MYP PERSONAL PROJECT:

PERSONAL STATEMENT DRAFT 3

MAKING AN ELECTRIC VEHICLE: "ECO-ATK 1"

BY: FRANK (THA-AN) LIN 11A

Acknowledgements

I would like to thank the following people, who have made invaluable contributions, without which, this project would not have been possible.

Most importantly, the biggest "thank you" goes to my Supervisor,
Mr. Hamish Wilson,
Who kept a close eye on me as the project went on,
Always ready to guide me when things go wrong,
Your help is greatly appreciated.

I would then like to thank all the school technicians,
Whose technical expertise and work behind the scenes.
Keep our school running efficiently,
Without their help,
This project would not have proceeded past the planning stage.

I would also like to thank both the drivers,
Who work at my father's company.
Their patience and cooperation was greatly helpful,
Without them, I would not have been able to buy all the materials.

I would like to thank my DT teacher, Ms Michaela Gillespie,
For her enthusiastic support and insight.

Lastly, I need to give a big thank you to my parents,
Without their generous funding,
This project would not have been able to leave the drawing board.

Contents

Introduction

We are living in a rapidly developing world. The threat posed by the fast industrialization of many countries puts a strain of many world resources. One of the biggest concerns today, is the problem of pollution by the use of fossil fuels. Not only are the worldly reserves rapidly depleting, the impact of burning these fuels bring many problems, such as global warming, disintegrating air quality just to name a few. A solution to the crisis would be a gradual change to alternative fuel sources. One of the most promising is electric power for transportation, which is clean and efficient. However, technology at now is heavy, expensive and difficult to maintain. A change is needed.

What is my Personal Project?

My Personal Project is “Working towards a cleaner Bangkok, through environmentally friendly transport technologies.”

Why did I decide to do this topic?

I have decided to choose this topic because of several reasons. Firstly, I am greatly concerned about the environment. Every time I walk down the road, I am faced with seeing hundreds of cars in long traffic jams. Each one is spewing out large amounts of choking exhaust, ruining the air quality in Bangkok. This makes me think, there must be a better way. So I have chosen to set my Personal Project to address the issue of worldwide air pollution from automobiles.

However, in order to achieve this goal, I needed a topic. Being an aficionado for heavy machines and fast cars, I have decided to create an actual working car. Since I was a small child, I have been fascinated by finding out how things work. Over the years, this passion has never died. Now, I have learned to appreciate the beauty in engineering and design, as well as the elegant processes that are behind the construction of these creations.

Also, my favorite shows on TV are ones like Junkyard Wars™ and Full Metal Challenge™, where people build large, complicated machines. The beauty and possibilities behind technology have never ceased to fascinate me. Thus, I decided to try my hand at embarking on an intrepid task to designing and building a car.

How did I get the idea?

The idea of building a car wasn’t new to me. Humans have always been fascinated with speed and power, and from the beginning of their history, cars have been the epitome of this obsession. It has been a childhood dream to own an automobile, one that is fast, fun, yet does not require a license.

The flames were ignited again when I went to the 2002 MYP Personal Project fair. I saw a boy from the year above me create a full-size gas-powered go-kart. The design itself was so big and chunky, resulting in bad performance, and the two-stroke motor was very polluting. I felt like I could do better, and achieve so much more than he did.

What was my goal?

The goal of my Personal Project is to create an affordable alternate form of transportation that is both environmentally friendly and fun to use. After creating the prototype electric working model, it will help to convince people that cleaner technologies do work, and they do help pave the way to a cleaner world.

How did I aim to achieve this goal?

I planned that I was going to achieve this goal by following a modified verion of the design cycle. This would provide with the basic framework for my Process of Creation.

First, I will research details on how to build the product. Also, I will investigate the resources available to me around the city. This will help to refine my design, which I will limit to only the more accessible and affordable parts.

Secondly, I have to plan the actual creation of my product. After looking into the research I have done, I can create a design that is affordable, efficient, easy to make, and performs well.

Thirdly, I need to find somewhere I can create my product. Clearly, I cannot do it in my apartment, and rules forbid me from using school resources. I will have to come up with somewhere I can do the creating stage, where the parts will be put together. All the while, I will evaluate myself, and provide myself with feedback regarding what to do next.

While I'm creating the product, there will be constant improvements and changes to the plan. This is important because I will not be devoting as much time into the planning stage.

Lastly, when the product is finished, I have to evaluate the product. This will come in the form of a battery of test drives. The statistics and specifications of my car will be formulated at the end.

The Process

What techniques did I use to reach my goal?

Conception

The idea behind my Personal Project was already in my head before I started. I first had to put the notion into words, in the form of a topic and a goal. After that, I can start thinking about ways to fulfill that goal.

Background Research – Go-karts and Electric Vehicles (appendix A, B)

Before I can start on my project, I need to do some background research on the topic of cars and go-karts. I learned about how go-kart steering worked, and the importance of steering geometry. This allowed me to create my own steering design with custom specifications. At first, before the goal was formulated, I wanted to create a gas-powered vehicle. But after learning about the environmental and economical issues, I have decided to create an eco-friendly electric car.

After that, I did research on electric vehicles and how they operate. This is to allow me to learn more about environmentally friendly technologies, which is what my goal has been.

Construction Techniques (appendix C)

I had to research construction techniques (appendix B) before I could begin to design. Knowing the limitations of different welding techniques, as well as the ones available to me, is important in knowing which designs are possible. I also had to gather information about electric arc welding, MIG welding, and TIG welding. I also needed to know about how a lathe works and where I can find lathe access.

Learning about these construction techniques and technicalities in construction allowed me to reflect on my goal. My goal was to creating something that was friendly to the environment, so it is important that I made sure that all the processes involved in creation are environmentally friendly.

Refining Ideas (appendix D)

During the course of investigating, I have created many possible plans of the final product (appendix C). Each one builds on newly gathered information, and so there is a continuous refining of the design. The design also changes as the process of collecting material went on, parts had to be modified or changed according to availability. I made a total of 6 designs, as seen in the appendix. The biggest change was from a design with a PVC tubing chassis to one made from metal tubing. This decision was made with the help of an interview with Ms. Gillespie, my DT teacher.

This is related to Homo Faber, where the development of a product is very important. I have made a series of design concepts, each on building on the last. They are listed in appendix C. The finalized product would become my plan for the creation of my product, which is what I wanted to do in my goal.

Collecting Materials (appendix E)

In fact, the materials collection aspect (appendix D) was the most difficult part of my project. I had to gather all the materials I needed to create my electric vehicle, according to my goal. In order to achieve that, I had to make sure that all the materials used are environmentally friendly.

I collected materials from al kinds of places. The parts and where they were obtained are listed in appendix D. Most of the materials were modified parts that were made from scrap. For example, the steering system was made from an old scooter and scrap bits of metal from the off cuts. All these were to minimize the economic impact of creating my car, using cheaper, environmentally friendly materials. It is also crucial that the whole product is friendly to the environment.

Finalized Design (appendix F)

The design (appendix E) for my electric vehicle was finalized only after the collection of most the materials. From the materials I have, and the fabrication techniques available to me, I can formulate design specifications of what the limitations of my design will be. Having made those specifications, I could create a final basic design which I will follow through creating.

This design is meant to have flaws that I will discover as time goes on. Relating back to how I was going to achieve my goal, I am going to create an electric car that environmentally friendly. This means I will be using the least amount of materials, and try to keep the environmental impact of using those materials to a minimum (AOI – Environment).

Construction (appendix G)

This is the most important part of my process. I spent most of my time on this stage. My goal was to create an electric vehicle, so I needed to do this stage well, in order to achieve my goal. The actual construction was done in the technician’s room. This stage lasted for about 2 months, and was the time in which I learnt the most. This stage is crucial, because my goal states that I needed to create the environmentally friendly vehicle.

Revisions and Improvements (appendix H)

During the course of the planning phase of my project, I had to continuously reflect on the process (appendix G), and to relate it to my original goal. I have not changed my goals a lot, but I have strayed away from my plan during the course of creating my product. Many times during the process, I have come across some parts that need modifying, strengthening, etc.

This reflects to my goal, to create a working car. As I have stated in “How I am going to achieve this goal”, I am not going to devote as much time to the planning stage. It is inevitable that I encounter some problems, and I have found ways around them. These problems are listed in appendix G, and contributed to the development of my product, a crucial aspect of Homo Faber.

Finished Product (appendix I)

After months of hard work, I finally finished my product. The car has been spray-painted with bright, sky-blue acrylic lacquer, to prevent rusting. Another coat of clear lacquer was applied to prevent scratching. Now, the car is a bright blue, with dark blue handlebars. It has a very clean, look to it, a simple elegance. I believe I have achieved my goal, creating the product that both environmentally friendly.

Evaluation of Product

Me creating my product was a great triumph for myself. Now, I needed to test it. Riding it around the school oval, I could feel how the car turns, accelerates and responds to road conditions. My actual product performed very well. It has a smooth, gentle acceleration, peaking at 40 km/h. My car has proved to be a very successful product, fulfilling my goal of being both fun to use and environmentally friendly. I have thoroughly enjoyed every single part of the process of making it.

Why did I use this method?

For my Personal Project, I chose this method because it was a simple and involved little complications. Improvements and changes are going to be needed as the project progresses, but these allow ample time to change those problems that could not possibly have been foreseen in planning alone.

Due to the nature of this project, I am not very familiar with making such vehicles. Instead of spending large amounts of time sitting down and thinking it over, I took it in steps. I first thought about the first step and I went ahead and did the work. Any problems that arose, I strove to solve quickly. The problems encountered help me decide the best course of action for the next step. This quickly built into a complicated web of things that need doing, a race against time to the Personal Project deadline. However, in the end, I finished well ahead of time.

I felt that this method was a very good way to approach the task. It allowed for a thorough development, and gave me many chances to learn from mistakes and problems. Research was done before hand, to familiarize myself with the processes involved.

Research

What research did I do?

On Go-Karts and engines (appendix A)

Before I had formulated my goal, I did some preliminary research on go-kart construction (sources 5, 6, 10, 11, 22), as well as for general information about engines (source 24). I learnt a lot about how go-karts and engines worked by looking at existing inventions (sources 1, 2, 10, 14, 16). I learned what a clutch was and why it is necessary (source 8).

I did research on go-kart steering, and why it is important to have Ackerman, Castor and Camber angles (source 17). After a while, I realized that it was going to be too complicated and bad for the environment to make a gas-powered go-kart (source 25). This helped me to focus my goal, to make it something easily attainable.

On Electric Vehicles (appendix B)

The research I did on electric vehicles helped in greatly later on (source 13, 15, 19, 20, 26). This allowed to learn about the development and context of electric vehicles (source 28). This is important in order to fulfill my goal, because I need to understand how clean technologies are advantageous, in order to teach people to adopt them. I also did research on batteries (source 9 and 12) and different types of chargers (source 3).

On Electric motors (appendix B)

Research was done on electric motors, as well as how the electrical wiring works (source 27). I examined the differences between different types of DC direct power and AC induction motors (source 3, 4, 23). The ways the motors were regulated using controllers such as MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) was also very interesting to learn about. I went on to investigate electric vehicles in general, and I learned a lot about the current technologies (source 7), in order to address my goal of teaching people to adopt them.

On Chassis Design (appendix C)

A lot of research went into the design of the chassis (source 18). It is what has to withstand all the forces while the car is moving, as well as support the weight of the driver and equipment. I investigated the effects of triangulation and torsion bars on the flexibility of a car's chassis (source 21). It is important to make a strong yet light chassis.

I researched how to use arc welding, MIG welding, TIG welding and many others (sources 29 and 30), comparing the limitations. I also did research on how lathes worked (source 31), and where I had access to one.

On Driving Technique

I also did some research regarding how to operate my car after it is finished (source 24). As go-karts do not have a differential, there are special techniques to allow for a tighter turning circle. This knowledge is particularly useful when operating my vehicle, as we already know it has problems with the rear wheels.

What sources did I use?

The Internet

For my research, I mostly used information that was contained in websites. The Internet is a great resource for information for different designs of cars, made by different people. This allowed me to get ideas for my designs, and to refine my construction techniques.

Books

I found that books were not as useful towards my project, because there are less books on the topic available to me. However, I did use one book on Metalwork (source 31)

Help from People

Most of my information, however, came from the experience of school technicians. They were always there to help me out, giving me advice and helping me with the more difficult parts of the construction. Without their advice, my project would never have gotten finished.

Interviews

I received very little advice and information from interviews and emails, although an interview with Ms. Gillespie proved to be useful. I corresponded with a man in Ireland who create a wonderful website about creating go-karts. He has some advice which made me decide to pursue making an electric car, since motors are too expensive.

What did I use from my research?

I have used everything from my research. Every little bit of knowledge counted into shaping my final product. I used the designs I found on the Internet to formulate a final design. I used guides I found on the Internet to provide a basic outline for the construction phase.

On Go-Karts and engines

My research on go-karts is very important (sources 5, 6, 10, 11, 22). It allowed me to make a decision early on about what kind of a product to make. It also proved useful later on, as I needed information on steering geometry. My research on what Ackerman, Camber, Castor angles gave me a better understanding about how it all works (source 17). Ackerman allows the steering to outside wheel to turn more than the inside on turns, Camber helps to make the steering wheel return to the neutral position when it is let go of, and Castor allows the kart to flip onto 3 wheels on turns.

The plans and pictures of other's people's karts proved to be very useful (sources 1, 2, 10, 14, 16). I decided things such as seating layout, vehicle specifications and many other things by looking at other people's karts. Other important things that I learnt from looking at other people's creations are the specifications for parts such as the spindle cradles and angles for the steering geometry. All this research helped give me the information I needed to create my product, hence achieve the goal of creating an electric vehicle.

On Electric Vehicles

The research I did on electric vehicles helped in greatly later on (source 13, 15, 19, 20, 26). This allowed to learn about the context of my product. Electric vehicles have not been around for a long time, and I have learned a lot about their development and impact on the world. Following this, I learned a lot about the current technologies (source 7) that are trying to work towards a petroleum-free future.

Research on batteries allowed me to know more about which kind to buy, and how to take care of it (source 9 and 12). In the end, I decided on a pair of 17 amp SLA batteries, because they were low maintenance. It also prompted me to buy a constant voltage charger (source 3), since it is a lot cheaper and simpler to use. This information contributed to the various decisions I made, in order to achieve my goal (such as what controller)

On Electric motors

Research was done on electric motors (source 27), I learned the differences between AC induction motors and DC brush less motors (source 3, 4, 23). It turns out that AC motors are more efficient and cheaper, but require an expensive controller. I found this to be fascinating, learning about all the different kinds motors and the differences between them. I decided to buy a DC motor, because it didn't need a complicated and expensive controller. It was interesting to learn about the MOSFETs. This helped me with my goal because it gave me information about which motor to buy.

On Chassis Design

The chassis of my car is probably the most important part of the design (source 18). It is what has to withstand all the forces while the car is moving, as well as support the weight of the driver and equipment. I had to keep in simple and light, yet strong and rigid at the same time. Using thin-walled steel tubing helped a lot, because it was cheap, light and strong. The layout of all the chassis tubing didn't require much technical expertise, since the car itself is not going to be a high-performance vehicle. The chassis was designed on the basis of a light and very simple, yet strong structure (source 21).

I did a lot of research on construction techniques (appendix D), in order to understand the possibilities and the limitations (sources 29 and 30). I researched how to use arc welding, MIG welding, TIG welding and many others, comparing the limitations. I figured that arc welding would be enough because it is simple, accessible and cheap. I also did research on how lathes worked (source 31), and where I had access to one. This allowed me to retrofit parts exactly to my specifications. All this research helped me tremendously with achieving my goal. It allowed me design the chassis, which is the most essential part of my product and a crucial step in attaining my goal.

On Driving Technique

I also did some research regarding how to operate my car after it is finished (source 24). As go-karts do not have a differential, there are special techniques to allow for a tighter turning circle. This knowledge is particularly useful when driving my car, due to the unresponsive turns from the differential-less axle. I learned that on turns, one can lean towards the apex of the car (the inside portion of the turn, close to the curb), and the shift in weight should allow for a smooth turn. I also learned that you need to hit the apex in the middle of your turning maneuver, so help reduce the need for a sharp turn.

Areas of Interaction

The two AOI's my project relates to

My project is closely related to two AOIs

Environment

This project is related to the environment because the main driving force behind its conception and creation is the want to help the environment. The goal is to help promote clean technologies, as they are just as good, and do not harm our precious environment. The product itself also needs to be safe for the environment, in order to accomplish the goal.

Homo Faber

This project is also related to Homo Faber because during the process of creating my product, I have come across many examples of human creativity. Human creativity is best expressed in technology, as new problems arise, old solutions are modified and new ones are created. The beauty behind the creation of these inventions which have become an integral part of our lives are all part of Homo Faber.

Discuss the AOI's in depth

Environment

The Environment is a big part of my Personal Project. I have tried to be aware of various environmental issues that arise from me creating my product. Much of the materials involved come from the environment, and I need to be very cautious in the usage of these resources.

After conducting research on welding techniques, which have been crucial to achieving my goal, I learned that it has affected our lives in many ways. So many things in our lives revolve around metals and metal fabrication. Our over dependence on metals have also affected the environment negatively, mining has stripped the countryside, landfills are full of old metal machinery and water with heavy-metal residues from factories taint our water supply.

Researching about electric vehicles taught me a lot about the issues facing the world today. Emissions from the industrialized world is increasing every year, causing great harm to the environment. Cars and other vehicles play a major role in this increase. The prices of fossil fuels are also on the rise, and incidents related to their extraction, such as oil spills, do happen. This relates my goal directly to the Environment.

I did research on batteries. This made me aware of the environmental impact of using batteries (even rechargeable ones), since almost all of them contain substances that are highly toxic to the environment. It is important that we dispose of them properly. However, using rechargeable batteries do help the environment, since they can be reused, less of them need to be thrown away.

Rechargeable batteries require electricity from the power grid to charge. This also brings us to another aspect relating to the environment. As the electricity to run the batteries is being generated, fossil fuels are being burnt to provide the energy. This is where the need for alternative power sources comes in. Technologies such as hydroelectric power and solar and wind energy provide clean, but relatively expensive electricity. It is crucial because if electric vehicles are to be the norm, we must begin to change to use these environmentally friendly power sources that don't harm the environment. This is a direct link to the AOI.

Homo Faber

Homo Faber is also a big aspect of my project. My whole project involved learning and appreciating the creativity, actions and thoughts that went into creating my product. My product also has an important context, origin, process of development and impact to the world.

I chose to use a modified version of the Design Cycle to produce my product. This is because this allows me to explicitly address all the Homo Faber aspects of my product. I have a clear origin of the idea, which is when I first conceived of it. This idea comes from my goal, which is to create an environmentally friendly car.

I learned a lot about the context of my vehicle when I did research on the investigation stage about go-karts and electric vehicles. It is important, because this also relates to my goal, as I needed to create a product yet at the same time, help convince people about the

Having a minimal planning stage and a longer create stage allowed for a lot of development to take place (see appendix G). The product has changed a lot from the original design, but I never strayed from the goal. During the course of the development of my product, various difficulties I encountered prompted me to change the design, thus leaving me with a refined final product.

My research on welding techniques (appendix B) allowed me to learn about the origin of the invention that has been essential to the creation of my product. I learned how welding processes developed, and its current impact to the world. Their invention helped start the industrial revolution, and has changed the world.

Electric transport also has a big impact on the world. I did research on the context of electric vehicles at the moment, and how it had progressed since its creation. The evidence I have found promoting the development clean technologies will hopefully help me achieve my goal of teaching the audience about alternative energy sources.

Other AOIs

My project is also related to the other AOIs. The product of the environmentally friendly car helps to pave the way to a cleaner world. At the moment, industrial emissions are very harmful to people, and can affect their health. Relating to Health and Social Education, I have decided not to create a gas-powered go-kart using a standard 2-stroke engine, because of the dangerous emissions. This important aspect of my project also relates directly to Community Service, because if all goes as planned, new cleaner technologies can have tremendous impacts and benefits for the immediate community around us.

Conclusion

Reflection on Goal

My goal at first seemed to be very unrealistic, because the project in itself was very ambitious. However, the goal changed very little as the process continued. I persevered to stick to my original goal, and eventually, every hurdle was passed. But there is still one part of the goal that I cannot attain, because I have not yet presented my product to the audience. However, I hope that when they see the performance of my product as well as the supporting evidence promoting it, they will be more willing to embrace these clean technologies.

Reflection on Process

I feel that using the process I used proved to be very useful in the creation of my product. It was an efficient method for the time I was allocated, because this removed the need for all the plans to be drawn out. This gave me more time to do the actual fabrication, and deal with the problems that arose. Despite the lack of a definite "planning" stage, I still adhered to the overall structure of the Design Cycle. I also reflected upon my goal on every step of the process.

Reflection on Product

After creating the product, I need to reflect on what I made. I feel that I did a very good job of it, and that I learned a lot in the creation of my product. However, as an electric vehicle, there are some performance issues. Having no differential, the car tends to have bad handling around corners, as the outside rear wheel turns faster than the one in the inside. Sometimes this causes the inner-tube to move out of place, making the tires bulge. Otherwise, there are almost no other issues with the operation of my car. Acceleration is smooth and quick, and the top speed is a respectable 40 km/h.

Relevance of Project

This project is a very worthwhile endeavor. Not only did I learn invaluable information about fabrication techniques and design, I learned how to work independently. The product will also have a relevance to the larger community. I am hoping that my product will achieve the goal I had set, and teach the general population a bit more about electric vehicles. And even convince them to adopt these new technologies.

Reflection on Self

I feel I have learned a lot about myself after creating this product, having to overcome obstacles as they appear. It is in my nature to want to get things done quickly, but this project taught me the importance of planning and taking things slowly. Writing the Personal Statement taught me a lot about how the AOIs, and I have learned a lot about their implementation in the world around us. I feel I have learned a lot about mechanical engineering in general, and construction techniques. This has fueled my interest in mechanical engineering, and I am looking forwards to pursuing this interest in the future.

Bibliography

1. "Barstool Racer." Online. Available http://www.geocities.com/hempev/plans.html. April 08, 2003

2. Barber, Richard. "Other Karts." Online. Available http://users.cwnet.com/jhenry/kart/others.html. March 09, 2003

3. "Basics of Electric Vehicles." Online. Available http://www.etvi.org/High_Tech/New_Electric_HiTech_right.html. April 27, 2003

4. "Best Buys." 2003. Online. Available http://www.electric-bikes.com/scoots.htm. April 27, 2003

5. "Buggy Links." Online. Available http://www.dune-buggy.com/buggylinks/Mini_Buggies/index.html. March 09, 2003

6. Burke, Stephen. "Free Kart Plans." Online. Available http://www.csn.ul.ie/~steviewdr/Freeplans/plans.htm. March 04, 2003

7. Burns, Lawrence D. and J. Byron McCormick and Christopher E. Borrini-Bird. "Vehicle of Change" Scientific American October 2002, p. 43

8. "Clutches." Online. Available http://www.kartworld.com/clutches-info.htm. March 28, 2003

9. Dawson, Sandra M. "Battery Power." 2003. Online. Available http://inventors.about.com/library/inventors/blbattery1.htm?terms=Battery. April 29, 2003

10. "Desert Design All Terrain Karts." Online. Available http://www.desertkarts.com/. April 10, 2003

11. "Designing a Formula 24 car." 2003. Online. Available http://www.greenpower.co.uk/design.htm. May 07, 2003

12. "Electricity and Magnetism." Jan 28, 2003. Online. Available http://www.microscopy.fsu.edu/electromag/electricity/batteries/. April 29, 2003

13. "Electric Go-karts." Online. Available http://www.innevations.com/go-karts.html. April 08, 2003

14. Greg and Lee. "Our Go-Kart Project." 2001. Online. Available http://www.geocities.com/gokartproject2001/new/Activity.html. April 10, 2003

15. Griffin, Bill. "Bill Griffin's Campro Electric Go-kart." Online. Available http://www.austinev.org/evalbum/436.html. April 08, 2003

16. "Homebuilt ATV." Online. Available http://www.ggimages.com/kart/index.html. March 09, 2003

17. Hughes, James. "Kart Setup." 2000. Online. Available http://www.karting.co.uk/KandK/Tech/KartSetup.html. May 08, 2003

18. Lawson, David. "Chassis Design." Online. Available http://www.slotcars.org/ssrc2/articles/chassisdesign/chassisdesigndave.htm. March 08, 2003

19. Lee, Robert K. "Robert K. Lee's Electric Go-kart Shock." Online. Available http://www.austinev.org/evalbum/251.html. April 08, 2003

20. Lee, Robert K. "Shock Pictures." Online. Available http://robertklee10.tripod.com/shock_pictures.htm. April 08, 2003

21. O'Reilly, Spike. "Chassis Design Mods." 30 March 2000. Online. Available http://home.mweb.co.za/pi/picons/fury/tech001.html. March 08, 2003

22. "Offroad Gokart Free Plans." Online. Available http://www.sadik.net/gokart/. March 09, 2003

23. "Price Comparisons." Online. Available http://www.electric-scooter-world.com/PriceComparisons.htm April 27, 2003

24. "Resonate Brendel Racing Kart Glossary." 2000. Online. Available http://www.brendel.com/racing/glossary_full.shtml. May 08, 2003

25. "Small Engines Emission Research." Online. Available http://www.egr.msu.edu/erl/emiss/emiss.htm. March 28 2003

26. "The Electric Storm." Online. Available http://www.electricgocarts.com/. April 08, 2003

27. "Test Results." Online. Available http://www.evdeals.com/DynoData.htm/Dyno-Index.htm. April 27, 2003

28. "Tranquility Base Electric Vehicles." Online. Available http://www.hilobay.com/quebok/ecar.htm. April 08, 2003

29. "Welding Techniques." December 24 2003. Online. Available http://www.materialsengineer.com/Stick%20Welding.htm/. July 14 2003

30. "Welding Services." Online. Available http://www.allwelding.com/mig_welding.html. July 14 2003

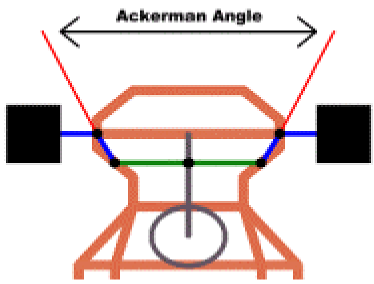
31. Victor E. Repp. Metalwork – Technology meets Practice. Illinois: Glencoe Division of the Macmillan/McGraw-Hill School Publishing Company, 1994.

Appendix A

Research on Go-Karts

Before I started the process of creating my vehicle, I needed some background information about cars.

Steering Geometry

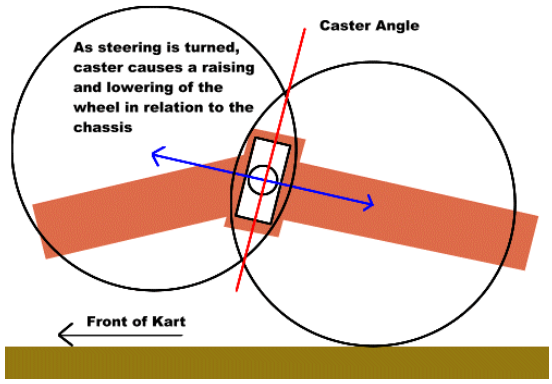


Ackerman

Is the angle the steering arm attached to the spindle is at, in relation to the axis of the car. This allows the inside wheel to turn at a greater angle than the outer wheel, on a turn. This reduces scrubbing (wheel rubbing against the ground), and makes turning smoother.

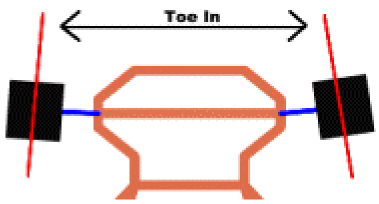
Camber

Is the angle at which the top of the steering spindle and kingpin is bent inwards. This angle helps to make the steering system "self-right" when the wheel is let go of.



Caster

Is the angle which the top of the kingpin is bent towards the rear of the kart. This allows the car to lower the inner front wheel and raise the outer one, in order to make the car tip over onto three wheels during the turn. This is important because karts don't have a differential and problems will arise when the rear wheels spin at different rates on a turn.



Toe

Is the angle at which the front of each wheel is bent inwards towards each other. It helps to improve handing on turns.

Go Kart Engines

Environmental Issues

Air pollution comes from vehicles can be separated into two sources. Cars and other large vehicles use big Internal Combustion engines. Go-Karts and other smaller applications use 2-stroke engines. In order to have a significant improvement in reduction of emissions, we must address the problem of these engines. They are fewer in number and are used less, but the amount of harmful gases they generate is much greater. Also, there are regulations for the emissions of cars, but none for these 2-stroke motors.

They are particularly harmful to the environment because they are particularly inefficient. The main types of emitted exhaust gases are: Carbon Monoxide (CO); various Oxides of Nitrogen (NO_X); Hydrocarbons; (HCs) and "particulates".

Carbon Monoxide is a poisonous gas which can (fatally) reduce the ability of the blood to deliver oxygen to vital organs, as well as causing headaches, dizziness, and comas at higher concentrations.

The oxides of Nitrogen are all harmful. Nitrogen Dioxide in particular, plays a principal role in a complex series of chemical reactions in which lower-level ozone or smog is formed, together with acid rain. Smog can cause various respiratory ailments and damages vegetation.

Unburnt fuel in exhaust gases usually comprises many different “Hydrocarbons” which are all treated together for present regulation purposes. Many hydrocarbons are volatile (VOCs) and participate in smog formation. Others, such as certain benzene derivatives, are carcinogenic.

“Particulates” are also found in exhaust from these 2-stroke engines. They are small solid matter or liquid droplets which remain suspended in the air and can cause respiratory diseases.

The biggest problem, is that changing the air-fuel ratio doesn’t solve the problem. Any alterations only reduce either NO_X or HC while increasing the other.

Clutches

Clutches are a component connected to the drive shaft from the engine. It is connected to the power train, and it is necessary to allow the kart to run the engine idly, at lower RPMs (Revolutions per Minute). The clutch disengages at a certain RPM, disconnecting power from the engine to the chain. When the throttle is increased, it automatically engages itself after a certain RPM, putting power into the wheels.

Appendix B

Research on Electric Vehicles

Batteries

Batteries are a very important part of our everyday lives. They are actually electric cells, a device which creates a current from a chemical reaction. A cell is composed of: a negative electrode; an electrolyte, which has ions; a separator, also an ion conductor; and a positive electrode. The electrolyte may be aqueous (made of water) or non-aqueous (not made of water), in liquid, paste, or solid form; and the casing. When the cell is connected the negative electrode supplies a current of electrons that flow through the load and are accepted by the positive electrode.

Batteries come in many forms, but usually they come in 3 shapes: round, prismatic (rectangular) and button. They can be separated into type different types. Primary batteries are ones where when it is used, the chemicals are slowly used up, and have to be thrown away. While in Secondary batteries, the process can be reversed by recharging, but eventually, they still have to be thrown away.

The more common types of batteries are shown below.

- Alkaline-Manganese Batteries – An alkaline-manganese dioxide battery contains an electrolytically manufactured manganese dioxide and aqueous alkaline electrolyte, as well as zinc metal as a powder. These batteries were developed in the early 1960's and are still widely used today. They are what we usually use for everyday uses, and have better performances than Zinc-Carbon Batteries.

- Lithium Batteries – These usually come as button cells, they give a high voltage, high energy density and have a long shelf life. They are made with a solid electrolyte, usually salts of lithium or organic liquids. The cathodes are made of various materials, such as carbon monoflouride, copper oxide, or vanadium pentoxide. Having no water in the electrolyte, this makes it more efficient, but also harder to make. They provide excellent power density, so they have become the standard for high performance batteries for the past ten years.

- Nickel-Cadmium Batteries (NiCd) – A simple rechargeable battery which is used in many applications. Most rechargeable batteries seen on the market are usually of this type, they can usually be charged and discharged 100+ times. They are made of a nickel hydroxide [$Ni(OH)_2$] cathode, and a cadmium hydroxide [$Cd(OH)_2$] anode. When it is charged, the nickel hydroxide changes to nickel oxyhydroxide [NiOOH]. While in the anode, cadmium hydroxide is transformed to cadmium. Discharging reverses this effect. The formula while it is discharged is show below.

$Cd + 2H_2O + 2NiOOH \rightarrow 2Ni(OH)_2 + Cd(OH)_2$

These batteries, however, contain cadmium, a poisonous metal, so it is starting to be replaced by more environmentally-friendly NiMH batteries.

- Nickel Metal Hydride Batteries (NiMH) – These are the better rechargeable batteries available, and can usually be charged and recharged 500+ times. They are made of a Nickel Hydroxide $Ni(OH)_2$ cathode, and an anode which serves as the hydrogen storage alloy and does not change its composition. Cobalt and chemicals are also added to improve conductivity. When a discharged Nickel Metal Hydride Battery is charged, the chemical composition of the cathode is transformed and the nickel hydroxide changes to nickel oxyhydroxide. When the battery is used, the process is reversed and the nickel oxyhydroxide changes to nickel hydroxide. They are environmentally friendly, cheap, and are used in many applications from mobile phones to power tools, which were traditionally powered by NiCd batteries.

- Zinc-Carbon Batteries - Zinc-carbon batteries have become the standard for the consumer battery industry of today because of their low cost, long shelf life, and low leakage during storage. They are made of a zinc anode, a manganese dioxide cathode, and an electrolyte of ammonium chloride or zinc chloride, which is dissolved in water. The cheaper batteries you see in the market are probably of this type.

As you can see, all these batteries have very technical names of the chemicals they are made of. Many of these, are harmful to the environment. As technological advances continue to create newer and newer products, there is the constant need to have portable power sources. Normal batteries contain many extremely toxic chemicals such as mercury, cadmium and lead. If not properly disposed, these chemicals can leach into ground water and eventually into the food chain.

There are many ways we can help conserve the environment. The simplest way, is to reduce the amount of batteries needed by switching to be using rechargeable batteries. Although they cost more, but they can last you a long time if you use them properly. When they do run out, you will find that they are more cost effective than buying normal batteries. Now, you have to dispose of them properly at special recycling plants, because most of these rechargeable batteries contain cadmium, which is extremely toxic.

Instead of batteries, there are also other ways of generating electricity. One method which has received much praise and recognition is the fuel cell. It uses only hydrogen as fuel, and gives out pure water, a very non-polluting substance. These can be up to 55% efficient compared to 30% of a normal combustion engine. A Proton Exchange Membrane (PEM) fuel cell has a two thin electrodes, separated by a membrane which only allows protons to pass. As hydrogen gas is fed into the anode side of the membrane, the electrons are separated from the protons, and travel into the anode to power the circuit. The lonely, electron-less protons migrate across the membrane, and turn up just in time to be reunited with its lost electrons. These hydrogen molecules then combine with oxygen from the air, to from water.

Other Power Sources

From the batteries to be charged, it also requires electricity. Most of the electricity generated comes from power plants, and most of these harm the environment in some way or another. Coal, oil and gas burning plants are particularly harmful. Other ways of generating electricity include:

- Solar power – this uses special solar cells to generate electricity. The amounts of energy produced are small, so large solar farms are required.
- Wind power – electricity is generated by the wind turning turbines. The amount produced is small, so large wind-farms are needed.
- Hydro-electric power – electricity is generated by falling water, trapped in the large, environmentally damaging reservoirs of dams.
- Geo-thermal energy – this not very practical method taps the energy inside the earth in the form of heat.

- Nuclear energy – this controversial method uses a controlled fission reaction in purified, radioactive elements such as uranium and plutonium. It produces radioactive waste that is hazardous to humans
- Fusion – this yet to be invented technology utilizes a controlled fusion reaction to fuse tritium and deuterium, to form helium, and also lots and lots of energy

Chargers

There are a number of different types of battery chargers, some as listen below:

<u>Constant Voltage</u>
A constant voltage is applied and the current flows into the battery (the highest current occurs when the battery has been fully discharged and steps down to a low current when the battery is nearly charged.) Electronics on constant voltage charges is relatively simple, therefore, these types of chargers tend to be less expensive.

<u>Constant Current</u>
A constant current is applied until the battery voltage reaches a set value. Generally, it is faster to charge using current then voltage. Electronics tend to be slightly more complex and these chargers are generally a little more expensive then constant voltage chargers.

<u>Combination Constant Current/Constant Voltage</u>
The charge cycle starts with a high constant current until the voltage reaches a set value, then changes to a constant voltage control. This is the most sophisticated of the basic types of battery chargers and generally increases the life of a battery by reducing heat during the charging process. These chargers also tend to increase battery performance.

Motors

Motors usually come in two main categories. There is the AC motor and the DC motor. The main difference between the two is the fact that the AC motor runs on alternating current, and will require a motor controller to regulate the power so the motor runs smoothly in the correct direction. The DC motor, on the other hand, runs on direct current, so it does not require a motor controller.

<u>AC Motor</u>
- Single-speed transmission - one speed only
- More RPMs - faster
- Light weight
- More expensive
- 95% Efficiency at full load - more efficient
- More expensive controller
- Requires an inverter
- Motor/controller/inverter more expensive

<u>DC Motor</u>
- Multi-speed transmission - different speeds
- Less RPMs - slower
- Heavier at equivalent power
- Less expensive
- 85-95% Efficiency at full load - less efficient
- Simple controller
- Motor/controller less expensive

Appendix C

Construction Techniques

I had to do research on possible construction techniques. When working with metal, the most versatile method of joining it is welding. It comes in many forms, and I have done research to understand the capabilities and differences. In relation to Homo Faber, I also learned about the origin, development and context of this invention.

Again, the process of welding metals cannot be accredited to one inventor. Instead, many inventors contributed to he development of this process, starting from 2000 years ago.

The process of welding metals (joining two pieces of metal by heat) has been around for many centuries. The earliest examples come from the Bronze Age. Small boxes were made by pressure welding lap joints (see “woodworking joints”) together. It is estimated that these boxes were made more than 2000 years ago. During the Iron Age the Egyptians and people in the eastern Mediterranean area learned to weld pieces of iron together. During the Middle Ages, the art of blacksmithing was developed and many items of iron were produced which were welded by heating and hammering.

Welding as we know it today was invented in the 19^{th} Century. in 1836, Edmund Davy of England discovered of acetylene. The production of an arc between two carbon electrodes using a battery is credited to Sir Humphry Davy in early 1800’s. In the mid-1800’s, the electric generator was invented and arc lighting became popular. During the late 1800s, gas welding and cutting using acetylene was developed. Finally, arc welding was developed in 1880 by Auguste De Meritens from the Cabot Laboratory in France. His Russian student, Nikolai N. Bernados patented the process. It was the beginning of the carbon arc welding process, and it became popular in the late 1890’s and 1900’s.

In 1890, C.L. Coffin of Detroit was awarded the first U.S. patent for an arc welding process using a metal electrode. This was the first account that metal melted from the electrode could be carried across the arc and deposited as filler metal in the joint to make a weld. The coated metal electrode was invented by Strohmenger in 1900, they were just bare iron wire dipped in carbonates and silicates, which produces a more stable arc. This was the beginnings of stick metal arc welding (SMAW) At around the same time, other welding processes such as resistance welding, spot welding, seam welding, projection welding and flash butt welding and Thermite welding for railroads were developed.

The process of cutting and welding metal using gas torches was developed at this time. In 1900, a torch suitable for low-pressure acetylene was developed. In 1920, welding with an automatic wire feed was developed (the beginnings of MIG welding). Later in the 1920’s, research was ongoing to find a solution to the problem of porous and brittle welds caused by exposure to the gases in the air. Alexander and Langmuir addressed this problem by using hydrogen as a shielding gas, but it never caught on.

But H.M. Hobart and P.K. Devers were doing similar work at the time, using atmospheres of argon and helium instead. In 1926 they applied for patents, and arc welding using gas shielding around the arc led to the development of the gas tungsten arc welding process (GTAW). Their patents also showed welding processed with the electrode being fed as a wire through the nozzle. This later became the gas metal arc welding process (GMAW). These processes were developed much later.

In 1930, the submerged arc welding process was developed by the National Tube Company for a pipe mill at McKeesport, Pennsylvania. It is one of the most productive welding processes and remains popular today. In the 1940's, the idea of gas tungsten arc welding (GTAW) was developed and was perfected in 1941. This process has become one of the most important today. The gas metal arc welding (GMAW) process was developed at the Battelle Memorial Institute in 1948. It replaced the tungsten electrode with a continuously fed electrode wire.

As one can see, the process has developed a lot since its origin back in ancient times. There are many welding processes available today. The 5 most popular ones (in order of availability) are:

- Stick Metal Arc Welding (SMAW)
- Oxyacetylene Torch Welding
- Gas Metal Arc Welding (GMAW)
- Gas Tungsten Arc Welding (GTAW)
- Submerged Arc Welding (SAW)

Stick Metal Arc Welding (SMAW)

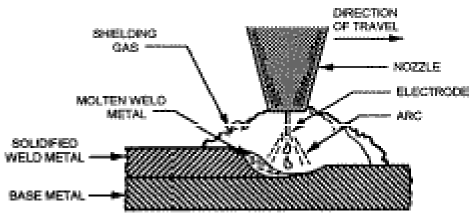
Stick Metal Arc Welding is the simplest welding process of all. It uses the heat of an electric welding arc between a coated metal electrode and the workpiece. As the electrode is melted away to become the deposited weld metal, shielding gases are produced from the coating of the electrode which protects the weld from gases in the air.

The main advantages of this process are that the equipment used is simple, inexpensive, and portable, the electrode provides and regulates its own flux. Also, it has a lower sensitivity to wind and drafts than gas shielded welding processes, as well as the capability to weld in all positions.

Oxyacetylene Torch Welding

Oxyacetylene Torch welding is a gas welding process. Metal is heated by the oxyacetylene flame until it melts and fuse together. This process is usually used with a filler rod, which is usually made of the same metal as the metal being welded. When welding, one can adjust the composition of the gases to achieve the appropriate type and size of the flame. This process can also be used, with the oxyacetylene cutting tip (sold separately) to cut metal.

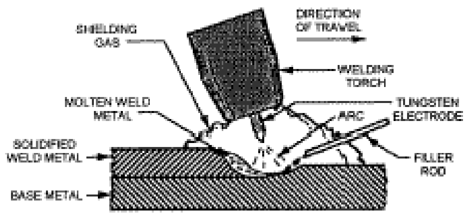
Gas Metal Arc Welding (GMAW)



Gas metal arc welding (GMAW).

Gas Metal Arc Welding or Metal Inert Gas (MIG) welding is a very versatile welding method. It uses the heat of an electric welding arc between a continuously fed wire electrode and the workpiece. Shielding is provided by an externally supplied shielding gas, usually Argon, Argon and 1 - 5% Oxygen, Argon and 3 - 25% CO_2 or Argon/Helium. Sometimes pure Carbon Dioxide gas is used in a process called Metal Active Gas welding (MAG).

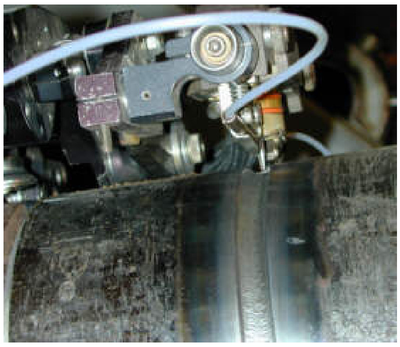
The advantages of this welding process are the all position capability, higher deposition rates than SMAW and the fact that long welds can be made without starts and stops. Also, less operator skill required and minimal post weld cleaning is needed. MIG/MAG welding is used on all thickness of steels, aluminum, nickel, stainless steels etc. The MAG process is suitable both for steel and unalloyed, low-alloy and high-alloy based materials. The MIG process, on the other hand, is used for welding aluminum and copper materials.



Gas tungsten arc welding (GTAW).

Gas Tungsten Arc Welding (GTAW)

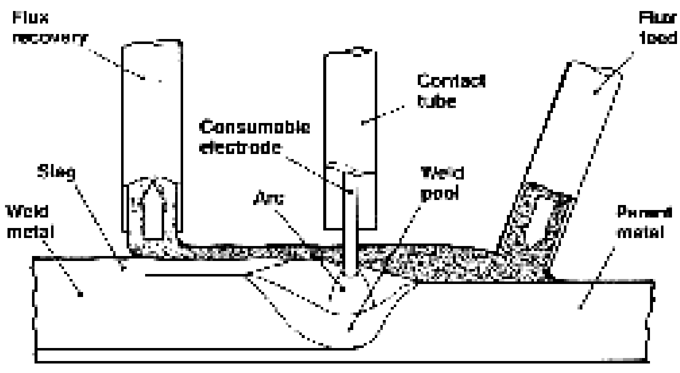
Gas Tungsten Arc Welding or Tungsten Inert Gas (TIG) welding is another popular welding method. It uses the heat of an electric welding arc between a tungsten electrode and the workpiece. Shielding is provided by an externally supplied shielding gas, usually Argon, Argon and Hydrogen or Argon and Helium.



The advantages of this welding process are that superior quality welds can be produced. Welds can be made with or without filler metal and the precise control of welding variables is possible. Also, the process is free of spatter and produces low distortion. However, it is costly for welding thick sections, is slow and requires greater dexterity.

Submerged Arc Welding (SAW)

Submerged Arc Welding uses the heat of an arc between a continuously fed electrode and the workpiece, and the heat of the arc melts the metal on the workpiece as well as the tip of the electrode. The molten metal from the electrode is transferred onto the workpiece through the arc, it becomes deposited weld metal. The process called "submerged" because of the fact that the welding occurs under a blanket of granular flux, which is deposited via a flux feed tube. The tube travels in front of the arc as the assembly moves along the joint the be welded, and the flux provides shielding for the weld bead, as well as purifying and fortifying it.



The advantages of this process are that extremely high deposition rates possible, with high quality welds. The process is easily automated and minimal operator skill is required.

Appendix D

Refining Ideas

During the course of investigating, I have created many possible plans of the final product (appendix C). Each one builds on newly gathered information, and so there is a continuous refining of the design. The design also changes as the process of collecting material went on, parts had to be modified or changed according to availability.

Idea Version 1.0 is a very basic design (see p. 83 of Process Journal), I made off the top of my head. It consists of a raised seat and a simplistic chassis.

Idea Version 2.0 is slightly more complicated (see p. 87 of my Process Journal), based on a triangulation design. I later learnt that this was superfluous, and just added to the weight of the car.

Idea Version 3.0 is made from PVC (see p. 93 of my Process Journal), because I learned that welding is not as accessible as I had first thought.

However, Version 3.5 (see p. 97 of my Process Journal) exploited the accessibility of PVC piping, and I've decided to make a roll cage out of it.

Version 4.0 (see p. 99 of my Process Journal) turned out to be a very simplified steel-tubing design, with a PVC roll cage. Note that the roll cage does not allow for easy entering into the car, so it may become a problem.

Lastly, I learned that the PVC roll cage itself is useless, because of the sufficient stability of my design. Another reason why it was unnecessary is because it is very cumbersome, and gets in the way when one tries to enter the kart.

Ironically, Version 5.0 turned out to be very similar to 1.0 in overall design, but the ideas and details behind it has progressed very far.

Appendix E

Collecting Materials

In fact, the materials collection aspect (appendix D) was the most difficult part of my project. I had to gather all the materials I needed to create my electric vehicle.

Firstly, I bought the wheels from a bicycle shop (see p.107 of my Process Journal). They were simple 12" wheels that are designed for children's bicycles. That same day, I found some shops that sell steel tubing.

Next, I had to go to a factory that makes scooters to buy the motor equipment (see p.109 of my Process Journal). Since the motor and batteries I needed were not in stock, I just bought the motor controller, accelerator and brakes. I also got accessories such as the fuse box and key switch, as well as the battery status meter. Lastly, I bought the corresponding chain and sprocket.

The seat was a cheap piece of plastic furniture from a hypermarket (see p.113 of my Process Journal).

This includes metal tubing from the metal shop, there I bought 1" metal tubing. I got the 1" square tubing cut into the correct sizes, and then the 1" round tubing was also cut into the appropriate sizes (see p.115 of my Process Journal). I also bought a hacksaw and metal for the tie-rods.

That same day, I bought the PVC tubing that I will be using for my rollcage (see p.119 of my Process Journal).

Next, I needed to go to the scooter factory again, after the summer break, to get the materials they shipped in for me. I obtained the motor and the batteries (see p.129 of my Process Journal).

The braking mechanisms and the bearings I bought from a motorcycle shop (see p.137 of my Process Journal)., and then took to a lathe workshop to get it custom-fitted.

Bearing housings had to be custom-made, and the axle had to be lathed down for the heavy-duty axle bearings (see p.139 of my Process Journal). All these were to minimize the economic impact of creating my car, using cheaper, environmentally friendly materials. The total cost of all the materials is 8314 Baht, including Tax.

Materials Collected

Assembly	Part	Material	Specification (length in mm)	Quantity	Price
Chassis	Chassis Tubing	1" round	1200	2	150
			700	2	
			600	2	
			500	2	
Seat Supports	Support	1" round	300	1	100
	Mount	2" flat	300	2	50
Spindle	Spindle	1" round	70	2	100
	Spindle Cradle	2" flat	180	2	100
	Spindle Insert	PVC tubing	70	2	50
Steering Arms	Steering arms	Flat metal rods	90	2	10
	Steering arm (center)		90	1	15
	Steering rods		160	2	10
Wheels	Front		12" diameter	2	380
	Back		12" diameter	2	400
Electronic Parts	Accelerator		Standard	1	200
	Brakes		Standard	1	200
	Motor Controller		Standard	1	500
	Fuse Box		Standard	1	100
	Key Switch		Standard	1	200
	Battery Status Meter		Standard	1	250
Drivetrain	Gear		170mm diamter	1	180
	Chain		700	1	180
Motor Mount	Mount	2" flat	270	2	85
Axle assembly	Rear Axle	5/8 rod	1000	1	37
	Bearings	5/8"	Koyo Roller	2	130
	Bearing housings		Custom	2	500
	Wheel Inserts		Custom	4	300
Powerplant	Motor		24V 300W	1	900
	SLA batteries		12V 17A	2	1800
Brakes	Drum Brake		Standard size	1	240
	Drum Brake cover		Standard size	1	240
	Brake Arm		Standard size	1	40
	Arm/Brake Rotator		Standard size	1	25
	Pin		Standard size	1	7
	Nut		Standard size	1	5
	Brake Cable		Standard size	1	40
	No 10 Hex bolt/nut		Standard size	1	10
	Brake Shoes		Standard size	2	35
	Springs		Standard size	2	5
Retrofitting	Cutting Fees				70
	Bend & drill cradles			2	120
	Axle lathing			1	200
	Re-boring brakes			1	200
Tools	Hacksaw		w/ metal-cutting blade	1	60
	File		12" half-round	1	90

Appendix F

Finalized Design

My finalized design consists of a chassis made from 1" square steel tubing. The seat is mounted near the center, with a simple tie-rod steering system. The Ackerman angles are developed from the steering arms that jut out of the spindle.

Motor and batteries are mounted in the rear, the motor is located outside the chassis due the way the motor turns. The chain is mounted on the inside of the left wheel, which makes it a lot simpler.

The drum brake is mounted inside of the chassis, to keep the wheelbase small. This is a very simple design that I won't have trouble making.

The wheelbase is small enough to fit into the lifts in my building, and the turning circle should be pretty tight due to the shortened distance.

Appendix G

Construction

The actual construction phase (appendix F) was the part in which I spent most of my time on. I cut the chair to specifications, made the seat supports to attach my chair (see p.131 of my Process Journal).

Next, as a starting point, I had to create the chassis from the various metal tubes (see p.133 of my Process Journal). They were arc-welded together, forming a strong framework for my car.

The spindles required filing between they will accept the kingpin (see p.141 of my Process Journal), and so that took me some time before that system was welded on.

The rear axle bearings I got back from the machine shop were too tight for the bearings (see p.143 of my Process Journal), so I ground the down using a hand-drill.

Next, I worked on welding on the front axle (see p.143 of my Process Journal), along with the spindles on each end, aligned to exactly the right angles.

After getting back the metal sleeves for the rear wheels (see p.147 of my Process Journal), I welded on the whole rear axles assembly (see p.149 of my Process Journal).

The rear sprocket was attached to the inside of one of the wheels, and the brakes were welded shut in the middle (see p.149 of my Process Journal). I then.

When the steering system was ready to be rigged up, I salvaged an old scooter I had lying around at home (see p.151 of my Process Journal), and implemented the handlebars as my primary tool for steering.

It also accepted the scooter accelerator and brake readily (see p.153 of my Process Journal). The brake cable was salvaged from the scooter too, and was connected up to the arm of the drum brake.

Appendix H

Revisions and Improvements

First, I realized that the metal that I originally intended for the spindle cradles were too weak, so I had to obtain thicker 1 cm metal pieces, which then required an industrial press to bend (see p.141 of my Process Journal). The bending of the spindles and the drilling of the holes for the kingpins were conducted at a shop specializing in heavy industrial machinery.

Then, I learnt that the join between the stub-axles and the steering spindle are too weak, so I needed to drill a hole into the spindle (see p.143 of my Process Journal), so that the stub axle and be inserted.

To make it even stronger, a metal square was welded to the bearing housings (the front wheels has internal bearings), which increased the surface area when welding to the spindle cradle (see p.145 of my Process Journal). This supporting fixture helped solve the problem of the wheels bending inwards.

When I bought the brakes and bearings from a motorcycle shop, I realized that the holes are regulation motorcycle sizes, and will not be compatible with my rear axle (which is of a standard metric measurement). So the drum brake had to have its holes re-bored and the axle needed to be taken down at the ends to fit the bearings.

The wheels were bought from very early on, and are actually the 12” wheels from a child’s bicycle. I later learned that they were designed for built-in bearings, and cannot accept the rear axle. So they required a pair of sleeves each, in order for the axle to fit snugly (see p.147 of my Process Journal). These were made at a machine shop for very little money.

At the end, I still noticed an increase in toe each time I sat in the car (!!). So a pair of supports made from the salvages scooter pieces was built, in order to stop the front wheels from bending (see p.153 of my Process Journal).

The motor mount was also necessary to be changed (see p.149 of my Process Journal), since I learned that because of the direction the motor turned, it had to be mounted outside the chassis, so I made a pair of sturdy mountings for the motor, that was welded onto the chassis, forming a little outboard platform for the electric motor (see p.155 of my Process Journal).

Appendix I

Finished Product

Me creating my product was a great triumph for myself. Now, I needed to test it. Riding it around the school oval, I could feel how the car turns, accelerates and responds to road conditions. My actual product performed very well. It has a smooth, gentle acceleration, peaking at 40 km/h. This was pretty impressive for a car made by a student, that weights more than 40 kilograms (unloaded).

The ride is smooth, and the tires absorb the shock from bumps very well. At the end of my first test run, I noticed that the drum brakes are loud and screechy, but that is one of the characteristics of drum brakes. After taking it our for more runs, I noticed that battery life is actually very efficient, with me only having to charge the batteries twice in the 2 months of testing.

The seat is comfortable, and there is enough leg room for a wide sampling of the general population, since it was designed for me (and I have very long legs). The controls are simple to use and understand, however, before I can allow anyone else to drive it, they need a short course on my car.

The wheels are slightly unreliable, the inner tube tends to come out of the groove, which requires immediate attention. Also, quick, sporadic flicks on the accelerator can put unnecessary strain on the batteries and controller, and should be avoided at all costs. But in conclusion, I am very happy with my product.

Now that everything is finished, my product needs a name. It will be called the ECO-ATK 1, which stands for ECOlogically Affable Test Kart (prototype 1).