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A Lap Time Simulation Of The Isle Of Man TT

School of Automotive and Mechanical Engineering

Motorcycle Engineering BEng

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Declaration

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree

Acknowledgements

During the course of this project there have been many ups and downs but this work has proved to be very rewarding, however I could never do this alone so I would to thank everyone who has helped me through this work both mentally and physically. I especially would like to thank my parents Alan Cartwright and Helen Cartwright as well as my two siblings Thomas Cartwright and Lucie Cartwright, for these 4 have always been there to help me through all of my work. I would also like to thank Beth Jones for always being there if I ever need someone to talk things through with. And finally I would like to thank Benjamin Way who has helped me through this project if I ever had a question or query that I need to discuss with some he has always be happy to help. Again I would like to that all of these people and many more for everything they have done for me throughout these course so thank you one and all.

Abstract

This report is about a lap time simulation based on the Isle of Man TT in a meter by meter account, this report aims to demonstrate the creation of the lap time simulation and to provide the information based around the results the simulation produces and what a real rider has achieved and to therefore compare the two to identify the human element in regards to this particular simulation. This is done using calculations to understand the geometry of the motorbike and the forces the machine is under during the racing of the isle of man TT. This report will equally demonstrate how the different variables will affect the motorbike and how to further the accuracy of the simulation. The motorbike this simulation has been based on is the Suzuki SV 650.

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Nomenclature

F_w	Front Wheel Radius
R_w	Rear Wheel Radius
W_f	Front Wheel Mass
W_r	Rear Wheel Mass
W_R	Load on the rear wheel
W_t	Total mass of the motorbike
$W_{r\text{lifted}}$	Load on the rear when lifted
θ	Angle of lift
L/P	Wheelbase
R_{av}	Average wheel radius
F	Braking Force
N_f	Load on the front wheel
M	Mass of the motorbike
G	Gravity
B	XCoG location
h	YCoG location
S	Driving Force
F_d	Drag Force
ρ	Air Density
CD	Coefficient Of Drag
A	Frontal Area
v	Velocity
P	Air Pressure
R	Specific Gas Constant
T	Temperature
V	Final Velocity
U	Initial Velocity
a	Acceleration
s	Distance

Introduction

This report is on a study done around the creation of a lap time simulation of the Isle of Man TT. This lap time simulation was designed to be able to be continually updated as time went by to create a more accurate lap time and to further understand the forces at work on a motorbike and how these forces dictate the speeds and times at which a motorbike can obtain. The idea for this study was due to two primary reasons, firstly it was to gain both knowledge and understanding of a motorbike and how these machines work and operate under such extreme conditions. This was a main point as understanding how something works in extreme conditions means that understanding in a simply format is both easier to understand and to explain. The second and main point was to identify the human element in regards to simulations and how this element affects the outcomes and even the potential performance a motorbike might be capable of. This human element is a factor that cannot be calculated and will differ from person to person as it dictates how an individual will operate under different circumstances and conditions, this includes things such as experience or reaction speed. This is the main reason for the study of the Isle of Man TT as the individuals who race on this track are put under pressure and extreme conditions due to the speeds and lethality of this particular race. It is suggested in many reports that a human's reactions and sense will differ when an individual is put under stresses or fears. There are also many studies into how adrenaline will affect the human mind which in turn can affect how a person perceives things and reacts to certain situations. This element is something that the Isle of Man TT might have as a defining feature as this would be something that couldn't be seen or calculated and by having this ratio to gain an understanding into how much a human is affected by these extreme conditions and how in turn they affect the potential or even surpass the potential of the motorbikes and their capabilities. The human mind is a complex part of the human being and there are many researchers still trying to understand this part of the human mind, so by having something that could light the way to truly understanding the human mind could bring a greater form of knowledge, this is also why by using engineering and understanding the engineering aspects of the world can a person understand what humans do and how they affect these machines and their capabilities be it positive or negative. The human element is an interesting factor and one that is worth studying. This report equally looks at the geometry and the dynamics of the motorbike and how different variables can affect parameters that could greatly influence the outcomes of any situation such as changing the masses or ratios of certain aspects. There are several assumptions made in the creation of this simulation and have been stated throughout this report.

Literature Review

Research paper titled: Aerodynamic Characteristics Of Automobile Models 1933

Author: R. H. Heald

This research paper was the oldest one that was read and reviewed for this report, the reason that this research paper was reviewed is due to the fact that the history of engineering is both interesting and vital to the advancements of engineering. This comes to light when looking through history and discovering inventions or theories that at the time were incredible, however with the newer and more modern technologies that are available in this day and age it is clear that an old research paper can bring to light a new and amazing invention that is only able to be implemented due to the advancements of the times. For this particular research paper it was given the main objectives of understanding how the different designs of the shell of a car would affect various variables such as the drag coefficient. This objective came to light as stated in the attempt to improve the fuel economy and to increase the speeds at which these vehicles could attain purely by changing the shells to design on that is more streamlined. This is an interesting point as this objective is still in effect in the modern world in the sense that for racing purposes the shapes of the vehicles have been designed so they are streamlined to aid in improving the downforce that is applied and in turn improving the speeds that could be attained. As for the fuel economy it is still a priority in the modern world to improve this factor more and more each day, the idea that changing the shape of a vehicle could improve the fuel economy is an accurate one and one worth studying. This particular research paper includes details on the various forces that are acting on the car as an example the lateral and longitudinal forces.

When this research paper was written the author looked into 6 designs to understand how the shape affects these forces and the vehicles characteristics, below is a figure showing these 6 layout that were researched and include in the paper was the idea that the aerodynamic forces were to be studied at different angles to further simulate the outcomes of driving to produce more accurate results. What the author equally looked into were the effects of side wind hence the desire to research and calculate using different angles of approach. The test that were conducted were implemented by creating the 6 models out of metals and wires to create a scaled down model of each design, these designs were then attached to the roof of the wind tunnels by a steel wire and were then observed. This is interesting in the sense that almost 90 years ago scale models were

being made to then be used in various simulations to calculate accurate readings the attempts to understand forces and to gain knowledge on what is the best design or ratios that a vehicle requires to perform in the best way it can for the desired purpose. This goes to show that although the times have changed the ideas and simulations that were conducted are not that different than they were before.

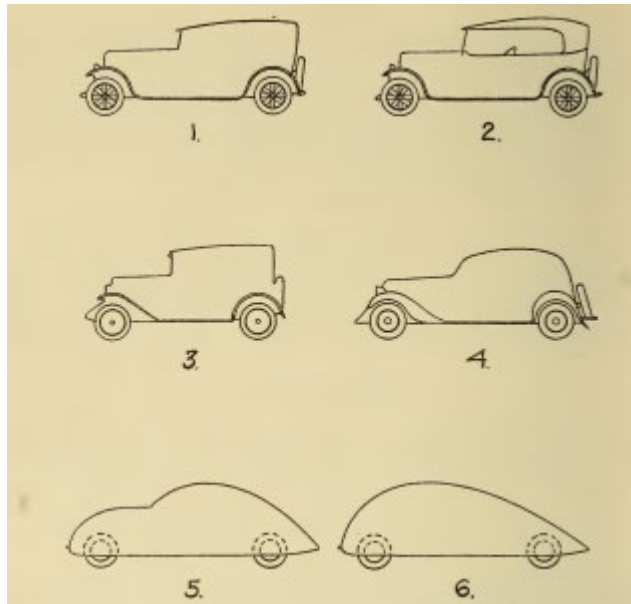


Figure 1 Model car shells

A Thesis titled: The Impact of Active Aerodynamics on Motorcycles Using Computational Fluid Dynamics Simulations

Author: Venkata Aditya Sripathi from the Automotive Engineering Technology Minnesota State University, Mankato May 2017

The purpose of this thesis is to provide knowledge and understanding into the uses of using computational methods to accurately design and analysis the results of the aerodynamic characteristics based on a designed motorbike. This thesis was chosen to review due to the required understanding of the aerodynamic forces and how these will affect the characteristics and the dynamic aspects of the motorbike and how these would influence the drag forces that have been demonstrated in this report.

During the process of this study the design of a motorbike was made based on a Honda CBR 1000RR Fireblade with the intentions of monitoring the values of the coefficient of lift and the coefficient of drag. This was then taken a step further and a 3d printed model was produced to perform test on to compare the results of these values. The model was also implemented with wings to demonstrate the uses and characteristics of these attachments and how having these wing set at different angles will affect the coefficient of lift and the drag coefficient. The angles at which these attachments were implement were at: 0°, 10° and 90° there was also a test done with no wings totalling a series of 4 test subjects.

The results of this thesis are interesting and show how the difference in these wings impact the aerodynamic characteristics it also shows the differences in using these computational methods when compared to the real data. The table below shows these values and the results that were conducted by Venkata Aditya Sripathi

Model	Lift (CFD)	Lift (Wind tunnel)	Drag (CFG)	Drag (Wind Tunnel)
Non-Wing	0.04682	0.046	0.25626	0.274
0 Degree Wing	0.04659	0.046	0.24133	0.265
10 Degree Wing	-0.01178	-0.011	0.26513	0.288
90 Degree Wing	N/A	N/A	0.29496	0.329

Figure 2 Aditya Sripathi's test results

When looking at these results and as stated in the thesis it is interesting to note how similar these values are when compared to the two tests. This brings it back to the simulation that has been created and how the accuracy of the calculation that have been done could mean that the real and simulated results could be similar. What is to note is the drag coefficient and how different it is to the values represented in the lap time simulation. To demonstrate this four charts have been created with the values of drag coefficients from the test performed on the wind tunnel. This is done to determine by implementing the drag coefficients from this thesis how this would impact the results of the simulation that has been created.

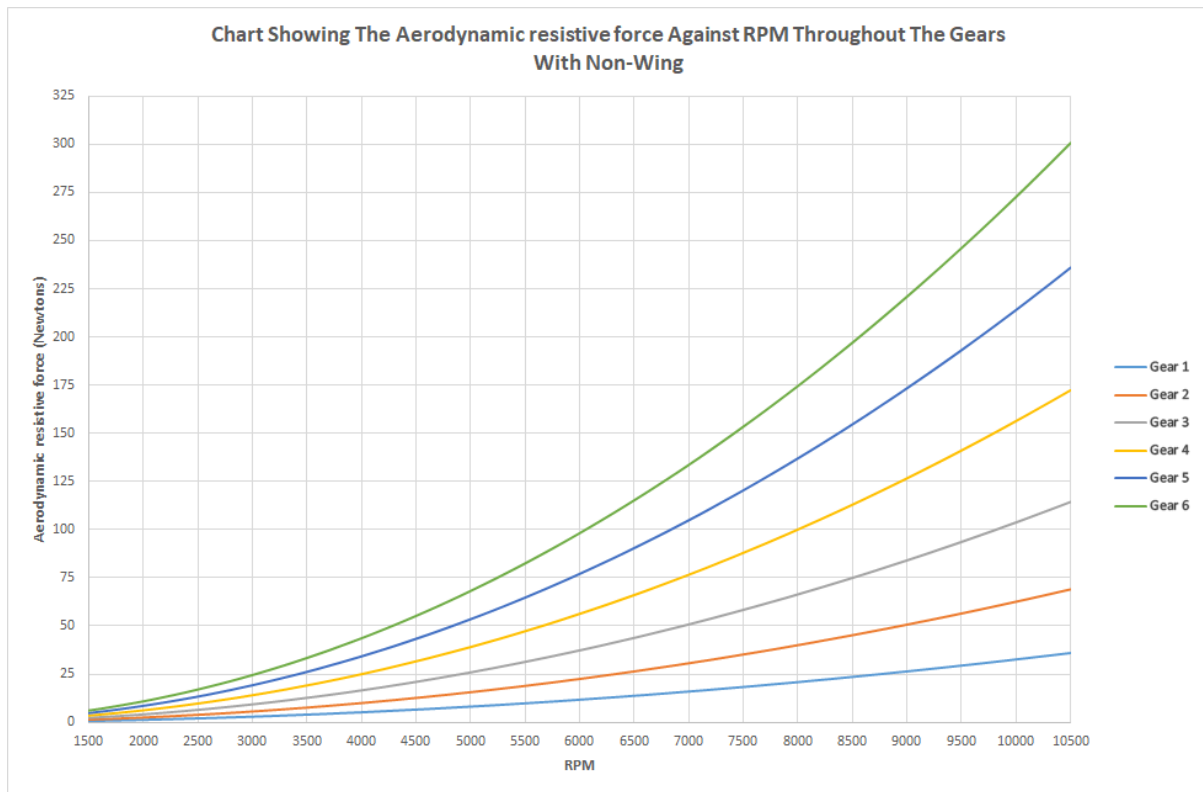


Figure 3 Drag forces against RPM with no wings

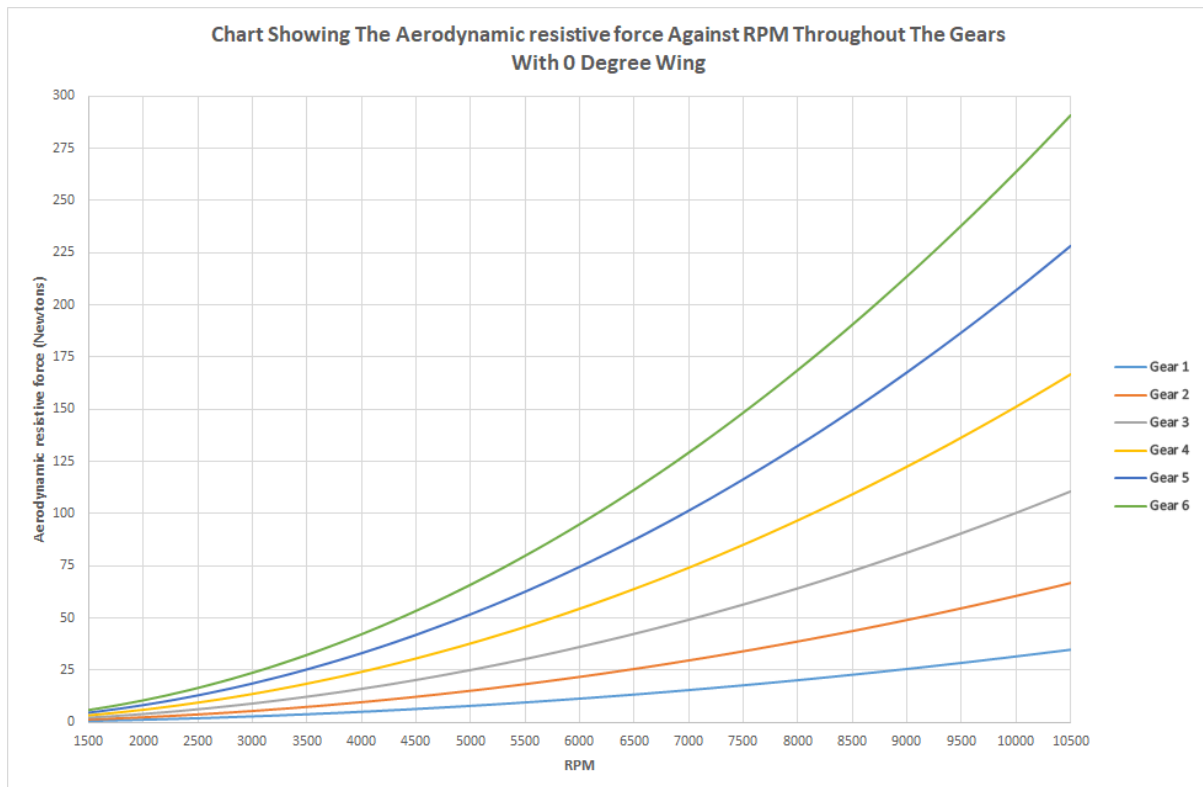


Figure 4 Drag forces against RPM with 0 degree wings

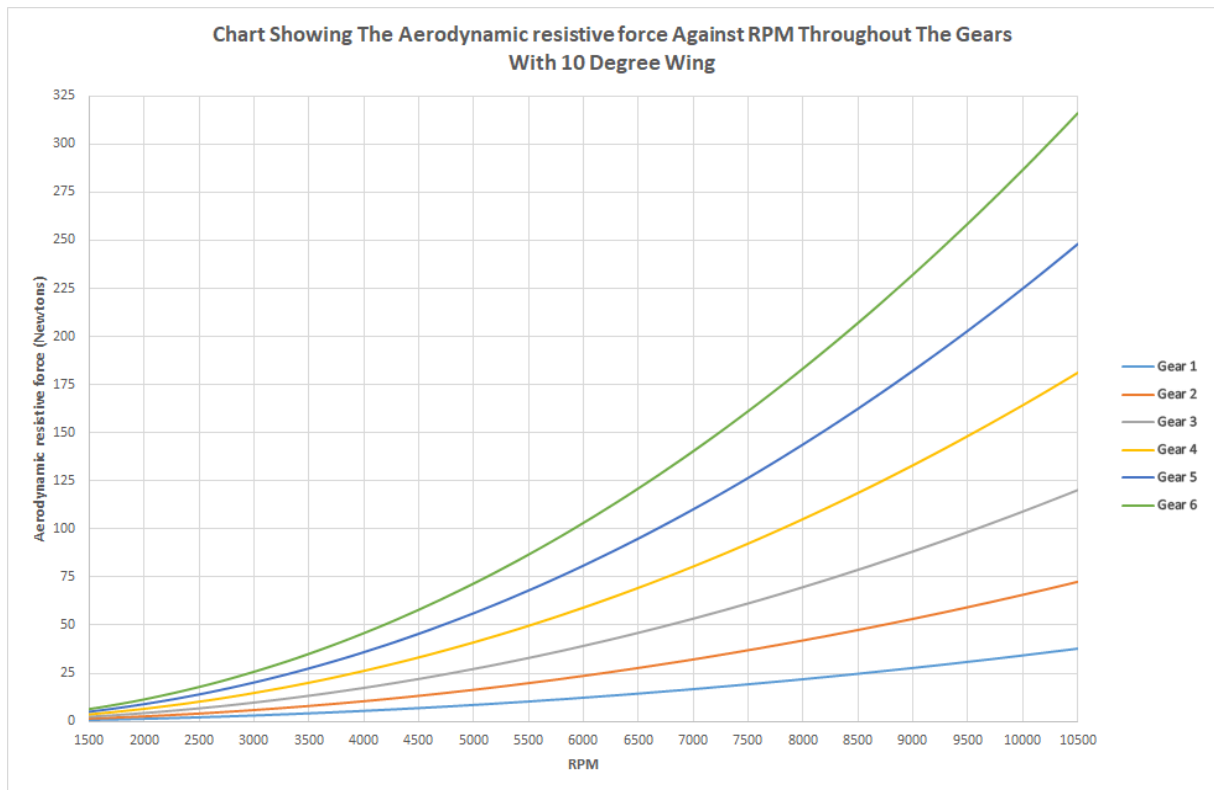


Figure 5 Drag forces against RPM with 10 degree wings

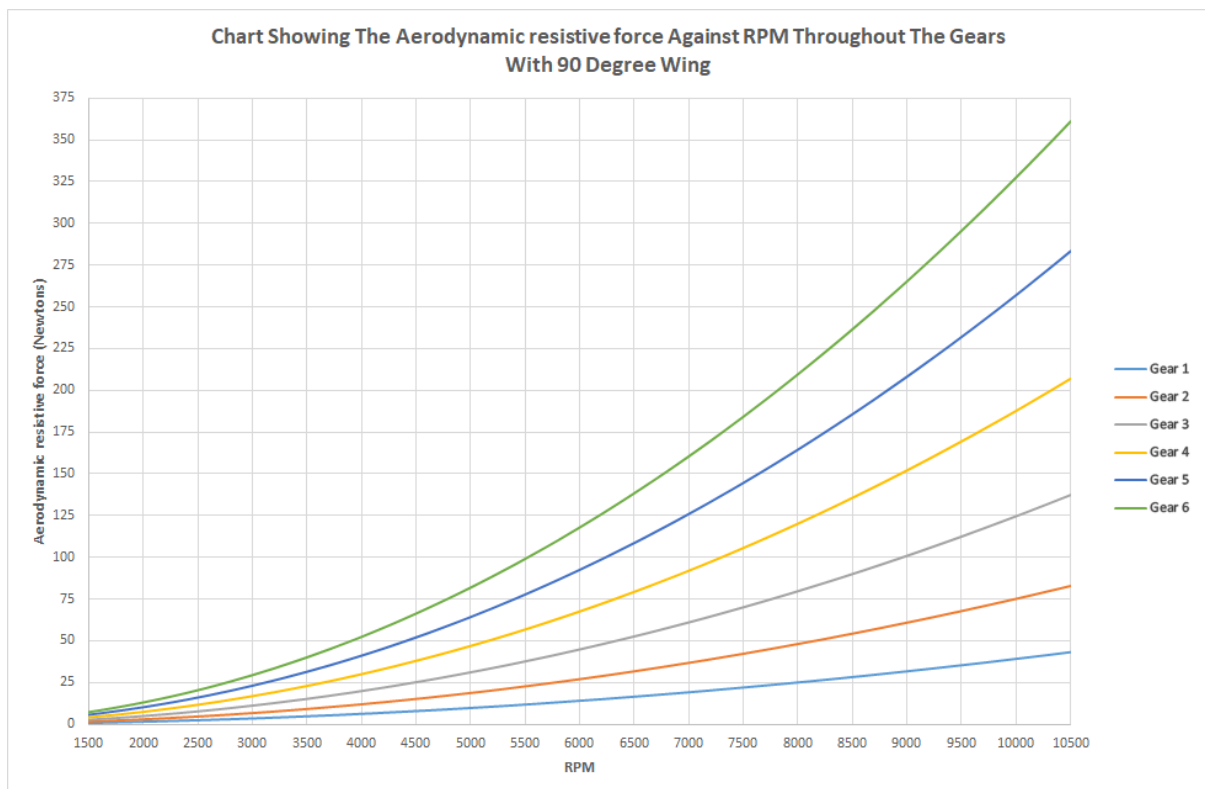


Figure 6 Drag forces against RPM with 90 degree wings

When looking at these charts it is interesting to see how the aerodynamic resistive forces have changed and to speculate at how using these values for the simulation would then affect the results in that study. In this sense it demonstrates how important these values are and how testing to understand what the actual values are for the designed motorbike that has been used in creating simulations really is and that to further the lap time simulation from this perspective is to then implement test to gain an accurate figure to complete the corresponding equations.

Thesis Titled: Motorcycle Cornering Improvement: An Aerodynamical Approach based on Flow Interference

Author: Vojtech Sedlak

This thesis is based on a study done on the intentions of improving the cornering performances of a MotoGP motorbike. This study has used various computational tools to gain an understanding of how the aerodynamic characteristics will change and how this can then be used to improve the cornering performance, this has been done in turn with implementing wings to aid in this endeavour and by staying true to the road racing regulations of MotoGP 2012. The reasoning for reviewing this thesis is due to the assumptions made on the corners in the lap time simulation. This study further shows how these forces change and how a more accurate reading can be taken. It also demonstrates how the addition of wings will affect the forces that are acting on the tyres during a constant velocity. This is an important aspect in the understanding the difference in simulations and real data. With these new forces that would be acting on the tyres it is very likely that the useful life of the tyres would then be reduced. This in turn would affect many aspects of the dynamics of the motorbike for example the coefficient of friction that has been used as this values would decrease meaning for the simulation the acceleration and braking distances would change therefore the time taken would increase.

The study done for this thesis uses two types of case studies and that is a 2D and a 3D model to determine how the values are different when these two types of studies are performed on the same designed wing. The values that this study aims to determine are the lift coefficient, drag coefficient and the pressures that would be acting upon the wings and the motorbike in question. The study uses a static numerical calculation to determine these values and to implement these into the 2D

and 3D models. The study states that although these results are positive there are however static values. The further development states that using a wind tunnel to determine if the results are reliable would be the next step in determining the usefulness of these wings and if they can improve the motorbikes that operate in MotoGP. This would impact the lap time simulation in the sense that if this study is continued then the knowledge and understanding provided for corners and the forces that they can be implemented at will increase. This will also reduce the assumptions made in the simulation which will provide a more accurate reading with the best results possible. It will also lead the way in implementing features to motorbikes to improve the characteristics of these machines to the best possible outcome for the desired task that they are designed for.

The results show as stated in this thesis that the inference on the wings that this study has researched and attempted to understand do in fact show that there is a positive effect on cornering and how these wings could improve the performance of the motorbike. This study states that there is potential in the results that have been gathered and that further development would be required to gain a better understanding and an idea as to if the potential of implementing the wings will aid the cornering performance or be a hindrance.

Research Paper Titled: The significance of high-order dynamics in lap time simulations

Author: Roberto Lot and Nicola Dal Bianco

This is a research project that was done on a lap time simulation based around the idea of understanding how complex a lap time simulation has to be. This simulations looks at 3 different models each with their own characteristics, the three models are as follows: a 14 degrees of freedom model which includes the chassis and wheels motion, a 10 degrees of freedom model which neglects the wheels hop dynamics and variables such as having a massless wheel. The final one of 7 degrees of freedom which is the idea of completely removing the suspension motion values. The study goes on to show how these three models are made and that the primary focus is the suspension modelling to determine what is required and what isn't to create a simpler but just as accurate simulation. The reason for reviewing this study was due to the fact that it was a lap time simulation model that incorporated a more accurate suspension model that would be there to

dictate the outcome and final results of the simulation that was created. This proved to be a point of interest as this had not been done to determine the characteristics of the motorbike and was neglected, this study was there to demonstrate the level of complexity that was required to create an accurate simulation based on suspension.

The set up for this simulation was based on the 14 degrees of freedom model of which variables were then removed to make the remaining 10 and 7 degrees of freedom models. The results of this study also state that in regards to the two smaller models the time taken to calculate these lap times were 43% less when compared to the more complex 14 model, it also stated that the 14 and 10 degrees of freedom model were almost identical meaning that having massless wheels as a parameter did very little in the form of changing the lap times. The study also goes on to state as a conclusion that the 10 degrees of freedom is a reasonable simplification of the original. This meant that with the simple 10 degrees of freedom model it was possible to gain accurate results for the calculations at almost half the time. This would help in a competitive environment due to the fact that both accuracy and time are essential so having a simulation that is still accurate but runs fast is a great thing to produce. The only problem with this idea is that it focuses on the time it takes to calculate, this is a reasonable response when it comes to creating simulations for companies or even teams however the differences in time was around 1700 seconds whereas the one for the simple model was 930 seconds. It is believed that if time is not the most important value and that the accuracy of the results are the key then waiting the extra 12 or so minutes is worth it for the level of accuracy that could be provided.

When looking through this paper it is clear that suspension modelling has an effect on the characteristics of any vehicle and can also influence the speeds, times and forces that the lap time simulation will produce. This shows that to further develop the lap time simulation of the Isle Of Man TT then suspension modelling will need to be researched further to gain knowledge and understanding, which can then be implemented to further increase the accuracy of the simulation.

Research Paper Titled: Comparative study of vehicle tyre-road friction coefficient estimation with a novel cost-effective method

Author: Boyuan Li, Haiping Du and Weihua Li

The research paper that is being reviewed is based on the idea on identifying and confirming if the calculation that they have performed are accurate when compared to a GPS data, the variable that this team has aimed to identify is the tyre to road friction coefficient. They have produced three methods that can be used to identify this value and they are as follows: the slip slope method which takes the longitudinal forces of the tyres against the ratio of slip curve. The second method that was studied was the individual wheel tire to road friction coefficient, this method looks at producing estimated values for the friction coefficient for each wheel instead of a general value. This could prove to be more accurate as the values would differ from wheel to wheel on a real vehicle however for simulation purposes the tyres are assumed to be of the same value. The final method is called the extended kalman filter which produces a value by estimating the vehicles motions and states to produce an accurate estimation of the coefficient of friction. This research paper is relevant to the lap time simulation due to the fact that the coefficient as stated is an estimated value and therefore having a series of calculation to provide a more accurate value for this figure would prove to be invaluable in the endeavour of increasing the accuracy of the simulation.

This paper shows these three methods and all the equations that would be needed to attain an accurate reading the paper then goes on to suggest various advantages and disadvantages in the decision of using one of these methods to finalise this calculation. This proves to be very informative and aids in research as this provides accurate examples and results to prove these methods work. It also means that with this level of accuracy the advantages and disadvantages suggested in this paper are worth considering. The results of this paper show that the slip and slope method is the better of the three however as stated in the paper this method can only estimate the overall longitudinal forces and the overall tyre to road friction coefficient. This means that if the desire is to identify the changes in the values with the wheel angular velocity or vehicle velocity then this method is not the one to use instead use the individual wheel estimation method as this method looks at these two variables and produce results from this. This method is not as accurate however it is still very close so this greatly depends on the desires of the users of the simulations. Therefore to further develop the lap time simulation with regards to this research then the slip and slope method would be used to identify the coefficient of friction due to the fact that the tyres and road surface during the

creation of this simulation have been assumed to be constant throughout the lap and therefore the values of the coefficients should be assumed as a constant value.

Research Paper Titled: The Stability And Control Of Motorcycles

Author: R. S. Sharp

This research paper looks at the understanding and demonstrating how a motorbike stays stable by analysing the natural frequencies and using the equations of motions to show understanding. This research paper uses many equations ranging from the use of the linear and lateral equations of motion to show understanding. The purpose in understanding the stability of a motorcycle is in discovering the characteristics of the motorcycle especial when analysing the suspension frequency and damping characteristics. This research paper looks at these variables of the damping characteristics and the suspension to show how these affect the stability and how important understanding these variables are and why simulations that incorporate these are not always accurate and more information and research is needed in this field to truly understand motorbikes and how they are as stable throughout the forces and pressures that these machines are under. This research paper was reviewed due to the interest of adding a suspension model to the lap time simulation to increase its accuracy. As stated in a previous literature review it is clear that having a suspension model would greatly aid in the attempt to creating an accurate simulation so understanding this field and attempting to incorporate this into the simulation would be the logical next step into reaching this goal.

Methodology

Geometry

The geometry of the motorbike is the building blocks to the lap time simulation, this is due to the fact that if this is wrong then the simulation will be wrong. There are many aspects to the geometry and for this reason not all are accounted for however many have been. What is to note is that the motorbike that has been used in this simulation is a Suzuki SV 650 and all forces have been measured to this motorbike in question. The geometry has been split into three sections: section one is the physical aspect, this refers to the masses and gearing of the motorbike and the final ratios that dictate the speeds at which the motorbike will apply and how these changes can affect the motorbike and how it operates. The second section is the positive forces such as the driving and braking forces, this is an important feature due to the fact that without this information the simulation cannot work or operate correctly. Lastly the final section are the negative forces or resistive forces, these include parameters such as the resistive force due to the aerodynamic resistance. There are 2 simulations that have been done one that has very few resistive forces and another with more, this has been done to demonstrate the importance of these forces and how they dictate the outcome and final results.

Section 1 physical aspect

As stated section one is the physical aspect with gearing and masses. Changing the gearing ratio is a continual study that many individuals have researched into understanding the best ratios required to attain the results that are desired by the machine in question. Equally in all racing aspects reducing the mass of a racing machine is always a priority when it comes to designing these machines.

Below is two charts one that has the actual ratios and one that has the sprocket ratio change. This ratio is the ratio between the gearbox sprocket and the rear wheel sprocket and as such is very important in understanding this final ratio. The initial set had this ratio of 15/45 which gives a value of 0.33, the new set up to demonstrate the importance of having this ratio is now 15/30 giving a ratio of 0.5.

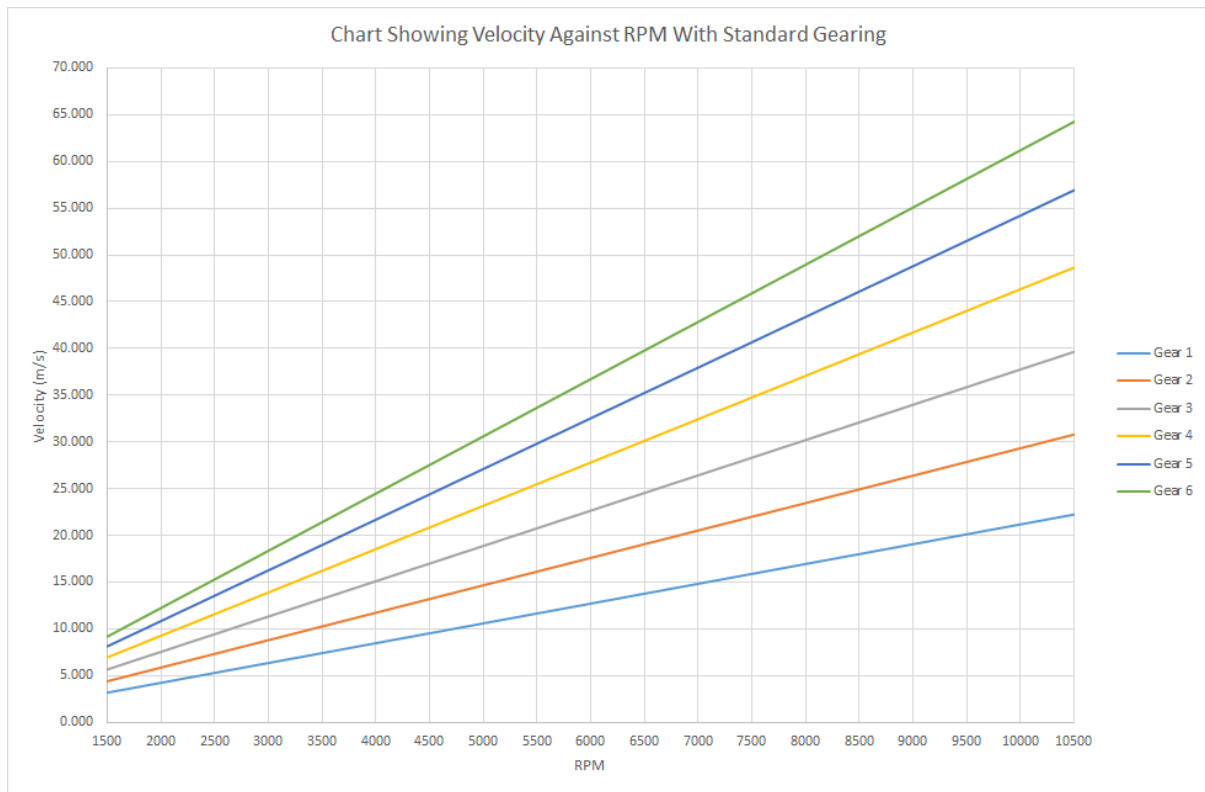


Figure 7 Velocity against RPM with standard gearing

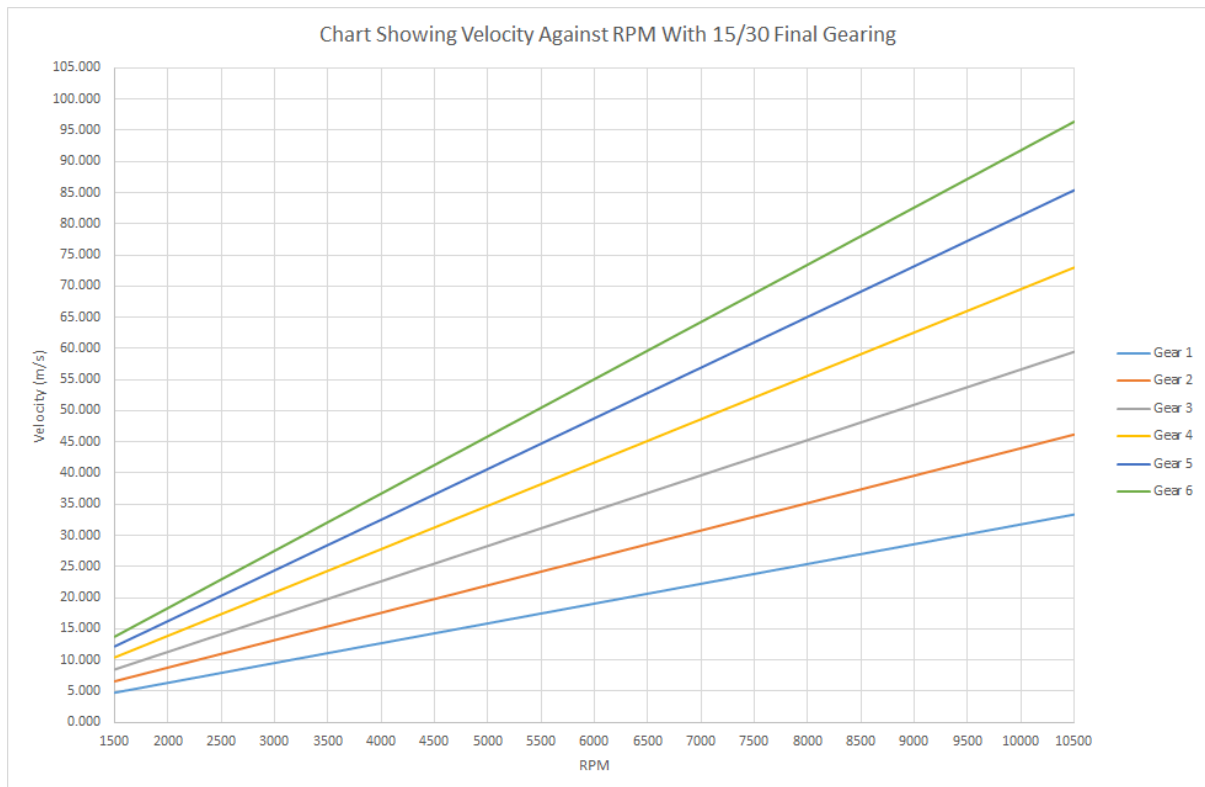


Figure 8 Velocity against RPM with different gearing

As expected due to this change in ratios the final velocities are a lot larger than what they were before. This poses an important point and that is that when it comes to the final drive changing these ratios is primarily a trade in performance. Having a larger ratio here will increase acceleration however the trade is that it will reduce the top speed at which the motorbike will go. This again refers to what the design purposes are for a vehicle and for the Isle Of Man TT there is a balance. This is due to the fact that most motorbikes will reach their top speeds at one point or another during this race and this is an important aspect to consider. The other point to consider when attempting to change ratios especially in a real sense is that by changing these ratios and increasing either the top speeds or the maximum acceleration it shows that by doing this the life span of the components could be altered. This again is always a main point when considering alterations to any and all machines and is there for a deciding factor in the creation of these ratios and alterations.

The other aspect is the mass which in turn is vital in all equations, the reason being as an example the acceleration is $a = \frac{F}{M}$ which as shown has the mass (M) incorporated into it. This means that if any alterations are to be made to the mass of the motorbike then all the variables will be affected. The other factor in regards to the changes in mass is the reduced mass value which is dictated by the inertia masses due to rotational bodies such as the wheels or gears. This is an important factor as the mass will change with these rotating components. The variables that have been included in this simulation are the wheels however to further the accuracy of this simulation then the other rotational components should be included, the way the reduced mass was calculated is shown in the equation below.

$$\text{Reduced Mass} = \text{Static Mass} + \left(\frac{1}{F_w} + (W_f \times F_w^2) \right) + \left(\frac{1}{R_w} + (W_r \times R_w^2) \right) + ETC$$

Table 1 Reduced Mass

Symbol	Meaning	Units
Fw	Front Wheel Radius	Meters
Rw	Rear Wheel Radius	Meters
Wf	Front Wheel Mass	Kg
Wr	Rear Wheel Mass	Kg

The ETC is in the equation due to the fact this formula continues for all rotating components throughout the vehicle in the same way the front and rear wheels were incorporated. From here as

an example the static mass of the motorbike was 240.6 Kg and when this is incorporated into the reduced mass equation with the front and rear wheels the final mass is 242.617 Kg. this is an important feature as this is the mass that was used in the simulation so to further the project the other rotational components should be incorporated into the reduced mass to identify what the final mass will actually be during operation.

Centre of Gravity

The centre of gravity is value that is dictated by many variables such as the distribution of the masses between the front and the rear of the motorbike, this value is always different from vehicle to vehicle and in regards to racing the lower the centre of gravity is the better it is. The centre of gravity is split into two parts the X and Y centre of gravity and each have their own formulas these are represented below.

The X centre of gravity (XCoG) is calculated using this formula

$$XCoG = \frac{Wr \times L}{Wt}$$

The Y Centre of gravity (YCoG) is calculated using this formula

$$YCoG = \frac{L \times (Wr - Wrlifted)}{Wt \times \tan \theta} + Rav$$

Table 2 Centre Of Gravity

Symbol	Meaning	Units
WR	Load on the rear wheel	Kg
Wt	Total mass of the motorbike	Kg
Wrlifted	Load on the rear when lifted	Kg
θ	Angle of lift	°
L	Wheelbase	Meters
Rav	Average wheel radius	Meters

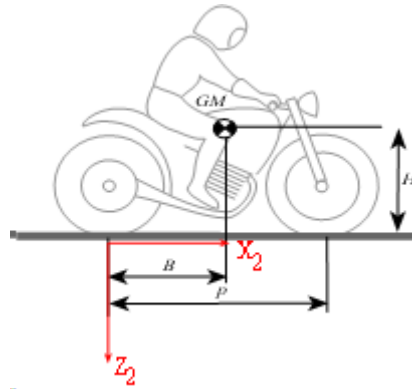


Figure 9 Centre Of Gravity

The figure above is a basic depiction of the centre of gravity where in this image p represents the wheelbase, B is the X centre of gravity location and H is the Y centre of gravity location. The centre of gravities are measured in meters and this value is important one. The centre of gravity affects the characteristics of the motorbike and has a large impact on the braking forces that are vital to completing the simulation.

Section 2 Positive Forces

This section primarily looks at the driving forces of the motorbike and what dictates them. There are many variables that influence the final driving forces within the simulation as some have been stated before. These variables include masses and the gearing ratios as an example. The positive variables for this section are depicted as the driving force and the braking force, although the braking force is represented as a negative value this is due to the direction of travel of the forces and how they act upon the motorbike. Both the driving and braking forces have been implemented with a traction coefficient of 0.7, this value is an estimation and with further research can be show to change and to further this be calculated accurately to determine the actual value and how it changes with the tyres and velocities.

Driving Force

The driving forces were calculated using the formula $F = \frac{p}{v}$ this is a basic formula which took the power in watts from a dyno graph to calculate the power for each RPM that could be ascertain. The formula to calculate the velocity required the understanding of the gear ratios and final drive ratios to take the RPM of the engine and to then apply that to the wheels throughout the gears giving values that could be used to calculate the driving force. Below is a series of graphs that represent this change driving force throughout the gears and how the final gearing ratio has affected this parameter. This driving force is also an important variable as it also dictates the acceleration values that the motorbike can achieve as the formula for acceleration is $F = ma$.

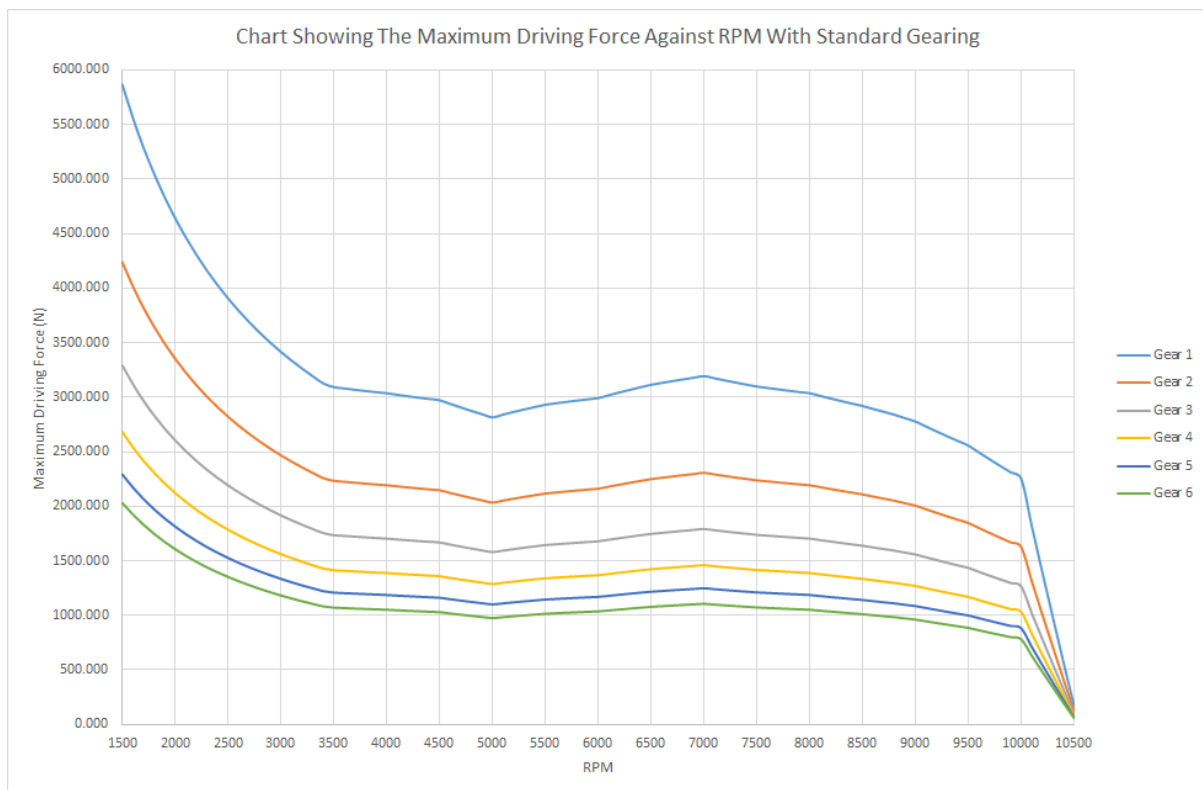


Figure 10 Driving force against RPM with standard gearing

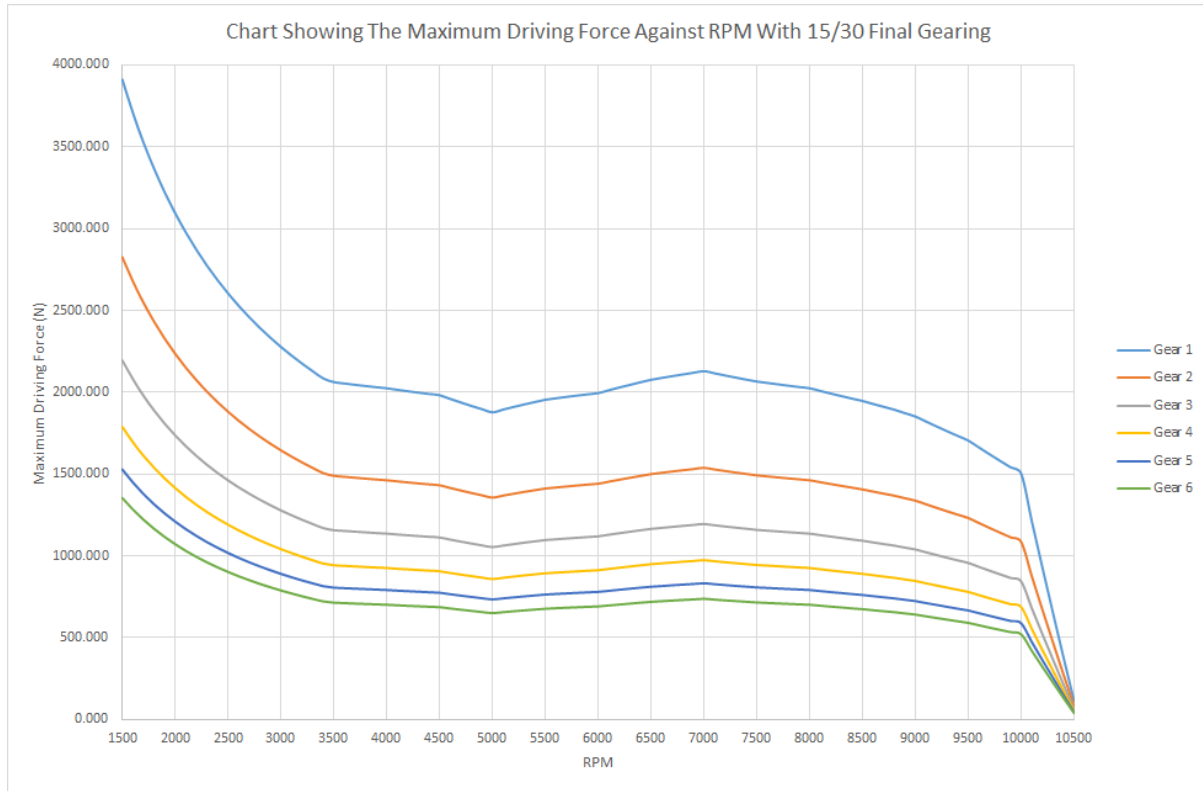


Figure 11 Driving force against RPM with different gearing

Braking Force

The braking force is the forces that the motorbike can apply whilst it is decelerating, the assumptions that are made for the braking force is that during braking 100% of the load is expected to be on the front of the motorbike leading to the maximum braking force possible. This is an accurate representation of the braking force and in future developments this variable need altering however for the sack of the simulation this assumption was made. The braking forces are calculated by using the formula below.

$$F = Nf - \frac{mgb}{h}$$

Table 3 Braking Force

Symbol	Meaning	Units
F	Braking Force	N
Nf	Load on the front wheel	N
M	Mass of the motorbike	Kg
G	Gravity	m/s ²
B	XCoG location	Meters
h	YCoG location	Meters

As this formula shows it clear that the centre of gravity has a large effect on the results of this particular variable and is therefore a reason to calculate this variable properly. Below is a series of charts that show the braking force against RPM for each gear as the variable Nf is dictated by the driving force which changes with the RPM and gears. For these two charts one has had the centre of gravity for both X and Y changed to demonstrate this difference. The original values are 0.76 meters for the XCoG and 0.567 meters for the YCoG, these are the values used in the first chart the second chart has both the X and Y centre of gravity values at 0.5 meters as an extreme case to show the differences and how they impact on the forces that they dictate.

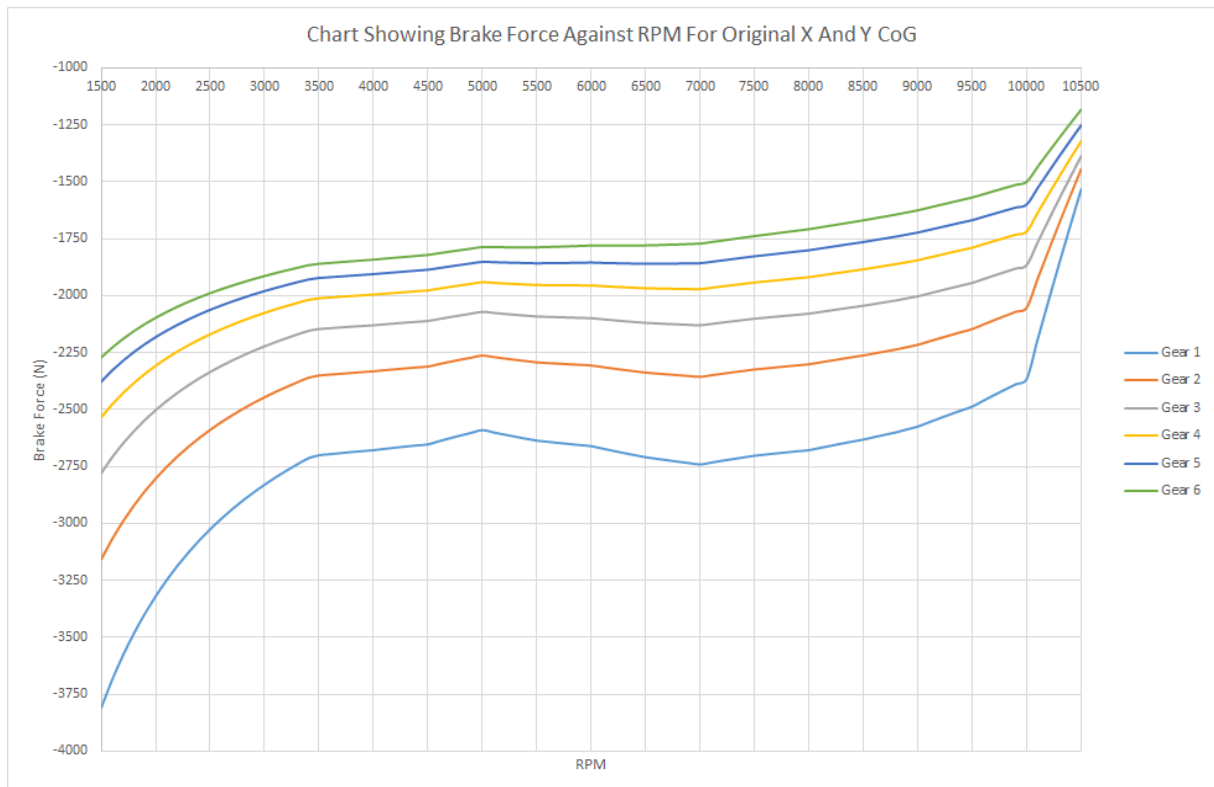


Figure 12 Brake force against RPM with standard CoG

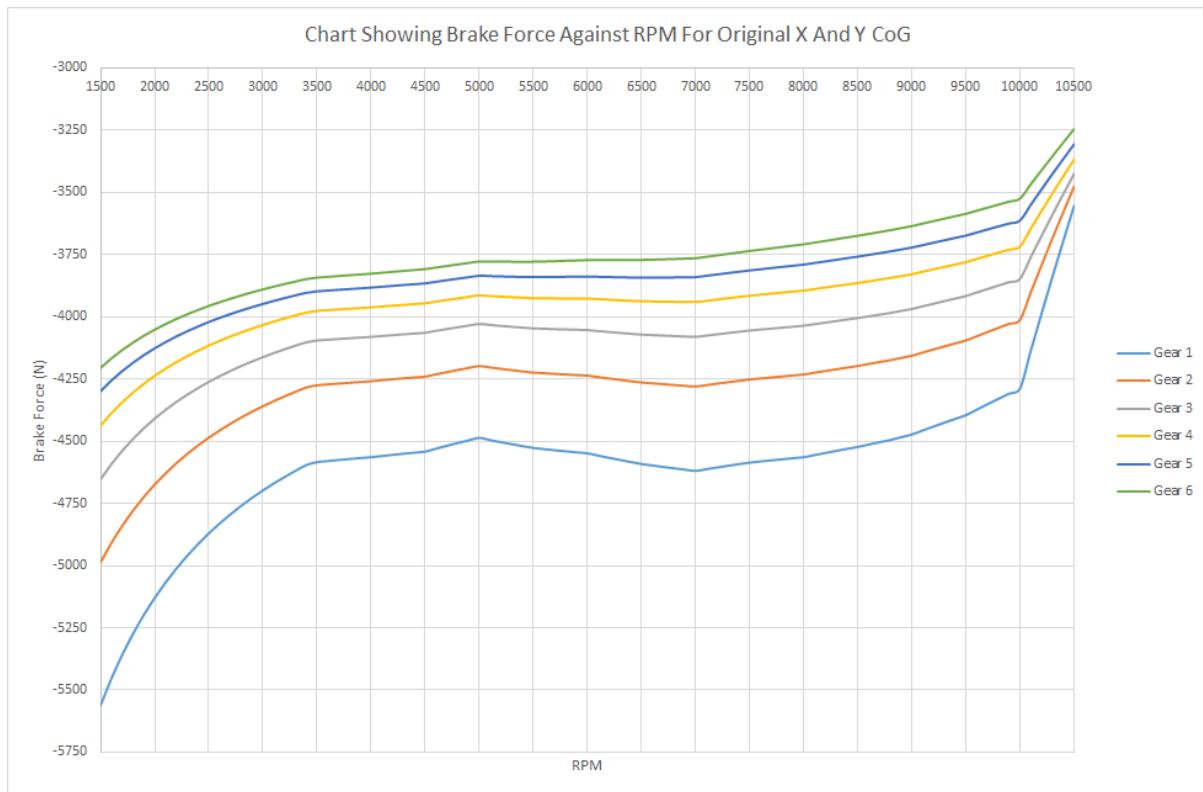


Figure 13 Brake force against RPM with different gearing

As the charts show there is a drastic difference in the braking forces when these two variables are change. The forces are all negative and this is to be expected as it's a reductive with the intent of reducing the speed of the motorbike so therefore it should be a negative force. However when viewing the chart with the X and Y CoG are the same these values are much higher that the values that were used in the simulation. In fact the lowest value for this graph is -3245 N which when looking at the actual chart the highest reading is -3807 N. the differences in these variables clearly show why it is important to understand the centre of gravity and to calculate it correctly. Of which many researchers change the centre of gravity to change the characteristics of the motorbike or vehicle to what the user desire for the best possible outcome. In this sense it would be worth testing to determine how the changes in wheel base or load transfers could affect the centre of gravity and in turn affect the dynamics of the motorbike and how it will operate. These values would be difficult to produce in the real world as this would be a manufacturing process however to further understanding looking at this by using various simulation would still produce results that are worth studying.

The load that is applied to the front of the motorbike is called N_f and this is the only variable that is accounted for when load transfer is conserved as the load on the rear (N_r) is assumed to be 0 for

maximum braking force, this is the key assumption that is made when creating the simulation as the load transfer is assumed to be 100%. The formula below depicts how the load on the front of the motorbike was calculated and as show the centre of gravity variables return to demonstrate the importance of this variable.

$$Nf = mg \frac{b}{p} - S \frac{h}{p}$$

Table 4 Frontal Load

Symbol	Meaning	Units
S	Driving Force	Newtons
P	Wheel base	Meters

This formula dictates the braking forces and other parameters of which when it comes to the driving forces the resistive forces have already been accounted for to give a more accurate figure. The only resistive force that has not been accounted for is the forces from the gradient change as that refers to the lap time simulation and will change dependant on a meter by meter bases not an RPM figure.

Section 3 Resistances to motion

Understanding the forces that are acting against the motorbike is a key feature and in understanding these forces then an accurate picture can be made of the motorbike and how it operates. There are many forces that act against the motorbike such as drag force and many of these forces have been taken into account when creating this lap time simulation, however in regards to corners this is not the case as assumptions have been made when calculating corners, the speeds at which they can be taken and the time it will therefore take to complete the corners.

The main formula used is the formula for acceleration which is below.

$$F=MA$$

This formula uses both the mass and force to calculate the final acceleration, this is the reason resistive forces must be calculated and understood as they are directly influential on the final acceleration value. The resistive forces are primarily a negative value however understanding the formulas this might not be the case. An example is resistive force due to the change in gradient,

although considered a resistive force that doesn't mean the value is negative due to the fact that if the gradient decreases then the value is positive.

Aerodynamic Resistance

This resistive force is a force that is the air or wind resistance acting on the motorbike during operation. This force is a key feature and is dictated by many factors such as the velocity of the motorbike.

$$Fd = \frac{1}{2} \rho CDA v^2$$

Table 5 Drag Force

Symbol	Meaning	Units
Fd	Drag Force	Newtons
ρ	Air Density	kg/m ³
CD	Coefficient Of Drag	
A	Frontal Area	m ²
v	Velocity	(M/Sec)

Above is the equation to calculate drag force which was used in the creation of the lap time simulation. What this equation shows is that as velocity increases so too does the resistive forces that are at work. The values of the coefficient of drag and air density also change however with this simulation they have been kept at a constant. These values will change especially with altitude however as the chart below which shows how the air density changes with altitude it is simple to see that this value doesn't change a great deal with the altitude changes that are being operated on.

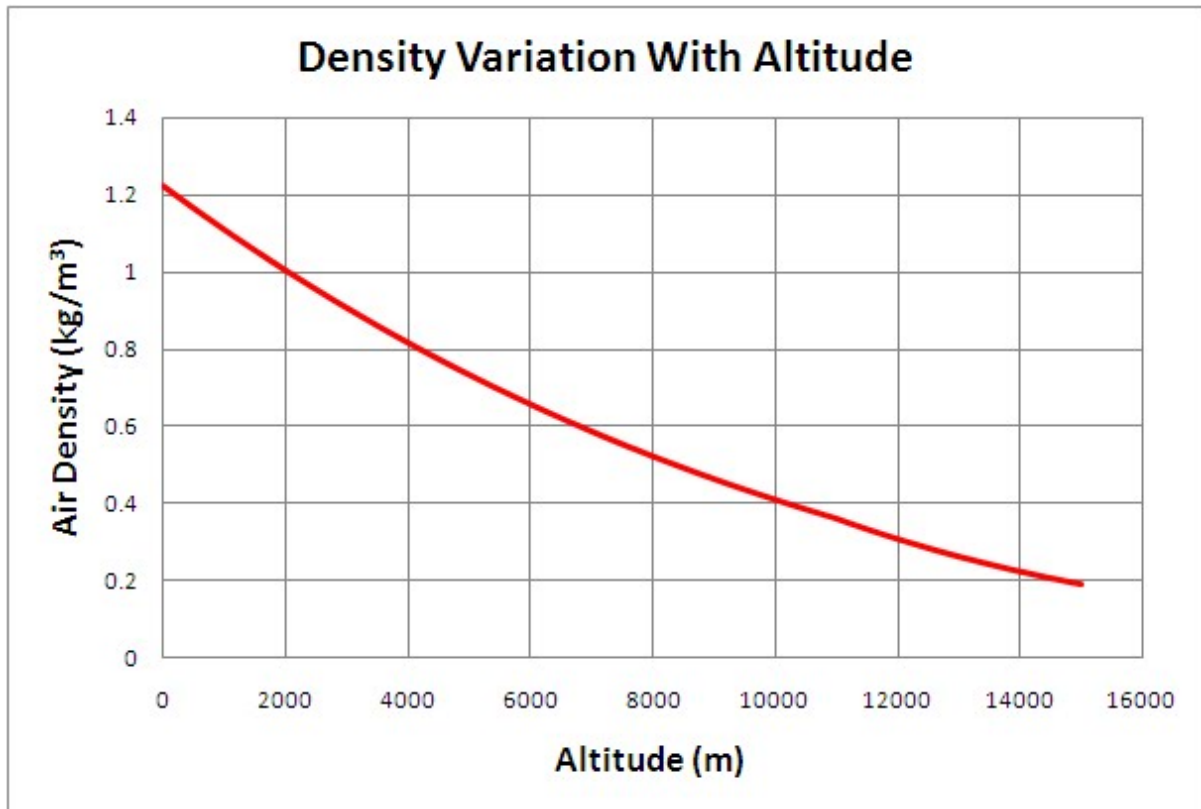


Figure 14 Density Change

As this chart shows there is a minimal difference between values when considering the air density and hence the reason for keeping this value a constant. For furthering this project this value for air density will be changed and analysed to further the accuracy of this simulation. The formula that would be used is below.

$$\rho = \frac{P}{R.T}$$

Table 6 Air Density

Symbol	Meaning	Units
ρ	Air Density	kg/m ³
P	Air Pressure	Pascals
R	Specific Gas Constant	Kg.K
T	Temperature	Kelvin

This formula has many changing variables of which when it comes to accuracy could be interpreted differently, for example the temperature which is a vital variable is continually changing so having an

assumed value might be the best decision. However to further this to gain an accurate result would be to base the simulation on an existing race and rider and from this discover the temperatures and pressures that were experienced on that day. This would show how accurate this simulation could be as it would be infused by an existing race and lap time with simulated conditions.

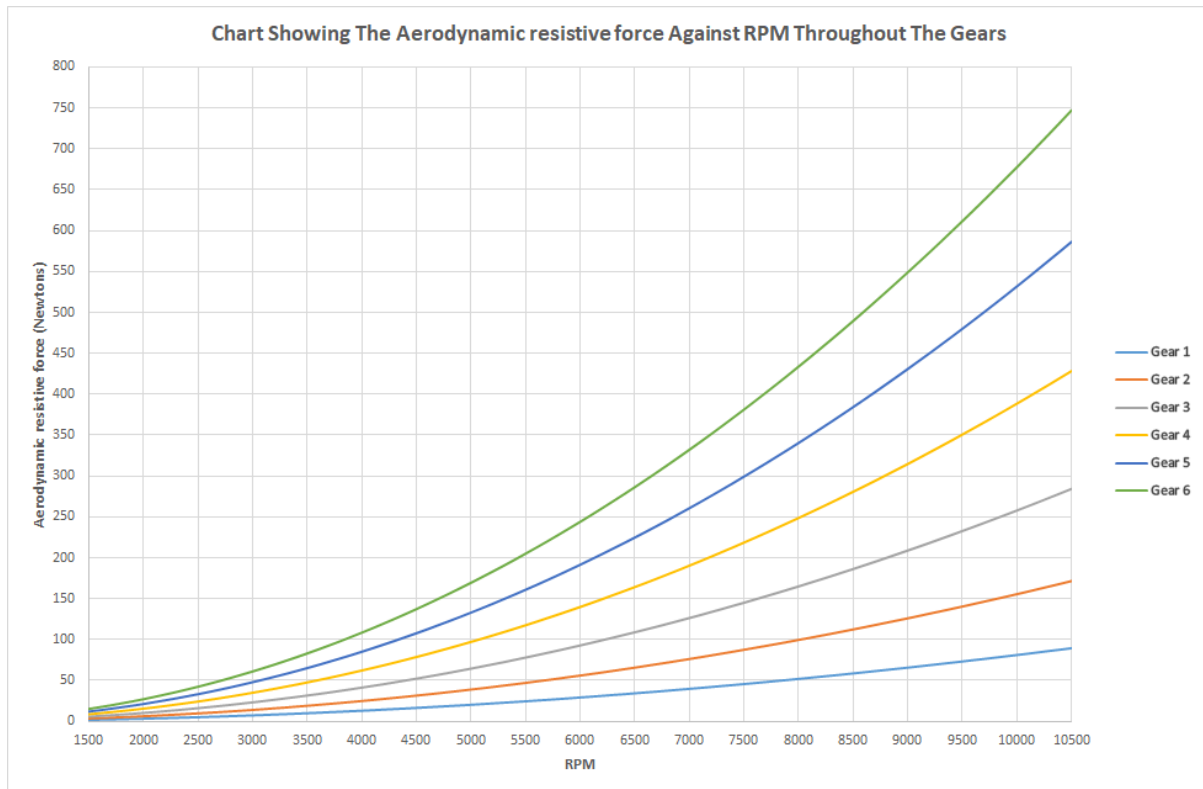


Figure 15 Drag force against RPM

What is shown in the chart above is the change in the drag force (F_D) in relation to RPM of each gear. What the charts show is that as the velocity increase so too does the drag force. Equally below there are two sets of three charts one set were each chart has a different air density value (ρ) to demonstrate how much of a difference this value makes when understanding this value. The 3 are 1.1 kg/m^3 , 1.2 kg/m^3 and finally 1.167 kg/m^3 . 1.167 kg/m^3 is the value that was used in the lap time simulation the other two values were chosen to demonstrate this change in drag force however as stated this change is unrealistic for this simulations. The second set of charts is the change in the coefficient of aerodynamic resistance or drag coefficient. The value used in the simulation was 0.7 the two other values that are displayed below to gain an understanding of how this value changes the results are 0.4 and 1. These were chosen as to demonstrate this change and equally to gain an understanding at how much of a difference these values could make to the final results.

Figure 17 Drag force against RPM with lower CD

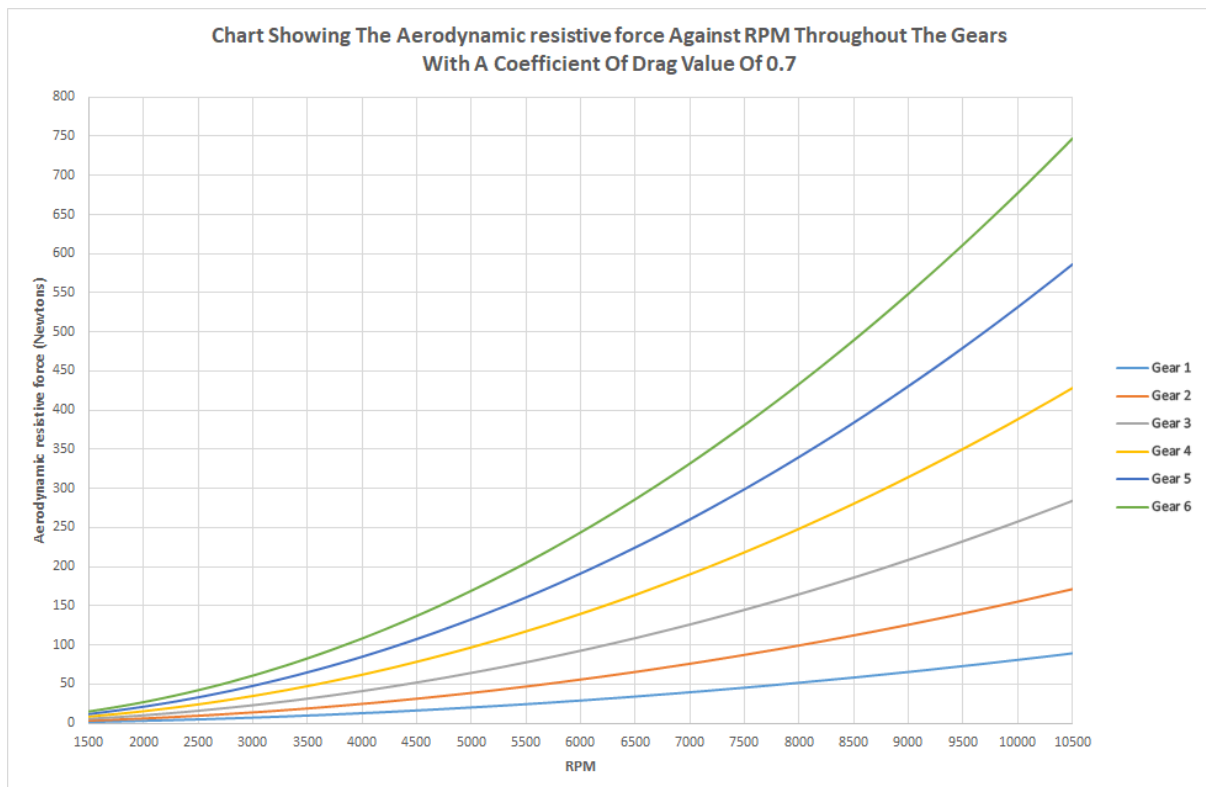
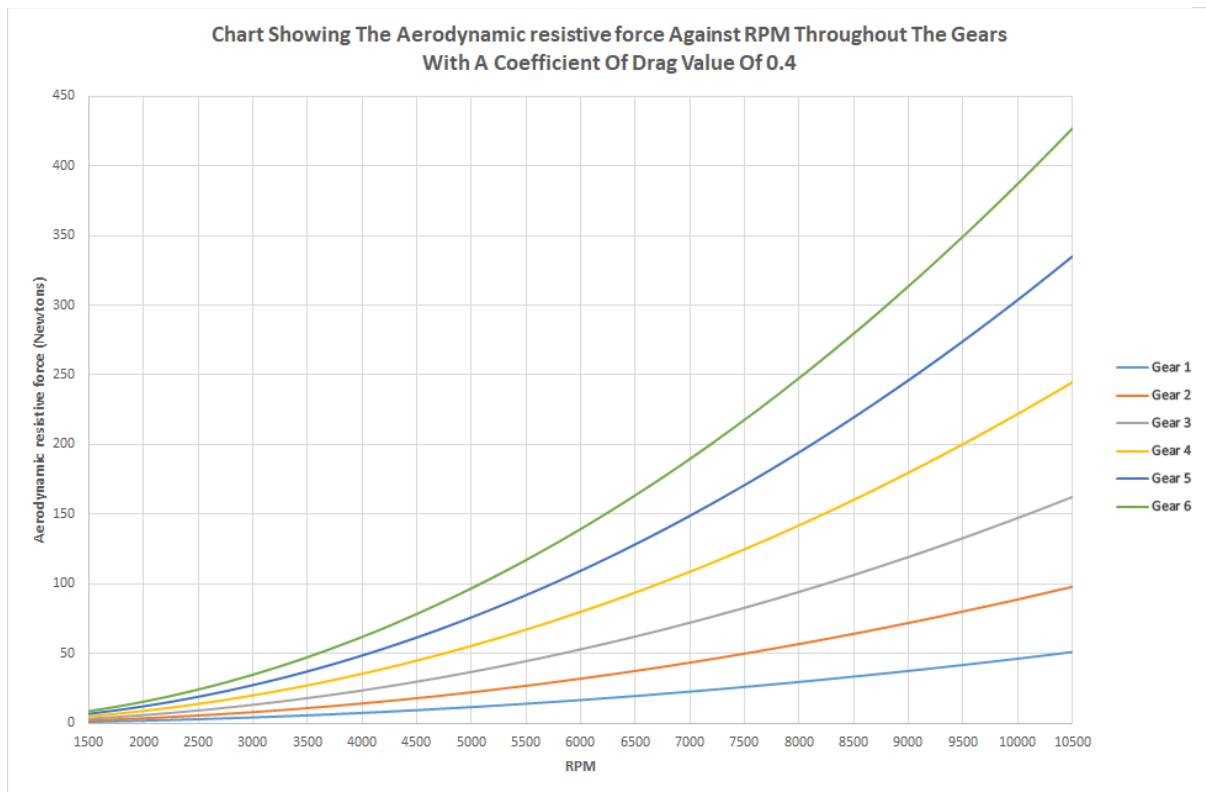
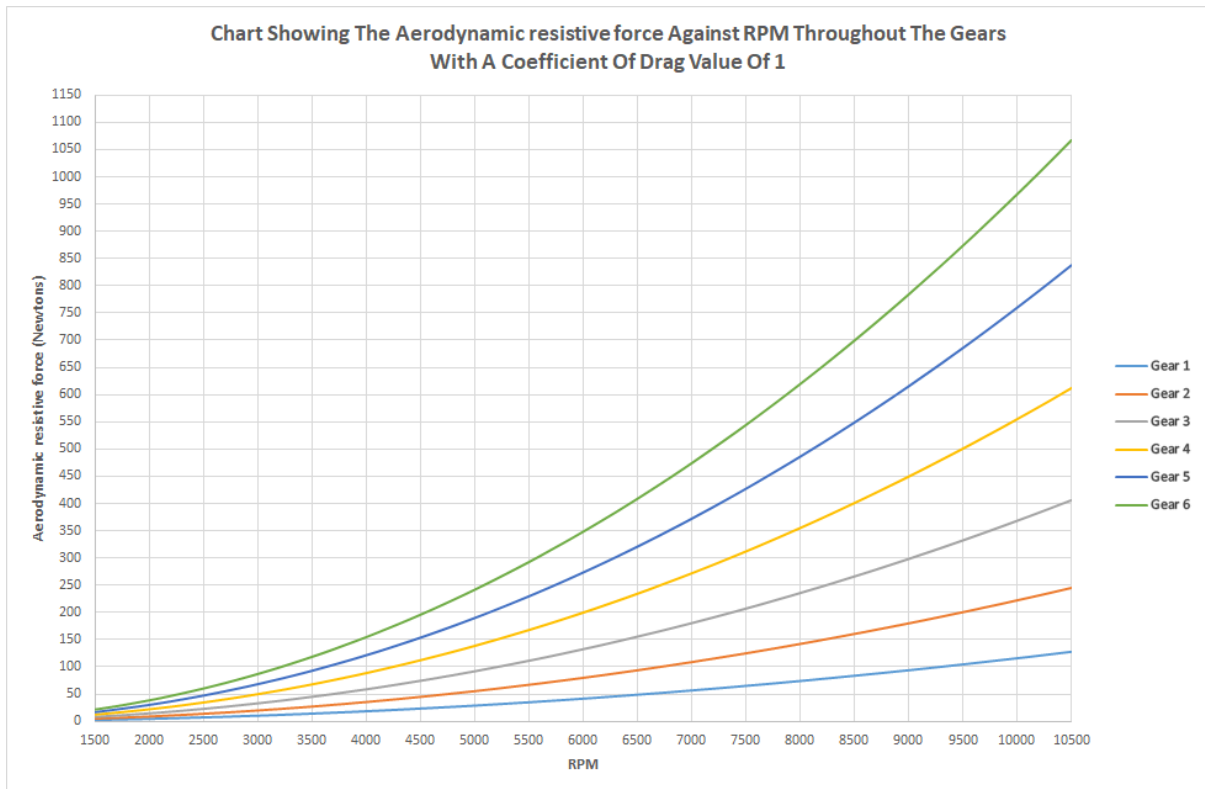


Figure 16 Drag force against RPM with standard CD

Figure 18 Drag force against RPM with higher CD



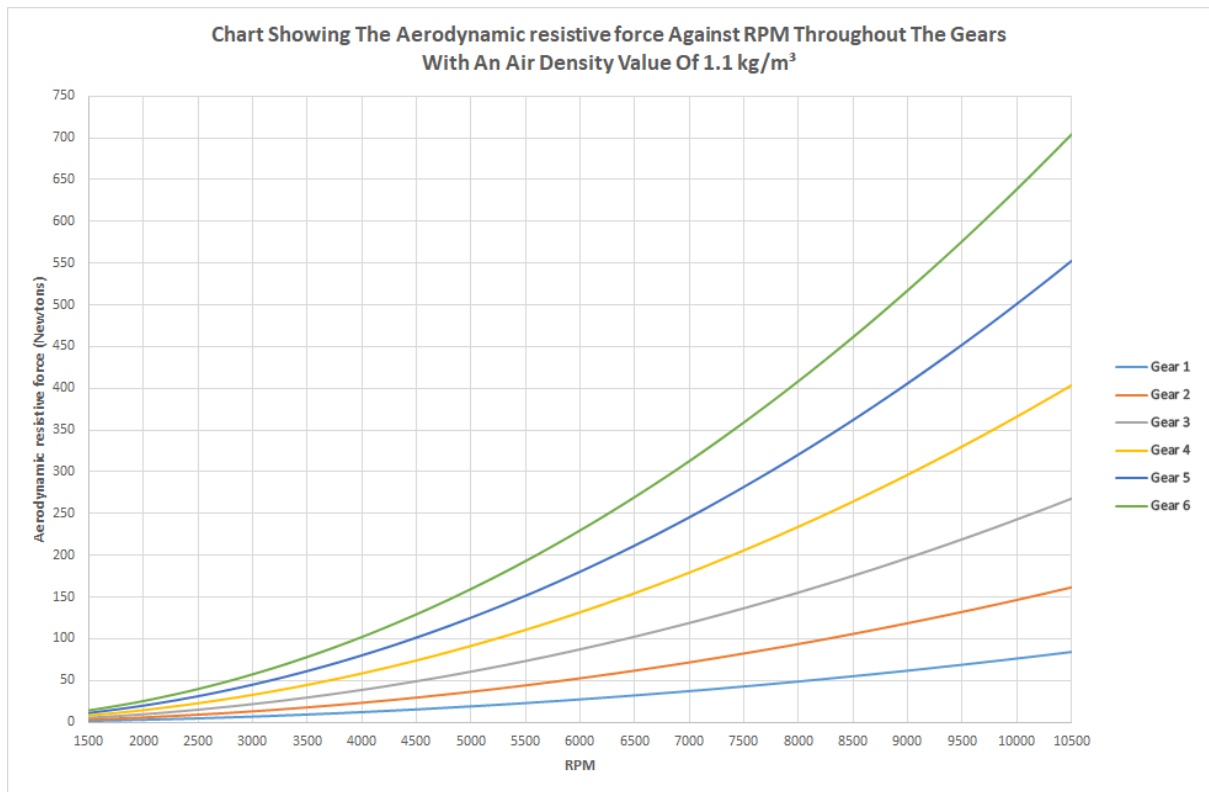


Figure 19 Drag force against RPM with lower p

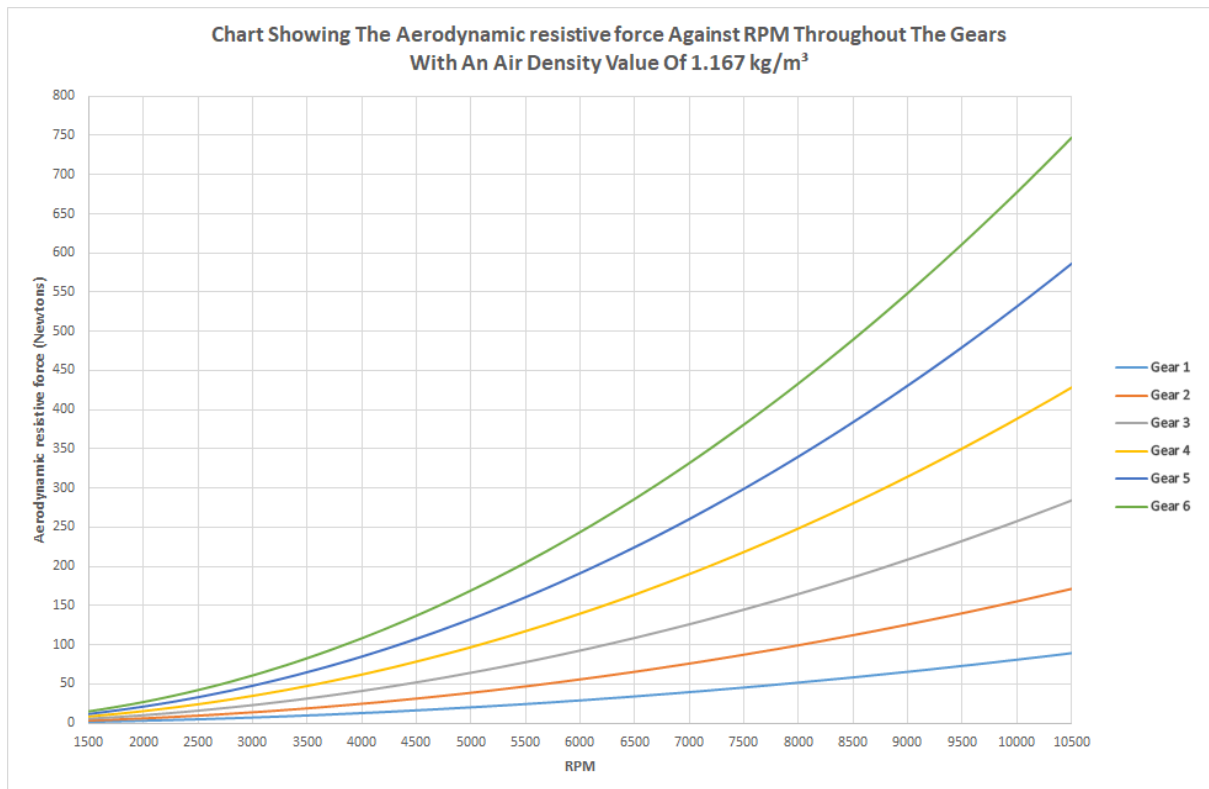


Figure 20 Drag force against RPM with standard p

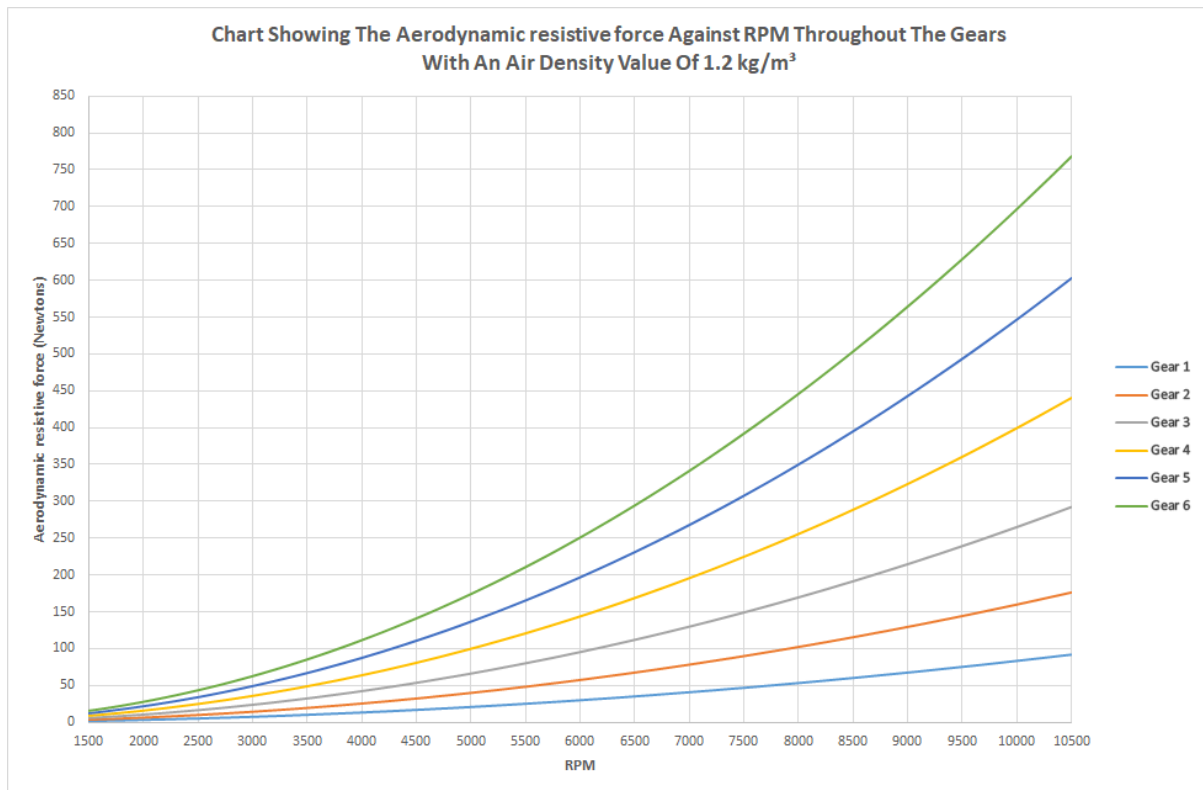


Figure 21 Drag force against RPM with higher ρ

When looking at the first set of graphs which has a change in air density there are slight differences as shown in the 1.2 kg/m^3 having the highest value and 1.1 kg/m^3 has the lowest which was to be expected however the change is minimal and as shown below is a table showing the changes in the air density with numbers to demonstrate this minimal change. This was the main reason why this value wasn't changed during the creation of the simulation and why this value was assumed to be 1.167 kg/m^3 . However to make a more realistic and accurate simulation these changes would be considered no matter how small. This is because even a small value can cause a great difference in the end.

Looking at the changing in results caused by a change in the drag coefficient it is clear that this holds a greater change in regards to the final drag forces that are acting on the motorbike. This shows the level of importance in studying and understanding this value and how changing it can greatly influence the outcomes of the results. The value used for the coefficient of drag is an estimated figure of 0.7 so to further the accuracy of this project a study would be conducted to determine the actual value of the coefficient of drag and how this in turn might change with the varying factors such as air density. This can be done in many different ways however when it comes to the design of

the motorbike then using either a computational method to design the motorbike and either 3d printing a scaled down model and using a wind tunnel rig to determine the values for drag or using a computational program to simulate this process to then gain values for this variable.

Gradients

The gradients have been taken into account when creating this lap time simulation and from this have produced interesting results. The gradients had to be considered when creating this simulation as to make it more accurate and to understand how much of a difference this factor makes. This has been done in a set of charts below which show one lap being done without gradients and another with. The reason for this accountability is due to the forces that will act on the motorbike due to this change in gradient. The formula for this is below.

$$FP = m \times g \times \sin\theta$$

This formula which shows what the change in the resultant force is due to gradient is a vital piece of information however to identify θ (angle A in figure) trigonometry is required and the figure below shows this process. The value for the adjacent (b in figure) is always 1 for this simulation due to the calculations being done in a meter by meter by meter process and has therefore been accounted for however when looking at the value for the opposite (a in figure) some assumptions are made. These assumptions refer to the tools ability of producing values that can be analysed. As an example a straight of 200 meters when using this tool is difficult to measure just 1 meter therefore the values have been averaged to accommodate this fact.

$$\tan \theta = \frac{a}{b}$$

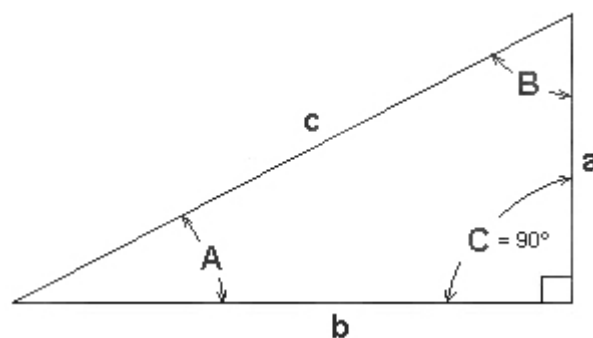


Figure 22 Triangle

The forces that are produced by the gradient will change throughout the course of the track and will affect the characteristics of the motorbike in different ways dependant on how the change has taken place. To demonstrate this, below are three graphs one that depicts the acceleration through the RPM of the motorbike without the change in gradients and two with a positive and negative change of 50 Newtons implemented by the change in gradient forces.

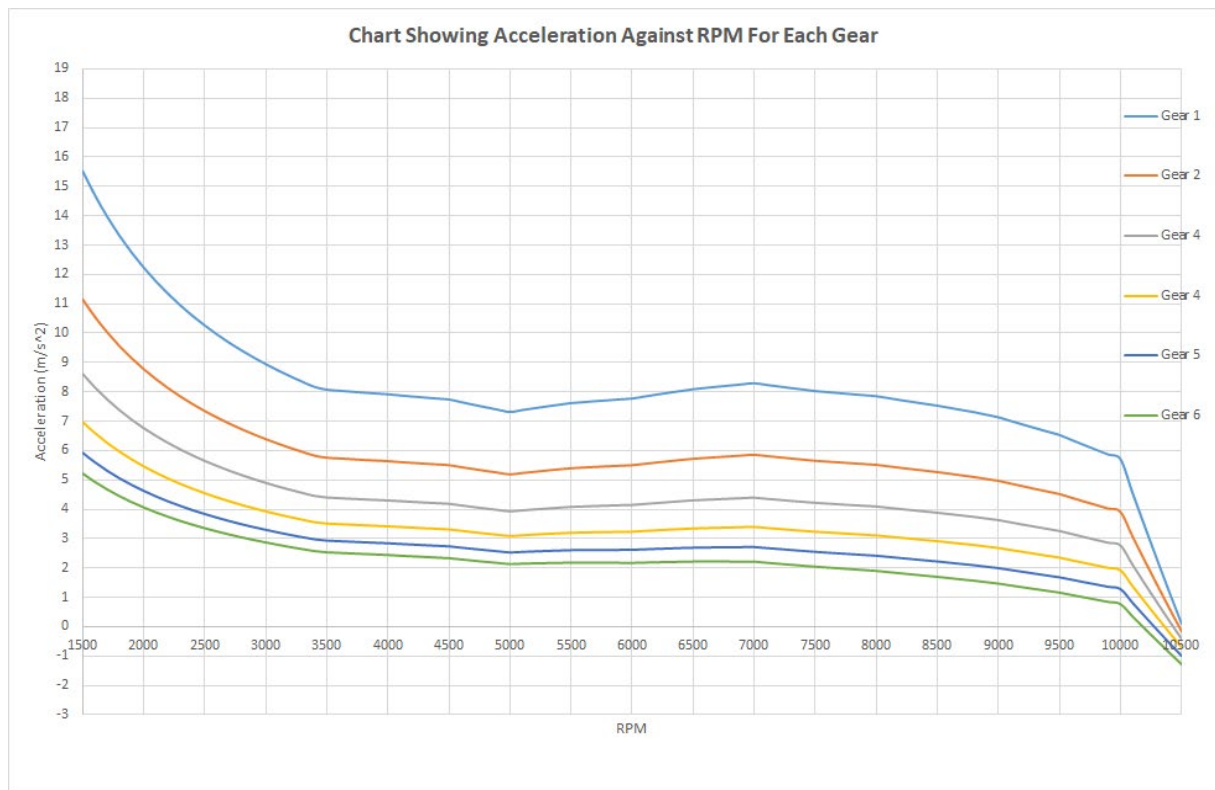


Figure 23 Acceleration against RPM

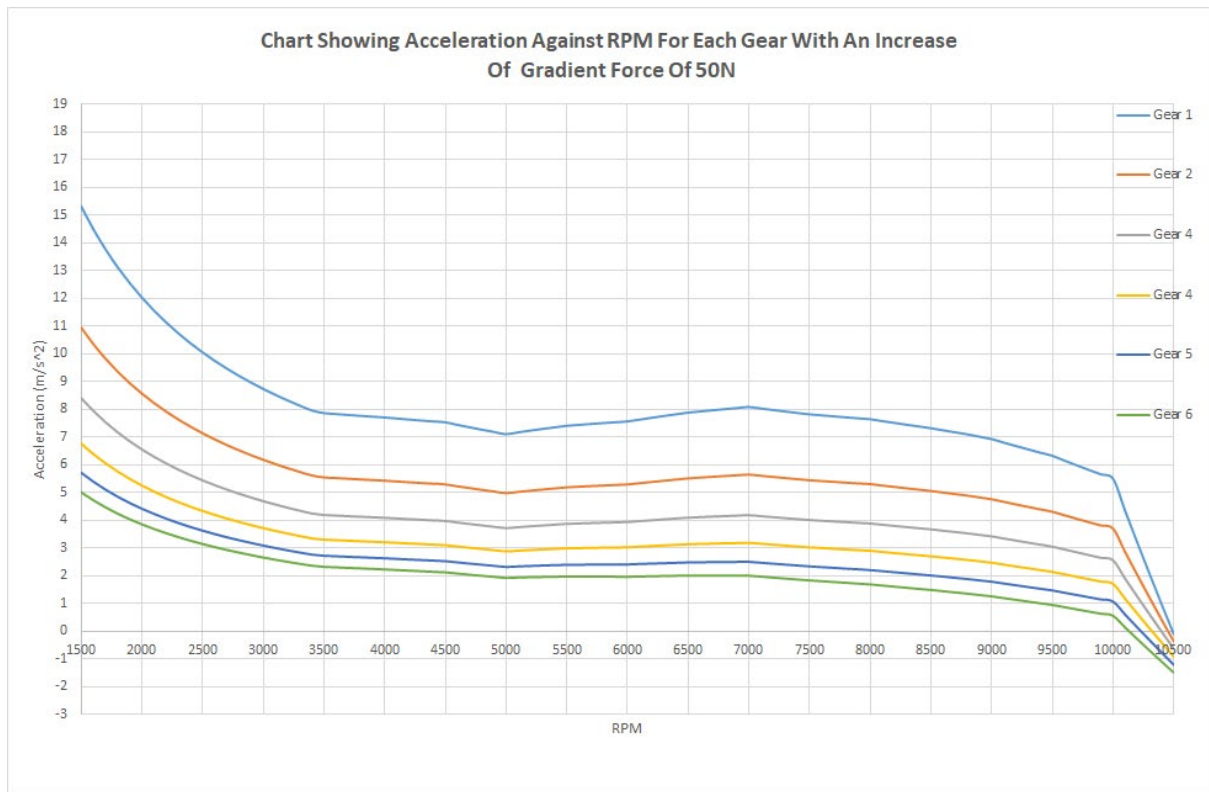


Figure 24 Acceleration against RPM With increased gradient

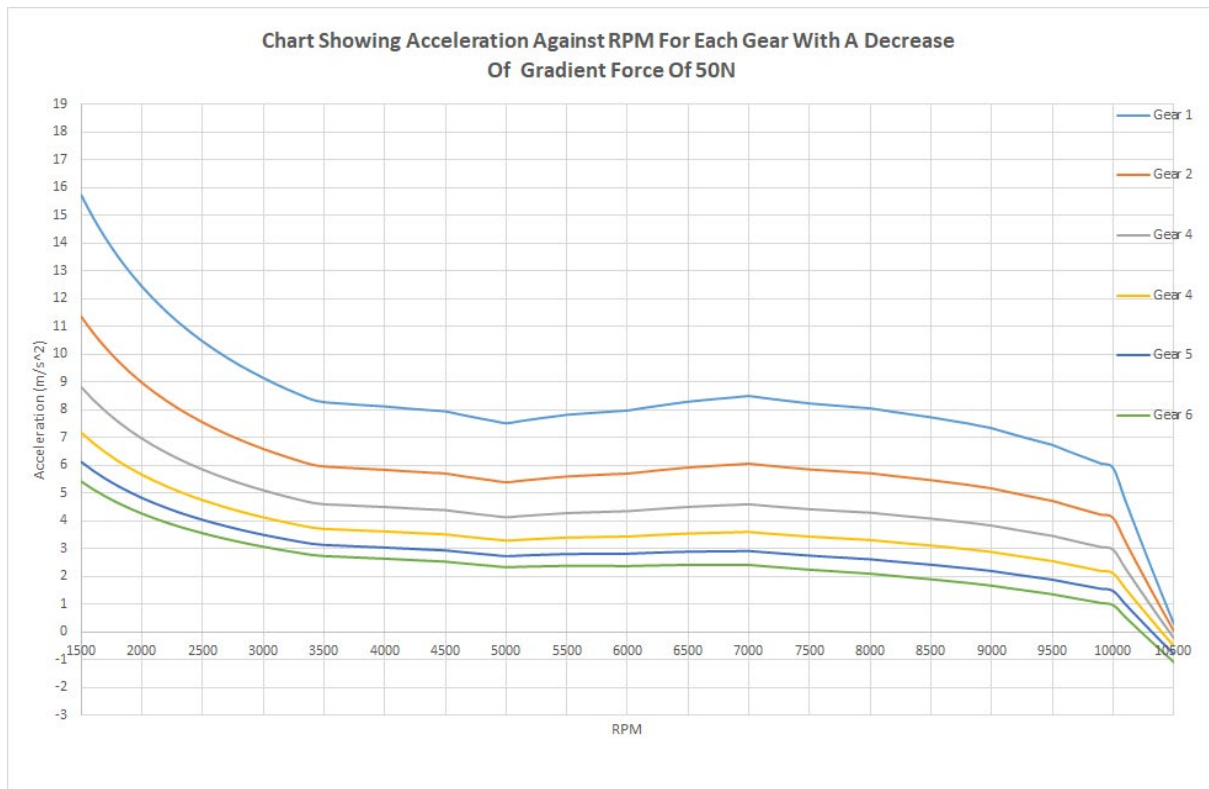


Figure 25 Acceleration against RPM with decreased gradient

The results of these charts produce interesting results in the sense that it shows how much the gradient can and will change the acceleration values of the motorbike and how the understanding of these forces is required. The changing of the gradient throughout the race varies from meter to meter as some stages of the race the gradient change is harsher than at other points. This is something to consider as the tool that was used to gather these values as stated couldn't do a meter by meter account. What is of interest is the final stages of each RPM as when the gradient forces are increased then as a result more of the higher RPM readings are negative giving a negative acceleration value. This is interesting as this has also been shown in the creation of the simulation with the changing of gears to suit the gradients or situations that the simulation has produced. This again refers to the interpretation of the results as they will differ from user to user which will produce different results as a result.

Below is a chart that shows the changes in gradient throughout the race and for the first 10000 meters, this was done to demonstrate the structure of the lap and how the forces can change drastically dependant on how the gradients have changed.

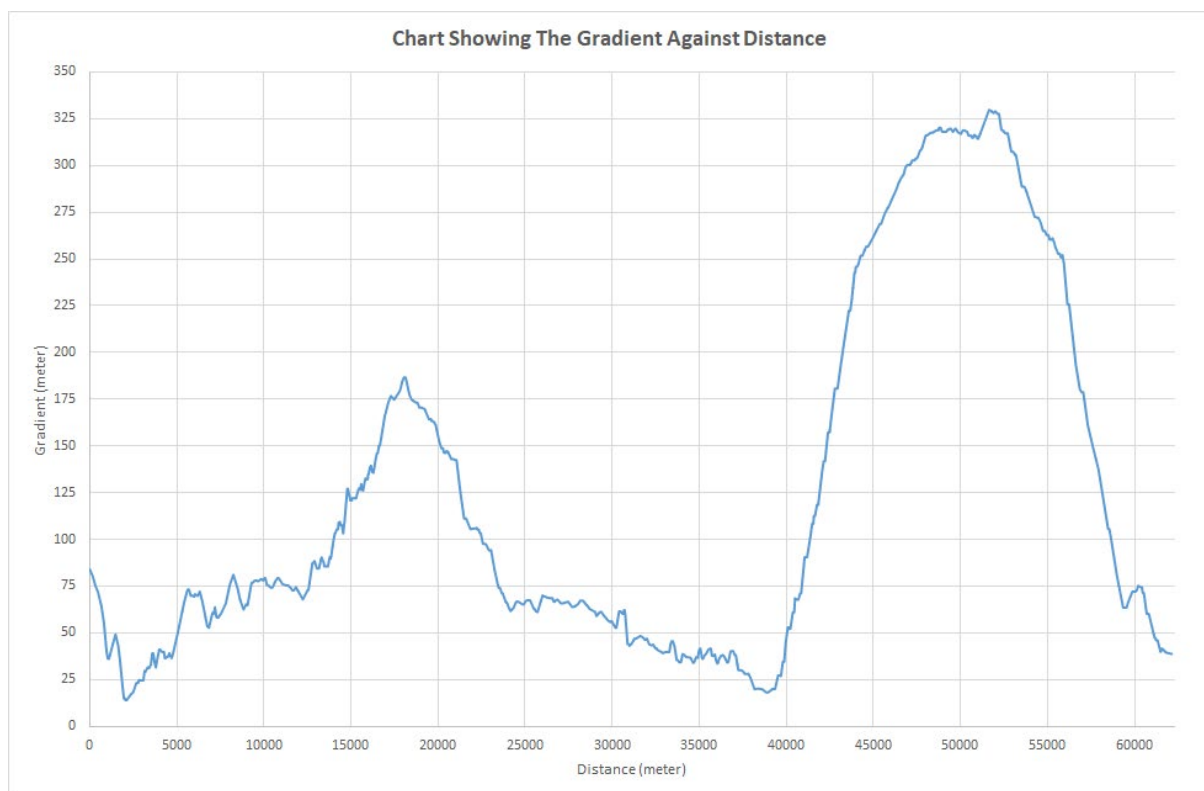


Figure 26 Gradient change throughout the lap

When looking at the chart of the full lap it shows that the highest point is 329 meters however when looking through the values manually it shows that the highest point is closer to 430 meters. Equally when looking at the end of the race the gradient is 38 meters which is a lot lower than it was at the

beginning of the race. This is due to the fact that the gradient changes through the corners aren't considered. This shows the level of difference that this makes and how much of a difference they can make when assumptions are made. Understanding these forces that are implemented in corners and how they change the outcomes is a vital component therefore to further the research of this project the assumptions made on the corners in regards to the gradient changes should be considered equally a more accurate program that can measure the changes in the gradients to a meter by meter process should be implemented to gain accurate results and to remove the averages and assumptions that have been made.

Rolling Resistance

The rolling resistance is the resistive force it takes for a wheel to overcome the force it takes to roll, this is due to the deflections in the tyre as shown in the figure below.

This is a minor resistive force and always present as the formula below shows there is no change in the variables with the 0.02 representing a common rolling resistance coefficient. This value however is also dictated by the speed at which the vehicle is traveling and is therefore an import variable to study. Knowing that this coefficient is variable with speed to further the simulation this variable will need analysis done to understand how this parameter changes and how much speed will actually affect this value. As stated below is the formula used and the value at which the simulation used as the mass (m) was 242.617kg and the force of gravity (g) was 9.81 m/s.

$$F_w = 0.02 \cdot m \cdot g$$

$$F_w = 0.02 \times 242.617 \times 9.81 = 47.21 \text{ N}$$

This value has remained as a constant value throughout the course of this simulation but as stated the rolling resistance coefficient does change with speed as demonstrated in the table below depicting this change when Cr is the representation of the rolling resistance coefficient in this example.

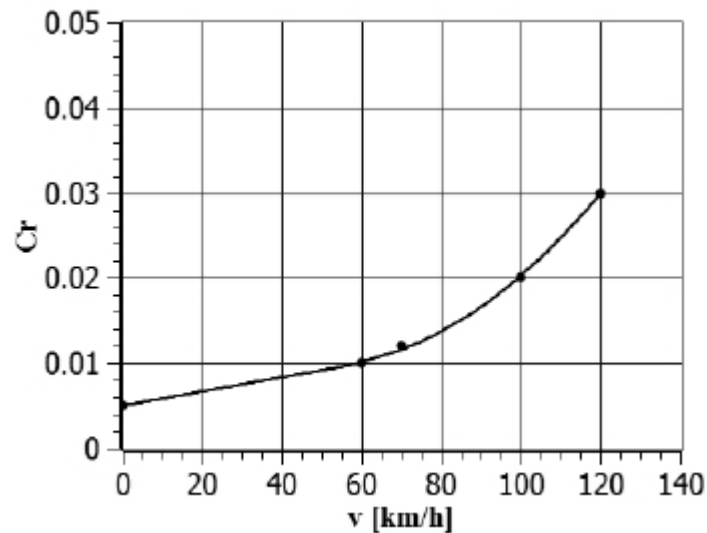


Figure 27 Change in rolling resistance coefficient against velocity

Lap Time Simulation

The lap time simulation comprises of a meter by meter account totalling over 62000 meters of calculated distances also almost 12000 meters of this track is considered a corner due to the layout of the course and how the map has been read and interpreted. This is an important aspect as reading and understanding the map and its layout will differ from person to person, this primarily refers to how a user might interpret the best race line for the riders to take to create the fastest time or to simulate an existing race line that a rider has done already to fully understand what that rider is infused by. What would be interesting with this layout is that by implementing an existing rider and how they have ridden this track would be that by completing this simulation the human factor would be this rider's influence and would therefore show how different a simulation is to the real rider and how much of an influence this makes.

Map

The initial steps in creating this simulation is to create the track its self. As no GPS data was used the layout of the track was instead designed using google earth. This tool was used as it allows the user to design a route dependant on the user's desires. This is a great advantage in regards to designing a racing track layout as a race line could be determined from the user's ideas and what the user believes will produce the best results for the outcome of the race. What this tool also provides is a display of the total distance of the sections that have been created in whatever units are required equally it allows the user to visualise the changes in gradients throughout the sections. In this case when it comes to calculating the resistive forces that are implemented due to the changes in gradients, this is how these values were obtained. As shown below is the layout of the track with 15000 meter labelled intervals.

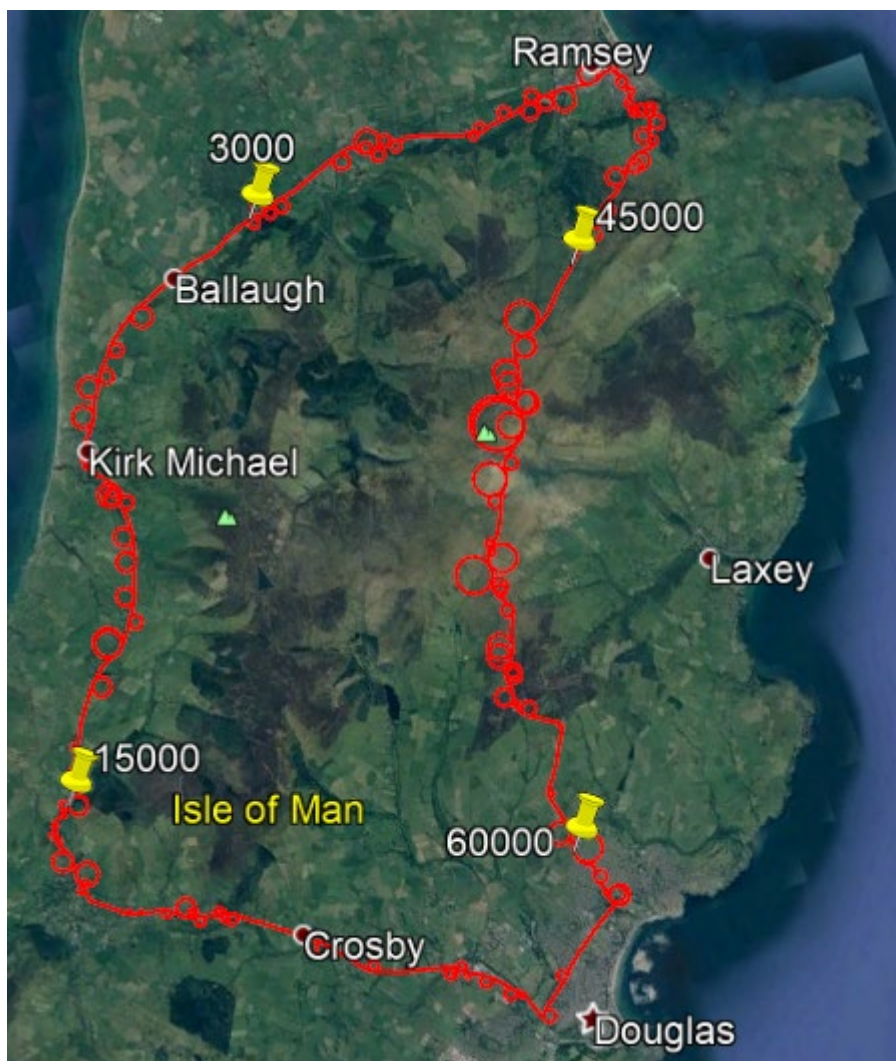


Figure 28 Isle of Man TT lap layout

The figures shown below are of both a straight and corners and how the distances and gradients were measured. This shows how the change in gradients were obtained and how the distances of the corners were also obtained as these were designed using circles during the creation of this simulation.



Figure 29 Isle of Man straight distance and gradient

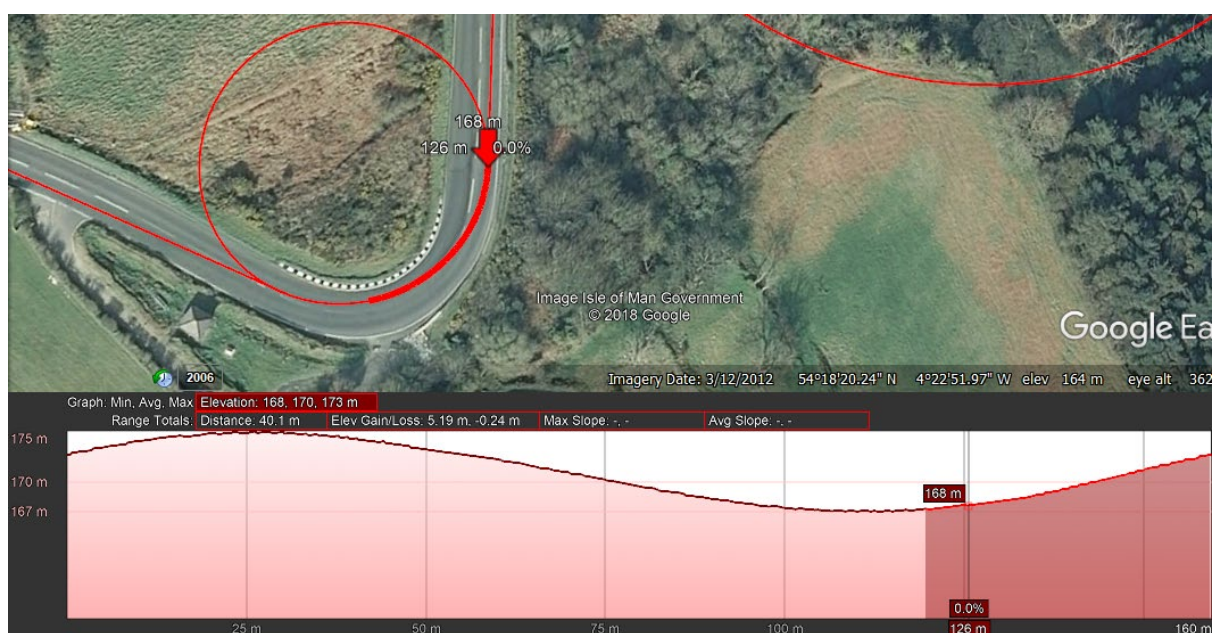


Figure 30 Isle of Man corner distance and gradient

Straights

The straights are fairly straight forward as they use the same formula throughout and are divided into two sections, acceleration and deceleration. These use two different sets of forces such as the driving forces and the braking forces that are calculated using the formula in the tables below. The ration between the two sections is around 2/3 acceleration and 1/3 deceleration, however in some circumstances these ratios have been changed due to the distances between corners and how the best speeds of these corners is to be obtained. The straights in this lap time simulation were also designed around the idea of using the best race line that could be obtained therefor it might not be what a rider can achieve however it is based on the best theoretical race line that is achievable.

$$V = \sqrt{u^2 + (2 \cdot a \cdot s)}$$

Table 7 Final velocity

Symbol	Meaning	Units
V	Final Velocity	m/s
U	Initial Velocity	m/s
a	Acceleration	m/s^2
s	Distance	Meters

As the formula shows the straights are simple to calculate but when it comes to the creation of the simulation it is just a case of trial and error to obtain the ratio between acceleration and deceleration per straight as each straight has different circumstances. Below is a table that shows the total distance covered by the straights, the maximum speed that is reach and the average speed for the entirety of the race. This has also then been compared to a real rider to show how different the calculations are when compared to that of the real riders and to further show that there is a difference.

Table 8 2 times

	Time (Minutes)	Average Speed (mph)
James Hillier	18.44	120.84
Full Simulation	23.38	103.5

Corners

In regards to corners there are several assumptions that have been made when creating this simulation. This is in regards to the speeds, resistances and the time taken to complete these sections of the lap. Primarily when it comes to the corners it is assumed that the speeds are constant, this means that there is no acceleration nor deceleration through them. Equally with regards to the changes in gradients, it is also assumed that the motorbike will be operating to keep this set speed for the corners and will therefore under assumption will accelerate or decelerate to equalise the change in resistive forces created due to the change in gradient. The final assumption that has been made is that the lean angle at which the corner is taken of 45 degrees. This is constant and instantaneous and has been included to be the best lean angle for operation. As these assumptions have been implemented on all corners it is also something to note that although some corners have been calculated to be able to be taken at higher speeds however this speed couldn't be achieved due to the straights not being long enough to either decelerate fast enough to the next corner or accelerate into the corner, the assumption that acceleration or deceleration do not occur is still in play. This means that although higher speeds could be obtained they will however not be as the assumptions have been implemented on all corners. They will have a constant speed but not the highest constant speed that could be taken in these corners. Below is the formula that is used to calculate the speeds of the corners, the time taken and as a theory the most affective lean angle that could be taken on a corner.

$$\theta = \tan^{-1} \cdot \frac{V^2}{r \cdot g}$$

This formula is then rearranged to find the velocity (v) giving:

$$V = \sqrt{\tan(\theta) \cdot r \cdot g}$$

By using this formula with an assumed constant lean angle (θ) of 45° then this formula can be used in unison with google maps to generate the radius of each of the corners to discover what the maximum velocity is that can be achieved on this particular corner as an example when:

$$\theta = 45^\circ$$

$$r = 50 \text{ meters}$$

$$g = 9.81 \text{ m/s}^2$$

Then using the formula above the following is produced:

$$V = \sqrt{\tan(45) \cdot 50 \cdot 9.81}$$

$$V = 22.15 \text{ m/s}$$

Final Lap Times

Below are a series of charts that show the differences between two simulations that have been done. These two simulations are the one that has been stated with all the forces implemented to create a more accurate simulation, the other is a simulation that was done that has no traction restriction and equally no gradient forces are implemented. This is show how different these two parameters are and how adding more forces to create a more accurate result will affect the final outcome and how much of an affect theses parameters have. The charts are the full laps, the first 10000 meters and the acceleration values. These with give a clear comparison into the differences between the two simulations and the importance of using the actual forces instead of assumptions.

Minimal Resistive Forces Lap

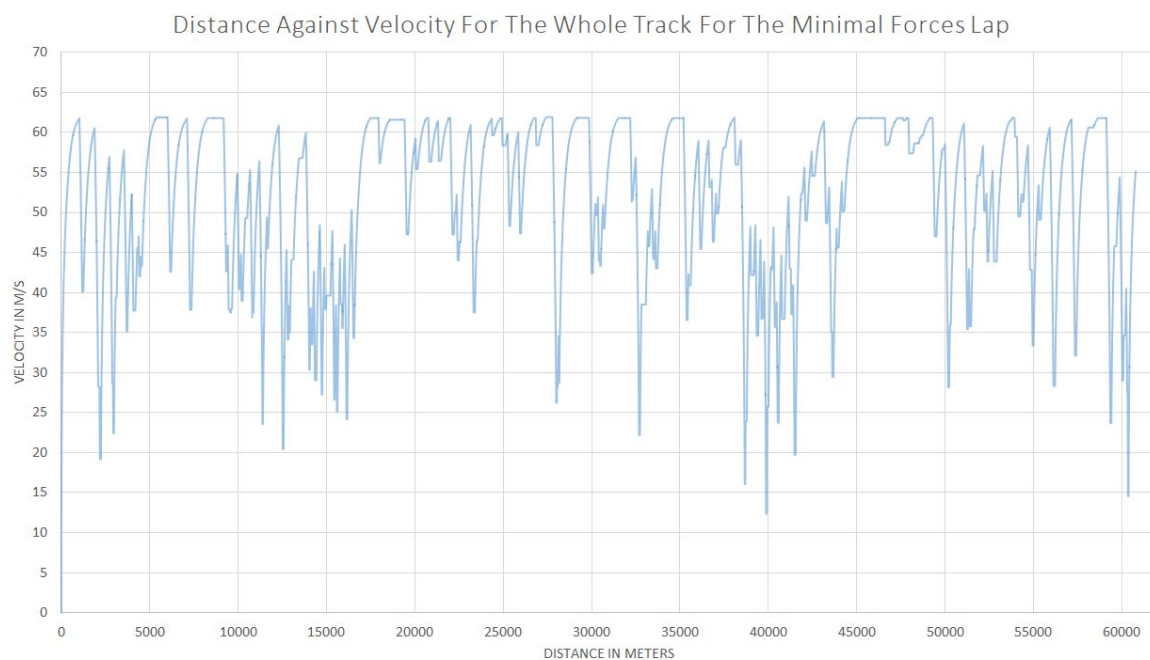


Figure 31 Velocity against distance for entire lap for minimal forces

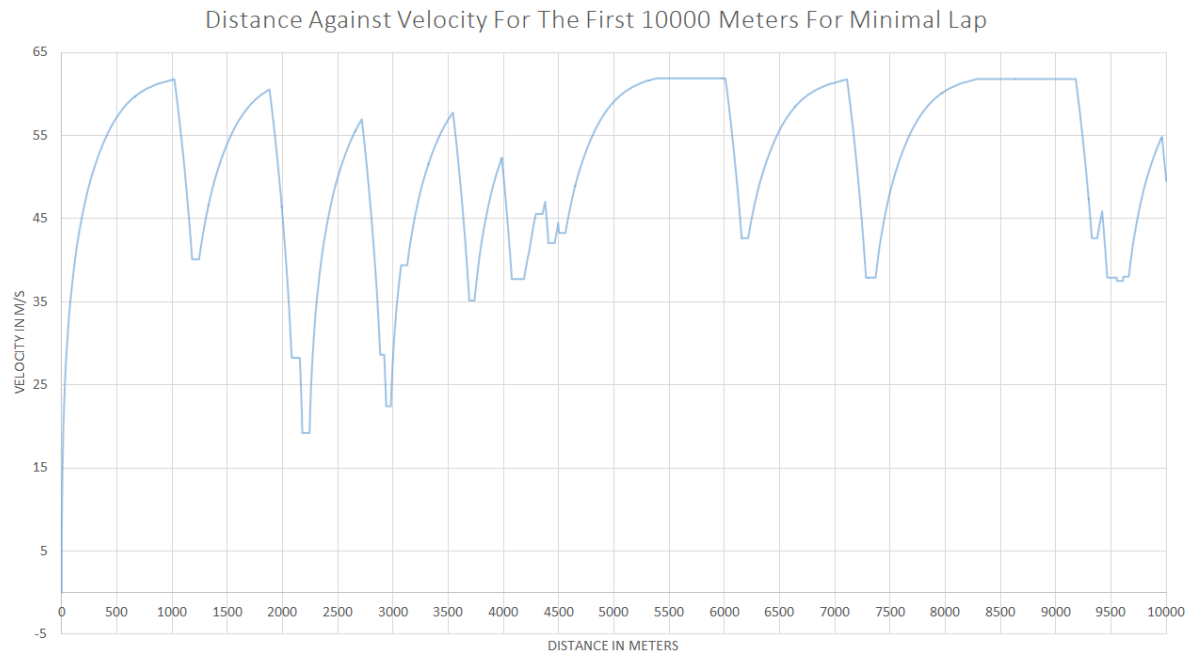


Figure 32 velocity against distance for 10000 meters for minimal forces

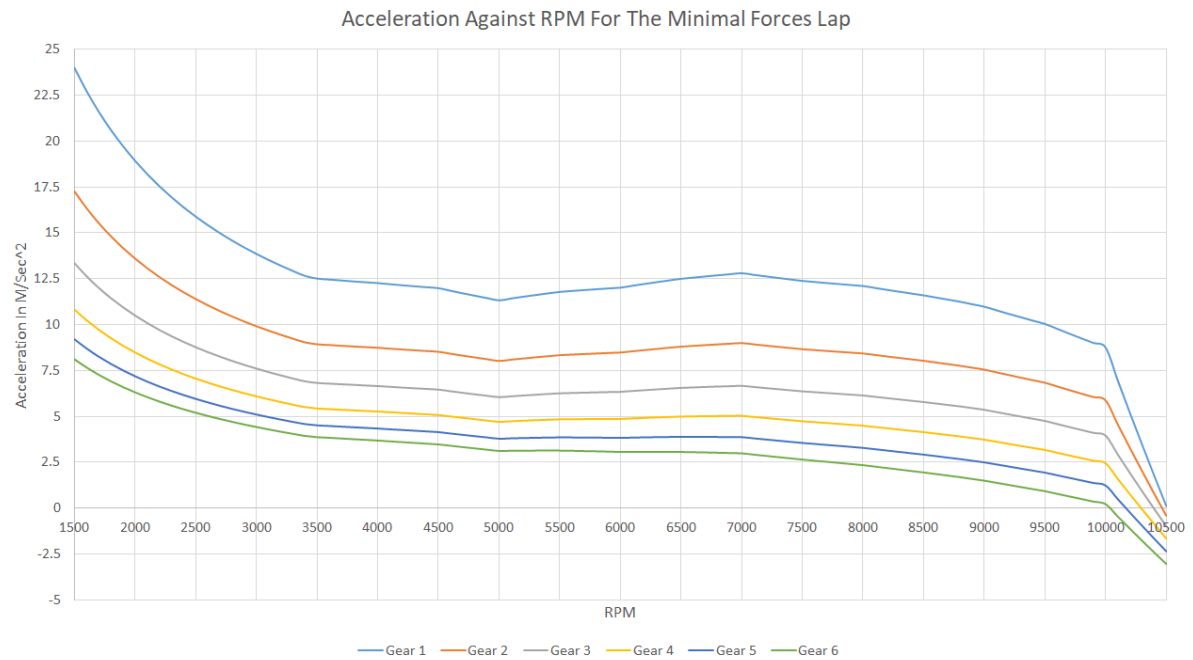


Figure 33 Acceleration against RPM for minimal forces

All Forces Lap

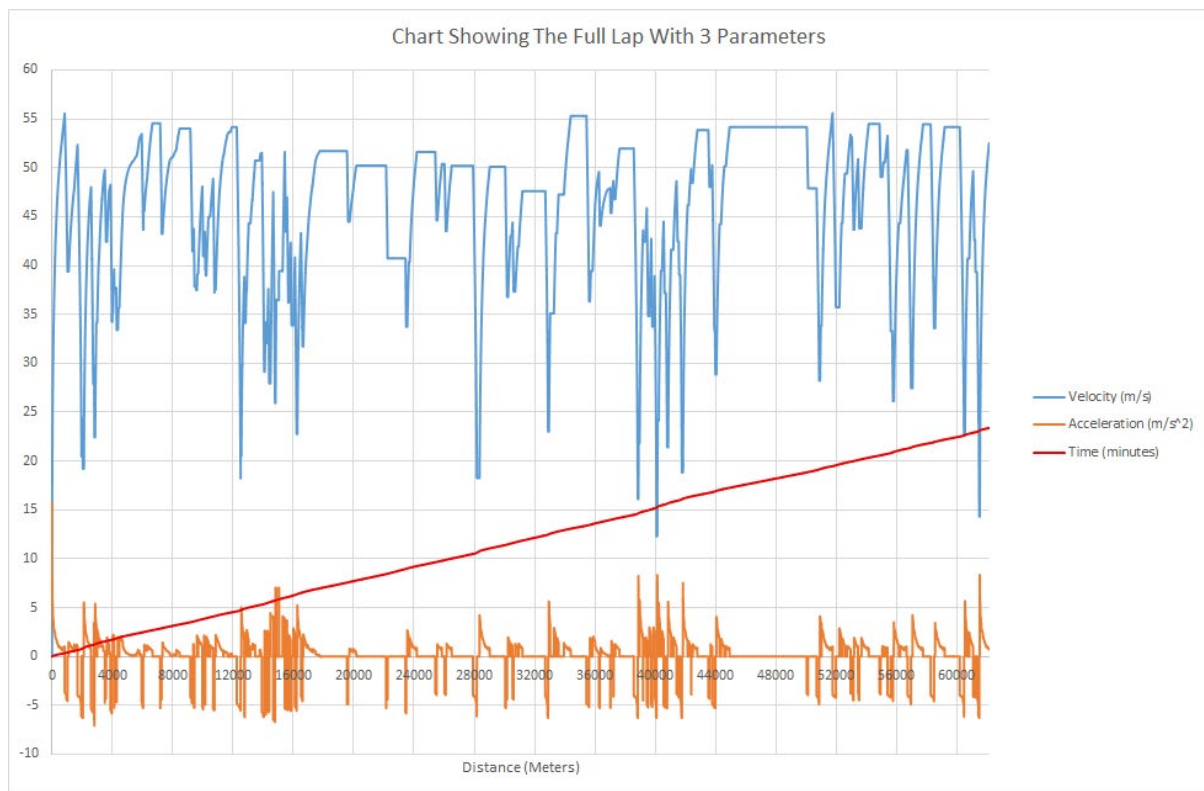


Figure 34 3 parameters against distance for full lap with all forces

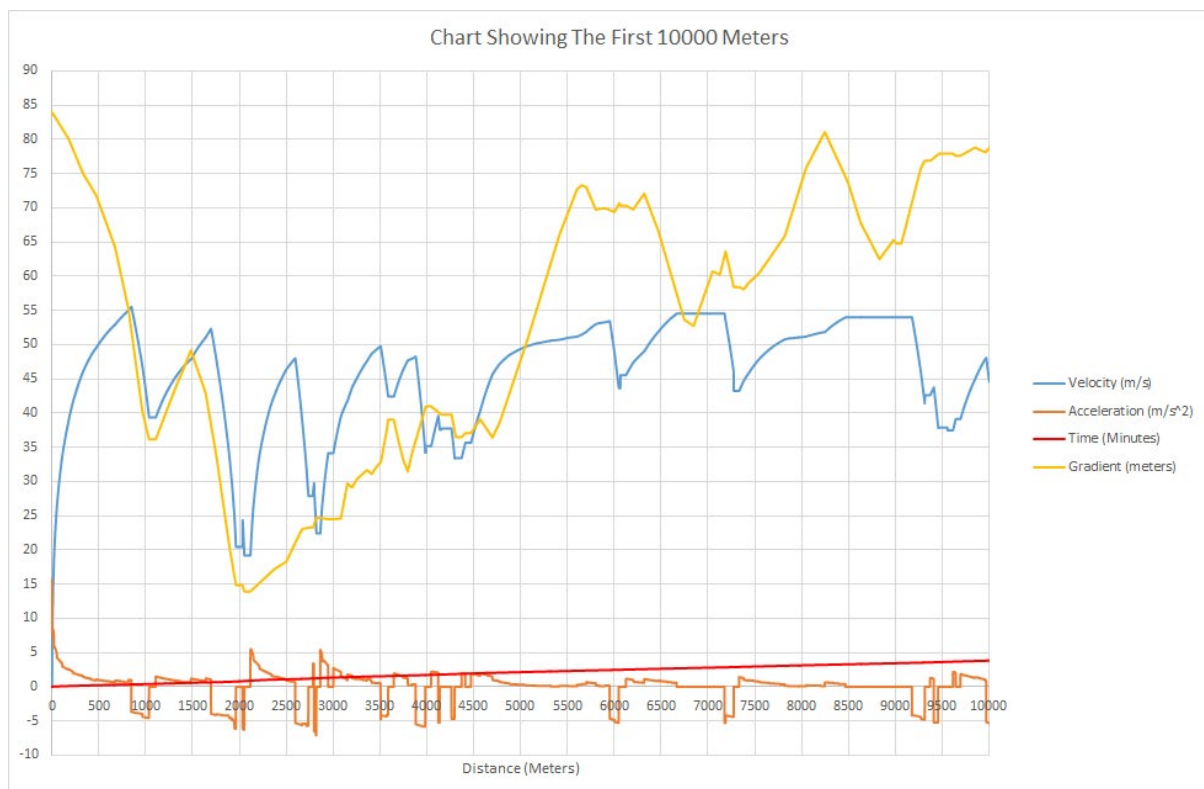


Figure 35 4 parameters against distance for the first 10000 meters

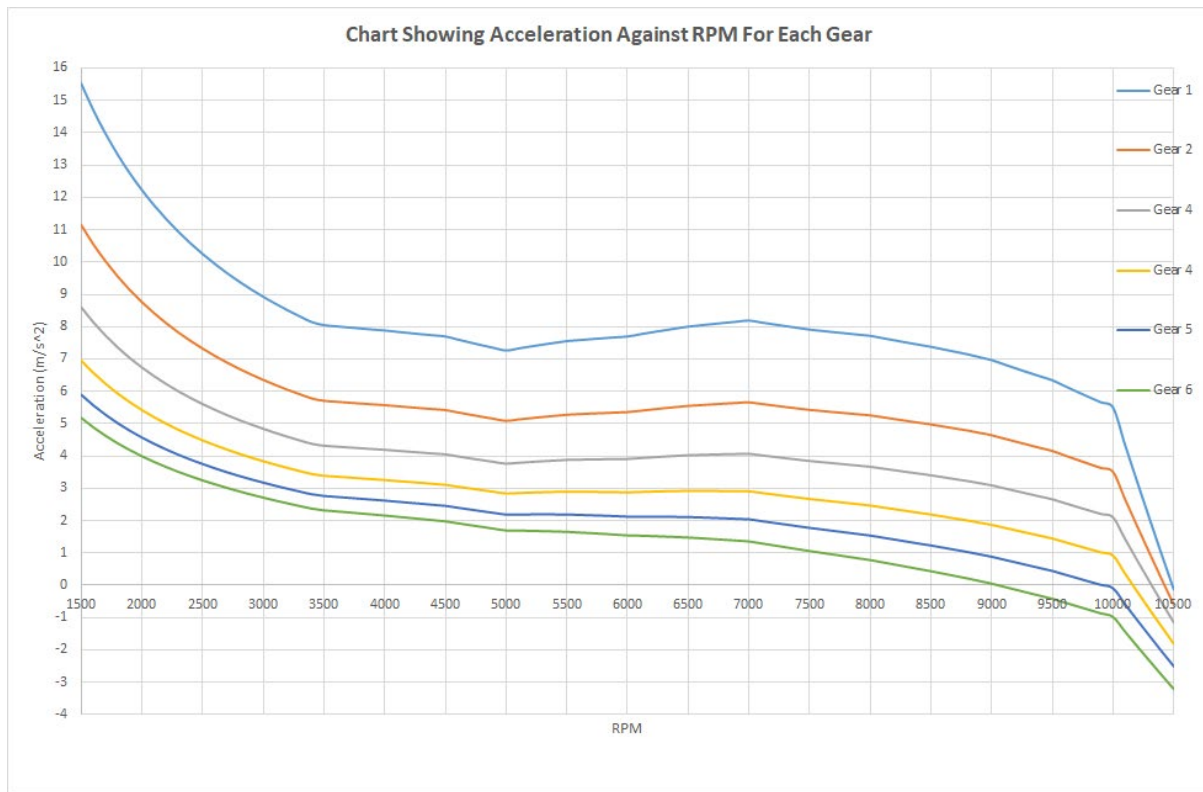


Figure 36 Acceleration against RPM for lap with all forces

Results

The results of this project have been interesting as there is proof of how certain variables change parameters but in the pursuit of understanding the human element and how they affect a machine this endeavour is not yet clear. Below is a table showing the average speeds and times that the two simulations have accomplished as well as the times of an actual rider called James Hillier of whom has one of the fastest times using a super twin Kawasaki 650.

Table 9 All times

	Time (Minutes)	Average Speed (mph)
James Hillier	18.44	120.84
Full Simulation	23.38	103.5
Minimal Forces Simulation	20.54	116.23

The differences in the times is astonishing in the sense that when looking at the two simulations the values for both times and average speed are very different with the simulation with more forces implemented being both the slowest and therefore having the lower average speed. This is however to be expected as the other simulation has minimal resistance and therefore will be perceived as

being faster however this is unrealistic and not very suitable for example the time for going from 0 to 60 mph was 3.2 seconds for the simulation for all the variables however the one with minimal was less than 1 second. This shows the level of unrealism when it comes to minimising the resistive forces. This also produce an interesting point and that is that although this was an unrealistic simulation it was still had a slower time and average speed when compared to James Hillier, this begs the question into why and there are many reasons. One such reason is the track layout as the track was laid out and interpreted differently than a rider would take on the actual course. This would mean that to produce results that could reflect this then identifying the layout that this rider took and implement their racing lines to further this goal. The results also show how the gradients have affected the acceleration in the sense that between the values of 4500 meters and 6000 meters they are very different when compared to the values for the simulation with less restrictions. This goes to further show how much of a difference the traction and gradients make when they are taken into account as the graph shows a less smooth climb in velocity as well as , this further shows why this simulation needs to have less assumption made and to implement more calculation to determine all variables no matter how small.

Further Developments

To further develop this project the continuation to implement more accurate measures to create a more accurate simulation must be obtained and implemented. This includes the smaller changes in values such as the air density as although this report shows that the change doesn't greatly affect the results of the forces it is however still a change and therefore to improve accuracy should be implemented. Equally full automating this simulation would also be the best solution in which when a value is changed such as the coefficient of friction is changed then the lap time simulation will change as well to reflect this change in value. This can be done using a series of IF statements in excel and by which taking the highest values with no resistance or changes to the dynamics of the motorbike to then create the fastest time that that motorbike can ever achieve to determine what the highest RPM jump each meter will take. From this RPM range IF statements would be created to state if the final velocity of that meter is over or equal to the velocity of the next RPM range then to calculate the next velocity using the new RPM range forces and accelerations or decelerations if the case requires it. Although this is a big endeavour it is still worth implementing due to the fact that with this change implemented the simulation can be used by any one and the idea of changing

certain values to determine how the motorbike will operate under certain conditions and how a user can then understand how both the gradients and riding conditions can change the outcomes is invaluable especially in a computing software heavy world that is the modern age.

Conclusion

In conclusion this project had the aim of demonstrating the difference in certain variables to determine how they affect the motorbike in its operation, these variable such as the coefficient of drag have indeed shown this difference as stated in the report it shows how much of a difference these variables can make. This is also the same for the smaller alteration such as air density which has a minimal effect on the values but enough to consider researching this further to determine the actual values that the motorbike will experience. The aim for accuracy will always be considered and if any variables are negligible for example the massless wheel suspension model that was done by Roberto Lot and Nicola Dal Bianco in their paper "The significance of high-order dynamics in lap time simulations"

Then these values will be studied first to discover what is required and what is not. This will also further the aim of understanding the actual dynamics of the motorbike and what actual interacts with the machine in its operating conditions. The assumptions that have been made are numerous especially in regards to the corners by having an assumed constant velocity no matter the case, this has been stated and warrants further study to remove these assumptions to analysis the actual forces and conditions that the motorbike will experience and be forced to comp with. This projects primary goal however was to complete an accurate lap time simulation of the Isle Of Man TT of which this has been done however there are many parameters that could be altered as stated to further the accuracy of this simulation. To further this goal more simulations must be done and to then incorporate the findings to understand the dynamics further. The final part of this project was the understanding of the human element which as this project has shown that this answer is not within reach at the current time and has therefor requires further testing and understanding but the main factor is understanding the riders and how they operate and the lines they take, this could give a final ratio that could determine what this element is and how a human affects the outcome of the race and how much of an effect a human has on the machines they operate. The human mind is a complex organ and will always require studying but in the endeavour of utilising machines that

coincide with humans a true understanding could then be studied to truly gather a value for this human element and if from person to person if this value could be calculated and be determined to further many fields of study in both the engineering world and the biological sciences.

References

- Anon., 2017. *Current Isle of Man TT Lap Records*. [Online]
Available at: <https://www.iomtt.com/TT-Database/TT-Records/Lap-Records.aspx>
- Boyuan Li, H. D. W. L., 2013. *A novel cost effective method for vehicle tire-road friction coefficient estimation*, University of Wollongong: s.n.
- Corno, M., 2008. On optimal motorcycle braking. *Control Engineering Practice*, pp. 644-657.
- Cossalter, V., 2006. *Motorcycle Dynamics Second Edition*. s.l.:Lightning Source UK Ltd.
- David.H.Weir, 2007. Motorcycle Dynamics and Rider Control. *Vehicle System Dynamics*.
- George, R., 2010. *Wind & Altitude : Effects On Power To Weight Ratio*. [Online]
Available at: <http://www.georgeron.com/2010/07/wind-altitude-effects-on-power-to.html>
[Accessed 2018].
- Heald, R. H., 1933. Aerodynamic Characteristics Of AutoMobile Models. *Bureau of Standards Journal of Research*, Volume 11, pp. 285-291.
- Hima, S., 2008. Suitable Two Wheeled Vehicle Dynamics Synthesis for Interactive Motorcycle Simulator. *IFAC Proceedings Volumes*, pp. 96-101.
- J.P.Meijaard, 2012. Motorcycle Dynamics. *Vehicle System Dynamics*.
- M.Kitano, 1997. An analysis of horizontal plane motion of tracked vehicles. *Journal of Terramechanics*, pp. 211-225.
- M.Olsson, 1991. On the fundamental moving load problem. *Journal of Sound and Vibration*, pp. 299-307.
- R.S.Sharp, 2004. Advances in the Modelling of Motorcycle Dynamics. *Multibody System Dynamics*, pp. 251-283.
- Roberto Lot, N. D. B., n.d. *The significance of high-order dynamics in lap time simulations*, s.l.: s.n.
- Sedlak, V., 2012. *Motorcycle Cornering Improvement: An Aerodynamical Approach based on Flow Interference*, s.l.: s.n.
- Sharp, R. S., 1971. The Stability And Control Of Motorcycles. *Journal Of Mechanical Engineering Science*, Volume 13, pp. 316-329.

Sripathi, V. A., 2017. *The Impact of Active Aerodynamics on Motorcycles Using Computational Fluid Dynamics Simulations*, Minnesota State University, Mankato: s.n.

Appendix

Appendix A Physical

Table 10 Physical variables

Wheels		Units	Bike Flat		Units	Bike inclined		Units			Units
WF-Rim	17.000	Inches	WF	114.500	KG	WFL	124.300	KG	Xcog	0.760	M
WR-Rim	17.000	Inches	WR	126.100	KG	WRL	116.300	KG	Ycog	0.567	M
WF Tyre Width	0.120	M	WT	240.600	KG	WTL	240.600	KG			
WR Tyre Width	0.160	M	WF Radius	0.300	M	WB	1.450	M	Load F	47.589	%
WF Tyre Height	0.084	M	WR Radius	0.312	M	Elevation	0.320	M	Load R	52.411	%
WR Tyre Height	0.096	M	RAV	0.306	M	θ	12.750	Degrees			
SV650						Moments of inertia					
Geomatry		Units				If	0.070783		8r	3.206156	
Engine Displacement	645	cc				Ir	0.119656		8f	3.334445	
Max RPM	10500	RPM				reduced mass		242.617			
Number of Gear	6	Up - 5 Down							New velocitys		
Wheelbase	1.42	m			Drop in RPM			Meters/m	Meters/Sec		
Swingarm Length	553	mm			Gear 1 To Gear 2	6500	1143.748		19.06247		
Fw	0.300		Front wheel radius		Gear 2 To Gear 3	6991.071	1583.651		26.39419		
Rw	0.3119		rear wheel radius		Gear 3 To Gear 4	7331.897	2038.724		33.97873		
Wr	1.23		rear wheel weight		Gear 4 To Gear 5	7692.308	2502.56		41.70934		
Wf	0.787		front wheel weight		Gear 5 To Gear 6	7973.333	2927.996		48.79993		
Ws	0.015		secondary shaft								
Wp	0.05		primary								
Wm	0.06		main								
Mass	240.6		bike weight								
Sr	3		sprocket ratio								
Mp	2.088235		crank to primary ratio								
Rake	23.5										
Weight	240.6 kg										
Air density	1.2 kg/m³ at 20°C and 987mbar										
CD	0.329										
A	0.443 m²										
CDA	0.146 m²										
CF	0.7										

Table 11 Gearing ratios part 1

	Engine RPM	Primary input	Primary output	Primary Transmission ratio	RPM input shaft	Input shaft number of Teeth	Output shaft number of teeth	Gear Ratio
1st Gear	10500	71	34	2.088	5028.169	32	13	2.462
2nd Gear	10500	71	34	2.088	5028.169	32	18	1.778
3rd Gear	10500	71	34	2.088	5028.169	29	21	1.381
4th Gear	10500	71	34	2.088	5028.169	27	24	1.125
5th Gear	10500	71	34	2.088	5028.169	25	26	0.962
6th Gear	10500	71	34	2.088	5028.169	23	27	0.852

Table 12 Gearing ratios part 2

RPM output shaft	Gearbox sprocket	Rear wheel sprocket	Sprocket Ratio	RPM rear wheel	Circumference of wheel	Metres per minute	M/S
2042.694	15	45	0.333	680.898	1.960	1334.373	22.240
2828.345	15	45	0.333	942.782	1.960	1847.593	30.793
3641.088	15	45	0.333	1213.696	1.960	2378.511	39.642
4469.484	15	45	0.333	1489.828	1.960	2919.654	48.661
5229.296	15	45	0.333	1743.099	1.960	3415.995	56.933
5902.633	15	45	0.333	1967.544	1.960	3855.847	64.264

Appendix B Resistive Forces

Table 13 Resistive forces gear 1 part 1

			Gear 1					
RPM	Velocity	FD (N)	FW (N)	Total resistance (N)	Power Needed (W)	Power Available		
1500	3.177	0.883	47.206	48.121	152.884	18642.500		
1600	3.389	1.004	47.206	48.242	163.487	18846.680		
1700	3.601	1.134	47.206	48.372	174.171	19050.860		
1800	3.812	1.271	47.206	48.509	184.940	19255.039		
1900	4.024	1.416	47.206	48.654	195.798	19459.219		
2000	4.236	1.569	47.206	48.807	206.751	19663.399		
2100	4.448	1.730	47.206	48.968	217.804	19867.579		
2200	4.660	1.899	47.206	49.137	228.962	20071.758		
2300	4.872	2.075	47.206	49.313	240.230	20275.938		
2400	5.083	2.260	47.206	49.497	251.612	20480.118		
2500	5.295	2.452	47.206	49.690	263.113	20684.298		
2600	5.507	2.652	47.206	49.890	274.740	20888.477		
2700	5.719	2.860	47.206	50.098	286.496	21092.657		
2800	5.931	3.076	47.206	50.313	298.386	21296.837		
2900	6.142	3.299	47.206	50.537	310.416	21501.017		
3000	6.354	3.531	47.206	50.769	322.591	21705.196		
3100	6.566	3.770	47.206	51.008	334.915	21909.376		
3200	6.778	4.017	47.206	51.255	347.394	22113.556		
3300	6.990	4.272	47.206	51.510	360.033	22317.736		
3400	7.201	4.535	47.206	51.773	372.836	22521.915		
3500	7.413	4.806	47.206	52.043	385.808	22930.275		
3600	7.625	5.084	47.206	52.322	398.955	23489.550		
3700	7.837	5.371	47.206	52.608	412.281	24048.825		
3800	8.049	5.665	47.206	52.903	425.792	24608.100		
3900	8.260	5.967	47.206	53.205	439.492	25167.375		
4000	8.472	6.277	47.206	53.515	453.387	25726.650		
4100	8.684	6.595	47.206	53.832	467.481	26286.640		
4200	8.896	6.920	47.206	54.158	481.780	26770.630		
4300	9.108	7.254	47.206	54.491	496.288	27292.620		
4400	9.319	7.595	47.206	54.833	511.010	27814.610		
4500	9.531	7.944	47.206	55.182	525.952	28336.600		

Table 14 Resistive forces gear 1 part 2

4600	9.743	8.301	47.206	55.507		540.806		28634.880
4700	9.955	8.666	47.206	55.872		556.195		28933.160
4800	10.167	9.039	47.206	56.244		571.818		29231.440
4900	10.378	9.419	47.206	56.625		587.680		29529.720
5000	10.590	9.808	47.206	57.013		603.786		29828.000
5100	10.802	10.204	47.206	57.410		620.142		30693.012
5200	11.014	10.608	47.206	57.814		636.752		31558.024
5300	11.226	11.020	47.206	58.226		653.622		32423.036
5400	11.437	11.440	47.206	58.645		670.755		33288.048
5500	11.649	11.867	47.206	59.073		688.158		34153.060
5600	11.861	12.303	47.206	59.508		705.835		34928.588
5700	12.073	12.746	47.206	59.952		723.791		35704.116
5800	12.285	13.197	47.206	60.403		742.031		36479.644
5900	12.497	13.656	47.206	60.862		760.561		37255.172
6000	12.708	14.123	47.206	61.329		779.385		38030.700
6100	12.920	14.598	47.206	61.803		798.507		39000.110
6200	13.132	15.080	47.206	62.286		817.934		39969.520
6300	13.344	15.571	47.206	62.776		837.670		40938.930
6400	13.556	16.069	47.206	63.275		857.720		41908.340
6500	13.767	16.575	47.206	63.781		878.089		42877.750
6600	13.979	17.089	47.206	64.295		898.783		43772.590
6700	14.191	17.611	47.206	64.816		919.805		44667.430
6800	14.403	18.140	47.206	65.346		941.161		45562.270
6900	14.615	18.678	47.206	65.883		962.857		46457.110
7000	14.826	19.223	47.206	66.429		984.896		47351.950
7100	15.038	19.776	47.206	66.982		1007.284		47724.800
7200	15.250	20.337	47.206	67.543		1030.027		48097.650
7300	15.462	20.906	47.206	68.112		1053.128		48470.500
7400	15.674	21.483	47.206	68.688		1076.593		48843.350
7500	15.885	22.067	47.206	69.273		1100.427		49216.200
7600	16.097	22.660	47.206	69.865		1124.635		49663.620
7700	16.309	23.260	47.206	70.466		1149.222		50111.040

Table 15 Resistive forces gear 1 part 3

7800	16.521	23.868	47.206	71.074		1174.193		50558.460
7900	16.733	24.484	47.206	71.689		1199.553		51005.880
8000	16.944	25.108	47.206	72.313		1225.306		51453.300
8100	17.156	25.739	47.206	72.945		1251.459		51677.010
8200	17.368	26.379	47.206	73.584		1278.015		51900.720
8300	17.580	27.026	47.206	74.232		1304.980		52124.430
8400	17.792	27.681	47.206	74.887		1332.359		52348.140
8500	18.003	28.344	47.206	75.550		1360.156		52571.850
8600	18.215	29.015	47.206	76.221		1388.378		52696.133
8700	18.427	29.694	47.206	76.899		1417.028		52820.417
8800	18.639	30.380	47.206	77.586		1446.112		52944.700
8900	18.851	31.075	47.206	78.280		1475.634		52944.700
9000	19.062	31.777	47.206	78.982		1505.601		52944.700
9100	19.274	32.487	47.206	79.693		1536.016		52646.420
9200	19.486	33.205	47.206	80.410		1566.884		52348.140
9300	19.698	33.930	47.206	81.136		1598.212		52049.860
9400	19.910	34.664	47.206	81.870		1630.003		51751.580
9500	20.121	35.406	47.206	82.611		1662.263		51453.300
9600	20.333	36.155	47.206	83.361		1694.996		50707.600
9700	20.545	36.912	47.206	84.118		1728.208		49961.900
9800	20.757	37.677	47.206	84.883		1761.903		49216.200
9900	20.969	38.450	47.206	85.656		1796.087		48470.500
10000	21.181	39.231	47.206	86.436		1830.765		47724.800
10100	21.392	40.019	47.206	87.225		1865.941		38925.540
10200	21.604	40.815	47.206	88.021		1901.621		30126.280
10300	21.816	41.620	47.206	88.825		1937.809		21327.020
10400	22.028	42.432	47.206	89.637		1974.511		12527.760
10500	22.240	43.252	47.206	90.457		2011.731		3728.500

Table 16 Resistive forces gear 2 part 1

			Gear 2						
RPM	Velocity	FD (N)	FW (N)	Total resistance (N)	Power Needed (W)			Power Available	
1500	4.399	1.692	47.206	48.930	215.246			18642.500	
1600	4.692	1.925	47.206	49.163	230.688			18846.680	
1700	4.986	2.174	47.206	49.411	246.344			19050.860	
1800	5.279	2.437	47.206	49.675	262.224			19255.039	
1900	5.572	2.715	47.206	49.953	278.343			19459.219	
2000	5.865	3.008	47.206	50.246	294.713			19663.399	
2100	6.159	3.317	47.206	50.555	311.348			19867.579	
2200	6.452	3.640	47.206	50.878	328.260			20071.758	
2300	6.745	3.979	47.206	51.216	345.464			20275.938	
2400	7.038	4.332	47.206	51.570	362.972			20480.118	
2500	7.332	4.701	47.206	51.938	380.798			20684.298	
2600	7.625	5.084	47.206	52.322	398.955			20888.477	
2700	7.918	5.483	47.206	52.721	417.456			21092.657	
2800	8.212	5.897	47.206	53.134	436.314			21296.837	
2900	8.505	6.325	47.206	53.563	455.542			21501.017	
3000	8.798	6.769	47.206	54.007	475.155			21705.196	
3100	9.091	7.228	47.206	54.466	495.164			21909.376	
3200	9.385	7.702	47.206	54.939	515.584			22113.556	
3300	9.678	8.191	47.206	55.428	536.427			22317.736	
3400	9.971	8.694	47.206	55.932	557.707			22521.915	
3500	10.264	9.213	47.206	56.451	579.437			22930.275	
3600	10.558	9.747	47.206	56.985	601.631			23489.550	
3700	10.851	10.296	47.206	57.534	624.300			24048.825	
3800	11.144	10.860	47.206	58.098	647.459			24608.100	
3900	11.437	11.440	47.206	58.677	671.122			25167.375	
4000	11.731	12.034	47.206	59.272	695.300			25726.650	
4100	12.024	12.643	47.206	59.881	720.008			26248.640	
4200	12.317	13.267	47.206	60.505	745.258			26770.630	
4300	12.611	13.907	47.206	61.144	771.064			27292.620	
4400	12.904	14.561	47.206	61.799	797.439			27814.610	
4500	13.197	15.230	47.206	62.468	824.397			28336.600	

Table 17 Resistive force gear 2 part 2

4600	13.490	15.915	47.206	63.120		851.517		28634.880
4700	13.784	16.614	47.206	63.820		879.670		28933.160
4800	14.077	17.329	47.206	64.534		908.444		29231.440
4900	14.370	18.058	47.206	65.264		937.854		29529.720
5000	14.663	18.803	47.206	66.009		967.912		29828.000
5100	14.957	19.562	47.206	66.768		998.632		30693.012
5200	15.250	20.337	47.206	67.543		1030.027		31558.024
5300	15.543	21.127	47.206	68.333		1062.110		32423.036
5400	15.837	21.932	47.206	69.137		1094.894		33288.048
5500	16.130	22.751	47.206	69.957		1128.393		34153.060
5600	16.423	23.586	47.206	70.792		1162.620		34928.588
5700	16.716	24.436	47.206	71.642		1197.588		35704.116
5800	17.010	25.301	47.206	72.507		1233.310		36479.644
5900	17.303	26.181	47.206	73.387		1269.800		37255.172
6000	17.596	27.076	47.206	74.282		1307.071		38030.700
6100	17.889	27.986	47.206	75.192		1345.136		39000.110
6200	18.183	28.911	47.206	76.117		1384.008		39969.520
6300	18.476	29.851	47.206	77.057		1423.701		40938.930
6400	18.769	30.807	47.206	78.012		1464.227		41908.340
6500	19.062	31.777	47.206	78.982		1505.601		42877.750
6600	19.356	32.762	47.206	79.968		1547.834		43772.590
6700	19.649	33.762	47.206	80.968		1590.941		44667.430
6800	19.942	34.778	47.206	81.983		1634.935		45562.270
6900	20.236	35.808	47.206	83.014		1679.829		46457.110
7000	20.529	36.853	47.206	84.059		1725.636		47351.950
7100	20.822	37.914	47.206	85.120		1772.369		47724.800
7200	21.115	38.989	47.206	86.195		1820.042		48097.650
7300	21.409	40.080	47.206	87.286		1868.668		48470.500
7400	21.702	41.186	47.206	88.391		1918.260		48843.350
7500	21.995	42.306	47.206	89.512		1968.831		49216.200
7600	22.288	43.442	47.206	90.648		2020.395		49663.620
7700	22.582	44.593	47.206	91.798		2072.965		50111.040

Table 18 Resistive forces gear 2 part 3

7800	22.875	45.758	47.206	92.964		2126.553		50558.460
7900	23.168	46.939	47.206	94.145		2181.174		51005.880
8000	23.462	48.135	47.206	95.341		2236.841		51453.300
8100	23.755	49.346	47.206	96.552		2293.566		51677.010
8200	24.048	50.572	47.206	97.778		2351.363		51900.720
8300	24.341	51.813	47.206	99.019		2410.245		52124.430
8400	24.635	53.069	47.206	100.275		2470.226		52348.140
8500	24.928	54.340	47.206	101.546		2531.318		52571.850
8600	25.221	55.626	47.206	102.832		2593.536		52696.133
8700	25.514	56.927	47.206	104.133		2656.891		52820.417
8800	25.808	58.244	47.206	105.449		2721.398		52944.700
8900	26.101	59.575	47.206	106.781		2787.070		52944.700
9000	26.394	60.921	47.206	108.127		2853.919		52944.700
9100	26.687	62.282	47.206	109.488		2921.960		52646.420
9200	26.981	63.659	47.206	110.864		2991.204		52348.140
9300	27.274	65.050	47.206	112.256		3061.667		52049.860
9400	27.567	66.457	47.206	113.662		3133.360		51751.580
9500	27.861	67.878	47.206	115.084		3206.297		51453.300
9600	28.154	69.315	47.206	116.520		3280.491		50707.600
9700	28.447	70.766	47.206	117.972		3355.956		49961.900
9800	28.740	72.233	47.206	119.439		3432.705		49216.200
9900	29.034	73.715	47.206	120.920		3510.750		48470.500
10000	29.327	75.211	47.206	122.417		3590.106		47724.800
10100	29.620	76.723	47.206	123.929		3670.785		38925.540
10200	29.913	78.250	47.206	125.455		3752.801		30126.280
10300	30.207	79.792	47.206	126.997		3836.167		21327.020
10400	30.500	81.348	47.206	128.554		3920.896		12527.760
10500	30.793	82.920	47.206	130.126		4007.001		3728.500

Table 19 Resistive forces gear 3 part 1

			Gear 3					
RPM	Velocity	FD (N)	FW (N)	Total resistance (N)	Power Needed (W)	Power Available		
1500	5.663	2.805	47.206	50.043	283.398	18642.500		
1600	6.041	3.191	47.206	50.429	304.623	18846.680		
1700	6.418	3.602	47.206	50.840	326.302	19050.860		
1800	6.796	4.039	47.206	51.276	348.461	19255.039		
1900	7.173	4.500	47.206	51.737	371.128	19459.219		
2000	7.551	4.986	47.206	52.224	394.332	19663.399		
2100	7.928	5.497	47.206	52.735	418.100	19867.579		
2200	8.306	6.033	47.206	53.271	442.461	20071.758		
2300	8.683	6.594	47.206	53.832	467.444	20275.938		
2400	9.061	7.180	47.206	54.417	493.076	20480.118		
2500	9.439	7.790	47.206	55.028	519.385	20684.298		
2600	9.816	8.426	47.206	55.664	546.401	20888.477		
2700	10.194	9.087	47.206	56.324	574.150	21092.657		
2800	10.571	9.772	47.206	57.010	602.662	21296.837		
2900	10.949	10.483	47.206	57.721	631.965	21501.017		
3000	11.326	11.218	47.206	58.456	662.086	21705.196		
3100	11.704	11.979	47.206	59.216	693.055	21909.376		
3200	12.081	12.764	47.206	60.002	724.898	22113.556		
3300	12.459	13.574	47.206	60.812	757.646	22317.736		
3400	12.836	14.409	47.206	61.647	791.325	22521.915		
3500	13.214	15.269	47.206	62.507	825.964	22930.275		
3600	13.591	16.154	47.206	63.392	861.591	23489.550		
3700	13.969	17.064	47.206	64.302	898.235	24048.825		
3800	14.347	17.999	47.206	65.237	935.923	24608.100		
3900	14.724	18.959	47.206	66.196	974.685	25167.375		
4000	15.102	19.943	47.206	67.181	1014.548	25726.650		
4100	15.479	20.953	47.206	68.191	1055.540	26248.640		
4200	15.857	21.988	47.206	69.225	1097.689	26770.630		
4300	16.234	23.047	47.206	70.285	1141.025	27292.620		
4400	16.612	24.132	47.206	71.369	1185.575	27814.610		
4500	16.989	25.241	47.206	72.479	1231.367	28336.600		

Table 20 Resistive forces gear 3 part 2

4600	17.367	26.375	47.206	73.581		1277.873		28634.880
4700	17.744	27.534	47.206	74.740		1326.222		28933.160
4800	18.122	28.719	47.206	75.924		1375.899		29231.440
4900	18.500	29.928	47.206	77.133		1426.931		29529.720
5000	18.877	31.162	47.206	78.367		1479.346		29828.000
5100	19.255	32.421	47.206	79.626		1533.173		30693.012
5200	19.632	33.704	47.206	80.910		1588.440		31558.024
5300	20.010	35.013	47.206	82.219		1645.176		32423.036
5400	20.387	36.347	47.206	83.553		1703.407		33288.048
5500	20.765	37.706	47.206	84.911		1763.164		34153.060
5600	21.142	39.089	47.206	86.295		1824.474		34928.588
5700	21.520	40.498	47.206	87.703		1887.364		35704.116
5800	21.897	41.931	47.206	89.137		1951.864		36479.644
5900	22.275	43.389	47.206	90.595		2018.002		37255.172
6000	22.652	44.873	47.206	92.078		2085.806		38030.700
6100	23.030	46.381	47.206	93.587		2155.304		39000.110
6200	23.408	47.914	47.206	95.120		2226.524		39969.520
6300	23.785	49.472	47.206	96.678		2299.495		40938.930
6400	24.163	51.055	47.206	98.261		2374.244		41908.340
6500	24.540	52.663	47.206	99.869		2450.801		42877.750
6600	24.918	54.296	47.206	101.502		2529.193		43772.590
6700	25.295	55.954	47.206	103.160		2609.449		44667.430
6800	25.673	57.637	47.206	104.842		2691.596		45562.270
6900	26.050	59.344	47.206	106.550		2775.663		46457.110
7000	26.428	61.077	47.206	108.283		2861.679		47351.950
7100	26.805	62.834	47.206	110.040		2949.671		47724.800
7200	27.183	64.617	47.206	111.822		3039.668		48097.650
7300	27.561	66.424	47.206	113.630		3131.698		48470.500
7400	27.938	68.256	47.206	115.462		3225.789		48843.350
7500	28.316	70.114	47.206	117.319		3321.969		49216.200
7600	28.693	71.996	47.206	119.202		3420.267		49663.620
7700	29.071	73.903	47.206	121.109		3520.711		50111.040

Table 21 Resistive forces gear 3 part 3

7700	29.071	73.903	47.206	121.109		3520.711		50111.040
7800	29.448	75.835	47.206	123.041		3623.329		50558.460
7900	29.826	77.792	47.206	124.998		3728.150		51005.880
8000	30.203	79.774	47.206	126.979		3835.201		51453.300
8100	30.581	81.781	47.206	128.986		3944.511		51677.010
8200	30.958	83.812	47.206	131.018		4056.108		51900.720
8300	31.336	85.869	47.206	133.075		4170.020		52124.430
8400	31.713	87.951	47.206	135.156		4286.276		52348.140
8500	32.091	90.057	47.206	137.263		4404.904		52571.850
8600	32.469	92.189	47.206	139.394		4525.931		52696.133
8700	32.846	94.345	47.206	141.551		4649.387		52820.417
8800	33.224	96.526	47.206	143.732		4775.300		52944.700
8900	33.601	98.732	47.206	145.938		4903.697		52944.700
9000	33.979	100.964	47.206	148.169		5034.607		52944.700
9100	34.356	103.220	47.206	150.425		5168.058		52646.420
9200	34.734	105.501	47.206	152.707		5304.079		52348.140
9300	35.111	107.807	47.206	155.012		5442.698		52049.860
9400	35.489	110.138	47.206	157.343		5583.942		51751.580
9500	35.866	112.493	47.206	159.699		5727.840		51453.300
9600	36.244	114.874	47.206	162.080		5874.421		50707.600
9700	36.622	117.280	47.206	164.486		6023.713		49961.900
9800	36.999	119.710	47.206	166.916		6175.743		49216.200
9900	37.377	122.166	47.206	169.372		6330.540		48470.500
10000	37.754	124.646	47.206	171.852		6488.133		47724.800
10100	38.132	127.152	47.206	174.358		6648.549		38925.540
10200	38.509	129.682	47.206	176.888		6811.817		30126.280
10300	38.887	132.237	47.206	179.443		6977.965		21327.020
10400	39.264	134.818	47.206	182.023		7147.022		12527.760
10500	39.642	137.423	47.206	184.628		7319.014		3728.500

Table 22 Resistive forces gear 4 part 1

			Gear 4						
RPM	Velocity	FD (N)	FW (N)	Total resistance (N)	Power Needed (W)		Power Available		
1500	6.952	4.226	47.206	51.447	357.637		18642.500		
1600	7.415	4.808	47.206	52.029	385.794		18846.680		
1700	7.878	5.428	47.206	52.649	414.789		19050.860		
1800	8.342	6.085	47.206	53.306	444.672		19255.039		
1900	8.805	6.780	47.206	54.001	475.495		19459.219		
2000	9.269	7.513	47.206	54.733	507.310		19663.399		
2100	9.732	8.283	47.206	55.503	540.170		19867.579		
2200	10.196	9.090	47.206	56.311	574.126		20071.758		
2300	10.659	9.935	47.206	57.156	609.231		20275.938		
2400	11.122	10.818	47.206	58.039	645.538		20480.118		
2500	11.586	11.738	47.206	58.959	683.098		20684.298		
2600	12.049	12.696	47.206	59.917	721.963		20888.477		
2700	12.513	13.692	47.206	60.913	762.187		21092.657		
2800	12.976	14.725	47.206	61.946	803.820		21296.837		
2900	13.440	15.795	47.206	63.016	846.916		21501.017		
3000	13.903	16.903	47.206	64.124	891.526		21705.196		
3100	14.367	18.049	47.206	65.270	937.703		21909.376		
3200	14.830	19.232	47.206	66.453	985.499		22113.556		
3300	15.293	20.453	47.206	67.674	1034.966		22317.736		
3400	15.757	21.712	47.206	68.932	1086.157		22521.915		
3500	16.220	23.007	47.206	70.228	1139.123		22930.275		
3600	16.684	24.341	47.206	71.562	1193.917		23489.550		
3700	17.147	25.712	47.206	72.933	1250.591		24048.825		
3800	17.611	27.121	47.206	74.341	1309.198		24608.100		
3900	18.074	28.567	47.206	75.788	1369.789		25167.375		
4000	18.537	30.051	47.206	77.271	1432.416		25726.650		
4100	19.001	31.572	47.206	78.793	1497.133		26248.640		
4200	19.464	33.131	47.206	80.352	1563.991		26770.630		
4300	19.928	34.727	47.206	81.948	1633.042		27292.620		
4400	20.391	36.361	47.206	83.582	1704.339		27814.610		
4500	20.855	38.033	47.206	85.254	1777.934		28336.600		

4700	21.782	41.489	47.206	88.694		1931.898		28933.160
4800	22.245	43.273	47.206	90.479		2012.693		29231.440
4900	22.708	45.095	47.206	92.300		2095.994		29529.720
5000	23.172	46.954	47.206	94.160		2181.855		29828.000
5100	23.635	48.851	47.206	96.057		2270.327		30693.012
5200	24.099	50.785	47.206	97.991		2361.462		31558.024
5300	24.562	52.757	47.206	99.963		2455.313		32423.036
5400	25.026	54.767	47.206	101.973		2551.932		33288.048
5500	25.489	56.814	47.206	104.020		2651.371		34153.060
5600	25.952	58.899	47.206	106.105		2753.682		34928.588
5700	26.416	61.021	47.206	108.227		2858.918		35704.116
5800	26.879	63.181	47.206	110.387		2967.131		36479.644
5900	27.343	65.379	47.206	112.584		3078.373		37255.172
6000	27.806	67.614	47.206	114.819		3192.696		38030.700
6100	28.270	69.886	47.206	117.092		3310.152		39000.110
6200	28.733	72.196	47.206	119.402		3430.794		39969.520
6300	29.197	74.544	47.206	121.750		3554.674		40938.930
6400	29.660	76.929	47.206	124.135		3681.845		41908.340
6500	30.123	79.352	47.206	126.558		3812.357		42877.750
6600	30.587	81.813	47.206	129.018		3946.264		43772.590
6700	31.050	84.311	47.206	131.516		4083.618		44667.430
6800	31.514	86.846	47.206	134.052		4224.471		45562.270
6900	31.977	89.419	47.206	136.625		4368.876		46457.110
7000	32.441	92.030	47.206	139.236		4516.884		47351.950
7100	32.904	94.678	47.206	141.884		4668.547		47724.800
7200	33.367	97.364	47.206	144.570		4823.919		48097.650
7300	33.831	100.087	47.206	147.293		4983.050		48470.500
7400	34.294	102.848	47.206	150.054		5145.994		48843.350
7500	34.758	105.646	47.206	152.852		5312.803		49216.200
7600	35.221	108.482	47.206	155.688		5483.528		49663.620
7700	35.685	111.356	47.206	158.562		5658.223		50111.040

Table 23 Resistive forces gear 4 part 2

7800	36.148	114.267	47.206	161.473		5836.939		50558.460
7900	36.612	117.216	47.206	164.422		6019.728		51005.880
8000	37.075	120.202	47.206	167.408		6206.643		51453.300
8100	37.538	123.226	47.206	170.432		6397.736		51677.010
8200	38.002	126.287	47.206	173.493		6593.059		51900.720
8300	38.465	129.386	47.206	176.592		6792.665		52124.430
8400	38.929	132.523	47.206	179.729		6996.605		52348.140
8500	39.392	135.697	47.206	182.903		7204.932		52571.850
8600	39.856	138.909	47.206	186.114		7417.699		52696.133
8700	40.319	142.158	47.206	189.364		7634.956		52820.417
8800	40.782	145.445	47.206	192.650		7856.757		52944.700
8900	41.246	148.769	47.206	195.975		8083.154		52944.700
9000	41.709	152.131	47.206	199.337		8314.199		52944.700
9100	42.173	155.530	47.206	202.736		8549.944		52646.420
9200	42.636	158.967	47.206	206.173		8790.441		52348.140
9300	43.100	162.442	47.206	209.648		9035.743		52049.860
9400	43.563	165.954	47.206	213.160		9285.902		51751.580
9500	44.027	169.504	47.206	216.710		9540.970		51453.300
9600	44.490	173.091	47.206	220.297		9801.000		50707.600
9700	44.953	176.716	47.206	223.922		10066.043		49961.900
9800	45.417	180.378	47.206	227.584		10336.151		49216.200
9900	45.880	184.078	47.206	231.284		10611.378		48470.500
10000	46.344	187.816	47.206	235.022		10891.775		47724.800
10100	46.807	191.591	47.206	238.797		11177.395		38925.540
10200	47.271	195.404	47.206	242.609		11468.289		30126.280
10300	47.734	199.254	47.206	246.460		11764.510		21327.020
10400	48.197	203.142	47.206	250.347		12066.110		12527.760
10500	48.661	207.067	47.206	254.273		12373.141		3728.500

Table 24 Resistive forces gear 4 part 3

			Gear 5					
RPM	Velocity	FD (N)	FW (N)	Total resistance (N)	Power Needed (W)		Power Available	
1500	8.133	5.785	47.206	53.006	431.114		18642.500	
1600	8.676	6.582	47.206	53.803	466.766		18846.680	
1700	9.218	7.430	47.206	54.651	503.760		19050.860	
1800	9.760	8.330	47.206	55.551	542.175		19255.039	
1900	10.302	9.281	47.206	56.502	582.097		19459.219	
2000	10.844	10.284	47.206	57.505	623.607		19663.399	
2100	11.387	11.338	47.206	58.559	666.790		19867.579	
2200	11.929	12.444	47.206	59.664	711.730		20071.758	
2300	12.471	13.601	47.206	60.821	758.510		20275.938	
2400	13.013	14.809	47.206	62.030	807.213		20480.118	
2500	13.556	16.069	47.206	63.290	857.924		20684.298	
2600	14.098	17.380	47.206	64.601	910.727		20888.477	
2700	14.640	18.743	47.206	65.963	965.704		21092.657	
2800	15.182	20.157	47.206	67.378	1022.939		21296.837	
2900	15.724	21.622	47.206	68.843	1082.516		21501.017	
3000	16.267	23.139	47.206	70.360	1144.519		21705.196	
3100	16.809	24.707	47.206	71.928	1209.032		21909.376	
3200	17.351	26.327	47.206	73.548	1276.137		22113.556	
3300	17.893	27.998	47.206	75.219	1345.919		22317.736	
3400	18.436	29.721	47.206	76.942	1418.461		22521.915	
3500	18.978	31.495	47.206	78.716	1493.847		22930.275	
3600	19.520	33.320	47.206	80.541	1572.160		23489.550	
3700	20.062	35.197	47.206	82.418	1653.485		24048.825	
3800	20.604	37.125	47.206	84.346	1737.904		24608.100	
3900	21.147	39.105	47.206	86.326	1825.502		25167.375	
4000	21.689	41.136	47.206	88.357	1916.362		25726.650	
4100	22.231	43.219	47.206	90.440	2010.568		26248.640	
4200	22.773	45.353	47.206	92.573	2108.203		26770.630	
4300	23.316	47.538	47.206	94.759	2209.351		27292.620	
4400	23.858	49.775	47.206	96.996	2314.096		27814.610	
4500	24.400	52.063	47.206	99.284	2422.521		28336.600	

Table 25 Resistive forces gear 5 part 1

4600	24.942	54.403	47.206	101.608		2534.334		28634.880
4700	25.484	56.794	47.206	103.999		2650.362		28933.160
4800	26.027	59.236	47.206	106.442		2770.322		29231.440
4900	26.569	61.730	47.206	108.936		2894.297		29529.720
5000	27.111	64.275	47.206	111.481		3022.370		29828.000
5100	27.653	66.872	47.206	114.078		3154.625		30693.012
5200	28.196	69.520	47.206	116.726		3291.146		31558.024
5300	28.738	72.220	47.206	119.425		3432.017		32423.036
5400	29.280	74.971	47.206	122.176		3577.321		33288.048
5500	29.822	77.773	47.206	124.979		3727.141		34153.060
5600	30.364	80.627	47.206	127.833		3881.562		34928.588
5700	30.907	83.532	47.206	130.738		4040.667		35704.116
5800	31.449	86.489	47.206	133.695		4204.539		36479.644
5900	31.991	89.497	47.206	136.703		4373.263		37255.172
6000	32.533	92.556	47.206	139.762		4546.922		38030.700
6100	33.076	95.667	47.206	142.873		4725.600		39000.110
6200	33.618	98.830	47.206	146.035		4909.379		39969.520
6300	34.160	102.043	47.206	149.249		5098.345		40938.930
6400	34.702	105.309	47.206	152.514		5292.580		41908.340
6500	35.244	108.625	47.206	155.831		5492.168		42877.750
6600	35.787	111.993	47.206	159.199		5697.193		43772.590
6700	36.329	115.413	47.206	162.618		5907.739		44667.430
6800	36.871	118.884	47.206	166.089		6123.889		45562.270
6900	37.413	122.406	47.206	169.612		6345.726		46457.110
7000	37.955	125.980	47.206	173.185		6573.335		47351.950
7100	38.498	129.605	47.206	176.810		6806.799		47724.800
7200	39.040	133.281	47.206	180.487		7046.202		48097.650
7300	39.582	137.009	47.206	184.215		7291.627		48470.500
7400	40.124	140.789	47.206	187.994		7543.158		48843.350
7500	40.667	144.619	47.206	191.825		7800.878		49216.200
7600	41.209	148.502	47.206	195.707		8064.872		49663.620
7700	41.751	152.435	47.206	199.641		8335.223		50111.040

Table 26 Resistive forces gear 5 part 2

7800	42.293	156.420	47.206	203.626		8612.014		50558.460
7900	42.835	160.457	47.206	207.663		8895.329		51005.880
8000	43.378	164.545	47.206	211.751		9185.253		51453.300
8100	43.920	168.684	47.206	215.890		9481.867		51677.010
8200	44.462	172.875	47.206	220.081		9785.257		51900.720
8300	45.004	177.117	47.206	224.323		10095.506		52124.430
8400	45.547	181.411	47.206	228.616		10412.697		52348.140
8500	46.089	185.756	47.206	232.961		10736.914		52571.850
8600	46.631	190.152	47.206	237.358		11068.241		52696.133
8700	47.173	194.600	47.206	241.806		11406.761		52820.417
8800	47.715	199.099	47.206	246.305		11752.558		52944.700
8900	48.258	203.650	47.206	250.856		12105.716		52944.700
9000	48.800	208.252	47.206	255.458		12466.318		52944.700
9100	49.342	212.906	47.206	260.111		12834.448		52646.420
9200	49.884	217.610	47.206	264.816		13210.189		52348.140
9300	50.427	222.367	47.206	269.573		13593.626		52049.860
9400	50.969	227.175	47.206	274.380		13984.841		51751.580
9500	51.511	232.034	47.206	279.240		14383.919		51453.300
9600	52.053	236.944	47.206	284.150		14790.943		50707.600
9700	52.595	241.907	47.206	289.112		15205.997		49961.900
9800	53.138	246.920	47.206	294.126		15629.165		49216.200
9900	53.680	251.985	47.206	299.191		16060.529		48470.500
10000	54.222	257.101	47.206	304.307		16500.174		47724.800
10100	54.764	262.269	47.206	309.475		16948.184		38925.540
10200	55.307	267.488	47.206	314.694		17404.641		30126.280
10300	55.849	272.759	47.206	319.964		17869.630		21327.020
10400	56.391	278.081	47.206	325.286		18343.234		12527.760
10500	56.933	283.454	47.206	330.660		18825.538		3728.500

Table 27 Resistive forces gear 5 part 3

			Gear 6					
RPM	Velocity	FD (N)	FW (N)	Total resistance (N)	Power Needed (W)	Power Available		
1500	9.181	7.370	47.206	54.592	501.182	18642.500		
1600	9.793	8.386	47.206	55.607	544.535	18846.680		
1700	10.405	9.467	47.206	56.688	589.816	19050.860		
1800	11.017	10.613	47.206	57.834	637.142	19255.039		
1900	11.629	11.825	47.206	59.046	686.633	19459.219		
2000	12.241	13.103	47.206	60.324	738.410	19663.399		
2100	12.853	14.446	47.206	61.667	792.592	19867.579		
2200	13.465	15.855	47.206	63.075	849.301	20071.758		
2300	14.077	17.329	47.206	64.549	908.656	20275.938		
2400	14.689	18.868	47.206	66.089	970.778	20480.118		
2500	15.301	20.473	47.206	67.694	1035.787	20684.298		
2600	15.913	22.144	47.206	69.365	1103.803	20888.477		
2700	16.525	23.880	47.206	71.101	1174.947	21092.657		
2800	17.137	25.682	47.206	72.903	1249.339	21296.837		
2900	17.749	27.549	47.206	74.770	1327.099	21501.017		
3000	18.361	29.482	47.206	76.702	1408.347	21705.196		
3100	18.973	31.480	47.206	78.701	1493.204	21909.376		
3200	19.585	33.544	47.206	80.764	1581.791	22113.556		
3300	20.197	35.673	47.206	82.894	1674.226	22317.736		
3400	20.809	37.868	47.206	85.088	1770.632	22521.915		
3500	21.421	40.128	47.206	87.349	1871.127	22930.275		
3600	22.033	42.454	47.206	89.674	1975.833	23489.550		
3700	22.645	44.845	47.206	92.066	2084.869	24048.825		
3800	23.257	47.302	47.206	94.522	2198.356	24608.100		
3900	23.870	49.824	47.206	97.045	2316.414	25167.375		
4000	24.482	52.412	47.206	99.633	2439.163	25726.650		
4100	25.094	55.065	47.206	102.286	2566.724	26248.640		
4200	25.706	57.784	47.206	105.005	2699.218	26770.630		
4300	26.318	60.568	47.206	107.789	2836.763	27292.620		
4400	26.930	63.418	47.206	110.639	2979.481	27814.610		
4500	27.542	66.334	47.206	113.555	3127.492	28336.600		

Table 28 Resistive forces gear 6 part 1

4600	28.154	69.315	47.206	116.520		3280.491		28634.880
4700	28.766	72.361	47.206	119.567		3439.440		28933.160
4800	29.378	75.473	47.206	122.679		3604.042		29231.440
4900	29.990	78.651	47.206	125.856		3774.418		29529.720
5000	30.602	81.893	47.206	129.099		3950.689		29828.000
5100	31.214	85.202	47.206	132.408		4132.974		30693.012
5200	31.826	88.576	47.206	135.782		4321.394		31558.024
5300	32.438	92.016	47.206	139.221		4516.069		32423.036
5400	33.050	95.521	47.206	142.726		4717.120		33288.048
5500	33.662	99.091	47.206	146.297		4924.667		34153.060
5600	34.274	102.727	47.206	149.933		5138.830		34928.588
5700	34.886	106.429	47.206	153.634		5359.729		35704.116
5800	35.498	110.196	47.206	157.402		5587.485		36479.644
5900	36.110	114.028	47.206	161.234		5822.218		37255.172
6000	36.722	117.927	47.206	165.132		6064.048		38030.700
6100	37.334	121.890	47.206	169.096		6313.096		39000.110
6200	37.946	125.919	47.206	173.125		6569.481		39969.520
6300	38.558	130.014	47.206	177.220		6833.325		40938.930
6400	39.171	134.174	47.206	181.380		7104.747		41908.340
6500	39.783	138.400	47.206	185.606		7383.868		42877.750
6600	40.395	142.691	47.206	189.897		7670.808		43772.590
6700	41.007	147.048	47.206	194.254		7965.687		44667.430
6800	41.619	151.470	47.206	198.676		8268.626		45562.270
6900	42.231	155.958	47.206	203.164		8579.745		46457.110
7000	42.843	160.511	47.206	207.717		8899.164		47351.950
7100	43.455	165.130	47.206	212.336		9227.004		47724.800
7200	44.067	169.814	47.206	217.020		9563.384		48097.650
7300	44.679	174.564	47.206	221.770		9908.425		48470.500
7400	45.291	179.379	47.206	226.585		10262.248		48843.350
7500	45.903	184.260	47.206	231.466		10624.973		49216.200
7600	46.515	189.207	47.206	236.412		10996.719		49663.620
7700	47.127	194.219	47.206	241.424		11377.608		50111.040

Table 29 Resistive forces Gear 6 part 2

7800	47.739	199.296	47.206	246.502		11767.759		50558.460
7900	48.351	204.439	47.206	251.645		12167.293		51005.880
8000	48.963	209.647	47.206	256.853		12576.330		51453.300
8100	49.575	214.921	47.206	262.127		12994.991		51677.010
8200	50.187	220.261	47.206	267.466		13423.395		51900.720
8300	50.799	225.666	47.206	272.871		13861.664		52124.430
8400	51.411	231.136	47.206	278.342		14309.916		52348.140
8500	52.023	236.672	47.206	283.878		14768.274		52571.850
8600	52.635	242.274	47.206	289.479		15236.856		52696.133
8700	53.247	247.941	47.206	295.146		15715.783		52820.417
8800	53.859	253.673	47.206	300.879		16205.176		52944.700
8900	54.471	259.471	47.206	306.677		16705.155		52944.700
9000	55.084	265.335	47.206	312.541		17215.839		52944.700
9100	55.696	271.264	47.206	318.470		17737.350		52646.420
9200	56.308	277.259	47.206	324.464		18269.808		52348.140
9300	56.920	283.319	47.206	330.524		18813.333		52049.860
9400	57.532	289.444	47.206	336.650		19368.045		51751.580
9500	58.144	295.635	47.206	342.841		19934.064		51453.300
9600	58.756	301.892	47.206	349.098		20511.511		50707.600
9700	59.368	308.214	47.206	355.420		21100.506		49961.900
9800	59.980	314.602	47.206	361.808		21701.170		49216.200
9900	60.592	321.055	47.206	368.261		22313.623		48470.500
10000	61.204	327.574	47.206	374.780		22937.984		47724.800
10100	61.816	334.158	47.206	381.364		23574.375		38925.540
10200	62.428	340.808	47.206	388.014		24222.915		30126.280
10300	63.040	347.523	47.206	394.729		24883.725		21327.020
10400	63.652	354.304	47.206	401.510		25556.926		12527.760
10500	64.264	361.150	47.206	408.356		26242.636		3728.500

Table 30 Resistive forces gear 6 part 3

Appendix C Driving Forces

RPM	power (h/p)	Power (W)	4700	38.8	28933.16			
1500	25	18642.5	4800	39.2	29231.44			
1600	25.27	18846.67976	4900	39.6	29529.72			
1700	25.55	19050.85952	5000	40	29828			
1800	25.82	19255.03929	5100	41.16	30693.012			
1900	26.10	19459.21905	5200	42.32	31558.024			
2000	26.37	19663.39881	5300	43.48	32423.036			
2100	26.64	19867.57857	5400	44.64	33288.048			
2200	26.92	20071.75833	5500	45.8	34153.06			
2300	27.19	20275.9381	5600	46.84	34928.588			
2400	27.46	20480.11786	5700	47.88	35704.116	8000	69	51453.3
2500	27.74	20684.29762	5800	48.92	36479.644	8100	69.3	51677.01
2600	28.01	20888.47738	5900	49.96	37255.172	8200	69.6	51900.72
2700	28.29	21092.65714	6000	51	38030.7	8300	69.9	52124.43
2800	28.56	21296.8369	6100	52.3	39000.11	8400	70.2	52348.14
2900	28.83	21501.01667	6200	53.6	39969.52	8500	70.5	52571.85
3000	29.11	21705.19643	6300	54.9	40938.93	8600	70.67	52696.13333
3100	29.38	21909.37619	6400	56.2	41908.34	8700	70.83	52820.41667
3200	29.65	22113.55595	6500	57.5	42877.75	8800	71	52944.7
3300	29.93	22317.73571	6600	58.7	43772.59	8900	71	52944.7
3400	30.20	22521.91548	6700	59.9	44667.43	9000	71	52944.7
3500	30.75	22930.275	6800	61.1	45562.27	9100	70.6	52646.42
3600	31.5	23489.55	6900	62.3	46457.11	9200	70.2	52348.14
3700	32.25	24048.825	7000	63.5	47351.95	9300	69.8	52049.86
3800	33	24608.1	7100	64	47724.8	9400	69.4	51751.58
3900	33.75	25167.375	7200	64.5	48097.65	9500	69	51453.3
4000	34.5	25726.65	7300	65	48470.5	9600	68	50707.6
4100	35.2	26248.64	7400	65.5	48843.35	9700	67	49961.9
4200	35.9	26770.63	7500	66	49216.2	9800	66	49216.2
4300	36.6	27292.62	7600	66.6	49663.62	9900	65	48470.5
4400	37.3	27814.61	7700	67.2	50111.04	10000	64	47724.8
4500	38	28336.6	7800	67.8	50558.46	10100	52.2	38925.54
4600	38.4	28634.88	7900	68.4	51005.88	10200	40.4	30126.28
						10300	28.6	21327.02
						10400	16.8	12527.76
						10500	5	3728.5

Table 31 Motorbike power

	Velocity (M/Sec)						4600	9.743	13.490	17.36691	21.31811	24.94218	28.1538
RPM	Gear 1	Gear 2	Gear 3	Gear 4	Gear 5	Gear 6	4700	9.955	13.784	17.74445	21.78154	25.48441	28.76584
1500	3.177	4.399	5.663121	6.951556	8.133321	9.18058	4800	10.167	14.077	18.12199	22.24498	26.02663	29.37788
1600	3.389	4.692	6.040663	7.414993	8.675542	9.79262	4900	10.378	14.370	18.49953	22.70842	26.56885	29.98992
1700	3.601	4.986	6.418204	7.87843	9.217764	10.4046	5000	10.590	14.663	18.87707	23.17185	27.11107	30.60196
1800	3.812	5.279	6.795746	8.341868	9.759985	11.0167	5100	10.802	14.957	19.25461	23.63529	27.65329	31.214
1900	4.024	5.572	7.173287	8.805305	10.30221	11.6287	5200	11.014	15.250	19.63215	24.09873	28.19551	31.82604
2000	4.236	5.865	7.550828	9.268742	10.84443	12.2407	5300	11.226	15.543	20.0097	24.56217	28.73773	32.43808
2100	4.448	6.159	7.92837	9.732179	11.38665	12.8528	5400	11.437	15.837	20.38724	25.0256	29.27996	33.05012
2200	4.660	6.452	8.305911	10.19562	11.92887	13.4648	5500	11.649	16.130	20.76478	25.48904	29.82218	33.66216
2300	4.872	6.745	8.683453	10.65905	12.47109	14.076	5600	11.861	16.423	21.14232	25.95248	30.3644	34.27419
2400	5.083	7.038	9.060994	11.12249	13.01331	14.6889	5700	12.073	16.716	21.51986	26.41591	30.90662	34.88623
2500	5.295	7.332	9.438535	11.58593	13.55553	15.3009	5800	12.285	17.010	21.8974	26.87935	31.44884	35.49827
2600	5.507	7.625	9.816077	12.04936	14.09776	15.9130	5900	12.497	17.303	22.27494	27.34279	31.99106	36.11031
2700	5.719	7.918	10.19362	12.5128	14.63998	16.5250	6000	12.708	17.596	22.65249	27.80623	32.53328	36.72235
2800	5.931	8.212	10.57116	12.97624	15.1822	17.137	6100	12.920	17.889	23.03003	28.26966	33.0755	37.33439
2900	6.142	8.505	10.9487	13.43968	15.72442	17.7491	6200	13.132	18.183	23.40757	28.7331	33.61773	37.94643
3000	6.354	8.798	11.32624	13.90311	16.26664	18.3611	6300	13.344	18.476	23.78511	29.19654	34.15995	38.55847
3100	6.566	9.091	11.70378	14.36655	16.80886	18.9732	6400	13.556	18.769	24.16265	29.65997	34.70217	39.17051
3200	6.778	9.385	12.08133	14.82999	17.35108	19.5852	6500	13.767	19.062	24.54019	30.12341	35.24439	39.78255
3300	6.990	9.678	12.45887	15.29342	17.89331	20.1972	6600	13.979	19.356	24.91773	30.58685	35.78661	40.39459
3400	7.201	9.971	12.83641	15.75686	18.43553	20.8093	6700	14.191	19.649	25.29528	31.05028	36.32883	41.00663
3500	7.413	10.264	13.21395	16.2203	18.97775	21.4213	6800	14.403	19.942	25.67282	31.51372	36.87105	41.61867
3600	7.625	10.558	13.59149	16.68374	19.51997	22.0334	6900	14.615	20.236	26.05036	31.97716	37.41328	42.2307
3700	7.837	10.851	13.96903	17.14717	20.06219	22.6454	7000	14.826	20.529	26.4279	32.4406	37.9555	42.84274
3800	8.049	11.144	14.34657	17.61061	20.60441	23.2574	7100	15.038	20.822	26.80544	32.90403	38.49772	43.45478
3900	8.260	11.437	14.72412	18.07405	21.14663	23.8695	7200	15.250	21.115	27.18298	33.36747	39.03994	44.06682
4000	8.472	11.731	15.10166	18.53748	21.68886	24.4815	7300	15.462	21.409	27.56052	33.83091	39.58216	44.67886
4100	8.684	12.024	15.4792	19.00092	22.23108	25.0936	7400	15.674	21.702	27.93806	34.29434	40.12438	45.2909
4200	8.896	12.317	15.85674	19.46436	22.7733	25.7056	7500	15.885	21.995	28.31561	34.75778	40.6666	45.90294
4300	9.108	12.611	16.23428	19.92779	23.31552	26.3176	7600	16.097	22.288	28.69315	35.22122	41.20883	46.51498
4400	9.319	12.904	16.61182	20.39123	23.85774	26.9297	7700	16.309	22.582	29.07069	35.68466	41.75105	47.12702
4500	9.531	13.197	16.98936	20.85467	24.39996	27.5417	7800	16.521	22.875	29.44823	36.14809	42.29327	47.73906

7900	16.733	23.168	29.82577	36.61153	42.83549	48.3511
8000	16.944	23.462	30.20331	37.07497	43.37771	48.96314
8100	17.156	23.755	30.58085	37.5384	43.91993	49.57517
8200	17.368	24.048	30.9584	38.00184	44.46215	50.18721
8300	17.580	24.341	31.33594	38.46528	45.00438	50.79925
8400	17.792	24.635	31.71348	38.92872	45.5466	51.41129
8500	18.003	24.928	32.09102	39.39215	46.08882	52.02333
8600	18.215	25.221	32.46856	39.85559	46.63104	52.63537
8700	18.427	25.514	32.8461	40.31903	47.17326	53.24741
8800	18.639	25.808	33.22364	40.78246	47.71548	53.85945
8900	18.851	26.101	33.60119	41.2459	48.2577	54.47149
9000	19.062	26.394	33.97873	41.70934	48.79993	55.08353
9100	19.274	26.687	34.35627	42.17277	49.34215	55.69557
9200	19.486	26.981	34.73381	42.63621	49.88437	56.30761
9300	19.698	27.274	35.11135	43.09965	50.42659	56.91965
9400	19.910	27.567	35.48889	43.56309	50.96881	57.53168
9500	20.121	27.861	35.86643	44.02652	51.51103	58.14372
9600	20.333	28.154	36.24398	44.48996	52.05325	58.75576
9700	20.545	28.447	36.62152	44.9534	52.59547	59.3678
9800	20.757	28.740	36.99906	45.41683	53.1377	59.97984
9900	20.969	29.034	37.3766	45.88027	53.67992	60.59188
10000	21.181	29.327	37.75414	46.34371	54.22214	61.20392
10100	21.392	29.620	38.13168	46.80715	54.76436	61.81596
10200	21.604	29.913	38.50922	47.27058	55.30658	62.428
10300	21.816	30.207	38.88677	47.73402	55.8488	63.04004
10400	22.028	30.500	39.26431	48.19746	56.39102	63.65208
10500	22.240	30.793	39.64185	48.66089	56.93325	64.26412

Table 32 Velocity

	Force (N)						4600	2939.009	2122.617	1648.819	1343.219	1148.05	1017.09
RPM	Gear 1	Gear 2	Gear 3	Gear 4	Gear 5	Gear 6	4700	2906.440	2099.095	1630.547	1328.334	1135.328	1005.82
1500	5867.812	4237.864	3291.913	2681.774	2292.114	2030.64	4800	2875.228	2076.554	1613.037	1314.069	1123.136	995.015
1600	5561.324	4016.512	3119.969	2541.699	2172.392	1924.58	4900	2845.290	2054.932	1596.242	1300.387	1111.441	984.655
1700	5290.893	3821.2	2968.254	2418.103	2066.755	1830.99	5000	2816.550	2034.175	1580.118	1287.251	1100.215	974.709
1800	5050.510	3647.59	2833.396	2308.241	1972.855	1747.8	5100	2841.402	2052.124	1594.06	1298.609	1109.923	983.309
1900	4835.430	3492.255	2712.734	2209.943	1888.84	1673.37	5200	2865.298	2069.382	1607.466	1309.531	1119.257	991.579
2000	4641.859	3352.453	2604.138	2121.474	1813.226	1606.38	5300	2888.292	2085.989	1620.366	1320.04	1128.239	999.536
2100	4466.722	3225.966	2505.884	2041.432	1744.813	1545.78	5400	2910.435	2101.981	1632.789	1330.16	1136.889	1007.2
2200	4307.508	3110.978	2416.563	1968.666	1682.62	1490.68	5500	2931.772	2117.391	1644.759	1339.912	1145.224	1014.58
2300	4162.138	3005.988	2335.009	1902.227	1625.835	1440.37	5600	2944.804	2126.803	1652.07	1345.867	1150.314	1019.09
2400	4028.882	2909.748	2260.251	1841.325	1573.782	1394.25	5700	2957.377	2135.884	1659.124	1351.614	1155.226	1023.44
2500	3906.286	2821.207	2191.473	1785.295	1525.893	1351.83	5800	2969.518	2144.652	1665.935	1357.162	1159.968	1027.65
2600	3793.122	2739.477	2127.986	1733.575	1481.688	1312.67	5900	2981.246	2153.122	1672.515	1362.523	1164.549	1031.7
2700	3688.339	2663.8	2069.202	1685.686	1440.757	1276.4	6000	2992.584	2161.311	1678.875	1367.705	1168.978	1035.63
2800	3591.041	2593.53	2014.617	1641.218	1402.75	1242.73	6100	3018.557	2180.069	1693.446	1379.575	1179.124	1044.62
2900	3500.454	2528.105	1963.796	1599.817	1367.365	1211.38	6200	3043.691	2198.221	1707.547	1391.062	1188.942	1053.31
3000	3415.905	2467.043	1916.363	1561.175	1334.338	1182.12	6300	3068.028	2215.798	1721.2	1402.184	1198.448	1061.74
3100	3336.811	2409.919	1871.991	1525.027	1303.442	1154.75	6400	3091.604	2232.825	1734.426	1412.959	1207.658	1069.9
3200	3262.661	2356.366	1830.392	1491.138	1274.477	1129.09	6500	3114.454	2249.328	1747.246	1423.403	1216.584	1077.8
3300	3193.004	2306.059	1791.313	1459.303	1247.267	1104.99	6600	3131.278	2261.479	1756.684	1431.092	1223.155	1083.63
3400	3127.445	2258.711	1754.534	1429.34	1221.658	1082.3	6700	3147.600	2273.266	1765.841	1438.551	1229.531	1089.27
3500	3093.175	2233.96	1735.308	1413.678	1208.272	1070.44	6800	3163.441	2284.708	1774.728	1445.791	1235.719	1094.76
3600	3080.601	2224.879	1728.254	1407.931	1203.36	1066.09	6900	3178.824	2295.817	1783.358	1452.822	1241.728	1100.08
3700	3068.707	2216.289	1721.581	1402.495	1198.714	1061.97	7000	3193.766	2306.609	1791.741	1459.651	1247.565	1105.25
3800	3057.439	2208.15	1715.26	1397.345	1194.312	1058.07	7100	3173.577	2292.028	1780.415	1450.424	1239.679	1098.26
3900	3046.749	2200.43	1709.262	1392.459	1190.136	1054.37	7200	3153.949	2277.852	1769.403	1441.453	1232.011	1091.47
4000	3036.593	2193.095	1703.565	1387.818	1186.169	1050.86	7300	3134.859	2264.065	1758.693	1432.728	1224.554	1084.86
4100	3022.639	2183.017	1695.736	1381.44	1180.718	1046.03	7400	3116.284	2250.65	1748.272	1424.239	1217.298	1078.44
4200	3009.349	2173.419	1688.281	1375.367	1175.527	1041.43	7500	3098.205	2237.592	1738.13	1415.976	1210.236	1072.18
4300	2996.678	2164.268	1681.172	1369.576	1170.577	1037.04	7600	3085.234	2228.225	1730.853	1410.048	1205.17	1067.69
4400	2984.583	2155.532	1674.386	1364.048	1165.853	1032.86	7700	3072.600	2219.1	1723.765	1404.274	1200.234	1063.32
4500	2973.025	2147.185	1667.902	1358.765	1161.338	1028.86	7800	3060.290	2210.209	1716.859	1398.648	1195.426	1059.06

7900	3048.291	2201.544	1710.128	1393.164	1190.739	1054.91
8000	3036.593	2193.095	1703.565	1387.818	1186.169	1050.86
8100	3012.144	2175.437	1689.848	1376.644	1176.619	1042.4
8200	2988.291	2158.21	1676.467	1365.742	1167.301	1034.14
8300	2965.013	2141.398	1663.407	1355.103	1158.208	1026.09
8400	2942.289	2124.986	1650.659	1344.718	1149.332	1018.22
8500	2920.100	2108.961	1638.211	1334.577	1140.664	1010.54
8600	2892.968	2089.366	1622.989	1322.177	1130.066	1001.15
8700	2866.460	2070.221	1608.118	1310.062	1119.711	991.981
8800	2840.555	2051.512	1593.585	1298.222	1109.592	983.016
8900	2808.638	2028.461	1575.679	1283.635	1097.124	971.971
9000	2777.431	2005.922	1558.172	1269.373	1084.934	961.171
9100	2731.434	1972.703	1532.367	1248.351	1066.967	945.253
9200	2686.438	1940.205	1507.123	1227.786	1049.39	929.682
9300	2642.408	1908.406	1482.423	1207.663	1032.191	914.445
9400	2599.316	1877.284	1458.247	1187.969	1015.358	899.532
9500	2557.131	1846.817	1434.581	1168.689	998.8792	884.933
9600	2493.820	1801.092	1399.063	1139.754	974.1485	863.023
9700	2431.815	1756.311	1364.277	1111.415	949.9277	841.566
9800	2371.075	1712.443	1330.201	1083.655	926.2012	820.546
9900	2311.562	1669.462	1296.814	1056.456	902.9541	799.95
10000	2253.240	1627.34	1264.094	1029.801	880.1718	779.767
10100	1819.603	1314.158	1020.819	831.6153	710.7823	629.7
10200	1394.468	1007.116	782.3133	637.3156	544.7142	482.576
10300	977.589	706.0364	548.439	446.7887	381.8707	338.309
10400	568.726	410.7469	319.0623	259.9257	222.1588	196.816
10500	167.652	121.0818	94.05464	76.6221	65.48898	58.0184

Table 33 Driving Force

	Acceleration (m/Sec^2)						4600	12.18178	8.757857	6.746338	5.422152	4.551719	3.947128
RPM	Gear 1	Gear 2	Gear 3	Gear 4	Gear 5	Gear 6	4700	12.04494	8.657266	6.665711	5.353226	4.489178	3.887969
1500	24.38468	17.60689	13.67076	11.12911	9.503277	8.410123	4800	11.91371	8.560688	6.588148	5.286726	4.428632	3.830498
1600	23.11034	16.68595	12.95455	10.54457	9.002458	7.965184	4900	11.78774	8.467873	6.513454	5.222494	4.369946	3.774594
1700	21.98583	15.87318	12.32232	10.02837	8.559972	7.571843	5000	11.66672	8.378592	6.441452	5.160385	4.312997	3.720147
1800	20.98618	15.15054	11.76005	9.56909	8.166062	7.221456	5100	11.76841	8.450121	6.494311	5.199925	4.342849	3.74252
1900	20.09166	14.5038	11.25668	9.157727	7.813025	6.907199	5200	11.86609	8.51872	6.544841	5.237497	4.370942	3.763253
2000	19.2865	13.92156	10.80336	8.787067	7.4947	6.623613	5300	11.96	8.584551	6.593167	5.273205	4.397363	3.782424
2100	18.55794	13.3946	10.39293	8.451275	7.206098	6.366279	5400	12.05033	8.647765	6.639407	5.307143	4.422193	3.800105
2200	17.89552	12.91537	10.01952	8.145575	6.943137	6.13158	5500	12.13729	8.708501	6.683668	5.3394	4.445508	3.816364
2300	17.2906	12.47764	9.678289	7.866021	6.702445	5.916531	5600	12.18969	8.744243	6.708461	5.355727	4.45513	3.82041
2400	16.73601	12.07621	9.365206	7.609328	6.481214	5.71864	5700	12.24016	8.778552	6.732086	5.371033	4.463801	3.823534
2500	16.22569	11.70671	9.076879	7.372732	6.277083	5.535819	5800	12.28879	8.811498	6.7546	5.385364	4.47156	3.825769
2600	15.75454	11.36547	8.81044	7.153898	6.088055	5.366296	5900	12.33569	8.843148	6.776054	5.398761	4.478444	3.827148
2700	15.3182	11.04933	8.563447	6.950835	5.912428	5.208566	6000	12.38092	8.873564	6.796495	5.411264	4.484485	3.827699
2800	14.91293	10.75559	8.333804	6.761838	5.748745	5.061336	6100	12.48695	8.947848	6.850959	5.451414	4.514078	3.849035
2900	14.53552	10.48194	8.119707	6.585435	5.595748	4.923493	6200	12.58947	9.019556	6.903368	5.489821	4.542103	3.868902
3000	14.18317	10.22635	7.919591	6.420352	5.452349	4.794072	6300	12.68863	9.088808	6.953817	5.52656	4.568624	3.887355
3100	13.85347	9.987075	7.732094	6.265479	5.317597	4.672231	6400	12.78461	9.155717	7.002391	5.561702	4.593703	3.90445
3200	13.54428	9.762578	7.556021	6.119844	5.190664	4.557236	6500	12.87754	9.220387	7.049173	5.595315	4.617397	3.920237
3300	13.25374	9.551511	7.390327	5.982594	5.070819	4.44844	6600	12.94538	9.266906	7.081801	5.617328	4.631097	3.92709
3400	12.9802	9.352682	7.234086	5.852975	4.957418	4.345273	6700	13.01111	9.311856	7.113158	5.638235	4.643775	3.932957
3500	12.83667	9.247714	7.150702	5.782639	4.894609	4.286845	6800	13.07481	9.355304	7.143294	5.658078	4.655465	3.937867
3600	12.78328	9.207812	7.117806	5.753365	4.866816	4.259359	6900	13.13657	9.397314	7.172259	5.676898	4.666202	3.941853
3700	12.73269	9.169889	7.086394	5.725229	4.839919	4.232585	7000	13.19648	9.437943	7.200099	5.69473	4.676018	3.944942
3800	12.68466	9.133785	7.056341	5.698131	4.813831	4.206447	7100	13.11033	9.373054	7.14592	5.645676	4.628587	3.897234
3900	12.63901	9.099354	7.027535	5.671979	4.788473	4.180876	7200	13.02648	9.309787	7.092948	5.597535	4.581859	3.850068
4000	12.59555	9.066467	6.999874	5.64669	4.763774	4.155808	7300	12.94484	9.248074	7.041129	5.550264	4.535797	3.803411
4100	12.53627	9.022118	6.963257	5.614035	4.732702	4.125013	7400	12.8653	9.187849	6.990412	5.503822	4.490364	3.757231
4200	12.47972	8.979703	6.928088	5.58249	4.702501	4.094908	7500	12.7878	9.12905	6.940749	5.458168	4.445527	3.711498
4300	12.4257	8.939083	6.894259	5.551967	4.673095	4.065428	7600	12.73149	9.085524	6.902897	5.422066	4.408777	3.672849
4400	12.37405	8.900131	6.861673	5.522387	4.644417	4.036512	7700	12.67656	9.042949	6.86573	5.386452	4.372365	3.634419
4500	12.3246	8.862732	6.830239	5.493676	4.616403	4.008104	7800	12.62294	9.001285	6.829217	5.351302	4.336271	3.59619

7900	12.57058	8.960496	6.79333	5.316592	4.300476	3.558144
8000	12.51943	8.920546	6.758041	5.282299	4.26496	3.520266
8100	12.41526	8.842261	6.692921	5.223634	4.208534	3.463782
8200	12.31354	8.765705	6.629091	5.165951	4.152869	3.407892
8300	12.21417	8.690814	6.5665	5.109207	4.097929	3.352563
8400	12.11708	8.617526	6.5051	5.053364	4.043681	3.297767
8500	12.02217	8.545781	6.444847	4.998385	3.990094	3.243475
8600	11.9067	8.459141	6.372968	4.933866	3.928274	3.181809
8700	11.79378	8.374311	6.302443	4.870379	3.867259	3.120776
8800	11.68333	8.291229	6.233222	4.807886	3.807014	3.060344
8900	11.54787	8.190043	6.149884	4.733822	3.736803	2.991002
9000	11.41533	8.090926	6.0681	4.660954	3.667535	2.922415
9100	11.22128	7.947352	5.951729	4.55984	3.574048	2.832291
9200	11.03136	7.80672	5.837589	4.460474	3.481976	2.74334
9300	10.84543	7.668931	5.725605	4.362794	3.391268	2.655516
9400	10.66336	7.533893	5.615704	4.266742	3.301872	2.568775
9500	10.48503	7.401518	5.507818	4.172262	3.213742	2.483074
9600	10.21887	7.205669	5.350572	4.0375	3.091106	2.366722
9700	9.958097	7.013677	5.19627	3.905067	2.970381	2.251983
9800	9.702553	6.825423	5.044817	3.774885	2.851503	2.1388
9900	9.452078	6.640791	4.896125	3.646883	2.734409	2.027116
10000	9.206518	6.459672	4.750107	3.520989	2.619039	1.91688
10100	7.401015	5.151889	3.72886	2.682016	1.894122	1.266549
10200	5.63082	3.869568	2.727337	1.859042	1.182801	0.628183
10300	3.894904	2.611967	1.744963	1.051597	0.484675	0.001425
10400	2.192276	1.378369	0.781181	0.259229	-0.20064	-0.61407
10500	0.521985	0.168087	-0.16454	-0.5185	-0.87353	-1.21862

Table 34 Acceleration

Acceleration with Resistive Forces (m/Sec ²)							4600	7.645172	5.426581	4.114103	3.24027	2.656963	2.244634
RPM	Gear 1	Gear 2	Gear 3	Gear 4	Gear 5	Gear 6	4700	7.556412	5.36068	4.060373	3.193192	2.613023	2.201882
1500	15.52223	11.15207	8.613166	6.972742	5.922373	5.215326	4800	7.471256	5.297343	4.008581	3.147621	2.570292	2.160117
1600	14.70061	10.55808	8.150917	6.595067	5.598339	4.926981	4900	7.389481	5.236409	3.9586	3.103455	2.528682	2.119264
1700	13.97556	10.03379	7.742759	6.261386	5.311828	4.671796	5000	7.310881	5.177729	3.910317	3.0606	2.488113	2.079251
1800	13.33098	9.567587	7.379661	5.964341	5.056551	4.444199	5100	7.375829	5.222685	3.942481	3.083211	2.503419	2.088655
1900	12.75416	9.150278	7.054492	5.698124	4.827542	4.239793	5200	7.438184	5.265729	3.973105	3.104497	2.517512	2.096904
2000	12.23493	8.774523	6.761546	5.458088	4.620831	4.055057	5300	7.498091	5.306966	4.002272	3.124524	2.530449	2.104046
2100	11.76505	8.434378	6.496207	5.24047	4.4332	3.887144	5400	7.555684	5.346493	4.030055	3.143353	2.542283	2.110129
2200	11.3378	8.124977	6.254695	5.042192	4.262021	3.733723	5500	7.611087	5.384401	4.056526	3.161042	2.553063	2.115195
2300	10.94761	7.842303	6.033889	4.860712	4.105118	3.592867	5600	7.644204	5.406174	4.070409	3.168405	2.554938	2.11229
2400	10.58984	7.583006	5.831189	4.693909	3.960681	3.462973	5700	7.676064	5.427	4.083503	3.175053	2.556122	2.108691
2500	10.2606	7.344275	5.644408	4.540005	3.827188	3.342693	5800	7.70673	5.446926	4.095842	3.181016	2.556641	2.10442
2600	9.956595	7.123729	5.471699	4.397493	3.703353	3.230887	5900	7.736261	5.465993	4.107459	3.18632	2.556517	2.099497
2700	9.675014	6.919341	5.311487	4.265091	3.588079	3.126582	6000	7.764712	5.484242	4.118386	3.19099	2.555772	2.093942
2800	9.413452	6.729372	5.16242	4.141697	3.480425	3.028946	6100	7.832338	5.530745	4.151207	3.213425	2.57013	2.101685
2900	9.169835	6.552325	5.023337	4.026366	3.379582	2.937262	6200	7.897687	5.575565	4.182665	3.234679	2.5834	2.108382
3000	8.942365	6.386901	4.893228	3.918273	3.284847	2.850907	6300	7.960867	5.61878	4.212821	3.254801	2.595623	2.114068
3100	8.729477	6.23197	4.771214	3.816706	3.195609	2.769339	6400	8.021976	5.66046	4.241732	3.273837	2.606837	2.118779
3200	8.5298	6.086542	4.656528	3.721036	3.111332	2.692085	6500	8.08111	5.700675	4.269449	3.29183	2.617081	2.122548
3300	8.342131	5.949748	4.548494	3.630714	3.031546	2.618727	6600	8.124065	5.729167	4.288005	3.302289	2.620806	2.120459
3400	8.165407	5.820819	4.446515	3.545254	2.955837	2.548898	6700	8.165641	5.756625	4.305704	3.311978	2.623793	2.117634
3500	8.072478	5.75237	4.391462	3.497951	2.91266	2.507808	6800	8.2059	5.783092	4.322579	3.320924	2.626066	2.114095
3600	8.037643	5.72584	4.368916	3.477059	2.891977	2.486564	6900	8.244896	5.808609	4.33866	3.329153	2.627646	2.109859
3700	8.004597	5.700563	4.347288	3.456844	2.871794	2.46568	7000	8.282682	5.833213	4.353978	3.33669	2.628554	2.104946
3800	7.973195	5.676435	4.326498	3.43724	2.852053	2.445106	7100	8.226313	5.789778	4.31639	3.301054	2.592484	2.06719
3900	7.94331	5.653363	4.306475	3.41819	2.832706	2.424798	7200	8.171415	5.747366	4.279541	3.265951	2.556789	2.029685
4000	7.914823	5.631263	4.287152	3.399639	2.813706	2.404716	7300	8.117924	5.705932	4.243399	3.231351	2.521444	1.992407
4100	7.876129	5.601752	4.262017	3.376283	2.790519	2.380842	7400	8.065784	5.665435	4.207928	3.197228	2.486428	1.955339
4200	7.839183	5.573465	4.237779	3.353586	2.767816	2.357315	7500	8.014938	5.625834	4.1731	3.163556	2.451718	1.918459
4300	7.803861	5.546312	4.214366	3.33149	2.745547	2.33409	7600	7.977746	5.596056	4.145847	3.135985	2.422142	1.886045
4400	7.770049	5.520211	4.191717	3.309945	2.72367	2.311129	7700	7.941424	5.566867	4.118997	3.108671	2.392706	1.853674
4500	7.737645	5.495089	4.169773	3.288904	2.702143	2.288397	7800	7.905937	5.538243	4.092531	3.081599	2.363398	1.821333
	7900	7.871253	5.51016	4.066432	3.054754	2.334204	1.789011						
	8000	7.837341	5.482595	4.04068	3.028121	2.305112	1.756697						
	8100	7.769235	5.430297	3.995661	2.985721	2.262464	1.712291						
	8200	7.702695	5.37909	3.951435	2.943896	2.220228	1.668169						
	8300	7.637662	5.328934	3.907971	2.902621	2.178382	1.624308						
	8400	7.574081	5.279788	3.865236	2.861869	2.136904	1.580692						
	8500	7.511901	5.231615	3.823203	2.821617	2.095773	1.537302						
	8600	7.436447	5.173816	3.773639	2.775158	2.049258	1.489059						
	8700	7.362632	5.117163	3.724909	2.729308	2.003184	1.441124						
	8800	7.290399	5.061613	3.676982	2.684041	1.957528	1.393478						
	8900	7.202029	4.99437	3.619917	2.63126	1.90537	1.339989						
	9000	7.115527	4.928438	3.563816	2.579192	1.853742	1.286887						
	9100	6.989369	4.833827	3.485383	2.50886	1.786425	1.219803						
	9200	6.865858	4.741089	3.40835	2.439597	1.719942	1.153376						
	9300	6.744908	4.650161	3.332669	2.371365	1.654259	1.087576						
	9400	6.626434	4.560983	3.258293	2.304124	1.589345	1.022375						
	9500	6.510359	4.4735	3.185178	2.23784	1.525169	0.957745						
	9600	6.337654	4.345078	3.080208	2.145534	1.438672	0.873259						
	9700	6.168414	4.219119	2.977098	2.054672	1.35333	0.789712						
	9800	6.002531	4.095548	2.875786	1.965204	1.269099	0.707069						
	9900	5.839904	3.974288	2.776217	1.877084	1.185941	0.625294						
	10000	5.680433	3.85527	2.678333	1.790266	1.103817	0.544351						
	10100	4.515417	3.009986	2.016242	1.243743	0.628702	0.115167						
	10200	3.373149	2.181092	1.366828	0.707476	0.162274	-0.3064						
	10300	2.252964	1.368109	0.729719	0.181162	-0.29573	-0.72059						
	10400	1.154225	0.570575	0.104556	-0.33549	-0.74555	-1.12762						
	10500	0.076319	-0.21195	-0.509	-0.84276	-1.18744	-1.52769						

Table 35 Acceleration Restricted

Appendix D Braking Forces

	Gear 1				4600	2890.888	2251.267415	109.0186	-2638.98
RPM	S	Nr	Nf	F	4700	2858.319	2238.264657	122.0213	-2625.98
1500	5819.691	3420.562031	-1060.28	-3808.28	4800	2827.107	2225.803682	134.4823	-2613.52
1600	5513.203	3298.1997	-937.914	-3685.91	4900	2797.169	2213.851317	146.4347	-2601.56
1700	5242.772	3190.232937	-829.947	-3577.95	5000	2768.429	2202.377047	157.909	-2590.09
1800	5002.389	3094.262482	-733.976	-3481.98	5100	2793.281	2212.298916	147.9871	-2600.01
1900	4787.309	3008.394179	-648.108	-3396.11	5200	2817.177	2221.839174	138.4468	-2609.55
2000	4593.738	2931.112707	-570.827	-3318.83	5300	2840.171	2231.019423	129.2666	-2618.73
2100	4418.602	2861.191375	-500.905	-3248.9	5400	2862.314	2239.859662	120.4263	-2627.57
2200	4259.387	2797.626528	-437.341	-3185.34	5500	2883.652	2248.378438	111.9076	-2636.09
2300	4114.017	2739.589059	-379.303	-3127.3	5600	2896.683	2253.580977	106.705	-2641.29
2400	3980.761	2686.388045	-326.102	-3074.1	5700	2909.257	2258.60097	101.685	-2646.31
2500	3858.166	2637.443113	-277.157	-3025.16	5800	2921.397	2263.44786	96.83814	-2651.16
2600	3745.001	2592.263175	-231.977	-2979.98	5900	2933.126	2268.130448	92.15555	-2655.84
2700	3640.218	2550.4299	-190.144	-2938.14	6000	2944.463	2272.65695	87.62905	-2660.37
2800	3542.92	2511.584715	-151.299	-2899.3	6100	2970.436	2283.026116	77.25988	-2670.74
2900	3452.333	2475.418509	-115.133	-2863.13	6200	2995.57	2293.060793	67.22521	-2680.77
3000	3367.784	2441.663383	-81.3774	-2829.38	6300	3019.907	2302.776909	57.50909	-2690.49
3100	3288.69	2410.086008	-49.8	-2797.8	6400	3043.483	2312.189396	48.0966	-2699.9
3200	3214.54	2380.482218	-20.1962	-2768.2	6500	3066.333	2321.312268	38.97373	-2709.03
3300	3144.884	2352.672597	7.613403	-2740.39	6600	3083.157	2328.028995	32.25701	-2715.74
3400	3079.325	2326.498837	33.78716	-2714.21	6700	3099.479	2334.545223	25.74078	-2722.26
3500	3045.055	2312.816895	47.46911	-2700.53	6800	3115.32	2340.869797	19.4162	-2728.58
3600	3032.481	2307.796902	52.4891	-2695.51	6900	3130.703	2347.01105	13.27495	-2734.72
3700	3020.586	2303.04826	57.23774	-2690.76	7000	3145.646	2352.976839	7.309161	-2740.69
3800	3009.318	2298.549546	61.73645	-2686.26	7100	3125.457	2344.916569	15.36943	-2732.63
3900	2998.628	2294.281536	66.00446	-2681.99	7200	3105.828	2337.080195	23.20581	-2724.79
4000	2988.472	2290.226926	70.05907	-2677.94	7300	3086.738	2329.458516	30.82748	-2717.17
4100	2974.518	2284.655958	75.63004	-2672.37	7400	3068.163	2322.042828	38.24317	-2709.76
4200	2961.229	2279.350274	80.93573	-2667.06	7500	3050.084	2314.824892	45.46111	-2702.54
4300	2948.557	2274.291367	85.99463	-2662	7600	3037.113	2309.646373	50.63963	-2697.36
4400	2936.462	2269.462409	90.82359	-2657.18	7700	3024.479	2304.602361	55.68364	-2692.32
4500	2924.904	2264.848072	95.43793	-2652.56	7800	3012.169	2299.687682	60.59832	-2687.4

Table 36 Braking force gear 1 part 1

7900	3000.171	2294.897426	65.38857	-2682.61
8000	2988.472	2290.226926	70.05907	-2677.94
8100	2964.023	2280.465828	79.82017	-2668.18
8200	2940.17	2270.942806	89.34319	-2658.66
8300	2916.892	2261.649255	98.63675	-2649.36
8400	2894.168	2252.576978	107.709	-2640.29
8500	2871.979	2243.718167	116.5678	-2631.43
8600	2844.847	2232.886153	127.3998	-2620.6
8700	2818.339	2222.30315	137.9828	-2610.02
8800	2792.434	2211.960671	148.3253	-2599.67
8900	2760.517	2199.2184	161.0676	-2586.93
9000	2729.31	2186.759291	173.5267	-2574.47
9100	2683.314	2168.395556	191.8904	-2556.11
9200	2638.317	2150.431032	209.855	-2538.14
9300	2594.288	2132.852842	227.4332	-2520.57
9400	2551.195	2115.648657	244.6373	-2503.36
9500	2509.01	2098.806664	261.4793	-2486.52
9600	2445.699	2073.530559	286.7554	-2461.24
9700	2383.694	2048.77561	311.5104	-2436.49
9800	2322.954	2024.525865	335.7601	-2412.24
9900	2263.442	2000.766013	359.52	-2388.48
10000	2205.119	1977.481358	382.8046	-2365.19
10100	1771.482	1804.356211	555.9298	-2192.07
10200	1346.348	1634.625675	725.6603	-2022.34
10300	929.4681	1468.190878	892.0951	-1855.9
10400	520.6056	1304.956749	1055.329	-1692.67
10500	119.531	1144.831842	1215.454	-1532.55

Table 37 Braking force gear 1 part 2

	Gear 2			
RPM	S	Nr	Nf	F
1500	4188.934071	2769.498978	-409.212978	-3157.21
1600	3967.348532	2681.033241	-320.7472407	-3068.75
1700	3771.789093	2602.958155	-242.6721553	-2990.67
1800	3597.915861	2533.541064	-173.2550639	-2921.25
1900	3442.302322	2471.413967	-111.1279666	-2859.13
2000	3302.207267	2415.482463	-55.19646344	-2803.2
2100	3175.411621	2364.860612	-4.57461163	-2752.57
2200	3060.099776	2318.823549	41.46245111	-2706.54
2300	2954.771883	2276.772476	83.51352408	-2664.49
2400	2858.178068	2238.208393	122.0776067	-2625.92
2500	2769.268436	2202.712142	157.5738584	-2590.43
2600	2687.154616	2169.929047	190.3569527	-2557.64
2700	2611.079846	2139.556981	220.7290187	-2527.27
2800	2540.395473	2111.336976	248.9490244	-2499.05
2900	2474.542313	2085.045782	275.2402179	-2472.76
3000	2413.035742	2060.489919	299.7960811	-2448.2
3100	2355.453665	2037.50087	322.7851302	-2425.21
3200	2301.426752	2015.931183	344.3548171	-2403.64
3300	2250.630438	1995.651279	364.6347207	-2383.36
3400	2202.778342	1976.546825	383.7391753	-2364.26
3500	2177.508832	1966.458234	393.8277663	-2354.17
3600	2167.893694	1962.619489	397.6665108	-2350.33
3700	2158.754386	1958.970715	401.3152851	-2346.68
3800	2150.052155	1955.496439	404.7895608	-2343.21
3900	2141.752223	1952.182777	408.1032231	-2339.9
4000	2133.823289	1949.017232	411.2687681	-2336.73
4100	2123.136229	1944.750534	415.5354662	-2332.46
4200	2112.914025	1940.669424	419.6165756	-2328.38
4300	2103.123195	1936.760537	423.5254634	-2324.47
4400	2093.733301	1933.011719	427.2742813	-2320.73
4500	2084.716612	1929.411899	430.8741012	-2317.13

Table 38 Braking force gear 2 part 1

4600	2059.496904	1919.343191	440.942809	-2307.06					
4700	2035.275529	1909.673057	450.6129431	-2297.39					
4800	2012.01919	1900.388204	459.897796	-2288.1					
4900	1989.667884	1891.464676	468.821324	-2279.18					
5000	1968.166406	1882.880433	477.4055669	-2270.59					
5100	1985.355375	1889.742951	470.5430485	-2277.46					
5200	2001.838971	1896.323857	463.9621431	-2284.04	7900	2107.398718	1938.467495	421.818505	-2326.18
5300	2017.65627	1902.63875	457.6472502	-2290.35	8000	2097.753953	1934.616922	425.6690778	-2322.33
5400	2032.843451	1908.702075	451.583925	-2296.42	8100	2078.885284	1927.083801	433.2021989	-2314.8
5500	2047.434065	1914.527227	445.7587731	-2302.24	8200	2060.43225	1919.716618	440.569382	-2307.43
5600	2056.010582	1917.951313	442.3346873	-2305.66	8300	2042.379285	1912.509158	447.7768419	-2300.22
5700	2064.241833	1921.237555	439.0484452	-2308.95	8400	2024.711562	1905.455502	454.8304975	-2293.17
5800	2072.1449	1924.392772	435.8932276	-2312.11	8500	2007.414955	1898.550011	461.7359892	-2286.26
5900	2079.735704	1927.423323	432.8626775	-2315.14	8600	1986.533793	1890.213423	470.0725773	-2277.93
6000	2087.029107	1930.335138	429.9508618	-2318.05	8700	1966.08805	1882.050671	478.2353291	-2269.76
6100	2104.876812	1937.46065	422.82535	-2325.17	8800	1946.062369	1874.055625	486.2303754	-2261.77
6200	2122.104385	1944.338581	415.9474192	-2332.05	8900	1921.680438	1864.321391	495.9646094	-2252.03
6300	2138.740642	1950.980434	409.3055658	-2338.69	9000	1897.795702	1854.785657	505.5003433	-2242.5
6400	2154.812593	1957.396995	402.8890052	-2345.11	9100	1863.21449	1840.979465	519.306535	-2228.69
6500	2170.345591	1963.598384	396.6876164	-2351.31	9200	1829.340407	1827.455587	532.8304128	-2215.17
6600	2181.510844	1968.055996	392.2300042	-2355.77	9300	1796.150157	1814.204723	546.0812771	-2201.92
6700	2192.298354	1972.362797	387.9232026	-2360.08	9400	1763.621436	1801.217967	559.0680328	-2188.93
6800	2202.72412	1976.525177	383.7608231	-2364.24	9500	1731.732879	1788.48679	571.7992099	-2176.2
6900	2212.803218	1980.549153	379.7368474	-2368.26	9600	1684.572018	1769.658304	590.6276963	-2157.37
7000	2222.549859	1984.440398	375.8456016	-2372.15	9700	1638.338884	1751.200203	609.0857971	-2138.91
7100	2206.908399	1978.195707	382.090293	-2365.91	9800	1593.004618	1733.100966	627.1850345	-2120.81
7200	2191.656924	1972.106713	388.1792868	-2359.82	9900	1548.541525	1715.349535	644.9364651	-2103.06
7300	2176.778789	1966.166771	394.1192286	-2353.88	10000	1504.923018	1697.935297	662.3507034	-2085.65
7400	2162.258248	1960.369596	399.9164042	-2348.08	10100	1190.228895	1572.29692	787.9890803	-1960.01
7500	2148.080398	1954.709235	405.5767647	-2342.42	10200	881.6605612	1449.104201	911.1817994	-1836.82
7600	2137.576798	1950.515782	409.7702185	-2338.23	10300	579.0391569	1328.285732	1032.000268	-1716
7700	2127.301478	1946.413466	413.8725338	-2334.13	10400	282.1927021	1209.772852	1150.513148	-1597.49
7800	2117.245079	1942.398553	417.8874469	-2330.11	10500	-9.044231467	1093.499515	1266.786485	-1481.21

Table 39 Braking force gear 2 part 2

	Gear 3			
RPM	S	Nr	Nf	F
1500	3241.87	2391.393	-31.1074	-2779.11
1600	3069.54	2322.593	37.69346	-2710.31
1700	2917.414	2261.858	98.42832	-2649.57
1800	2782.12	2207.843	152.4431	-2595.56
1900	2660.996	2159.486	200.8003	-2547.2
2000	2551.914	2115.936	244.3502	-2503.65
2100	2453.15	2076.505	283.781	-2464.22
2200	2363.292	2040.63	319.6556	-2428.34
2300	2281.177	2007.847	352.4392	-2395.56
2400	2205.833	1977.766	382.5195	-2365.48
2500	2136.445	1950.064	410.2221	-2337.78
2600	2072.322	1924.464	435.8223	-2312.18
2700	2012.878	1900.731	459.5551	-2288.44
2800	1957.607	1878.665	481.6214	-2266.38
2900	1906.076	1858.091	502.1947	-2245.8
3000	1857.907	1838.861	521.4253	-2226.57
3100	1812.775	1820.842	539.4442	-2208.56
3200	1770.39	1803.92	556.3658	-2191.63
3300	1730.502	1787.995	572.2908	-2175.71
3400	1692.887	1772.978	587.308	-2160.69
3500	1672.801	1764.959	595.3271	-2152.67
3600	1664.862	1761.789	598.4967	-2149.5
3700	1657.279	1758.762	601.524	-2146.48
3800	1650.023	1755.865	604.421	-2143.58
3900	1643.066	1753.087	607.1986	-2140.8
4000	1636.384	1750.42	609.8664	-2138.13
4100	1627.546	1746.891	613.3949	-2134.6
4200	1619.055	1743.501	616.7845	-2131.21
4300	1610.887	1740.24	620.0456	-2127.95
4400	1603.017	1737.098	623.1877	-2124.81
4500	1595.424	1734.067	626.2193	-2121.78

4600	1575.238	1726.008	634.2782	-2113.72
4700	1555.807	1718.25	642.0357	-2105.96
4800	1537.113	1710.787	649.4992	-2098.5
4900	1519.108	1703.599	656.6874	-2091.31
5000	1501.751	1696.669	663.6172	-2084.38
5100	1514.434	1701.732	658.5536	-2089.45
5200	1526.556	1706.572	653.7139	-2094.29
5300	1538.147	1711.2	649.0862	-2098.91
5400	1549.236	1715.627	644.6592	-2103.34
5500	1559.848	1719.864	640.4225	-2107.58
5600	1565.775	1722.23	638.0562	-2109.94
5700	1571.421	1724.484	635.8022	-2112.2
5800	1576.798	1726.631	633.6554	-2114.34
5900	1581.92	1728.675	631.6106	-2116.39
6000	1586.797	1730.623	629.6634	-2118.34
6100	1599.859	1735.838	624.4483	-2123.55
6200	1612.427	1740.855	619.4308	-2128.57
6300	1624.522	1745.684	614.602	-2133.4
6400	1636.165	1750.333	609.9535	-2138.05
6500	1647.377	1754.809	605.4774	-2142.52
6600	1655.183	1757.925	602.3612	-2145.64
6700	1662.681	1760.919	599.3673	-2148.63
6800	1669.886	1763.795	596.491	-2151.51
6900	1676.808	1766.559	593.7274	-2154.27
7000	1683.458	1769.214	591.0723	-2156.93
7100	1670.375	1763.99	596.2958	-2151.7
7200	1657.581	1758.882	601.4038	-2146.6
7300	1645.063	1753.885	606.4012	-2141.6
7400	1632.81	1748.993	611.293	-2136.71
7500	1620.81	1744.202	616.0838	-2131.92
7600	1611.651	1740.546	619.7405	-2128.26
7700	1602.656	1736.954	623.3316	-2124.67
7800	1593.818	1733.426	626.8602	-2121.14

Table 40 Braking force gear 3 part 1

7900	1585.13	1729.957	630.3288	-2117.67
8000	1576.585	1726.546	633.7403	-2114.26
8100	1560.862	1720.268	640.0176	-2107.98
8200	1545.449	1714.115	646.1713	-2101.83
8300	1530.333	1708.08	652.2062	-2095.79
8400	1515.503	1702.159	658.1269	-2089.87
8500	1500.948	1696.348	663.9378	-2084.06
8600	1483.595	1689.42	670.8656	-2077.13
8700	1466.568	1682.622	677.6637	-2070.34
8800	1449.853	1675.949	684.3369	-2063.66
8900	1429.741	1667.92	692.3662	-2055.63
9000	1410.003	1660.039	700.2467	-2047.75
9100	1381.942	1648.836	711.4497	-2036.55
9200	1354.417	1637.847	722.4387	-2025.56
9300	1327.41	1627.065	733.2209	-2014.78
9400	1300.904	1616.483	743.8032	-2004.2
9500	1274.882	1606.094	754.1923	-1993.81
9600	1236.983	1590.963	769.323	-1978.68
9700	1199.792	1576.115	784.1713	-1963.83
9800	1163.285	1561.54	798.7461	-1949.25
9900	1127.442	1547.23	813.056	-1934.94
10000	1092.242	1533.177	827.1093	-1920.89
10100	846.4612	1435.051	925.2348	-1822.76
10200	605.4254	1338.82	1021.466	-1726.53
10300	368.9958	1244.428	1115.858	-1632.14
10400	137.0389	1151.822	1208.464	-1539.54
10500	-90.5738	1060.95	1299.336	-1448.66

Table 41 Braking force gear 3 part 2

	Gear 4			
RPM	S	Nr	Nf	F
1500	2630.32661	2147.241	213.0449	-2534.95
1600	2489.66995	2091.085	269.2007	-2478.8
1700	2365.45476	2041.494	318.7923	-2429.21
1800	2254.93483	1997.37	362.9162	-2385.08
1900	2155.94182	1957.848	402.4382	-2345.56
2000	2066.74105	1922.235	438.0507	-2309.95
2100	1985.92828	1889.972	470.3143	-2277.68
2200	1912.35455	1860.598	499.6879	-2248.31
2300	1845.07074	1833.736	526.5502	-2221.45
2400	1783.28593	1809.069	551.2172	-2196.78
2500	1726.33572	1786.332	573.954	-2174.05
2600	1673.65793	1765.301	594.985	-2153.01
2700	1624.77369	1745.784	614.5016	-2133.5
2800	1579.27252	1727.619	632.6674	-2115.33
2900	1536.80056	1710.662	649.6239	-2098.38
3000	1497.05112	1694.793	665.4935	-2082.51
3100	1459.75711	1679.903	680.3827	-2067.62
3200	1424.68481	1665.901	694.385	-2053.61
3300	1391.62883	1652.704	707.5822	-2040.42
3400	1360.40794	1640.239	720.0469	-2027.95
3500	1343.44955	1633.469	726.8173	-2021.18
3600	1336.3694	1630.642	729.644	-2018.36
3700	1329.56231	1627.924	732.3617	-2015.64
3800	1323.00377	1625.306	734.9801	-2013.02
3900	1316.67177	1622.778	737.5081	-2010.49
4000	1310.54649	1620.332	739.9535	-2008.05
4100	1302.64779	1617.179	743.107	-2004.89
4200	1295.01521	1614.132	746.1542	-2001.85
4300	1287.62757	1611.182	749.1037	-1998.9
4400	1280.4656	1608.323	751.963	-1996.04
4500	1273.51176	1605.547	754.7393	-1993.26

Table 42 Braking force gear 4 part 1

4600	1256.2712	1598.664	761.6224	-1986.38	7900	1228.74276	1587.673	772.6128	-1975.39
4700	1239.63955	1592.024	768.2624	-1979.74	8000	1220.40991	1584.346	775.9396	-1972.06
4800	1223.59054	1585.616	774.6698	-1973.33	8100	1206.21202	1578.678	781.608	-1966.39
4900	1208.08621	1579.426	780.8597	-1967.14	8200	1192.2491	1573.103	787.1825	-1960.82
5000	1193.09162	1573.44	786.8462	-1961.15	8300	1178.5113	1567.619	792.6672	-1955.33
5100	1202.55278	1577.217	783.0689	-1964.93	8400	1164.98925	1562.22	798.0657	-1949.93
5200	1211.53952	1580.805	779.481	-1968.52	8500	1151.674	1556.904	803.3817	-1944.62
5300	1220.07658	1584.213	776.0727	-1971.93	8600	1136.06236	1550.671	809.6145	-1938.38
5400	1228.18685	1587.451	772.8348	-1975.16	8700	1120.69821	1544.538	815.7485	-1932.25
5500	1235.89156	1590.527	769.7587	-1978.24	8800	1105.57183	1538.498	821.7875	-1926.21
5600	1239.76243	1592.073	768.2133	-1979.79	8900	1087.66072	1531.348	828.9384	-1919.06
5700	1243.38677	1593.52	766.7663	-1981.23	9000	1070.0362	1524.311	835.9748	-1912.02
5800	1246.77538	1594.873	765.4135	-1982.59	9100	1045.61477	1514.561	845.7248	-1902.27
5900	1249.93835	1596.135	764.1507	-1983.85	9200	1021.61278	1504.979	855.3073	-1892.69
6000	1252.88507	1597.312	762.9742	-1985.03	9300	998.015477	1495.558	864.7283	-1883.27
6100	1262.48264	1601.143	759.1425	-1988.86	9400	974.808757	1486.293	873.9933	-1874.01
6200	1271.65975	1604.807	755.4787	-1992.52	9500	951.979096	1477.178	883.1079	-1864.89
6300	1280.43461	1608.311	751.9754	-1996.02	9600	919.456886	1464.194	896.092	-1851.91
6400	1288.82433	1611.66	748.6259	-1999.37	9700	887.493709	1451.433	908.853	-1839.15
6500	1296.84495	1614.862	745.4237	-2002.58	9800	856.071303	1438.888	921.398	-1826.6
6600	1302.07356	1616.95	743.3363	-2004.66	9900	825.172141	1426.552	933.7342	-1814.27
6700	1307.03509	1618.931	741.3554	-2006.64	10000	794.779399	1414.418	945.8682	-1802.13
6800	1311.73966	1620.809	739.4772	-2008.52	10100	592.818576	1333.787	1026.499	-1721.5
6900	1316.1968	1622.588	737.6977	-2010.3	10200	394.706184	1254.693	1105.593	-1642.41
7000	1320.41552	1624.273	736.0134	-2011.99	10300	200.329039	1177.09	1183.196	-1564.8
7100	1308.54029	1619.532	740.7545	-2007.24	10400	9.57830956	1100.934	1259.352	-1488.65
7200	1296.8838	1614.878	745.4082	-2002.59	10500	-177.65069	1026.185	1334.101	-1413.9
7300	1285.43552	1610.307	749.9788	-1998.02					
7400	1274.18549	1605.816	754.4703	-1993.53					
7500	1263.12427	1601.4	758.8864	-1989.11					
7600	1254.36012	1597.901	762.3854	-1985.61					
7700	1245.71238	1594.448	765.8379	-1982.16					
7800	1237.17513	1591.04	769.2463	-1978.75					

Table 43 Braking force gear 4 part 2

	Gear 5			
RPM	S	Nr	Nf	F
1500	2239.108	1991.051	369.2348	-2378.76
1600	2118.59	1942.935	417.3507	-2330.65
1700	2012.104	1900.422	459.8639	-2288.14
1800	1917.305	1862.574	497.7116	-2250.29
1900	1832.338	1828.652	531.6337	-2216.37
2000	1755.721	1798.064	562.2221	-2185.78
2100	1686.255	1770.33	589.956	-2158.04
2200	1622.956	1745.059	615.2274	-2132.77
2300	1565.014	1721.926	638.3602	-2109.64
2400	1511.752	1700.662	659.6242	-2088.38
2500	1462.604	1681.04	679.2463	-2068.75
2600	1417.087	1662.868	697.4182	-2050.58
2700	1374.794	1645.983	714.3034	-2033.7
2800	1335.373	1630.244	730.0418	-2017.96
2900	1298.522	1615.532	744.7543	-2003.24
3000	1263.978	1601.74	758.5455	-1989.45
3100	1231.514	1588.779	771.5066	-1976.49
3200	1200.929	1576.569	783.7172	-1964.28
3300	1172.048	1565.038	795.2475	-1952.75
3400	1144.717	1554.127	806.1594	-1941.84
3500	1129.556	1548.074	812.2121	-1935.79
3600	1122.819	1545.384	814.9019	-1933.1
3700	1116.296	1542.78	817.5061	-1930.49
3800	1109.966	1540.253	820.0332	-1927.97
3900	1103.81	1537.795	822.4908	-1925.51
4000	1097.812	1535.4	824.8855	-1923.11
4100	1090.279	1532.393	827.8931	-1920.11
4200	1082.954	1529.468	830.8176	-1917.18
4300	1075.819	1526.62	833.6662	-1914.33
4400	1068.857	1523.84	836.4455	-1911.55
4500	1062.054	1521.124	839.1616	-1908.84

4600	1046.442	1514.891	845.3946	-1902.6
4700	1031.329	1508.858	851.4284	-1896.57
4800	1016.694	1503.015	857.2711	-1890.73
4900	1002.506	1497.35	862.9356	-1885.06
5000	988.7338	1491.852	868.4339	-1879.57
5100	995.8448	1494.691	865.5949	-1882.4
5200	1002.531	1497.361	862.9255	-1885.07
5300	1008.814	1499.869	860.4172	-1887.58
5400	1014.712	1502.224	858.0623	-1889.94
5500	1020.245	1504.433	855.8535	-1892.15
5600	1022.481	1505.325	854.9606	-1893.04
5700	1024.488	1506.126	854.1596	-1893.84
5800	1026.273	1506.839	853.4467	-1894.55
5900	1027.847	1507.468	852.8185	-1895.18
6000	1029.216	1508.014	852.2718	-1895.73
6100	1036.251	1510.823	849.4633	-1898.54
6200	1042.906	1513.48	846.8061	-1901.19
6300	1049.199	1515.992	844.2938	-1903.71
6400	1055.143	1518.365	841.9206	-1906.08
6500	1060.753	1520.605	839.6811	-1908.32
6600	1063.956	1521.884	838.402	-1909.6
6700	1066.913	1523.064	837.2218	-1910.78
6800	1069.63	1524.149	836.137	-1911.86
6900	1072.116	1525.142	835.1443	-1912.86
7000	1074.38	1526.045	834.2407	-1913.76
7100	1062.868	1521.449	838.8365	-1909.16
7200	1051.524	1516.921	843.3654	-1904.63
7300	1040.339	1512.455	847.831	-1900.17
7400	1029.304	1508.049	852.2366	-1895.76
7500	1018.411	1503.7	856.5856	-1891.41
7600	1009.462	1500.128	860.1584	-1887.84
7700	1000.593	1496.587	863.6991	-1884.3
7800	991.7996	1493.076	867.2099	-1880.79

Table 44 Braking force gear 5 part 1

7900	983.0762	1489.593	870.6927	-1877.31
8000	974.4186	1486.137	874.1491	-1873.85
8100	960.7288	1480.671	879.6146	-1868.38
8200	947.2205	1475.278	885.0077	-1862.99
8300	933.8853	1469.954	890.3316	-1857.67
8400	920.7152	1464.696	895.5896	-1852.41
8500	907.7025	1459.501	900.7848	-1847.21
8600	892.7078	1453.515	906.7713	-1841.23
8700	877.9053	1447.605	912.681	-1835.32
8800	863.2867	1441.769	918.5174	-1829.48
8900	846.2687	1434.974	925.3116	-1822.69
9000	829.4763	1428.27	932.0158	-1815.98
9100	806.8553	1419.239	941.047	-1806.95
9200	784.5735	1410.343	949.9428	-1798.06
9300	762.6182	1401.578	958.7082	-1789.29
9400	740.9774	1392.938	967.3481	-1780.65
9500	719.6396	1384.419	975.867	-1772.13
9600	689.9983	1372.585	987.701	-1760.3
9700	660.8155	1360.934	999.3519	-1748.65
9800	632.0755	1349.46	1010.826	-1737.17
9900	603.7634	1338.157	1022.129	-1725.87
10000	575.8649	1327.018	1033.268	-1714.73
10100	401.3076	1257.328	1102.958	-1645.04
10200	230.0203	1188.944	1171.342	-1576.66
10300	61.90625	1121.826	1238.46	-1509.54
10400	-103.128	1055.938	1304.348	-1443.65
10500	-265.171	991.2436	1369.042	-1378.96

Table 45 Braking force gear 5 part 2

	Gear 6				4600	900.5671	1456.652	903.6336	-1844.37
RPM	S	Nr	Nf	F	4700	886.2497	1450.936	909.3496	-1838.65
1500	1976.052	1886.029	474.2574	-2273.74	4800	872.3365	1445.382	914.9043	-1833.09
1600	1868.972	1843.278	517.008	-2230.99	4900	858.7986	1439.977	920.3092	-1827.69
1700	1774.304	1805.483	554.803	-2193.2	5000	845.6096	1434.711	925.5748	-1822.42
1800	1689.97	1771.813	588.4728	-2159.53	5100	850.9015	1436.824	923.462	-1824.54
1900	1614.326	1741.613	618.6727	-2129.33	5200	855.7971	1438.778	921.5075	-1826.49
2000	1546.06	1714.359	645.9271	-2102.07	5300	860.3151	1440.582	919.7038	-1828.3
2100	1484.109	1689.625	670.6606	-2077.34	5400	864.4728	1442.242	918.0438	-1829.96
2200	1427.601	1667.065	693.2205	-2054.78	5500	868.2864	1443.765	916.5213	-1831.48
2300	1375.82	1646.392	713.8938	-2034.11	5600	869.16	1444.113	916.1725	-1831.83
2400	1328.165	1627.367	732.9194	-2015.08	5700	869.8098	1444.373	915.9131	-1832.09
2500	1284.134	1609.788	750.4984	-1997.5	5800	870.244	1444.546	915.7397	-1832.26
2600	1243.301	1593.485	766.8005	-1981.2	5900	870.4703	1444.637	915.6494	-1832.35
2700	1205.303	1578.315	781.9707	-1966.03	6000	870.4958	1444.647	915.6392	-1832.36
2800	1169.83	1564.153	796.133	-1951.87	6100	875.5202	1446.653	913.6333	-1834.37
2900	1136.614	1550.892	809.3943	-1938.61	6200	880.1892	1448.517	911.7692	-1836.23
3000	1105.422	1538.439	821.8473	-1926.15	6300	884.5166	1450.244	910.0416	-1837.96
3100	1076.052	1526.713	833.5729	-1914.43	6400	888.5152	1451.841	908.4451	-1839.55
3200	1048.328	1515.644	844.6416	-1903.36	6500	892.1973	1453.311	906.9751	-1841.02
3300	1022.093	1505.17	855.1157	-1892.88	6600	893.7282	1453.922	906.3639	-1841.64
3400	997.2104	1495.236	865.0497	-1882.95	6700	895.0198	1454.438	905.8483	-1842.15
3500	983.0905	1489.599	870.6869	-1877.31	6800	896.0798	1454.861	905.4251	-1842.57
3600	976.4134	1486.933	873.3527	-1874.65	6900	896.9153	1455.194	905.0915	-1842.91
3700	969.9059	1484.335	875.9507	-1872.05	7000	897.5332	1455.441	904.8448	-1843.15
3800	963.5496	1481.798	878.4884	-1869.51	7100	885.9277	1450.808	909.4782	-1838.52
3900	957.3277	1479.314	880.9725	-1867.03	7200	874.4508	1446.226	914.0602	-1833.94
4000	951.2253	1476.877	883.4088	-1864.59	7300	863.0944	1441.692	918.5941	-1829.41
4100	943.743	1473.89	886.396	-1861.6	7400	851.8511	1437.203	923.0829	-1824.92
4200	936.4251	1470.968	889.3176	-1858.68	7500	840.7136	1432.757	927.5294	-1820.47
4300	929.2556	1468.106	892.18	-1855.82	7600	831.2785	1428.99	931.2963	-1816.7
4400	922.2199	1465.297	894.9889	-1853.01	7700	821.8944	1425.243	935.0428	-1812.96
4500	915.3048	1462.536	897.7497	-1850.25	7800	812.5569	1421.515	938.7707	-1809.23

Table 46 Braking force gear 6 part 1

7900	803.2618	1417.804	942.4817	-1805.52
8000	794.0049	1414.109	946.1774	-1801.82
8100	780.27	1408.625	951.661	-1796.34
8200	766.6758	1403.198	957.0883	-1790.91
8300	753.2151	1397.824	962.4623	-1785.54
8400	739.8807	1392.5	967.7859	-1780.21
8500	726.6658	1387.224	973.0619	-1774.94
8600	711.675	1381.239	979.0468	-1768.95
8700	696.8345	1375.314	984.9717	-1763.03
8800	682.137	1369.446	990.8395	-1757.16
8900	665.2938	1362.722	997.564	-1750.44
9000	648.6306	1356.069	1004.217	-1743.78
9100	626.7836	1347.347	1012.939	-1735.06
9200	605.2172	1338.737	1021.549	-1726.45
9300	583.9201	1330.234	1030.052	-1717.95
9400	562.8818	1321.835	1038.451	-1709.55
9500	542.0918	1313.535	1046.751	-1701.25
9600	513.9256	1302.29	1057.996	-1690
9700	486.1456	1291.199	1069.087	-1678.91
9800	458.738	1280.257	1080.029	-1667.97
9900	431.6895	1269.458	1090.828	-1657.17
10000	404.9874	1258.797	1101.489	-1646.51
10100	248.3366	1196.256	1164.03	-1583.97
10200	94.56278	1134.864	1225.422	-1522.58
10300	-56.4198	1074.585	1285.701	-1462.3
10400	-204.693	1015.389	1344.897	-1403.1
10500	-350.338	957.2417	1403.044	-1344.95

Table 47 Braking force gear 6 part 2

Appendix E First 200 Meters Of The Lap Time Simulation

Distance	Gradient	θ	Force	New tot	New acc	Distance	Initial Velocity	Acceleratio	Final Veloc	Time
1	0.022	0.022	51.941	2049.914	15.73632	1	0.000	15.736	5.610	0.357
2	0.022	0.022	51.941	1325.541	10.17068	2	5.610	10.171	7.198	0.156
3	0.022	0.022	51.941	1117.12	8.556219	3	7.198	8.556	8.302	0.129
4	0.022	0.022	51.941	1067.626	8.157397	4	8.302	8.157	9.233	0.114
5	0.022	0.022	51.941	1051.388	8.017948	5	9.233	8.018	10.064	0.104
6	0.022	0.022	51.941	1021.184	7.7705	6	10.064	7.770	10.808	0.096
7	0.022	0.022	51.941	990.8646	7.524969	7	10.808	7.525	11.483	0.090
8	0.022	0.022	51.941	1025.356	7.769771	8	11.483	7.770	12.141	0.085
9	0.022	0.022	51.941	1043.093	7.890151	9	12.141	7.890	12.775	0.080
10	0.022	0.022	51.941	1056.792	7.978799	10	12.775	7.979	13.385	0.076
11	0.022	0.022	51.941	1084.645	8.174954	11	13.385	8.175	13.982	0.073
12	0.022	0.022	51.941	1101.898	8.295197	12	13.982	8.295	14.563	0.070
13	0.022	0.022	51.941	1120.609	8.419987	13	14.563	8.420	15.130	0.067
14	0.022	0.022	51.941	1125.793	8.440401	14	15.130	8.440	15.678	0.065
15	0.022	0.022	51.941	1113.371	8.332012	15	15.678	8.332	16.201	0.063
16	0.022	0.022	51.941	1097.756	8.191833	16	16.201	8.192	16.699	0.061
17	0.022	0.022	51.941	1093.934	8.155511	17	16.699	8.156	17.180	0.059
18	0.022	0.022	51.941	1083.18	8.051428	18	17.180	8.051	17.643	0.057
19	0.022	0.022	51.941	1060.045	7.851749	19	17.643	7.852	18.082	0.056
20	0.022	0.022	51.941	1045.643	7.725988	20	18.082	7.726	18.505	0.055
21	0.022	0.022	51.941	1028.219	7.576719	21	18.505	7.577	18.910	0.053
22	0.022	0.022	51.941	1019.839	7.504486	22	18.910	7.504	19.302	0.052
23	0.022	0.022	51.941	814.3061	5.914763	23	19.302	5.915	19.607	0.051
24	0.022	0.022	51.941	819.544	5.943254	24	19.607	5.943	19.907	0.051
25	0.022	0.022	51.941	824.67	5.970712	25	19.907	5.971	20.205	0.050
26	0.022	0.022	51.941	829.6898	5.99718	26	20.205	5.997	20.500	0.049
27	0.022	0.022	51.941	834.6085	6.022696	27	20.500	6.023	20.791	0.048
28	0.022	0.022	51.941	839.4312	6.0473	28	20.791	6.047	21.080	0.048
29	0.022	0.022	51.941	835.3883	6.003865	29	21.080	6.004	21.363	0.047
30	0.022	0.022	51.941	831.5022	5.961453	30	21.363	5.961	21.640	0.047
31	0.022	0.022	51.941	827.7672	5.92002	31	21.640	5.920	21.912	0.046
32	0.022	0.022	51.941	824.1775	5.879522	32	21.912	5.880	22.179	0.045

Table 48 Lap start part 1

33	0.022	0.022	51.941	820.7282	5.839922	33	22.179	5.840	22.441	0.045
34	0.022	0.022	51.941	818.5851	5.810143	34	22.441	5.810	22.698	0.044
35	0.022	0.022	51.941	818.5851	5.810143	35	22.698	5.810	22.953	0.044
36	0.022	0.022	51.941	816.5422	5.780954	36	22.953	5.781	23.203	0.043
37	0.022	0.022	51.941	814.5963	5.75233	37	23.203	5.752	23.450	0.043
38	0.022	0.022	51.941	812.7441	5.724247	38	23.450	5.724	23.693	0.042
39	0.022	0.022	51.941	810.9829	5.696682	39	23.693	5.697	23.932	0.042
40	0.022	0.022	51.941	810.9829	5.696682	40	23.932	5.697	24.169	0.042
41	0.022	0.022	51.941	806.0136	5.644384	41	24.169	5.644	24.401	0.041
42	0.022	0.022	51.941	801.21	5.593178	42	24.401	5.593	24.629	0.041
43	0.022	0.022	51.941	796.5668	5.543021	43	24.629	5.543	24.853	0.040
44	0.022	0.022	51.941	796.5668	5.543021	44	24.853	5.543	25.075	0.040
45	0.022	0.022	51.941	792.0787	5.493875	45	25.075	5.494	25.294	0.040
46	0.022	0.022	51.941	787.7409	5.445702	46	25.294	5.446	25.508	0.039
47	0.022	0.022	51.941	782.1687	5.387904	47	25.508	5.388	25.718	0.039
48	0.022	0.022	51.941	782.1687	5.387904	48	25.718	5.388	25.927	0.039
49	0.022	0.022	51.941	776.7693	5.33125	49	25.927	5.331	26.132	0.038
50	0.022	0.022	51.941	771.5371	5.2757	50	26.132	5.276	26.333	0.038
51	0.022	0.022	51.941	771.5371	5.2757	51	26.333	5.276	26.532	0.038
52	0.022	0.022	51.941	764.8006	5.208457	52	26.532	5.208	26.728	0.038
53	0.022	0.022	51.941	683.4506	4.568065	53	26.728	4.568	26.898	0.037
54	0.022	0.022	51.941	683.4506	4.568065	54	26.898	4.568	27.068	0.037
55	0.022	0.022	51.941	683.4506	4.568065	55	27.068	4.568	27.236	0.037
56	0.022	0.022	51.941	681.2439	4.530477	56	27.236	4.530	27.402	0.037
57	0.022	0.022	51.941	681.2439	4.530477	57	27.402	4.530	27.567	0.036
58	0.022	0.022	51.941	679.1723	4.493629	58	27.567	4.494	27.729	0.036
59	0.022	0.022	51.941	679.1723	4.493629	59	27.729	4.494	27.891	0.036
60	0.022	0.022	51.941	679.1723	4.493629	60	27.891	4.494	28.051	0.036
61	0.022	0.022	51.941	677.2312	4.457486	61	28.051	4.457	28.210	0.036
62	0.022	0.022	51.941	677.2312	4.457486	62	28.210	4.457	28.367	0.035
63	0.022	0.022	51.941	675.4163	4.422016	63	28.367	4.422	28.523	0.035
64	0.022	0.022	51.941	675.4163	4.422016	64	28.523	4.422	28.678	0.035
65	0.022	0.022	51.941	675.4163	4.422016	65	28.678	4.422	28.831	0.035

Table 49 Lap start part 2

66	0.022	0.022	51.941	673.7236	4.387187	66	28.831	4.387	28.983	0.035
67	0.022	0.022	51.941	673.7236	4.387187	67	28.983	4.387	29.134	0.034
68	0.022	0.022	51.941	673.0589	4.359934	68	29.134	4.360	29.283	0.034
69	0.022	0.022	51.941	673.0589	4.359934	69	29.283	4.360	29.432	0.034
70	0.022	0.022	51.941	673.0589	4.359934	70	29.432	4.360	29.580	0.034
71	0.022	0.022	51.941	672.4852	4.333084	71	29.580	4.333	29.726	0.034
72	0.022	0.022	51.941	672.4852	4.333084	72	29.726	4.333	29.871	0.034
73	0.022	0.022	51.941	672.4852	4.333084	73	29.871	4.333	30.016	0.033
74	0.022	0.022	51.941	672.0001	4.306619	74	30.016	4.307	30.159	0.033
75	0.022	0.022	51.941	672.0001	4.306619	75	30.159	4.307	30.301	0.033
76	0.022	0.022	51.941	672.0001	4.306619	76	30.301	4.307	30.443	0.033
77	0.022	0.022	51.941	671.6011	4.280519	77	30.443	4.281	30.584	0.033
78	0.022	0.022	51.941	671.6011	4.280519	78	30.584	4.281	30.723	0.033
79	0.022	0.022	51.941	671.2859	4.254767	79	30.723	4.255	30.861	0.032
80	0.022	0.022	51.941	671.2859	4.254767	80	30.861	4.255	30.999	0.032
81	0.022	0.022	51.941	671.2859	4.254767	81	30.999	4.255	31.136	0.032
82	0.022	0.022	51.941	668.492	4.209748	82	31.136	4.210	31.271	0.032
83	0.022	0.022	51.941	668.492	4.209748	83	31.271	4.210	31.405	0.032
84	0.022	0.022	51.941	668.492	4.209748	84	31.405	4.210	31.539	0.032
85	0.022	0.022	51.941	665.8401	4.165522	85	31.539	4.166	31.671	0.032
86	0.022	0.022	51.941	665.8401	4.165522	86	31.671	4.166	31.802	0.032
87	0.022	0.022	51.941	665.8401	4.165522	87	31.802	4.166	31.933	0.031
88	0.022	0.022	51.941	663.3261	4.122058	88	31.933	4.122	32.061	0.031
89	0.022	0.022	51.941	663.3261	4.122058	89	32.061	4.122	32.190	0.031
90	0.022	0.022	51.941	663.3261	4.122058	90	32.190	4.122	32.318	0.031
91	0.022	0.022	51.941	663.3261	4.122058	91	32.318	4.122	32.445	0.031
92	0.022	0.022	51.941	660.9457	4.079324	92	32.445	4.079	32.570	0.031
93	0.022	0.022	51.941	660.9457	4.079324	93	32.570	4.079	32.695	0.031
94	0.022	0.022	51.941	660.9457	4.079324	94	32.695	4.079	32.820	0.031
95	0.022	0.022	51.941	658.6953	4.03729	95	32.820	4.037	32.943	0.030
96	0.022	0.022	51.941	658.6953	4.03729	96	32.943	4.037	33.065	0.030
97	0.022	0.022	51.941	658.6953	4.03729	97	33.065	4.037	33.187	0.030
98	0.022	0.022	51.941	655.4994	3.987726	98	33.187	3.988	33.307	0.030

Table 50 Lap start part 3

99	0.022	0.022	51.941	655.4994	3.987726
100	0.022	0.022	51.941	655.4994	3.987726
101	0.022	0.022	51.941	655.4994	3.987726
102	0.022	0.022	51.941	652.4508	3.938996
103	0.022	0.022	51.941	652.4508	3.938996
104	0.022	0.022	51.941	652.4508	3.938996
105	0.022	0.022	51.941	649.5455	3.891069
106	0.022	0.022	51.941	649.5455	3.891069
107	0.022	0.022	51.941	649.5455	3.891069
108	0.022	0.022	51.941	649.5455	3.891069
109	0.022	0.022	51.941	645.4848	3.834005
110	0.022	0.022	51.941	645.4848	3.834005
111	0.022	0.022	51.941	645.4848	3.834005
112	0.022	0.022	51.941	596.8065	3.445438
113	0.022	0.022	51.941	596.8065	3.445438
114	0.022	0.022	51.941	596.8065	3.445438
115	0.022	0.022	51.941	596.8065	3.445438
116	0.022	0.022	51.941	596.5962	3.411315
117	0.022	0.022	51.941	596.5962	3.411315
118	0.022	0.022	51.941	596.5962	3.411315
119	0.022	0.022	51.941	596.5962	3.411315
120	0.022	0.022	51.941	596.5962	3.411315
121	0.022	0.022	51.941	596.5962	3.411315
122	0.022	0.022	51.941	596.5962	3.411315
123	0.022	0.022	51.941	596.5027	3.377643
124	0.022	0.022	51.941	596.5027	3.377643
125	0.022	0.022	51.941	596.5027	3.377643
126	0.022	0.022	51.941	596.5027	3.377643
127	0.022	0.022	51.941	597.2639	3.350072
128	0.022	0.022	51.941	597.2639	3.350072
129	0.022	0.022	51.941	597.2639	3.350072
130	0.022	0.022	51.941	597.2639	3.350072
131	0.022	0.022	51.941	597.2639	3.350072

99	33.307	3.988	33.426	0.030
100	33.426	3.988	33.545	0.030
101	33.545	3.988	33.664	0.030
102	33.664	3.939	33.781	0.030
103	33.781	3.939	33.897	0.030
104	33.897	3.939	34.013	0.029
105	34.013	3.891	34.128	0.029
106	34.128	3.891	34.241	0.029
107	34.241	3.891	34.355	0.029
108	34.355	3.891	34.468	0.029
109	34.468	3.834	34.579	0.029
110	34.579	3.834	34.690	0.029
111	34.690	3.834	34.800	0.029
112	34.800	3.445	34.899	0.029
113	34.899	3.445	34.997	0.029
114	34.997	3.445	35.096	0.029
115	35.096	3.445	35.194	0.028
116	35.194	3.411	35.291	0.028
117	35.291	3.411	35.387	0.028
118	35.387	3.411	35.483	0.028
119	35.483	3.411	35.579	0.028
120	35.579	3.411	35.675	0.028
121	35.675	3.411	35.771	0.028
122	35.771	3.411	35.866	0.028
123	35.866	3.378	35.960	0.028
124	35.960	3.378	36.054	0.028
125	36.054	3.378	36.147	0.028
126	36.147	3.378	36.241	0.028
127	36.241	3.350	36.333	0.027
128	36.333	3.350	36.425	0.027
129	36.425	3.350	36.517	0.027
130	36.517	3.350	36.608	0.027
131	36.608	3.350	36.700	0.027

Table 51 Lap start part 4

132	0.022	0.022	51.941	597.2639	3.350072	132	36.700	3.350	36.791	0.027
133	0.022	0.022	51.941	598.1165	3.322758	133	36.791	3.323	36.881	0.027
134	0.022	0.022	51.941	598.1165	3.322758	134	36.881	3.323	36.971	0.027
135	0.022	0.022	51.941	598.1165	3.322758	135	36.971	3.323	37.061	0.027
136	0.022	0.022	51.941	598.1165	3.322758	136	37.061	3.323	37.151	0.027
137	0.022	0.022	51.941	598.1165	3.322758	137	37.151	3.323	37.240	0.027
138	0.022	0.022	51.941	598.1165	3.322758	138	37.240	3.323	37.329	0.027
139	0.022	0.022	51.941	599.0585	3.295686	139	37.329	3.296	37.417	0.027
140	0.022	0.022	51.941	599.0585	3.295686	140	37.417	3.296	37.505	0.027
141	0.022	0.022	51.941	599.0585	3.295686	141	37.505	3.296	37.593	0.027
142	0.022	0.022	51.941	599.0585	3.295686	142	37.593	3.296	37.680	0.027
143	0.022	0.022	51.941	599.0585	3.295686	143	37.680	3.296	37.768	0.027
144	0.022	0.022	51.941	599.0585	3.295686	144	37.768	3.296	37.855	0.026
145	0.022	0.022	51.941	600.088	3.268841	145	37.855	3.269	37.941	0.026
146	0.022	0.022	51.941	600.088	3.268841	146	37.941	3.269	38.027	0.026
147	0.022	0.022	51.941	600.088	3.268841	147	38.027	3.269	38.113	0.026
148	0.022	0.022	51.941	600.088	3.268841	148	38.113	3.269	38.199	0.026
149	0.022	0.022	51.941	600.088	3.268841	149	38.199	3.269	38.284	0.026
150	0.022	0.022	51.941	600.088	3.268841	150	38.284	3.269	38.370	0.026
151	0.022	0.022	51.941	601.2029	3.242208	151	38.370	3.242	38.454	0.026
152	0.022	0.022	51.941	601.2029	3.242208	152	38.454	3.242	38.538	0.026
153	0.022	0.022	51.941	601.2029	3.242208	153	38.538	3.242	38.622	0.026
154	0.022	0.022	51.941	601.2029	3.242208	154	38.622	3.242	38.706	0.026
155	0.022	0.022	51.941	601.2029	3.242208	155	38.706	3.242	38.790	0.026
156	0.022	0.022	51.941	601.2029	3.242208	156	38.790	3.242	38.873	0.026
157	0.022	0.022	51.941	600.3159	3.199808	157	38.873	3.200	38.956	0.026
158	0.022	0.022	51.941	600.3159	3.199808	158	38.956	3.200	39.038	0.026
159	0.022	0.022	51.941	600.3159	3.199808	159	39.038	3.200	39.119	0.026
160	0.022	0.022	51.941	600.3159	3.199808	160	39.119	3.200	39.201	0.026
161	0.022	0.022	51.941	600.3159	3.199808	161	39.201	3.200	39.283	0.025
162	0.022	0.022	51.94122	600.3159	3.199808	162	39.283	3.200	39.364	0.025
163	0.022	0.022	51.94122	600.3159	3.199808	163	39.364	3.200	39.445	0.025
164	0.022	0.022	51.94122	600.3159	3.199808	164	39.445	3.200	39.526	0.025

Table 52 Lap start part 5

165	0.022	0.022	51.94122	599.5617	3.157984	165	39.526	3.158	39.606	0.025
166	0.022	0.022	51.94122	599.5617	3.157984	166	39.606	3.158	39.686	0.025
167	0.022	0.022	51.94122	599.5617	3.157984	167	39.686	3.158	39.765	0.025
168	0.022	0.022	51.94122	599.5617	3.157984	168	39.765	3.158	39.845	0.025
169	0.022	0.022	51.94122	599.5617	3.157984	169	39.845	3.158	39.924	0.025
170	0.022	0.022	51.94122	599.5617	3.157984	170	39.924	3.158	40.003	0.025
171	0.022	0.022	51.94122	598.9371	3.116708	171	40.003	3.117	40.081	0.025
172	0.022	0.022	51.94122	598.9371	3.116708	172	40.081	3.117	40.158	0.025
173	0.022	0.022	51.94122	598.9371	3.116708	173	40.158	3.117	40.236	0.025
174	0.022	0.022	51.94122	598.9371	3.116708	174	40.236	3.117	40.313	0.025
175	0.022	0.022	51.94122	598.9371	3.116708	175	40.313	3.117	40.391	0.025
176	0.033	0.033	77.7571	573.1212	3.223114	176	40.391	3.223	40.470	0.025
177	0.033	0.033	77.7571	573.1212	3.223114	177	40.470	3.223	40.550	0.025
178	0.033	0.033	77.7571	572.6228	3.182362	178	40.550	3.182	40.628	0.025
179	0.033	0.033	77.7571	572.6228	3.182362	179	40.628	3.182	40.706	0.025
180	0.033	0.033	77.7571	572.6228	3.182362	180	40.706	3.182	40.785	0.025
181	0.033	0.033	77.7571	572.6228	3.182362	181	40.785	3.182	40.863	0.024
182	0.033	0.033	77.7571	572.6228	3.182362	182	40.863	3.182	40.940	0.024
183	0.033	0.033	77.7571	572.6228	3.182362	183	40.940	3.182	41.018	0.024
184	0.033	0.033	77.7571	572.6228	3.182362	184	41.018	3.182	41.096	0.024
185	0.033	0.033	77.7571	572.2475	3.14211	185	41.096	3.142	41.172	0.024
186	0.033	0.033	77.7571	572.2475	3.14211	186	41.172	3.142	41.248	0.024
187	0.033	0.033	77.7571	572.2475	3.14211	187	41.248	3.142	41.324	0.024
188	0.033	0.033	77.7571	572.2475	3.14211	188	41.324	3.142	41.400	0.024
189	0.033	0.033	77.7571	572.2475	3.14211	189	41.400	3.142	41.476	0.024
190	0.033	0.033	77.7571	572.2475	3.14211	190	41.476	3.142	41.552	0.024

Table 53 Lap start part 6

191	0.033	0.033	77.7571	572.2475	3.14211	191	41.552	3.142	41.627	0.024
192	0.033	0.033	77.7571	571.1191	3.095651	192	41.627	3.096	41.702	0.024
193	0.033	0.033	77.7571	571.1191	3.095651	193	41.702	3.096	41.776	0.024
194	0.033	0.033	77.7571	571.1191	3.095651	194	41.776	3.096	41.850	0.024
195	0.033	0.033	77.7571	571.1191	3.095651	195	41.850	3.096	41.924	0.024
196	0.033	0.033	77.7571	571.1191	3.095651	196	41.924	3.096	41.997	0.024
197	0.033	0.033	77.7571	571.1191	3.095651	197	41.997	3.096	42.071	0.024
198	0.033	0.033	77.7571	571.1191	3.095651	198	42.071	3.096	42.145	0.024
199	0.033	0.033	77.7571	570.1281	3.049801	199	42.145	3.050	42.217	0.024
200	0.033	0.033	77.7571	570.1281	3.049801	200	42.217	3.050	42.289	0.024

Table 54 Lap start part 7