Systems Engineering 3/4

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Student Number:

Contents

Three Designs

Electrically motorized Drift Tricycle

The 2 systems, mechanical and electrical, are the electric motor in the wheel hub and the electronic motor controller.

A standard three wheeled "Huffy Slider" with an electric bike conversion kit.

- BBQ Rotisserie
- A universal BBQ Rotisserie made to fit and function on any sized BBQ. This will include a timer as well.
- The 2 systems, mechanical and electrical, are the motor for the rotation and the electronic timer and temperature probe.

- Electric Golf Buggy
- Standard golf buggy fitted with a motor for convenience
- The 2 systems, mechanical and electrical, are the motor for the drive and the electronic power and speed controller.

Chosen Design

400W Electric Drift Trike

- I have chosen this product due to the fact that I already have the tricycle, the electric hub motor and battery, whereas otherwise these items would be very costly and the design would not be an

design of function of the final product. The Trike will also still be

Design Brief

My systems project will be a standard "Huffy Slider" (also known as a drift trike) with an electric bike conversion kit retro-fitted on it. The forks will not fit the motor hub so the front forks will need to be extended/modified. The electric bike conversion kit is a 400 watt brushless hub motor with a proposal of a 36 volt battery. The batteries will be mounted in a row over the rear axels in a bracket I have made, this placement will increase the inertia of the rear of the trike and extend the trike ability to drift when turning. This distribution of weight is effective and adds to the main concept of the trike's original design, to drift. Possible later modifications are a headlamp, painted frame, better seat and longer frame.

Considerations	Constraints
PVC pipe around the wheels would reduce friction	Must be able to drift
Will use 3x Sealed Lead Acid 12V Batteries	Must be battery powered
Will be painted in matte yellow Australian Export spray paint	Must be painted in a professional manner
Will make suitable footrests for all sizes.	Must be suitable for all heights above 140cm.

Production Procedure

1. The Slider will first need to be dissembled and the front wheel removed then the forks removed.
2. The new forks will then be measured, cut and new ones will be welded.
3. The frame will be painted yellow.
4. A cradle or mount will be measured and produced for the battery pack.
5. The mount will then be fitted behind the seat of the Slider.
6. All the electronics will need to be fitted, including the throttle, the brake with kill-switch and the motor controller.
7. The cables and wires will need to be cabled tied to the frame and protected in some way.
8. Test and mount the motor.
9. Test the brakes and the kill switch.
10. The seat will be removed
11. The new mount for the seat will be welded on.
12. The new seat will be screwed into place.
13. The headlight mount will be welded onto the front of the trike.
14. The headlight will be wired to the battery and the switch.
15. The headlight will be mounted.
16. The original ‘Huffy Slider’ wheels will be removed and replaced with ‘Huffy Green Machine’ wheels.
17. The battery will be charged and connected.
18. The product will be ready for testing and evaluation

Design and Procedure

Design Element	Description
	The battery mount, it has 2 hinges and Velcro strips to secure it. It will be painted matte black to match the seat, if I find that the inertia of the batteries will be too strong for the straps I will add flat bar clamps over the top. This bracket has been design to fit the batteries perfectly.
	The original wheels are seen on the left, they are official Huffy Slider wheels, however through my research I have found that the Green Machine wheels are more effective for drifting because they have less contact area and therefore less traction and friction.
	My foot pegs will be just above the flat bar motor mounts. They are designed to rest your feet on whilst riding, they are suitable for most height from 150cm to 190cm.
	The motor mounts are made from 2 lengths of 20mm flat bar per side. They have enough room to securely fit the flat sides of the electric motors shaft.
	The frame is be painted in a gloss yellow finish before the assembly begins, the original blue pain was removed with paint stripper.
	2 holes are drilled in the frame, one at the top and one under the seat, these have the wires from all the handle bar controls fed through them to ensure the trike had a professional and tidy appearance.
	On the rear of the base of the seat I cut out the strengthening bars to create room for the wires to pass under the seat neatly.

Tools and Plant List

Tools and Plant List	Use
Drill	Drill holes into frame to mount new seat
Screwdriver	To screw in all components like the brakes
Circular Saw	To cut the steel for the forks
Wire Cutters	To cut any wires to length
Spanners	To attach the wheel to new frame
Clamp	To hold metal in place for welding
Cutting Blade Press	To cut the metal for the battery mount
Welder	To weld the forks and battery mount
Spray Booth	To spray paint the frame in a safe manner
Metal Bending Equipment	To bend the thin sheet metal for the battery mount
Mounted Circular Saw	To cut the metal for the forks to length

Risk Assessment

Procedure	Possible Hazard	Possible injury attained	Likelihood of accident (1-5)	Seriousness of accident (1-5)	Methods of Prevention
Welding	Burning after welding when metal is still hot	Severe burn, up to 3rd degree	3	4	Use the Welder with extreme care and wear safety gear
Using Circular Saw					
Testing the motor	Jam hand in spokes	Bruising and cuts on fingers	2	1	Keep fingers clear of spokes
Testing the Final Product					
Drilling holes for Seat	Drilling hand	Severe cuts to hands or finger	2	4	Use the drill correctly and take all precautions, wear safety goggles

Rating	Description of Seriousness Rating
1	Not too serious, wont need any medical attention.
2	
3	Bleeding and/or bruising dressing required
4	
5	Large Lacerations, urgent medical attention need, definite hospitalization.

Evaluation Criteria

Will the slider still slide/drift?

During my initial tests before the battery was mounted at the back the slider would drift after turns of 85° or more at speeds above 8Km/h, after mount the battery on the rear of the unit and increasing rear inertia the unit now readily drifts will only small turns at lower speeds.

Will it go over 25Km/h?

due to the faulty hall effect sensor the motor is only running at 1 half to 2 thirds capacity and is therefore not able to achieve my desired 25Km/h, however at the current capacity it achieved 20.8Km/h which is quite close considering the motor is only running on 2 of three cylinders (coils)!

Will the battery last the desired time of over 2 hours?

Is the unit more than 25kg?

Does it have a professional and smart finish?

After stripping the paint I coated the trike in a primer and painted it gloss yellow. I then assembled the trike and finished the design, whilst reassembling the trike the frame got many scuffs and scratches and did not look professional. So after completion of all other parts I sanded down the exposed surface area and re-coated it with another 3-4 coats of paint. The unit now has a smart and professional finish. To add to this I also drilled 2 holes into the frame to thread the wires down internally to ensure the trike looked smart and professional.

Will the motor have enough torque to propel the unit up an incline of 10°?

Is the unit comfortable to sit on/ride?

The original Huffy had a plastic seat on it, this seat had a large cracked in the top and a section had come out. With the larger front wheel, the angle of the trike itself was much greater and therefore cause the user to place more weight on the upper back of the seat. With the broken and jagged edge it was uncomfortable and dangerous, I cut the affect area out and shaped it into a ergonomic and comfortable design that the back fits into properly. This modification makes the unit very comfortable to sit on and ride.

Do the forks have a gap of 145mm to hold the hub motor?

The original forks were not intended to house a wider electric hub motor, so I had to manufacture my own forks from 20mm square steel tube. These were measured to fit the electric hub motor and had a precise gap between the mounts of 145mm.

Evaluation

- After completion my product I was able to test it and review its effectiveness. The overall success of the product was quite good I believe, it was able to meet all of my necessary evaluation criteria and my considerations and constraints. I have completed my product in the time available and it is of a smart and professional finish, it also is not a rushed or hurried effort. My timeline was quite accurate and easy to follow, it definitely help me ensure I met the deadline. In reflection the elements that worked well in my design were the rear mounted battery mount, it was extremely effective but also kept the weight distribution of my trike towards the rear to increase outwards force when turning and also the inertia of the rear wheels, this enabled the trike to drift much better than expected. Also in reflection the elements of my product that I would have done differently next time are the painting, I mistimed the painting and underestimated the amount of scuffs and marks I would make on it whilst reassembling the trike. If I was to make this product again I'd also make sure I tested the motor completely much earlier in the process to ensure I would have plenty of time to replace any faulty parts. If I was to make the forks again I would ensure I accommodated for the size and width of the motor cables so that they could be internal to the frame rather than underneath. If there was more time to complete the product possible additions would be a better designed seat and also a pair of rear lights and front indicators. Another possible addition with time could also be a solar panel on the rear above the batteries to recharge the unit whilst in use. Although there is plenty of scope for future additions given the deadline my overall review of my product is quite good, it meets all required functions and my implied constraints and also has a very good 'Wow" factor to it and managed to attract a large amount of public attention during testing. The unit is also heavily improved on the pre-motorized original unit, proved through comparison to initial preproduction testing and postproduction testing. As seen below.

	Manual (pedal) Power Preproduction	Automatic (motor) Power Postproduction
Maximum Speed		
-10° Decline Speed (Gravity)		

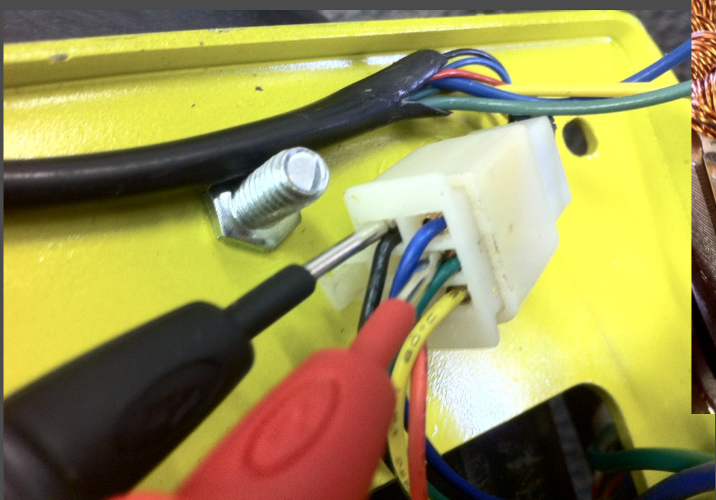
Testing

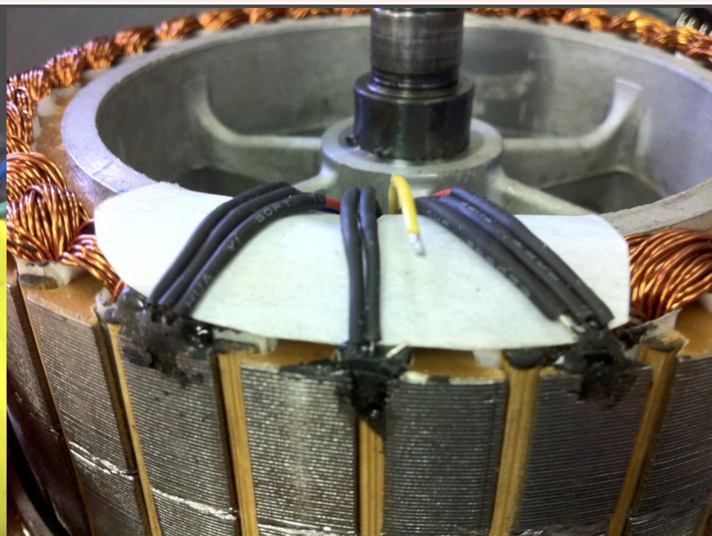
	Test	Tools and Equipment	Expected Result	Actual Result
1	Test the drifting capabilities of the trike – Ride the trike around on an asphalt surface at speeds 15-20Km/h to determine if the trike drifts during turns. Ride the trike on an asphalt surface Reach a speed over 15Km/h Turn on a sharp angle of over 90° Observe to see whether the trike loses traction on the rear wheels and drifts.	Stopwatch Calculator Chalk Measuring tape An observer A large area of asphalt at least 50m long	The Trike will successfully drift during turns at speeds of 15Km/h+	The bike easily drifts at speeds above 8Km/h and turns of 50°. When at speeds over 15Km/h the trike readily drifts with almost any degree of turning above 20°
2	Test the speed of the trike – Ride the trike on an asphalt with plenty of space and ride the trike at full throttle. The trike should travel at least 25Km/h Ride the trike on an asphalt surface Mark out two lines with some chalk and time the gap between the line Start 40m behind the lines to gain speed Ride between the lines at full throttle Calculate the speed of the trike	Chalk Stopwatch At least a 60m straight of asphalt An observer to measure Measuring tape	The Trike travels at speeds of 25Km/h easily and with little strain on the motor	Because of the faulty hall effect sensor the motor is only running at 1 half to 2 thirds capacity and is therefore not able to achieve my desired 25Km/h, however at the current time it achieved 20.8Km/h
3	Test the Duration of the Battery – Ride the trike on an asphalt surface and time with a stopwatch how long it takes for the batteries to discharge Ride the trike on an asphalt surface Take regular breaks every 10 minutes for 10 minutes to simulate regular use Time how long it takes for the battery to run down	Stopwatch A suitable area of asphalt	The battery will last over 2 hours before discharging completely	
4	Test the Weight of the Trike – weight the trike on appropriately sized scales Tie string/rope to even points on the trike to make a balanced structure to hang it Place the pieces of string/rope on some butchers scales that are securely attached to the roof or a sturdy structure that will hold the trike Mark down the weight of the trike from the reading on the scales	Butchers scales String or rope A suitable structure to hang the trike from	The Trike will weight just over 25Kg and under 30Kg	
5	Test the Torque of the Trike – ride the trike on slanted surfaces to test that the motor has enough talk to propel it up an incline of 10° Locate an incline of 10° Ride the trike up the incline and note strain on the motor and the drop in speed Have an observer decide whether the trike visible lost speed when driving up the incline	iPhone with Gyroscope app Stopwatch Observer	The Trike will easily travel up inclines of 10° with very little strain on the motor and will lose very minimal amounts of speed	The trike, even in its faulty state manages to ascend an incline of 10° with minimal effort, however if stopped on the incline the motor will not always be able to take off due to the one coil being inactive.

Diagnostics

- After initial assembly to test my product I noticed the motor was quite jerky and jumpy, it also wouldn't start from certain points on the wheel. I started my diagnostics with some research as to why an electric brushless hub motor would behave this way. The site I used was…
  - http://electricmotoring.forumup.co.uk/viewtopic.php?t=238&highlight=phase+wires&mforum=electricmotoring
- On all the forums and websites I viewed almost all of them suggested it was a faulty or broken hall-effect sensor, (A hall effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall sensors are used for proximity switching, positioning, speed detection, and current sensing applications) after my diagnostic testing I determined that this was the problem. I enquired where to buy these form the specific model I had and it would to be ordered taking up to 6 weeks to arrive. This then was not an option because of the deadline and the motor can still function without the sensor so I reassembled the motor and took notes on the problem and the outputs of the effected sensor. The faulty sensor was outputting 3.06V when a magnet was applied and the working sensors would put out 5.08V with the same magnet. To check if the hall effect sensor was working the black probe of a multimeter (on the voltage setting) was inserted into the black wire on the plug, the red then inserted systematically into the three different colour wires. With the motor power supply cables disconnected you rotate the wheel and each sensor should jump between 2 voltages 23 times per rotation. My results are displayed in this table…

	Blue (Faulty)	Green	Yellow
With Magnet	3.06V	5.08V	5.08V
No Magnet	0.23V	0.018V	0.018V





Diagnostics (continued)

- After determining that the blue wired hall effect sensor was faulty, I removed it and placed the exposed wires left behind in a piece of heat shrink tubing to prevent any short circuiting inside the motor hub, I also cleared the space where the sensor was to leave room for it to be replaced in future. Having a hall effect sensor missing simply means that one of the coils on the stator will not pull the magnets for that section, I researched whether it was still safe to use the motor without it and it does not put any extra stress or strain on the other coils it only lowers the power and torque of the motor. 1 of 3 coils will not be activated so it will run at approximately 1 third of full potential, this will effect my testing and evaluation criteria because the motor is not performing at full power.

- After installing the headlight unit there was a problem, the motor was not running however there was power to the headlight unit. I drew a rough circuit diagram to ensure my wiring was correct. I tested the returning voltage to the motor controller and it was a full 36V. At first I thought the problem was the extra supply plug in the battery connector, I fixed this problem by reconnecting the missing cable and the motor was still not running. Since the case of the motor controller is earthed and it is in contact with the trike's frame I thought there may have been a short between the positive return from the headlight unit, to fix this I re-heatshrinked the positive wire that was close to the frame, this still did not fix my problem. I checked over all of my connections and found the problem was when I had re-inserted the plug into the plastic connector I had crossed two wires over and the throttle was not wired correctly, no damage was done to either parts and the motor now worked.

Timeline

Term 1	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Outline of situation										
Specifications										
Evaluation Criteria										
Concept and CAD Drawings										
Component alternative Research										
Electrical drawings and diagrams										
Finnish Folio										
Daily Log										

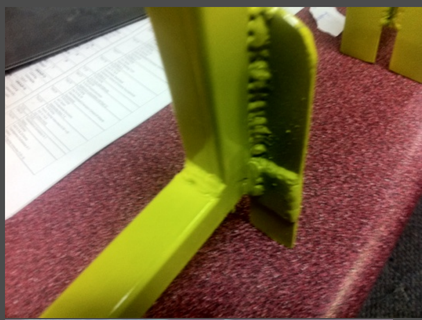
Term 2	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
Gathering materials									
Measuring and marking									
Cutting and Welding									
Electronics Assembly									
Painting									
Electronics Fitting									
Front Wheel Assembly									
Daily Log									

Term 3	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9
New Seat Replacement									
Brake Testing and Fitting									
Battery Testing and Mounting									
Speed Testing									
Battery Life Testing									
Headlight Fitting and wiring									
Final Tests									
Daily Log									

Weekly Journal

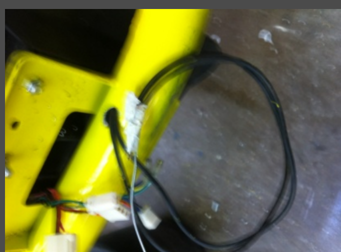
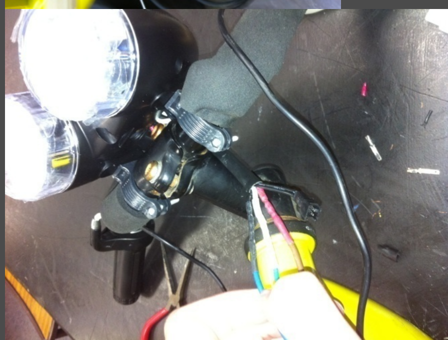
- **Term 3**
- Week 1
  - Began gathering parts
  - Removed original wheel
  - Marked measurements on original forks
- Week 2
  - Disassembled trike. (forks, seat, rear and front wheels and handle bars)
  - Cut original forks
- Week 3
  - Measured out new forks from 20mm square tube steel
  - Began welding forks
- Week 4
  - Finished welding forks
  - Grinded the welds
  - Measuring the motor mounts
- Week 5
  - Began welding the motor mounts from 20mm flat bar
  - Grinded the welds for the mounts
  - Sprayed the battery holder matte black
  - Began spraying the front forks
- Week 6
  - Finished spraying the forks
  - Used paint stripper to remove the paint
  - Began spraying first coat of the frame
  - Began second coat
- Week 7
  - finished third coat
  - Fitted accelerator and brake cut off to handle bars
  - Filed the base of seat down to allow room for the cables
  - Bent and cut the holders for the motor controller
  - Drilled holes for rivets for motor controller mounts and battery holder
- Week 8
  - Drilled holes to thread wires through
  - Mounted motor controller
  - Reattached seat, forks and rear wheels
  - Mounted front motorized wheel
- Week 9
  - Riveted the motor controller mounts and battery holder to the frame
  - Threaded wires down the frame
  - Connected all wires
  - Installed the headlight unit
- Week 10
  - Wired the headlight unit









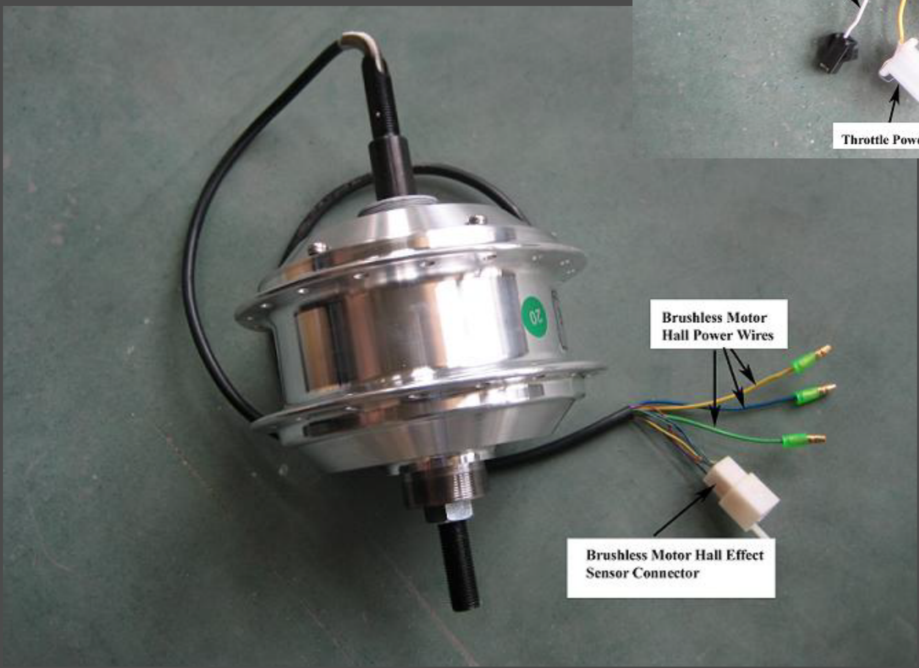




Electrical Diagrams and Components

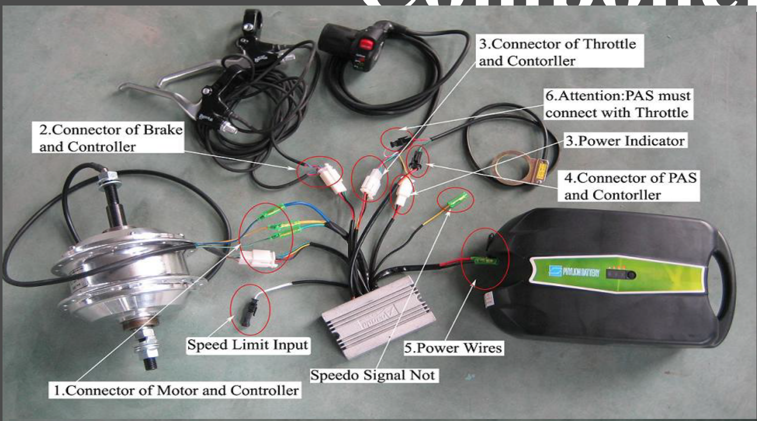
Brake Cut-Off Switches

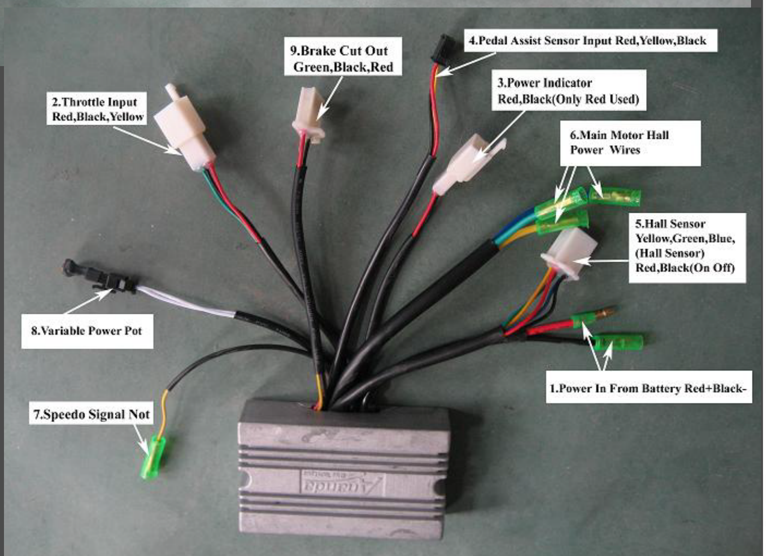
Throttle and Battery indicator

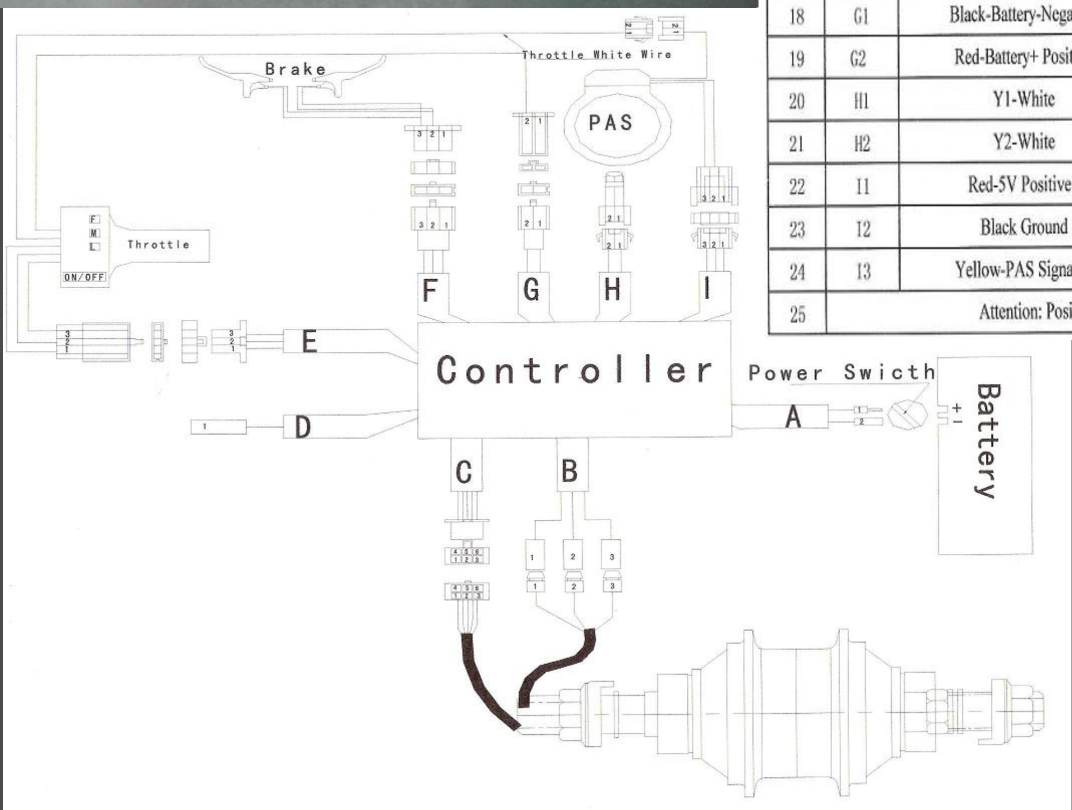
Electric Hub Motor



Electrical Diagrams and Components (cont.)







Y-Spark Complete E-bike Circuit wiring diagram			
Connectors from Controller			Related parts
NO.	Code	Characteristic	Characteristic
1	A1	Red-Battery+Positive	Battery+Positive
2	A2	Black-Battery-Negative	Battery-Negative
3	B1	Yellow-output C	Motor 1 Yellow-motorpower C
4	B2	Green-output B	Motor 2 Green-motorpower B
5	B3	Blue-output A	Motor 3 Blue-motorpower A
6	C1	Yellow- Hall C	Motor1 Yellow Motor Hall Signal H3
7	C2	Green- Hall B	Motor2 Green Motor Hall Signal H2
8	C3	Blue-Hall A	Motor3 Blue Motor Hall Signal H1
9	C4	Red-5V Positive+	Motor4 Red Motor Hall Power Positive
10	C6	Black Ground	Motor6 Black Motor Hall Power Negative
11	D1	Yellow-Simulator Signal In	NULL
12	E1	Red-5V Positive+	Throttle+Positive
13	E2	Black Ground	Throttle-Negative
14	E3	Yellow-Speed Adjust Signal In	Throttle signal line
15	F1	Green-Brake Signal In	NULL
16	F2	Black Ground	Left and right Brake Lever Negative
17	F3	Red-5V Positive+	Left and right Brake Lever Positive
18	G1	Black-Battery-Negative	NULL
19	G2	Red-Battery+ Positive	throttle power indicator
20	H1	Y1-White	speed limit
21	H2	Y2-White	speed limit
22	I1	Red-5V Positive+	NULL
23	I2	Black Ground	PAS Negative
24	I3	Yellow-PAS Signal In	PAS signal of PAS
25	Attention: Positive of PAS must connect with throttle .		

Purchases

- The batteries I had originally for the kit were Sealed Lead Acid and had been left discharged over a long period of time and were therefore useless.
    - I purchased 3 12V 15AH CSB AGM Sealed Lead Acid Batteries From The Battery Guru they were $50 each (total = $153 +GST)
    - These batteries were most suitable to me because…
        - They were within my budget
        - Had a higher amp-hour rating than the previous ones
        - Were identical sizing to my old batteries
        - They are the “Electric Vehicle” (EVH) model designed for electric vehicles.

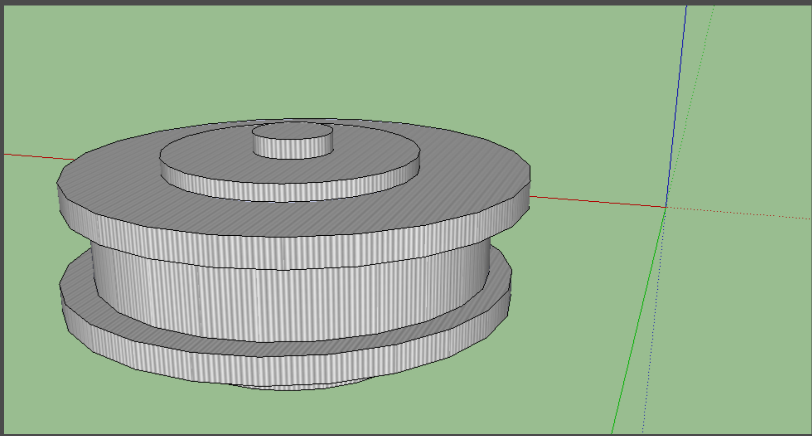
- I purchased a headlight unit that also included a battery level meter, a horn and a key lock. I purchased this from eBay for $25.

	Batteries	Headlight
Cost ($)	3x $50 ($153 incl. GST)	$25
Website	Seller: http://batteryguru.com.au/2.html Manufacturer: http://www.csb-battery.com/english/01_product/01_series_01series.php?fid=13	Seller: http://www.ebay.com.au/itm/140582237007?ssPageName=STRK:MEWNX:IT&_trksid=p3984.m1439.l2649#ht_4530wt_905
Description	3x 12V 15AH CSB AGM EVH Sealed Lead Acid Batteries.	36V All-in-one Headlight, Key lock, Battery monitor and horn unit for Electric Bikes.
Reason	My first batteries that I intended to use were faulty and did not work.	My trike needed a way of monitoring the battery level and a headlight.
Purpose	To power my trike after the initial batteries proved faulty.	To add safety, security and additional features planned as future additions.

Technical Drawings

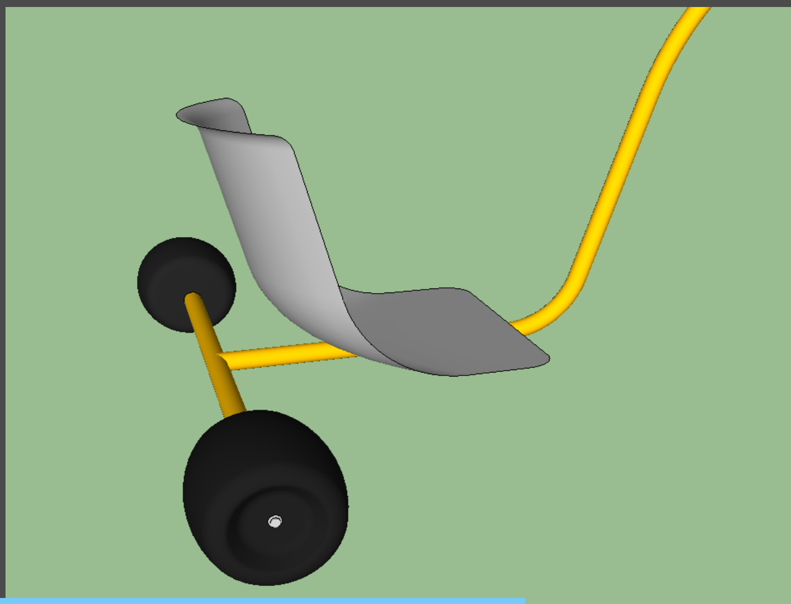
Isometric

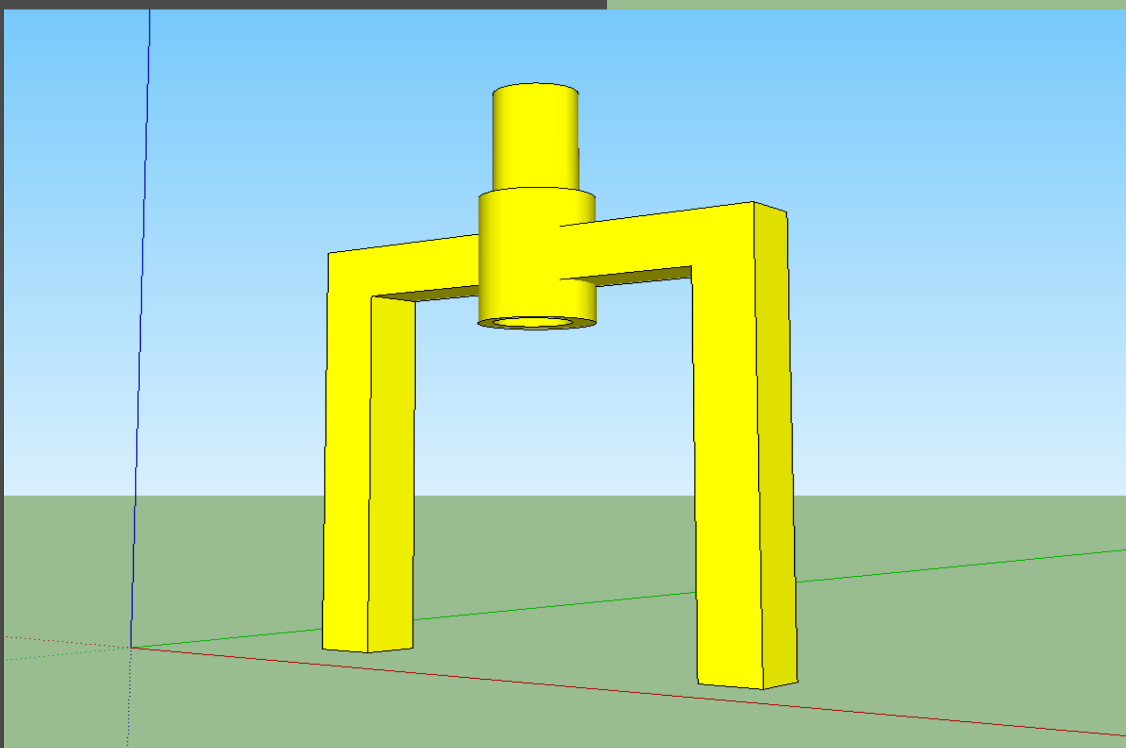
CAD



Electric Hub Motor

Rear view of trike and seat.





Front Forks design

Component Research

Different types of Components

Electric Motors - Research

Type	Pros	Cons	Typical Uses
Shaded-pole Motor DC	Long lifespan, low cost	Low efficiency, Low starting torque, small ratings, Rotation slips from frequency	Fans, record players
Brushed DC	Simple speed control	Medium life span, high maintenance, expensive brushes and communicator	Treadmill, steel mill, automotive accessories
Stepper DC	High holding torque, precision positioning	Requires a controller, high cost	Floppy drives and printers
Brushless DC	Highly efficient, low maintenance, long lifespan	Requires a controller, expensive	Hard drives, cd/dvd players, electric vehicles
Pancake DC	Compact design, simple speed control	Medium cost, short lifespan, high torque	Slot cars, fans, office equipment
Universal Motor DC	High speed, compact, high starting torque	High maintenance, short lifespan, low economic rating,	Vacuums, drills, blenders

I have elected to use a brushless pancake DC motor because it is slim and very powerful. The design is a small and compact shape and the magnets are on the top and bottom of the motor housing as opposed to a regular brushless DC motor which is on the outside, this is why the design is flat and compact. The flat design will fit easily into my forks and frame nicely. The brushless component makes it more efficient and higher torque compared to a brushed DC. The Pancake brushless DC motor is ideal for my product because it has a very high torque to weight ratio which is important because my product will have to carry large loads and need to travel at fast speeds.

Batteries - Research

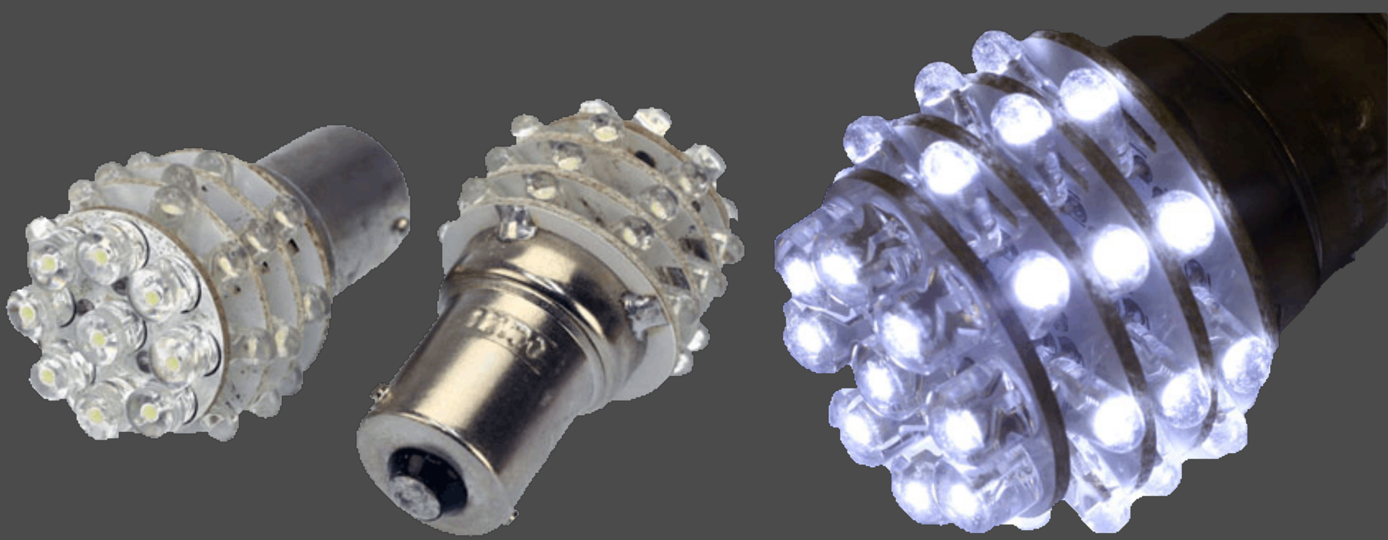
Type	Pros	Cons	Typical Uses	Cell Voltage
Lead Acid (Gel Cell)	Inexpensive,	Heavy, large, contains a corrosive liquid, memory effect, fast loss of charge	Petrol Cars, Cheaper electric bike kits,	2.105 Volts
Lithium-ion	Small, lightweight, fast charge, slow loss of charge, no memory effect	Expensive, rarely available in 36 Volts,	Mid-Range Electric bikes,	3.6-3.7 Volts
Lithium Iron Phosphate (LiFePo4)	Small and lightweight, extremely high power to weight ratio,	Very Expensive, still only in early stages of development, not as readily available	Top of the range electric bike kits, laptops, certain electric cars, R/C Appliances	3.3 Volts

I have elected to use a sealed lead acid battery. I have chosen this because it is the only battery that will fit into my price range and I already have a mount to fit the sized of the batteries. LiFePo4 batteries were considered but are still only a new technology and are very expensive. The batteries I have chosen are three AGM 12 Volt 15 amp hour batteries. In series these batteries total to 36 Volt. The batteries are 150mm(L) x 100mm(W) x 93mm(H), so three side by side are 150mm(L) x 300mm(W) x 93mm(H) plus up to 10mm extra in all directions for the case and space between batteries. The batteries will cost a total of $100-$200 purchased from The Battery Guru.

Light Globes - Research

Type of Light	Lumens Per Watt	Average Lifetime	Operating Temperature	Colour	Price ($)
Incandescent Globe	12-17	1000-20,000	90-160°C	Yellowy-white	15-30
Halogen Lamp	16-23	3000-6000	120-180°C	Yellowy-white (more white than incandescent)	30-35
Fluorescent Lamp	50-100	8000-20,000	Room Temperature	white and slightly blue	20-30
LED Lamps	90-120	25,000-100,000	25-30°C	White	10-25

I have elected to use a LED Globe, this is a light globe made up of 15-50 small LED's. It has a normal light bulb bayonet fitting so I can purchase a normal light globe cradle, the globes are cheaper than most of the other options, they are also brighter per watt and have a better lifetime. The LED globe is the obvious choice in every aspect. I will purchase the globe from eBay and it will cost between $10-$25. the globe I will purchase will have at least 12 smaller LED's and will run at 36 Volt.



Modifications

- Headlight, with horn and key switch included
  - It was part of my original plan to have a LED headlight included, although this would mean they have to be 12V and wired separately to the motor controller, this would be tedious and unnecessary. So I purchased a 36V LED headlight that also included a horn, keylock and battery monitor. This unit was much simpler and looks more professional than the bulb and headlight mount I had created, it also incorporated all the additional parts I had planned to add later. It still required a large amount of wiring and I had to read thread all my wires down the frame and once I installed it I encountered a range of problems. Although this unit not only adds safety through vision but also safety through the horn and the ability to alert others to your presence, with a keylock it adds security and safety for the bike from unwanted use. The battery monitor also adds an element of safety of ensuring the user knows the range left on the trike.
- Foot pegs
  - In my first vision of the bike I had thought to include the pedals (fixed in place) as my foot pegs however they were made out of solid aluminium and I did not have the resources available to weld that and it was much simpler to add 2 more 150mm pieces of 20mm square tube steel to the sides above the motor mounts, they have proved effective and well located.
- **Motor control mount variation**

  Initially my plan for the motor controller was to mount it under the seat, however as I began to add the battery holder and when I moved the seat forward it left a space on the frame that wa a precise size for the controller. I had not anticipated how low the trike was to the ground and if I mounted it under the seat the wires would either be exposed from under the seat or dangerously close to the ground. So with the decided position these problems are avoided because the wires feed straight under the seat and all the connects and wiring can be containe under there without being too close to the ground.