Chassis Design Review

Analysis on design of feature-rich aluminium chassis using synthetic suspension

MI

Mechanical Design and Innovation SubGroup

X.1 Table of Contents

1.1 Abstract

The following document mentions the design decisions, considerations, and features of the new aluminum chassis for the electric vehicle.

This short document first describes the reasoning behind switching the chassis and considerations that must be taken into account. Next the final design is drafted with considerations and features taken into account based on real-world data and analysis. Lastly, a technical drawing is drafted to allow for the production of the chassis by a manufacturer.

1.2 Reasoning

1.2.1 Introduction

While elaborate cost-analysis and simulations can be run to validate the design, the simple fact is that for the given speeds and forces steel is not required for the chassis with meaningful, suitable, and purposeful design choices. This therefore means that a different material of a lighter weight can be employed to reduce the overall static mass of the car, thereby reducing the total mass that needs to be accelerated by the motor and batteries, thus reducing power draw and therefore improving vehicle performance.

1.2.2 Density and Mass Analysis

Looking at the densities of structural steel [2] (median value) and 7075 aluminum [1] we can already see quite a substantial difference:

$V_{chassis} = 0.002811\ m^3$ as taken from Fusion 360
$\rho_{steel\ median} = 7850\ kg\ m^{-3}$ as taken from [2]

$\rho_{7075\ aluminium} = 2810\ kg\ m^{-3}$ As taken from [1, 4]

$\Rightarrow \quad \rho = m/V$
$\Rightarrow \quad \rho = m/V_{chassis}$
$\Rightarrow \quad \rho V_{chassis} = m_{chassis}$
$\Rightarrow \quad \rho_{steel\ median} V_{chassis} = m_{chassis}$
$\Rightarrow \quad m_{chassis} = 22.06635\ kg$

$\Rightarrow \quad \rho = m/V$
$\Rightarrow \quad \rho = m/V_{chassis}$
$\Rightarrow \quad \rho V_{chassis} = m_{chassis}$
$\Rightarrow \quad \rho_{7075\ aluminium} V_{chassis} = m_{chassis}$
$\Rightarrow \quad m_{chassis} = 7.89891\ kg$

This therefore means that we are able to obtain a reduction in mass of 14.167 kg simply by changing the material without reducing the crash performance of the vehicle given the speeds of the vehicle [5].

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Steel chassis                       22.06635 kg
Aluminum Chassis                    7.89891 kg
Batteries Total                     66 kg          as taken from [3]
Other weighty items                 5 kg
Driver and Ballast                  80 kg

Total Weight STEEL CHASSIS          173.06636 kg
Total Weight ALUMINIUM CHASSIS      158.89891 kg
```

1.2.3 Further Improvements

While we are here reverse engineering the kit chassis, we can incorporate further improvements to the vehicle chassis to increase race performance:

(1) Synthetic Suspension (see definition below)
(2) Larger wheels for reduced road friction and an increase in cornering
(3) Bespoke mounts for floor without using finicky aluminum plates
(4) Bespoke mounts for batteries and other electronics to isolate wires from being touched by environmental factors and humans
(5) Bespoke mounts for batteries to allow center of mass to be lower in the vehicle and thus increase vehicle stability in turns as vehicle is less top-heavy

It can therefore be found that switching the chassis is a lucrative albeit time consuming endeavor that will be able to increase the performance of the vehicle, make the chassis more feature-rich for end-user (a joy for mechanics to assemble!) without compromising on strength or crash safety.

1.3 Design Process

1.3.1 Overall Process

(1) Disassemble vehicle carefully and organize all parts
(2) Reverse-engineering the chassis by taking measurements
    a. Use calipers and micrometers to measure chassis
    b. Use LIDAR photogrammetry to model awkward shapes
    c. Trace curves on paper to allow for easily replication in CAD, curves can include rollcage, etc.
(3) Place the measurements in CAD using Fusion 360
(4) Validate that aluminium will work and will not get damaged based on the forces in the race
(5) Since we are altering the frame take this opportunity to improve the design and thereby improve many aspects of the vehicle.

1.3.2 Manufacturing Processes

Processes required will be as follows:

(1) Cutting Aluminium
(2) Drilling Aluminium
(3) Tapping Aluminium
(4) Welding Aluminium
(5) Bending Aluminium

1.3.3 Tools Required

Tools required will be as follows:

(1) Welding Machine (as given for different process available)
(2) Hacksaw, auto-hacksaw
(3) Various Drills, Drill press
(4) Various Taping sets
(5) Some sort of hydraulic or mechanically enhanced pipe bender.

1.3.4 Further Considerations

Further considerations taking during design will be as follows:

(1) All holes are lengths are in metric mm.
(2) All lengths have been rounded to nearest 1mm, with tolerances of ±3mm. Geometry maintained is simple in the sense that lengths are usually rounded to tenths or ½ tenths in the sense the lengths are 35, 45, 50, 60, 100 to keep everything simple.
(3) Rough forged Aluminium plates are suitable, they do not need to be machines exactly to 5mm.
(4) Rough forged Aluminium box tubes are suitable, they do not have to machine-grade or precision grade.

1.4 Final Design and Feature-set

Important!	For further detail to the design considerations in the aluminium chassis refer to the following link. https://www.youtube.com/watch?v=g_upgBN0yWs

1.4.1 Synthetic Suspension

This is a term coined by the design Aluminium Chassis whereby we use no shock, springs, hydraulics, etc. to have a smoother ride. This reduced the weight of the vehicle without compromising on the smooth ride.

The curved box tubes in this design (see 1.7 the beam in blue and orange) act this sort of suspension.

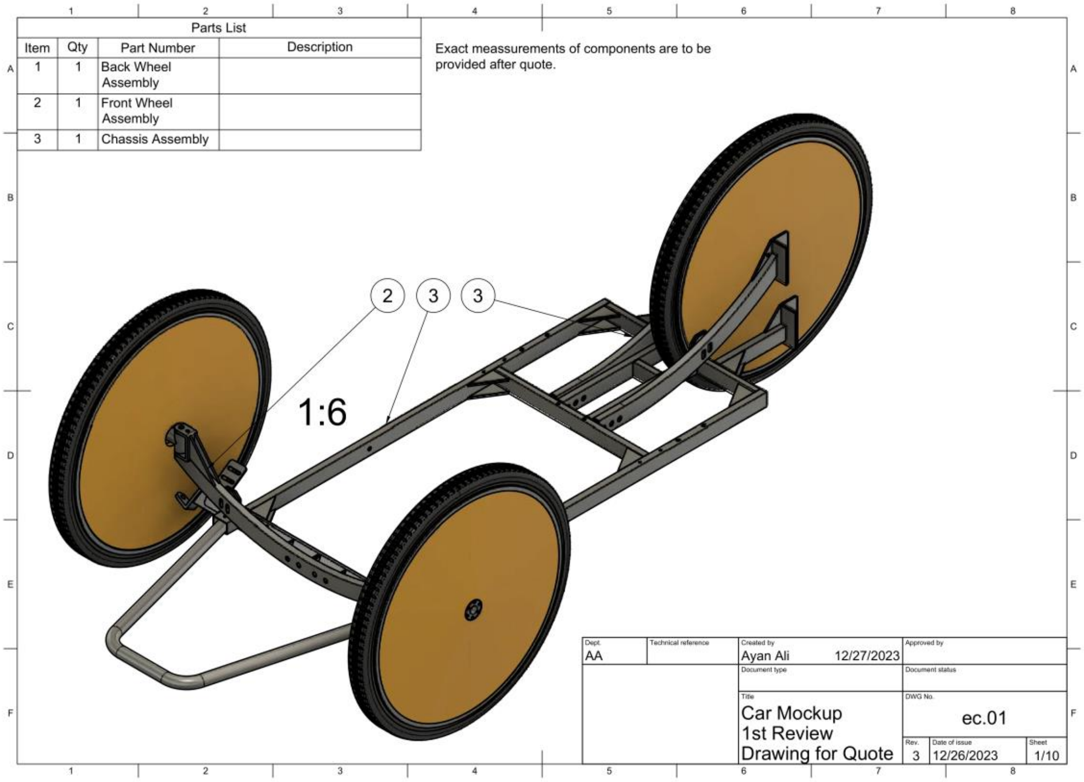
1.4.2 Disc Covers

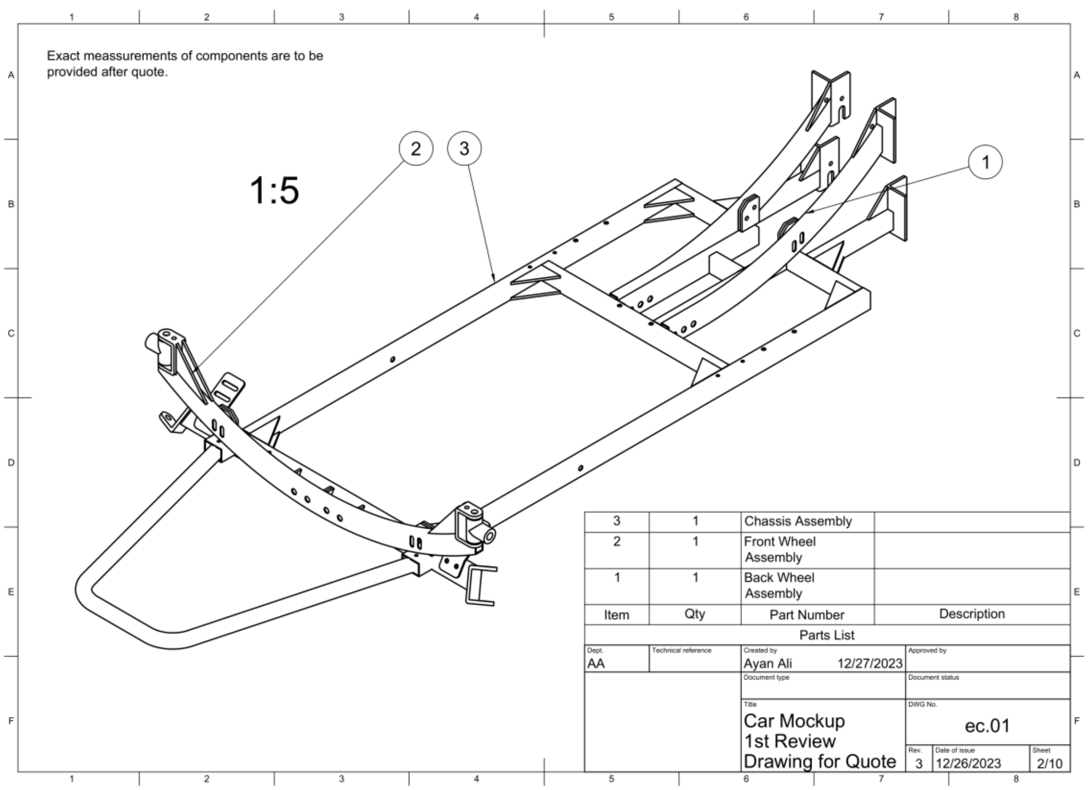
Disc covers can be 3D printed and placed over the bicycle tires to reduce the air-resistance against the vehicle thus improving efficiency and thereby endurance.

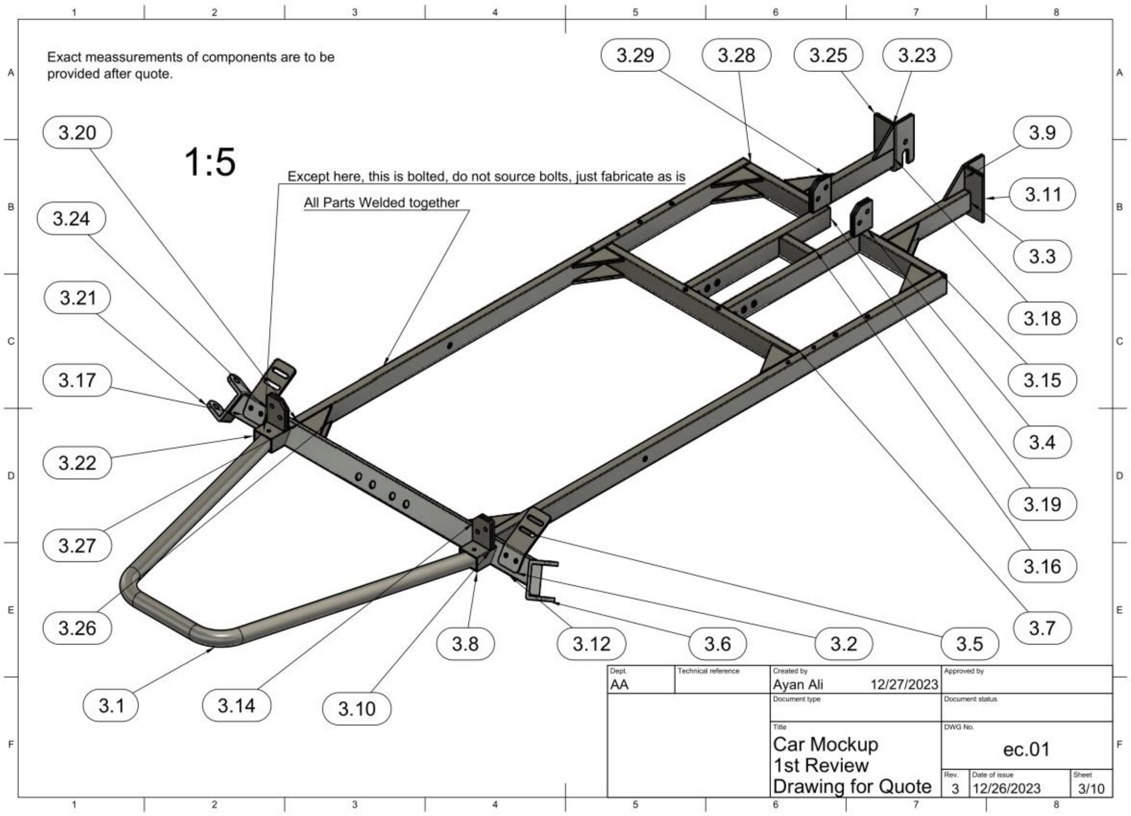
1.4.3 Minor Design Choices

The original frame is still maintained in case the old tires need to be installed or if the old battery assembly needs to be installed with the screw mounts being in the same place.

1.5 Technical Drawing







Parts List			
Item	Qty	Part Number	Description
3.17	1	Front Rollcage Bracket(Mirror)	
3.18	1	210mm 2040 BoxTube(Mirror)	
3.19	1	350mm 2040 BoxTube(Mirror)	
3.20	1	1160mm 2040 BoxTube(Mirror)	
3.21	1	Old Wheel Mount 20 Degree Incline(Mirror)	
3.22	1	Front Bumper Mount 3045 BoxTube(Mirror)	
3.23	1	50x50 Brace Plate(Mirror)	
3.24	2	New Wheel Suspension Constrictor Plate(Mirror)	
3.25	1	Wheel Mount(Mirror)	
3.26	1	100x60 Brace Plate(Mirror)	
3.27	7	80x50 Brace Plate(Mirror)	
3.28	1	180mm 2040 BoxTube(Mirror)	
3.29	4	New Wheel Suspension Constrictor	

Parts List			
Item	Qty	Part Number	Description
3	1	Chassis Assembly	
3.1	1	Front Bumper	
3.2	1	Front Rollcage Bracket	
3.3	1	210mm 2040 BoxTube	
3.4	1	350mm 2040 BoxTube	
3.5	1	1160mm 2040 BoxTube	
3.6	1	Old Wheel Mount 20 Degree Incline	
3.7	1	472.5mm 2040BoxTube	
3.8	1	Front Bumper Mount 3045 BoxTube	
3.9	1	50x50 Brace Plate	
3.10	2	New Wheel Suspension Constrictor Plate	
3.11	1	Wheel Mount	
3.12	1	30 Degree 2045 BoxTube	
3.13	1	100x60 Brace Plate	
3.14	7	80x50 Brace Plate	
3.15	1	180mm 2040 BoxTube	
3.16	1	72.5mm 2040 BoxTube	

Dept.	Technical reference	Created by	Approved by
AA		Ayan Ali 12/27/2023	
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			Rev. 3 / Date of issue 12/26/2023 / Sheet 4/10

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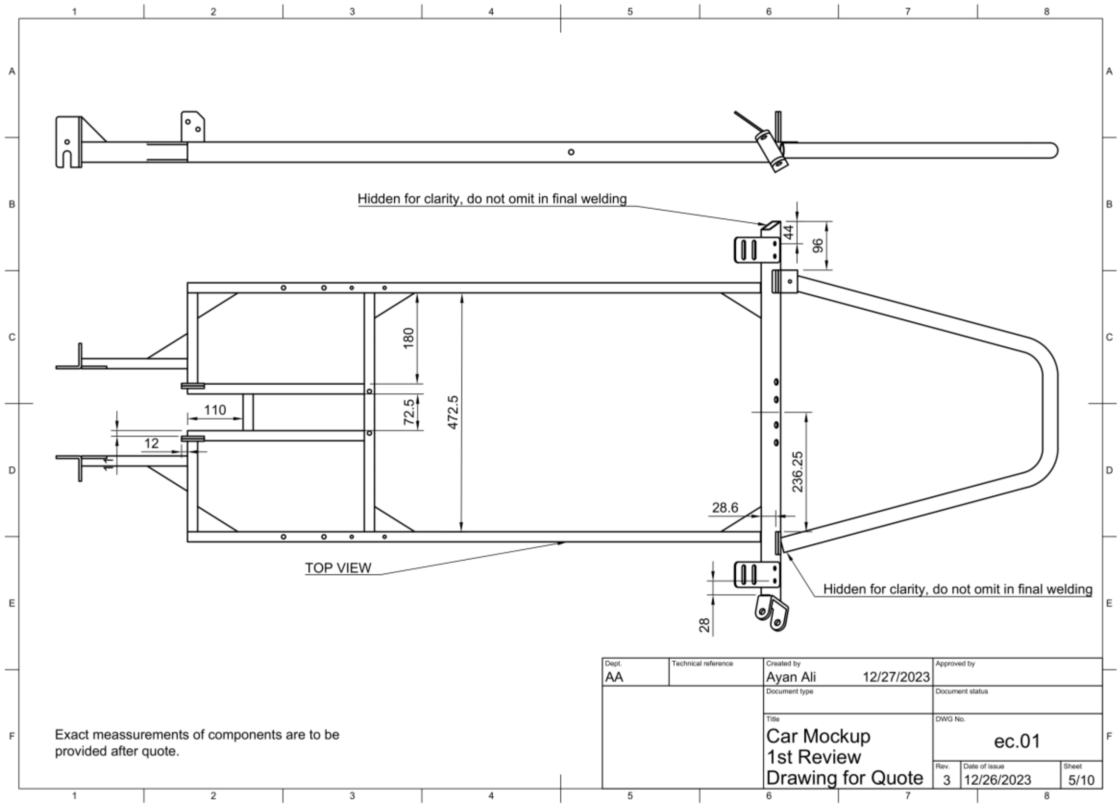
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28.6
TOP VIEW
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Exact meassurements of components are to be provided after quote.
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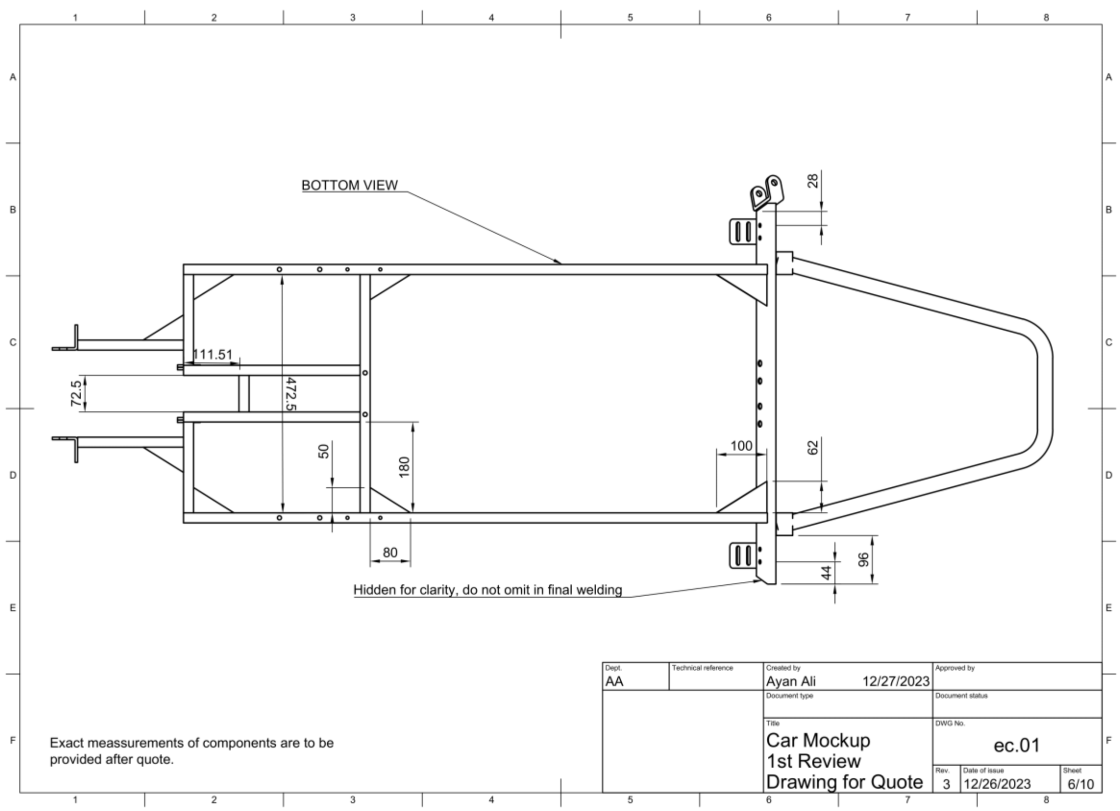
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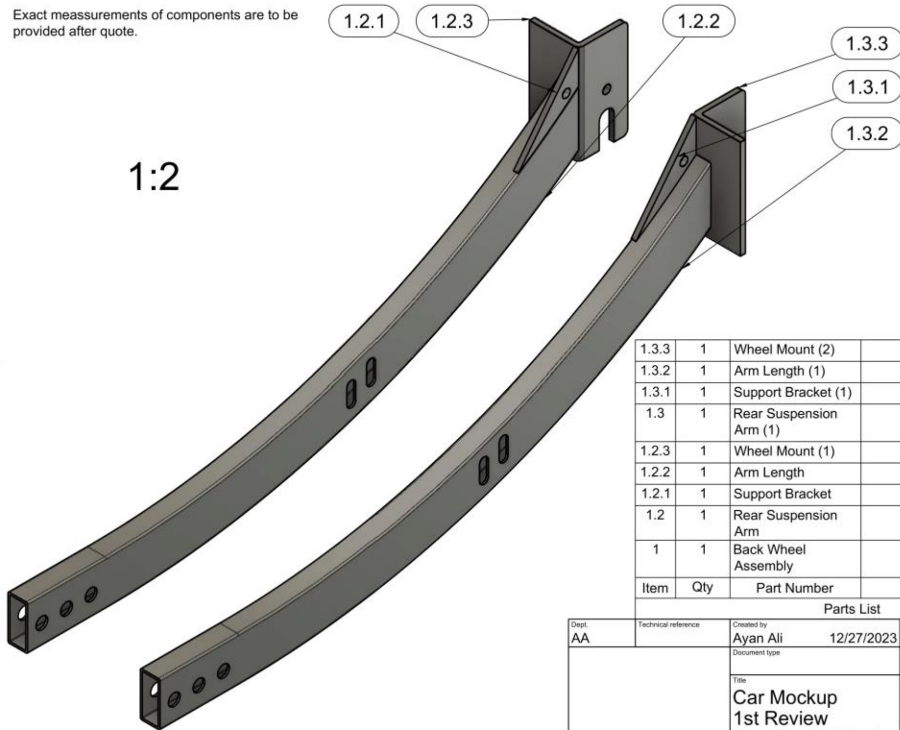

Item	Qty	Part Number	Description
1.3.3	1	Wheel Mount (2)	
1.3.2	1	Arm Length (1)	
1.3.1	1	Support Bracket (1)	
1.3	1	Rear Suspension Arm (1)	
1.2.3	1	Wheel Mount (1)	
1.2.2	1	Arm Length	
1.2.1	1	Support Bracket	
1.2	1	Rear Suspension Arm	
1	1	Back Wheel Assembly	

Parts List

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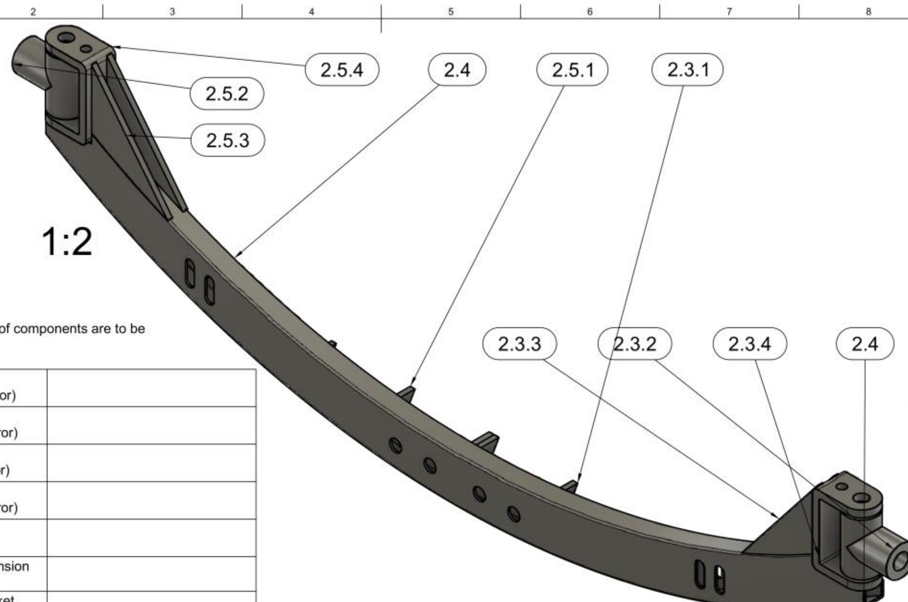

Exact meassurements of components are to be provided after quote.

Item	Qty	Part Number	Description
2.5.4	1	Wheel Bracket(Mirror)	
2.5.3	2	Wheel Support(Mirror)	
2.5.2	1	Bearing Holder(Mirror)	
2.5.1	3	20x35 Support(Mirror)	
2.5	1	Left Wheel Assembly	
2.4	1	Main Suspension Bar	
2.3.4	1	Wheel Bracket	
2.3.3	2	Wheel Support	
2.3.2	1	Bearing Holder	
2.3.1	3	20x35 Support	
2.3	1	Right Side Wheel Assembly	
2	1	Front Wheel Assembly	

Parts List

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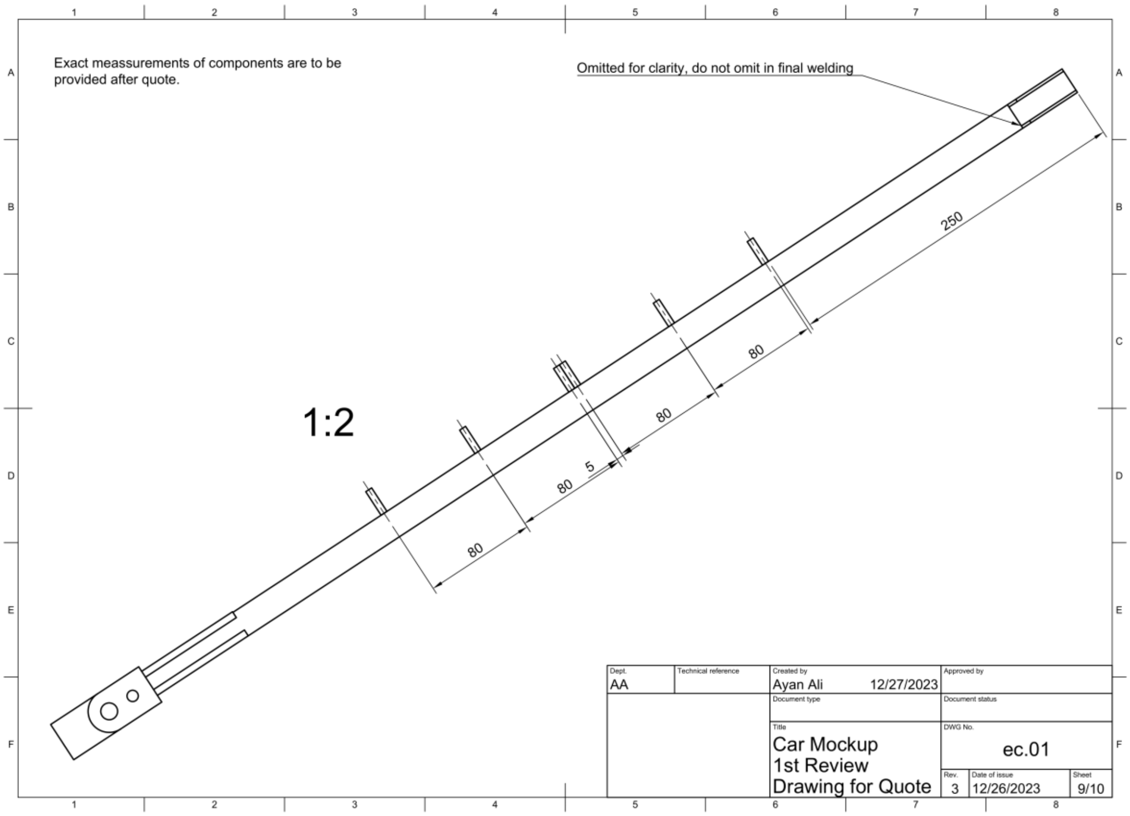
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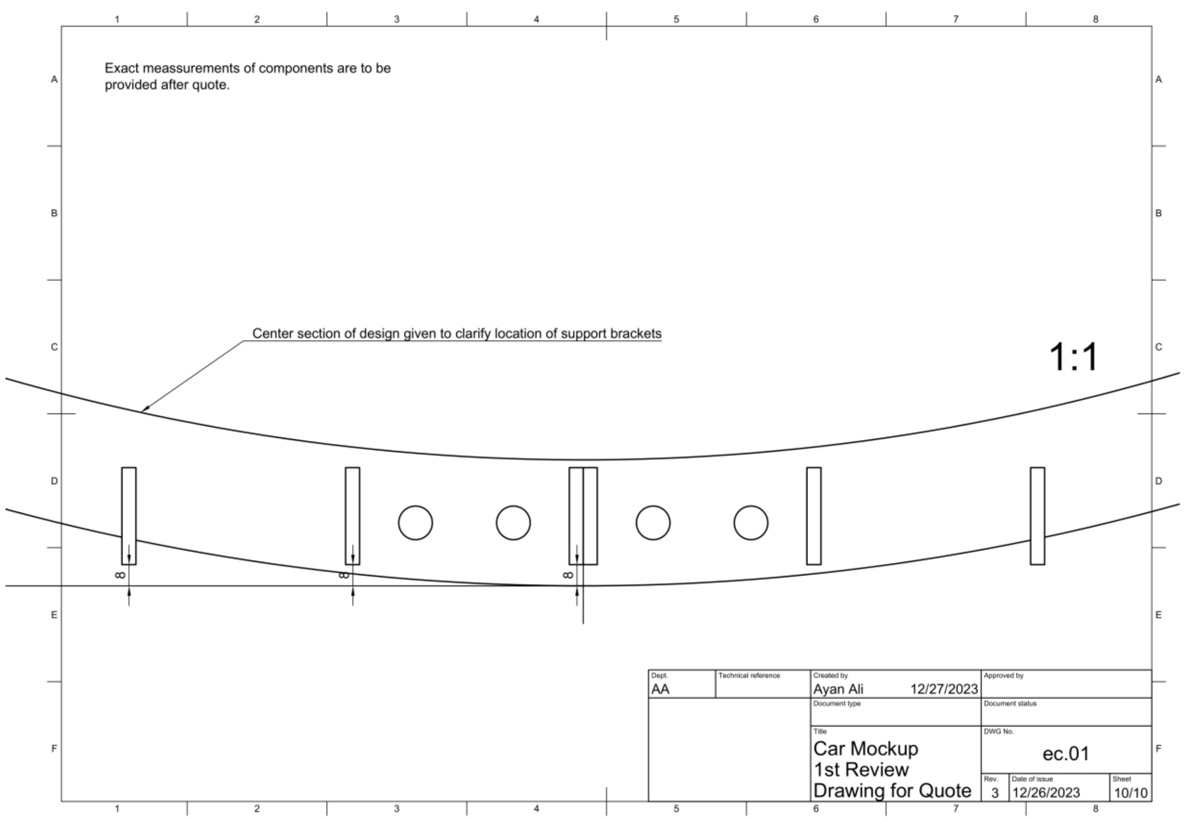
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1.6 References

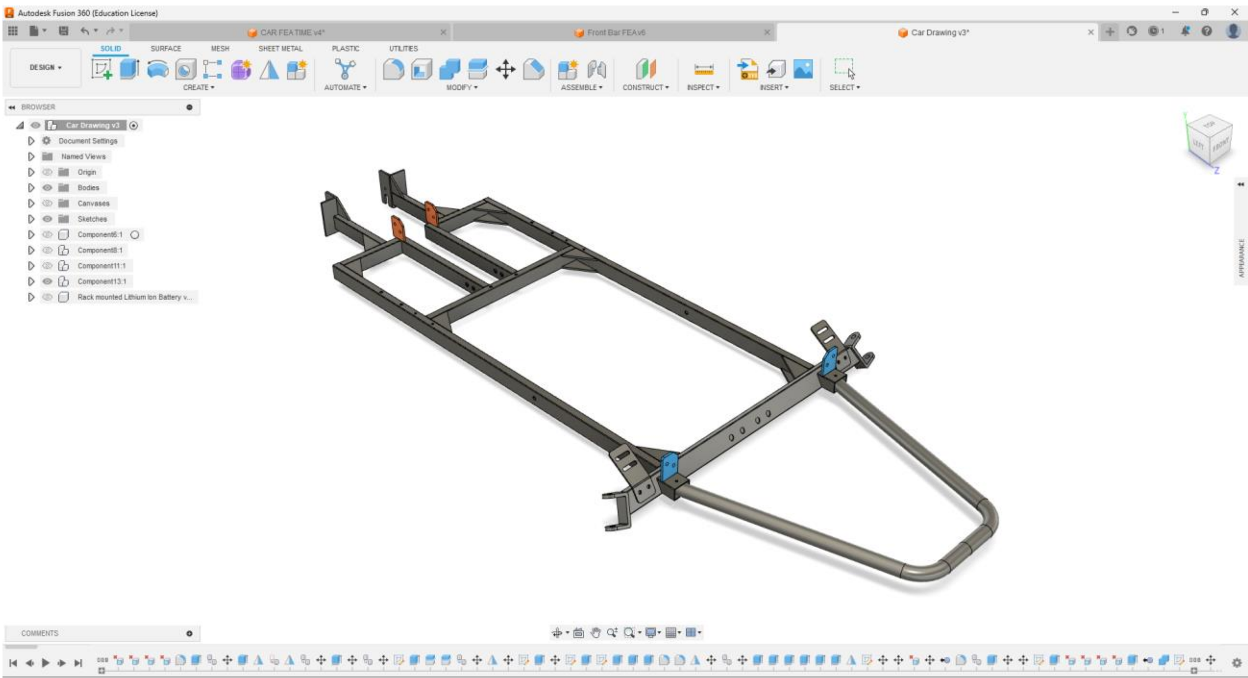
[1] "ASM Material Data Sheet." ASM. Accessed: Feb. 6, 2024. [Online]. Available: https://asm.matweb.com/search/SpecificMaterial.asp?bassnum=ma7075t6

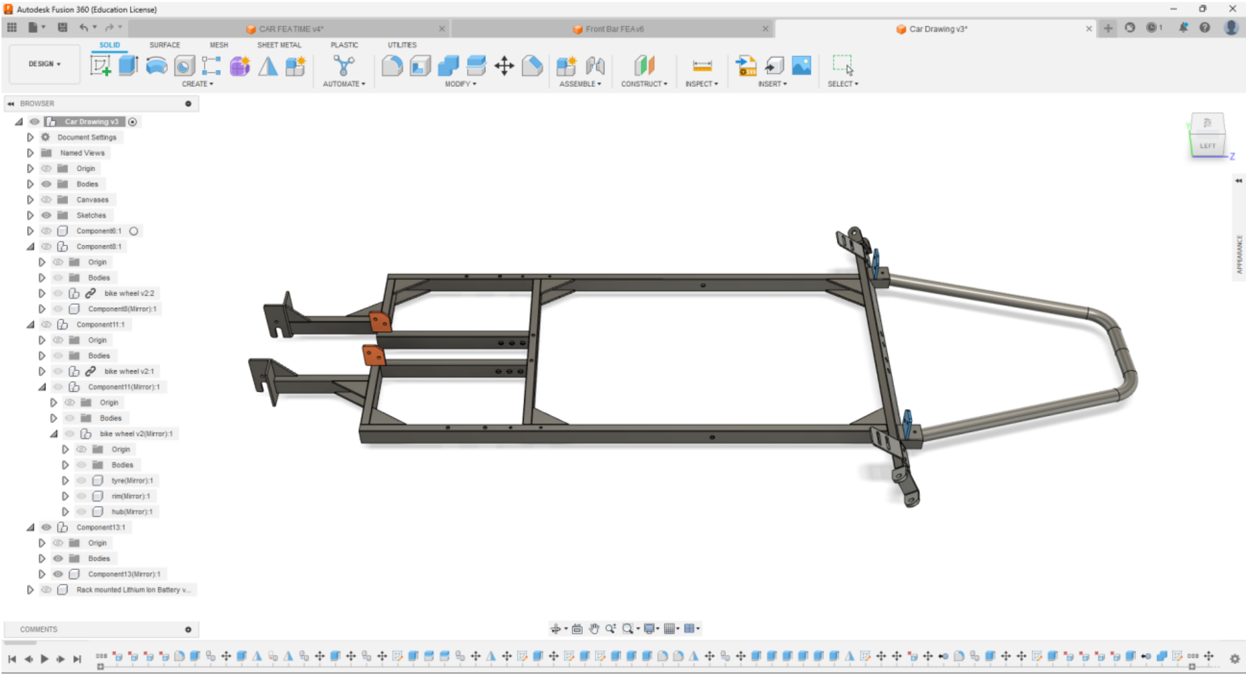
[2] "Reference Values for Metal Density & Specific Gravity | Zahner." Architectural Metal Fabrication | Zahner. Accessed: Feb. 6, 2024. [Online]. Available: https://www.azahner.com/resources/metal-density

[3] "12V 50Ah Battery, Sealed Lead Acid battery (AGM), B.B. Battery EB50-12, 197x165x171 mm (LxWxH), Terminal I2 (Insert M6)." UPS Batteries and Sealed Lead-acid batteries. Accessed: Feb. 6, 2024. [Online]. Available: https://www.battery-direct.com/12v-50ah-battery-eb50-12.html

[4] "7075 Aluminium Tube." https://www.sasaalloy.com/. Accessed: Feb. 6, 2024. [Online]. Available: https://www.sasaalloy.com/7075-aluminium-tube.html

1.7 Further Photos

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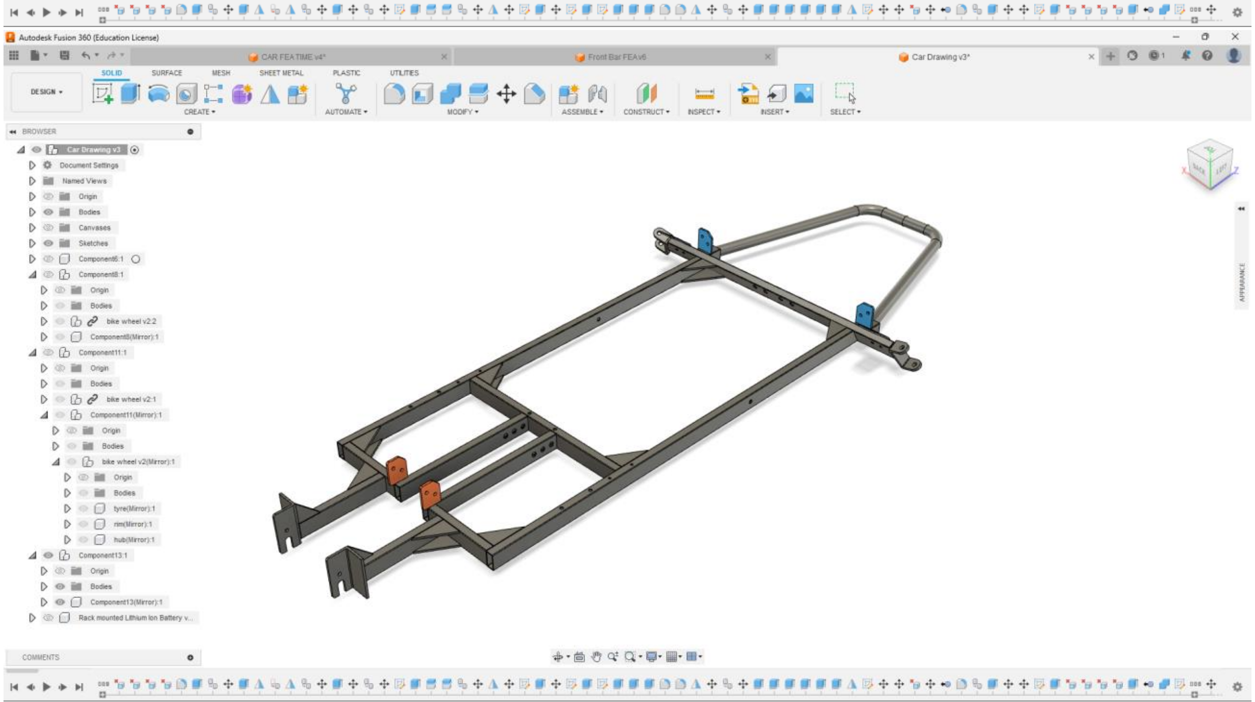
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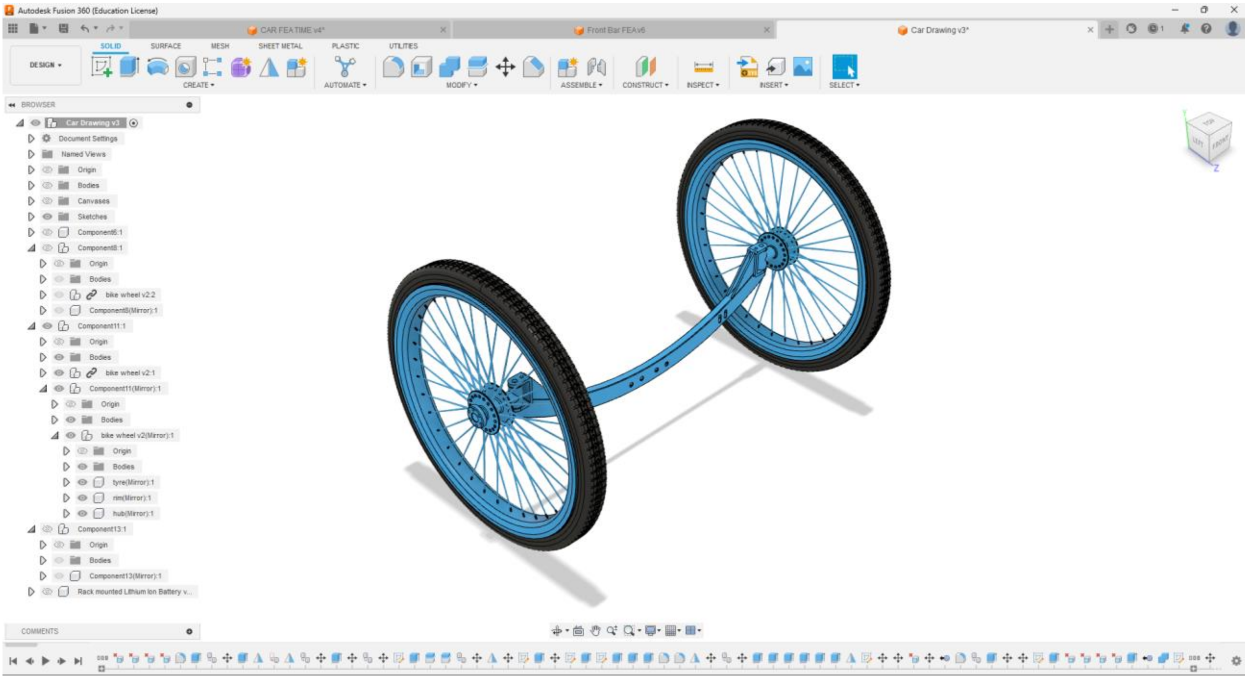
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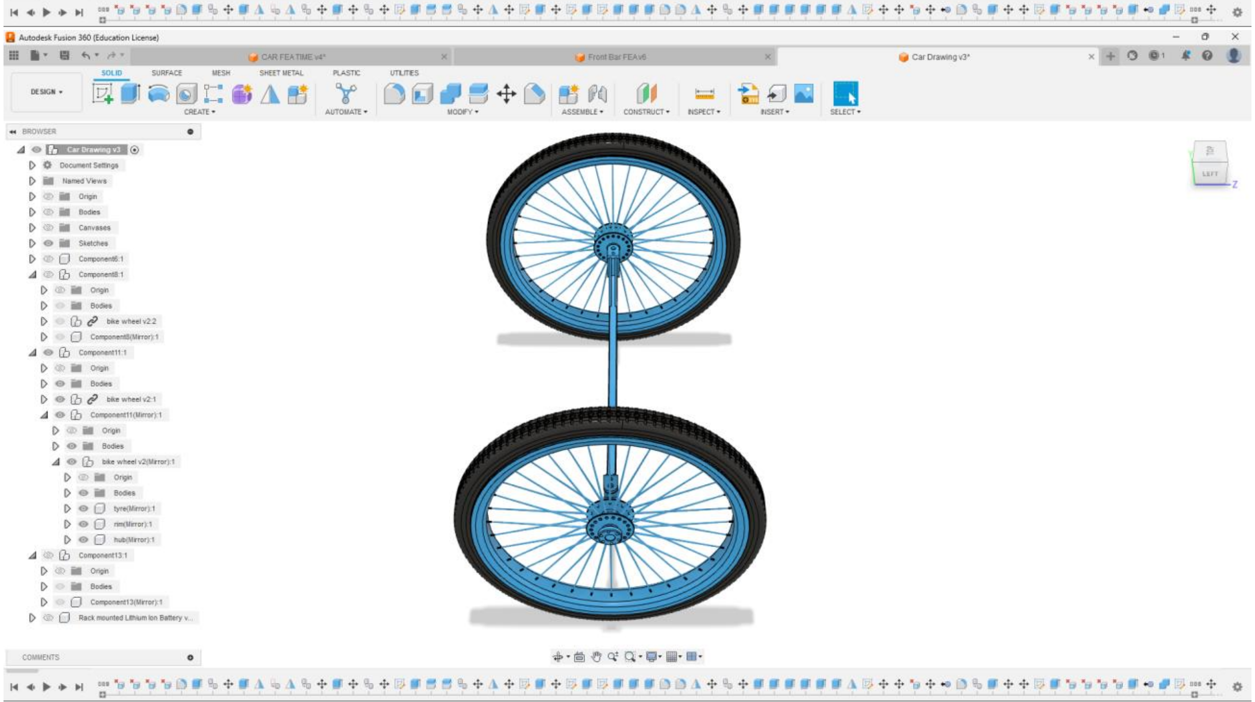
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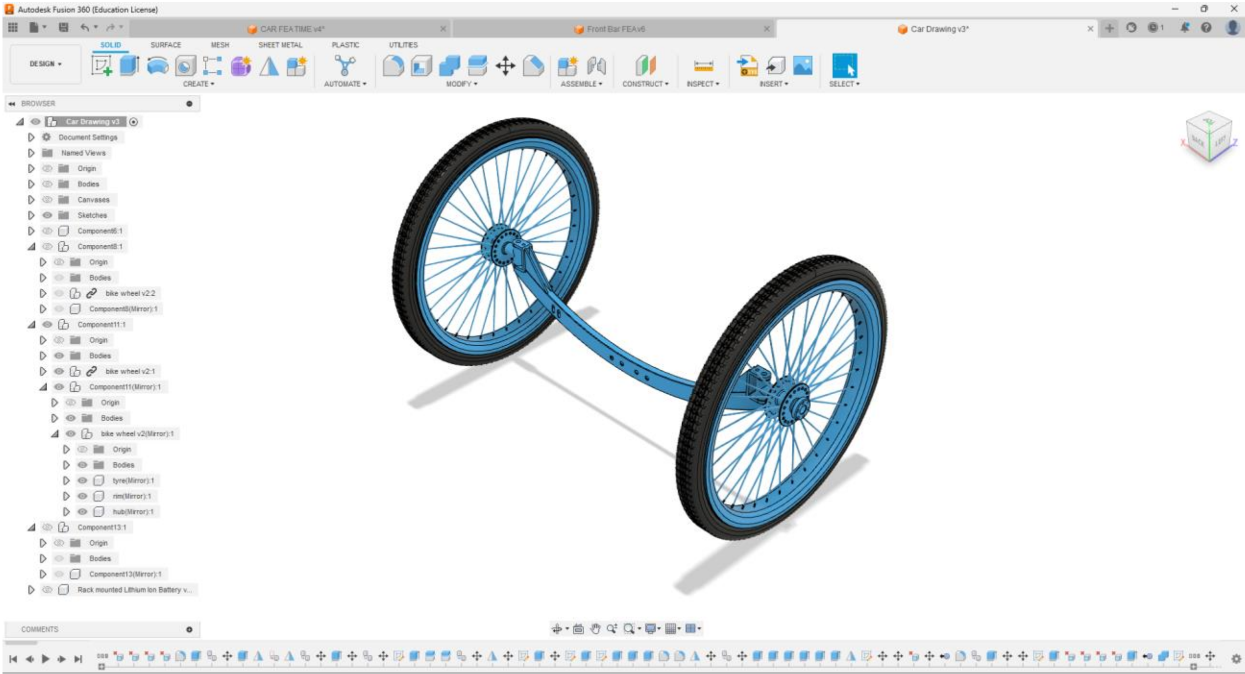

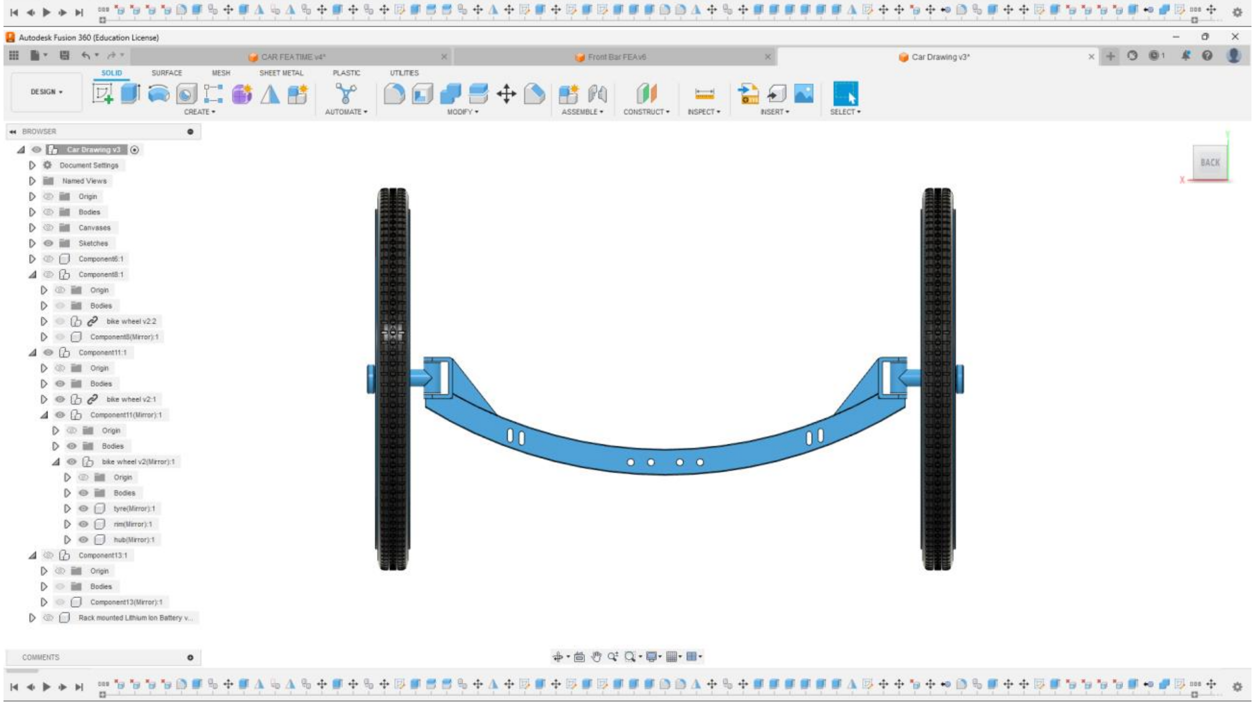

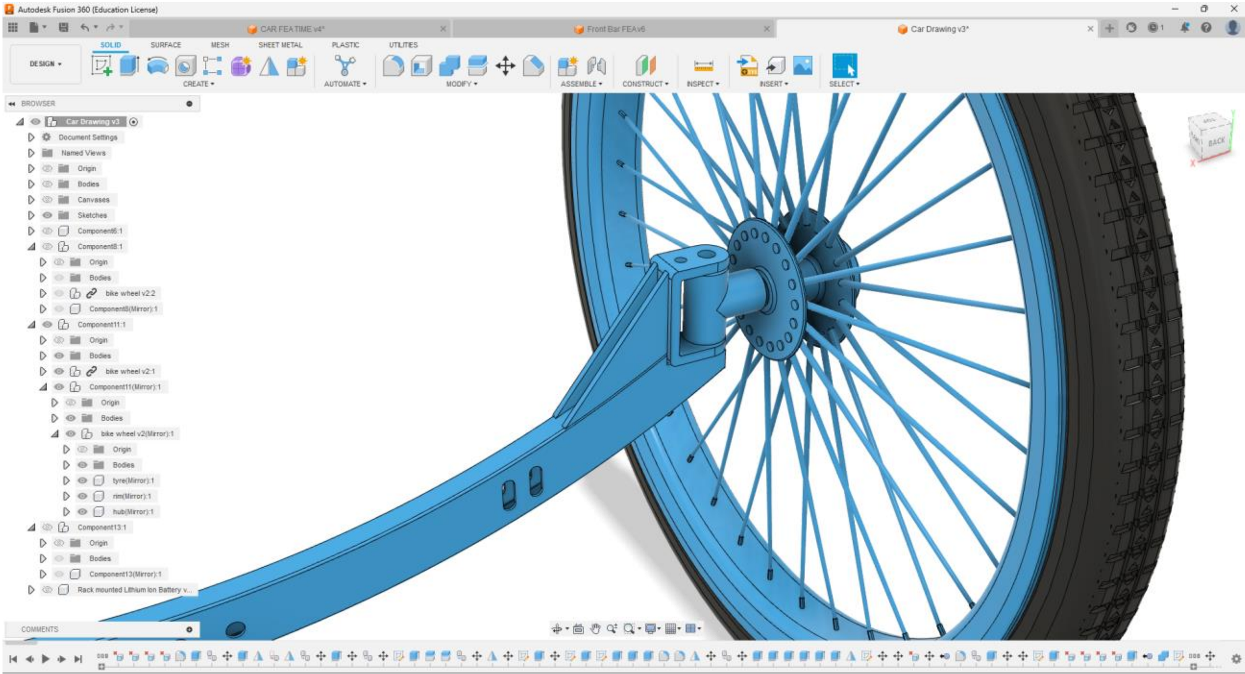
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Component11:1
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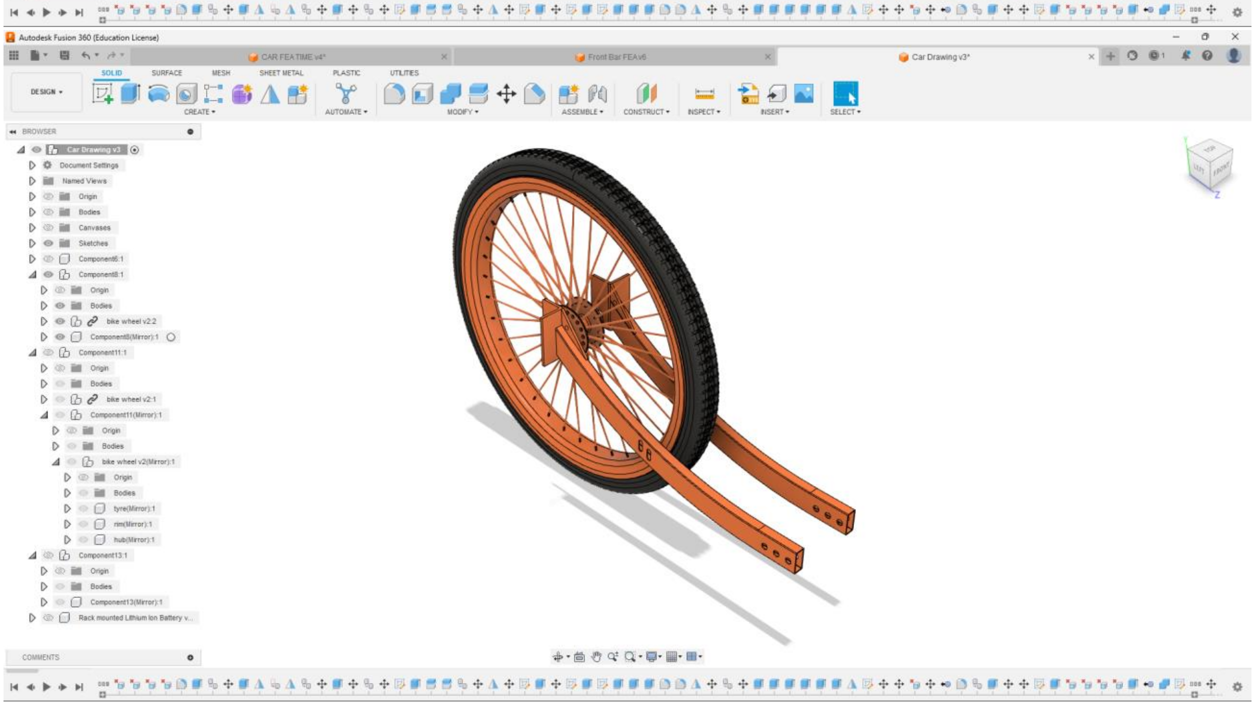
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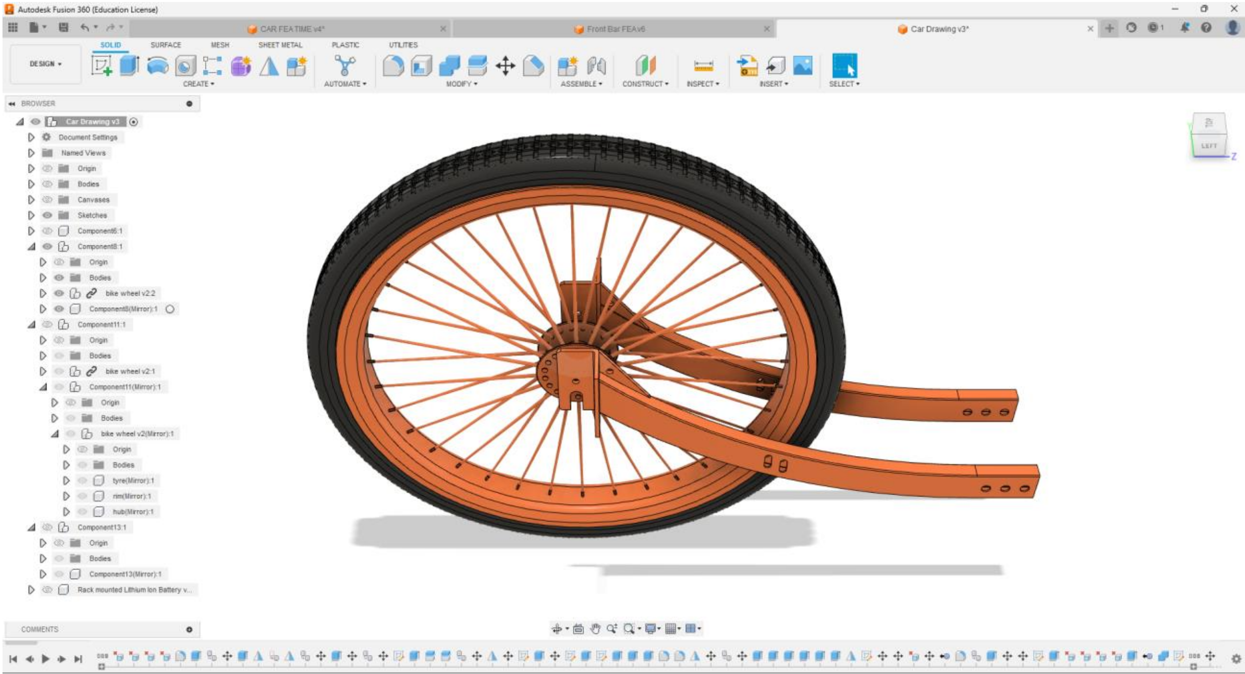

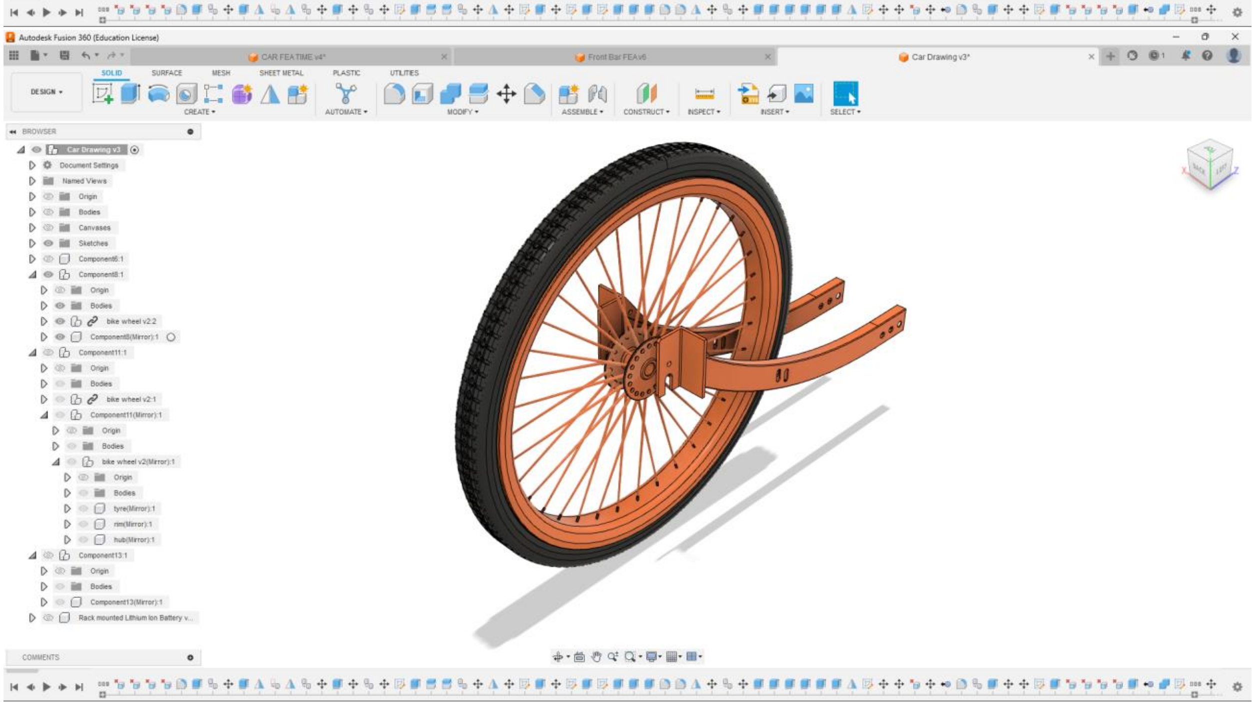

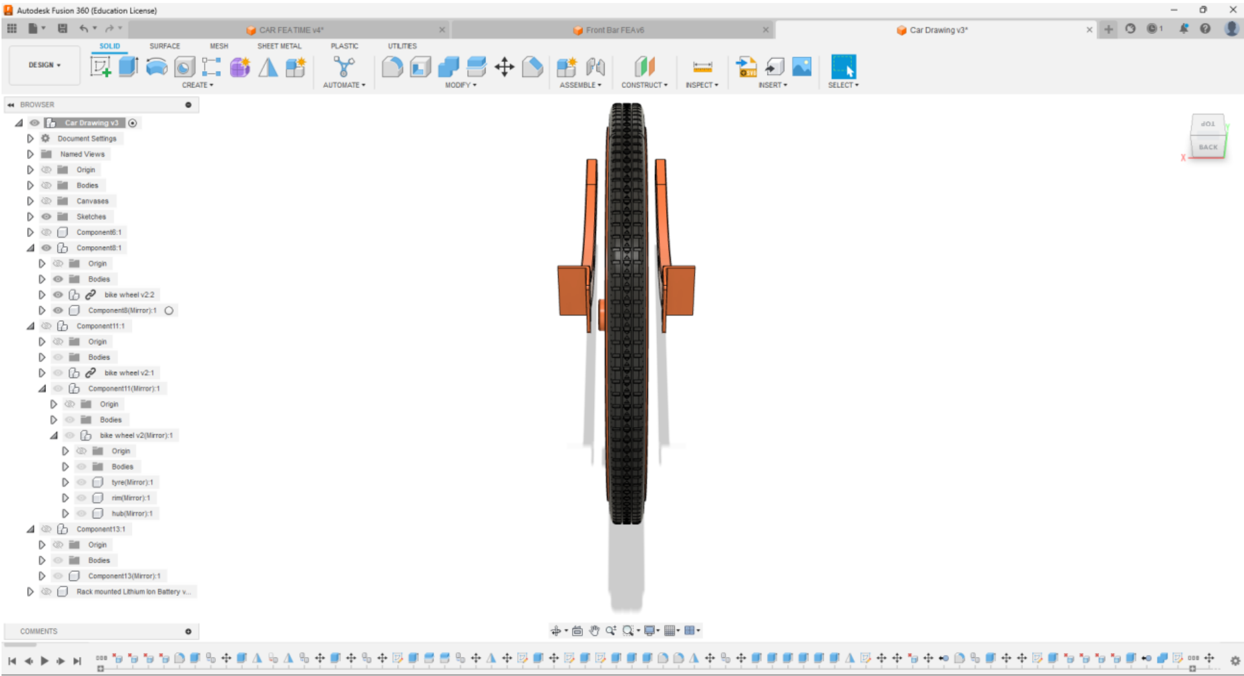
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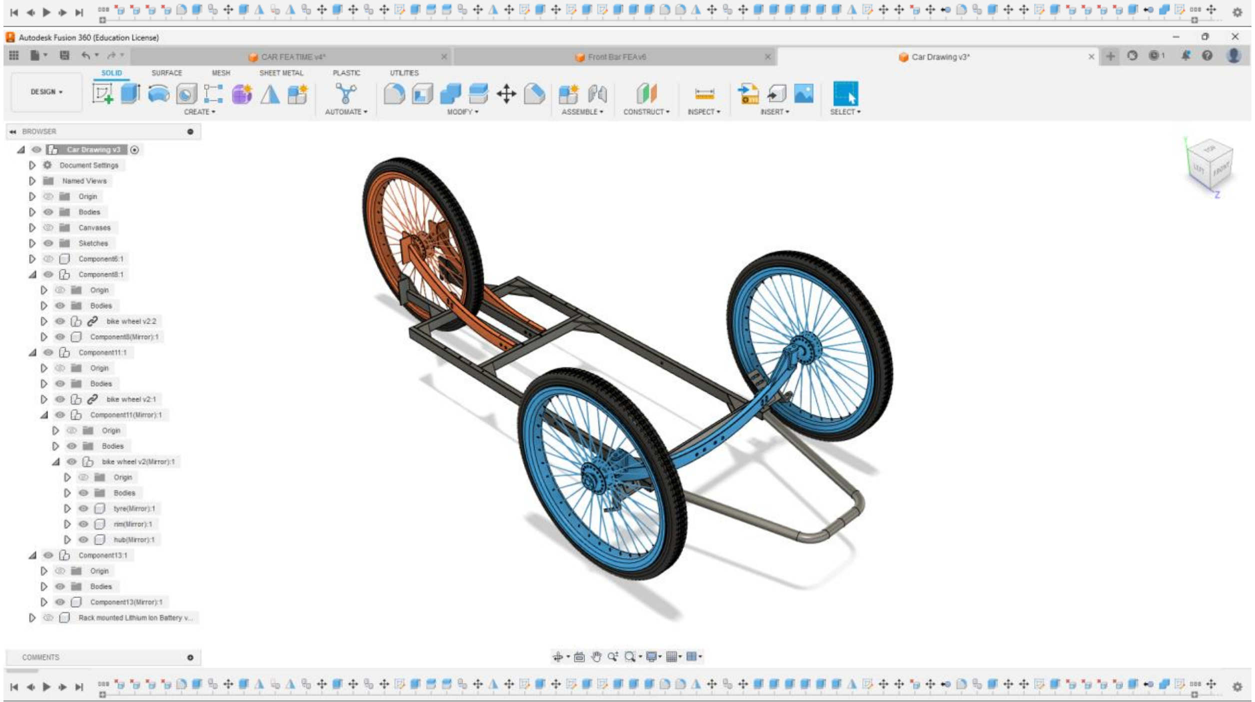
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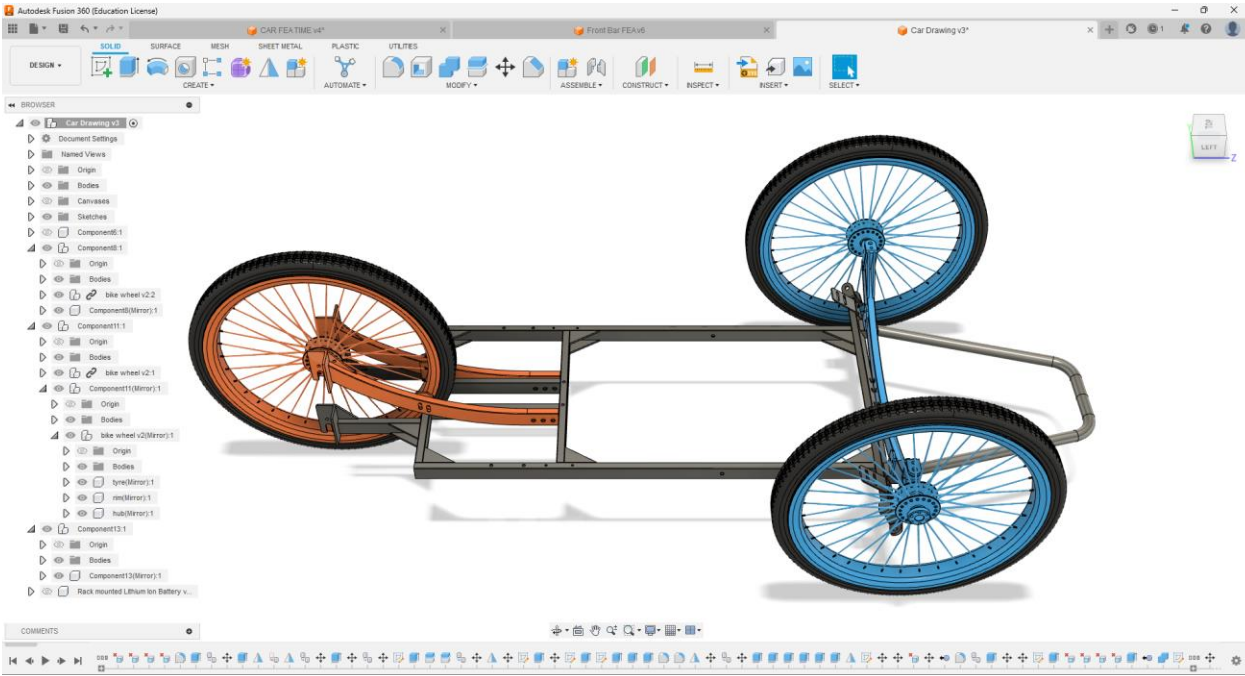
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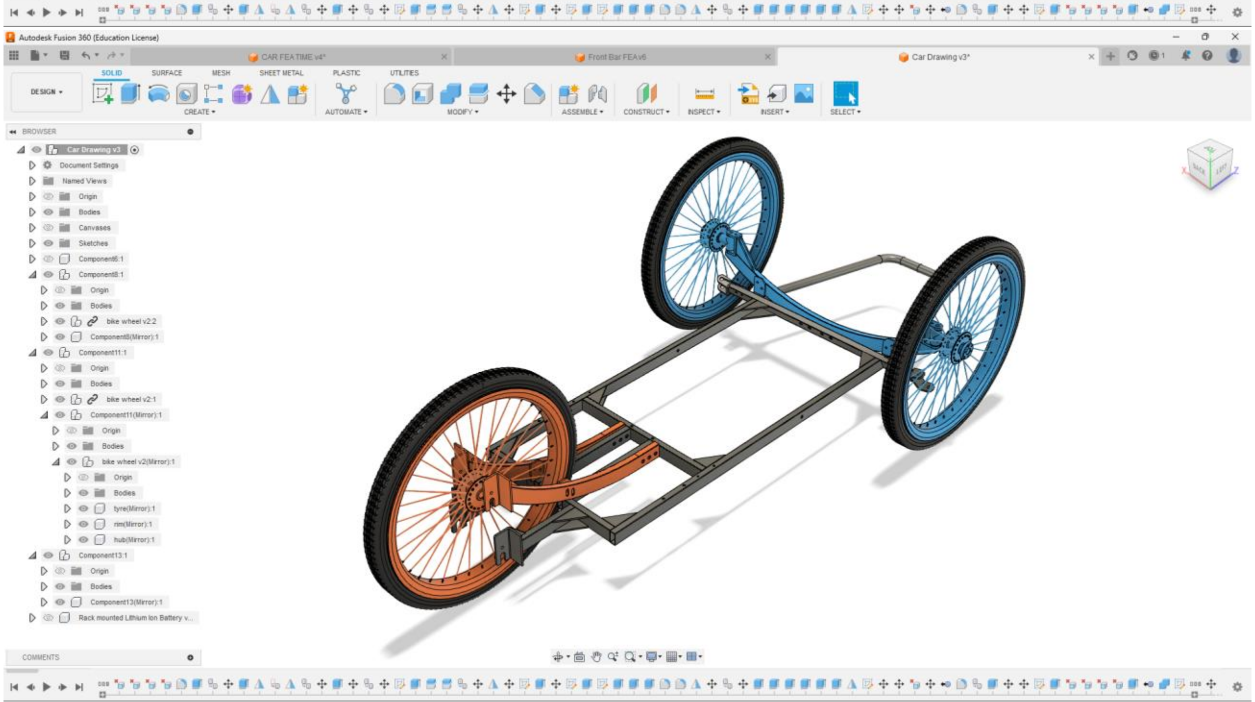
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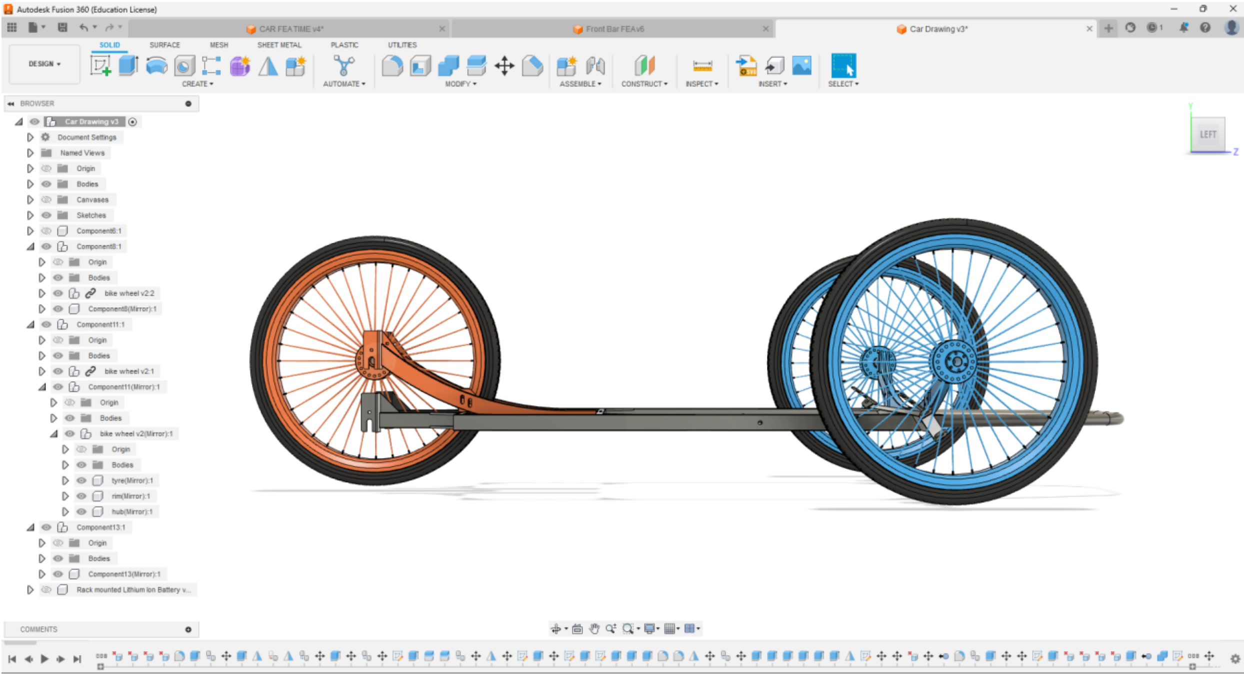

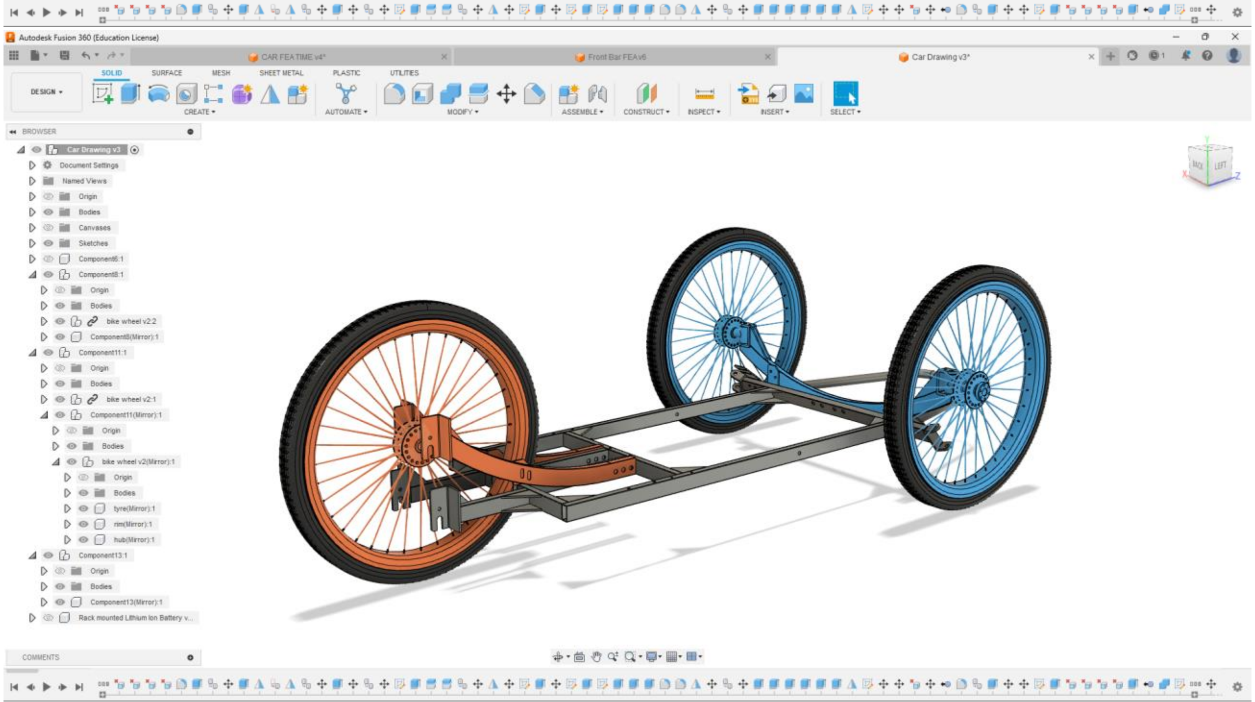

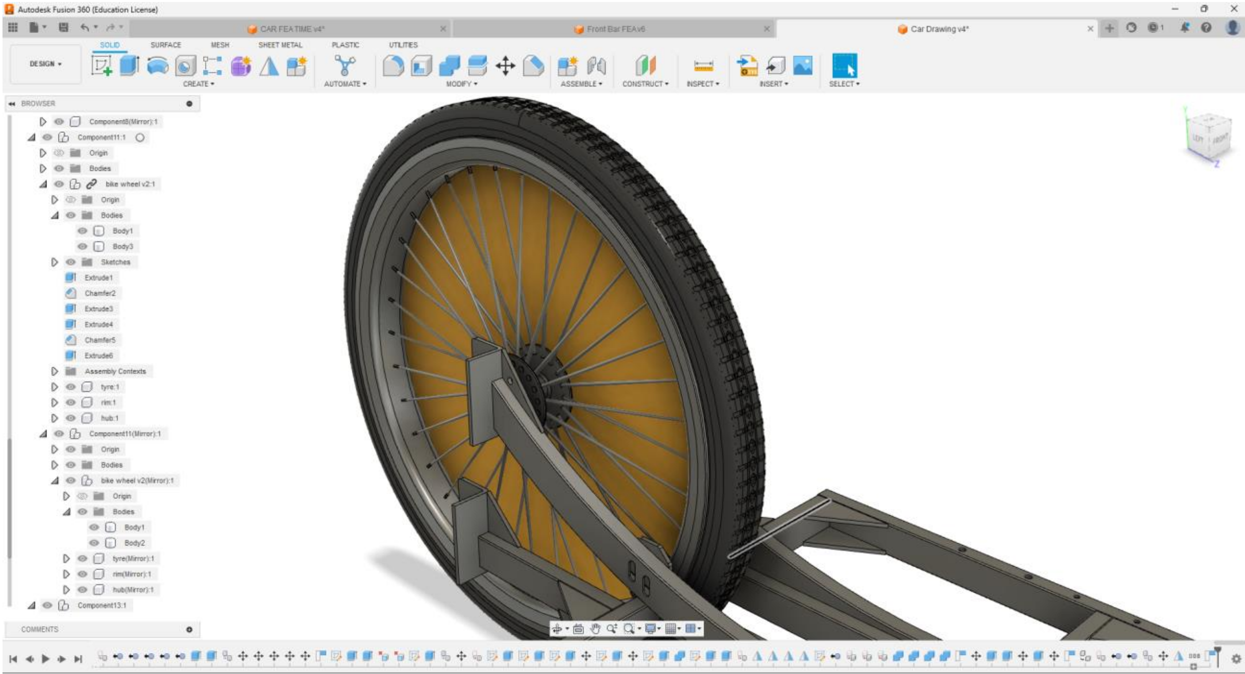
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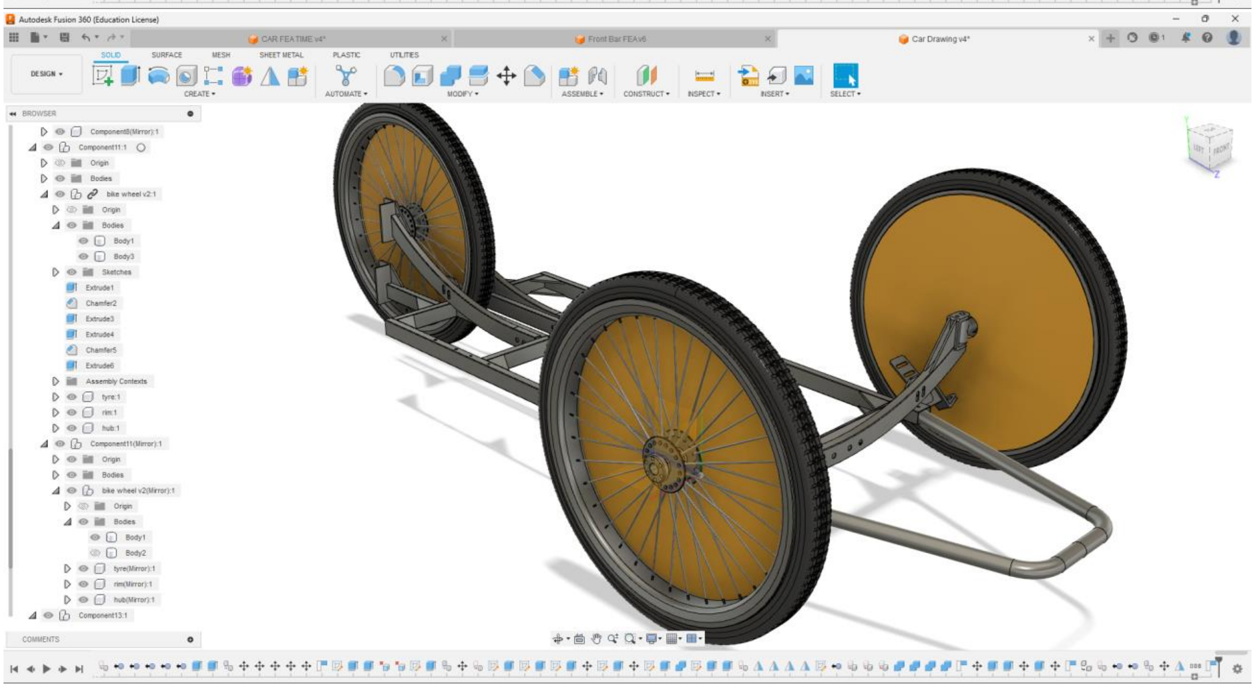
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DESIGN
BROWSER
COMMENTS