

# Manufacturing Report

E-BAJA 22

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# Gearbox

The gearbox is mainly used to get variable speed and torque. A gearbox reduces the shaft speed of motor and increases the torque and vice versa.

Specifications:-

- ❖ Max. Power to be transmitted = 6000 W
- ❖ Max. Torque to be transmitted = 300 N-m
- ❖ Gear Ratio = 3




# Gearbox components:-

A gearbox case :-

- ❖ Gearbox casing is the one which will hold mechanical components of a transmission. It provides the mechanical support to parts which are rotating in it, a mechanical protection from the surface world for those internal parts, and a fluid-tight instrumentation to carry the lubricator that bathes those parts.
- ❖ Our gearbox is made from Aluminium(Al6061)

Gears:-

- ❖ Gears are toothed wheels designed to transmit torque to another gear or toothed component. For example in our gearbox we have pinion gear and ring gear with a gear ratio of 3, that is for every 3 turns of the driveshaft, the front wheel will spin once.
  - ❖ Our gears are made from Low alloy steel
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# Process of making of gearbox components:-

For Gearbox case:-

Operational Sequence	Operational Details	Method Used	Machine/Tool Used	Inspection gauge
1	Deformation process (shaping of material) through hammering, pressing.	Forging	Forging press	Scale, Vernier Calipers, Screw gauge.
2	To create desired shape through die	Extrusion	extruder	Vernier Calipers
3	accuracy for placement of gear train and fasteners	CNC milling	Milling cutter	Scale.

## For gears:-

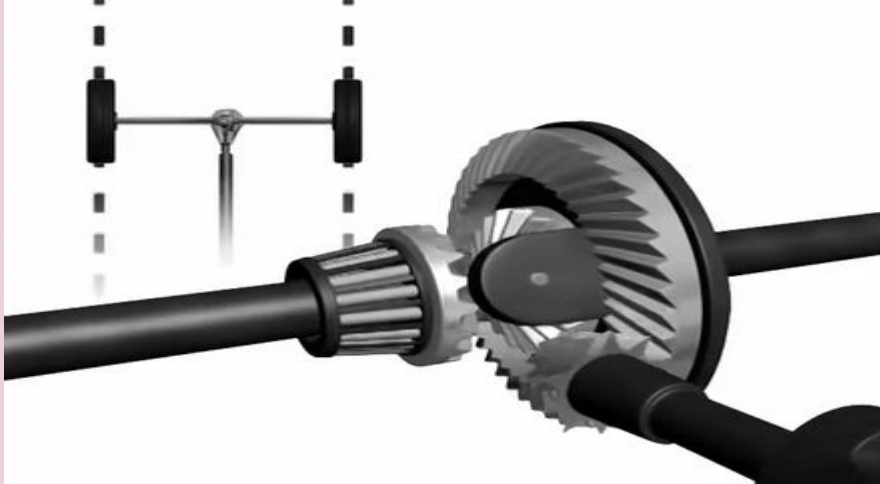
Operational Sequence	Operational Details	Machine or process	Tools Used For Machining	Inspection gauge
1	Creating blank gear shaft	Sawing	Saw	Scale
2	Making it round	CNC Lathe	Turning Cutter	Feed parameters, Scale
3	Cutting teeth on the blank gear	Hobbing	Hobbing machines	Scale, Vernier calipers
4	Removing the burrs	Deburring machine	None	None
5	Coat them in a black oxide finish	None	None	None

# Differential

The differential plays an integral role in how your car makes turns. The differential is designed to drive a pair of wheels while allowing them to rotate at different speeds. This function provides proportional RPMs between the left and right wheels.

Specifications:-

- ❖ Max. Power to be transmitted = 6000 W
- ❖ Max. Torque to be transmitted = 300 N-m




# Differential components:-

A differential case :-

- ❖ Differential casing is the one which will hold mechanical components of a transmission. It provides the mechanical support to parts which are rotating in it, a mechanical protection from the surface world for those internal parts, and a fluid-tight instrumentation to carry the lubricator that bathes those parts.
- ❖ Our case is made from Aluminium alloy

Ring, pinion and side Gears:-

- ❖ Gears are toothed wheels designed to transmit torque to another gear or toothed component. For example in our differential we have pinion gear and ring gear ratio of 3.
  - ❖ Our gears are made from Low alloy steel
- 

## The Differential flange and locker shaft :-

- ❖ Propeller shaft turns the pinion, which in turn drives the transverse ring gear of the differential transmitting power to the wheels.
- ❖ Our shafts are made from Mild steel.

## The Differential tapered and thrust bearings:-

- ❖ Bearings for Differential Gears Reduce Loss of Driving Force.
- ❖ Our bearings are made from high chromium bearing steel.





# We are using locking differential because:-

## 1. The two fold functioning:

- ❖ Lock differential is suitable for both drifting and racing. When unlocked, it acts as an open differential, so sharp turns can be taken easily. When it is locked, it is easy drive through muddy and slippery surfaces.

## 2. Easy to lock:

- ❖ The differential can be locked just by engaging a lever. It can be positioned near the feet of the driver. So, whenever required, it can be engaged by applying a gentle pressure.

## 3. Rough terrain advantage:

- ❖ In rough terrain, one tyre of the vehicle often gets into the air. The open differential provides all the power to that tyre/wheel. The LSD, requires a minimum RPM difference to work(slow). So, the solution is the Lock differential. The rough terrain can be easily and fastly passed through by using a lock differential.

# Process of making of differential components:-

For Differential case:-

Operational Sequence	Operational Details	Machine or process	Tools Used For Machining	Inspection gauge
1	Casting the material into shape of the cage	Casting Molds	Furnace, Casting sand, Hammer	Scale, Vernier Calipers, Screw gauge.
2	OD Turning	CNC Lathe	Turning Cutter	Scale, Vernier calipers
3	ID Turning	CNC Lathe	Turning cutter	Scale, Vernier calipers
4	Piercing holes for window of cages	None	None	Vernier Calipers, Screw Gauge
5	Making the surfaces precise and uniform	CNC Milling	Milling Cutter	Scale.

## For pinion, side and ring gears:-

Operational Sequence	Operational Details	Machine or process	Tools Used For Machining	Inspection gauge
1	Creating blank gear shaft	Sawing	Saw	Scale
2	Making it round	CNC Lathe	Turning Cutter	Feed parameters, Scale
3	Cutting teeth on the blank gear	Hobbing	Hobbing machines	Scale, Vernier calipers
4	Removing the burrs	Deburring machine	None	None
5	Coat them in a black oxide finish	None	None	None

## For flange and locker shaft:-

Operational Sequence	Operational Details	Machine or process	Tools Used For Machining	Inspection gauge
1	Hot rolling the material to achieve perfect cylindrical shape	Hot rolling mills	Furnace, rollers	Scale, Vernier Calipers, Screw gauge.
2	Cold drawing to reduce the cross section area of some part of shaft as per the need	Cold draw	Prongs	Scale
3	ID Turning to make grooves fit for gears	CNC Lathe	Turning cutter	Scale, vernier scale, Feed parameters.
4	Making the surfaces precise and uniform	CNC Milling	Milling Cutter	Scale, vernier scale, Feed parameters

## For thrust and tapered bearings:-

Operational Sequence	Operational Details	Machine or process	Tools used for machining	Inspection Gauge
1.	Rings made by casting of required thickness	Casting	Furnace, Mould,	Scale, Vernier Calipers
2.	surface of the two rings are then shaped to a precise roundness and diameter.	Assembly	CNC	Scale, Vernier Calipers, Screw gauge
3.	Steel wire is cut into pieces and punched to form rough balls. These balls then pass through a grinder where bumps are removed and machined to give mirror finish.	Cutting, Grinding	Grinder	None
4.	The balls are first passed through a furnace to harden them	Heat Treatment	Furnace,	Heating parameters
5.	Ball cages are then installed first into the half with rivet holes, then the part with rivets.	Assembly	Nuts and bolts, joints.	Vernier Calipers, Screw gauge
6.	The bearings are finally lubricated with grease and a rubber seal is applied	Lubrication,	greasing	None

# Wheel

The most integral part of a vehicle are its wheels. Wheels are the most basic block of a land transport system.

Components of wheel:-

- ❖ Wheel hub
- ❖ Disc rotor
- ❖ Rim
- ❖ Ball bearings
- ❖ Tyres
- ❖ Nut and bolts

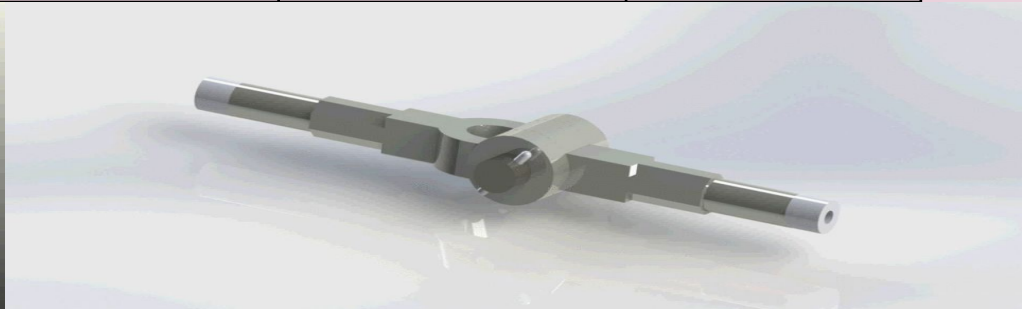
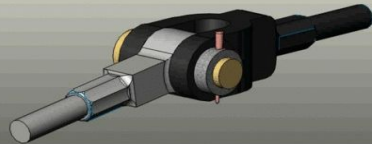


# Process for manufacturing of Wheel components:-



# For knuckle:-

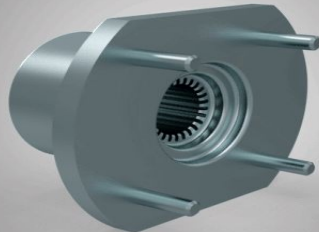
Operational sequence	Operational details	Machine	Tool used for machining	Inspection gauge
1	casting of the cast iron to get the required shape of it.	Flask	casting components.	Scale, Vernier calliper
2	forging operation, to make it strong and to get the required dimension	Furnace	Hammer	None
3	Milling operation: face milling will be done	Milling machine	Milling cutter	Scale
4	Drilling operation to make holes to attach it with control arms	Drilling machine	Multipoint cutter	Scale, Vernier calliper
5	Heat treatment: to test the strength of the material.	Furnace , Hardness testing machine	Hammer,	None





# Fir wheel hub:-

Operational sequence	Operational details	Machine	Tool used for machining	Inspection gauge
1	Turning Operation, we can make blank steel and give it the specific shape.	Lathe machine	Turning cutter	Scale, Vernier calliper
2	Facing Operation, the facing operation can be done for smooth finishing.	Lathe machine	Single point cutting tool	Scale Vernier calliper
3	Drilling and Threading: As hubs have the whole for inserting the bolt, this space needs to be drilled and threaded.	Lathe machine	Multipoint cutting tool	Taps, Vernier calliper
4	Hardening, Quenching process to increase the hardness.	Furnace	Hammer, Tongue,	Hardness testing machine
5	Grinding: With a glider, the hub can get the final glossy finishing.	Grinding machine	Abrasive cutter	None



# For disc rotor:-

Operational sequence	Operational details	Machine	Tool used for machining	Inspection gauge
1	Melting casting After induction melting, metal testing and sand testing of cast is done. Mixture is then poured into the mold cavity.	Flask, Hardening machine, Casting	Mould	None
2	Holes are made by VMC drilling.	Drilling machine	Multipoint cutting tool	Scale, feed parameters, Vernier caliper
3	Finishing: After some quality control checks are made, machine balancing, painting, and laser marking are done.	Grinding machine	Abrasive cutter	None



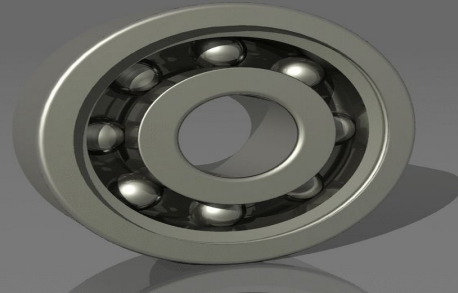
# For Rim:-

Operational Sequence	Operational Details	Machine	Tools used for machining	Inspection Gauge
1.	Two or more types of liquid resins (typically polyol and isocyanate) are poured into separate holding tanks	None	None	None
2.	The plastics are conditioned to the correct temperatures, pressures, and gravities.	None	None	None
3.	A dispensing unit switches to a higher pumping pressure and the liquid plastics are injected to completely mix the liquids and produce a chemical reaction as the mold is filled with liquid material	Injection moulding machine	Mix head valve	Measuring equipment.
4.	After the mold is filled, the freshly molded part is allowed to cure in the mold	Injection moulding machine	None	None



## For ball bearings:-

Operational Sequence	Operational Details	Machine or process	Tools used for machining	Inspection Gauge
1.	Rings made by casting of required thickness	Casting	Furnace, Mould,	Scale, Vernier Calipers
2.	surface of the two rings are then shaped to a precise roundness and diameter.	Assembly	CNC	Scale, Vernier Calipers, Screw gauge
3.	Steel wire is cut into pieces and punched to form rough balls. These balls then pass through a grinder where bumps are removed and machined to give mirror finish.	Cutting, Grinding	Grinder	None
4.	The balls are first passed through a furnace to harden them	Heat Treatment	Furnace,	Heating parameters
5.	Ball cages are then installed first into the half with rivet holes, then the part with rivets.	Assembly	Nuts and bolts, joints.	Vernier Calipers, Screw gauge
6.	The bearings are finally lubricated with grease and a rubber seal is applied	Lubrication,	greasing	None

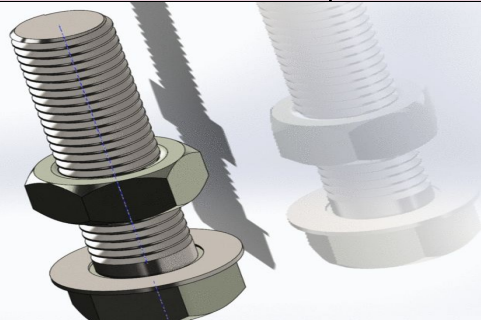


# For tyres:-

Operational Sequence	Operational Details	Machine	Tools used for machining	Inspection Gauge
1.	Mixing of components under heat and pressure	Blunders	Flask	Measuring components
2.	Adding polyester fabric to rubber	Calendars	Rollers	Measuring Components
3.	Applying different color stripes for identification of ingredients.	Paint Rollers	None	Measuring Components
4.	Slicing tread rubber to length.	None	Blade	Scae
5.	Attaching bead hoops, airtight piece of rubber and coded ply to form the inner tube.	Rotating drum	None	Measuring Components
6.	For the outer layer narrow strips of rubber ply are formed on the rubber embedded with steel cord and then the tread rubber is applied.	Building Drum	None	Measuring Components
7.	The two parts are assembled and connected. Compressed air is used to inflate the tyre to shape it	None	Transfer ring	None
8.	It's passed into a mold to bake and shape the tyre. The bladders of the mold transfer the tread pattern to it.	Mold	Bladders	None

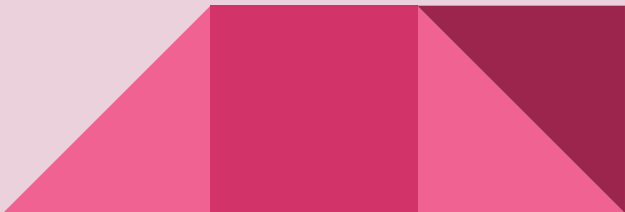
# For nut and bolt:-

Operational Sequence	Operational Details	Machine	Tools used for machining	Inspection Gauge
1.	Wire - Uncoiled, straightened and cut to length	CNC	Hacksaw	Scale
2.	Cold forging - Molding the steel into the right shape at room temperature.	Furnace	Hammer	Scale, Hardness testing components,
3.	Bolt head - Progressively formed by forcing the steel into various dies at high pressure.	Turning	CNC	Scale, vernier calipers.
4.	Threading - Threads are formed by rolling or cutting.	Lathe machine	Tapers	Threading parameters, vernier calipers,
5.	Heat treatment - The bolt is exposed to extreme heat to harden steel.	Furnace	Flask,	None
6.	Surface treatment - It depends on the application. Zinc-plating is common to increase corrosion resistance.	Polishing, Coating	None	None



# Continuous Variable Transmission

## Components

- Primary Clutch  
Fix Pulley, Movable Pulley, Spider, Cam Follower, Primary Spring
  - Secondary Clutch  
Pulleys, Secondary Spring, Spring Retainer Plate
  - Belt
- 

# Pulley

Operational Sequence	Operational Details	Method Used	Machine/Tools Used	Inspection gauge
1	Making Appropriate Size Thick Circular Ring	Boring	Lathe Machine with Boring Tool	Screw Gauge, scale, Vernier Calliper
2	Making of Internal Tray	Casting	Specific Shape Mold	Scale,
3	Making Joints of Tray and Circular Ring	Welding	Double Sided Welding Machine	None

# Cam and Follower

Operational Sequence	Operational Details	Method Used	Machine/Tools Used	Inspection gauge
1	Giving the product its actual shape	Surface Finishing	Using Cutting Tool with Lathe or Milling	Scale, Vernier Calliper
2	Boring appropriate holes in the metal	Boring	Lathe using Boring Tool Or Milling Machine	Taps, Screw gauge, Vernier Calliper



# Retainer Plate

Operational Sequence	Operational Details	Method Used	Machine/Tools Used	Inspection gauge
1	Making of Retainer Plate as whole	Casting	Metallic Mold	Vernier Calliper
2	Machining of the final product	Finishing	Using Finishing tools.	None

# Spider

Operational Sequence	Operational Details	Method Used	Machine/Tools Used	Inspection gauge
1	Making of Spider as whole	Casting	Metallic Mold	Taps, Vernier Calliper
2	Machining of the final product	Finishing	Using Finishing tools.	None

# Steel Belt

Operational Sequence	Operational Details	Method Used	Machine/Tools Used	Inspection gauge
1	Making Steel Rings of Different Diameters	Sheet Forming	Sheet Forming Tools like Cutter etc.	Scale, Vernier Calliper
2	Joining Cutted Steel to give it a shape of ring	Welding	Welding Machine, Abrasive Cutting machine	Scale for Marking
3	Manufacturing Elements	Casting	Mold	Scale, Vernier Calliper
4	Making Final Belt	Stacking Elements over Ring	Manual mostly In mass production computerised machines can be used.	Scale, Vernier Calliper

# Motor

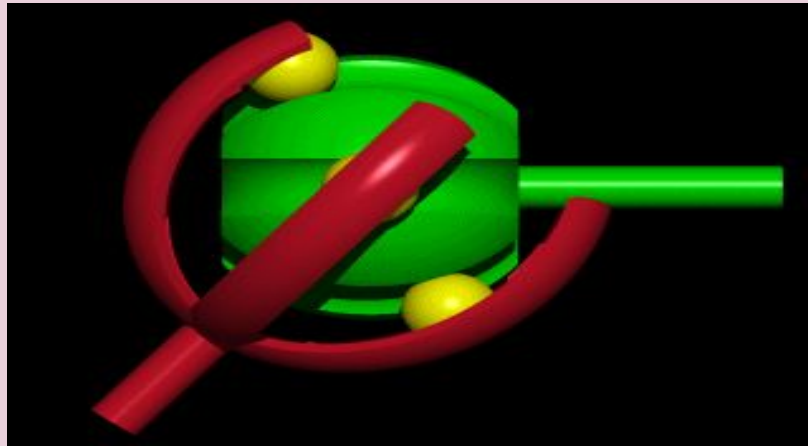
## Specifications

e_BAJA Drivetrain Parameters	Values
No. of Electric Motors used in the transmission system	1
Motor Model: Peak Mechanical Power (kW)	9 kW
Motor Model: Terminal Voltage (V)	48 V
Motor Model: Peak Maximum Torque (Nm)	30 Nm
Motor Model: Maximum rot. Speed (rpm)	3500 rpm
Motor Model: Rated Efficiency	85%
Mass of Electric Motor (kg)	13 kg
Inertia of Electric Motor (Ixx/Iyy/Izz)	5.11/2.13/6.393 Kg-m <sup>2</sup>

# JOINTS

Joints are one of the most important of our vehicle. We see every part of vehicle joined with the other. For different purposes different types of joints are used.

For e.g. , there are CV joints which connects vehicle's transmission to it's wheel and purpose of using it is that it allows drive shaft to transmit power through a variable angle, at constant rotational speed.



# CV JOINTS

CV joints connects vehicle's transmission to it's wheel. Different parts of CV joints are mentioned below in the slides.

## OUTER RACE

Operational Sequence	Operational Details	Machine	Tools Used For Machining	Inspection gauge
1	Hot forging for collaborations	Hot Forging Machine	Furnace,Tong,Hammer	Scale,Vernier calliper
2	Turning of inner surface	CNC Lathe	Taper Turning Cutter	Hole gauge, Vernier calliper
3	Turning of Outer Surface	CNC Lathe	Turning cutter	Scale,Vernier calliper

## CAGE

Operational Sequence	Operational Details	Machine	Tools Used For Machining	Inspection gauge
1	Hot forging	Hot Forging Machine	Furnace,Tong,Hammer	None
2	OD Turning	CNC Lathe	Turning Cutter	Screw gauge ,Vernier calliper
3	ID Turning	CNC Lathe	Turning cutter	Hole gauge
4	Piercing holes for window of cages	None	None	Hole gauge
5	Making the surfaces precise and uniform	CNC Milling	Milling Cutter	Roughness tester



## INNER RACE

Operational Sequence	Operational Details	Machine	Tools Used For Machining	Inspection gauge
1	Cold forging	Cold Forging Machine	Tong, Hammer	Vernier calliper
2	Making of ball tracks	CNC Lathe	Taper Turning Cutter	Taper parameters
3	Pitch making of inner surface	CNC Lathe	Turning cutter	Scale, Vernier calipers

## TULIP

Operational Sequence	Operational Details	Machine	Tools Used For Machining	Inspection gauge
1	Hot forging	Hot Forging Machine	Furnace, Tong, Hammer	None

SHAFT-CV

Operational Sequence	Operational Details	Machine	Tools Used For Machining	Inspection gauge
1	Cold forging	Cold Forging Machine	Tong,Hammer	None
2	Shaping shaft geometry	CNC Lathe	Turning Cutter	Scale, Vernier Calipers, Slide calipers

TRIPOD

Operational Sequence	Operational Details	Machine	Tools Used For Machining	Inspection gauge
1	Hot forging	Hot Forging Machine	Furnace, Tong, Hammer	Scale
2	OD Turning	CNC Lathe	Turning Cutter	Feed Parameters
3	ID Turning	CNC Lathe	Turning cutter	Feed parameters
4	Internal pitch making	CNC Lathe	Turning Cutter	Tapers, Scale





## WORKING OF STEERING KNUCKLE

## SPUR GEAR SYSTEM

Spur Gear System play a important role in transferring motion and power from one shaft to another.

Operational Sequence	Operational Details	Machine or process	Tools Used For Machining	Inspection gauge
1	Creation of gear blank	Sawing	Sawing Tool(Saw)	Tapers, Screw gauge
2	Gear Cutting	Hobbing Machine	Hob Cutter	Scales

**BALL JOINTS:** In an automobile, ball joints are spherical bearings that connect the control arms to the steering knuckles, and are used on virtually every automobile made.

Operational Sequence	Operational Details	Machine	Tools Used For Machining	Inspection gauge
1	Making ball joints by assembling all parts	Caulking Machine	Roller	None

# BEVEL GEAR SYSTEM

Gearbox is connected to the differential through a bevel gear system.

Operational Sequence	Operational Details	Machine or Process	Tools Used For Machining	Inspection gauge
1	Cutting of material in size	Sawing	Saw	Scale, vernier calipers
2	Turning into gear blank	CNC Lathe	Turning Cutter	Scale, vernier calipers
3	Gear Cutting	Coniflex Generator	Turning cutter	Scale, feed parameters



# CURVED JAW COUPLING

Curved jaw couplings are an ideal compact solution for high revolutions per minute (RPM) applications that require a zero backlash and also reduce the system torque ripple.

Operational Sequence	Operational Details	Machine or Process	Tools Used For Machining	Inspection gauge
1	Material removal of solid block	CNC Lathe	Turning Cutter	Scale
2	Removing small effects on sharp edges	Deburring	Deburring Tool	None
3	Molding of spider	Injection Molding Machine	Molds	Scale, vernier calipers,

# The manufacturing process involved in this project can be listed as follows.

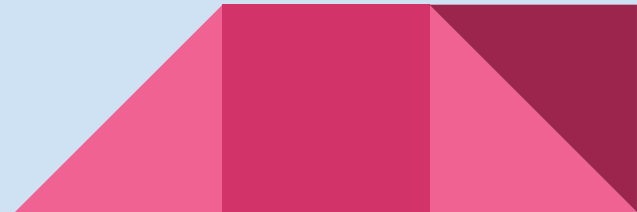
Process	Part Names
Casting	Hub, Disk Rotor, Knuckle, Spider, Steel Belt, Retainer Plate, Pulley, Gear Box, Wheels
Milling	Hub, Disk, Knuckle, joints, Gear, Differentials, Inner Race, Outer Race, Cage, Cam & Follower, Wheels
Turning	Wheel Hub, Rim, Race joints, Differentials, Nut & Bolt
Forging	Nut and Bolt, Balls, U-joints, Ball Joints, Knuckle Joint, Tripod, Tulip, Inner Race, Cage, Outer Race, Knuckle, wheels
Heat Treatment	Knuckle, Nut, Balls, Hubs, Joints, gears, Differentials, Axles,
Faching	Wheel Hub, Rim, Race joints, Differentials, Nut & Bolt, cage.
Drilling	Hub, Nut, Disc Rotor, Wheel Hub, Knuckle
Cutting	Knuckle, Nut, Balls, Hubs, Joints, gears, Differentials, Axles, material

Process	Part Names
Hardening	Knuckle, Nuts, Ball Joints, Tulip, Outer Race, wheel Hub
Grinding	Knuckle, Nut, Balls, Hubs, Joints, gears, Differentials, Axles, material cutting.
Boring	Pulley,Cam & Follower,
Hobbing	Input gear,Output gear,
Conditioning	Rims, Joints
Injection	Rims, Boot cover, Spiders
Descaling	Balls, Rims
Lapping	Balls, Knuckles



# Assembly Process Sheet

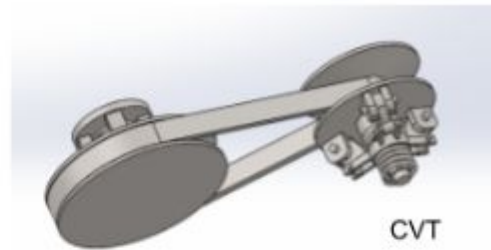
The Overall Assembly of the vehicle consist of the drivetrain parts such as Differential, Gearbox, axles, motors, CVT etc. In order to making the assembly we could look for various joints. Moreover, the different manufacturing process is applied for different parts of the assembly. There are core mechanical manufacturing processes are involved in making of the parts. The assembly sheet includes the assembly parts, the tentative joining equipments, tools.



Assembly Sequence	Part Assembled	Assembly Process	Tools Used
1	Motor	Fix the motor to the center of the chassis using screws	Screwdriver and washers
2	CVT	Attach the CVT to the chassis using nuts and washers	Torque wrench, Joints
3	Curved Jaw Couplings	The Motor is mechanically joined to the CVT using curved jaw couplings	Spanner and torque wrench, Nut bolts
4	Spur gear	Attach spur gear a shaft using fixtures	Drill & Pin
5	Shaft	Fix the shaft such that the spur gear on it makes contact with the gear inside the CVT	Joints, Nuts and bolts
6	Gearbox	Fix the gearbox such that the shaft from the gearbox is perpendicular to the shaft coming out from the CVT	Joints, Nuts and bolts



7	Bevel gear system 1	The bevel gear system is placed in contact with both the pinion on the shaft coming out from the CVT and the shaft going into the gearbox	Joints
8	Differential	The differential is placed on the chassis	Joints, Nut bolts, Machining components
9	Bevel gear system 2	Bevel gear system 2 is placed in contact between the shaft coming out from the gearbox and the differential.	Joints, Nut bolts, Machining components
10	Axles	The Axles (1 and 2) are mounted through the wheel hubs on either side	Spanner and torque wrench, joints.
11	CV shaft 1	CV shaft 1 is used to connect the left differential output shaft to the left axle	Drill & Pin
12	CV shaft 2	CV shaft 2 is used to connect the right differential output shaft to the right driveshaft	Drill & Pin



CVT



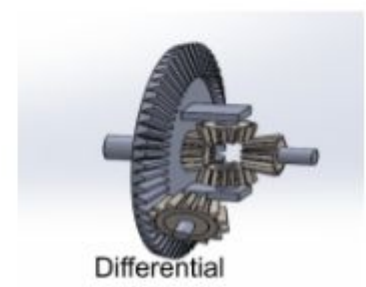
Master Cylinder



Steering  
Assembly

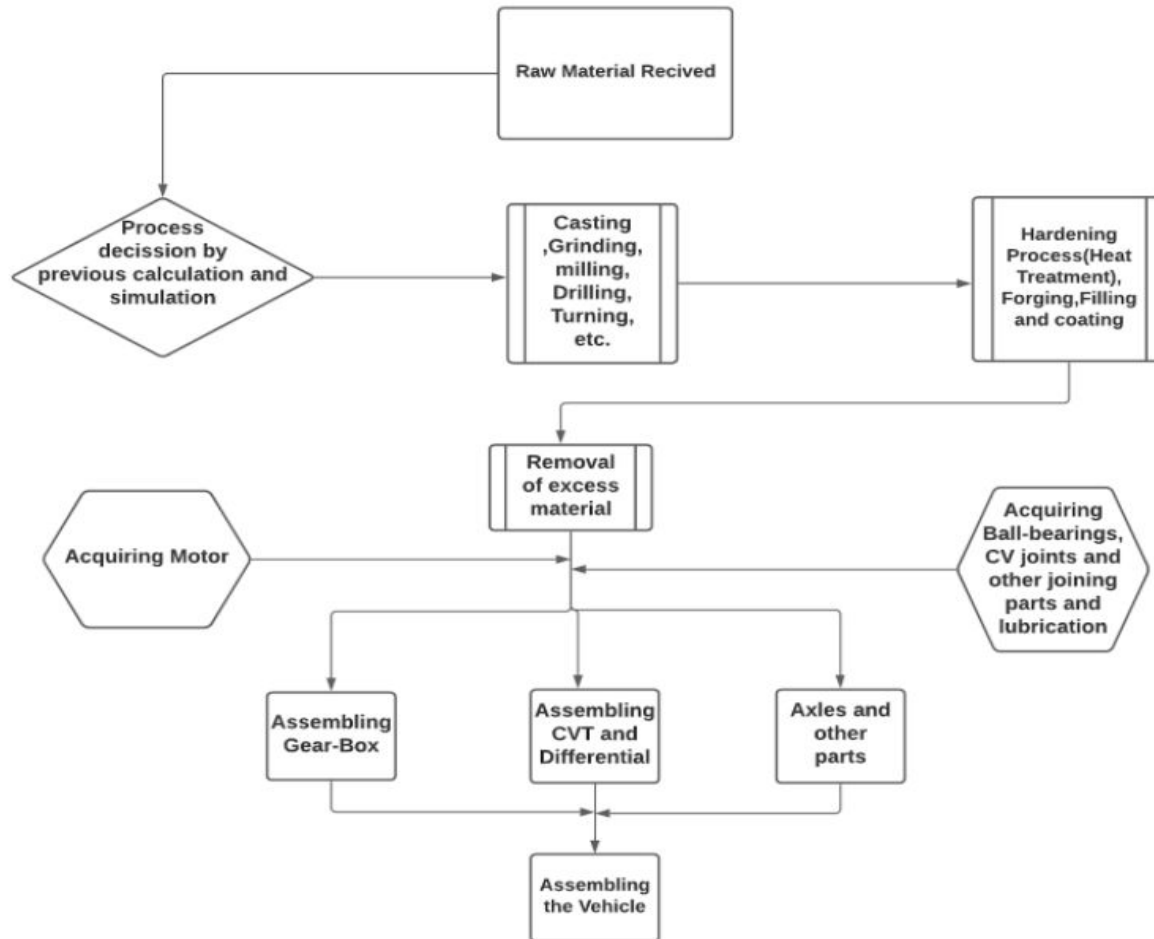


Suspension



Differential

## Manufacturing Processes Involved, Workflow Organization



# Raw material Selection Criteria

Raw Material	Material Code	Part Names
Steel (EN353)	EN353	Input gear,Output gear
Aluminium (Al6061)	Al6061	Gear box
Aluminium Alloy / Cast Iron		Differential Case
Alloy Steel / Mild Steel		Differential Locker
Iron		Differential Locker Flange Shaft
High Carbon Chromium Bearing Steel		Differential Needle Roller Thrust Bearing



Raw Material	Material Code	Part Names
made from neoprene, synthetic rubber, higher resistant material on temperature changes, oil, grease, fuels		Dust hood
made of plastic covered by PTFE		Ball joint seat
wear resistant flexible polyurethane		Ball joint boot
high strength hardened steel		Universal joints (U-joints) or constant-velocity (CV) joints.
aluminum or steel		Curved jaw coupling Hubs
Urethane & Hytrel		Spiders
Aluminium 6061	6061	Wheel Assembly
AISI 1020	1020	Wishbone

# Identification of Critical Quality Control parameters along with the process failure

**Modes, MFMEA:** This part includes the various Limitations of different components while making it.

Component	Limitation
Gear, Gear Box	A secondary finishing process is required, size might be limited because of the press size, maintenance cost is high.
Differential Case	Casting gives low fatigue strength, due to the nature of metals shrinking as they cool, the dimensional accuracy can fluctuate along the surfaces
Differential Case Flange Shaft, Locker Flange Shaft	Due to uneven heating & cooling of the members during the hot rolling, the members may distort resulting in additional stresses
Differential needle roller thrust bearing, Tapered Roller Bearing, Differential pinion gear, side gear and ring gear	The gears made by the hobbing process have a lot of burrs, even after using the deburring machine the burrs can remain for a long time reducing the lifetime of gear.
CVT - Pulley	Boring is a technique of utmost concentration hence has to be careful while operation, casting gives low fatigue strength and due to the nature of metals shrinking as they cool, the dimensional accuracy can fluctuate along the surfaces, welded joints are more brittle and therefore their fatigue strength is less than the members joined, due to uneven heating & cooling of the members during the welding, the members may distort resulting in additional stresses

Retainer Plate	Casting gives low fatigue strength, due to the nature of metals shrinking as they cool, the dimensional accuracy can fluctuate along the surfaces
Steel Belt	Forming times are long and the parts are not suitable for high-temperature use, welded joints are more brittle and therefore their fatigue strength is less, casting gives low fatigue strength and dimensional accuracy can fluctuate along the surfaces
Spider	Casting gives low fatigue strength, due to the nature of metals shrinking as they cool, the dimensional accuracy can fluctuate along the surfaces
Cam & Follower	Handling Milling and Lathe is a matter of utmost concentration hence has to be careful while operation.
Wheels	During the molding process, the part might shrink to some extent, sink marks may appear on the rim while injection moulding if the cooling time proves to be insufficient for the plastic to fully cool and cure while in the mold.

# Mass Production of Different Components

## Mass production of gear and gearbox:

For production of gear, we require steel (EN353) which is easily available in the market and produced by many industries like National Steel Industries. For gearbox, we need Aluminium (Al6061). Nova steel corporation is one of the leading 6061 T651 Plates Manufacturer, Supplier, and Dealer in India.

To give accurate dimensions we would require a vertical CNC machine which will cost us around INR 20,00,000/-. As it measures 1200 x 1100 x 2000 mm, we would require a room of 2000 x 2000 x 2000 mm.

## Mass production of differential:

To set the production line of differential, we require casting molds, furnaces, casting sand, hammer, CNC lathe, rolling mill, saw, hobbing machine and CNC milling. For the furnace, we will have to contact any manufacturer who is in business of die casting and crucible as we would require them to keep melted metal. As India is growing a lot in the field of manufacturing, we would like to give orders for furnaces to local businessmen as it would be beneficial for both of them and be cost effective.

Casting sand is nothing but silica sand used for foundry. One of the leading manufacturers of silica sand of 90 percent grade is Uthaya chemicals. Cost of 1 Mt silica sand is around INR 2800/-. As they provide them in 50 kg bags, we would require a big godown for its storage to complete the order of 4000 differential.

Hammer and saw will be easily available in the market.

JC steel products are well known for their quality. They do produce rolling mills which we require to get cylindrical shape.

As order is big, using the same CNC machine for different purposes may not be that time efficient. So, we would require different CNC machines for different purposes. Tirupati CNC products is one of the manufacturers who produce CNC Lathe machines. Octagon produces CNC milling machines. For both of them we would require different rooms as required for production of gears. Hobbing machine are made by milling machines producers. So we would buy it from the same vendor of milling machine. This would help us keep our books a little less messy.



### **Mass production of CVT:**

We would require steel/aluminium alloy for pulley which could be acquired from the vendor of steel we selected for material of gear. As we already have one lathe machine, we only need to buy a boring set. Raj tool centre has managed to attain a strong market reputation in trading and supplying Carbide Products.

Double sided welding machines are easily available online. We would require two of them so two workers can work at the same time. There are many manufacture like Thanusar Enterprises

Who make industry quality moulds and are cost effective.

### **Mass production of joints:**

We would require hard stainless steel and other metals which could be bought from the National steel industries. We would need tools like saws, hammer cutters, tong,etc. which are easily available in the market.

We would need turning cutters and deburring tools which could be bought from vendor of boring tools.

Deburring machine, used for finishing can be obtained from S. A. Finishing Systems. Die can be bought from indegenous brands like Namdhari. Cold forging machine can be bought from Labh Projects Pvt. Ltd. Hot forging machine can be bought from Basant Industries - Power Press Manufacturer. Coniflex Generator can be bought from Tirupati CNC. Injection Moulding Machine can be bought from Techno Plast Injection moulding machine. All the machines would require a separate room of around 2000mm x 2000mm x 2000mm.

## Dimension and Specification Checklist

Components	Dimension	Specifications
Gear	Gear Ratio = 3	Max. Power to be transmitted = 6000 W Max. Torque to be transmitted= 300 N-m
Differential	--	Max. Power to be transmitted = 6000 W Max. Torque to be transmitted= 300 N-m
CVT	--	Transmission ratio range = 0.8 to 2 Max. Power to be transmitted = 6000 W Max. Torque to be transmitted = 120 N-m
Tyre	Front wheel tyre: Height: 22 inches Width: 7 inches Rear wheel tyre: Height: 24 inches Width: 8 inches	
Wheel Rim	Front Rim - 10in, 5in	Rear Rim - 12in, 7in

# Bill of Materials



BAJA 2021 - BOM for eBAJA Vehicle					
Part Number	Part Name	Material	Type of Material ( Enter as Inhouse/Vendor/ Hardware)	Quantity per Vehicle	Weight (in Kg)
B21-00-0001	Vehicle assembly complete				
B21-10-1000	Assy Differentials				
B21-10-1001	Differential Case	Aluminium Alloy / Cast Iron	Vendor	1	
B21-10-1002	Differential Case Flange Shaft	Alloy Steel / Mild Steel	Vendor	1	
B21-10-1003	Differential Locker	Iron	Vendor	1	
B21-10-1004	Differential Locker Flange Shaft	Alloy Steel / Mild Steel	Vendor	1	
B21-10-1005	Differential Needle Roller Thrust Bearing	High Carbon Chromium Bearing Steel	Vendor	2	
B21-10-1006	Differential Pinion Gear	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	2	
B21-10-1007	Differential Ring Gear	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1008	Differential Roller	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1009	Differential Side Gear	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	2	
B21-10-1010	Differential Stud	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1011	Differential Stud Pin	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1012	Differential Stud Screw	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	2	
B21-10-1013	Differential Synchronizer Hub	Steel	Vendor	1	
B21-10-1014	Differential Synchronizer Sleeve	Steel	Vendor	1	
B21-10-1015	Differential Tapered Roller Bearing	Bearing Steel	Vendor	2	
B21-20-1000	Assy Wheels				
B21-20-1100	Knuckle	Cast Iron	Inhouse	4	
B21-20-1101	Bearings	52100 chrome steel	Hardware	4	
B21-20-1200	Wheel Hub	Aluminium (6061 T6)	Hardware	4	
B21-20-1201	Disc Rotor	Gray Cast Iron or Steel	Hardware	4	
B21-20-1202	Nut and Bolts	40Ni14 and 40Ni6Cr4Mo2	Hardware		
B21-20-1300	Rim	Cast Aluminum Alloy	Hardware	4	8
B21-20-1301	Seals	Nitrile rubber or Buna rubber	Hardware		
B21-20-1400	Tyre	Styrene-Butadiene Rubber (SBR)	Hardware	4	6.5
B21-30-1000	Assy Gears				
B21-30-1001	Input Gear	Steel (EN353)	Vendor	1	
B21-30-1002	Output Gear	Steel (EN353)	Vendor	1	
B21-30-1003	Gear Box	Aluminium (Al6061)	Vendor	1	
B21-40-1000	Assy CVT				
B21-40-1100	Sub Assy Primary Clutch				

B21-40-1101	Fix Pulley	Steel / Aluminum Alloy	Hardware	1	
B21-40-1102	Movable Pulley	Steel / Aluminum Alloy	Hardware	1	
B21-40-1103	Spider	Cast Iron	Hardware	1	
B21-40-1104	Cam	Cast Iron	Hardware	1	
B21-40-1105	Follower	Carbonitrided 52100 / 4130 steel	Hardware	1	
B21-40-1106	Primary Spring	Chosen according to tension	Hardware	1	
B21-40-1200	Sub Assy Secondary Clutch		Hardware	1	
B21-40-1201	Pulleys	Steel / Aluminum Alloy	Hardware	1	
B21-40-1202	Secondary Spring	Chosen according to tension	Hardware	1	
B21-50-1000	Assy Double Wishbone Suspension				
B21-50-1100	Front Suspension				
B21-50-1101	Upper Control Arm (Upper wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1102	Lower Control Arm (Lower wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1103	Shock Absorber	Fox Float 3 Shocks (830-12-301)	Hardware	2	4.14
B21-50-1104	Wheel Upright	Aluminium 6061	Hardware	2	0.78
B21-50-1200	Rear Suspension				
B21-50-1201	Upper Control Arm (Upper wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1202	Lower Control Arm (Lower wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1203	Shock Absorber	Fox Float 3 Shocks (830-12-302)	Hardware	2	4.14
B21-50-1204	Wheel Upright	Aluminium 6061	Hardware	2	0.78
B21-60-1000	Assy Chasis				
B21-60-1100	Roll cage	AISI 4130 CHROMOLY STEEL ALLOY	Vendor	1	66.1
B21-60-1101	Battery	Lithium Ion	Hardware	1	
B21-60-1102	Roll cage sheets	Epoxy fibre glass	Vendor	12	8
B21-70-1000	Assy Steering				
B21-70-1100	Rack and Pinion	Aluminium	Hardware	1	
B21-70-1101	Steering Wheel	Metal with hard black plastic	Hardware	1	
B21-70-1102	Tie rods	High Strength Steel	Hardware	1	
B21-70-1103	Shafts	Mild Steel	Hardware	1	
B21-80-1000	Assy Drivetrain				
B21-80-1101	Motor		Hardware	1	
B21-80-1102	Differential	Aluminium alloy, Cast Iron, Mild Steel	Vendor	1	
B21-90-1101	Motor Driver		Hardware	1	
B21-90-1102	BMS		Hardware	1	
B21-100-1000	Assy Braking system				
B21-100-1101	Tendern Master Cylinder		Hardware	1	
B21-100-1102	Brake Pedal	Structural Steel	Inhouse	1	
B21-100-1103	Brake Lines		Inhouse	1	
B21-100-1104	Brake Fluid		Hardware	1	
B21-100-1106	Front disc rotors		Hardware	2	
B21-100-1107	Rear disc rotors		Hardware	2	
B21-100-1108	Brake Callipers front		Inhouse	2	
B21-100-1109	Brake Callipers Rear		Inhouse	2	
B21-110-1000	Seat	Glass Fibre Reinforced Plastic	Inhouse	1	10
B21-110-1101	Shoulder Belts	Nylon	Hardware	1	
B21-110-1102	Anti-submarine Belts	Nylon	Hardware	1	
B21-110-1103	Lap Belts	Nylon	Hardware	1	
B21-110-1104	Buckles		Hardware	1	

# Bill of Materials

(for Drivetrain System)



BAJA 2021 - BOM for eBAJA Vehicle					
Part Number	Part Name	Material	Type of Material ( Enter as Inhouse/Vendor/ Hardware)	Quantity per Vehicle	Weight (in Kg)
B21-00-0001	Vehicle assembly complete				
B21-10-1000	Assy Differentials				
B21-10-1001	Differential Case	Aluminium Alloy / Cast Iron	Vendor	1	
B21-10-1002	Differential Case Flange Shaft	Alloy Steel / Mild Steel	Vendor	1	
B21-10-1003	Differential Locker	Iron	Vendor	1	
B21-10-1004	Differential Locker Flange Shaft	Alloy Steel / Mild Steel	Vendor	1	
B21-10-1005	Differential Needle Roller Thrust Bearing	High Carbon Chromium Bearing Steel	Vendor	2	
B21-10-1006	Differential Pinion Gear	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	2	
B21-10-1007	Differential Ring Gear	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1008	Differential Roller	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1009	Differential Side Gear	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	2	
B21-10-1010	Differential Stud	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1011	Differential Stud Pin	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	1	
B21-10-1012	Differential Stud Screw	Pre-alloyed low-alloy steel PF-4620 and modified PF-4620	Vendor	2	
B21-10-1013	Differential Synchronizer Hub	Steel	Vendor	1	
B21-10-1014	Differential Synchronizer Sleeve	Steel	Vendor	1	
B21-10-1015	Differential Tapered Roller Bearing	Bearing Steel	Vendor	2	
B21-20-1000	Assy Wheels				
B21-20-1100	Knuckle	Cast Iron	Inhouse	4	
B21-20-1101	Bearings	52100 chrome steel	Hardware	4	
B21-20-1200	Wheel Hub	Aluminium (6061 T6)	Hardware	4	
B21-20-1201	Disc Rotor	Gray Cast Iron or Steel	Hardware	4	
B21-20-1202	Nut and Bolts	40Ni14 and 40Ni6Cr4Mo2	Hardware		
B21-20-1300	Rim	Cast Aluminum Alloy	Hardware	4	8
B21-20-1301	Seals	Nitrile rubber or Buna rubber	Hardware		
B21-20-1400	Tyre	Styrene-Butadiene Rubber (SBR)	Hardware	4	6.5
B21-30-1000	Assy Gears				
B21-30-1001	Input Gear	Steel (EN353)	Vendor	1	
B21-30-1002	Output Gear	Steel (EN353)	Vendor	1	
B21-30-1003	Gear Box	Aluminium (Al6061)	Vendor	1	
B21-40-1000	Assy CVT				
B21-40-1100	Sub Assy Primary Clutch				



B21-40-1101	Fix Pulley	Steel / Aluminum Alloy	Hardware	1	
B21-40-1102	Movable Pulley	Steel / Aluminum Alloy	Hardware	1	
B21-40-1103	Spider	Cast Iron	Hardware	1	
B21-40-1104	Cam	Cast Iron	Hardware	1	
B21-40-1105	Follower	Carbonitrided 52100 / 4130 steel	Hardware	1	
B21-40-1106	Primary Spring	Chosen according to tension	Hardware	1	
B21-40-1200	Sub Assy Secondary Clutch		Hardware	1	
B21-40-1201	Pulleys	Steel / Aluminum Alloy	Hardware	1	
B21-40-1202	Secondary Spring	Chosen according to tension	Hardware	1	
B21-50-1000	Assy Double Wishbone Suspension				
B21-50-1100	Front Suspension				
B21-50-1101	Upper Control Arm (Upper wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1102	Lower Control Arm (Lower wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1103	Shock Absorber	Fox Float 3 Shocks (830-12-301)	Hardware	2	4.14
B21-50-1104	Wheel Upright	Aluminium 6061	Hardware	2	0.78
B21-50-1200	Rear Suspension				
B21-50-1201	Upper Control Arm (Upper wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1202	Lower Control Arm (Lower wishbone)	AISI 1020	Hardware	2	1.2
B21-50-1203	Shock Absorber	Fox Float 3 Shocks (830-12-302)	Hardware	2	4.14
B21-50-1204	Wheel Upright	Aluminium 6061	Hardware	2	0.78



**THANK YOU**

