Drivetrain

The **drivetrain** of a motor vehicle is the group of components that deliver power to the driving wheels. This excludes the engine that generates power. In contrast, the powertrain is considered to include both the engine and the drivetrain. The **function** of the **drivetrain in a vehicle** is to couple the engine that produces the **power** to the driving wheels that use this mechanical **power** to rotate the axle.

This connection involves the physical linkage of the two components, which might be at opposite ends of the **vehicle** hence requiring a long propeller shaft or **drive** shaft. The operating speed of the engine and wheels are also different and must be matched by the correct gear ratio. As the vehicle speed changes, the ideal engine speed must remain approximately constant for efficient operation and so this gearbox ratio must also be changed, either manually, automatically or by an automatic continuous variation.

Our power train assembly performance, are optimal for our event with maximum speed = 60.3 km/h , and further calculation can show we need the enlisted specifications to achieve the best relation.

Specifications:

Gear Ratio:	**10:1**
Power to Mass Ratio :	**0.02 Hp/kg**
Max Torque:	**18.57Nm @2600rpm**
Max Power:	**7.5Hp@ 3600rpm (considering 25%loss)**
Top Speed :	**60.372 kmph acceleration=0.98m/s^2**

Inbuilt Locked Differential facilitate different power requirements & smooth cornering.

Performance Characteristics:

The performance characteristics of BAJA vehicle strongly depends upon four main factors which are:

a.) Gradeability
b.) Top Speed
c.) Acceleration
d.) Reduction in lower gear ratio

Constant value:

Air density(ρ)	=1.12gm/cc
mass(m) (of buggy)	=250kg
Acceleration due to gravity(g)	=9.8m/s^2
Dynamic rolling friction(mr)	=0.085
Air Drag coefficient(cd)	=1.08
Frontal area(Ar) (of buggy)	=0.95m^2

For Gradeability:

Gradeability is defined as the ability of a vehicle to climb uphill at a certain angle without the slip occurring. It is an important factor that decides the maximum pulling force that can be applied by the engine on the wheels.

In general sense gradeability is defined in terms of percentage, let say X%. This means that vehicle will cover Xm distance in vertical direction while moving 100 m in a horizontal direction.

For getting an essence of this we try to calculate the variation in traction and various speeds, The following type of drag we need to understand first:

Rolling resistance:=
Rolling resistance is a result of energy loss in the tyre, which can be traced back to the deformation of the area of tyre contact and the damping properties of the rubber. These lead to the transformation of mechanical into thermal energy, contributing to warming of the tyre.

Aerodynamic Resistance:=
Aerodynamic drag of a vehicle is determined by the aerodynamic shape of the body, described by the drag coefficient(Cd), and by the projected frontal area of the vehicle(Af). The aerodynamic force increases with the square of the vehicle's velocity(v).

Grade Resistance:=
Grade resistance is the simplest form of resistance. It is the gravitational force acting on the vehicle. This force may not be exactly perpendicular to the roadway surface, especially in situations when an elevation is present.

For this calculation, formulae used are listed below:

Rolling resistance:=
mass x acceleration(gravity) x μ(friction coefficient) x Cos(angle of elevation)

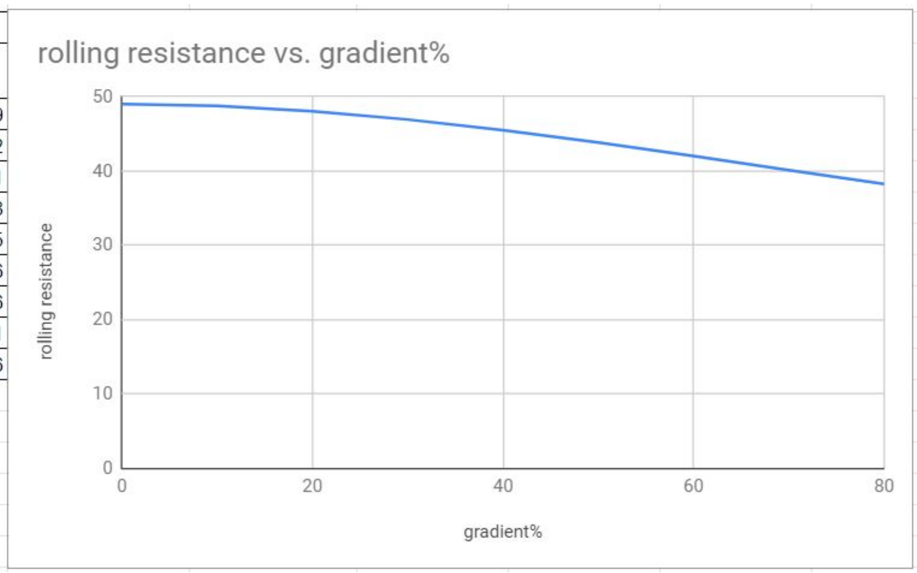
Grade resistance:=
mass x acceleration(gravity) x Sin(angle of elevation)

Aerodynamic resistance:=
½ x ρ(density of air) x A(frontal area) x V^2 (velocity of the buggy) x Cd(drag coefficient)

For calculating grade% of our buggy, we first try to analyze the variation of different speed and different grade%

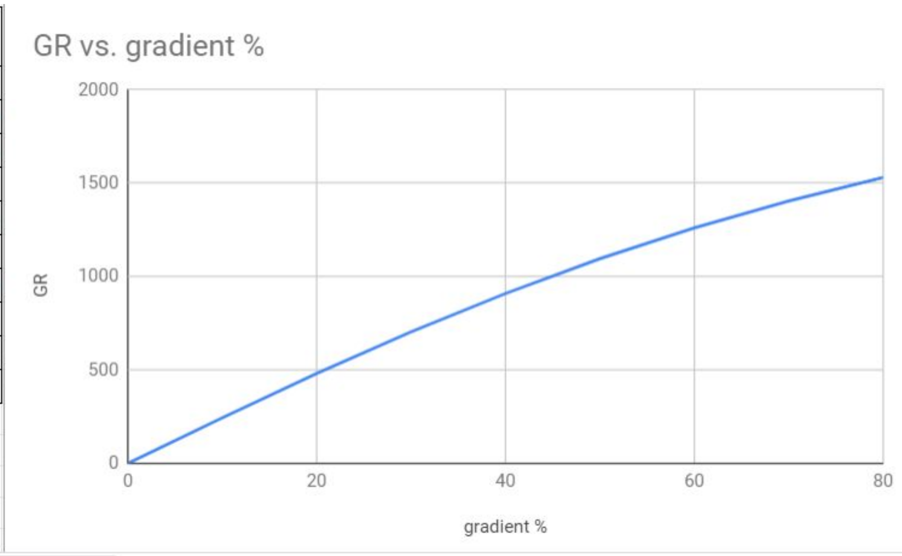
Rolling resistance:

rolling resistance	
gradient%	rolling resistance
0	49
10	48.75682232
20	48.04845311
30	46.93348798
40	45.49535785
50	43.82693236
60	42.01715336
70	40.14236411
80	38.26257166



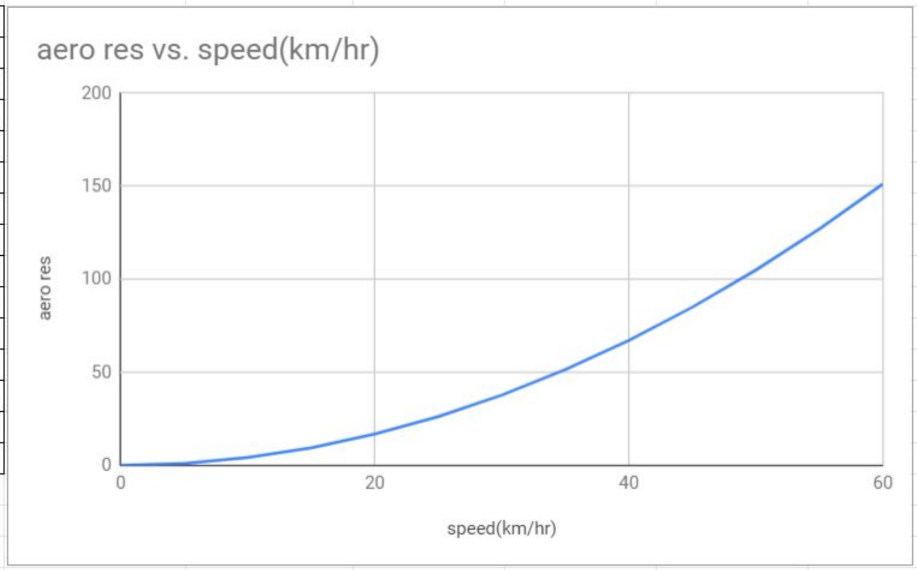
Gradient resistance:

Gradient resistance	
gradient %	GR
0	0
10	243.7841116
20	480.4845311
30	704.0023196
40	909.9071571
50	1095.673309
60	1260.514601
70	1404.982744
80	1530.502867



Aerodynamic resistance:

Aero Res	
speed(km/hr)	aero res
0	0
5	1.05
10	4.2
15	9.45
20	16.8
25	26.25
30	37.8
35	51.45
40	67.2
45	85.05
50	105
55	127.05
60	151.2

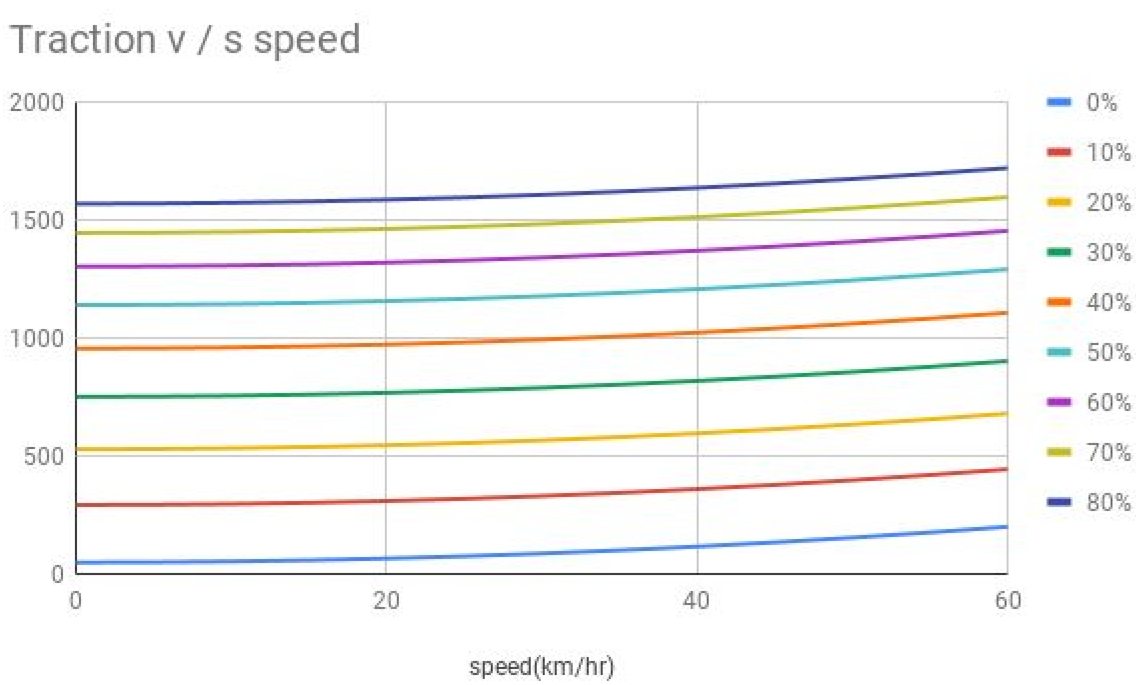


Total Tractive Effort:=

Total Tractive Effort is the net horizontal force applied by the drive wheels to the ground. If the design has two drive wheels, the force applied per drive wheel (for straight travel) is half of the calculated TTE. The total wheel torque does not change with the number of drive wheels. The sum of the individual drive motor torques must be greater than or equal to the computed Wheel Torque. The Maximum Tractive Torque represents the maximum amount of torque that can be applied before slipping occurs for each drive wheel. The total wheel torque must be less than the sum of the Maximum Tractive Torques for all drive wheels or slipping will occur.

Total traction effort is defined as SUM OF ALL THE RESISTANCE:=
TTE = RR + GR + AR

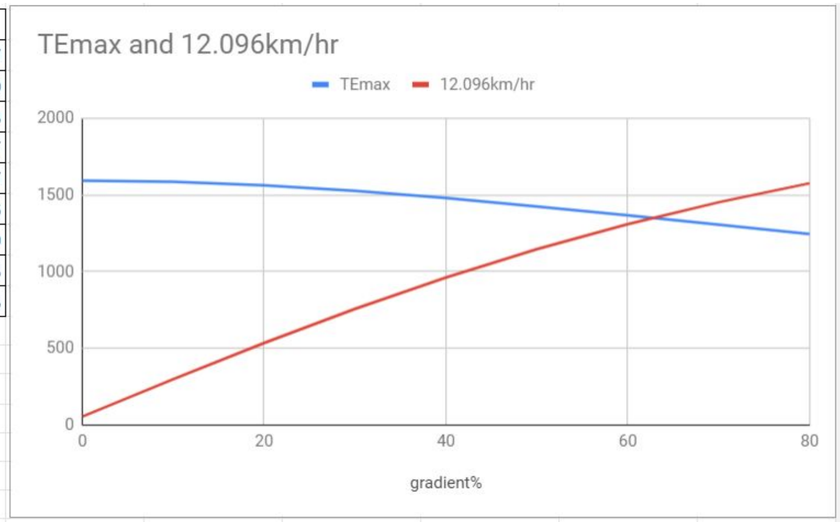
speed(km/hr)	0%	10%	20%	30%	40%	50%	60%	70%	80%
0	49	292.5409339	528.5329842	750.9358076	955.4025149	1139.500241	1302.531754	1445.125108	1568.765438
5	50.05	293.5909339	529.5829842	751.9858076	956.4525149	1140.550241	1303.581754	1446.175108	1569.815438
10	53.2	296.7409339	532.7329842	755.1358076	959.6025149	1143.700241	1306.731754	1449.325108	1572.965438
15	58.45	301.9909339	537.9829842	760.3858076	964.8525149	1148.950241	1311.981754	1454.575108	1578.215438
20	65.8	309.3409339	545.3329842	767.7358076	972.2025149	1156.300241	1319.331754	1461.925108	1585.565438
25	75.25	318.7909339	554.7829842	777.1858076	981.6525149	1165.750241	1328.781754	1471.375108	1595.015438
30	86.8	330.3409339	566.3329842	788.7358076	993.2025149	1177.300241	1340.331754	1482.925108	1606.565438
35	100.45	343.9909339	579.9829842	802.3858076	1006.852515	1190.950241	1353.981754	1496.575108	1620.215438
40	116.2	359.7409339	595.7329842	818.1358076	1022.602515	1206.700241	1369.731754	1512.325108	1635.965438
45	134.05	377.5909339	613.5829842	835.9858076	1040.452515	1224.550241	1387.581754	1530.175108	1653.815438
50	154	397.5409339	633.5329842	855.9358076	1060.402515	1244.500241	1407.531754	1550.125108	1673.765438
55	176.05	419.5909339	655.5829842	877.9858076	1082.452515	1266.550241	1429.581754	1572.175108	1695.815438
60	200.2	443.7409339	679.7329842	902.1358076	1106.602515	1290.700241	1453.731754	1596.325108	1719.965438



Maximum grade is achieved when we have our maximum acceleration, ie engine is working on its best performance using “Briggs & Stratton model 19 engine” report we get the value to be: 18.57Nm.

For that particular torque vehicle, our vehicle achieves 3.362 m/s i.e. @ 12.096 Km/hr.

gradient%	TEmax	12.096km/hr
0	1592.5	55.14515507
10	1584.596725	298.686089
20	1561.574726	534.6781393
30	1525.338359	757.0809627
40	1478.59913	961.54767
50	1424.375302	1145.645396
60	1365.557484	1308.676909
70	1304.626833	1451.270263
80	1243.533579	1574.910593



Using linear interpolation between gradient% of 60 and 70 we get the X(grade) and Y(N) as:

62.79 and 1348.54.

Greadiblity = 62.79.

Maximum velocity:

Let the maximum velocity be V (m/s)
Maximum output from the engine(max_eng)=

10hp =7457W

Maximum output at wheels(max_out)=

max_eng x (transmission efficiency)=

7457 x 0.7 =**5219.9W**

For maximum velocity net force on a body must be zero.

Therefore ,

Rolling resistance(RR)
= **μ** x m x g
= 0.09 x 250 x 9.8

=220.5 N

Aerodynamic resistance(AR)
= **½ x ρx Ar x V^2x Cd**
= 0.5 x 1.12 x 0.95 x 1.08 x V^2
= 0.57456 V^2 N

Total effort x **V** =**5219**.9 N

Net force = 0N

Power must be compensated by net resistive forces
RR x **V**+AR x **V**=max_out
0.57456(V^3) + 208.25**V** -5219.9=0

On solving
V = 15.26m/s =54.93 km/hr

<u>Maximum acceleration</u> :

Maximum acceleration will be achieved when there will be least resistance to the vehicle.

Let ‘a’ be the acceleration that we need to calculate.

For a body in motion:

Force = mass(m) x acceleration(a)

Te =18.66 N-m**(Torque delivered by engine)**
Iglow = 30
Tw = Te * iglow *ηtransmission
(iglow is the overall reduction in low gear
ηtransmission is the transmission efficiency)
Tw= 419.85 N-m (Torque @ wheels)

Pull at wheels,

Fw = Tw/dynamic radius of tire (Force @ wheels)
Fw = 419.85/27.566 x 100N
Fw = 1523.07 N

Total Tractive effort required (TTE) = RR+ AR+GR

RR = 49N (dry road)
GR= m* g *sin(tan-1(0)
GR = 0 N (0% Gradient track)
AR=145.6870303
TTE=194.6870303

a=(Fw-TTE)/m
a=5.31 m/s^2

a = 5.31/9.8 g
= 0.541 g

<u>Reduction in LOWER GEAR RATIO</u>:

Tw = (Total Road Load)* (dynamic rolling radius)

Tw = (1387.473)*(0.27566)
Tw= 387.65 N-m
Te = 18.66 N-m
ηtransmission=0.7

The relation between Torque@wheels and Tourque@engine is

Tw = Te* iglow * ηtransmission

iglow=Tw/(Te* ηtransmission)
=387.65/(18.66 * 0.7)
=29.688

Where,

iglow is the overall reduction in low gear
ηtransmission is the transmission efficiency

We need to decide between CVtech and Gaged CVT.
Reduction for CVtech= 29.688/3= 9.89
Reduction for Gaged CVT= 29.688/3.9= 7.61

RESULT:

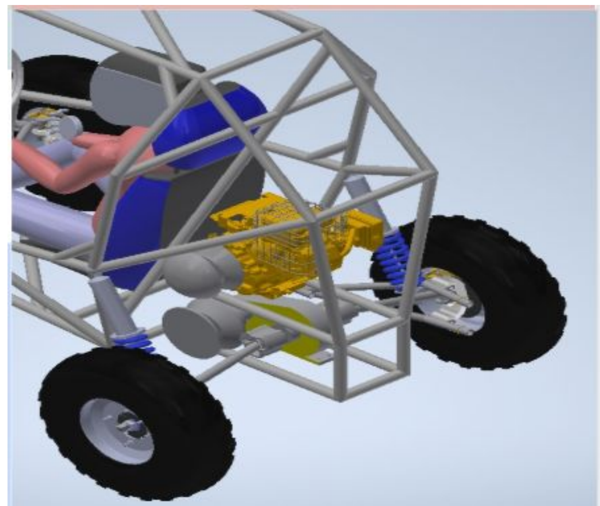
Maximum velocity	**54.93 km/hr**
Gradeability	**62.79**
Reduction to be used	● For CVTech = 9.81 = 10 approx ● For Gaged CVT=7.61= 8 approx
Maximum acceleration	5.31 m/s^2

Power train placement: the engine is placed in the rear part of the assembly. To balance the CG, we try to minimize the verticle placement of the engine and the CV points, further more we try to place the cvt casing and cv translation as to reduce the wheel base. We try different values of center to center distance that suits our conditions. To resolve the challenge of CVT mounting we final C-C distance as 231 mm.

Engine Mounting Frame Dampers

The efficiency of vehicle gets reduced by the vibrations produced by the engine of the ATV. To increase the efficiency, we need to reduce NVH and for that we would be using rubber bushes as engine mounting frame dampers to effectively reduce the resulting NVH in the vehicle. The placement of rubber bushes is done at the point of engine mounting and reduction mounting in the presented vehicle.

Design Scheme:

In our previous year's design, we had placed engine and CVT allignment as wheelbase was large enough. As to overcome that we had aligned the CVT and engine such that there is a reduction in wheelbase.	

CVT Casing

In order to prevent any external particle from hampering the smooth operation of our CVT and preventing the guard from getting injured due to rotating sheaves of the CVT we designed a cvt casing to house our transmission system using a 1.5mm thick AISI 1010 Steel sheet and abiding by the safety standards, the design is as follows.