A Simulation for Determining the Relation between Position of the Center Mass and the Impact of the Accident's Fatality on the Car Driver.

By

Maksat Nuriyev

Final Report

A project dissertation submitted to the
Department of Electrical & Electronics Engineering
Universiti Teknologi PETRONAS
In partial fulfillment of the requirements for the
BACHELOR OF ENGINEERING (Hons)
(ELECTRICAL& ELECTRONICS ENGINEERING)

JUNE 2007

DR ABDALLAH BELAL ADAM
Senior Lecturer
rical & Electronics Engineering Progr
New Academic Block 22-3-25
Universiti Teknologi PETRONAS
50 Tronoh
Perak Darul Ridzuan, MALAYSIA.

Approved by:

…………………………………
(Dr. Abdullah Belal Adam)

CERTIFICATION OF APPROVAL

A Simulation for Determining the Relation between Position of the Center Mass and the Impact of the Accident's Fatality on the Car Driver.

By:

Maksat Nuriyev

A project dissertation submitted to the
Department of Electrical & Electronics Engineering
Universiti Teknologi PETRONAS
In partial fulfillment of the requirements for the
BACHELOR OF ENGINEERING (Hons)
(ELECTRICAL& ELECTRONICS ENGINEERING)

Approved by:

……………………………..
(Dr. Abdullah Belal Adam)

University Technology Petronas
Bandar Seri Iskandar
31750 Tronoh/Perak
Block 23, Level 3.

CERTIFICATE OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and the original work contained herein have not been undertaken or done by unspecified sources or person.

Maksat Nuriyev

AKNOWLEDGMENTS

First of all, I would like to thank my supervisor Dr. Abdallah Belal Adam who has been very helpful through out the year with his very helpful guidance, endless support and encouragement. His support was very crucial during the most demanding phases of this research.

And I sincerely wish to express my appreciation to my friends, without whose help and support at critical times in my research could not have gone so far.

ABSTRACT

The most dangerous type of collision between two cars is a head on collisions, which can be fatal to either or both drivers. The data collected on that suggest the risk of fatality to driver is less if that driver has a passenger or passengers in that car. The main objective of this study is to show with a help of simulation the relation between position of the center mass and the impact of the accident's fatality on the drivers. Moreover, this report starts with the statement of the problem and the theoretical knowledge of the project. Then on the way the software used for simulation is included with the results. As a result many figures can be seen and the various relations between accident concepts can be found. Later the calculation part justifies the obtained results as a proof. Following the discussion part explains about the problem faced during preparation of this project. Through discussions the report moves to conclusion and recommendations.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Vehicular accidents are soaring high [1]. In fact, every year it continues to take lives, injure people and damage properties. Thus, there is an indispensable need to know the facts revolving vehicular accidents to make sense of the damage that it has caused and will probably cause us in the future.

Road traffic crashes occur on all continents, in every country of the world. Every year they take the lives of more than a million people and incapacitate many millions more. Pedestrians, users of non-motorized vehicles – including bicycles, rickshaws and carts – and motorcyclists in low-income and middle-income countries carry a large proportion of the global burden of road traffic death and serious injury.

Despite the growing burden of road traffic injuries, road safety has received insufficient attention at both the international and national levels. The reasons include lack of general awareness and specific information on the scale of the problem, on the health, social and economic costs of road traffic crashes, and on the interventions that can prevent crashes or reduce the harm they cause [1].

The objective of this project is to build a simulation which determines the relation between position of the central mass and the impact of the accident's fatality on drivers. Because a lot of people die or get injured from road accidents, it is important to analyze and understand the principles of accidents and their cause in order to reduce the accident's fatality on drivers, passengers and pedestrians.

The road traffic injury problem began before the introduction of the car. However, it was with the car – and subsequently buses, trucks and other vehicles – which the problem escalated rapidly. But anything that has a beginning has also an ending. These problems can be solved. If it can not be solved it can be at least minimized which can safe thousands of peoples life. [1]

Road traffic crashes are predictable and can be prevented. Many high-income countries have shown sharp reductions in crashes and casualty numbers over the past couple of decades. This has been achieved by adopting a systems approach to road safety that emphasizes environment, vehicle and road user interventions, rather than solely focusing on direct approaches aimed at changing the behavior of road users. Although solutions for low-income and middle-income countries may differ from those that have a longer history of motorization, some basic principles are the same. These include, for example, good road design and traffic management, improved vehicle standards, speed control, the use of seat-belts and the enforcement of alcohol limits. The challenge is to adapt and evaluate existing solutions, or else create new solutions in low-income and middle-income countries.

Vehicle based strategies for safety generally fall into two categories:

- ✓ Crashworthiness – technologies intended to mitigate the injury potential of a crash (Sometimes called "passive safety").
- ✓ Collision avoidance – technologies that assist road users in avoiding potential crashes (sometimes called "active safety" technologies). [2]

Vehicle crashworthiness is measured by analysis of real-world collision data and assessment of the likelihood of injury given a collision. Crashworthiness is provided by optimized vehicle structure and by vehicle restraint technologies. In every collision, the kinetic energy of the vehicle (a function of vehicle mass and travel velocity) must be dissipated. Energy is dissipated by the deformation of the vehicle structure or by collision-related friction forces, such as the vehicle-to-ground contact points (usually the tires). In either case, structural performance affects the vehicle response. How a vehicle responds to collision forces influences the collision-related forces affecting occupants. These forces (along with human tolerance levels) affect occupant injury outcomes.

A world class car manufacturer Mercedes Benz can be taken as an example. Because it is a pioneer in automotive safety. Mercedes-Benz has been passionate about making cars – each one even better than the last – from day one. Since the first models invented by Gottlieb Daimler and Karl Benz, cars have become not only faster but also more comfortable and considerably safer. And even though the volume of traffic on our roads has increased several-fold, the safety risks to the driving public remain relatively low thanks to the enormous progress made in the areas of active safety (accident prevention) and passive safety (minimizing injury during accidents). Mercedes-Benz has made key contributions in these fields with a safety development program spanning several decades [2]. Safety-conscious design has always been and remains a vital aspect of Mercedes-Benz passenger car development.

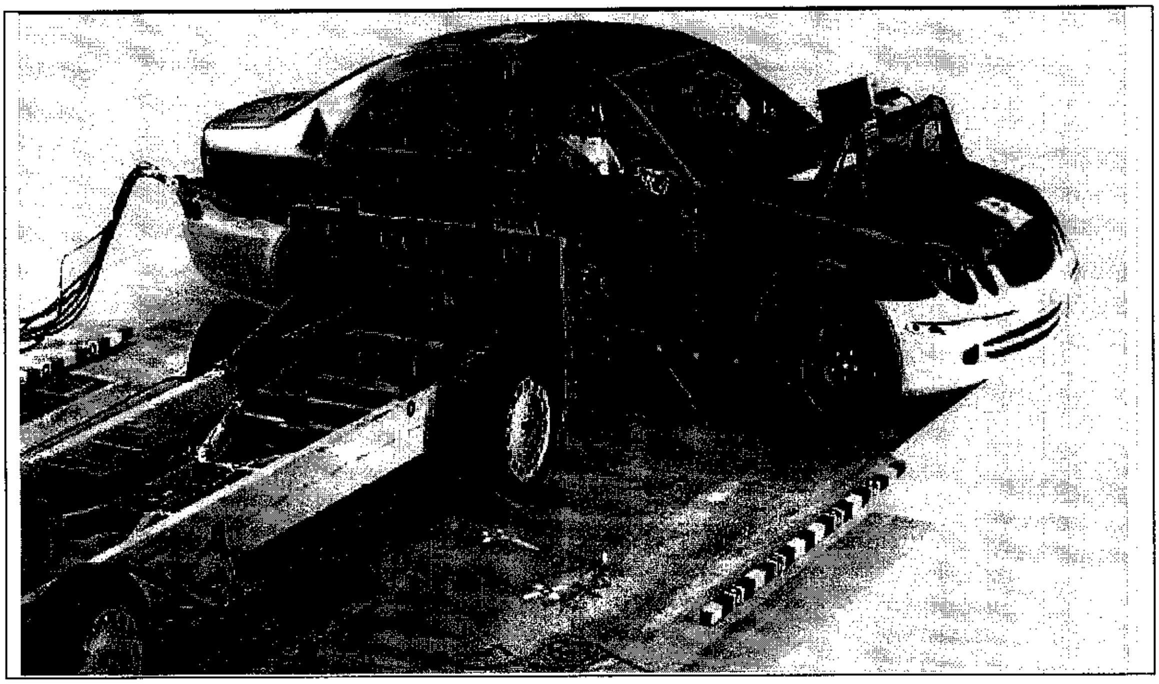


Figure 1: Mercedes Benz safety testing. [2]

Many new developments in automotive safety first saw the light of day in a Mercedes, often long before they appeared in other vehicles. As a result, the Mercedes-Benz brand has become synonymous with automotive safety around the world. Seat belts and air bags are perhaps two of the most well known – and still most effective – passive safety features. Mercedes-Benz first offered its customers 3-point seat belts in1968; and, in 1980 was the world's first automotive manufacturer to install front airbags in standard-production vehicles.

1.2 Problem Statement

Motor vehicle crashes which remain the leading cause of death and disability for different ages. The citing traffic safety looks, such as seat belts, air bags and center still need other supports to facilitate safety much more effectively. Performing this simulation a relation between the driver and the impact force will be determined. The justification of central mass and the driver will be illustrated by the graphs, which may improve the safety tools.

1.3 Objectives and Scope of Study

The main objective of this project is to prepare a simulation determining the relation between position of the center mass and the impact of the accident's fatality on the drivers.

CHAPTER 2

LITERATURE REVIEW AND THEORY

2.1 Literature Review

More than 25 years ago research established that drivers of larger, heavier cars have lower risks in crashes than drivers of smaller, lighter cars. However, the question of how adding mass to an existing car affects safety has remained unanswered. One common way to express this question is "Am I safer if I put bricks in my trunk?" While kinematic considerations suggest an answer, there are no empirical studies. Data sets rarely contain information on cargo or on actual mass during crashes. All that is generally coded is a curb mass that is identical for all cars of the same make and model. Information is, however, available on occupants. The present investigation estimates how adding mass to existing cars affects driver fatality risk by interpreting the addition of a passenger to be equivalent to the addition of cargo [3]. Head-on crashes between two cars are examined using 1975-1998 Fatality Analysis Reporting System (FARS) data. One car contains only one occupant, a driver, while the other contains also a right-front passenger. If all other factors are the same, the masses of the cars differ by the mass of the passenger.

The results contribute to the development of an equation which distinguishes between causal contributions from mass and size. The many relationships reported between fatality risk and car mass and between fatality risk and car size cannot distinguish between such causal contributions because mass and size are so highly correlated. The equation derived expresses the risk to a driver as a function of the size and mass of both involved cars.

Types of vehicle collision on highways can generally be classified as [4]:

- Head-on collisions
- Rear-end collisions

- Side collisions
- Rollovers
- Single-vehicle collision
- Multiple-vehicle collision
- Backup accidents
- Level crossing accidents

During head-on and front to back collisions, the symmetry axes of the vehicles are mostly congruent or parallel to each other. However, in the third case, eccentric impact, potential results are difficult to predict due to displacements caused by rotation. This is observed mostly in accidents at intersections. What are important are the changed directions of the vehicles after the collision, their displacements and their ultimate positions (overturned, rolled over, and displaced).

The intensity of the impact depends on the velocity (V) of the vehicle, its mass (m) and the material the vehicle is made of. Consequently, some accidents may result in greater damage whereas others may cause only minor damage. More detail can be obtained through analysis of the Impulse-Momentum Laws.

2.2 Empirical Study

To understand the collision principle the simple pendulum can be used. A simple gravity pendulum or bob pendulum (plural pendulums or pendula), is a weight on the end of a rigid rod (or a string/rope), which, when given an initial push, will swing back and forth under the influence of gravity over its central (lowest) point [5].

The pendulum was discovered by Ibn Yunusbl during the 10th century, who was the first to study and document its oscillatory motion. Its value for use in clocks was introduced by physicists during the 17th century, following observations from Galileo.

Pendulums are used for the car crash tests. Because if the real test is performed there will be a lot of things needed to perform that specific test. But with the simulation of the pendulums it can easily be done. Through this, the average speed of the vehicles, directions can be calculated.

If two pendulums are put next to each other and two balls a swung, they can be assumed as cars for example and their impact on each other can be observed.

This comparison deals with a model of the mechanics [6]. The features to be compared represent a large number of events, the numerical accuracy, the iteration of a boundary value, and stochastic parameter variations. Piecewise, constant velocities permit both a continuous and a discrete treatment.

Subject of the investigation are sequences of collisions, caused by the impact of a sphere on a resting row of spheres. In the elastic case only one impact occurs between neighboring spheres, whereas one can observe many interactions if elasticity decreases. Numerical problems result from the peculiarity, that the relative distances and velocities at a low elasticity can be smaller by orders of magnitude than the absolute variables. In order to avoid small faulty differences of great values, the relative quantities are used as variables, and absolute quantities are obtained by summation.

The collision shall take place at $t = 0$ with the velocities v_1, v_2 (Figure 2a). The force $F(t)$ being exerted from both masses on each other, rises first with t and reaches its maximum at $t = t^*$ (Figure 2b). In this compression phase, the bodies are increasingly deformed in the immediate vicinity of the contact place. At the end (maximum deformation) both bodies have the same velocity v^*. In the following restitution period the deformations disappear partially or [6]

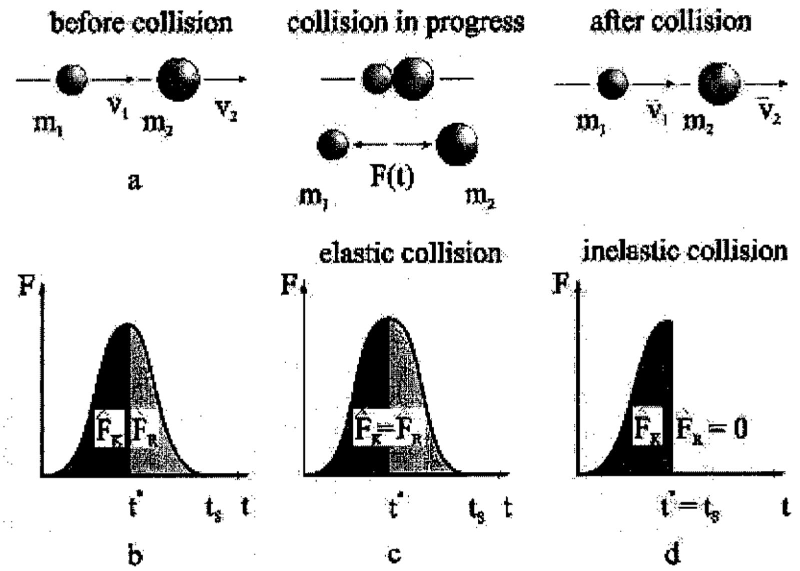


Figure 2: Central impact of two masses.

completely, concurring with a reduction of the contact force F(t). After the time interval tS the collision process is finished and both masses move with velocities $\bar{v}_1$and$\bar{v}_2$, respectively.

The force impulses $\hat{F}_K$ and $\hat{F}_R$, exerted during both periods, determine the momentum change. They are represented by the areas below the force curve F (t). The force impulse in the restitution phase reaches at most the value of the compression phase:

$$\hat{F}_R = e \times \hat{F}_K, \quad \text{With } 0 \le e \le 1. \tag{1}$$

e restitution coefficient (collision coefficient)

An elastic impact has the collision coefficient e = 1, whereas an inelastic collision is known to have no restitution phase (e = 0). In general, partially elastic case the collision coefficient takes on values of 0 < e < 1. Using the momentum conservation law, the new velocities in the next period follow this piecewise description:

$$\bar{V}_1 = V_1 - (1+e)\frac{m_2}{m_1 + m_2}(V_1 - V_2)$$

$$\overline{V}_2 = V_2 - (1+e)\frac{m_1}{m_1+m_2}(V_1 - V_2) \tag{2}$$

After the limiting process of the collision time, $t_s \to 0$, the impact shall be modeled in the following as a state event that takes place immediately.

2.2.1 Mathematical model of a spheres row

In order to obtain an ideal translation, the p spheres arranged in a row are tied up with infinite long threads without any friction (Figure 3). The model consists of $p = 4$ spheres;

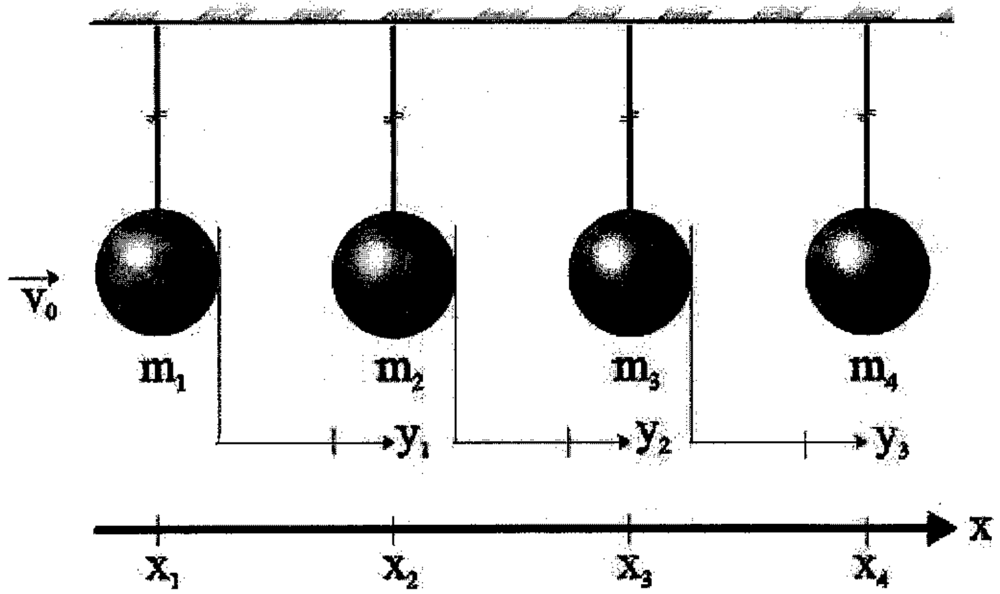


Figure 3: Collision pendulum of four spheres. [6].

or all collisions e takes on a constant value that does not depend on the velocities. A further precondition is the equality of the diameters d for all spheres, their masses m_i and distances a from each other.

In the model description the relative quantities are variables:

n the model description the relative quantities are variables [6]:

$$y_1 = x_2 - x_1 - d, y_2 = x_3 - x_2 - d, y_3 = x_4 - x_3 - d,$$
$$\dot{y}_1 = \dot{x}_2 - \dot{x}_1, \dot{y}_2 = \dot{x}_3 - \dot{x}_2, \dot{y}_3 = \dot{x}_4 - \dot{x}_3. \tag{3}$$

For determination of the remaining absolute quantities by summation equations of motion for the inner distances y_i (i=1, 2, 3) and the absolute variable x_1 are needed. The initial conditions are chosen so that sphere 1 strikes the motionless other three spheres with velocity v_0. An influence of external forces is not considered.

Equations of motion [6]

$$\ddot{x}_1 = 0; \dot{x}_1(0) = v_0, x_1(0) = 0,$$
$$\ddot{y}_1 = 0; \dot{y}_1(0) = -v_0, y_1(0) = a,$$
$$\ddot{y}_2 = 0; \dot{y}_2(0) = 0, y_2(0) = a,$$
$$\ddot{y}_3 = 0; \dot{y}_3(0) = 0, y_3(0) = a, \tag{4}$$

Absolute quantities

$$x_2 = x_1 + y_1 + d, x_3 = x_2 + y_2 + d, x_4 = x_3 + y_3 + d$$
$$\dot{x}_2 = \dot{x}_1 + \dot{y}_1, \dot{x}_3 = \dot{x}_2 + \dot{y}_2, \dot{x}_4 = \dot{x}_3 + \dot{y}_3 \tag{5}$$

The expressions on the right side of equations (6) describing the velocities after a collision contain the relative velocities at the moment of impact as derivatives of the distance variables y_i, that determine the time of collision. [6].

Collision 1-2

$$\dot{x}_1 = \dot{x}_1 + (1+e) \times \frac{m_2}{m_1 + m_2} \dot{y}_1$$

$$\dot{y}_2 = \dot{y}_2 + (1+e) \times \frac{m_1}{m_1 + m_2} \dot{y}_1 \tag{6a}$$

$$\dot{y}_1 = -e \times \dot{y}_1$$

Collision 2-3

$$\dot{y}_1 = \dot{y}_1 + (1+e) \times \frac{m_3}{m_2 + m_3} \dot{y}_2$$

$$\dot{y}_3 = \dot{y}_3 + (1+e) \times \frac{m_2}{m_2 + m_3} \dot{y}_2 \qquad \textbf{(6b)}$$

$$\dot{y}_2 = -e \times \dot{y}_2$$

Collision 3-4

$$\dot{y}_2 = \dot{y}_2 + (1+e) \times \frac{m_4}{m_3 + m_4} \dot{y}_3 \qquad \textbf{(6c)}$$

$$\dot{y}_3 = -e \times \dot{y}_3$$

Insignificant or positive relative velocities $(\dot{y}_1 \geq 0) \wedge (\dot{y}_2 \geq 0) \wedge (\dot{y}_3 \geq 0)$, i.e., monotonously increasing absolute velocities, establish the termination criterion for a simulation run, that is, no further collisions will occur and the velocities will not change.

2.3 Reaction Time

One reason for this increased risk is reaction time – the time it takes between a person perceiving a danger and reacting to it. Consider this example. Two cars of equal weight and braking ability are travelling along the same road. Car 1, travelling, [7] at 65 kilometers/hour, is overtaking Car 2, which is travelling at 60 kilometers/hour. A child on a bicycle – let's call him Sam – emerges from a driveway just as the two cars are side-by-side. The drivers both see the child at the same time and both take 1.5 seconds before they fully apply the brakes. In those few moments, Car 1 travels 27.1 meters and Car 2 travels 25.0 meters. The difference of 2.1 meters might seem relatively small, but combined with other factors it could mean the difference between life and death for Sam.

The figure of 1.5 seconds is the reaction time of average drivers. A driver who is distracted for example, listening to loud music, using a mobile phone or who is sleepy may take as long as 3 seconds to react.

2.4 Breaking Distance

The braking distance (the distance a car travels before stopping when the brakes are applied) depends on a number of variables. For example, the slope or grade of the roadway is important – a car will stop more quickly if it is going uphill because gravity will help. The frictional resistance between the road and the car's tyres is also important – a car with new tyres on a dry road will be less likely to skid and will stop more quickly than one with worn tyres on a wet road. If slope and frictional resistance are equal, the factor that has most influence on braking distance is initial speed [7].

The formula used to calculate braking distance could be derived from a general equation of physics:

$$V_f^{\,2} = V_0^{\,2} - 2ad \qquad \textbf{(7)}$$

Where V_f is the final velocity, $V0$ is the initial velocity, a is the rate of deceleration and d is the distance travelled during deceleration. Since we know that V_f will be zero [7] when the car has stopped, this equation can be re-written as:

$$d = \frac{V_o^{\,2}}{2a} \qquad \textbf{(8)}$$

From this we can see that braking distance is proportional to the square of the speed – which means that it increases considerably as speed increases. If we assume that a is 10 meters per second per second and assume that the road is flat and the braking systems of the two cars are equally effective, we can now calculate braking distance for cars 1 and 2 in our example. For car 1, $d = 16.3$ meters, while for Car 2, $d = 13.9$ meters.

Adding reaction distance to braking distance, the stopping distance for Car 1 is 27.1 + 16.3 = 43.4 meters. For Car 2, stopping distance is 25 + 13.9 = 38.9 meters. Car 1 therefore takes 4.5 more meters to stop than Car 2, a 12 per cent increase. [8].

We can now see why Car 1 is more likely than Car 2 to hit Sam. If Sam is 40 meters from the cars when the drivers see him, Car 2 will stop just in time. Car 1, though, will plough straight into him. By re-writing the first equation, we can calculate the speed at which the collision occurs:

$$V_f = \sqrt{V_0^2 - 2ad} = 8.2 \text{ Meters per second. [8]} \tag{9}$$

(Where $d = 40$ meters minus the reaction distance of 27.1 meters = 12.9 meters).

Thus, the impact occurs at about 30 kilometers/hour, probably fast enough to kill Sam. If the car's initial speed was 70 kilometers/hour, the impact velocity would be 45 kilometers/hour, more than fast enough to kill.

These calculations assume that the driver has an average reaction time. If the driver is distracted and has a longer than average reaction time, then he or she may hit Sam without having applied the brakes at all.

2.5 Impact on Pedestrian

Because pedestrians are so much lighter than the car, he has little effect upon its speed. The car, however, very rapidly increases pedestrian's speed from zero to the impact speed of the vehicle. The time taken for this is about the time it takes for the car to travel a distance equal to Sam's thickness – about 20 centimeters [9]. The impact speed of Car 1 in our example is about 8.1 meters per second, so the impact lasts only about 0.025 seconds. Sam must be accelerated at a rate of about 320 meters per second per second during this short time. If Sam weighs 50 kilograms, then the force required is the product of his mass and his acceleration – about 16,000 newtons or about 1.6 tones weight.

Since the impact force on Sam depends on the impact speed divided by the impact time, it increases as the square of the impact speed. The impact speed, as we have seen above, increases rapidly as the travel speed increases, because the brakes are unable to bring the car to a stop in time.

Once a pedestrian has been hit by a car, the probability of serious injury or death depends strongly on the impact speed. Reducing the impact speed from 60 to 50 kilometers/hour almost halves the likelihood of death, but has relatively little influence on the likelihood of injury, which remains close to 100 per cent. Reducing the speed to 40 kilometers/hour, as in school zones, reduces the likelihood of death by a factor of 4 compared with 60 kilometers/hour, and of course the likelihood of an impact is also dramatically reduced [9].

Modern cars with low streamlined bonnets are more pedestrian-friendly than upright designs, such as those found in 4-wheel drive vehicles, since the pedestrian is thrown upwards towards the windscreen with a corresponding slowing of the impact. Cars with bull bars are particularly unfriendly to pedestrians and to other vehicles, since they are designed to protect their own occupants with little regard to others.

2.6 Killer Speed

All these factors show that the risk of being involved in a casualty crash increases dramatically with increasing speed. In the University of Adelaide study referred to earlier, this was certainly true in zones where the speed limit was 60 kilometers/hour: the risk doubled with every 5 kilometers/hour above the speed limit. A corresponding decrease is to be expected in zones with lower speed limits [10].

Is the risk worth it? In our hypothetical case, the driver of Car 2, travelling at the speed limit, would have had a nasty scare, but nothing more. The driver of Car 1, driving just 5 kilometers/hour above the limit would not be so lucky: whether Sam had lived or died, the driver would face legal proceedings, a possible jail sentence, and a whole lifetime of guilt.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 Process Identification

There were many approaches used to find the resultant of the project assigned. And one of them is C++ programming language. C++ program developed is a simple but yet effective program where it asks user to input limited number of inputs. Here, in this project the number of inputs is limited to 7 inputs or values. Then the program calculates the new total weight on one side of the bar, distance x is the distance between central mass and the weight and lastly the central mass displacement.

3.2 Simulation Software

C++ is an "object oriented" programming language created by Bjarne Stroustrup and released in 1985. It implements "data abstraction" using a concept called "classes", along with other features to allow object-oriented programming. Parts of the C++ program are easily reusable and extensible; existing code is easily modifiable without actually having to change the code. C++ adds a concept called "operator overloading" not seen in the earlier OOP languages and it makes the creation of libraries much cleaner [11].

C++ maintains aspects of the C programming language, yet has features which simplify memory management. Additionally, some of the features of C++ allow low-level access to memory but also contain high level features.

C++ could be considered a superset of C. C programs will run in C++ compilers. C uses structured programming concepts and techniques while C++ uses object oriented programming and classes which focus on data.

C++ is viewed as a superset of C, and thus offers backward compatibility with this language. This reliance on C provides important benefits:

- Reuse of legacy C code in new C++ programs
- Efficiency
- Platform neutrality
- Relatively quick migration from C to C++

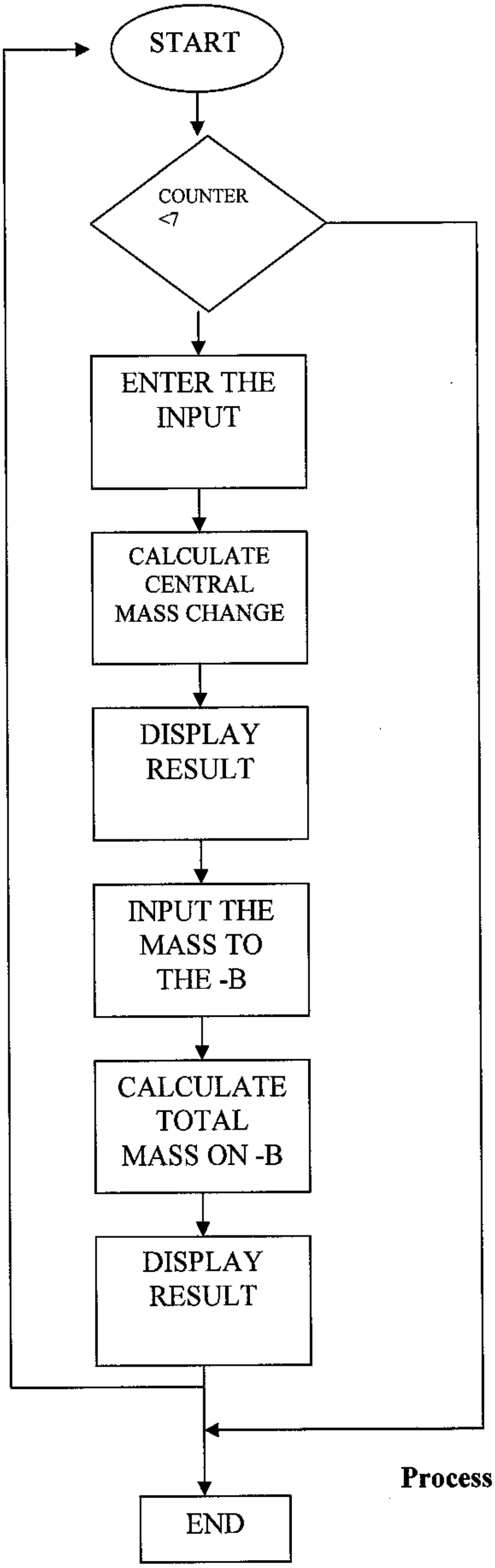
Yet it also incurs certain complexities and ailments such as manual memory management, pointers, unchecked array bounds, and cryptic *declarator* syntax, as described in the following sections [11].

As opposed to many other programming languages, C++ doesn't have versions. Rather, it has an International ANSI/ISO Standard, ratified in 1998, that defines the core language, its standard libraries, and implementation requirements.

3.3 Process Flow

Here it is shown the flow chart of the whole programming C++ code. After the program starts, it asks the user to enter the input: cout<<"Please enter your input" <<endl; Then, the program calculates the displacement of the central mass. Later, program asks the user to input the second value, which is the additional weight to the point B. It is also displayed on the program.

This program will take five inputs from the users. And according to those inputs the program will calculate how much the central mass has been shifted and display the result. There is a counter put at the beginning of the program. So when the first input is entered it will start counting. For this the programming C++ has very user friendly function called *looping*. With *looping* the same functions can be run many times with. And when the counter reaches five it will automatically go to the end of the program. With these values the user can plot the graph and see that as the weight or force is added to the point B, the central mass displacement increases. And graph line will be showing upward indicating that both the force or net weight and the central mass displacement increase proportionally. In real life application it is actually true. Because as much as the accident impact increases the displacement of central mass increases.



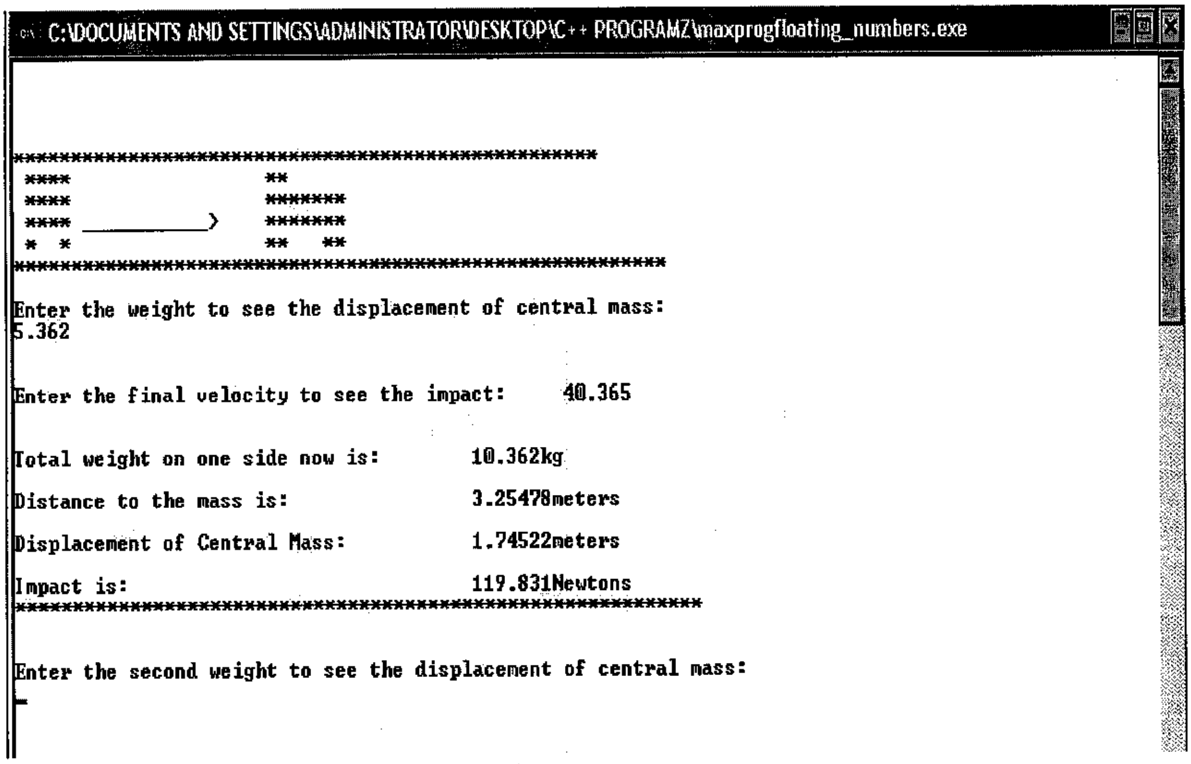
Process flow diagram.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULTS

The output window displays and shows the results as it is shown on the picture below. It should be noted that the fist value is taken as 5.362kg. And initially assumed that the central mass is at the center, and the length of the car is 10meters. Moreover, each side of the bar has a 5 kg weight. And additional weights are presumed to be the hitting force by other car. Note that the output results from C++ programming can be compared by the Section *4.2 Calculations* below. And the results correspond to the results obtained by calculation.

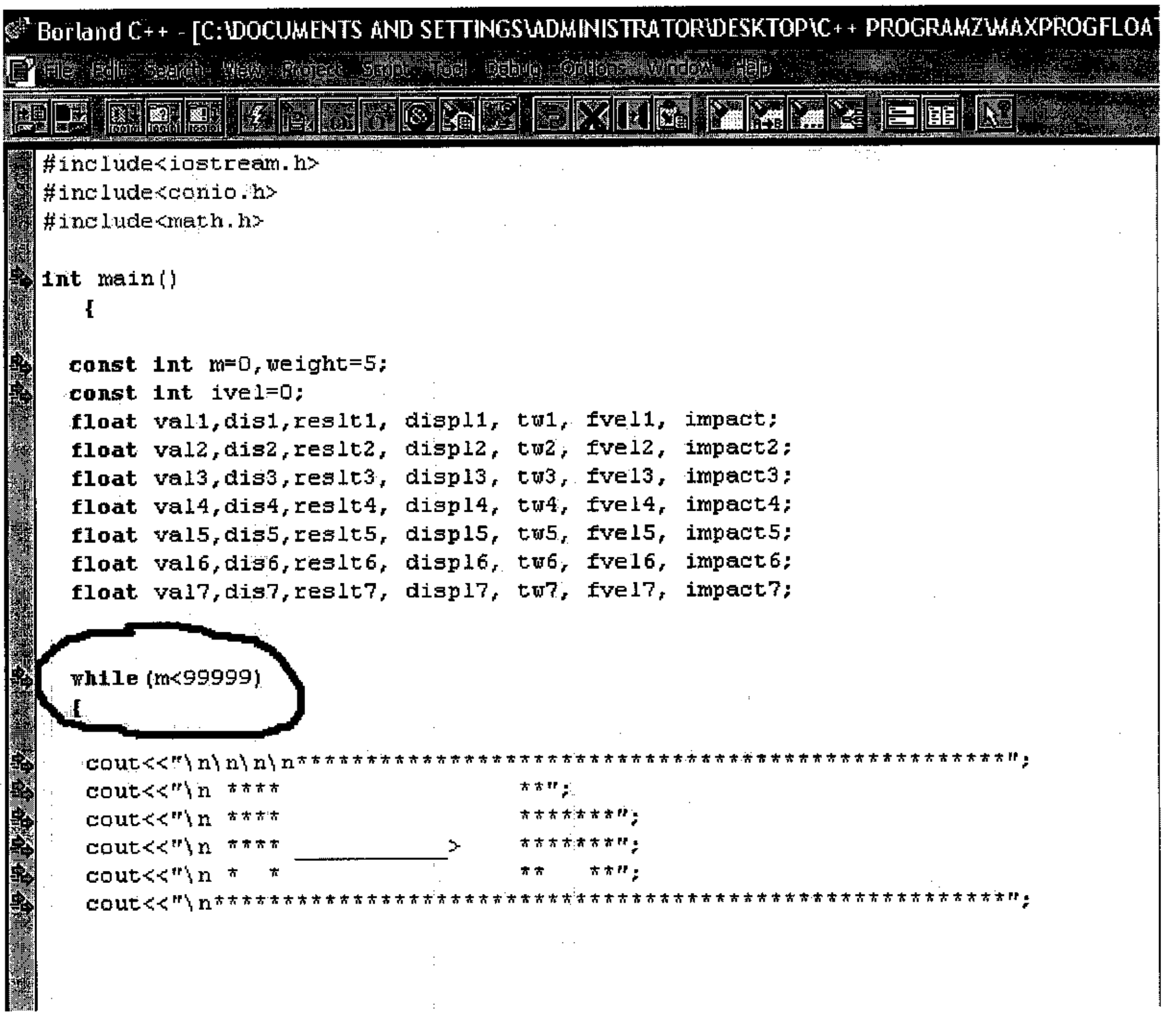


```
***************************************************
 ****               **
 ****               *******
 **** ___________>   *******
 *  *               **    **
*********************************************************

Enter the weight to see the displacement of central mass:
5.362


Enter the final velocity to see the impact:     40.365


Total weight on one side now is:        10.362kg

Distance to the mass is:                3.25478meters

Displacement of Central Mass:           1.74522meters

Impact is:                              119.831Newtons
************************************************************


Enter the second weight to see the displacement of central mass:
_
```

Figure 4: Displaying Output of the 1st Result

The above program functions using *looping* of the C++ programming. Looping functions continuously repeats itself till the predefined limits. These functions like while, if-else asks user to enter 7 inputs till the defined *X* (meters) is equal to 5. Later it calculates the resultant central mass displacement. This looping is done by using *if-else or while* function.

It can also be done by using other looping functions like do-*While*. Do-While function of the C++ programming is much easier than if-else. It really shortens the length of the program. Also, the program is infinitely looping itself as long as user wants to input and see other results. By this, the *while* looping function makes the program a simulation.

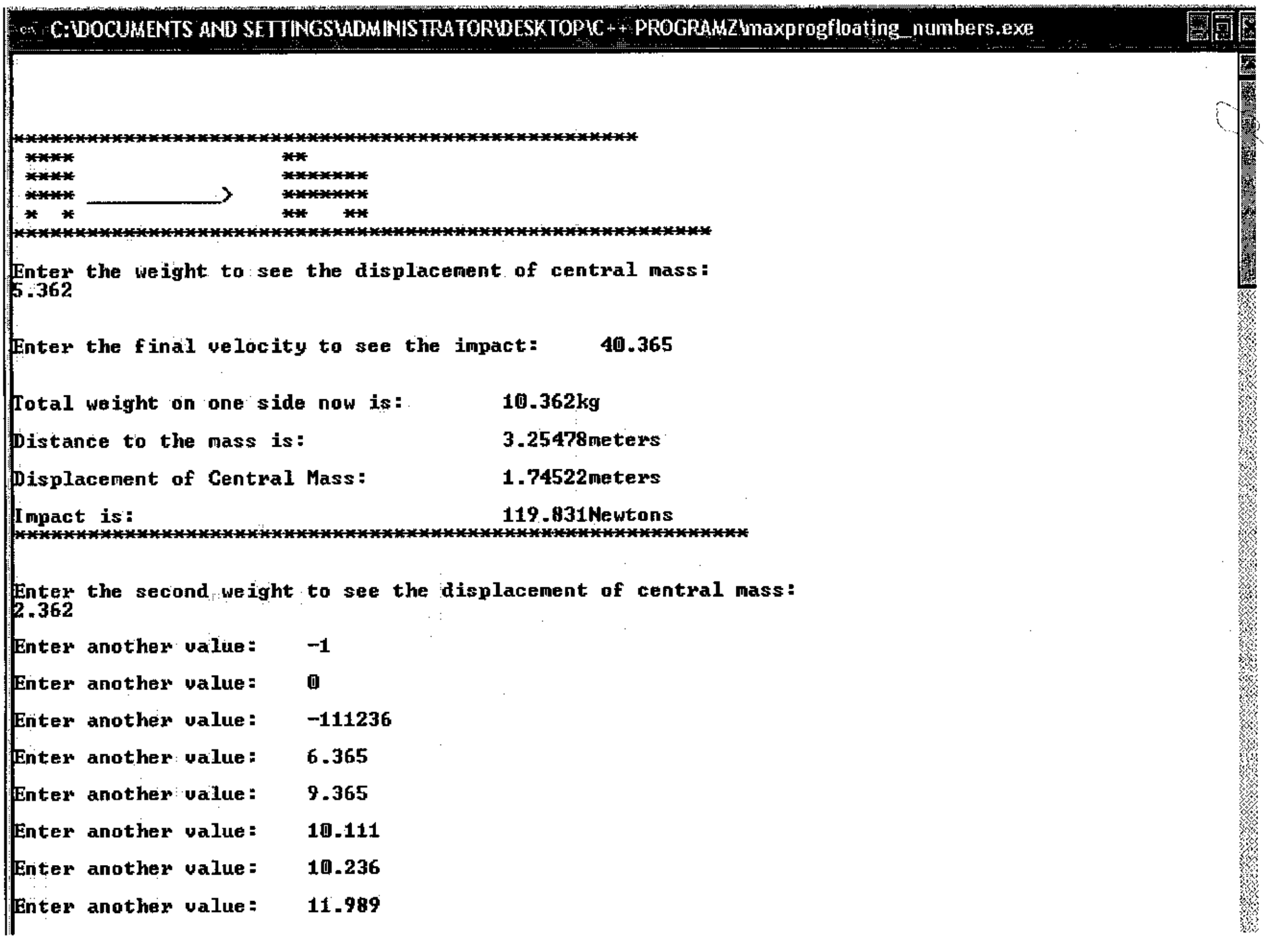


```
#include<iostream.h>
#include<conio.h>
#include<math.h>

int main()
  {

 const int m=0,weight=5;
 const int ivel=0;
 float val1,dis1,reslt1, displ1, tw1, fvel1, impact;
 float val2,dis2,reslt2, displ2, tw2, fvel2, impact2;
 float val3,dis3,reslt3, displ3, tw3, fvel3, impact3;
 float val4,dis4,reslt4, displ4, tw4, fvel4, impact4;
 float val5,dis5,reslt5, displ5, tw5, fvel5, impact5;
 float val6,dis6,reslt6, displ6, tw6, fvel6, impact6;
 float val7,dis7,reslt7, displ7, tw7, fvel7, impact7;


 while (m<99999)
 {

  cout<<"\n\n\n\n****************************************************";
  cout<<"\n ****                 **";
  cout<<"\n ****                 ********";
  cout<<"\n **** ___________>     ********";
  cout<<"\n *  *                 **   **";
  cout<<"\n**********************************************************";
```

Figure 5: While looping makes program infinitely loop itself.

In many programming situations it the exact number of loop repetitions cannot be determined before loop executions begin. The number of repetitions may depend on some aspect of the data that is not known before the loop is entered but that usually can be stated by a condition.

But here user can input as much as it is desired and see the resultant values. The resultant graphs will differ accordingly with values user enters. Since it is the relation of many aspects it is desired to see the increasing velocity for instance, or the impact to the driver of a car by the change of the central mass. When user inputs smaller value than the previous entered value, the program automatically will ask the user to input another figure of numbers which should be bigger than previous ones. Here is the picture of such case:



```


***************************************************
 ****                **
 ****                *******
 **** __________>    *******
 *  *                **   **
*********************************************************

Enter the weight to see the displacement of central mass:
5.362

Enter the final velocity to see the impact:     40.365

Total weight on one side now is:        10.362kg

Distance to the mass is:                3.25478meters

Displacement of Central Mass:           1.74522meters

Impact is:                              119.831Newtons
************************************************************

Enter the second weight to see the displacement of central mass:
2.362

Enter another value:    -1

Enter another value:    0

Enter another value:    -111236

Enter another value:    6.365

Enter another value:    9.365

Enter another value:    10.111

Enter another value:    10.236

Enter another value:    11.989
```

Figure 6: Program asking user to enter another value.

On the first step shown above, the total weight on one side is 10.362 kg. Then as a next step user enters 2.362kg which is obviously smaller than the previous value. Later, user inputs many smaller values. For all of them, the program asks to input another value. The program stops asking when the bigger value is entered. This case is also true for the velocity values. When the smaller velocity or negative velocity entered the program asks user to re-enter the values.

As a final result the program calculates the displacement of central mass, the distance to the weight on one side and the impact to the driver. Then, it automatically plots the relation graphs, for instance impact versus final velocity. The graph below shows the result:

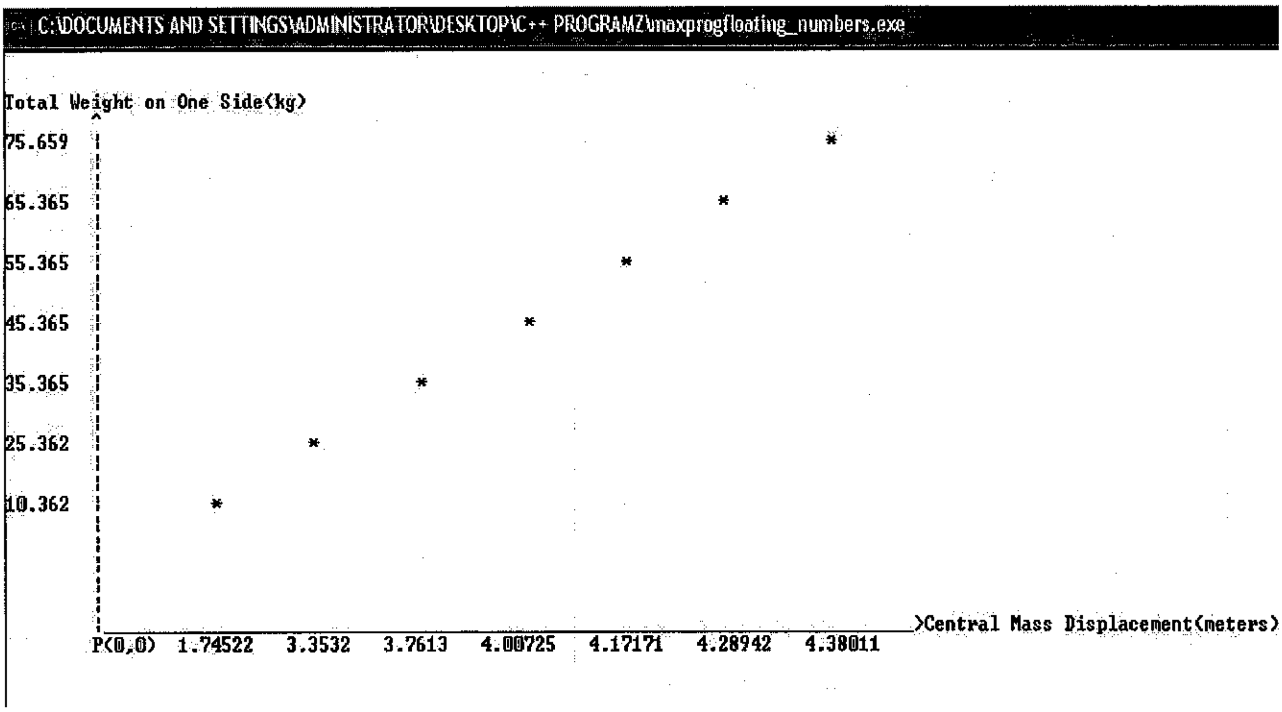
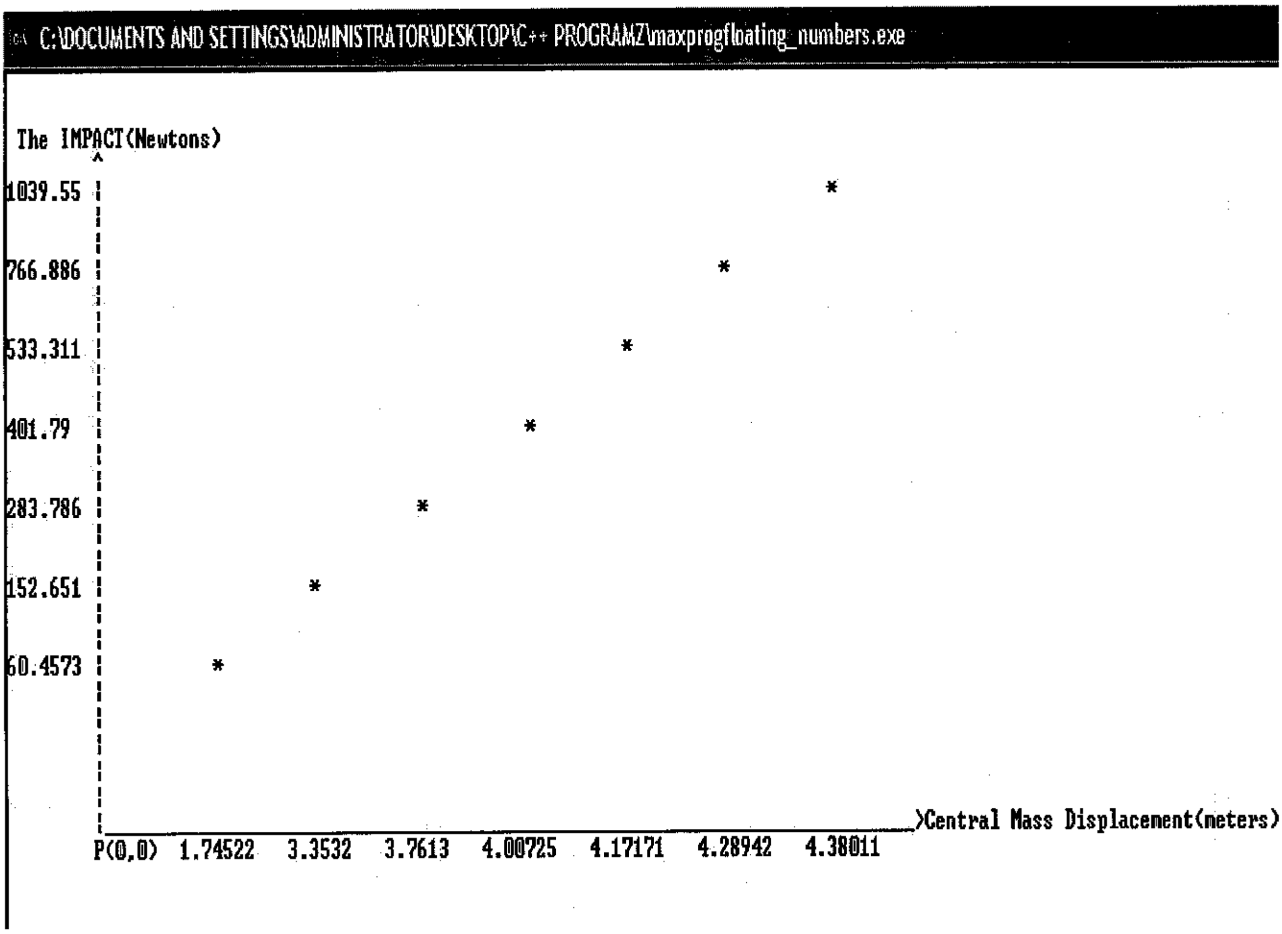


Figure 7: The Total Weight versus Central Mass Displacement.

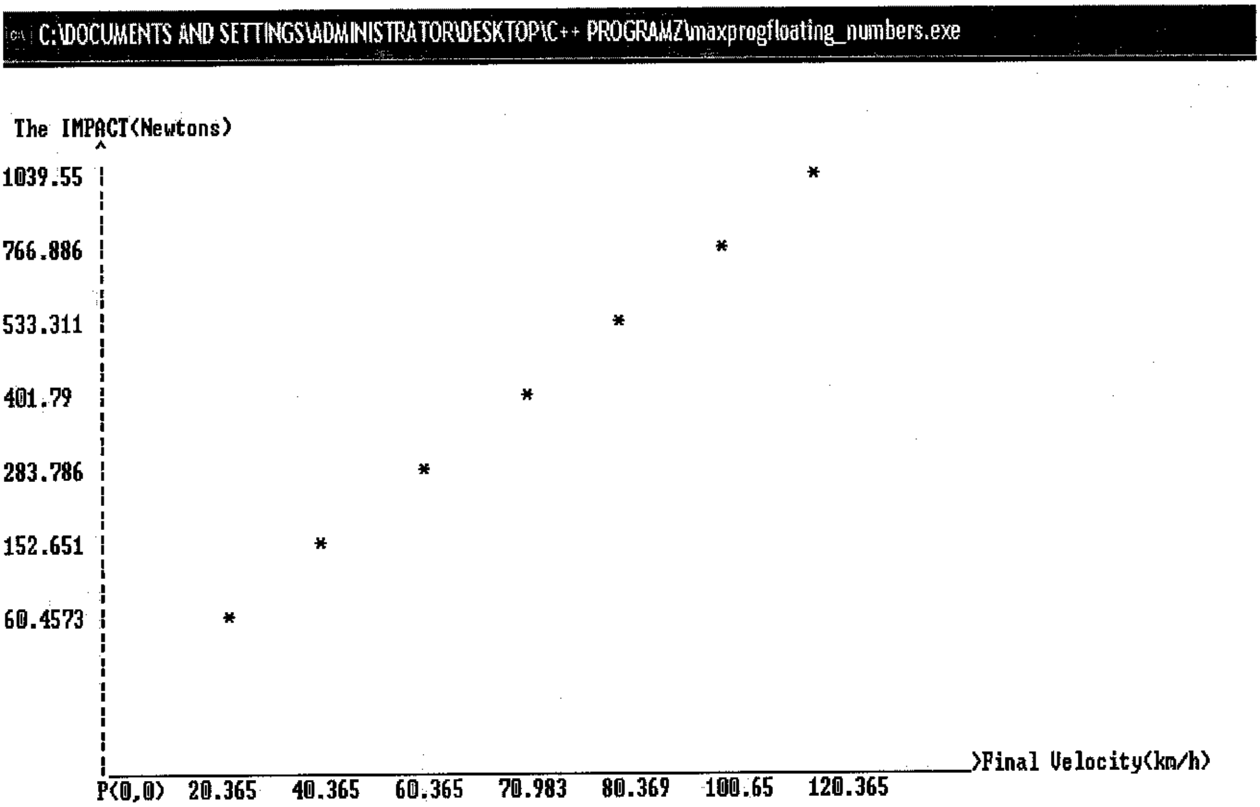
Here the relation between the total weight on one side in kg versus the central mass displacement is shown. And it can be seen that as the total weight on one side increases the displacement of central mass also increases. They are proportional to each other. Hence, on the (Figure 8) below the relation between the impact forces to the driver and the displacement of central mass shown. It is also clearly seen that as the displacement of the central mass increases the impact to the driver proportionally increases. The impact is calculated using the Newton's second law. For example, when the central mass displacement is 4.380 meters it is so close to the weight on the one side of the car. Meaning it is very close to the driver. And when it is 4.380 meters of displacement the impact to the driver increases, which is in this case 1039.55 Newtons.



```
 The IMPACT(Newtons)
        ^
1039.55 |                                                                   *
        |
        |
766.886 |                                                         *
        |
        |
533.311 |                                                *
        |
        |
401.79  |                                       *
        |
        |
283.786 |                             *
        |
        |
152.651 |                   *
        |
        |
60.4573 |          *
        |
        |
        |
        |
        |
        |___________________________________________________________________________>Central Mass Displacement(meters)
        P(0,0)  1.74522   3.3532   3.7613   4.00725   4.17171   4.28942   4.38011
```

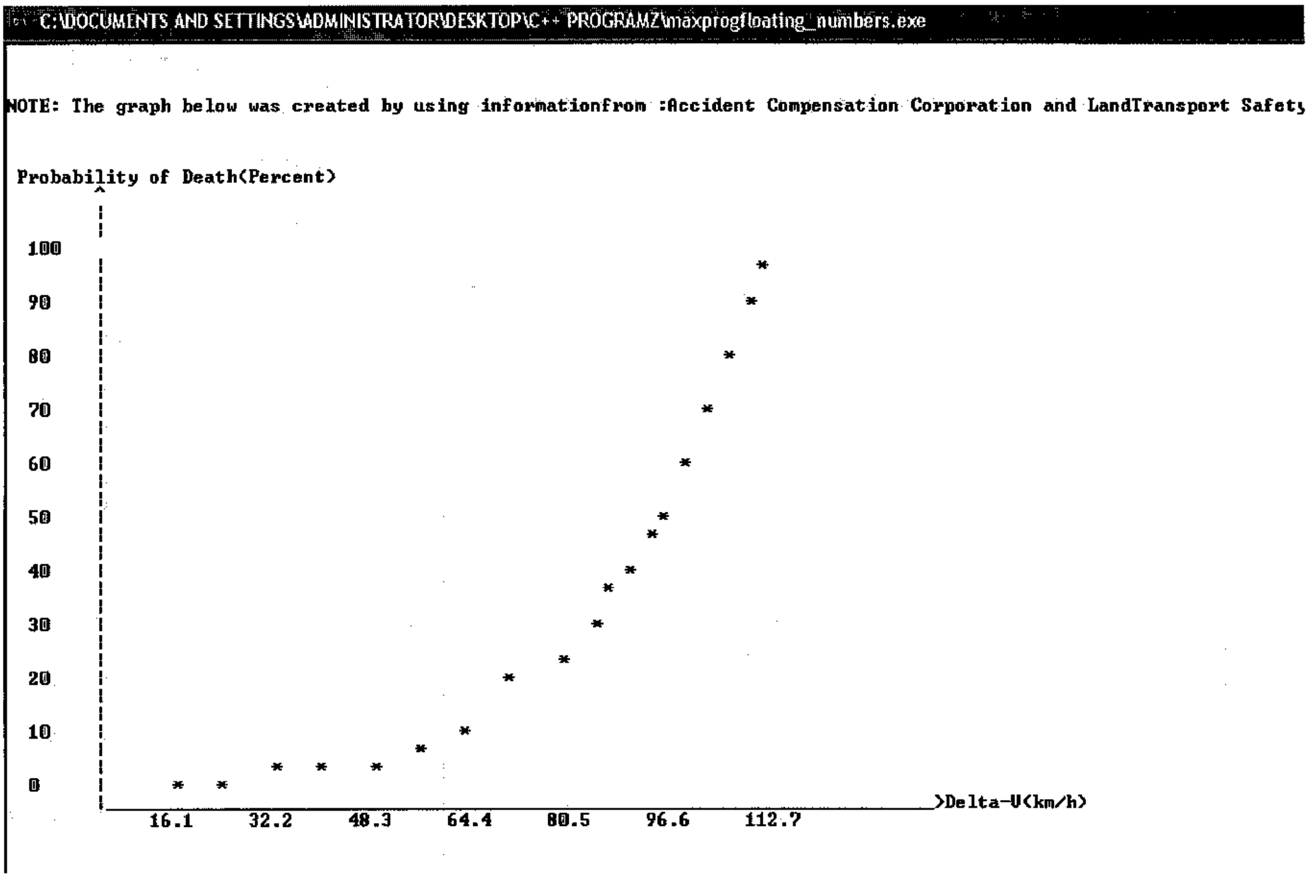
Figure 8: Relation between Impact and Central Mass Displacement.

On (Figure 9) the relation between the impact forces (Newtons) versus final velocity is shown. On the previous figure the relation between the central mass and the impact forces were shown and here the impact effect is shown with different aspect. Because it is actually interesting to know the final speed of the vehicle and how much impact force driver gets. As it is seen while the velocity of the vehicle increases the impact to driver of a car also increases.



```
 The IMPACT(Newtons)
         ^
1039.55  |                                                            *
         |
         |
766.886  |                                                    *
         |
         |
533.311  |                                           *
         |
         |
401.79   |                                    *
         |
         |
283.786  |                           *
         |
         |
152.651  |                  *
         |
         |
60.4573  |          *
         |
         |
         |
         |
         |__________________________________________________________________________>Final Velocity(km/h)
        P(0,0)  20.365   40.365   60.365   70.983   80.369   100.65   120.365
```

Figure 9: Relation between Impact and Final Velocity.



```
C:\DOCUMENTS AND SETTINGS\ADMINISTRATOR\DESKTOP\C++ PROGRAMZ\maxprogfloating_numbers.exe

NOTE: The graph below was created by using informationfrom :Accident Compensation Corporation and LandTransport Safet
```

Figure 10: Probability of death versus Delta-V.

From the results above it has been known that as the velocity increases the impact also increases. So at the *Picture X* the probability of the driver death versus delta-V is shown. When vehicle crashes something it undergoes the sudden change in speed. And this sudden change in speed is called Delta-V. It should be noted that this graph was created as using the internet resources to show the user the real life relationship between speeding up and injure or death probability. In most countries the maximum speed limit on the roads is 90 km/h. The above relation tells us that car occupants get 50% of survival chance. So car occupants still got 50% of death probability. This is still the big number. However, to avoid this many countries decrease the speed limit to 70 km/h. Or this is done by some private firms, companies. And they might even not allow driving at night. Some people may say that this is too much but all this are done because they care more about their workers.

4.2 CALCULATIONS

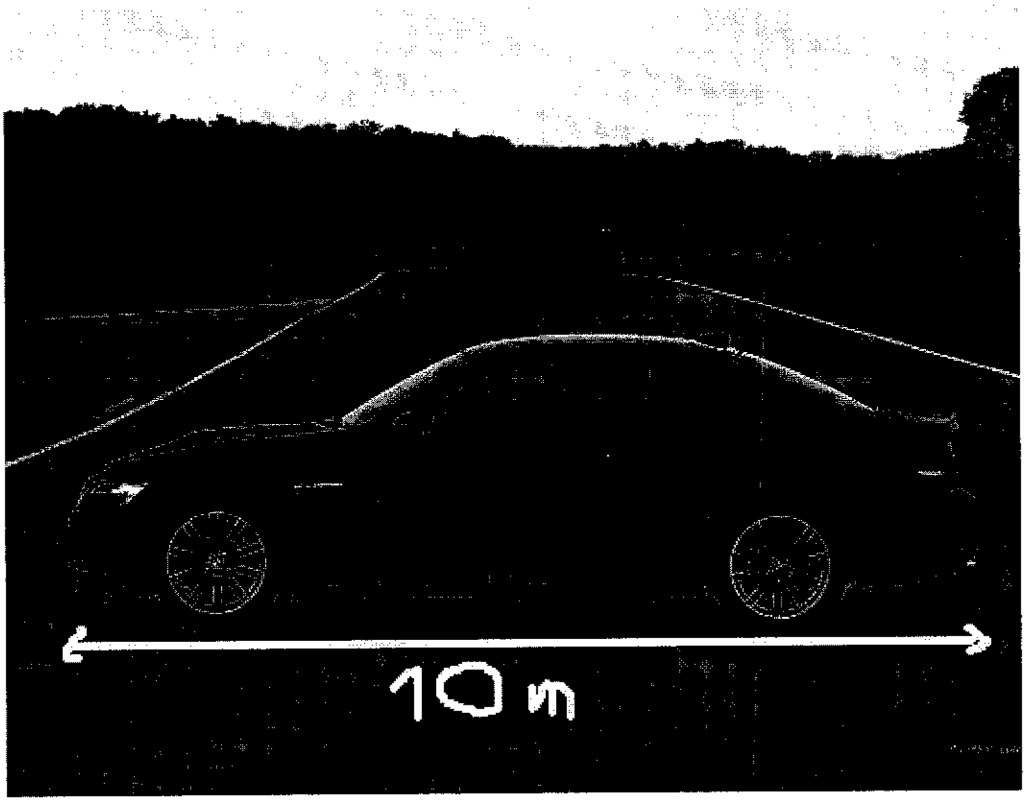
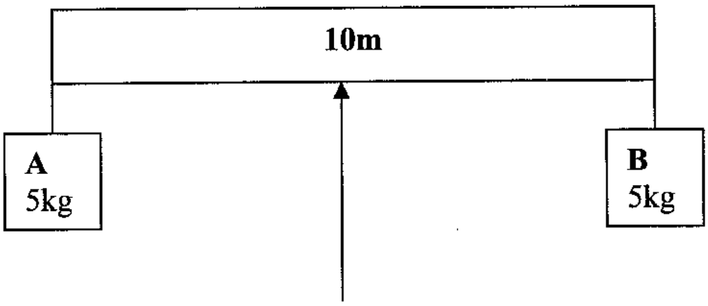


Figure 11: The length of the car assumed 10 meters

First of all the equilibrium bar is taken and the weights are put to the sides of the bar as it is shown on the figure below.



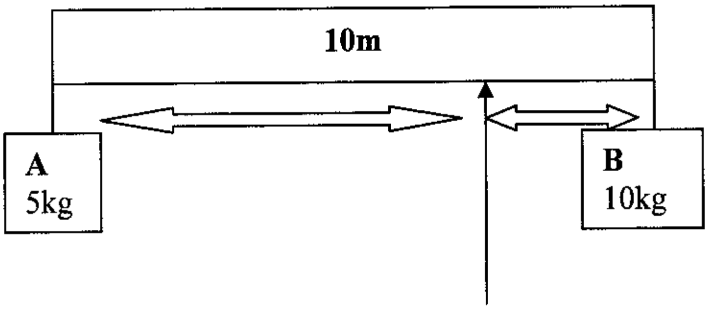
Center of the mass.

FIGURE 12: The Bar Showing Center of the Mass

This equilibrium bar is thought to be a vehicle. As it is seen above the central of the mass is at the center of the car. The weights are labeled as A and B in order to differentiate them later on. Later, some weight samples are applied to the point B (5kg).

Here, the weight is assumed to be as a force. The force from the crash which occurs after accident. Total seven samples are taken and a graph is plotted. The graphical representation of obtained data gives us additional weight or as it is named force and the displacement of central mass. It should be noted that the above illustrated values are taken only for the example calculations. They are not permanent values to be executed on a programming language C++.

For example, the 5kg is added to the point B which also 5 kg. Resultant 10 kg is heavier and central mass will move to the side of B as it is shown below. If we assume that the distance between the central mass and the point B is *x* the other part will be ***10-x.***



Adding 5kg

Equation will be:

$5 \times (10 - x) = 10 \times x$

$50 - 5 \times x = 10 \times x$

$50 = 15 \times x$

$x = 3.33m$

Displacement of the Central Mass = 5 –x

Displacement of the Central Mass = 5 –3.33

Displacement of the Central Mass = 1.66m

Adding 10kg

Equation will be:

$5 \times (10 - x) = 15 \times x$

$50 - 5 \times x = 15 \times x$

$50 = 20 \times x$

$x = 2.5m$

Displacement of the Central Mass = 5 –x

Displacement of the Central Mass = 5 –2.5

Displacement of the Central Mass = 2.5m

Adding 15kg

Equation will be:

$5 \times (10 - x) = 20 \times x$

$50 - 5 \times x = 20 \times x$

$50 = 25 \times x$

$x = 2.0m$

Displacement of the Central Mass = 5 –x

Displacement of the Central Mass = 5 –2.0

Displacement of the Central Mass = 3.0m

Adding 20kg

Equation will be:

$5 \times (10 - x) = 25 \times x$

$50 - 5 \times x = 25 \times x$

$50 = 30 \times x$

$x = 1.66m$

Displacement of the Central Mass = 5 –x

Displacement of the Central Mass = 5 –1.66

Displacement of the Central Mass = 3.33m

Adding 25kg

Equation will be:

$5 \times (10 - x) = 30 \times x$

$50 - 5 \times x = 30 \times x$

$50 = 35 \times x$

$x = 1.428m$

Displacement of the Central Mass = 5 –x

Displacement of the Central Mass = 5 –1.428

Displacement of the Central Mass = 3.57m

Then we plot the graph of the displacement of the central mass and the additional weight samples. Figure 13 is plotted using another graph plotting software, where the user enters the values and the program itself automatically plots the graph. It shows the linear relationship between the additional weight which is supposed to be the force hitting a car with the central mass displacement. Meaning the central mass displacement will increase with addition of new more weight.

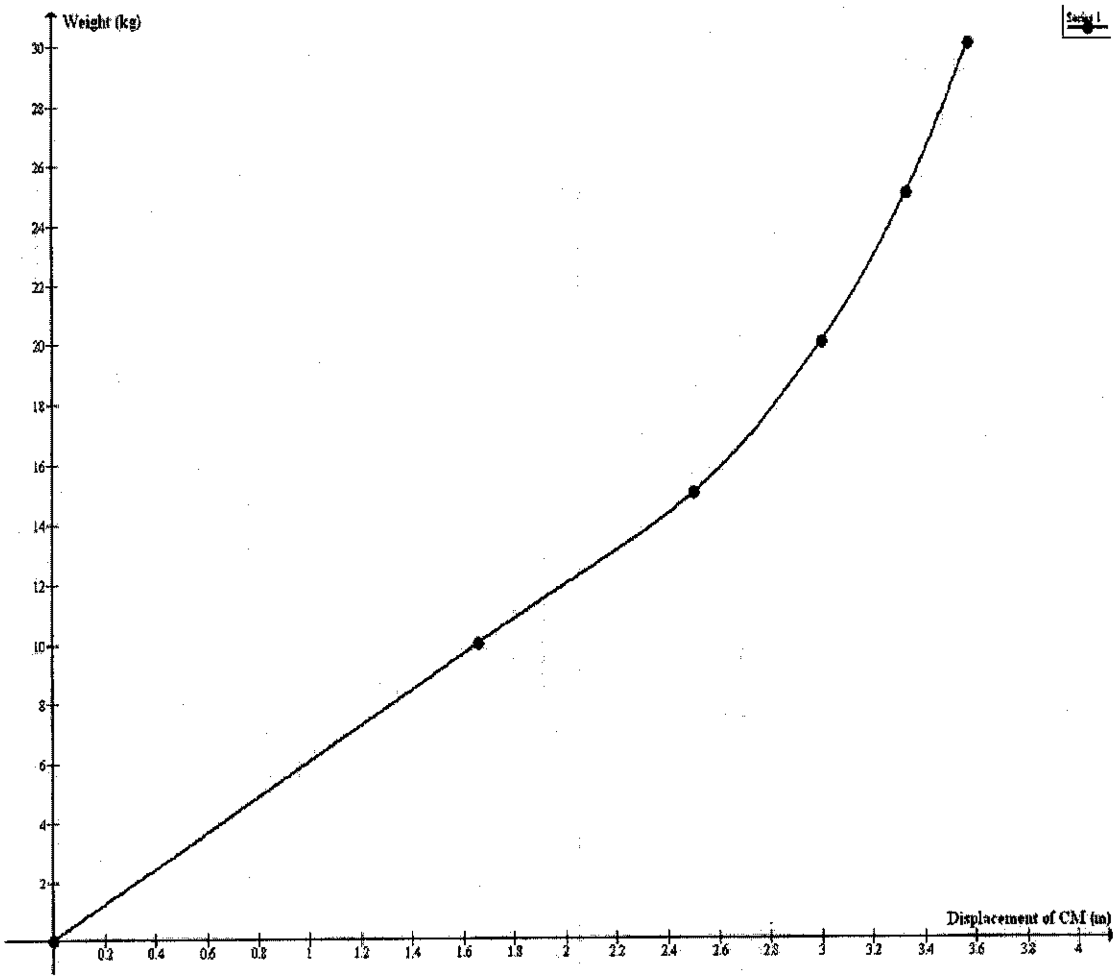


Figure 13: Displacement of Central Mass versus Weight (Force) graph.

4.3 Discussion

The objective of the project which is preparing simulation for determining the relation between central mass displacement and accident's fatality to the driver has been achieved through the C++ programming. There were many stages where student thought a lot about the selection and usage of specific software for this project. At the beginning the MATLAB program was chosen to use. But then, the using MATLAB will give the results easily and there will not be any simulation done. The person just enters the value and gets the resultant graph for instance. Also, MATLAB does not repeat itself as many times as user wants. The user has to restart again and enter the values. Moreover, the special software could be used. There are many specially prepared soft wares where user easily gets the result and see the actual accident recovery and fatality. But yet it is the ready software.

Then the solution was obtained using Borland C++ programming. Because the C++ programming is user interface and very user friendly. By using C++ programming user can input values and get the result according to predetermined equations. For this project the main problem was to obtain the resultant graphs. The drawing of the graph on C++ was something that is not done so frequently. And there is no any examples showing the graph plotting on C++ programming. The student wanted to use PHP programming to plot the graphs. C++ programmed codes is to be placed to the PHP (Hypertext Pre-processor). It is a web design programming. And the simulation can be developed by using PHP programming. PHP is a reflective programming language originally designed for producing dynamic Web pages. It is used mainly in server-side scripting, but can be used from a command line interface or in graphical applications. But then it created many problems and student kept on trying by C++ programming. The main idea came to the mind as to use the reference point and plot. Because when there is a reference point (here for example it is P (0, 0)), it is easy concentrate. And the rest of the values are plotted according to the reference point. By using this concept the resultant graphs are plotted and shown.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

First of all as it has been stated many times above, the C++ program has already been developed. There were many problems encountered while preparing this project but with a continuous passion and desire to learn more made all this possible. This project enhanced our knowledge on programming C++, MATLAB and PHP to more advanced levels. Moreover, the project showed the relation of the real life applications which will be used throughout our life.

4.2 Recommendation

Preparing a simulation of accident's fatality on car driver is not a trivial exercise. It needs clear understanding of the entire situation and conditions of accidents. Hence, the following recommendations should be kept in mind:

- Giving more projects like this which are based on the real life applications.
- The selection of software is to be left to the choice of student like in this project. Because some students are good at specific software than others.
- Take it to more advanced levels for example, real life crashes.
- Regular information updates about simulation and accidents should be carried out, as these things provide the decision-making power (involving large amounts of money), money related policies and future action plans.

- In the future it would be good if another student studies the same project but takes it to more advanced levels so that the people understand the cars and their safety, or killer speed that they are using in every day life.

REFERENCES

[1] Deguchi M., Modeling of a motorcycle for collision simulation, 18th ESV Paper No.157-O, 2003.

[2] International Standard ISO 13232: 1996(E). Motorcycles – Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles, Parts 1 to 8, International Standards Organizations, Geneva, December 1996.

[3] Marc Ross, Deena Patel, and Tom Wenzel. Vehicle Design and the Physics of Traffic Safety. 2001

[4] Campbell, BJ; Reinfurt, DW. The relationship between driver crash injury and passenger car weight. Chapel Hill, NC: Highway Safety Research Center, University of North Carolina; 1973.

[5] Fildes B., Lee S. & Lane J. (1993). Vehicle mass, size and safety, Report CR133, Australian Transport Safety Bureau, Canberra, Australia.

[6] Haworth N. Tingvall C. & Kowadlo N. (2000). Review of best practice road safety initiatives in the corporate and/or business environment, Report 166, Monash University Accident Research Centre, Melbourne, Australia.

[7] Marc Ross, Deena Patel, and Tom Wenzel. Vehicle Design and the Physics of Traffic Safety. 2001

[8] Evans L. Small cars, big cars: what is the safety difference? Chance -- New Directions for Statistics and Computing, a journal of the American Statistical Association.1994; 7(No.3):9-16.

[9] Evans L. Driver injury and fatality risk in two-car crashes versus mass ratio inferred using Newtonian Mechanics. *Accident Analysis Prev.* 1994;26:609-616.

[10] Severy, DM; Harrison, MB; Blaisdell DM Smaller vehicle versus larger vehicle collisions. SAE Transactions, (paper number 710861). 1971;80:2929-58

[11] Down with Speed: A Review of the Literature, and the Impact of the Speed on New Zealanders. Accident Compensation Corporation and Land Transport Safety Authority, 2000

[12] http://www.freetechbooks.com/about60.html

[13] http://www.functionx.com/cpp/references/projectcreation.htm

[14] http://www.wtvl.net/mike/webjr/begcpp.htm

[15] http://www.research.att.com/~bs/applications.html

[16] http://richardbowles.tripod.com/cpp/projects/proj4.htm

[17] http://www.winprog.org/tutorial/bcpp.html

[18] http://www.geocities.com/binnyva/code/cpp/projects.html

[19] http://en.wikipedia.org/wiki/Car_accident#First_fatality

[20] http://www.science.org.au/nova/057/057key.htm

[21] http://en.wikipedia.org/wiki/PHP

APPENDIX –A

The below is given the C++ coding of the project:

```
#include<iostream.h>
#include<conio.h>
#include<math.h>

int main()
  {

  const int m=0,weight=5;
  const int ivel=0;
  float val1,dis1,reslt1, displ1, tw1, fvel1, impact;
  float val2,dis2,reslt2, displ2, tw2, fvel2, impact2;
  float val3,dis3,reslt3, displ3, tw3, fvel3, impact3;
  float val4,dis4,reslt4, displ4, tw4, fvel4, impact4;
  float val5,dis5,reslt5, displ5, tw5, fvel5, impact5;
  float val6,dis6,reslt6, displ6, tw6, fvel6, impact6;
  float val7,dis7,reslt7, displ7, tw7, fvel7, impact7;


  while(m<99999)
  {

   cout<<"\n\n\n\n***************************************************";
   cout<<"\n ****             **";
   cout<<"\n ****             *******";
   cout<<"\n **** ___________>   *******";
   cout<<"\n *  *             **  **";
   cout<<"\n**********************************************************";


   //first value input

 cout<<"\n\nEnter the weight to see the displacement of "
 "central mass:\t"<<endl;
 cin>>val1;



   cout<<"\n\nEnter the final velocity to see the impact:\t";
   cin>>fvel1;
```

```
tw1=weight + val1;

cout<<"\n\nTotal weight on one side now is:\t" <<tw1<<"kg"<<endl;

reslt1=tw1;
dis1=50/(reslt1+5);
cout<<"\nDistance to the mass is:\t\t"<<dis1<<"meters"<<endl;

displ1=5-dis1;
cout<<"\nDisplacement of Central Mass:\t\t"<<displ1<<"meters"<<endl;

impact=tw1*(fvel1-ivel)/(2*displ1);
cout<<"\nImpact is:\t\t\t\t"<<impact<<"Newtons";

cout<<"\n******************************************************************"<<endl;



//second value input


cout<<"\n\nEnter the second weight to see the displacement of "
"central mass:\t"<<endl;
cin>>val2;

while(val2<tw1)
        {
cout<<"\nEnter another value:\t";
cin>>val2;
}

cout<<"\n\nEnter the final velocity to see the impact:\t";
cin>>fvel2;

   while(fvel2<fvel1)
    {
     cout<<"\nEnter another velocity:\t";
                cin>>fvel2;
                        }

tw2=weight + val2;

cout<<"\n\nTotal weight on one side now is:\t" <<tw2<<"kg"<<endl;


reslt2=tw2;
```

```
dis2=50/(reslt2+5);
cout<<"\nDistance to the mass is:\t\t"<<dis2<<"meters"<<endl;

displ2=5-dis2;
cout<<"\nDisplacement of Central Mass:\t\t"<<displ2<<"meters"<<endl;

impact2=tw2*(fvel2-ivel)/(2*displ2);
cout<<"\nImpact is:\t\t\t\t"<<impact2<<"Newtons";
cout<<"\n**************************************************************"<<endl;


//third value input


cout<<"\n\nEnter the third weight to see the displacement of "
"central mass:\t"<<endl;
cin>>val3;

while(val3<tw2)
  {
cout<<"\nEnter another value:\t";
cin>>val3;
}

cout<<"\n\nEnter the final velocity to see the impact:\t";
cin>>fvel3;

          while(fvel3<fvel2)
    {
         cout<<"\nEnter another velocity:\t";
                   cin>>fvel3;
                             }

tw3=weight + val3;

cout<<"\n\nTotal weight on one side now is:\t" <<tw3<<"kg"<<endl;



reslt3=tw3;
dis3=50/(reslt3+5);
cout<<"\nDistance to the mass is:\t\t"<<dis3<<"meters"<<endl;

displ3=5-dis3;
cout<<"\nDisplacement of Central Mass:\t\t"<<displ3<<"meters"<<endl;

impact3=tw3*(fvel3-ivel)/(2*displ3);
```

```
cout<<"\nImpact is:\t\t\t\t"<<impact3<<"Newtons";
cout<<"\n****************************************************************"<<endl;



//fourth value input



cout<<"\n\nEnter the fourth weight to see the displacement of "
"central mass:\t"<<endl;
cin>>val4;

while(val4<tw3)
{
cout<<"\nEnter another value:\t";
cin>>val4;
}

cout<<"\n\nEnter the final velocity to see the impact:\t";
cin>>fvel4;

        while(fvel4<fvel3)
    {
        cout<<"\nEnter another velocity:\t";
                cin>>fvel4;
                        }

tw4=weight + val4;

cout<<"\n\nTotal weight on one side now is:\t" <<tw4<<"kg"<<endl;



reslt4=tw4;
dis4=50/(reslt4+5);
cout<<"\nDistance to the mass is:\t\t"<<dis4<<"meters"<<endl;

displ4=5-dis4;
cout<<"\nDisplacement of Central Mass:\t\t"<<displ4<<"meters"<<endl;

impact4=tw4*(fvel4-ivel)/(2*displ4);
cout<<"\nImpact is:\t\t\t\t"<<impact4<<"Newtons";
cout<<"\n****************************************************************"<<endl;
```

```
//fifth value input


cout<<"\n\nEnter the fifth weight to see the displacement of "
"central mass:\t"<<endl;
cin>>val5;

while(val5<tw4)
{
cout<<"\nEnter another value:\t";
cin>>val5;
}

cout<<"\n\nEnter the final velocity to see the impact:\t";
cin>>fvel5;

        while(fvel5<fvel4)
   {
        cout<<"\nEnter another velocity:\t";
                 cin>>fvel5;
                          }

tw5=weight + val5;

cout<<"\n\nTotal weight on one side now is:\t" <<tw5<<"kg"<<endl;



reslt5=tw5;
dis5=50/(reslt5+5);
cout<<"\nDistance to the mass is:\t\t"<<dis5<<"meters"<<endl;

displ5=5-dis5;
cout<<"\nDisplacement of Central Mass:\t\t"<<displ5<<"meters"<<endl;

impact5=tw5*(fvel5-ivel)/(2*displ5);
cout<<"\nImpact is:\t\t\t\t"<<impact5<<"Newtons";
cout<<"\n**************************************************************"<<endl;




//sixth value input

cout<<"\n\nEnter the sixth weight to see the displacement of "
"central mass:\t"<<endl;
cin>>val6;
while(val6<tw5)
```

```
 {
cout<<"\nEnter another value:\t";
cin>>val6;
}

cout<<"\n\nEnter the final velocity to see the impact:\t";
cin>>fvel6;

        while(fvel6<fvel5)
   {
        cout<<"\nEnter another velocity:\t";
                cin>>fvel6;
                        }

tw6=weight + val6;

cout<<"\n\nTotal weight on one side now is:\t" <<tw6<<"kg"<<endl;



reslt6=tw6;
dis6=50/(reslt6+5);
cout<<"\nDistance to the mass is:\t\t"<<dis6<<"meters"<<endl;

displ6=5-dis6;
cout<<"\nDisplacement of Central Mass:\t\t"<<displ6<<"meters"<<endl;

impact6=tw6*(fvel6-ivel)/(2*displ6);
cout<<"\nImpact is:\t\t\t\t"<<impact6<<"Newtons";
cout<<"\n******************************************************************"<<endl;


//seventh value input


cout<<"\n\nEnter the seventh weight to see the displacement of "
"central mass:\t"<<endl;
cin>>val7;

while(val7<tw6)
{
cout<<"\nEnter another value:\t";
cin>>val7;
}

cout<<"\n\nEnter the final velocity to see the impact:\t";
cin>>fvel7;
```

```
        while(fvel7<fvel6)
   {
        cout<<"\nEnter another velocity:\t";
                  cin>>fvel7;
                             }

tw7=weight + val7;

cout<<"\n\nTotal weight on one side now is:\t" <<tw7<<"kg"<<endl;



reslt7=tw7;
dis7=50/(reslt7+5);
cout<<"\nDistance to the mass is:\t\t"<<dis7<<"meters"<<endl;

displ7=5-dis7;
cout<<"\nDisplacement of Central Mass:\t\t"<<displ7<<"meters"<<endl;

impact7=tw7*(fvel7-ivel)/(2*displ7);
cout<<"\nImpact is:\t\t\t\t"<<impact7<<"Newtons";
cout<<"\n***********************************************************************"<<endl;




         cout<<"\n\n\n\nTotal Weight on One Side(kg)"<<endl;
         cout<<"\t^"<<endl;
         cout<<tw7<<"\t|                                                               "<<"*"<<endl;
         cout<<"\t|"<<endl;
         cout<<"\t|"<<endl;
         cout<<tw6<<"\t|                                                                    "<<"*"<<endl;
         cout<<"\t|"<<endl;
         cout<<"\t|"<<endl;
         cout<<tw5<<"\t|                                                   "<<"*"<<endl;
         cout<<"\t|"<<endl;
         cout<<"\t|"<<endl;
         cout<<tw4<<"\t|                                   "<<"*"<<endl;
         cout<<"\t|"<<endl;
         cout<<"\t|"<<endl;
         cout<<tw3<<"\t|                        "<<"*"<<endl;
         cout<<"\t|"<<endl;
         cout<<"\t|"<<endl;
         cout<<tw2<<"\t|           "<< "*"<<endl;
         cout<<"\t|"<<endl;
         cout<<"\t|"<<endl;
```

```
        cout<<tw1<<"\t|         "<<"*"<<endl;
        cout<<"\t|"<<endl;

        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|___________________________________________________________"
"_______________>Central Mass Displacement(meters)"<<endl;

cout<<"\tP(0,0)  "<<displ1<<"   "<<displ2<<"   "<<displ3<<"   "
<<displ4<<"   "<<displ5<<"   "<<displ6<<"   "<<displ7;




        cout<<"\n\n\n\n\n\n\n The IMPACT(Newtons)"<<endl;
        cout<<"\t^"<<endl;
        cout<<impact7<<"\t|                                                  "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact6<<"\t|                                                     "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact5<<"\t|                                         "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact4<<"\t|                               "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact3<<"\t|                   "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact2<<"\t|           "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact<<"\t|       "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|___________________________________________________________"
"_______________>Central Mass Displacement(meters)"<<endl;

cout<<"\tP(0,0)  "<<displ1<<"   "<<displ2<<"   "<<displ3<<"   "
```

```
<<displ4<<"  "<<displ5<<"  "<<displ6<<"  "<<displ7;




        cout<<"\n\n\n\n\n\n\n The IMPACT(Newtons)"<<endl;
        cout<<"\t^"<<endl;
        cout<<impact7<<"\t|                                                "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact6<<"\t|                                            "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact5<<"\t|                                       "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact4<<"\t|                         "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact3<<"\t|               "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact2<<"\t|       "<< "*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<impact<<"\t|   "<<"*"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|"<<endl;
        cout<<"\t|____________________________________________________________"
"_______________>Final Velocity(km/h)"<<endl;

cout<<"\tP(0,0) "<<fvel1<<"  "<<fvel2<<"  "<<fvel3<<"  "
<<fvel4<<"  "<<fvel5<<"  "<<fvel6<<"  "<<fvel7;



cout<<"\n\n\n\n\nNOTE: The graph below was created by using information"
"from :Accident Compensation Corporation and Land"
"Transport Safety Authority, 2000.";
```

```
          cout<<"\n\n\n\n Probability of Death(Percent)"<<endl;
          cout<<"\t^"<<endl;
          cout<<"\t|"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  100"<<endl;
          cout<<"   "<<"\t|\t\t\t\t\t\t         "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  90"<<"\t|\t\t\t\t\t\t\t   "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  80"<<"\t|\t\t\t\t\t\t       "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  70"<<"\t|\t\t\t\t\t\t     "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  60"<<"\t|\t\t\t\t\t\t   "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  50"<<"\t|\t\t\t\t\t        "<<"*"<<endl;
          cout<<"   "<<"\t|\t\t\t\t\t       "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  40"<<"\t|\t\t\t\t            "<<"*"<<endl;
          cout<<"   "<<"\t|\t\t\t\t\t    "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  30"<<"\t|\t\t\t                "<<"*"<<endl;
          cout<<"\t|"<<endl;
           cout<<"   "<<"\t|\t\t\t\t       "<<"*"<<endl;
          cout<<"  20"<<"\t|\t\t\t          "<<"*"<<endl;
          cout<<"\t|"<<endl;
          cout<<"\t|"<<endl;
          cout<<"  10"<<"\t|\t\t             "<<"*"<<endl;
          cout<<"   "<<"\t|\t\t          "<<"*"<<endl;
          cout<<"   "<<"\t|           "<<"*"<<"  *  "<<" * "<<endl;
          cout<<"  0"<<"\t|    "<<"*"<<"  *  "<<endl;
cout<<"\t|_______________________________________________________________________"
"______________>Delta-V(km/h)"<<endl;


cout<<"\t    16.1    32.2    48.3    64.4    80.5    96.6"
"    112.7";


    }


getch ();
return 0;
}
```