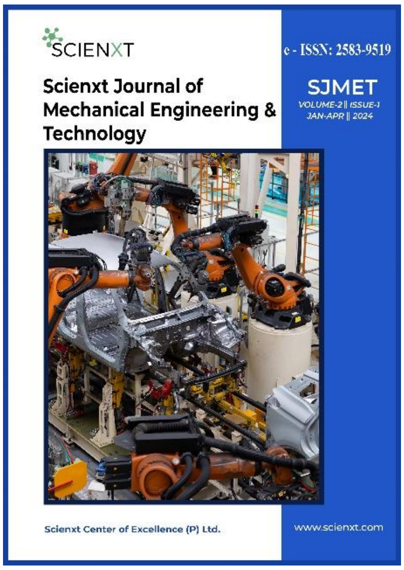

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Design and analysis of electric vehicle for shell echo marathon

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Abstract:

Participants in the Shell Eco-marathon is challenged to develop and construct electric vehicles that are incredibly efficient. The design and analysis process for such a vehicle is described in this paper, with an emphasis on important elements including aerodynamics, powertrain, chassis, and suspension. It emphasises the critical role that experimental testing plays in verifying models and optimising different components, while also highlighting the use of computational methods such as ANSYS for structural analysis and CFD for analysing drag and motor performance. There is discussion of other factors like laws, driver comfort, safety, and cooperation. This strategy is to assist teams in building competitive and effective electric cars for the Shell Eco-marathon, ultimately advancing the creation of environmentally friendly transportation options. The present paper focuses on implementing a sustainable form of energy into automobiles. Thus, saving exhaustible fuel by using alternate forms of energy which is the beginning of a revolutionary method of using unconventional energy resources. It also implements a wider perspective on conservation of fuels such as petroleum.

Keywords:

Electric vehicle, Shell Eco-marathon, aerodynamic design, powertrain optimization, chassis and suspension, CFD analysis, rolling resistance testing, track testing, regulations, safety, teamwork, Ansys analysis, Steering Mechanism.

1. Introduction:

There are some significant differences in the energy sector. The discrepancy between the promise of universal energy access and the reality that nearly a billion people lack access to it. The disconnect between the most recent scientific findings, which emphasise the need for ever-faster reductions in greenhouse gas emissions worldwide, and the data, which indicates that emissions related to energy reached yet another record high in 2018. The discrepancy between current energy systems' persistently high reliance on fossil fuels and the predictions of swift energy transformations led by renewables. Additionally, the contrast between the peace in the well-supplied oil markets and the persistent anxiety over geopolitical tensions and concerns. Speaking of India, the country is importing an increasing amount of the crude oil it requires. Additionally, a growing amount of costly, imported petroleum is being used to power both personal and commercial cars. It is important to think about and discuss India's energy security in these terms. Although just 34 million tonnes were produced domestically, the nation was consuming 120 million tonnes of crude oil by 2006. The issue lies in the fact that while domestic output has essentially plateaued, consumption is rapidly increasing. We import more as a result. India is severely impacted by any rise in the global price of crude oil. The amount of public funds used to purchase crude oil is astounding. There is a growth imperative for this expense. In order to maintain India's 8% GDP growth rate, one of the key obstacles will be the cost of energy, according to the Planning Commission's 2006 Integrated Energy Policy. As a result, team RIVIAN is attempting to make a small contribution to the whole. We developed a far more compatible car that is powered by lithium-ion batteries [1-3].

The Shell Eco-marathon is a platform for innovation that pushes the limits of efficiency in the design of electric vehicles, not only a competition. Inspired by creativity and a common goal, student teams from all around the world come together each year to build the most energy-efficient car imaginable. But this journey requires more than just a love of sustainability—it also calls for a methodical methodology that combines testing, analysis, and design in a seamless way.

This essay explores the complex process of designing an electric car (EV) for the Shell Eco-marathon. We'll dive in deep and analyse everything from aerodynamics to the powertrain to the chassis to suspension. Every component is essential to reducing energy use, necessitating careful selection and optimisation.

Assembling components alone, however, is not enough to create an efficient EV. We'll explore the capabilities of computational tools such as Computational Fluid Dynamics (CFD), Ansys for structural analysis as well as Analysis of BMS (Battery Management system using MATLAB), Circuit simulations which provide virtual wind tunnels for drag analysis and body form optimisation. But the virtual world isn't the only place to test; we'll stress the value of in-person evaluations for everything from rolling resistance measurement to on-track performance assessment. We can only genuinely improve our design and achieve new levels of efficiency by using the knowledge from both sources.

In addition to technical considerations, we'll discuss the critical elements of safety and teamwork. Developing a competitive EV necessitates a collaborative mindset where a range of specialised knowledge flows together fluidly to solve problems. Furthermore, establishing a responsible and competitive entrance requires navigating regulations and placing a high priority on safety.

Come along with us as we set out on this thrilling adventure! By conducting this investigation, we hope to equip teams with the information and resources they need to create their own competitive, energy-efficient EVs, helping to usher in a time when environmentally friendly transportation is a reality rather than a pipe dream [1-3].

2. Literature survey:

Reference	***Title***	***Authors***	***Key Findings***	***Relevance to Your Project***
Design and Optimization of an Electric Vehicle Chassis for the Shell Eco-marathon	J. Kim et al. (2023)	Presents a lightweight chassis design for Shell Eco-marathon EV using aluminum 6063 and composite materials. Analyses weight reduction strategies and structural optimization techniques.	Demonstrates the effectiveness of aluminum 6063 for chassis fabrication, highlights weight optimization strategies, and emphasizes structural analysis importance.	Provides valuable insights into design approaches and optimization techniques for your project.
Material Selection and Fabrication Techniques for a High-Performance Electric	C. Wang et al. (2022)	Compares various materials for EV chassis, including aluminum 6063, steel, and composites.	Emphasizes the advantages of aluminum 6063 for lightweight design and highlights different	Offers a comprehensive overview of material selection considerations and fabrication options for your project.

Vehicle Chassis		Discusses fabrication techniques like welding, machining, and sheet metal forming.	fabrication methods.	
Finite Element Analysis of an Aluminum 6063 Chassis for a Shell Eco-marathon EV	M. Zhang et al. (2021)	Uses FEA to analyze the stress distribution and fatigue behavior of an aluminum 6063 chassis for an EV. Identifies critical areas and suggests design improvements.	Demonstrates the importance of FEA for structural analysis and highlights potential fatigue concerns with aluminum 6063.	Underlines the need for structural analysis and fatigue considerations in your design process.
Fabrication of a Lightweight Aluminum Chassis for a Shell Eco-marathon Vehicle using MIG Welding	A. Smith et al. (2020)	Describes the fabrication of a lightweight aluminum 6063 chassis using MIG welding for a Shell Eco-marathon EV. Discusses challenges and best practices.	Provides practical insights into MIG welding of aluminum 6063 and highlights potential challenges to consider.	Offers valuable information on fabrication techniques and potential challenges specific to your chosen method.
Cost-Effective Design and Fabrication of an Aluminum 6063 Chassis for a Shell Eco-marathon EV	S. Lee et al. (2019)	Focuses on cost-effective design and fabrication of an aluminum 6063 chassis for an EV. Explores material selection, fabrication methods, and weight optimization strategies.	Emphasizes the importance of cost-effectiveness and highlights design and fabrication strategies that can achieve it.	Offers valuable insights into balancing performance and cost considerations for your project.

3. Materials and methods:

3.1. Materials:

Utilizing Aluminum 6063 for Your Shell Eco-marathon EV Chassis: A Strategic Choice Choosing aluminum 6063 for your Shell Eco-marathon electric vehicle (EV) chassis demonstrates a well-informed decision. Here's why:

Table. 1: Shows the properties of Aluminum 6063

Property	***Value***	***Description***
Density	2700 kg/m³	Mass per unit volume
Melting Point	622 °C	Temperature at which the material transitions from solid to liquid
Modulus of Elasticity	69 GPa	Measure of material's stiffness under tension or compression
Tensile Yield Strength	240 MPa	Maximum stress before plastic deformation occurs
Ultimate Tensile Strength	310 MPa	Maximum stress a material can withstand before failure
Shear Strength	270 MPa	Maximum stress before failure in shear loading
Brinell Hardness	73 HB	Resistance to indentation by a steel ball
Thermal Conductivity	175 W/mK	Ability to transfer heat through the material
Electrical Conductivity	34.3 MS/m	Ability to conduct electricity
Coefficient of Thermal Expansion	23.6 µm/mK	Expansion of material with increasing temperature
Fatigue Strength (10 million cycles)	120 MPa	Stress level that can be sustained without failure for a specific number of cycles
Corrosion Resistance	Good	Resists corrosion in most environments, but can be further improved with surface treatments

3.2. Advantages of 6063 aluminium for your chassis:

1. Lightweight: In the Shell Eco-marathon, minimising weight is crucial to optimising performance. Aluminium 6063 offers a significant weight reduction without sacrificing strength because it is substantially lighter than steel. Better performance and reduced energy consumption are the primary results of this.
2. Excellent Strength and Formability: This alloy has a good strength-to-formability ratio that lets you form complicated forms that are essential for aerodynamic efficiency without sacrificing structural integrity. This is essential for creating a chassis that maintains its lightweight design while withstanding the demands of racing.
3. Weldability: Aluminium 6063 is easily welded in a variety of ways, making it possible to construct complex structures with sturdy joints. This adaptability makes it possible to assemble and customise your chassis design quickly and effectively.
4. Machinability: During the design and testing stages, exact component production and adjustments are made possible by the ease of machining aluminium 6063. This

adaptability is useful for customising your chassis according to analysis and testing findings.

5. Corrosion Resistance: When properly treated, this aluminium alloy has good corrosion resistance. This guards against any damage and preserves performance consistency by guaranteeing the chassis' robustness in a range of weather scenarios.
6. Cost and Availability: Aluminium 6063 is a reasonably priced and readily available material when compared to other choices. This balances performance with financial limits, making it a sensible option for student teams competing in the tournament [1-3].

3.3. Extra things to think about:

Although aluminium 6063 has many advantages, you should be aware of its drawbacks and use it wisely in your overall design:

1. Lower Strength Compared to Steel: Alternative materials, such as high-strength steels or composites, may be taken into consideration to assure structural integrity for certain components that require extraordinary strength, such as high-stress areas or crash protection features.
2. Fatigue Resistance: Under persistent stress and vibration, fatigue resistance is normally good but can become problematic. To reduce this risk, designing with low stress concentrations and using the right heat treatment are essential [1-3].

3.4. Enhancing the design of your chassis:

1. Targeted Application: Use aluminium 6063 carefully in your chassis design, concentrating on areas where its formability and light weight provide the biggest advantages. Take into account different materials for certain high-stress regions.
2. Weight Optimisation: To further minimise weight while preserving strength, investigate various fabrication methods such as sheet metal forming or extrusion. Use software for topology optimisation to find places where material can be removed without sacrificing functionality.
3. Maintain structural integrity by making sure your design and analysis are sound enough to resist the stresses involved in competition. Make use of finite element analysis (FEA) software to optimise your design for strength and stiffness by simulating stresses [1-3].
   You may build a competitive Shell Eco-marathon EV with a lightweight and efficient chassis by taking these elements into careful consideration and making the most of

aluminium 6063. Recall that the secret is to strike the ideal balance between the design, material qualities, and overall performance goals.

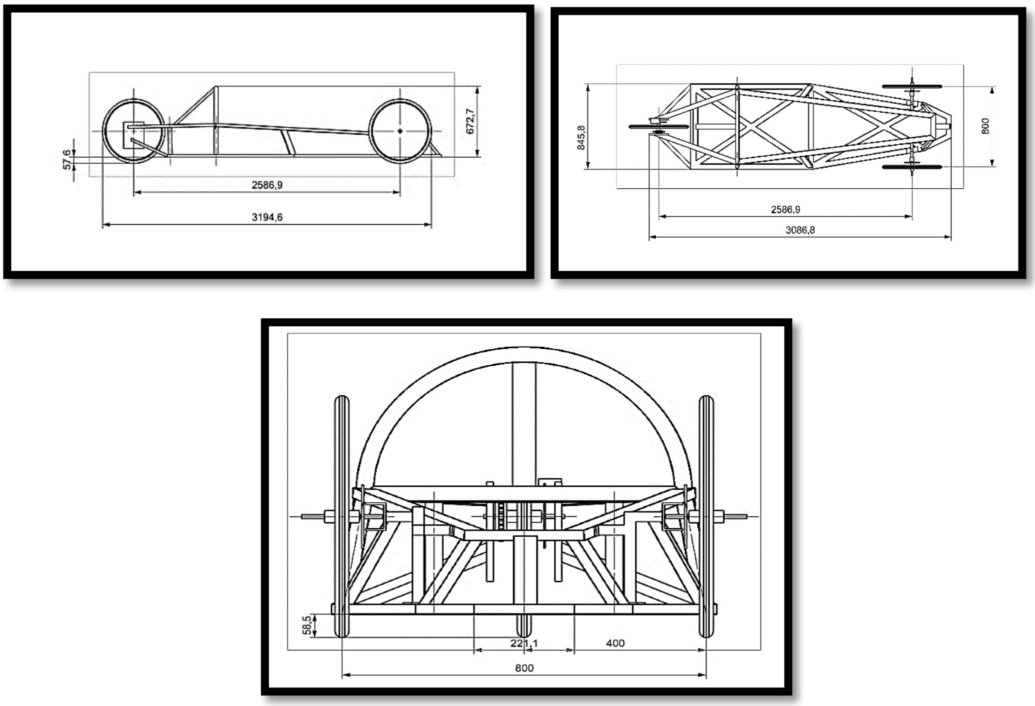


Figure. 1: Shows the front view, top view and side view of the aluminum 6063 chassis

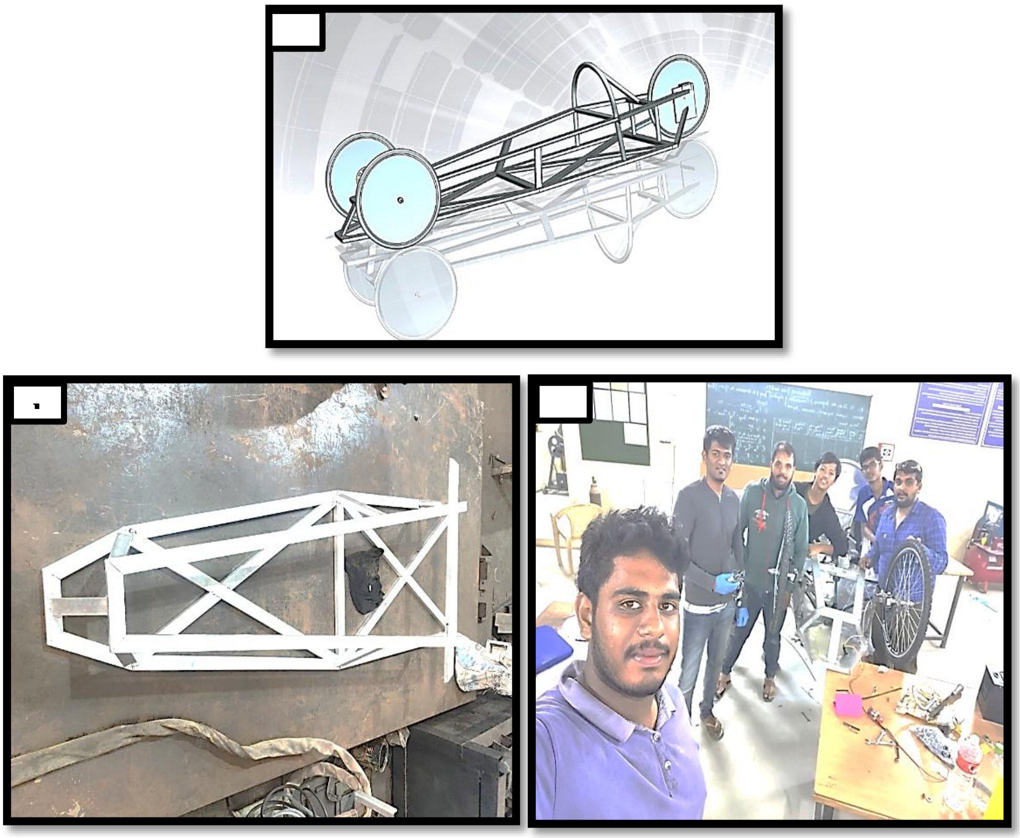


Figure. 2: a Isometric view of complete model, 2 b Aluminum chassis and 2 c my team members working on the model

4. Methods:

How Your Aluminium 6063 Shell Eco-marathon EV Chassis Is Fabricated: For your Shell Eco-marathon EV chassis, there are a few different fabrication techniques that can be used with aluminium 6063, each with their own benefits and things to keep in mind:

4.1. Welding:

1. TIG welding provides accurate, high-quality welds with less distortion caused by heat, making it perfect for thin sheet metal and important joints. Needs specialised equipment and operators with experience.

2. Larger constructions and thicker sections are suited for MIG welding, which is quicker and more effective than TIG welding. For better looks and a smoother finish, post-processing could be necessary.

3. Aluminium is less frequently arc welded because of the increased heat input and warping risk. However, with the right setup and expertise, it might be a reasonably priced choice for thicker parts.

4.2. The process of machining:

1. CNC machining: Provides intricate geometry design and exact control for unique components. Costly for large-scale manufacture, yet appropriate for intricate details and crucial elements.

2. Manual machining is less expensive than CNC, but it needs trained operators and might not be as intricate. Ideal for simple parts and adjustments.

4.3. Forming sheet metal:

1. Bending: Using press brakes or brakes on sheet metal, curved shapes are produced. Effective for big, straightforward panels with regular bends.

2. Rolling: Using rollers, one can create curved objects with different radii. Provides greater flexibility than bending, but specific tools could be needed.

3. Deep Drawing: Using sheet metal blanks, one may create intricate shapes with different depths. Usually utilised for high-volume production; requires specialised tooling and trained personnel.

4.4. Joining methods:

1. Riveting is a quick and easy way to attach sheet metal components together, but in high-stress locations, it could not be as sturdy as welding.
2. Bolting: Versatile and simple to disassemble, although it adds weight and might need more room for the bolt heads.
3. Adhesives: Can be utilised in some bonding applications, however in order to provide strong and long-lasting joins, careful selection and surface preparation are essential.

4.5. Selecting the appropriate approach:

1. Several criteria determine which fabrication procedure is optimal.
2. Design complexity: More intricate designs could call for sophisticated sheet metal forming methods or CNC machining.
3. Required strength: TIG welding or other stronger welding processes may be advantageous for high-stress areas and critical joints.
4. Fabrication resources: When choosing techniques, take your team's experience, the equipment at hand, and your financial limitations into account.
5. Production volume: Automated techniques like as roll forming or CNC machining may be more effective for large-scale production.

4.6. Extra advice:

1. Optimise design for selected fabrication techniques: Create chassis components that take use of selected fabrication techniques' advantages and reduce the requirement for labour-intensive post-processing.
2. Seek to work together with specialists in fabrication: For advice on intricate procedures or specialised equipment, seek the advice of knowledgeable individuals or fabrication shops as needed.
3. Put quality and safety first: To guarantee structural integrity and functionality, make sure that the right safety measures are followed throughout fabrication and carry out comprehensive quality checks.

You may build a competitive Shell Eco-marathon EV with an aluminium 6063 chassis that is robust, light, and efficient by carefully choosing and implementing the right fabrication techniques. To get the greatest result, keep in mind that the best strategy is to strike a balance between the demands of the design, the available resources, and the skills of your team [1-3].

5. Analysis of the chasis made form aluminium 6063:

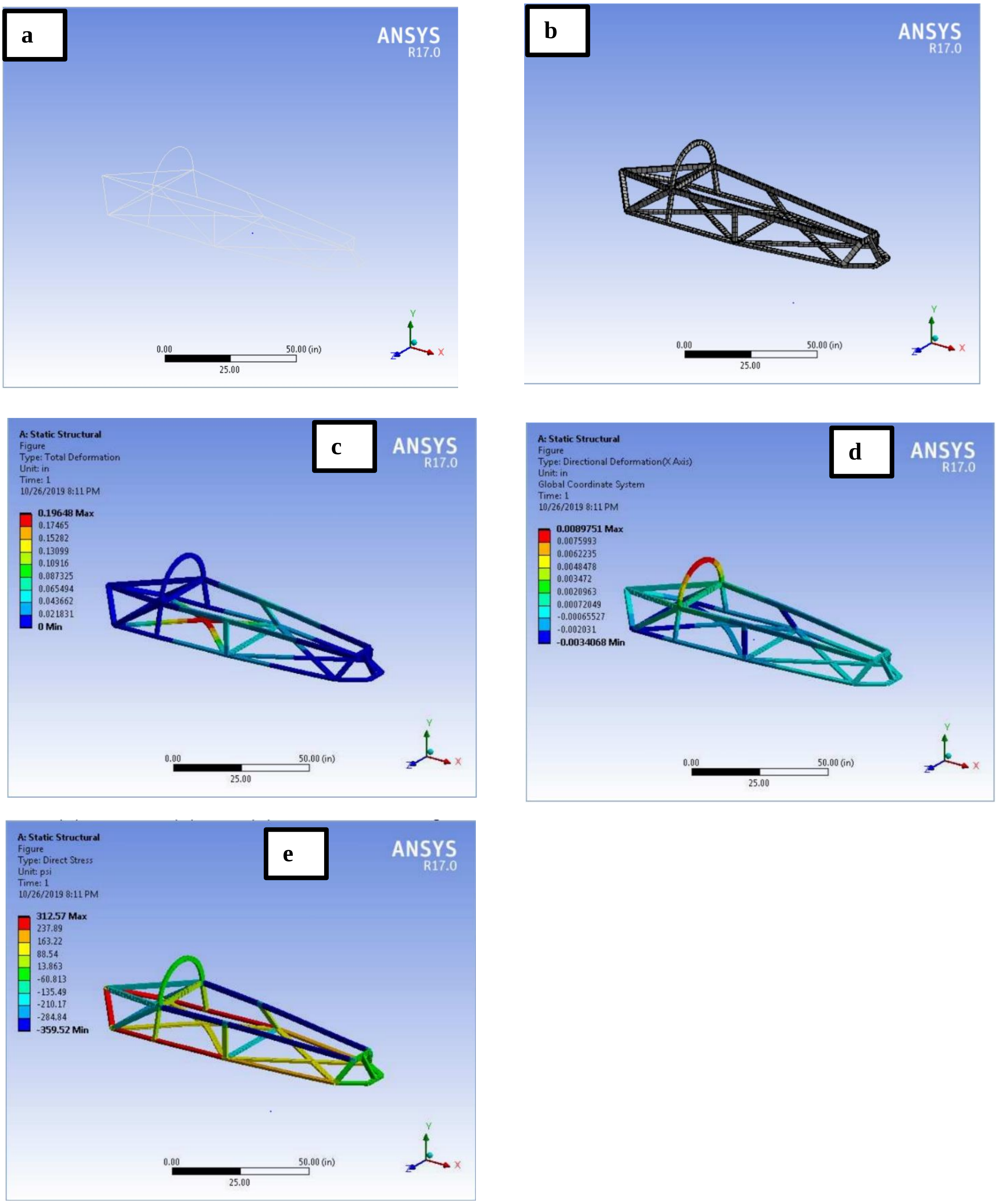


Figure.

5.1. Battery used:

A 48-volt, 20 AH lithium-ion battery was used. Rechargeable lithium-ion batteries are composed of one or more cells, which are separate units that provide electricity, just like regular batteries.

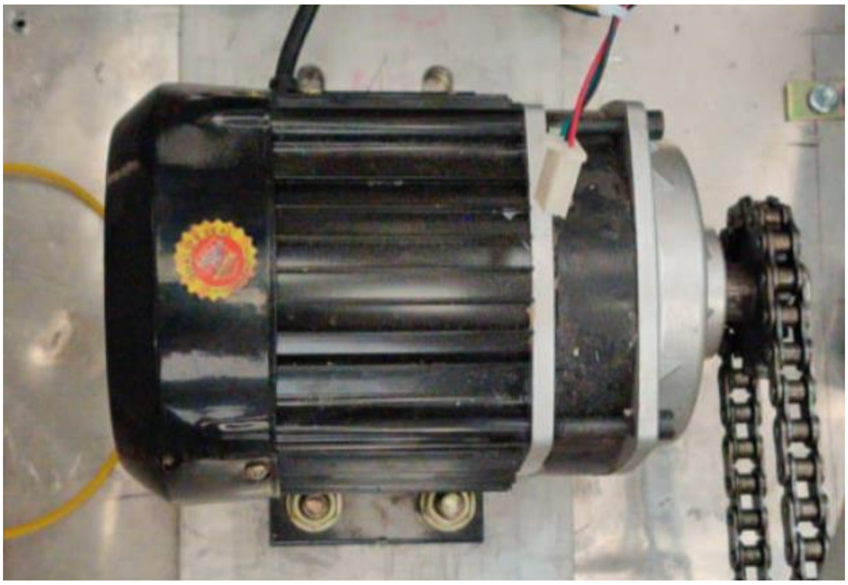


Figure. 4: Circuit diagram of electronic controller

In essence, each cell possesses three components consist of an electrolyte, which is a chemical, between a positive electrode that is attached to the battery's positive or + terminal and a negative electrode that is connected to the negative or − terminal. Typically, lithium-cobalt oxide (($LiCoO_2$) or, in more recent batteries, lithium iron phosphate ($LiFePO_4$) is used to make the positive electrode.

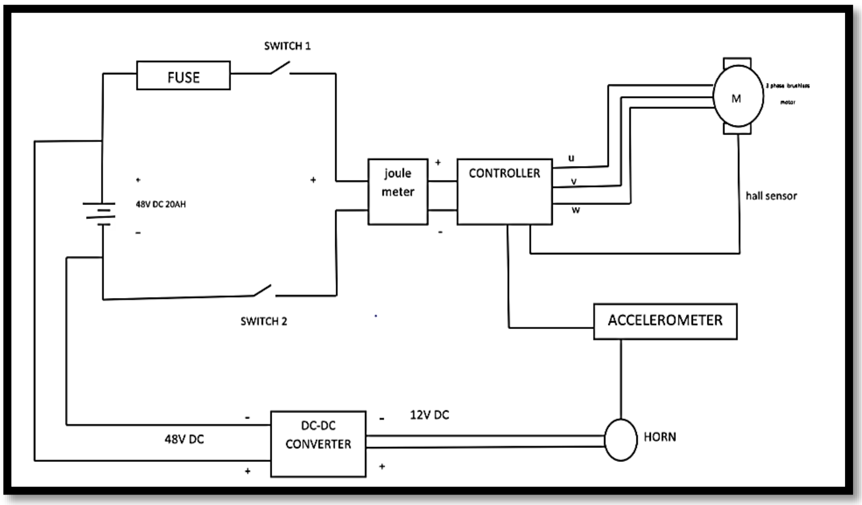


Figure. 5: Circuit Diagram of electronic controller

Although the electrolyte varies depending on the type of battery, it is commonly composed of carbon (graphite) for the negative electrode. However, this information isn't very crucial for comprehending the fundamental principles of battery operation.

The general operation of all lithium-ion batteries is the same. As soon as the battery is as the positive electrode of lithium-cobalt oxide charges up, some of its lithium ions are released and go through the electrolyte to the negative electrode of graphite. Just stay there. Throughout this process, energy is taken in and stored by the battery. The energy that powers the battery is produced when the lithium ions travel back across the electrolyte to the positive electrode during the discharge process. In both situations, the ions around the outside circuit are flown in the opposite direction by electrons. The electrolyte functions as an effective insulating barrier, preventing electrons from passing through it [1-3].

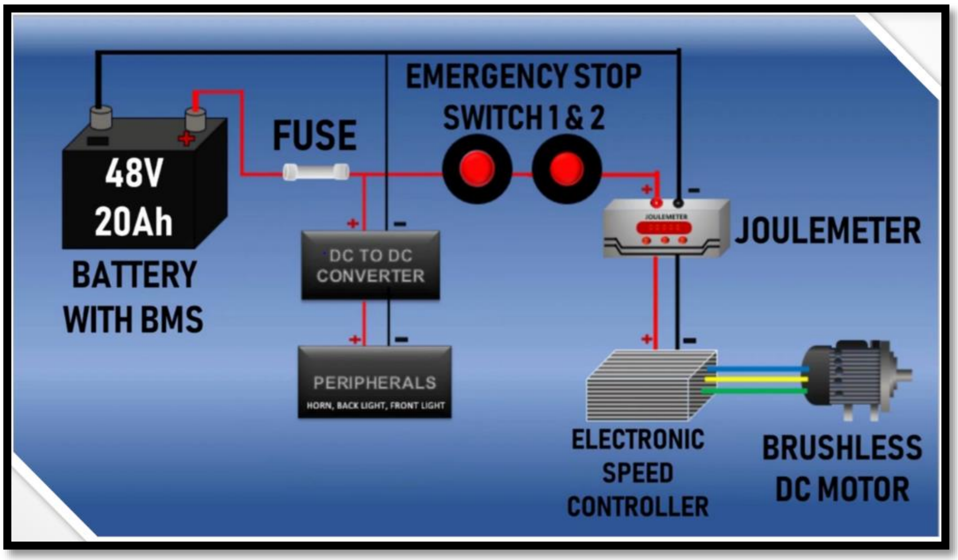


Figure. 6: Energy Supply system

The flow of electrons over the external surface and ions via the electrolyte circuit, on the other hand) are linked operations; the cessation of one result in the cessation of the other. If the ions in the electrolyte cease to flow because the battery electrons are unable to flow through the outer circuit when the circuit fully discharges, therefore you become powerless. In a similar vein, when you turn off anything that the battery is powering, both the flow of ions and electrons cease. The battery essentially stops discharging at a rapid pace when the appliance is unplugged, albeit it still discharges at a very slow rate.

Lithium-ion batteries, in contrast to more basic ones, contain integrated electronic controllers that control how they charge and discharge. They stop the overheating and overcharging that, in certain cases, can result in lithium-ion battery explosions.

5.2. Steering mechanism:

By turning the steering wheel rim a long way to move the road wheels a small distance, the steering system translates the rotation of the steering wheel into a swiveling action of the road wheels. Steering becomes dangerously sloppy and imprecise with even a small amount of looseness in the joints, which need to be adjusted extremely carefully.

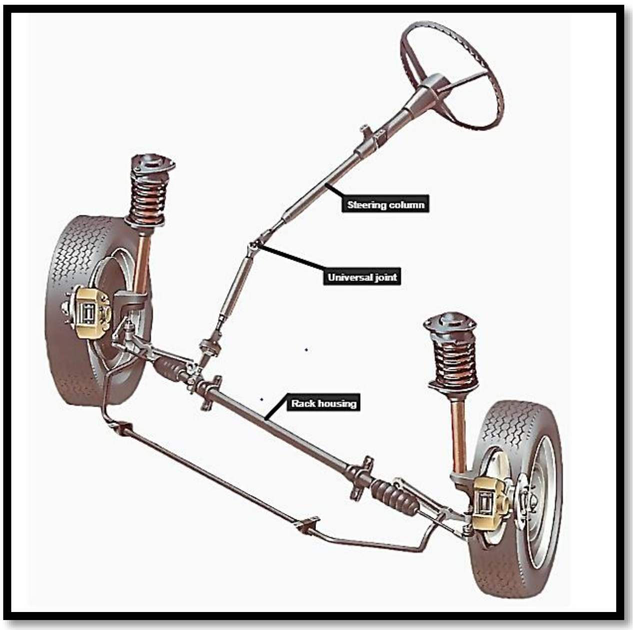


Figure. 7: Shows the steering mechanism used

5.3. Design requirements as per the rule book:

Chassis: Structural Integrity, Visibility, Vehicle access

Body

Max height < 100 cm & < 1.25 times track width

Width < 130 cm

Length < 350 cm

Ventilation

Steering assembly

Track width > 50 cm

Wheelbase >100 cm

Total weight of vehicle < 140 kg (w/o driver)

6. Results:

Per charge expecting: 250km/kWh

Body: glass fiber with 3 wheels

Motor driven, 48V, 550W BLDC

Vehicle weight: 60kg

Cost: 2.5 lakhs

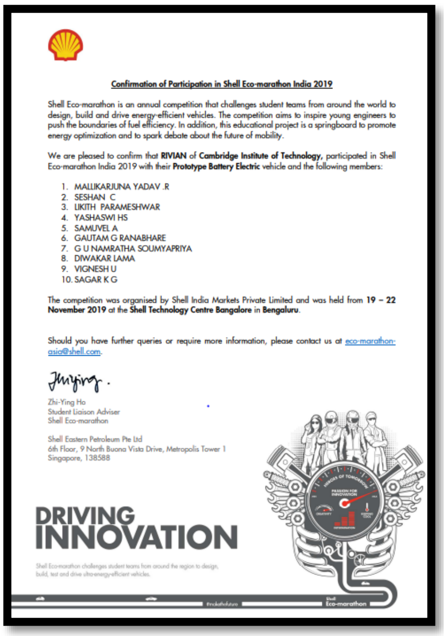
Conflicts of Interests

No Conflicts of Interests

6.1. Acknowledgement:

I want acknowledge the Management of Cambridge Institute of Technology epically COE Mr Nitin Mohan for his valuable support and Dr Suresh L Principal, I want to thank my team members also.

Team Member list



Confirmation of Participation in Shell Eco-marathon India 2019

Shell Eco-marathon is an annual competition that challenges student teams from around the world to design, build and drive energy-efficient vehicles. The competition aims to inspire young engineers to push the boundaries of fuel efficiency. In addition, this educational project is a springboard to promote energy optimization and to spark debate about the future of mobility.

We are pleased to confirm that **RIVIAN** of **Cambridge Institute of Technology,** participated in Shell Eco-marathon India 2019 with their **Prototype Battery Electric** vehicle and the following members:

1. MALLIKARJUNA YADAV .R
2. SESHAN C
3. LIKITH PARAMESHWAR
4. YASHASWI HS
5. SAMUVEL A
6. GAUTAM G RANABHARE
7. G U NAMRATHA SOUMYAPRIYA
8. DIWAKAR LAMA
9. VIGNESH U
10. SAGAR K G

The competition was organised by Shell India Markets Private Limited and was held from **19 – 22 November 2019** at the **Shell Technology Centre Bangalore** in **Bengaluru**.

Should you have further queries or require more information, please contact us at eco-marathon-asia@shell.com.

Zhi-Ying Ho
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DRIVING INNOVATION

Shell Eco-marathon challenges student teams from around the region to design, build, test and drive ultra-energy-efficient vehicles.

#makethefuture

Shell Eco-marathon

7. Conclusions:

1. The selected fabrication techniques—welding, machining, etc.—achieve the intended result and are appropriate for the particular design.
2. Critical sections in the chassis design that need to be modified or reinforced were found by the FEA study.

3. Utilising aluminium 6063 helps the electric vehicle (EV) reach a weight goal and may increase its efficiency.
4. All things considered, the design strategy utilising FEA analysis and aluminium 6063 shows promise for producing a lightweight, durable, and effective chassis for the Shell Eco-marathon EV.

8. References:

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Appendix I

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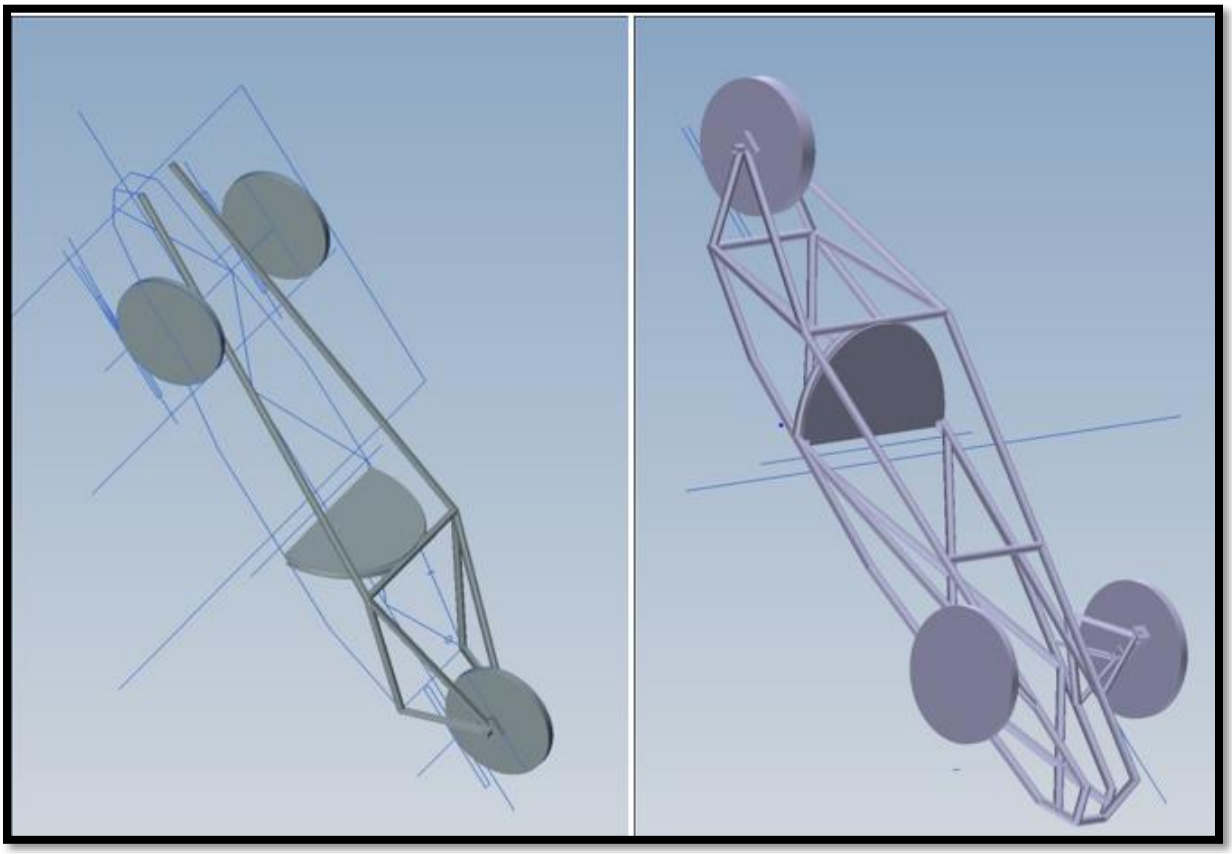

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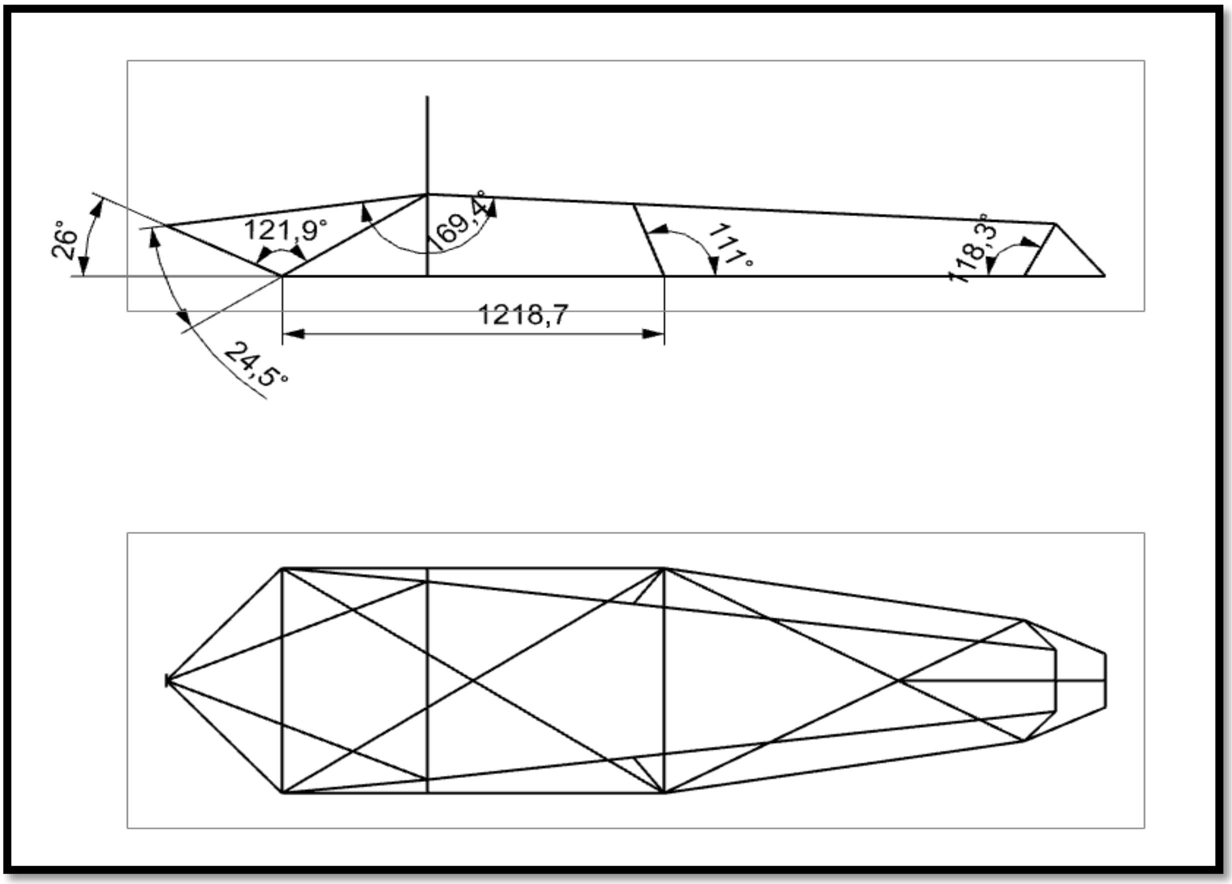

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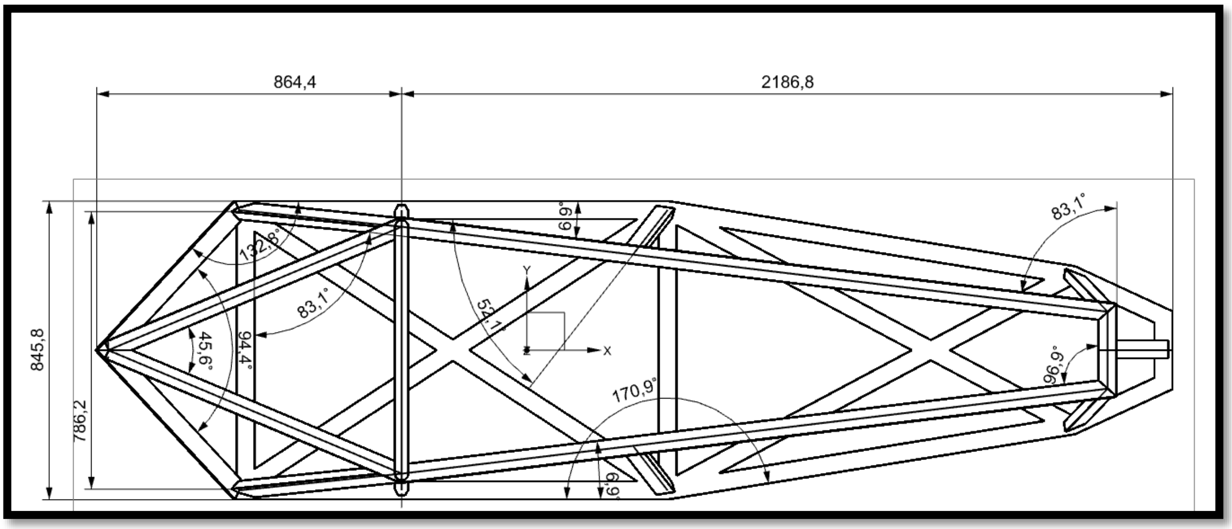

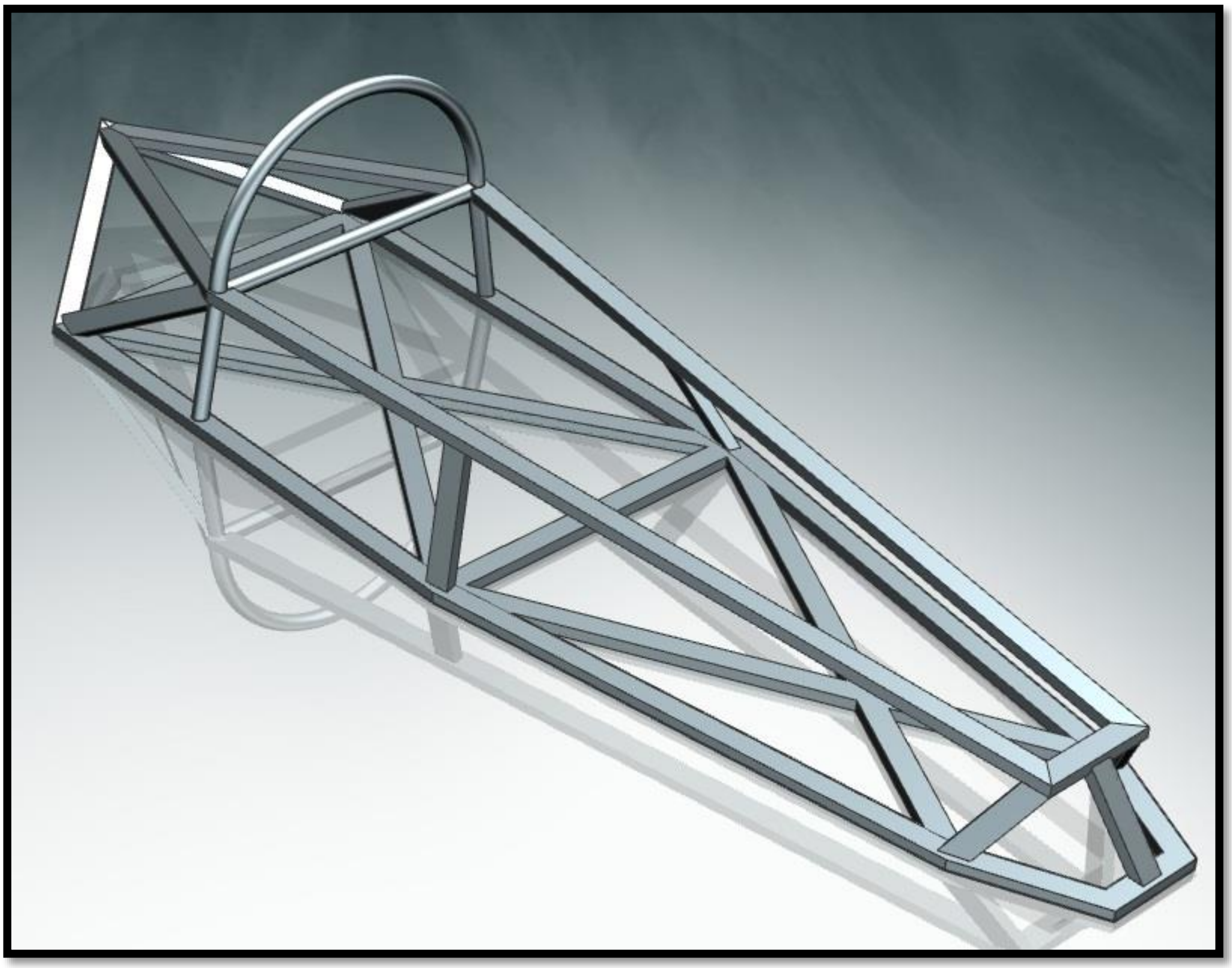

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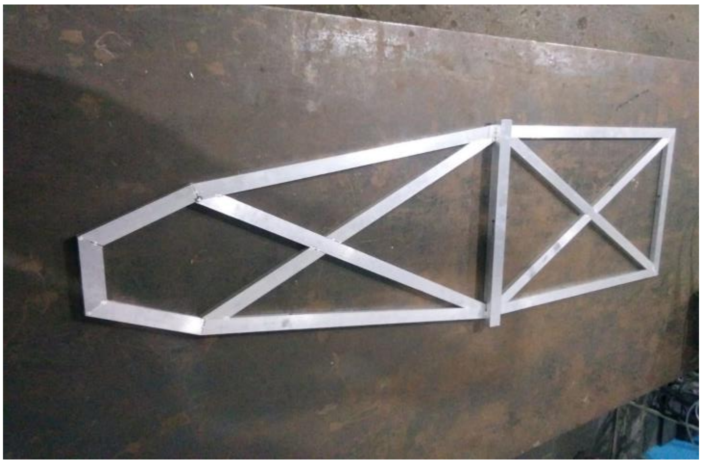

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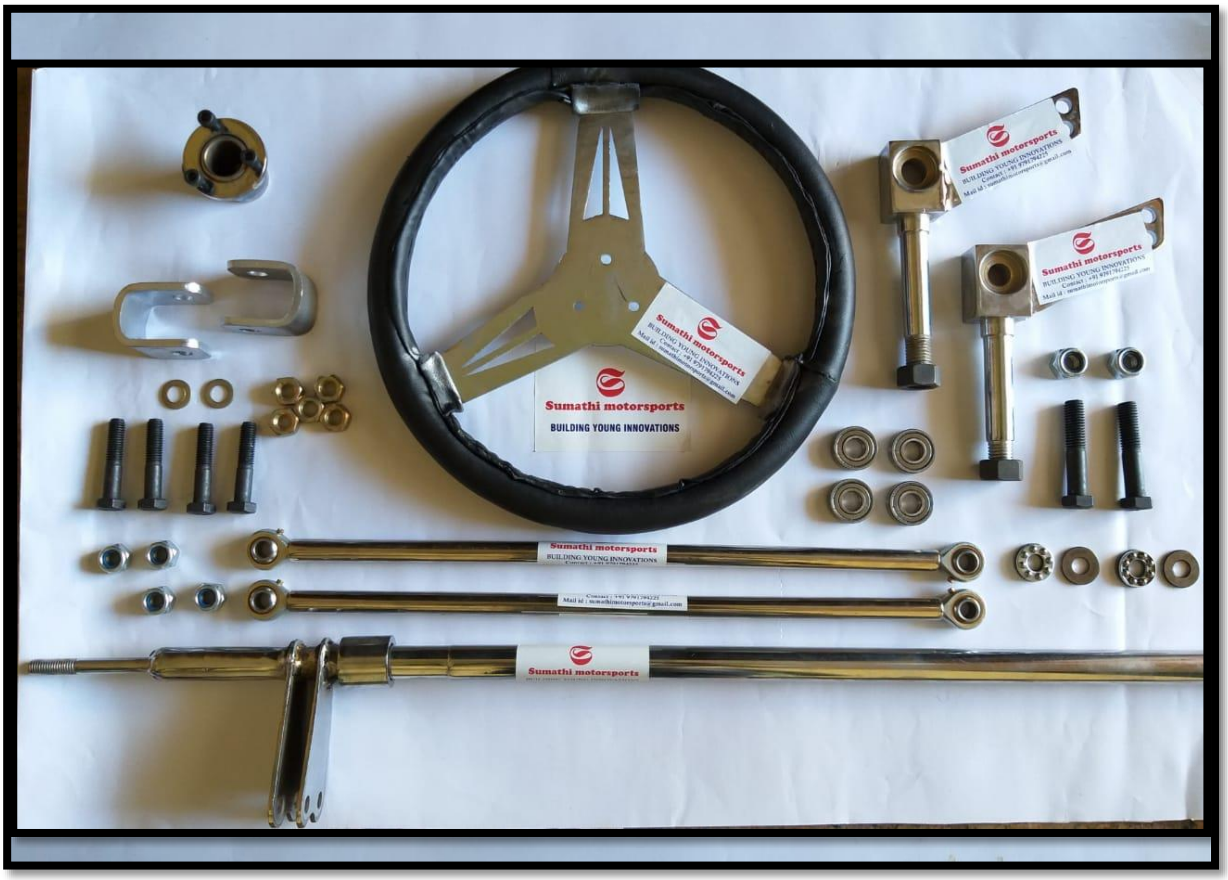
Sumathi motorsports
BUILDING YOUNG INNOVATIONS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Steering mechanism:

Figure.