight down the middle of the original bicycle make it possible to be weld together with the front part of the other bicycle. Then I end up cutting the entire rear triangle of the front bike off. Cutting machine has been used to implement this project.

Figure 4.2: Cutting process

Figure 4.3: Cutting machine

Figure 4.4: Rear part that has been cut

Shearing and band saw machines are also being used for the cutting process of the foot rest frame part.

Figure 4.5: Cutting machine

Figure 4.6: Cutting process

Figure 4.7: Band Saw machine

Figure 4.8: Cutting process

4.1.3 DRILLING

Drilling has been used for making a hole depends on the diameter of the screw selected. I've decide to use an 8.8 mm drill for the entire hole needed for my project. Most of the hole is being used for the assembly of the other part with the frame of the bicycle like the foot rest seat and bottle holder part.

Figure 4.9: Drilling process on frame

Figure 4.10: Drilling process on the seat

4.1.4 WELDING

I've matched it up with the seat tube of the frame after cutting off the upper chain stays. Then I clamped it with some vice grips to hold it in place. I put the tires on at this point in order to make sure that the bottom brackets were both the right distance from the ground. Then we welded those two pieces together and then welded the top bar from another bike between the two bottom brackets for added support. Make sure the two frames are lined up straight, ensuring that the distance is equal on both sides. Note that the stoker (person in the back) is pretty close to the person in the front as compared to traditional tandem frames. Thus the stoker will need to be a smaller individual or someone who likes to ride in the upright position. The safety precaution for us when welding the two frames together is to not damage the bottom brackets of the seat tubes. Welding process is also being used in the fabrication of the foot rest frame.

Figure 4.11: Welding tandem frame part

Figure 4.12: Welding tandem frame

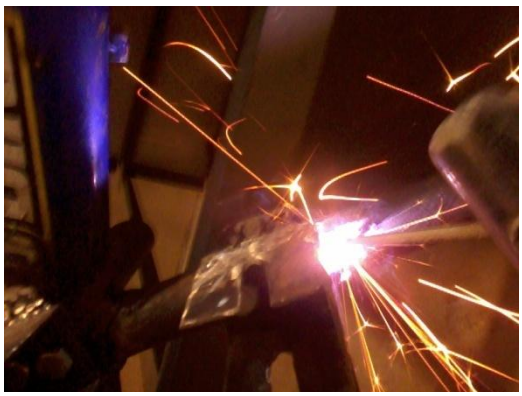


Figure 4.13: Welding foot rest frame part

4.1.5 SANDING

Here we just roughing up the original paint or actually taking all of the original paint off. We went somewhere in-between and sanded off the paint we

could with a wire brush. Then we roughed up the rest as well as we could with sand paper.

Figure 4.14: Sanding process

Figure 4.15: Sanding process

Figure 4.16: Product after sanding process

4.1.6 COATING

Next job was to paint the frame. We researched lots of different types of paints and processes, and decided to go with the cheapest and most durable we could find. We decided to use Hammered, which is a metal-specific paint that is strong and doesn't require a primer coat. It is also a good rust protector. We used rolled up newspapers to protect the seat tubes and bottom brackets and put masking tape around anything else we didn't want paint on. We put a seat and post into the front frame and hung the bike from my homemade bicycle repair stand. We brought it inside to dry by the furnace for 2 days before beginning to build up the bike.

Figure 4.17: Coating process

Figure 4.18: Coating process

Figure 4.19: Product after coating process

4.1.7 ASSEMBLING

Final touch of the project is the assembling process. I've assembled all the features of the tandem like the foot rest, pedal, brake system, chain, sit rest and the handle bar with the rear part of the tandem.

Figure 4.20: Assembling rest part

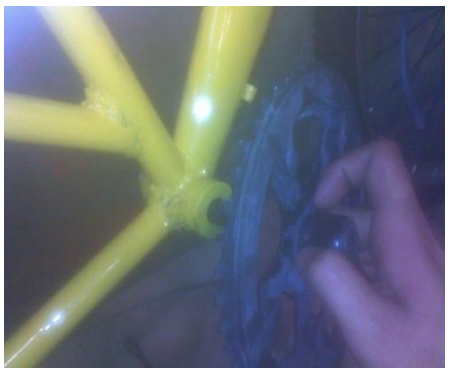


Figure 4.21: Assembling chain wheel part

Figure 4.22: Assembling seat part

4.2 MATERIAL SELECTION

Table 4.1: Material Selection

No.	Item	Quantitiy	Price per unit (RM)	Price
1	Brake pedal	2	5	10
2	Inner cable lead	2	3	6
3	Brake shoe set	2	5	10
5	Bottle holder	1	10	10
6	Seat	1	15	15
7	Chain ring	2	20	40
8	Free wheel	1	3	3
9	Tyre	1	20	20
10	Rim	1	30	30
11	Chain	2	15	30
12	Foot pedal	2	4	8
13	Round hollow beam	6m	40/m	240
14	M08 nut	6	0.8	4.8
15	Rivet	2	2	4
16	Pedal bearing	2	0.5	1.00
		TOTAL		431.8

CHAPTER 5

RESULT AND DISCUSSION

5.0 INTRODUCTION

This chapter will be focused on the final product that has been fabricated include with some simple stress simulation analysis to know for sure about the firmness and durability of the product with depends on the material usage and the structure of the project design before proceed to the fabricating process. The analysis has been applying using Solidwork software. The red color shows a critical part that has a higher force that will cause a fracture on the part.

5.1 ANALYSIS RESULT

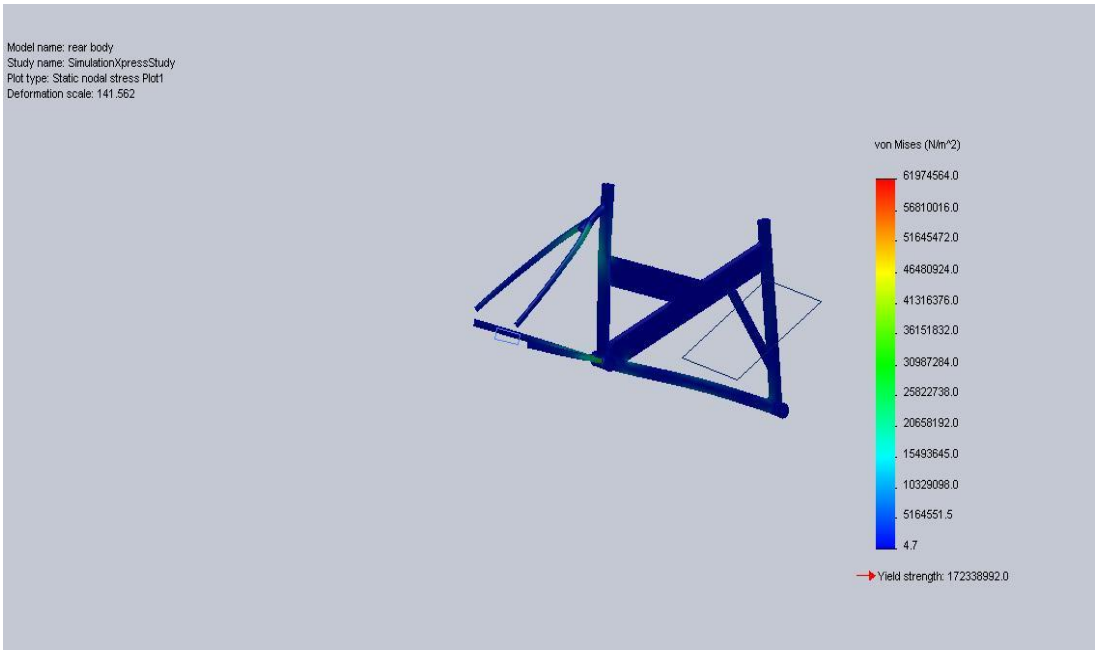


Figure 5.1: Analysis of the frame part

Figure 5.1 shows the stress simulation analysis for the frame part of the tandem. I have care the elderly as a reference for the force given to the frame and it is about 686 N of weight. A deformation scale about 141.562 has been generated. A green color means the part that has received a higher force are strength enough to bear the force and no fracture are produced.

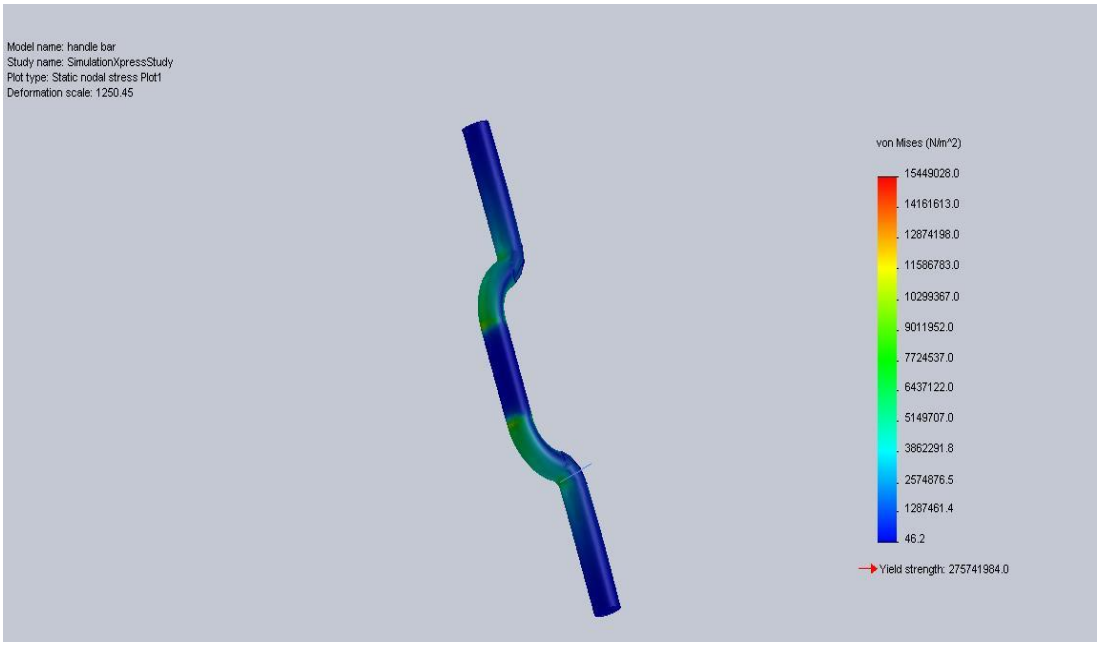


Figure 5.2: Analysis of the handle part

Figure 5.2 shows the stress simulation analysis for the handle part of the tandem. As much as 343 N has been applied on the handle part and about 1250.45 deformation scale has been generated. There are also no fractures in this design of handle part means this design are strength enough to be fabricated.

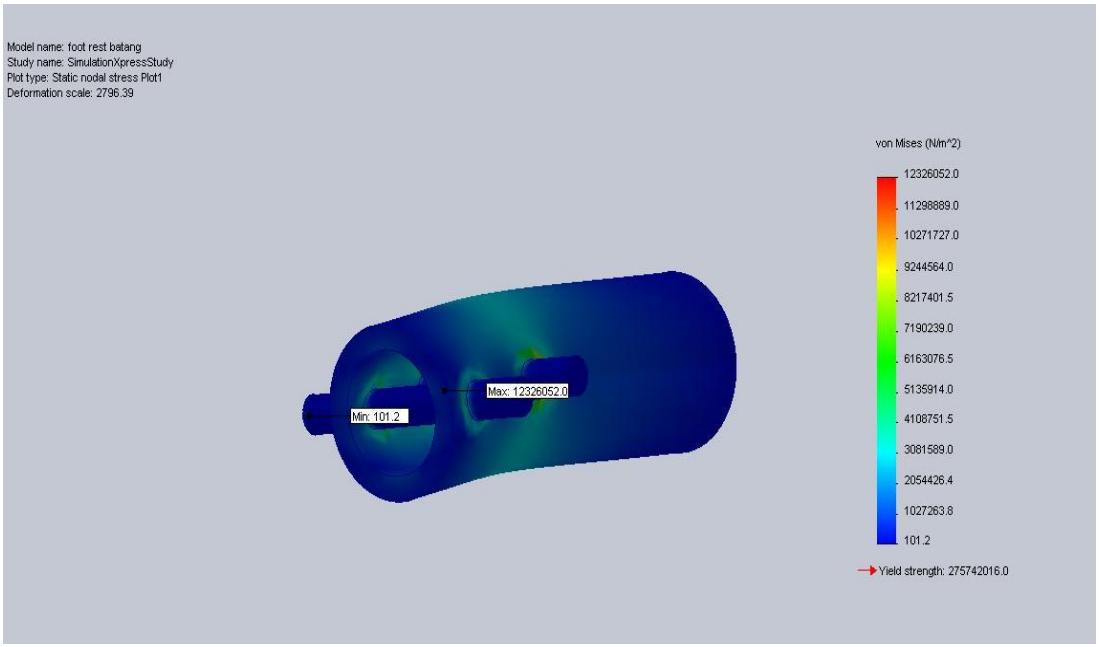


Figure 5.3: Analysis of the foot rest part

Figure 5.3 shows the analysis for the foot rest part of the tandem. 343 N also had been applying for these parts and 2796.39 deformation scales are generated. Same as before, a green color shows the parts are durable enough to bear the force given by the stoker foot.

5.2 FINAL PRODUCT

Figure 5.4: Final Product

Figure 5.4 shows the final product that has been completely fabricated by me and my project partner for this final year project. Testing has been made and surely this tandem can bear the force that been applied by a normal person.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.0 INTRODUCTION

In this chapter, a summary are established to conclude the whole final year product and also included a few problems faced during the fabrication of these project. There also will be a recommendations form for the improvement of this project in the future.

6.1 PROBLEM ENCOUNTERED

During the design process of the tandem, a problem such a lack of idea is occurred because tandem is a common product that has many type of design in the market so it is quite troublesome to generate a new design of a tandem that is different from the market.

Other than that, there are also a problem occurred during the welding process. As the bicycle frame is made from the chrome iron steel, so it is easy for the frame to be perforated. So we need to recover the hollow on the frame using a sheet metal so from that I have wasted some time for the fabrication process.

6.2 CONCLUSION

For the conclusion, the project objective is achieved which is to design and fabricate a tandem rear part with the scope for the elder or the child with the comfortable condition. I have been use many skills that have been learnt in previous mechanical laboratory such as measuring, cutting, drilling, welding and grinding during the fabrication process. The fabrication process provides the experience to develop the skills and the ways to operate the machines to complete the project. At last, the entire problem during the designing and fabrication process is successfully being solved. From that I've learn about a proper action to be taken to solve a problem occurred during the fabrication.

6.3 RECOMMENDATIONS

A recommendation for the similar project in the future is as follows. First of all before generate a design, all the possibility to fabricate the design need to be considered to avoid wasting time during the fabrication process.

Next, for a tandem it is better if the stoker and the captain can be pedaling their pedal in a different cadence. It means if the stoker or the captain attempts to stop cycling they can just put their feet on the pedal and to make this features is possible two freewheel is needed to be placed in the left and the right side of the tandem that connect the front and rear chain of the tandem.

REFERENCES

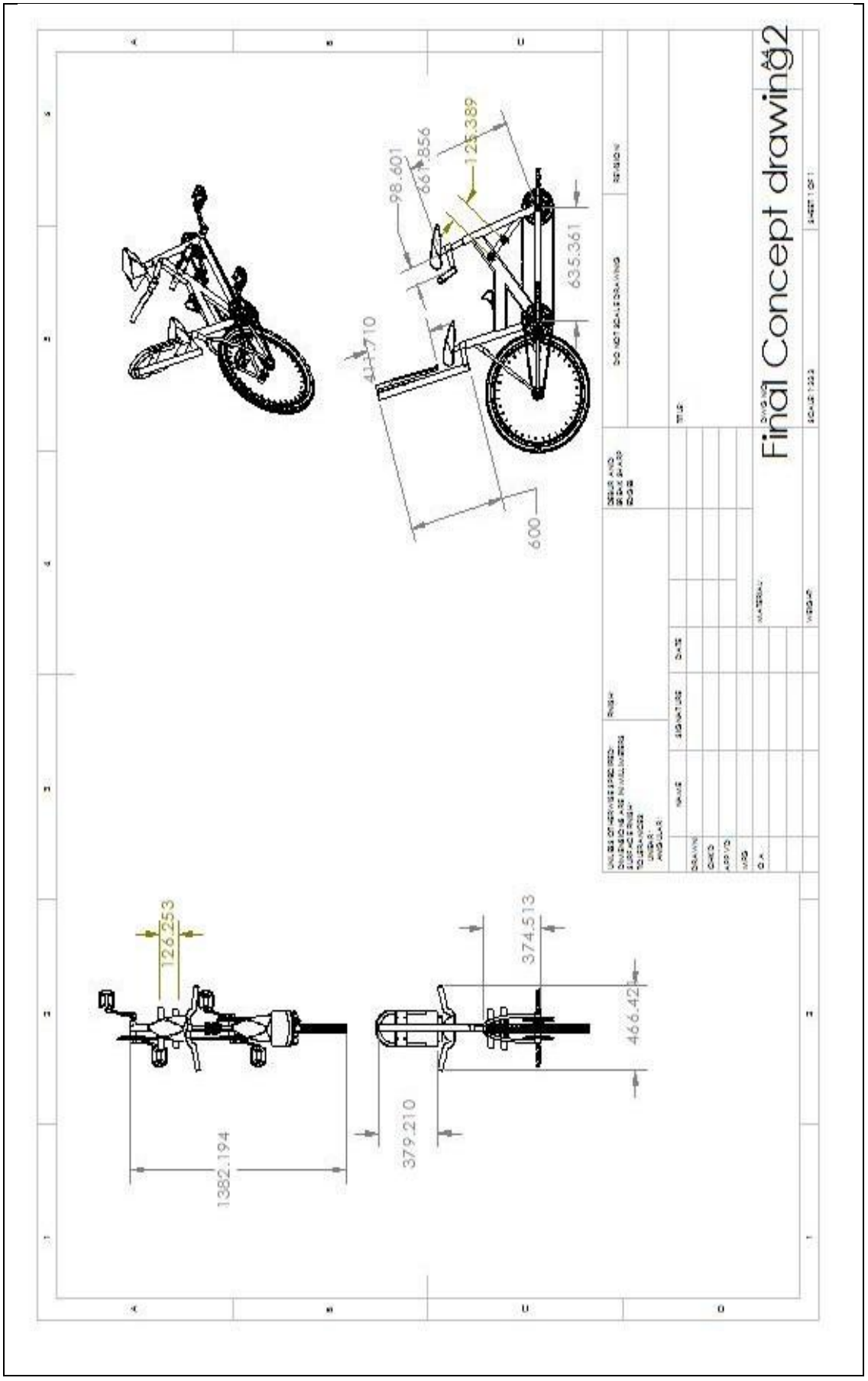
http://sheldonbrown.com/tandkids.html

www.bicycleman.com/recumbents/rans/rans_screamer.htm

bikefriday.com

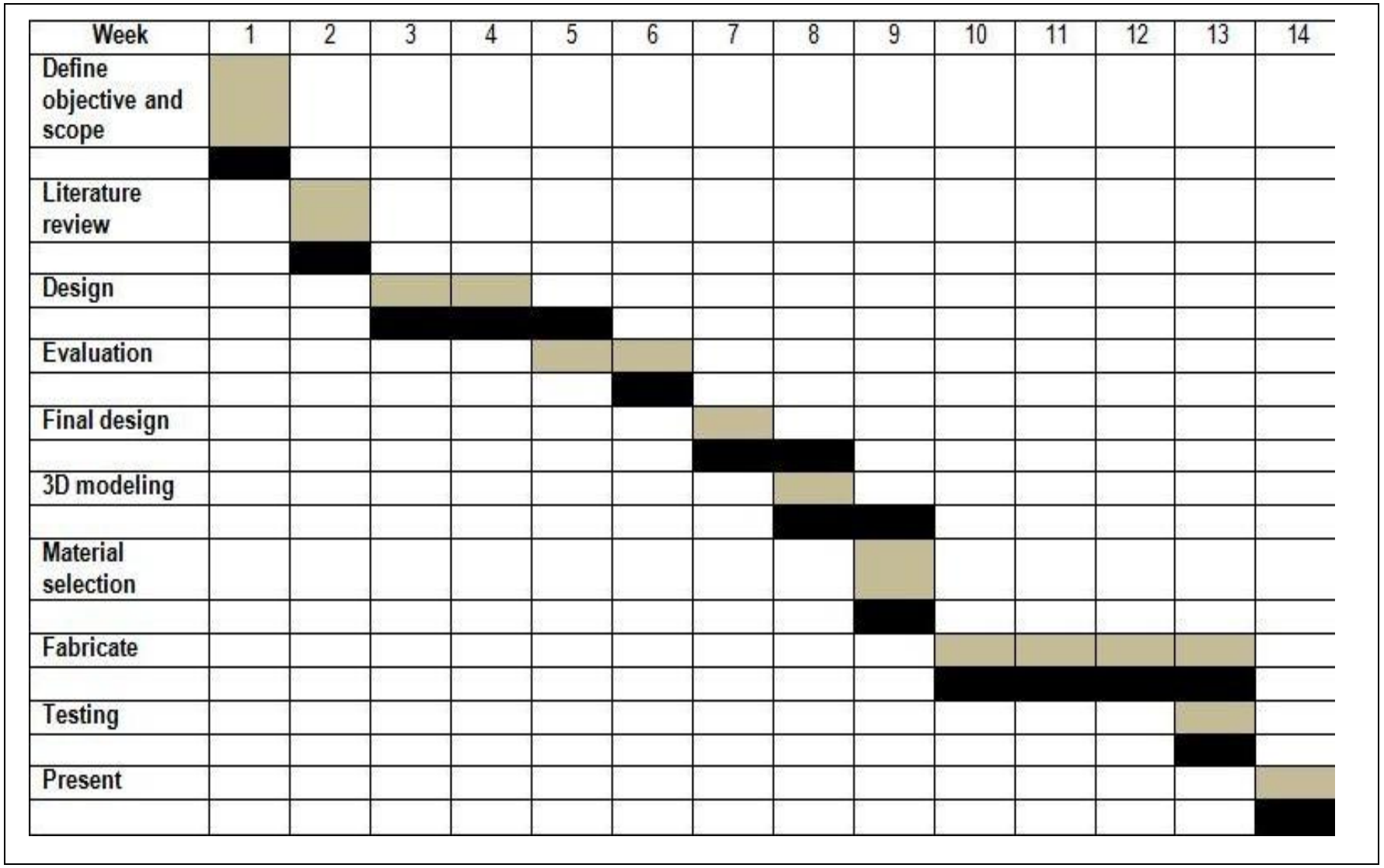
APPENDIX A

FINAL PROJECT DRAWING


Final Concept drawing2
A4
98.601
661.856
125.389
635.361
447.710
600
126.253
374.513
466.42
379.210
1382.194

APPENDIX B

GANTT CHART


Week
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Define objective and scope
Literature review
Design
Evaluation
Final design
3D modeling
Material selection
Fabricate
Testing
Present