IMPACT TEST INVESTIGATION OF LOCALLY FABRICATED VEHICLE SEATS IN MINIBUSES IN GHANA

By

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DECLARATION

I hereby declare that this submission is my own work towards the Master of Science in Mechanical Engineering and that, to the best of my knowledge, it contains no material which has been accepted for the award of any other degree of the university or any other university, except where due acknowledgement has been made in the text.

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ABSTRACT

The rate at which road transportation fatalities and injuries occur is escalating. The need to promote the use of safe public transport systems and ensure the use of safer vehicles, among other things is essential. Vehicles associated with road crashes in Ghana are mostly good-carrying/cargo vehicles, which are fitted with seats fabricated by local artisans. It seems that there are no standards for the design, fabrication, installation and inspection of these vehicles seats. This study aimed at ascertaining the safety of these seats during impact. This is achieved by measuring the accelerations of human body during impact as this is a key factor as regards to the severity impact. The study made use of seat dimensions that were obtained by measuring the dimensions of samples of the seats in minibuses at some seat fabrication shops at Suame Magazine, Kejetia and Asafo Lorry parks in Kumasi. In addition, a human dummy based on human body mass distribution was constructed and three-dimensional accelerometer sensors were mounted at various points on the dummy to measure the accelerations. Finally, a sled test experiment was used for the study as it offered the freedom to analyze occupant kinematics and restraint system performance for frontal and rear-end impact modes and their various speeds. The experimental seat was designed to allow backward and downward movement in the backrest and seat base. The head, leg and the knee joint are human body parts normally affected during impact, thus, acceleration readings were taken for these areas. From the experimental results, seat base angles that offered the lowest impact forces were identified and it was concluded that, a seat base angle of 12^o to the horizontal axis and seat heights of 34 cm and 40 cm for the front and back legs respectively generated comparatively low impact forces, and can be regarded as the

recommended seat base angle for commercial vehicle seat design. It was also realised that some accident injuries in commercial buses, especially the head, knee and leg injuries may be due to the vehicle-seat design and construction.

DEDICATION

To God almighty and to all commercial vehicle seat designers

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LIST OF ACRONYMS AND ABBREVIATIONS

No.	Acronym/Abbreviation	Full Name
1	KATH	Komfo Anokye Teaching Hospital
2	A&E	Accident and Emergency
3	NRSC	National Road Safety Commission
4	2D	Two-dimensional
5	3D	Three-dimensional
6	KNUST	Kwame Nkrumah University of Science and Technology
7	MVMA	Motor Vehicle Manufacturers Association

CHAPTER 1

INTRODUCTION

1.1 Motivation

Road transportation renders enormous benefits to both individuals and country alike. However, the rate at which fatalities and injuries occur is escalating. Road accidents are a global problem facing all countries with motorized forms of transport. For a country as small as Ghana, these numbers are absurdly high. In the short space of two decades (1990 – 2010), there have been 200,678 crashes (accidents) on the roads in Ghana involving 311,075 vehicles: 29,808 people (9.58%) have died in these accidents, 96,891 people (31.15%) have been seriously injured and 146,004 (46.94%) have suffered minor injuries [1]. Between January and May 2011, Ghana recorded 5,340 road accidents which claimed 740 lives and 4,950 sustained various degrees of injury [2, 24]. According to statistics from the National Road Safety Commission (NRSC) in 2011, Ghana recorded an average of 11,400 road traffic crashes (accidents), resulting in 1,800 fatalities and 14,000 injuries annually [2, 4].

In 2007, it was realized that about 46% of registered vehicles in Ghana are commercial [29]. This clearly shows that more people use commercial vehicles than private vehicles. Hence, a far greater proportion of the Ghanaian population traveled in commercial vehicles rather than in private vehicles. Thus, it is disturbing that some of the most widely used passenger transport vehicles within the country, notably the 12-15 Seater buses as well as the Mercedes Benz 207 and Sprinter buses, are mostly fitted with these locally fabricated seats [4].

The causes of road accidents in Ghana vary: Excessive and inappropriate speeding is reported by media to be the major cause, accounting for about 60% of all reported crashes in 2010 [4]. Other causes which can also lead to unsafe behavior by road users include driving under the influence of alcohol, medicinal or recreational drugs, fatigue, travelling in darkness, inadequate visibility because of environmental factors (making it hard to detect vehicles and other road users), and poor eyesight of road users. Factors such as brake handling and vehicle maintenance are contributed by the vehicle towards accidents while defects in road design, layout and road maintenance are mostly contributed by the road. Several strategies have been used to fight this problem and they include anti-drunk driving measures, speed control, vehicle inspection, driver's licensing requirements, promotion of use of seat belts, and infrastructural changes [3]. Thus, the need to promote the use of safe public transport systems, improve active collaboration with the private sector, implement an integrated speed management programme and ensure the use of safer vehicles is essential. However, little attention has been directed to passenger safety during the design and fabrication of these seats.

Buses with passengers, minibuses and trucks are frequently involved in crashes in low-income countries [5]. In Ghana, buses and minibuses are among the commonest forms of transport for many people. In 2005, they accounted for over 35% of all reported road crashes in the country [4]. Meanwhile, most of these vehicles are imported into the country as goods transport vans and so are without seats for public transportation. Local artisans fabricate seats to be fitted into these vehicles so that they can be used for passenger transport purposes. Locally fabricated seats are sometimes added to those of the manufacturers' seats so as to increase the passenger-payload capacity of the vehicle.

These additional seats are normally mounted on walkways and stairways, which create their own safety challenges. It appears the seats are designed with inaccurate and unsuitable data, if any at all, making them unsafe for passenger use. However nothing has been done on the vehicles seat design yet. Recent research with statistics found evidence that some of the injuries sustained by road traffic accident victims are as a result of the bad design of locally fabricated seats found in the vehicles involved. During construction of these seats features like sharp edges, use of angle irons and exposed unpadded surfaces were noticed, the spacing between the rear seats is not taken into consideration. This shows that there is no standard used during design, construction, installation and inspection of these vehicles seats.

1.2 Justification

Medical Practitioners at the Accident and Emergency (A&E) Centre of the Komfo Anokye Teaching Hospital (KATH), Kumasi, have long hypothesised that, some of the injuries sustained by road traffic accident victims may be due to the design of seats found in the vehicles involved. Locally designed and fabricated vehicle seats were particular of interest since they are not known to be designed according to any accepted safety standards [4].

A recent research found evidence in support of this hypothesis. Using the software *Working Model* 2D and vehicle accident injury data spanning a three month period that was gathered from the A&E Centre of KATH, the research established that some of the injuries are as a result of the bad design of these locally fabricated seats. It was also able to identify some particular design features of the seats that were responsible for some of the recorded injuries. Substantial research and development efforts directed toward construction and installation of safer vehicle seats will reduce the impact forces during collision. Key among the recommendations of that research was that, the seats should be re-designed and tested for safety during impact.

Seats serve two main purposes in any vehicle; passenger safety and passenger comfort. One of the requirements for passenger safety will be that the seat should be able to dampen some of the impact forces that will be experienced by the occupant of the seat during an accident, so as to reduce the severity of injuries.

The information currently available pertaining to accidents and the existing inspection strategies for these vehicles are the data to be used for analysis and improvement. Understanding the use of these data and their analysis will help achieve more and better results. When vehicles impact or hit a surface, the distance moved by passengers during jerking from impact is proportional to the speed of the vehicle before impact and inversely proportional to the time taken during the impact. Basically, if the distances travelled by the individuals are taken into consideration before these locally fabricated vehicle-seats are constructed, the severity of the injuries will not be serious. The importance of engineering controls in safety management is the ability to use the creative minds to eliminate or reduce exposure to hazards and reinforce the principle that the potential causes of accidents can be minimized [6].

1.3 Objectives

The main objective of this research is to determine experimentally the three-dimensional acceleration and the positions of some injury prone areas of the human body during an impact of a vehicle having locally fabricated vehicle seats.

Specific objectives include:

- To design and construct a sled test bed for the experiment.
- To construct a dummy fitted with sensors to measure the acceleration of the human body part of interest.
- To confirm if some of the injuries sustained by occupants of the locally fabricated seats, as identified by an earlier research that was based on computer simulations and accident data from KATH.
- To vary the seat design and compare the impact accelerations on both the frontal and rear impact.

1.4 Methodology

Literature was reviewed to get an understanding of accident research as well as occupant behaviour in accidents. After which a sled test bed was constructed with dimensions of seats and the spacing between the rear seats as collected. A dummy was constructed with appropriate dimensions and fitted with sensors to measure accelerations of various body parts of interest. This dummy was placed on the seat of the sled bed during the experiment. Sled tests were then run for different seat base angles and seat heights to measure the accelerations at different points. Results was collated and presented in a report at the end of the research.

1.5 Limitations

The standard recognised dummy with features of human being known as the 50th hybrid percentile was not used for the experiment, reasons being its high cost. The research was limited to identifying the acceleration, looking the various effects and positioning of some injury prone areas of the human body during a car accident involving a vehicle using locally designed vehicle-seats using a sled test. The parameters were collected and used to re-design the frame of the seats.

CHAPTER 2

LITERATURE REVIEW

2.1 A brief review

Buses are designed to transport passengers with a high level of personal comfort but that is a different story these days. Road traffic injuries are a major public health problem and a leading cause of death and injury around the world. Approximately 1.2 million people are killed each year in road crashes worldwide, with up to 50 million more injured [7, 10]. Over 95% of these deaths and injuries occur in the low and middle-income countries of Africa, Asia, Latin America, the Caribbean and Eastern Europe which Ghana is included [7].

In Ghana, most vehicles associated with road crashes are typically privately owned buses, mini-buses, converted pick-up trucks, and taxis [8]. From a recent study which aimed at estimating the percentage of motor vehicle related injuries that involved commercial vehicles in Ghana. The setting for the focus groups was the Kejetia Lorry Park in Kumasi. The commercial status of the vehicles involved was known for 108 of the 122 injuries. Among those injuries involving vehicles of known status, 88 (81%) were commercial vehicles. This varied only minimally by location, with 85% of injuries associated with commercial vehicles in the urban area and 71% in the rural area [17]. The distribution of vehicle types shown in Table 2.1 reveals at the vehicles commonly involved in accidents were buses (40%, including minibuses) and taxis (24%). From Table 2.1, it basically shows that minibuses are the major causes of injuries during accidents. These projections highlight the essential need to address road-traffic injuries as a public-health priority and associated causes include driver fatigue and other forms of risky driving, overcrowding of vehicles, poor condition of vehicles, and poor road networks.

Table 2-1: Types of vehicles involved in motor vehicle related injuries [3]

Vehicle	**No (%)**
Bus	43 (40)
Taxi	26 (24)
Truck	15 (14)
Motorcycle	
Commercial	4 (3)
Private	6 (6)
Passenger car (private)	14 (13)
Total	108 (100)

2.2 Physics behind road traffic accident

When a road traffic crash occurs, a car occupant without a seat-belt will continue to move at the same speed at which the vehicle was travelling before the collision and will be catapulted or propelled forward into the structure of the vehicle – most likely into the back of the front seats if they are rear seat passengers. This is as a result of the objects resistance (inertia) in changing its speed and direction of travel. The unbelted occupant is most likely to be propelled into the steering wheel if she/he is driving. Alternatively, they can be ejected from the vehicle completely. Being ejected from a vehicle drastically increases the probability of sustaining severe personal injury or being killed [3, 9].

2.3 Severity of accidents

Injury severity data are provided through police observations at the scene and follow up through hospital records at 30 days if the injured person requires hospitalization. Fatal injury is defined by the police as death occurring within 30 days from injuries sustained in the crash. Major injury includes injuries that require medical treatment at a hospital/clinic. Minor injury includes injuries that require medical attention (for example in emergency room) but not hospitalization while minimal injury refers to injuries such as abrasions and bruises that do not require medical attention at the hospital or clinic at all [11].

Table 2-2: Levels of injuries [11]

Fatal injury crash	At least one person (driver or passenger) killed (within 30 days) by injuries sustained in the crash.
Major injury crash	At least one person injured and admitted to hospital but no fatalities.
Minor injury crash	At least by one person requiring medical care but no fatalities or injuries requiring hospitalization
Minimal injury crash	At least one person injured (for example minor abrasions/bruises) but no medical attention required and no other more severe injuries

Further, the Ashanti region of Ghana, is among five (5) regions in the country (Eastern, Greater Accra, Central and Western) which have consistently experienced road traffic accidents in recent times and account for 80% of all the road traffic fatalities [7].

Table 2-1: Class of People Killed or Injured in Road Accidents [11]

Road user class	Casualty Severity						Total
	Fatal	%Fatal	Serious	%Serious	Slight	%Slight	
Pedestrian	**72**	**70.6**	**130**	**52.2**	**131**	**27.2**	**333**
Car	**10**	**9.8**	**36**	**14.5**	**130**	**27.0**	**176**
HGV	**4**	**3.9**	**14**	**5.6**	**24**	**5**	**42**
Bus/minibus	**7**	**6.9**	**39**	**15.7**	**152**	**31.6**	**198**
Motor cycle	**4**	**3.9**	**25**	**10**	**26**	**5.4**	**55**
Pickup 4*4	**2**	**2**	**2**	**0.8**	**13**	**2.7**	**17**
Bicycle	**3**	**2.9**	**3**	**1.2**	**5**	**1**	**11**
Others	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total	**102**	**100**	**249**	**100**	**481**	**100**	**832**

Available data from the road traffic crashes in 2009 indicate that out of all the injuries recorded in the Kumasi Metropolis, a considerable number are commercial vehicle occupants. For instance in 2009, out of a total of 730 injuries (serious and slight) recorded for buses/minibus, 47.3% accounts for serious and slight injuries for occupants.

2.4 Types of injuries sustained by vehicle occupants

Collisions can take place on roads and can also be described as a situation in which a vehicle crashes into another vehicle, pedestrian, animal, or any other stationary or moving obstruction in its path of travel. Collisions may involve one or more vehicles. Collisions can be further classified as head-on (front), rear, and side collisions.

2.4.1 Head-on collision

Head-on (front) collisions are road traffic accidents in which the front of a vehicle of interest crashes into another vehicle, a pedestrian, animal or any stationary obstruction, as illustrated in Figure 2-1. It is one of the commonest types of RTAs and can have very serious consequences. Head-on collisions can involve vehicles travelling in the same or opposite directions, stationary vehicles and stationary or moving obstructions such as pedestrians.

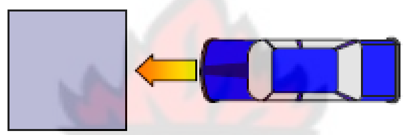

Figure 2-1: Head on (front) collision

2.4.2 Rear collision

Rear collisions occur when another vehicle crashes into the rear of the vehicle of interest, as shown in Figure 2-2 or the vehicle of interest crashes into something while reversing. They are caused by poor visibility and when followed too closely. Most rear collisions occur at night, during dry or harmattan season, when the weather becomes fog and when it is raining heavily. It is also common for a small vehicle to run into the rear end of badly lighted heavy trucks, or heavy truck to run over a small vehicle when the small vehicle is in the blind zone of the truck.

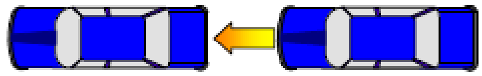

Figure 2-2: Rear collision

2.4.3 Side collision

Side impacts occur when a vehicle of interest is impacted on its side either by an object, as shown in Figure 2-3. They are normally caused by uncontrollable skidding on the part of the vehicle, or by another vehicle, often at intersections.

Figure 2-3: Side collision

Further, there are also three “collisions” that occur in every crash where occupants are unrestrained. The first collision involves the vehicle and another object, e.g. another vehicle(s), a stationary object (tree, signpost, ditch) or a human or animal. The second collision occurs between the unbelted occupant and the vehicle interior, e.g. the passenger hits his knee on the back of the front seats. Finally, the third collision occurs when the internal organs of the body hit against the chest wall or the skeletal structure. It is actually the second collision that is most responsible for injuries. Hips, legs, knees, heels, ankles, and feet are also commonly damaged in car accidents. Achilles tendon injuries, ankle sprains, collateral ligament injuries and stress fractures are typical [12].

2.5 Insight on Road transportation accidents in Ghana

Road transportation provides obvious benefits to countries and individuals. It facilitates the movement of goods and people, creating employment, supporting economic growth, enhancing access to education and health care, and connecting people to families and entertainment.

In Ghana, road transport accounts for 96-98% of overall national movement of people and goods [7]. Thus, road transport remains the backbone of the national economy. As a result, the performance of the transport system is of crucial importance for individual mobility, commerce and for the welfare and economic growth of the nation [7].

Injury prevention efforts rely on accurate data which provides insight into aspects of the problem that are amenable to public health interventions and which can be used to grade the effectiveness of such programs over time. As stated earlier, buses and minibuses are most notably among the commonest forms of transport for many people and are an enormous source of injury and disability in Ghana. And when accidents occur, most of these occupants would not incur severe and serious injuries if the vehicle seat were properly designed.

2.6 Seats

The seat has an important role to play in satisfying human comfort. Seats are generally classified into two groups;

1. Dynamic seat

2. Stationary seat

Dynamic seats allow movement of the chair back lumbar support. Dynamic movement allows a reclined posture to be achieved allowing relaxation of back muscles and movement of the spinal column. The outcome of using a dynamic seat is reduction of spinal shrinkage, which usually occurs in a static posture. Stationary seats have a feature such as a fixed back support [24]. The stationary seats are mostly found on the buses and minibuses. Typical examples are the locally fabricated seats. The aim of seat design should be to reduce or eliminate factors causing discomfort and impact forces rather than to elicit feelings of well-being.

Furthermore, the design parameters on seats are divided into three categories.

1. Fit parameter levels are determined by the anthropometry of the occupant population and include such measures as the length of the seat cushion.
2. Feel parameters relate to the physical contact between the sitter and the seat and include the pressure distribution and upholstery properties.
3. Support parameters affect the posture of the occupant and include seat contours and adjustments.

There is considerable interaction between parameters, both within and among these categories. For example, a change in backrest curvature (Support) will affect the pressure distribution (Feel) and also change the effective cushion length (Fit). However, this parameter categorization is useful because the knowledge required to specify parameter levels in each of these categories comes from distinct areas of research. Fit parameter levels are set with reference to anthropometric measures using data on the distributions of particular body dimensions in the population. Feel parameter levels are set using a combination of subjective assessments and objective measurements made with tools, such as pressure measurement mats and sweat impulse testers. Support parameters, which include lumbar support and backrest angle, are specified with reference to physiological measures related to internal body stresses associated with various postures [28].

2.6.1 Locally Fabricated Vehicle-Seat

Locally fabricated seats are mostly found in commercial vehicles (buses and minibuses) used for public transportation, mostly to accommodate more occupants. In Ghana, most of these seats are incorporated to the carriage of the commercial vehicles for instance the Mercedes Benz 207 and the 12/15 seat buses. The design is more like a bench seat type without some basic features such as seatbelts, anti-submarining pans and headrests. The seat basically comprises a metal frame fabricated from mostly galvanised steel pipes, to which plywood of about 2 cm thickness is attached to complete the base and backrests [4]. The base and the front of the backrest is cushioned with high density foam and covered with synthetic leather cover. Depending on the type of vehicle, the backrest is designed in attempt to make a separate backrest for each individual intended to occupy the seat (Mercedes Benz 207 or Sprinter) or wide for all occupants of a seat (12/15 Seats).

Normally the seats with appropriate dimensions (allow tolerance) designed for these commercial vehicles are removed and replaced with the locally fabricated seats. The seats fall into two basic general categories; Seats with foldable (middle or left) end and those without foldable end. 12/15 Seater buses belong to the foldable seats while the 207 sprinter and some Benz buses (with 30 Seats capacity and above) belong to seat without foldable seats. The foldable seats are designed to allow movement from entrance to the back through the foldable seat part which is shown at Figure 2-5 while those without foldable seats are designed to have a movement space for embarking and disembarking through the centre, this type of seat is also shown at Figure 2-6. Most of the dimensions for these seats vary. Figure 2-4 and Table 2-4 show an approximate seat frame and dimensions retrieved from recent research which vary from one artisan to another.

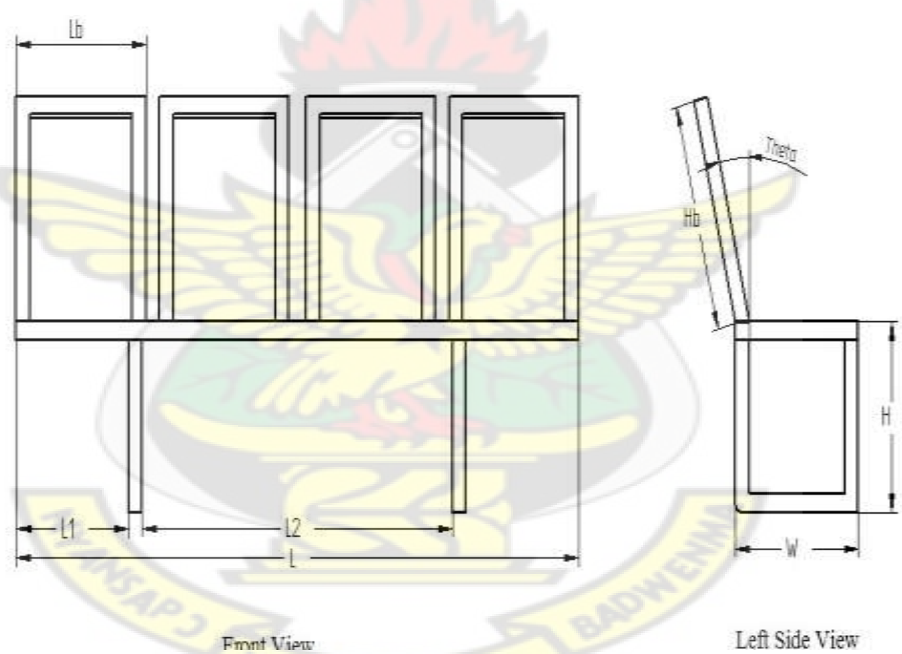

Figure 2-4: Locally Fabricated Seat Dimension [4]

Table 2-4: Approximate Seat Frame Dimensions (Dimensions vary from artisan to artisan) [4]

Vehicle	Seat type	L	L1	L2	Lb	W	H	Hb	Theta*
207/ Sprinter	Back Seat	163	36	83	39	36	45	59	14
	Other Seats	158	36	78	39	36	45	59	14
12/15	Back Seat	127	25	94	127	36	40	50	14
	Middle double seats	82	0	55	82	36	40	50	14
	Middle single seats	38	0	38	38	36	40	50	14
	Seat behind driver	110	20	82	110	36	40	50	14

*** With the exception of Theta (in degrees), all other dimensions are in cm.**

Figure 2-5: Seats with foldable seats at One End in a 12/15 – Seater Bus.

Figure 2-6: Seats without Foldable Seats in a 12/15 – Seater Bus.

2.6.2 Passengers' Safety

Anything that moves has the potential to collide with another object. The existing human culture is heavily reliant on the transportation of both people and goods over a wide range of distances at a wide range of speeds. Whether from human error, mechanical failure or the forces of nature, transportation collisions occur on a frequent basis. In 2004, approximately 1.2 million people are killed and up to 50 million are injured in traffic collisions worldwide [7, 14].

Further, the contribution of vehicles to accidents in Ghana is attributable to the state of their structure brought about by improper vehicle conversion and reconstruction and lack of maintenance. The laws of Ghana mandate that vehicles allowed on roads be assessed for road worthy.

From the above report, it was noted that the vehicles seats are reconstructed without the occupant's consideration. This clearly signifies that the occupants are not fully safe during transportation as long as these commercial vehicles are on road.

2.6.3 The need for vehicle-seat reconstruction.

Many manufacturers of vehicle seats in Ghana still have a long way in improving seat design that will protect occupants from injuries. Recent injury statistics show that the vehicle seats have certainly contributed a lot to injuries. Vehicle-seat reconstruction is the science of determining and correcting the causes of vehicle seat related injuries during accidents. Ideally, the aim of vehicle seat reconstruction is to understand the causes of a vehicle seat related injuries so that, if necessary, steps can be taken to reduce the likelihood of similar injuries occurring in the future. In such circumstances a conservative estimate of vehicle seat is required from the reconstructionist.

Several studies have however established that, the forces that are at play when road traffic crashes occur during short trips are enough to cause severe injuries and even fatalities [16]. With this, the need to generate parameters which will help in reconstructing good vehicle seats that will improve crash-productive design and reduce the impact forces arises.

2.6.4 Past Research

A research can be defined as a study undertaken within a framework of a set of approaches using procedures, methods and techniques that have been tested for their validity and reliability. A very important part of every research is the procedure adopted in conducting the research, also known as the Research Design. Basically, the research design determines the kind of information or data that was required and to some extent, the data collection methods that should be used in getting this data.

Further, researches into occupant safety in vehicles are still on-going and are being carried out by institutions, automobile and aircraft design and manufacturing companies as well as individuals, focusing on such areas as injury mechanism, occupant response during impacts, the human body tolerance to impact forces experienced during accidents, rear seat occupant safety, child occupant protection technologies and assessments of existing occupant protection technologies [4].

Road Traffic Accidents research in Ghana has not advanced as in the developed countries. It seems most of these researches are conducted by the NRSC and a few

NGOs and individuals, trying to establish the accident situation within the country through surveys. Others focus on determining the causes of accidents [4, 17].

In developed countries, mathematical models of Road Traffic Accidents scenarios have been developed in the past. The first software of this nature included the MVMA2D and the CAL3D model also known as the Crash Victim Simulator [4]. At the moment, the most popular accident simulation software is MADYMO.

But early researches into occupant safety adopted an experimental approach using a sled test. Sled tests were performed with dummies and sensors attached to it, to get an understanding of occupant behaviour during accidents with the various parameters needed to attain. Results from these experiments have been proven by various researches to be satisfactorily accurate.

2.7 Sled Testing

Sled testing offers the freedom to analyze occupant kinematics and restraint system performance for numerous impact modes and speeds depending on the test apparatus set-up [19]. Vehicle and human safety considerations have become increasingly important in recent years. As a result of this considerable research has been going on for the past few years. By comparing the kinematics of real people in real collisions with that of dummies in comparable collisions, the limitations of our current test tools can be examined [23]. Sled testing is the most efficient way of crash testing and today's accelerometers are collecting more reliable data than before. Over the years, sled testing has been used by different industries and several companies for a wide range of test applications [18]. Within the automotive sector, sled testing has been known to involve airbag deployment, side and front impact, seatbelt anchors, interior components, human biological limits, seats, child-restraint systems, bumpers, panels, wheelchairs, van conversions, motorcycles and ambulance cots [18, 19]. Utilizing a sled allows for dynamic test results more consistent with that seen in real-world accidents while being able to reuse a vehicle buck (partial vehicle) or occupant compartment for multiple tests [19]. The use of sleds rather than crashing cars into barriers or each other, provides several value propositions, in the form of much lower costs, quicker reporting of results, greater data reliability and control over repeatability of the crash event [18]. The sled can either be powered manually (it makes use of a falling mass suspended by block and tackle arrangement) or automatically (with a hydraulic pump). A good example of the sled test equipment is shown in Figure 2.7 with the skeletal dimensioned analysis.

Sensor size is often important, and small sensors are desirable for many reasons including easier use, a higher sensor density, and lower material cost [20]. Sensors allow detection, analysis, and recording of physical phenomenon that are difficult to otherwise measure by converting the phenomenon into a more convenient signal. Sensors convert physical measurements such as displacement, velocity, acceleration, force, pressure, chemical concentration, or flow into electrical signals [18, 20].

Acceleration is typically the most used measurement in crash and sled testing and provides the greatest amount of information. Simple integration of acceleration can provide velocity and displacement and is useful when determining the forces applied to an object using the simple F = m x a. The sensors can be used as triggers or mounted in dummies or on the test components on the sled itself. The primary aim of sled testing is to replicate an acceleration/deceleration versus time curve and these ‘pulses’ can vary, depending on the need. Sled testing can provide a non-destructive testing platform that can accurately recreate a pulse from a destructive barrier-type test. This is helpful as the same fixture can be used many times to test a given scenario [18].

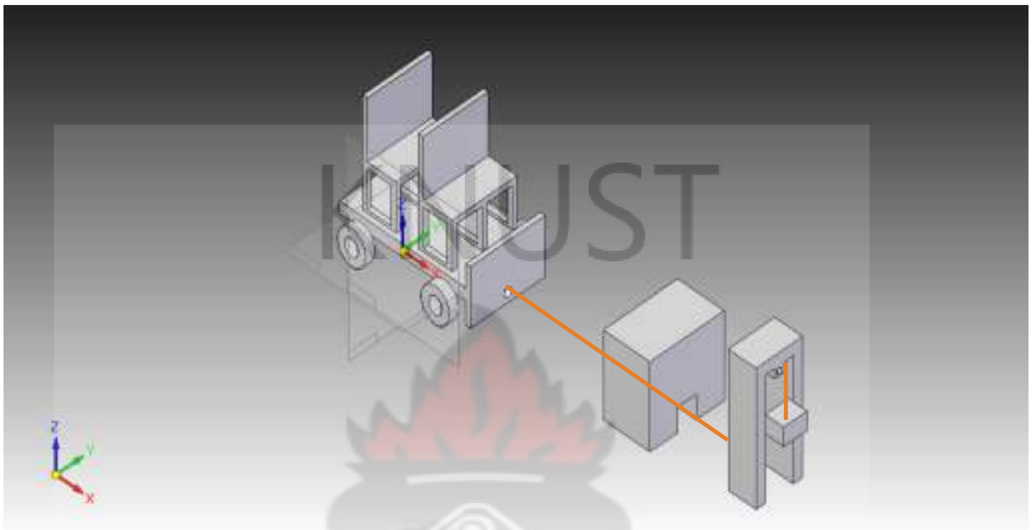

Figure 2-7: Sled bed in a in a 3D plane.

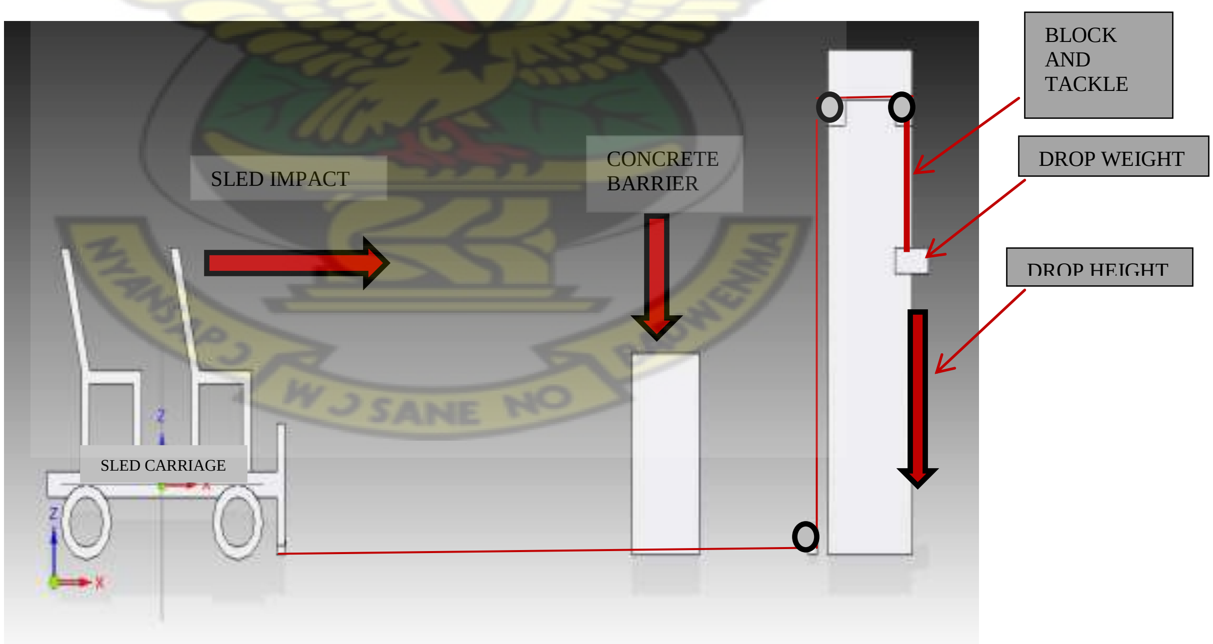

Figure 2-8: Sled test experiment in 2D drawing

2.7.1 Accelerometer Sensors

Accelerometer sensor is an instrument used to measure the acceleration experienced by the sensor and anything to which the sensor is directly attached. Basically, accelerometer sensors have many applications. In engineering, accelerometers can be used to measure vibration on cars, machines, measure seismic activity, inclination, machine vibration, dynamic distance and speed with or without the influence of gravity [22]. The most common commercial application is impact sensors for triggering airbag deployment in automobiles: for instance, when the acceleration exceeds 30 to 50 g's, an accident is assumed and the airbags deploy. Such sensors are designed to be reliable, and are made in high volume and at low cost [20]. When working with accelerometers in the earth's gravitational field, there is always acceleration due to gravity. Thus the signal from an accelerometer sensor can be separated into two signals: the acceleration from gravity, and external acceleration. The acceleration from gravity allows measurement of the tilt of the sensor by identifying which direction is "down". Filtering out the external acceleration, the orientation of a three-axis sensor can be calculated from the accelerations on the three accelerometer axes [21, 22]. But more importantly accelerometer is used in; crash test dummy instrumentation, crash vehicles, road trial, test stand, ride comfort.

2.7.2 Dummy

The second major area of experimental biomechanics in the 1980s and 1990s was in the development of human surrogates or dummies [23]. The main reason for this development was to duplicate the exact human frame with sufficient biofidelity. With instruments (sensors) placed on the head, chest, legs and elsewhere in the dummy, parameters like acceleration and others can be determined and analyzed during the sled test experiment. For an approach like this, it can be assumed that a physical dummy, made of steel and plastics, can replicate the response of the biological materials which make up the human frame. Basically, different crash conditions require different dummies and the consented dummies for the female and male reactions are the 5th percentile female and 95th percentile male dummies.

2.8 Acceleration and Evaluation Analysis

Acceleration and evaluation process involves systems where components and subcomponents are mounted to achieve different aims; this process is normally used to generate data for analysis. Figure 2.9 explains how the acceleration and evaluation process is actualized.

The purpose of the laboratory testing phase is basically to simulate the operational environment through testing, which is modeled after a series of worst-case event scenarios, such as a rapid leg injuries event or other crash incidences or mishaps. Ultimately testing is used to ensure that these seats will not by any chance lead to a critical injury on impact and on implementation will reduce the severity of these injuries.

2.9 Ergonomic knowledge

The principle that the seat should fit the sitter is the most universally employed concept in seating ergonomics and there has been an increased design emphasis on seat comfort with the ergonomic knowledge being applied in the seat design. This is primarily because driver and passengers comfort have been seen as an increasingly important aspect of the competitive marketing of vehicles. Research related to seating comfort is not common in Ghana and people fabricating the seats have not worked to increase the comfort of their products. One reason for continuing seating research must certainly be that the recommendations made are not always followed by artisans.

The need for the artisans to reduce the total number of fabricated seats used in commercial vehicle when constructing and the distance between the rear seats was adequately effective as compared to when the seat base is tilted to specified seat base angle (see Figure 2.10). The impact of the inclination angle on seats gives the opportunity for the vehicle owners to maximize their profits by not reducing the number of seats fitted in a vehicle yet reduce the impact forces surrounding the occupants during accidents.

The human locomotor system consists of muscles, tendons, ligaments, joints and bones and is highly complex. The spine, which supports the entire body, is the central component. An ergonomically correct posture is important when sitting in order to avoid putting the spine into an incorrect position [31].

2.9.1 Seat design

Ergonomically, unsuitable vehicle seat design gives rise to psychophysical fatigue [30]. The two basic designs a vehicle seat should have are; design which is especially supportive of spinal column health, as well as their many different adjustment possibilities. These include the ability to adjust the seat's length, height and tilt to optimally distribute pressure throughout the seat, as well as its freely adjustable two-chamber lumbar support. Since the occupants' seat is designed to average anthropometric measurements of the human body, all persons who do not fit these measurements have certain difficulties when sitting in the vehicles.

2.9.2 Seating and posture

Most commercial vehicles in Ghana, will not allow as much flexibility for occupant posture as possible. A lot of commercial vehicles may cause the occupants to adopt a coping posture that will affect them later in life. Taller occupants will feel lack of space but with a reduced impact on collision while shorter occupants with shorter limbs will experience much space which will result to greater impact during collision.

Meanwhile, orthopedic and muscular aspects of sitting helps to decreases the stress in the muscles and joints of the hip and knee and decreases the range of motion needed at the hip and knee joints.

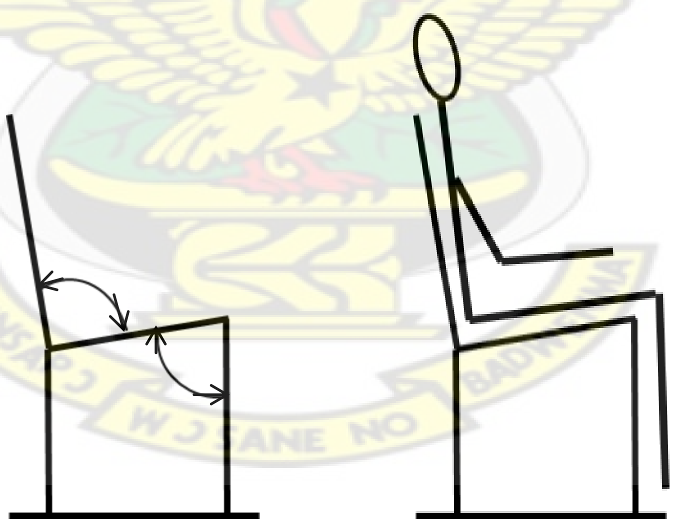

Figure 2-9: Definition of seats with recommended posture angles

Figure 2.9 shows the recommended seat design that was used for the fabrication of the seats for the test.

Acceleration Test and Evaluation Process

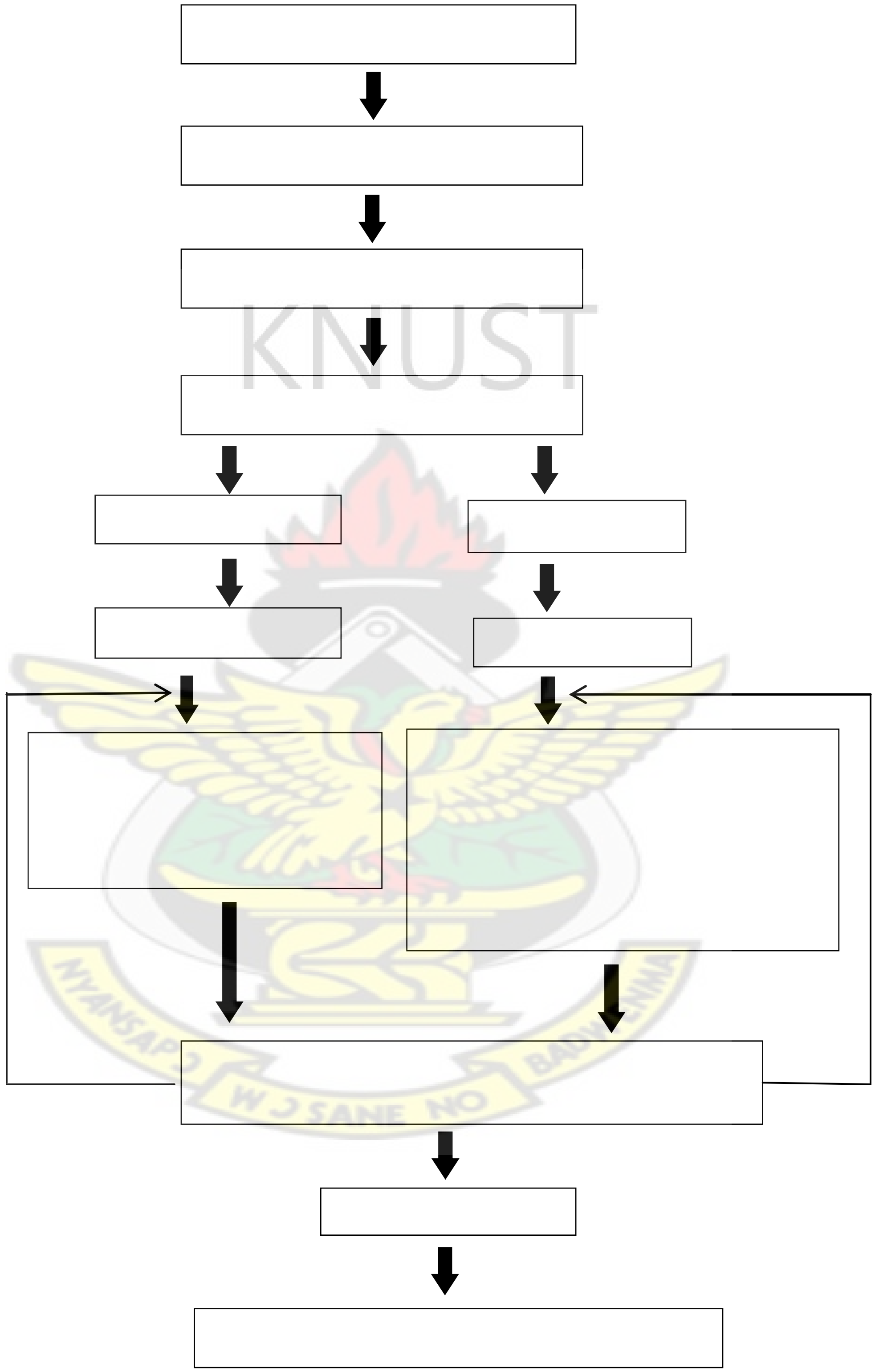

Figure 2-10: Acceleration Test and Evaluation Process

CHAPTER 3

METHODOLOGY

3.1 Focal Point

A recent research performed by matching accident data from KATH with computer simulation using software (2D working model) was used to determine and confirm the prone areas that were normally affected during accidents. With the prone known, during this experiment the accelerometer were placed at these prone areas and data were recorded. The need to determine the accelerations was a key factor as regards to the severity and reduction of the impact forces. The priority of this study was to develop a seat design frame which will be able to reduce the severity of the impact forces on collision. Madymo and crash are the highly rated software used for this experiment but the cost is quite high as compared to the sled testing and moreover most of the materials that was used for the sled experiment can be obtainable. Since sled test offers the freedom to analyze occupant kinematics and restraint system performance for numerous impact modes and speeds, decision on what method to be used for the experiment is certain which is to design and construct a sled test setup that will help achieve this aim.

3.2 Research Information/Study Areas

Familiarization of the sled test experiment and providing the specific design which was used for the experiment was properly executed. Information concerning the vehicle seats; the seat dimensions, the type of seat materials and fabrication methods used were also obtained from recent research [4]. A more detailed research was done concerning the dummy, its specific weight and height. Using these data a dummy was constructed with the specified features. An overview of the dummy's movement and the speed at which the experiment was conducted is a factor that was used to determine the type of sensors incurred for the experiment.

3.3 Mechanical Analysis of the System

The schematic diagram of the system with consideration to the weight of the sled, the dummy, the drop weight and the forces acting on them was illustrated in this section. The velocity of the sled and the tension (at the sled carriage and the drop weight) can be determined using the various established formulas. The dynamic analysis of the experimental setup is shown in appendix B.

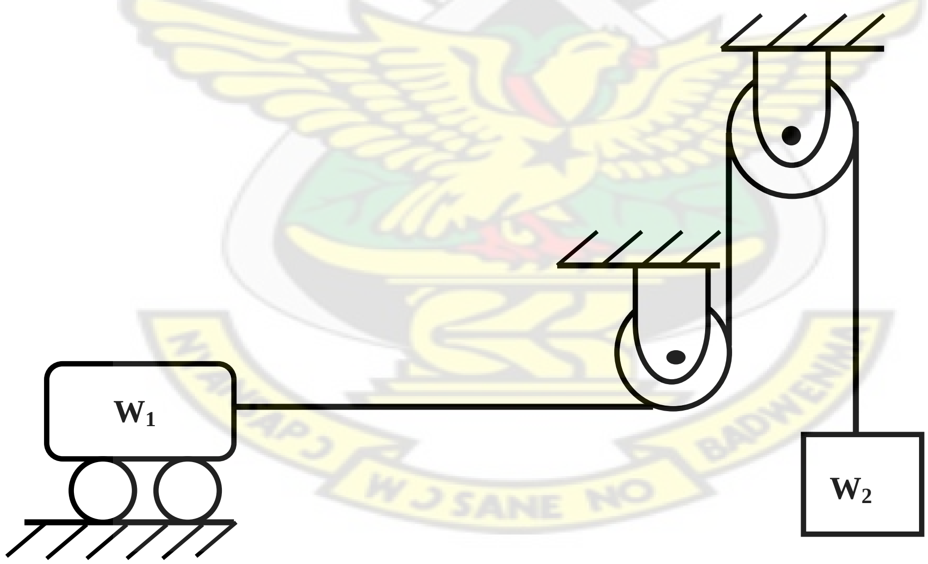

Figure 3-1: Schematic diagram of the system

3.4 Sled Test Setup/Design

The entire tests were conducted at the mechanical engineering laboratory, KNUST. Frontal and rear impact tests were conducted utilizing an acceleration sled. The fixtures include sled carriage that was accelerated by way of a pushing the sled carriage at a constant velocity. The sled was designed in such a way that it allows a free movement without interception till it gets to the deformable/concrete barrier. The sled test used a locally fabricated vehicle seats dimensions from commercial vehicles. Meanwhile a standard automobile seat bench for use in impact tests is defined as a platform which yields controlled and repeatable known interaction with a system being tested with it [26]. The sled setup consisted of two (2) row seats; the front and rear, attached on the carriage. The front row was always unoccupied and provided surface for the dummy at the rear row to strike (with knees and other parts). The rear row was used for the dummy which had the sensors attached at the areas of interest. An electrical circuit which allows the flow of signals from the sensors to the memory card was also attached to the bed. The memory card stored data produced by the sensors.

The sled was accelerated to the desired impact speed into the concrete barrier which was deformable, allowing the sensors to determine the actual acceleration travelled by the dummy at the various preferred prone areas at which the sensors were placed. The suspended mass was used to accelerate the sled bed to the desired impact speed. Higher mass will result to a higher speed for the sled speed travel. For this experiment, having in mind the desired velocity to attain, some basic formulas were used to achieve the mass that would be used to accelerate the sled (see equations in appendix B).

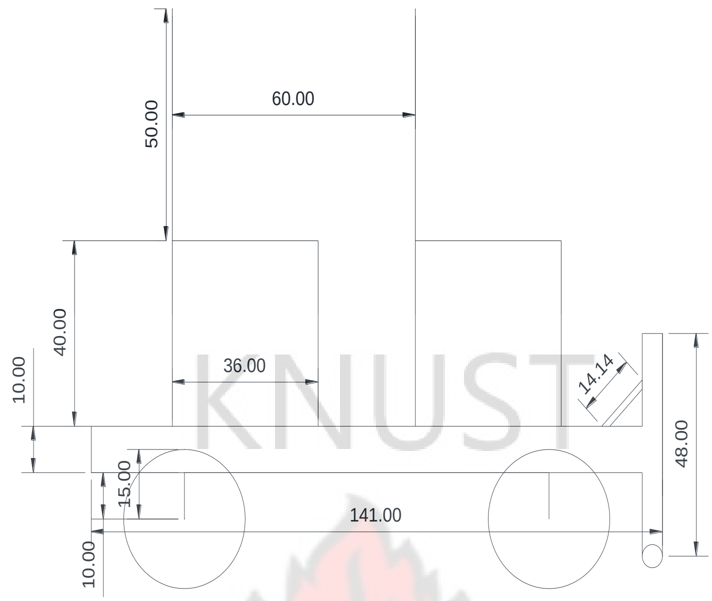

Figure 3-2: Skeletal (dimensioned) sled bed used for the experiment

The experimental seat attached to the carriage were designed to allow backward and downward movement in the backrest (α) and seat base (β) respectively; this was properly illustrated on Figure 3.3. This allows the same experiment to be repeated with different seat base angles. Different results from the experiments present the design which gave the best performance on the dummy as regards to the acceleration i.e. the design that produced the lowest impact acceleration reduces the severity of injuries. The angles of inclination on the seat base which attained the lowest value on the experimental seat (rear seat) was as well be suggested when considering the design to be used in fabrication of the locally vehicle seats. Figure 3.3 clearly shows the directions at which the backrest and the seat base were inclined as different readings of the accelerations were recorded.

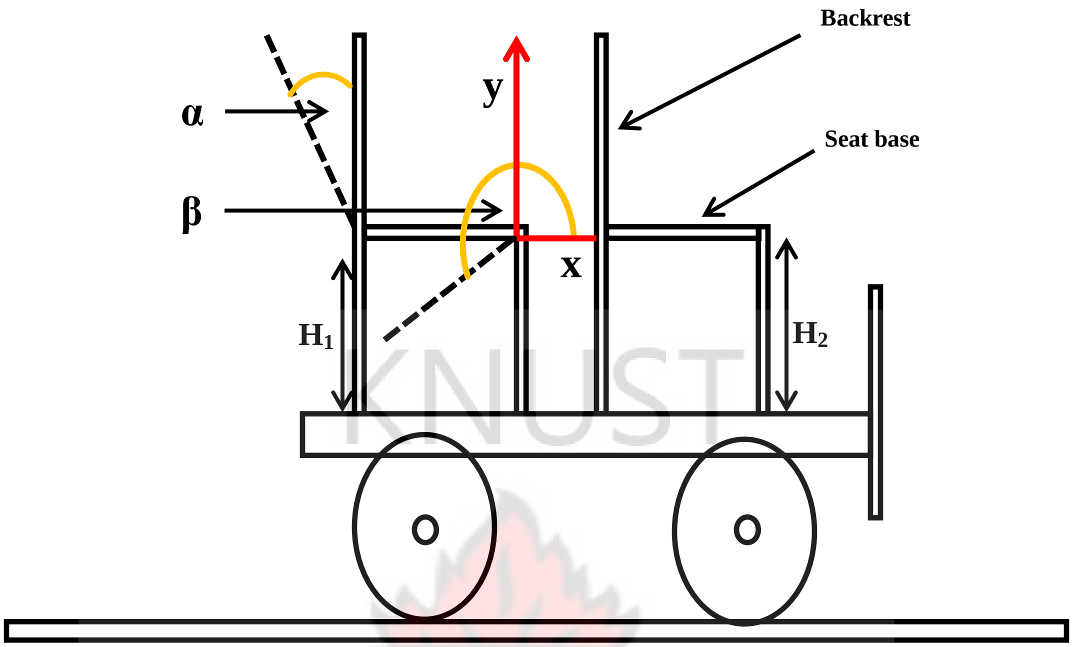

Figure 3-3: Illustration of the various parameters considered during the experiment.

Having in mind that the seat leg height (H_1 and H_2) contributed to severity reduction, the length of the seat height was also recorded on each experiment. Holes were also created on the seat height which clearly explains the position at which the dummy was examined and results from sensors fitted in the dummy shows the various accelerations travelled. A slot was created beneath the seat base which allowed movement on the back rest of the seat. This ensures the back rest angle of the seat to be placed at the specified angle of interest during the experiment. This is clearly illustrated at Figure 3.4.

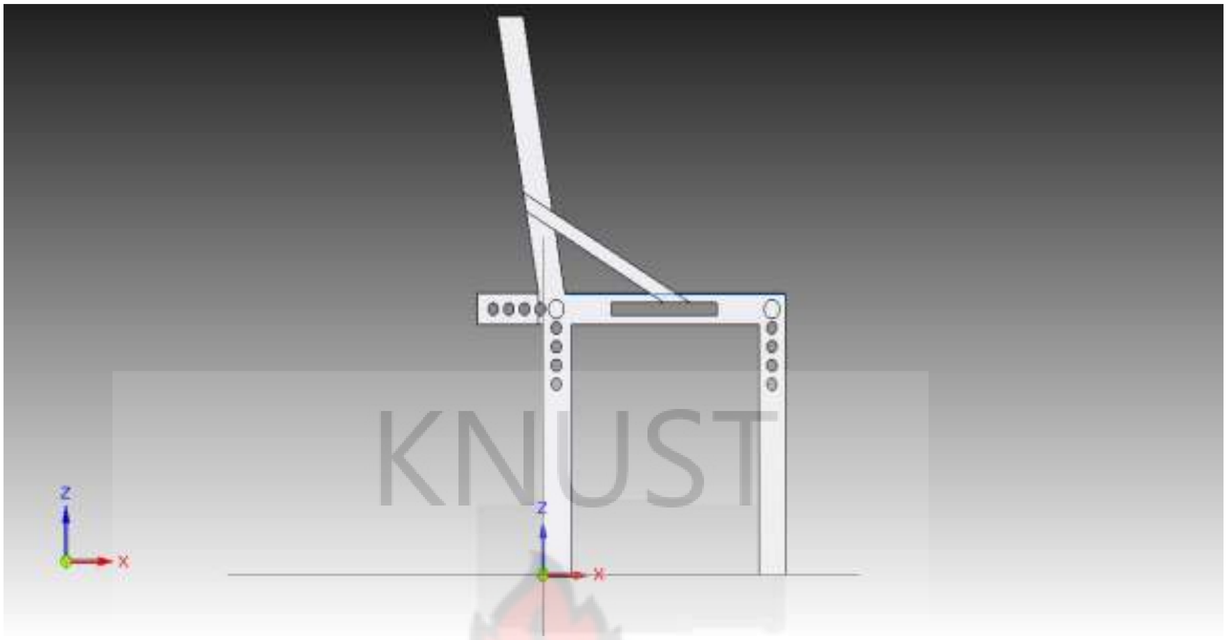

Figure 3-4: The designed rear seat (experimental seat)

The experiment was divided into two categories;

(1) The frontal impact

(2) The rear impact

The frontal impact was conducted while looking at 2 phases;

Phase 1: When the seat back rest angle is fixed at 20^{o} to the vertical axis and the seat base angle (β) is placed at 180^{o} to the horizontal axis.

Phase 2: When the seat back rest angle is fixed at 20^{o} to the vertical axis and the seat base angle (β) is varied at different positions on the experimental seat (the seat base was be positioned at different holes that are made on the experimental seat).

However rear impact was carried out to analyze only the head movement of the dummy because the head flips backwards during rear impact. On this experiment the seat base angle and the seat height was also varied at holes H_1 and H_2 of the experimental seat.

Figure 3.5 illustrates the areas were the sensors are placed during the experiment. The respective details are of the dummy with the sensors are also shown in the appendix D.

Figure 3-5: Positioning of the sensors

Experiments were performed and for each particular sitting angle, the test was run three times and the average of the results taken as the main data for the experiment. The sensors recorded values in the x, y, and z directions. The x-axis displays values for the horizontal movements, the y-axis shows values on the vertical movements of the dummy while the z-axis takes care of the side movements of the dummy

CHAPTER 4

TEST RESULTS AND ANALYSIS

4.1 Experimental results

For the frontal impact test, the maximum accelerations values on impact for frontal impact in x-direction (horizontal) are shown in Table 4.1;

Table 4-1: Peak values of accelerations frontal impact in x-direction

Exp.	Seat heights (cm)		Tilt angles (degrees)		Sensor 1 values in x-direction	Sensor 2 values in x-direction	Sensor 3 values in x-direction
	H1	H2	Back rest (to vertical)	Seat base (to horizontal)	Maximum Head Acceleration (g’s)	Maximum knee joint Acceleration (g’s)	Maximum hip joint Acceleration (g’s)
1	40	40	20	180	3.4	4.0	4.1
2	36	40	20	188	3.2	3.8	4.0
3	34	40	20	192	3.0	3.7	3.7
4	34	34	20	180	3.3	3.8	3.9
5	32	34	20	184	3.1	3.7	3.7
6	32	32	20	180	3.2	3.8	3.8

The maximum accelerations values on impact for frontal impact in y-direction (vertical) are also shown in Table 4.2;

Table 4-2: Peak values of accelerations frontal impact in y-direction

Exp.	Seat heights (cm)		Tilt angles (degrees)		Sensor 1 values in y-direction	Sensor 2 values in y-direction	Sensor 3 values in y-direction
	H1	H2	Back rest (to vertical)	Seat base (to horizontal)	Maximum Head Acceleration (g's)	Maximum knee joint Acceleration (g's)	Maximum hip joint Acceleration (g's)
1	40	40	20	180	3.3	3.4	4.0
2	36	40	20	188	3.8	3.2	3.9
3	34	40	20	192	3.9	3.4	3.8
4	34	34	20	180	3.2	3.4	3.8
5	32	34	20	184	3.7	3.1	3.7
6	32	32	20	180	3.0	3.3	3.8

The maximum accelerations values on impact for frontal impact in z-direction are also shown in Table 4.3;

Table 4-3: Peak values of accelerations frontal impact in z-direction

Exp.	Seat heights(cm)		Tilt angles(degrees)		Sensor 1 values in z-direction	Sensor 2 values in z-direction	Sensor 3 values in z-direction
	H1	H2	Back rest (to vertical)	Seat base (to horizontal)	Maximum Head Acceleration (g's)	Maximum knee joint Acceleration (g's)	Maximum hip joint Acceleration (g's)
1	40	40	20	180	3.4	3.7	3.4
2	36	40	20	188	3.2	3.8	3.4
3	34	40	20	192	3.3	3.5	3.4
4	34	34	20	180	3.3	3.6	3.3
5	32	34	20	184	3.4	3.6	3.4
6	32	32	20	180	3.3	3.6	3.2

And for the rear impact test, the maximum accelerations values on the rear impact test (x-y-z-direction) in experiments 1, 2 and 3 are also shown in Table 4.4;

Table 4-4: Peak values of accelerations rear impact in x-y-z direction

Exp.	Seat heights(cm)		Tilt angles(degrees)		Sensor 1 values in x-direction	Sensor 1 values in y-direction	Sensor 1 values in z-direction
	H1	H2	Back rest (to vertical)	Seat base (to horizontal)	Maximum Head Acceleration (g's)	Maximum head Acceleration (g's)	Maximum head Acceleration (g's)
1	40	40	20	180	4	3.4	3.7
2	36	40	20	188	4	3.4	3.6
3	34	40	20	192	4.1	3.4	3.6

4.2 Analysis

A total of nine (9) experiments were performed using the experimental techniques described in the previous chapter. Six (6) tests are for the frontal impact while three (3) tests are for the rear impact. The sled velocity was almost constant at approximately 8 m/s and the rear seat's back rest was set to a total recline angle of approximately 20^o to vertical axis for the experiments. The test subject was a constructed dummy with a height of 174 cm. Different seat base angle positions before each experiment were shown on the appendix C.Also the detailed values of the data collected by the accelerometers for each experiment were shown in the appendix D. The following paragraphs summarize the test conditions and results for the frontal and rear impact.

4.2.1 Frontal impact experiment

During the first experiment, the seat base was placed on H_1 (40 cm), H_2 (40 cm) and angle 180^o respectively. The horizontal motions of the dummy at different prone areas basically the head, knee and the hip as the sled carriage impacts was shown on Figure 4.1. During the start of the experiment from Figure 4.1 and others, the bed experienced an inherent vibration as a result of the surface area. A lot of factors were not considered around the starting of the experiment till it gets to the area where the spike was experienced. Generally the dummy was seen to accelerate with the knees and the head making contacts on the frontal seat back. The spikes on the knee joint, head and hip joint were noted at 4g, 3.4g and 4.1g respectively.

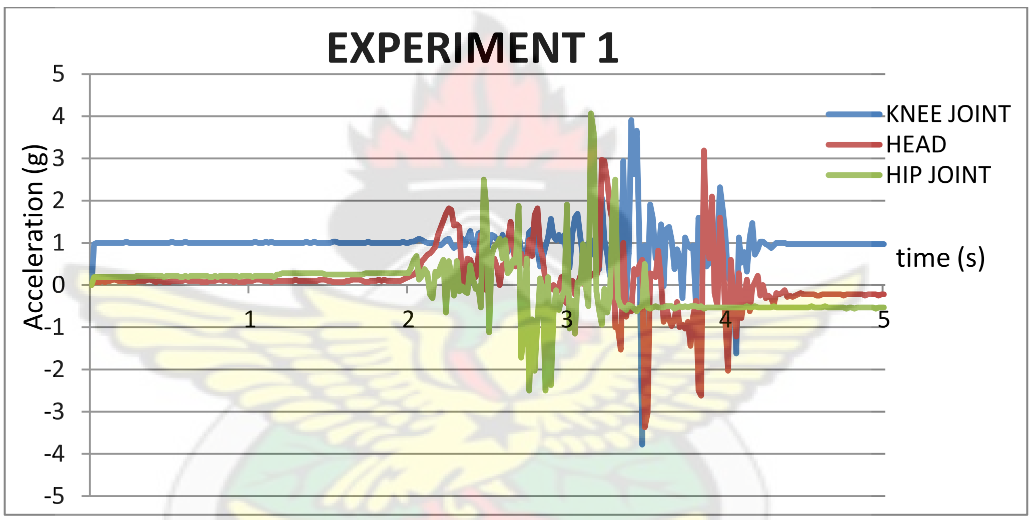

Figure 4-1: Acceleration of an impacted sled bed at H_1 (40 cm) and H_2 (40 cm) for the knee, head and hip joint

The ‘’g’’ is known as the acceleration due to gravity and 1g equals 9.81m/s^2. These values of the knee joint, head and the hip were taken as the reference value for comparison in the further experiments.

On the second experiment, the seat base angle was increased by 8^o from the reference position (180^o) but the test subject and the sled velocity remained constant for this experiment. The seat height H_1 and H_2 are 36 cm and 40 cm respectively. Figure 4.2 shows the test horizontal motions of the dummy at the head, knee and the hip as the sled carriage impacts. The duration of the impact on the dummy increased during this test, but it produced a lower acceleration at all the various prone areas where the sensors were placed. On inclination of the seat base, the dummy had to counter a little resistance before accelerating with reference to the first experiment. The maximum values (spike) of the knee joint, head and hip joint are 3.8g, 3.2g and 4g respectively.

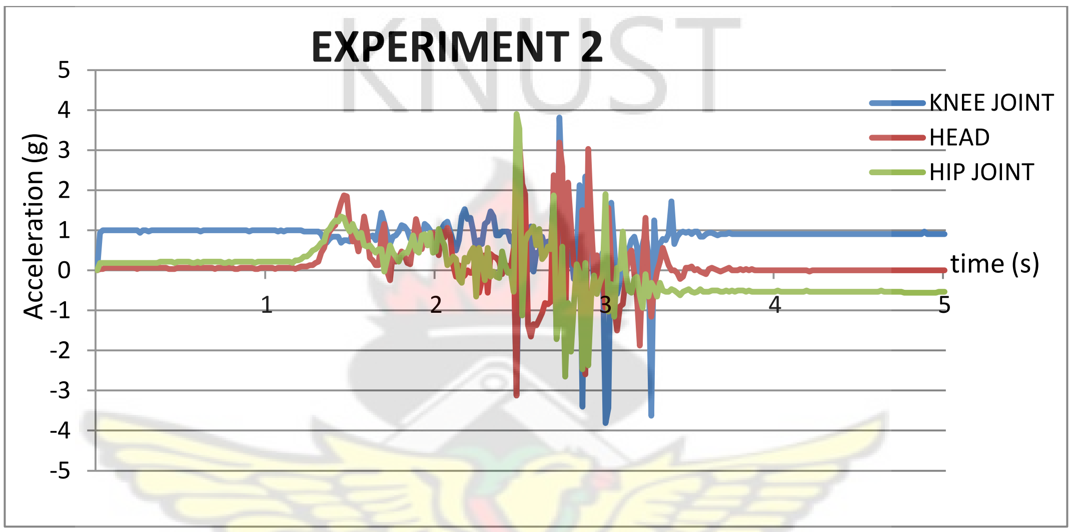

Figure 4-2: Acceleration of an impacted sled bed at H_1 (36 cm) and H_2 (40 cm) for the knee, head and hip joint

On the third experiment, the seat base angle was further increased and the seat heights were reduced respectively while the sled speed and the test subject remained the same. The seat base angle was increased 12^o to the reference horizontal axis while the seat heights were 34 cm and 40 cm for H_1 and H_2. Figure 4.3 below shows the test graph motion for the experiment. This experiment produced the lowest acceleration on the knee joint, hip joint and the head impact considering the inclination angle of the seat base. There were no major change in the duration of impart compared to the previous test. The maximum values of the knee joint, head and hip joint were 3.7g, 3g and 3.7g respectively.

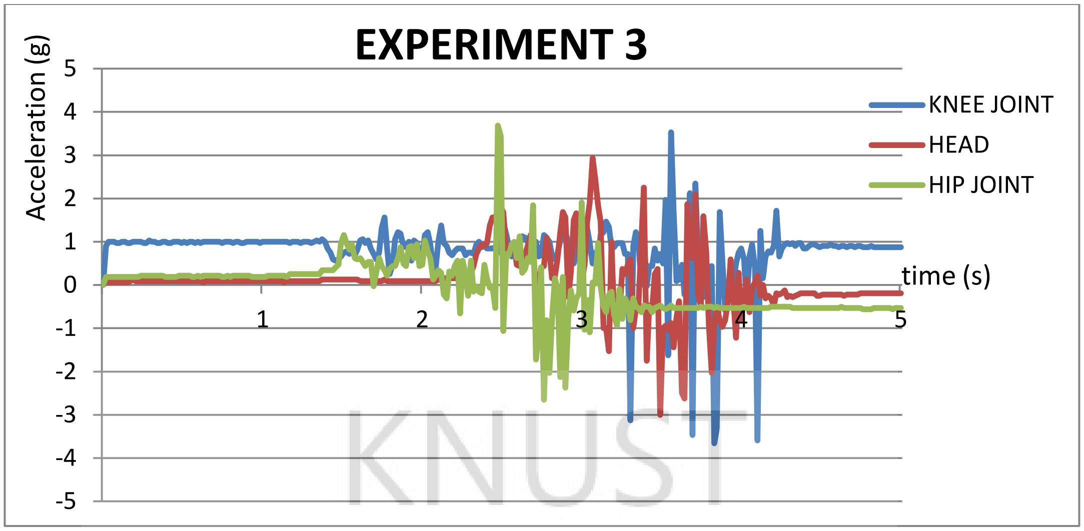

Figure 4-3: Acceleration of an impacted sled bed at H_1 (34 cm) and H_2 (40 cm) for the knee, head and hip joint.

The fourth experiment considered situation where the seats heights were leveled at 32 cm for both H_1 and H_2 respectively. The sled subject and the sled speed were still constant. The seat base angle was placed at 180^o with respect to the horizontal axis. The test graph of motion was shown in Figure 4.4.

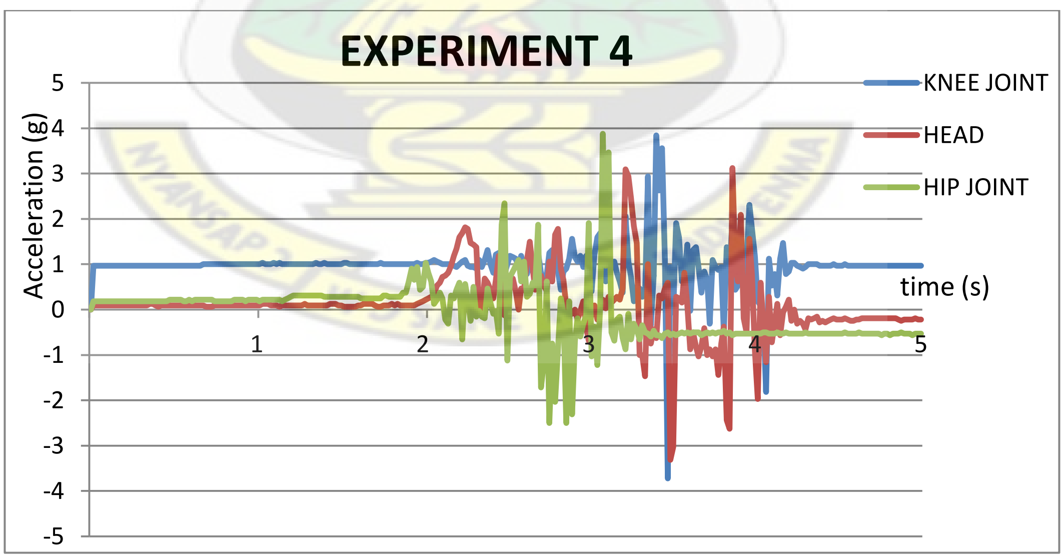

Figure 4-4: Acceleration of an impacted sled bed at H_1 (34 cm) and H_2 (34 cm) for the knee, head and hip joint

Due to the reduction in height, the dummy experienced a decrease in acceleration on the sensor-attached areas. The movement of the dummy produced a motion similar to the first experiment. The maximum values of the knee joint, head and hip joint were 3.8g, 3.3g and 3.9g respectively.

The fifth experiment looked at situation where the seat base angle is increased with reference to the fourth experiment. The seat base was also reduced to 32 cm at H_1 but the H_2 was left at 34 cm. The seat base was also increased by 4^o to the horizontal axis. The test subject and the speed were also kept constant. The test graph of motion was shown in Figure 4.5. Here again, the duration of the impact on the dummy decreased in this test compared to the first experiment and the dummy also produced a lower acceleration at all the various areas at which the sensors were placed as compared to the last test. The maximum values of the knee joint, head and hip joint were 3.7g, 3.1g and 3.7g respectively.

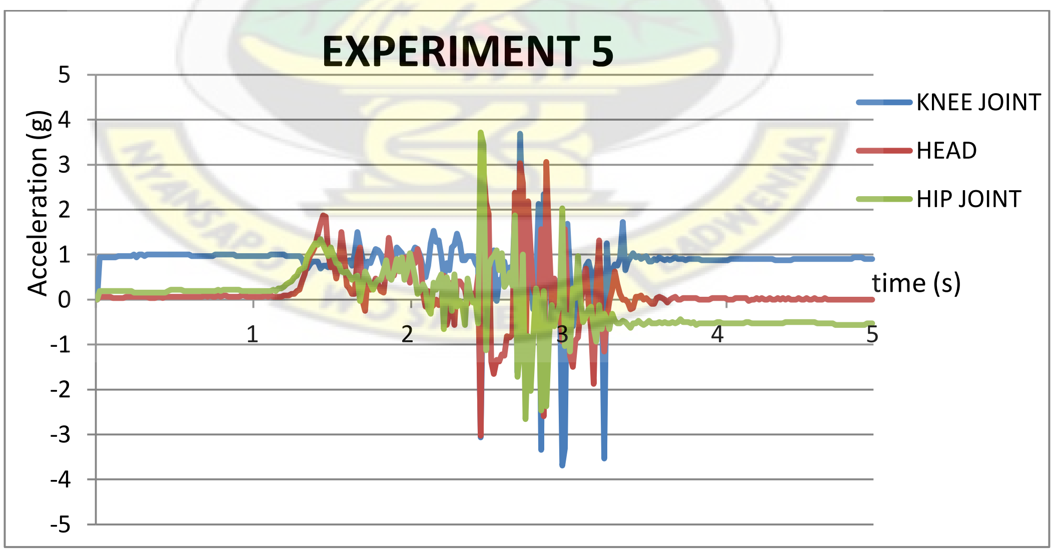

Figure 4-5: Acceleration of an impacted sled bed at H_1 (32 cm) and H_2 (34 cm) for the knee, head and hip joint.

The sixth experiment involved 32 cm for H_1 and H_2 seat height, the seat base angle was placed at 180^o to the horizontal axis. The test subject and the speed were still the same. The test graph was shown in Figure 4.6;

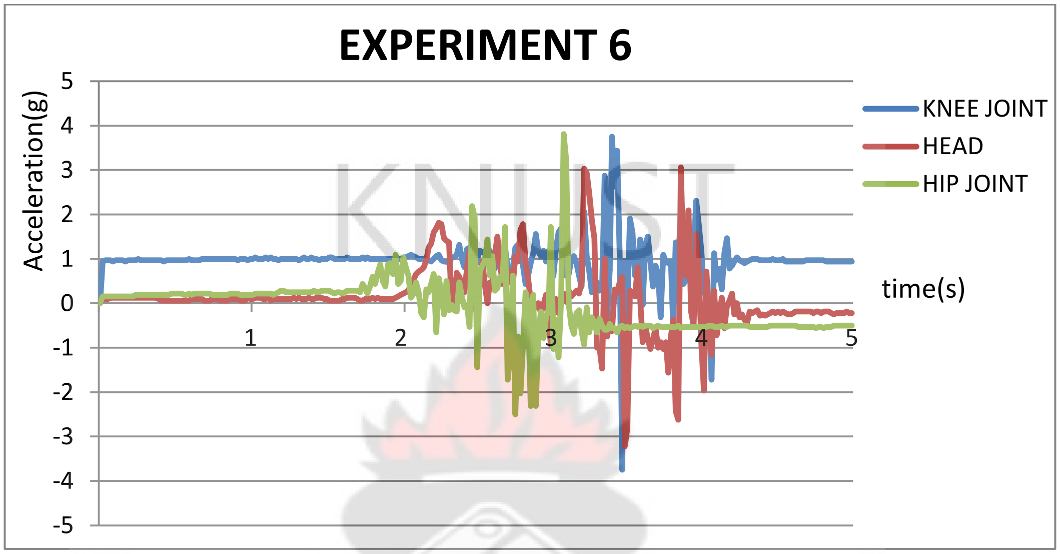

Figure 4-6: Acceleration of an impacted sled bed at H_1 (32 cm) and H_2 (32 cm) for the knee, head and hip joint

On this experiment, the accelerations on the head, hip and the knee joint increased as compared to the last experiment. The duration of the impact on the dummy was normal as expected in this test. The maximum values of the knee joint, head and hip joint for this experiment were 3.8g, 3.2g and 3.8g respectively.

4.2.2 Rear impact experiment

The rear tests were performed at the same speed and using the same principles but more emphasis was laid on the flexion of the head. Here, only sensor 1 one was used because the analysis was reduced to the head motion.

In experiment seven, the seat base was placed on H_1 (40 cm), H_2 (40 cm) and angle 180^o respectively. Figure 4.7 shows the graph of motion on the dummy.

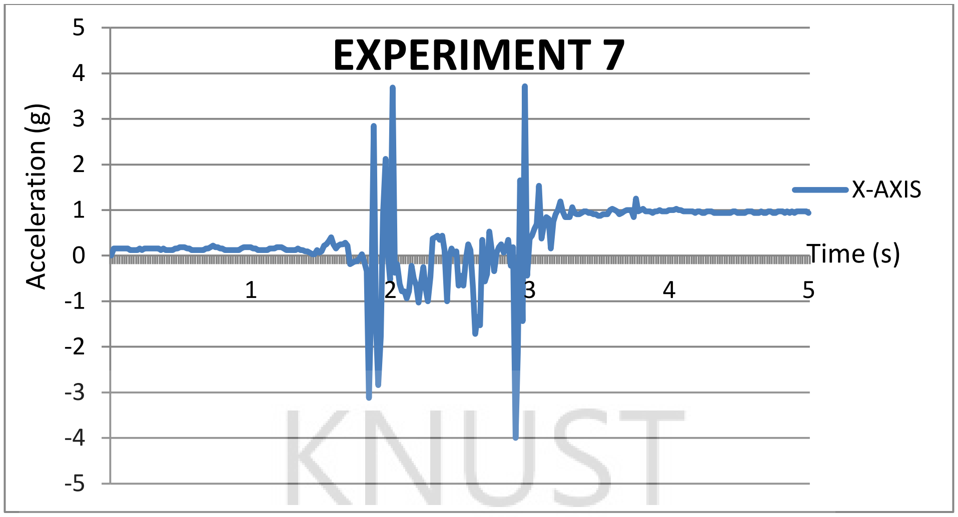

Figure 4-7: Acceleration of an impacted sled bed at H_1 (40 cm) and H_2 (40 cm) for sensor 1.

As a result of the high speed for the rear test, the dummy initially engaged in a forward motion before the impact, which was also as expected before the second spike on impact. The maximum acceleration value on the head is 4g.

The seat base angle was increased by 8^o to the horizontal with the seat leg height H_1 and H_2 to be 36 cm and 40 cm in experiment eight and the sled speed was kept constant. No changes were found in the experiment as the seat was increased. The sled motion graph as shown in Figure 4.7 followed the same pattern with the latter. With reduction of the seat leg heights to 36 cm for H_1 and H_2, leaving the angle to be 180^o to the horizontal axis in experiment nine. The motion graph took the same pattern as the sled was accelerated.

The maximum acceleration value on the head is 4g. The graph of motion during the experiment was shown in Figure 4.8;

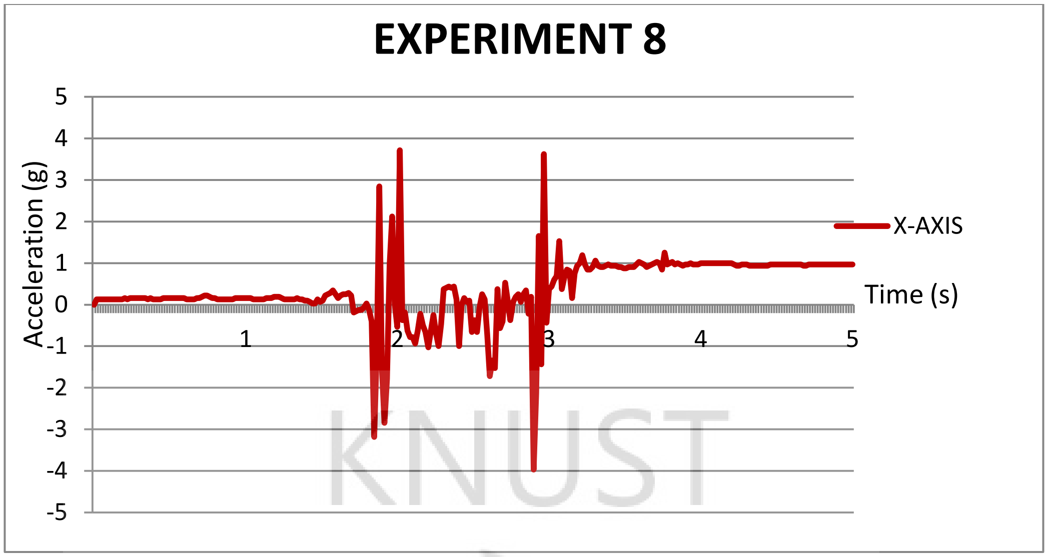

Figure 4-8: Acceleration of an impacted sled bed at H_1 (36 cm) and H_2 (40 cm) for sensor 1.

4.3 The observations and effects on the dummy

The pertinent impact data for the experiments are summarized in Tables 4.1, 4.2 and 4.3 respectively. With the flexion of the femur as the knee impacts, a serious damage on the bones surrounding the knee was developed. This was also be experienced on the head with the injuries associated to it. Acceleration (which is basically a sudden change) unlike velocity affects the direction of motion in a human body as shown in Figure 4.9. On motion, acceleration affects the blood flow in human system (the hard impact energy on the blood) which causes it to flow. If acceleration is applied in the direction opposite to the flow, it will impinge the flow of blood instantly. For instance, if acceleration is directed towards the head, the amount of blood that flows towards the brain will increase and if the acceleration is reversed, the direction of the flow will suddenly change causing a restriction of blood flow in the brain. This situation has effects with time on the human beings like unconsciousness, point blindness and strange behavior of the victim during accidents.

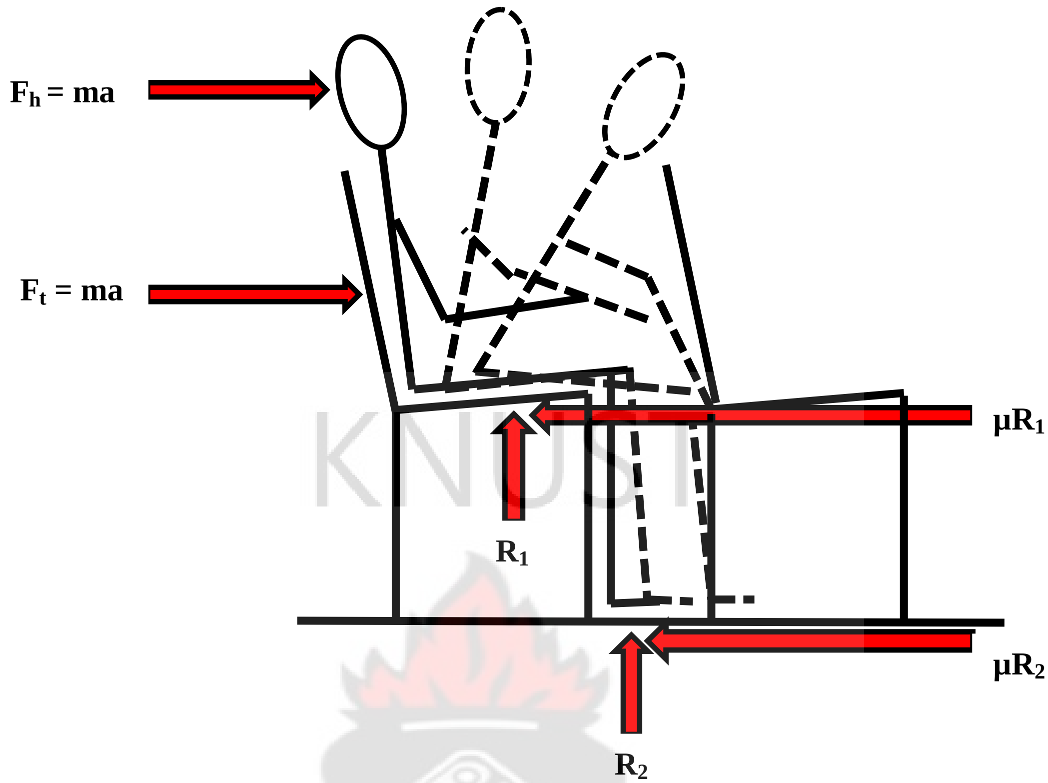

Figure 4-9: Movement of humans on impact

The determinants of trunk/thigh angle are the backrest angle and the seat base angle which is the most important angles related to seat comfort. Reclining the trunk 20^o substantially decreases back muscle activity and opens the trunk thigh angle, decreasing the necessity for lumbar flexion. Thus give advantages like reduced stresses at joints, reduced compressive stress on the posterior annulus, improved transport of disc metabolites and high compressive strength of the spine.

The configuration of the test subject was intended to simulate that of a seated motor vehicle occupant striking his knee and head on the frontal back seat in an accident having in mind that some of the injuries incurred during accidents in commercial vehicles are as a result of the bad design of these locally fabricated seats. It was also of interest to confirm the prone areas that were affected when accidents occurs and to see if there would be a shift in the injury pattern when going through the sled test but there were no changes from what was expected.

There were no much involvement of the hip joint and the mid shaft of the femur. At high speed, the injuries will definitely increase leading to damages at the femur shaft, head and other parts that made contact with the frontal back seat.

The data presented in the tables above prove the success of the sled test technique. It was important to note the peak values occurred mostly at the fourth (4th) and sixth (6th) experiment as the accelerations tend to be with high data with reference to the first (1st) experiment. It was also realised that the experiment three (3rd) and five (5th) produced the lowest data which yielded a lower impact force. This will result to a reduced severity when it comes to injuries that may be incurred by the commercial vehicle occupant. It was also noted that the hip joint accelerated at peak values (Table 4.2) which indicates that there could be structural failure of the pelvis (hips) and the legs. This proves the relationship that exists between the hip and the femur because the relative loading capability of the hip joint transfers load from knee to the femur system. And also the rate at which the knee impacts the obstacle might produce more hip rotational motion.

Figure 4.10 shows a bar chart of the peak (spike) values on the knee joint, head and hip joint in x-direction (forward movement) versus the different seat designs. It was drawn that the experiments 2, 3 and 5, which involved an inclined seat base produced reduced acceleration and also as the seat height is reduced in experiments 2, 3, 4, 5 and 6, the impact accelerations on the dummy decreased on the prone areas as well. This happens to be a good factor to consider when fabricating vehicle seat. The change in seat base angle and seat height tend not to influence the rear impact experiment. The same data were collected for all the three experiments.

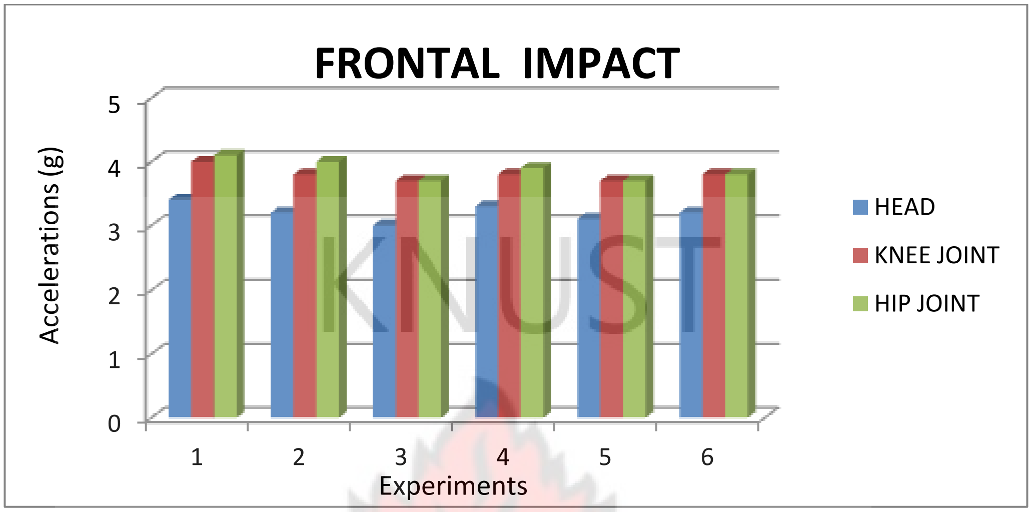

Figure 4-10: Analysis of the peak values for the head, knee joint and hip joint

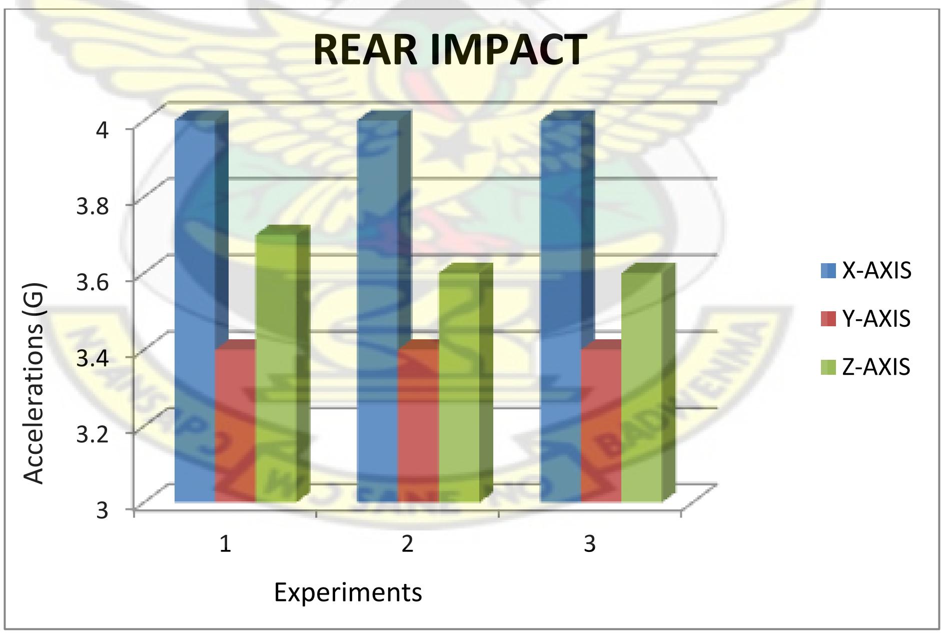

Figure 4-11: Analysis of the peak values for the head motion

Although an infinitesimal change was spotted on the z-axis as the seat height and angle were reduced. Figures 4.10 and 4.11 summarize the experiment.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A series of nine (six frontal and three rear) sled tests were conducted with a constructed dummy to study the acceleration phenomena surrounding the locally fabricated vehicle-seat designs under simulated car crash conditions. The purpose of the study was to determine experimentally the three-dimensional acceleration and the positions of some injury prone areas of the human body during an impact of a vehicle using locally fabricated vehicle seats. The tests were successful in achieving both goals.

The following conclusions can be drawn from the test;

- An inclination of the seat base angle from the horizontal position had high effect on the acceleration produced during impact and also acceleration reduces as the heights of the seats were reduced. This effect was only positive on the frontal impact.
- No changes were observed during the rear test which proves that it's only the back rest angle tilt and the kind of materials used for padding the back rest seat that can pose a change.
- The upper leg and the head injuries, which account for a lot of injuries in accident cases, will occur with the sled impact test conditions used in this study.
- The hip accelerations during the test were influenced by transferred forces from the knee joints during the knee impact. This clearly shows that a rotational

motion was experienced by the femur due to inertia of the upper body (mostly from the truck and head).

From the test series it may conclude that seat base angle 12^o to the horizontal axis and seat leg heights of 34 cm and 40 cm for H_1 and H_2 respectively generated low results comparatively and can be regarded as recommended seat base angle for commercial vehicle seat design It was realised that some accident injuries in commercial buses, especially the head, knee and leg injuries may be due to the vehicle-seat design and construction.

5.2 Recommendations

- The test should be subjected to 13.3 m/s speed to experience the impact forces surrounding the prone areas. This will actually expose the intensity of the injuries sustained by the occupants.
- A real dummy is suggested for this experiment. Though it is expensive but it would give a standard behaviour of the human.
- The frame of the seat in commercial vehicle should be redesigned in real life cases with an introduction of the seat base angle tilted to the horizontal and elastic bands attached to the top and base of the backrest to damper the impact forces experienced on the knee and head.

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APPENDICES

A: Seat angles and different heights used for the experiment.

Experiment 1: The experimental seat positioned at 40cm for H1 and 40cm for H_2

Experiment 2: The experimental seat positioned at 36cm for H_1 and 40cm for H_2

Experiment 3: The experimental seat positioned at 34cm for H_1 and 40cm for H_2

Experiment 4: The experimental seat positioned at 34cm for H_1 and 34cm for H_2

Experiment 5: The experimental seat positioned at 32cm for H_1 and 34cm for H_2

Experiment 6: The experimental seat positioned at 32cm for H_1 and 32cm for H_2

Experiment 7: The experimental seat positioned at 40cm for H_1 and 40cm for H_2

Experiment 8: The sled bed positioned at 36cm for H_1 and 40cm for H_2

Experiment 9: The sled bed positioned at 36cm for H_1 and 36cm for H_2

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B: Dynamic Analysis of Experimental Setup

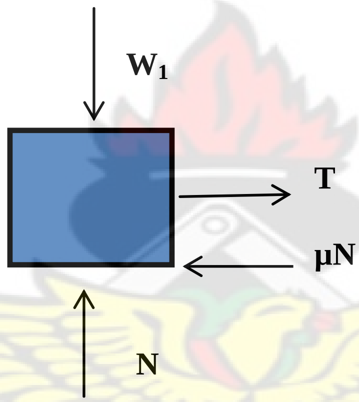
Where W_1 = weight of the sled + weight of the dummy.

W_2 = weight of falling mass.

a_1 and a_2 = acceleration of both masses.

T = tension, force pulling on sled.

μ = coefficient of friction.



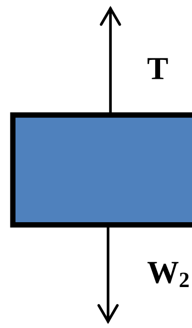
$$\sum F_y = 0$$

$$\therefore N = W$$

$$\oplus \rightarrow \sum F_x = m_1 a_1$$

$$T - \mu N = m_1 a_1$$

$$T - \mu mg = m_1 a_1 \text{.............}(1)$$



$\oplus \downarrow \sum F_y = m_2 a_2$

$W_2 - T = m_2 a_2$...........(2)

Assuming there is no slip on the pulley

Solving equation (1) and (2) simultaneously

$m_2 g - (m_1 a_1 + \mu\, m_1 g) = m_2 a_2$……….. (3)

Assuming that the masses of the pulleys are negligible

$a_1 = a_2 = a$

$m_2 g - \mu m_1 g \ = (m_1 + m_2)a$…………. (4)

Technically acceleration,

$$a = \frac{m_2 g - \mu m_1 g}{m_1 + m_2} \text{……….. (5)}$$

Assuming $\mu \gg$ small

$$a = \frac{m_2 g}{m_1 + m_2} \text{…………. (6)}$$

From this equation the velocity equation,

Where $a = \frac{v-u}{t}$ and $u = 0$

$$v = t\left(\frac{m_2 g}{m_1+m_2}\right) \text{……….} \quad (7)$$

To determine the value of T which is the tension, this will be used to determine the strength of the rope to be used to pull the sled.

From equation (2) $W_2 - T = m_2 a_2$

$$T = m_2 g - m_2\left(\frac{m_2 g}{m_1+m_2}\right) \text{………….} \quad (8)$$

Alternatively if the velocity of impact is known, a more précised equation can be used to determine the acceleration of the sled bed is stated below;

$$v^2 = u^2 + 2as \text{……….} \quad (9)$$

Knowing that the initial velocity (u) equals zero (0)

$$v^2 = 2as \qquad a = \frac{v^2}{2s}$$

Where v equals the final velocity, a is the acceleration and s is the distance travelled.

With knowledge of the amount of force F that the sled bed will produce, the height h for the fallen mass can also be determined as well;

$$mgh = F \times s \text{………..} \quad (10)$$

$$h = \frac{F \times s}{mg} \text{……..} \quad (11)$$

C: Sensors positioning during the experiments

Sensor 1 placed at head

Sensor 2 placed at the knee joint

Sensor 3 placed at the hip joint

D: Values generated by the sensors during the experiment

Experiment 1

KNEE JOINT	HEAD	HIP JOINT
0	0	0
0.96875	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.09375	0.1875
1	0.0625	0.1875
1	0.09375	0.1875
1	0.09375	0.1875
1	0.125	0.1875
1	0.125	0.1875
1	0.09375	0.1875
1	0.09375	0.1875
1	0.09375	0.1875
1.03125	0.09375	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.125	0.21875
1	0.125	0.21875
1	0.09375	0.21875
1	0.0625	0.21875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.0625	0.1875
1	0.0625	0.21875
1	0.0625	0.21875
1.03125	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.1875
1	0.09375	0.1875
1.03125	0.125	0.21875
1	0.09375	0.1875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.21875

Experiment 2

KNEE JOINT	HEAD	HIP JOINT
0	0	0
0.9375	0.03125	0.1875
1	0.03125	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.03125	0.1875
0.9375	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
0.96875	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.03125	0.21875
1	0.03125	0.21875
1	0.03125	0.1875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.21875
0.96875	0.0625	0.1875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875

1	0.09375	0.21875	1	0.0625	0.21875
1	0.0625	0.21875	1	0.03125	0.21875
1	0.0625	0.21875	1	0.0625	0.21875
1	0.0625	0.21875	1	0.0625	0.21875
1	0.09375	0.1875	1	0.0625	0.1875
1	0.09375	0.1875	1	0.0625	0.1875
1	0.09375	0.21875	1	0.0625	0.21875
1	0.125	0.1875	1	0.0625	0.1875
1	0.125	0.21875	1	0.03125	0.21875
1	0.09375	0.21875	1	0.03125	0.21875
1	0.125	0.21875	1	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1	0.0625	0.21875	0.96875	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1	0.0625	0.1875	1	0.03125	0.1875
1	0.0625	0.21875	1	0.03125	0.21875
1	0.0625	0.21875	1	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1	0.09375	0.1875	1	0.0625	0.21875
1.03125	0.125	0.21875	1	0.0625	0.21875
1	0.125	0.21875	1	0.03125	0.21875
1	0.125	0.21875	0.96875	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1.03125	0.09375	0.21875	0.96875	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1.03125	0.0625	0.21875	1	0.0625	0.21875
1	0.09375	0.1875	1	0.0625	0.1875
1	0.09375	0.25	1	0.03125	0.25
1	0.09375	0.25	1	0.0625	0.25
1	0.09375	0.28125	1	0.09375	0.28125
1	0.09375	0.28125	0.96875	0.09375	0.34375
1	0.09375	0.28125	0.96875	0.09375	0.34375
1	0.09375	0.28125	0.96875	0.125	0.40625
1	0.09375	0.28125	0.96875	0.125	0.5
1	0.125	0.28125	0.96875	0.1875	0.53125
1	0.09375	0.28125	0.96875	0.21875	0.59375
1	0.09375	0.28125	0.90625	0.4375	0.6875
1	0.09375	0.28125	0.75	0.5625	0.71875
1.03125	0.09375	0.28125	0.6875	0.8125	0.96875
1	0.09375	0.28125	0.78125	0.96875	1.03125
1	0.09375	0.28125	0.84375	1.0625	1.15625
1.03125	0.09375	0.28125	0.84375	1.125	1.25

1	0.09375	0.28125	0.84375	1.4375	1.21875
1	0.125	0.28125	0.6875	1.6875	1.34375
1	0.125	0.28125	0.75	1.875	1.3125
1	0.125	0.25	0.75	1.84375	1.09375
1	0.09375	0.25	0.71875	1.125	0.96875
1	0.09375	0.25	0.9375	0.71875	1.15625
1.03125	0.0625	0.25	1	0.8125	0.96875
1.03125	0.0625	0.25	0.875	0.46875	0.8125
1	0.0625	0.25	0.90625	0.8125	0.9375
1	0.0625	0.25	0.84375	1.34375	0.625
1	0.0625	0.25	0.84375	0.96875	0.59375
1	0.09375	0.25	0.84375	0.3125	0.625
1	0.09375	0.25	0.875	0.25	0.53125
1	0.125	0.25	0.75	0.125	0.4375
1	0.125	0.25	1	0.125	0.53125
1	0.125	0.25	1.4375	0.875	0.53125
1	0.125	0.25	1.1875	1.15625	-0.03125
1	0.09375	0.25	0.90625	-0.03125	0.28125
1	0.0625	0.28125	0.65625	-0.25	0.625
1.03125	0.0625	0.28125	0.84375	0.4375	0.4375
1	0.09375	0.28125	0.875	0.21875	0.34375
1	0.09375	0.28125	0.96875	0.3125	0.21875
1	0.09375	0.28125	1.125	0.46875	0.375
1	0.125	0.28125	1.09375	0.375	0.4375
1	0.09375	0.28125	1	0.1875	0.4375
1	0.125	0.28125	0.78125	0.15625	0.625
1	0.09375	0.28125	0.84375	0.71875	0.875
1	0.09375	0.28125	1	1.28125	0.5
1	0.09375	0.28125	0.65625	1	0.4375
1	0.09375	0.28125	0.6875	0.53125	0.875
1	0.09375	0.28125	1.15625	0.8125	0.90625
1	0.09375	0.28125	1.09375	0.625	0.625
1.03125	0.125	0.28125	1	0.6875	0.9375
1	0.15625	0.28125	0.6875	0.9375	0.4375
1	0.1875	0.28125	0.59375	0.65625	0.46875
1.03125	0.21875	0.40625	0.71875	0.375	1.03125
1.03125	0.25	0.59375	1.03125	0.96875	0.78125
1.0625	0.3125	0.6875	1.15625	0.8125	0.625
1.09375	0.375	0.125	1.21875	1.0625	0.125
1.0625	0.5625	0.21875	0.96875	0.875	0.21875
1.03125	0.625	0.375	0.71875	0.125	0.34375
1	0.71875	0.28125	0.5	-0.15625	0.28125
1	0.75	-0.21875	0.75	0.125	-0.21875
1	0.8125	-0.3125	1.34375	-0.1875	-0.3125

1	0.90625	0.3125	1.53125	-0.125	0.3125
0.9375	1.1875	0.21875	1.28125	0	0.21875
0.9375	1.34375	0.4375	1.3125	-0.0625	0.4375
1	1.53125	0.59375	0.96875	-0.0625	0.5625
1.0625	1.6875	-0.65625	0.5	0.53125	-0.65625
1.09375	1.8125	0.5625	0.75	-0.5625	0.5625
0.96875	1.78125	0.25	0.65625	-0.25	0.25
0.875	1.40625	-0.25	1.15625	0.375	-0.25
0.9375	1.4375	0.5625	1.21875	-0.5625	0.5625
0.90625	1.375	-0.15625	1.46875	0.40625	-0.15625
1.09375	-0.0625	-0.03125	1.34375	0.34375	-0.03125
0.9375	-0.0625	-0.15625	0.875	0.3125	-0.15625
1.09375	0.625	-0.1875	0.875	0.21875	-0.1875
1.28125	0.59375	0.46875	0.96875	-0.09375	0.46875
1	0.4375	0.15625	0.96875	0.15625	0.15625
0.8125	0.1875	-0.09375	0.96875	0.09375	-0.0625
1.21875	0.65625	-0.03125	0.71875	0.0625	-0.03125
1.25	1.1875	-0.53125	0.71875	0.53125	-0.53125
0.875	0.3125	2.5	-3.125	-3.125	3.90625
0.78125	-0.125	1.875	0.90625	3.1875	3.53125
1	0.4375	-1.125	1.21875	2.15625	-1.125
1.1875	0.46875	0.71875	1.03125	1.90625	0.71875
1.15625	0.625	0.90625	0	-1.375	0.90625
1.0625	0.40625	0.96875	1.09375	-1.65625	0.96875
0.9375	0	1.09375	-0.03125	-1.34375	1.09375
1.1875	0.46875	0.625	0.4375	-1.375	0.625
0.84375	0.4375	1.0625	0.4375	-1.21875	1.03125
0.78125	1.03125	0.28125	0.84375	-1.0625	0.28125
1.0625	1.5	0.375	0.5625	-0.8125	0.375
1.09375	0.90625	0.59375	0.71875	-0.84375	0.59375
1.09375	0.4375	0.53125	0.5	-0.78125	0.53125
1.21875	0.78125	1.875	1.96875	2.375	1.875
0.8125	0.75	-1.71875	-1.625	-0.3125	-1.71875
0.59375	0.53125	-1.15625	3.8125	3.1875	-1.15625
0.78125	0.40625	0.625	1.71875	2.59375	0.59375
1.25	1.0625	-2.5	0.09375	-1.625	-2.65625
1.3125	0.6875	-0.8125	0.125	2.1875	-0.8125
1.1875	1.65625	-2.03125	0.46875	1.125	-2.03125
0.84375	1.8125	-0.875	-0.21875	0.15625	-0.875
0.4375	0.90625	0.15625	0.4375	0.0625	0.15625
0.625	0.65625	-0.0625	2.125	-0.09375	-0.0625
0.90625	0.0625	-2.5	-3.40625	1.5	-2.46875
1.125	0	0.1875	2.34375	-2.59375	0.1875
1.5625	-0.09375	-2.375	0.75	3.03125	-2.375

1.15625	0	-0.6875	0.59375	1.21875	-0.6875
1.0625	-0.21875	-0.125	-0.28125	-0.09375	-0.125
1.1875	-0.03125	-0.59375	-0.15625	0.375	-0.59375
1.03125	0.1875	-0.3125	0.21875	-0.34375	-0.3125
1.1875	-0.375	-0.125	0.4375	-0.1875	-0.125
0.5	-0.4375	1.90625	-3.8125	-0.9375	1.90625
0.40625	0	-1.03125	-3.4375	1.5625	-1.03125
1.21875	0.09375	-0.375	1.6875	0.15625	-0.34375
1.59375	-0.21875	-1.15625	0.59375	-0.90625	-1.15625
1.6875	0	0.0625	-0.59375	-1.5	0.0625
1.125	0.21875	0.03125	-0.28125	-0.90625	0.03125
0.625	0.03125	0.96875	0.3125	-0.84375	0.96875
0.65625	0.25	-0.03125	0.03125	-0.1875	-0.03125
1	0.15625	-0.5	0.5	0.375	-0.5
1.0625	0.21875	4.0625	0.75	0.5	-0.5625
0.75	0.28125	3.59375	0.84375	-0.09375	-0.21875
0.625	0.21875	-0.15625	0.59375	-0.65625	-0.15625
0.375	0.46875	-0.625	-0.40625	-1.875	-0.625
2.0625	2.96875	-0.9375	0.65625	0.21875	-0.9375
1.0625	2.9375	-0.09375	0.9375	1.3125	-0.09375
0.71875	2.46875	-0.65625	0.40625	-0.4375	-0.65625
0.21875	1.84375	-0.3125	-3.625	-1.15625	-0.3125
0.5	1.46875	1.875	1.25	-0.4375	-0.4375
0.46875	-1	2.5	0.15625	-0.03125	-0.65625
0.3125	-1	-0.3125	0.65625	0.21875	-0.3125
0.3125	-1.53125	-0.5	0.78125	0.5625	-0.5
2.9375	1	-0.53125	0.75	0.34375	-0.53125
-0.34375	-0.75	-0.59375	0.90625	0.125	-0.53125
0.75	-0.4375	-0.46875	1.71875	0	-0.46875
3.90625	-0.625	-0.5	0.65625	0	-0.5
2.625	0.375	-0.5625	0.84375	-0.0625	-0.5625
3.65625	0.25	-0.625	0.9375	-0.21875	-0.625
1.09375	0.46875	-0.53125	0.96875	-0.15625	-0.53125
-3.78125	0.59375	-0.5	0.9375	0.0625	-0.5
0.9375	-3.375	0.5	0.96875	0.0625	-0.46875
-0.0625	-3.03125	-0.53125	0.90625	0.09375	-0.53125
1.90625	0.28125	-0.5625	0.96875	0	-0.5625
1.59375	0.25	-0.53125	0.96875	0.03125	-0.53125
0.625	0.1875	-0.5	0.84375	-0.03125	-0.46875
0.75	0.8125	-0.53125	0.84375	-0.0625	-0.53125
1.4375	0.09375	-0.53125	0.90625	-0.09375	-0.53125
-0.03125	-0.875	-0.53125	0.9375	0.03125	-0.53125
1.3125	-0.5	-0.5	0.9375	0.0625	-0.5
1.375	-0.8125	-0.5	0.90625	0.03125	-0.5

1.0625	-0.96875	-0.5	0.875	0	-0.5
0.375	-0.8125	-0.5625	0.90625	-0.03125	-0.53125
0.84375	-0.40625	-0.53125	0.90625	0	-0.53125
0.65625	-1	-0.5	0.90625	0.03125	-0.5
-0.3125	-0.9375	-0.53125	0.9375	0.0625	-0.53125
1.125	-1.03125	-0.5	0.90625	0	-0.5
0.9375	-0.875	-0.53125	0.90625	0	-0.53125
0.875	-1.4375	-0.5	0.90625	0	-0.5
0.9375	-0.75	-0.5	0.90625	0.03125	-0.5
-0.5	-0.375	-0.5	0.90625	0	-0.5
1.59375	-2.5	-0.53125	0.90625	0.03125	-0.53125
0.84375	-2.625	-0.5	0.90625	0	-0.5
2.03125	3.1875	-0.5625	0.90625	0.03125	-0.53125
0.4375	0.96875	-0.53125	0.90625	0	-0.53125
0.53125	0.625	-0.53125	0.90625	0	-0.53125
0.84375	2.09375	-0.53125	0.90625	0	-0.53125
0.59375	-0.1875	-0.53125	0.90625	0	-0.53125
1.0625	-0.5	-0.53125	0.90625	0	-0.53125
2.3125	1.59375	-0.53125	0.90625	0	-0.53125
1.78125	0.75	-0.53125	0.90625	0	-0.53125
1.1875	-0.90625	-0.53125	0.90625	0	-0.53125
0.1875	-2.03125	-0.53125	0.90625	0	-0.5
0.0625	0.59375	-0.53125	0.90625	0	-0.53125
-0.0625	-0.28125	-0.53125	0.90625	0	-0.53125
-1.625	-1.21875	-0.53125	0.90625	0	-0.53125
1.125	0.28125	-0.53125	0.90625	0	-0.53125
0.53125	-0.78125	-0.53125	0.90625	0	-0.53125
0.78125	-0.28125	-0.53125	0.90625	0	-0.53125
0.3125	0.125	-0.5	0.90625	0	-0.53125
1.125	-0.625	-0.53125	0.90625	0	-0.53125
1.46875	-0.0625	-0.53125	0.90625	0	-0.53125
0.71875	0.0625	-0.5	0.90625	0	-0.5
0.84375	0.21875	-0.53125	0.90625	-0.03125	-0.53125
1.03125	-0.25	-0.53125	0.90625	0	-0.53125
1.03125	0	-0.53125	0.90625	0	-0.53125
0.96875	-0.3125	-0.53125	0.90625	0	-0.53125
0.9375	-0.25	-0.53125	0.90625	0	-0.53125
0.875	-0.3125	-0.53125	0.90625	0	-0.53125
0.9375	-0.46875	-0.5	0.90625	0	-0.53125
1	-0.1875	-0.53125	0.90625	0	-0.53125
1	-0.21875	-0.53125	0.90625	0	-0.53125
1	-0.1875	-0.53125	0.90625	0	-0.53125
1	-0.125	-0.53125	0.90625	0	-0.53125
0.96875	-0.28125	-0.53125	0.90625	0	-0.53125

0.96875	-0.25	-0.53125	0.90625	0	-0.53125
0.96875	-0.28125	-0.53125	0.90625	0	-0.53125
0.96875	-0.25	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.1875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.5	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.25	-0.53125	0.90625	0	-0.53125
0.96875	-0.25	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.5	0.90625	0	-0.5
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.25	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.5625	0.90625	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.21875	-0.5625	0.90625	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.25	-0.53125	0.96875	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.21875	-0.53125	0.90625	0	-0.5625
0.96875	-0.21875	-0.5625	0.90625	0	-0.5625
0.96875	-0.25	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125
0.96875	-0.21875	-0.53125	0.90625	0	-0.53125

Experiment 3

KNEE JOINT	HEAD	HIP JOINT
0	0	0
0.90625	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.09375	0.1875
1	0.125	0.1875
1	0.09375	0.1875
1	0.09375	0.1875
1	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
1.03125	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
1	0.09375	0.1875
1	0.09375	0.1875
1	0.09375	0.21875
0.96875	0.09375	0.21875
1	0.09375	0.21875
0.96875	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.1875
0.96875	0.09375	0.1875
1	0.09375	0.21875
0.96875	0.09375	0.1875
1	0.0625	0.21875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.21875

Experiment 4

KNEE JOINT	HEAD	HIP JOINT
0	0	0
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.09375	0.1875
0.96875	0.0625	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.09375	0.21875
0.96875	0.09375	0.1875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
1	0.09375	0.21875

1	0.09375	0.21875	1	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
1	0.09375	0.21875	1	0.0625	0.21875
0.96875	0.09375	0.1875	1	0.09375	0.1875
1	0.09375	0.1875	1	0.09375	0.1875
1	0.09375	0.21875	1	0.09375	0.1875
1	0.09375	0.1875	1	0.09375	0.1875
0.96875	0.09375	0.21875	1	0.09375	0.1875
1	0.09375	0.21875	1	0.09375	0.1875
1	0.09375	0.21875	1	0.09375	0.1875
0.96875	0.09375	0.21875	1	0.09375	0.21875
0.96875	0.09375	0.21875	1	0.09375	0.21875
1	0.09375	0.21875	1	0.09375	0.21875
1	0.09375	0.21875	1	0.09375	0.21875
1	0.09375	0.1875	1	0.09375	0.1875
1	0.09375	0.1875	1	0.09375	0.21875
1	0.09375	0.1875	1	0.09375	0.21875
0.96875	0.09375	0.1875	1	0.09375	0.21875
1	0.09375	0.1875	1	0.09375	0.21875
1	0.09375	0.1875	1	0.09375	0.1875
1	0.09375	0.21875	1.03125	0.125	0.21875
1	0.09375	0.21875	1	0.125	0.21875
1	0.09375	0.21875	1	0.125	0.21875
1	0.09375	0.21875	1	0.09375	0.21875
1	0.09375	0.21875	1.03125	0.09375	0.21875
1	0.09375	0.21875	1	0.09375	0.21875
1	0.0625	0.21875	1.03125	0.0625	0.21875
1	0.09375	0.1875	1	0.09375	0.1875
0.96875	0.09375	0.25	1	0.09375	0.21875
1	0.09375	0.25	1	0.09375	0.25
1	0.09375	0.25	1	0.09375	0.28125
1	0.09375	0.25	1	0.09375	0.3125
0.96875	0.09375	0.25	1	0.09375	0.3125
1	0.09375	0.25	1	0.09375	0.3125
1	0.09375	0.25	1	0.09375	0.3125
1	0.09375	0.25	1	0.125	0.3125
0.96875	0.09375	0.25	1	0.09375	0.3125
1	0.09375	0.25	1	0.09375	0.3125
1.03125	0.09375	0.25	1	0.09375	0.3125
1	0.09375	0.25	1.03125	0.09375	0.3125
1.0625	0.125	0.34375	1	0.09375	0.3125
1	0.125	0.34375	1	0.09375	0.3125
0.84375	0.125	0.34375	1.03125	0.09375	0.28125

0.75	0.125	0.34375	1	0.09375	0.28125
0.59375	0.125	0.34375	1	0.125	0.28125
0.5625	0.125	0.40625	1	0.125	0.28125
0.59375	0.125	0.46875	1	0.125	0.28125
0.65625	0.125	0.96875	1	0.09375	0.28125
0.75	0.125	1.15625	1	0.09375	0.28125
0.78125	0.125	0.96875	1.03125	0.0625	0.28125
0.71875	0.125	0.8125	1.03125	0.0625	0.28125
0.75	0.125	0.9375	1	0.0625	0.28125
0.6875	0.125	0.625	1	0.0625	0.28125
0.8125	0.125	0.59375	1	0.0625	0.28125
1.03125	0.09375	0.625	1	0.09375	0.28125
1.0625	0.09375	0.53125	1	0.09375	0.25
0.96875	0.09375	0.4375	1	0.125	0.25
1.03125	0.09375	0.53125	1	0.125	0.25
0.84375	0.09375	0.53125	1	0.125	0.25
0.71875	0.09375	-0.03125	1	0.125	0.25
0.59375	0.09375	0.28125	1	0.09375	0.25
0.75	0.09375	0.625	1	0.0625	0.25
1.3125	0.09375	0.4375	1.03125	0.0625	0.25
1.5625	0.125	0.34375	1	0.09375	0.3125
0.84375	0.09375	0.21875	1	0.09375	0.3125
0.25	0.09375	0.375	1	0.09375	0.28125
0.46875	0.09375	0.4375	1	0.125	0.28125
1.0625	0.09375	0.4375	1	0.09375	0.28125
1.21875	0.09375	0.625	1	0.125	0.28125
1.1875	0.09375	0.875	1	0.09375	0.28125
0.90625	0.09375	0.5	1	0.09375	0.375
0.875	0.09375	0.4375	1	0.09375	0.375
1	0.09375	0.875	1	0.09375	0.625
0.5625	0.09375	0.90625	1	0.09375	0.90625
1.03125	0.09375	0.625	1	0.09375	0.65625
0.96875	0.09375	0.9375	1.03125	0.125	0.9375
0.75	0.09375	0.4375	1	0.15625	0.4375
0.65625	0.09375	0.46875	1	0.1875	0.5
1.15625	0.09375	1.03125	1.03125	0.21875	1.03125
1.21875	0.09375	0.78125	1.03125	0.25	0.8125
0.9375	0.09375	0.625	1.0625	0.28125	0.625
0.375	0.09375	0.125	1.09375	0.34375	0.125
0.40625	0.09375	0.21875	1.0625	0.53125	0.21875
1	0.125	0.34375	1.03125	0.59375	0.375
1.375	0.15625	0.28125	1	0.71875	0.25
0.96875	0.15625	-0.21875	1	0.75	-0.21875

0.90625	0.15625	-0.3125	1	0.8125	-0.3125
0.75	0.15625	0.3125	1	0.96875	0.3125
0.6875	0.15625	0.21875	0.96875	1.1875	0.25
0.78125	0.15625	0.4375	0.9375	1.34375	0.4375
0.84375	0.15625	0.5625	1	1.59375	0.59375
0.84375	0.125	-0.65625	1.0625	1.6875	-0.65625
0.84375	0.15625	0.5625	1.09375	1.8125	0.5625
0.6875	0.1875	0.25	0.96875	1.78125	0.25
0.75	0.21875	-0.25	0.9375	1.46875	-0.25
0.75	0.28125	0.5625	0.9375	1.4375	0.5
0.71875	0.4375	-0.15625	0.90625	1.375	-0.15625
0.9375	0.71875	-0.03125	1.09375	-0.0625	-0.03125
1	0.84375	-0.15625	0.9375	-0.0625	-0.15625
0.875	0.9375	-0.1875	1.09375	0.6875	-0.1875
0.90625	0.90625	0.46875	1.3125	0.59375	0.46875
0.84375	0.96875	0.15625	1	0.4375	0.15625
0.84375	1.375	-0.0625	0.8125	0.25	-0.09375
0.84375	1.5625	-0.03125	1.21875	0.65625	-0.03125
0.875	1.5625	-0.53125	1.25	1.1875	-0.53125
0.75	1.6875	3.6875	0.90625	0.25	1.875
1	1.78125	3.4375	0.78125	-0.125	2.34375
1.4375	1.6875	-1.0625	1	0.4375	-1.125
1.1875	0.84375	0.71875	1.1875	0.46875	0.71875
0.90625	0.78125	0.6875	1.15625	0.6875	0.84375
0.65625	0.9375	0.9375	1.125	0.40625	0.96875
0.84375	0.90625	1	0.9375	0	1.09375
0.875	0.46875	0.625	1.1875	0.46875	0.625
0.96875	0.4375	1.125	0.90625	0.4375	1.0625
1.125	0.625	0.28125	0.78125	1.09375	0.28125
1.09375	0.6875	0.375	1.0625	1.5	0.34375
1	0.90625	0.625	1.09375	0.90625	0.59375
0.78125	1.15625	0.53125	1.09375	0.4375	0.53125
0.84375	0.8125	1.84375	1.25	0.75	1.875
1	-0.125	-1.71875	0.8125	0.75	-1.71875
0.65625	-0.125	-1.15625	0.59375	0.53125	-1.15625
0.6875	0.40625	0.40625	0.78125	0.40625	0.625
1.15625	0.4375	-2.65625	1.25	1.0625	-2.5
1.09375	1.09375	-0.8125	1.3125	0.625	-0.75
1	0.78125	-2.03125	1.1875	1.65625	-2.03125
0.6875	0.15625	-0.8125	0.84375	1.78125	-0.875
0.59375	0.1875	0.15625	0.4375	0.90625	0.25
0.71875	0.59375	-0.0625	0.84375	0.65625	-0.0625
1.03125	1.21875	-2.125	0.90625	0.0625	-2.5

1.15625	1.6875	0.1875	1.125	0	0.1875
1.21875	1.5625	-2.375	1.5625	-0.09375	-2.3125
0.96875	-0.28125	-0.75	1.15625	0	-0.6875
0.71875	0.28125	-0.125	1.0625	-0.21875	-0.1875
0.5	1.5	-0.59375	1.1875	-0.03125	-0.59375
0.75	1.65625	-0.3125	0.9375	0.1875	-0.3125
1.34375	0.71875	-0.1875	1.1875	-0.375	-0.125
1.53125	0.0625	1.90625	0.5	-0.6875	1.90625
1.28125	0.46875	-1.03125	0.40625	0	-1.03125
1.3125	1.46875	-0.34375	1.21875	0.09375	-0.375
0.96875	1.90625	-1.09375	1.59375	-0.21875	-1.21875
0.5	2.9375	0.0625	1.6875	0	0.0625
0.75	2.46875	0.03125	1.625	0.21875	3.875
0.65625	1.84375	0.96875	0.625	0.03125	0.96875
1.15625	1.46875	-0.03125	0.65625	0.28125	3.46875
1.21875	-1	-0.5	1	0.15625	-0.5
1.46875	-1	-0.625	1.0625	0.21875	-0.6875
1.34375	-1.53125	-0.21875	0.8125	0.28125	-0.21875
0.875	1	-0.15625	0.625	0.21875	-0.15625
0.875	-0.75	-0.6875	0.375	0.46875	-0.625
0.96875	-0.4375	-0.9375	2.0625	3.09375	-0.875
0.96875	-0.625	-0.09375	1.0625	2.9375	-0.09375
0.96875	0.375	-0.78125	0.71875	2.46875	-0.65625
0.71875	0.25	-0.3125	0.1875	1.84375	-0.3125
0.71875	0.46875	-0.4375	0.5	1.46875	-0.4375
-3.125	0.59375	-0.8125	0.46875	-1	-0.65625
0.90625	-1	-0.3125	0.28125	-1	-0.34375
1.21875	-0.5625	-0.5	0.3125	-1.46875	-0.5
1.03125	-0.5	-0.53125	2.9375	1	-0.53125
0	1	-0.625	-0.34375	-0.75	-0.59375
1.09375	2.25	-0.46875	0.75	-0.4375	-0.46875
-0.03125	-1.75	-0.5	3.84375	-0.625	-0.5625
0.4375	-0.46875	-0.5	2.625	0.3125	-0.5625
0.4375	-0.5625	-0.625	3.5625	0.25	-0.625
0.84375	0.25	-0.53125	1.09375	0.46875	-0.53125
0.5625	0.375	-0.5	-3.71875	0.59375	-0.5
0.71875	-3	-0.46875	0.9375	-3.3125	-0.5625
0.5	-1	-0.53125	-0.0625	-3.03125	-0.53125
1.96875	-0.9375	-0.5625	1.90625	0.28125	-0.5625
-1.625	-1.03125	-0.53125	1.59375	0.25	-0.53125
3.53125	-0.875	-0.46875	0.625	0.15625	-0.5
1.71875	-1.4375	-0.53125	0.75	0.8125	-0.53125
0.09375	-0.75	-0.53125	1.4375	0.09375	-0.5

0.125	-0.375	-0.53125	-0.03125	-0.875	-0.53125
0.46875	-2.5	-0.53125	1.3125	-0.5	-0.5
-0.21875	-2.625	-0.53125	1.375	-0.8125	-0.5
0.4375	1.875	-0.53125	0.9375	-1.03125	-0.5
2.125	0.96875	-0.53125	0.375	-0.8125	-0.5625
-3.46875	0.625	-0.53125	0.84375	-0.40625	-0.53125
2.34375	2.09375	-0.53125	0.65625	-1	-0.5
0.75	-0.1875	-0.53125	-0.3125	-0.875	-0.53125
0.59375	-0.5	-0.5	1.09375	-1.03125	-0.5
-0.28125	1.59375	-0.53125	0.9375	-0.875	-0.53125
-0.15625	0.75	-0.5	0.875	-1.4375	-0.5
0.21875	-0.90625	-0.5	0.9375	-0.75	-0.5
0.4375	-2.03125	-0.5	-0.5	-0.375	-0.46875
-3.65625	-0.875	-0.53125	1.375	-2.4375	-0.53125
-3.3125	-0.5	-0.5	0.84375	-2.625	-0.5
1.6875	-0.8125	-0.53125	2.03125	3.125	-0.5625
0.59375	-0.96875	-0.53125	0.4375	0.96875	-0.53125
-0.59375	-0.8125	-0.53125	0.53125	0.625	-0.53125
-0.28125	-0.40625	-0.53125	0.84375	2.09375	-0.53125
0.3125	0.59375	-0.53125	0.59375	-0.1875	-0.53125
0.03125	-0.28125	-0.53125	1.125	-0.5	-0.53125
0.5	-1.21875	-0.53125	2.3125	1.5625	-0.53125
0.75	0.28125	-0.53125	1.78125	0.75	-0.53125
0.84375	-0.78125	-0.53125	1.1875	-0.90625	-0.53125
0.59375	-0.28125	-0.5	0.1875	-1.96875	-0.53125
-0.40625	0.125	-0.53125	0.09375	0.59375	-0.53125
0.65625	-0.625	-0.53125	-0.0625	-0.28125	-0.5
0.9375	-0.0625	-0.53125	-1.8125	-1.15625	-0.5
0.40625	0.0625	-0.53125	1.125	0.28125	-0.53125
-3.59375	0.21875	-0.53125	0.53125	-0.71875	-0.53125
1.25	-0.25	-0.53125	0.78125	-0.28125	-0.53125
0.15625	0	-0.53125	0.3125	0.125	-0.5
0.65625	-0.3125	-0.53125	1.125	-0.5625	-0.53125
0.78125	-0.25	-0.53125	1.46875	-0.0625	-0.53125
0.75	-0.3125	-0.5	0.78125	0.0625	-0.5
0.90625	-0.46875	-0.5	0.84375	0.21875	-0.53125
1.71875	-0.1875	-0.5	1.03125	-0.25	-0.53125
0.65625	-0.21875	-0.5	1.03125	0	-0.53125
0.84375	-0.1875	-0.5	0.96875	-0.3125	-0.53125
0.9375	-0.125	-0.5	0.9375	-0.25	-0.53125
0.96875	-0.28125	-0.5	0.90625	-0.3125	-0.53125
0.9375	-0.25	-0.5	0.9375	-0.4375	-0.5
0.96875	-0.28125	-0.53125	1	-0.1875	-0.53125

0.90625	-0.25	-0.53125	1	-0.21875	-0.53125
0.96875	-0.21875	-0.53125	1	-0.1875	-0.53125
0.96875	-0.1875	-0.53125	1	-0.15625	-0.53125
0.84375	-0.1875	-0.53125	0.96875	-0.28125	-0.53125
0.84375	-0.1875	-0.53125	0.96875	-0.25	-0.53125
0.90625	-0.1875	-0.53125	0.96875	-0.28125	-0.53125
0.9375	-0.1875	-0.53125	0.96875	-0.25	-0.53125
0.9375	-0.1875	-0.53125	0.96875	-0.21875	-0.53125
0.90625	-0.25	-0.53125	1	-0.1875	-0.53125
0.875	-0.25	-0.53125	0.96875	-0.21875	-0.53125
0.90625	-0.21875	-0.53125	0.96875	-0.21875	-0.53125
0.90625	-0.21875	-0.53125	0.96875	-0.21875	-0.53125
0.90625	-0.21875	-0.53125	1	-0.1875	-0.5
0.9375	-0.21875	-0.53125	0.96875	-0.21875	-0.53125
0.90625	-0.21875	-0.53125	0.96875	-0.25	-0.53125
0.90625	-0.21875	-0.53125	0.96875	-0.25	-0.53125
0.875	-0.21875	-0.53125	0.96875	-0.21875	-0.53125
0.90625	-0.21875	-0.5	0.96875	-0.21875	-0.5
0.90625	-0.25	-0.53125	0.96875	-0.1875	-0.53125
0.875	-0.21875	-0.53125	0.96875	-0.1875	-0.53125
0.90625	-0.21875	-0.53125	0.96875	-0.1875	-0.53125
0.90625	-0.21875	-0.53125	0.96875	-0.1875	-0.53125
0.875	-0.21875	-0.53125	0.96875	-0.1875	-0.53125
0.90625	-0.21875	-0.53125	0.96875	-0.1875	-0.53125
0.90625	-0.1875	-0.53125	0.96875	-0.1875	-0.53125
0.875	-0.1875	-0.5625	0.96875	-0.1875	-0.5625
0.875	-0.1875	-0.5625	0.96875	-0.1875	-0.53125
0.875	-0.1875	-0.5625	0.96875	-0.1875	-0.53125
0.90625	-0.1875	-0.5625	0.96875	-0.1875	-0.5625
0.875	-0.1875	-0.53125	0.96875	-0.1875	-0.53125
0.875	-0.1875	-0.53125	0.96875	-0.1875	-0.53125
0.875	-0.1875	-0.53125	0.96875	-0.21875	-0.53125
0.875	-0.1875	-0.53125	0.96875	-0.25	-0.5
0.875	-0.1875	-0.53125	0.96875	-0.21875	-0.53125
0.875	-0.1875	-0.53125	0.96875	-0.21875	-0.53125
0.875	-0.1875	-0.53125	0.96875	-0.21875	-0.53125
0.875	-0.1875	-0.5625	0.96875	-0.21875	-0.5625
0.875	-0.1875	-0.53125	0.96875	-0.1875	-0.53125
0.875	-0.1875	-0.53125	0.96875	-0.21875	-0.53125
0.875	-0.1875	-0.53125	0.96875	-0.21875	-0.53125

xperiment 5

KNEE JOINT	HEAD	HIP JOINT
0	0	0
0.9375	0.0625	0.1875
0.9375	0.0625	0.1875
0.9375	0.0625	0.1875
0.9375	0.0625	0.1875
0.9375	0.0625	0.1875
0.9375	0.03125	0.1875
0.9375	0.03125	0.1875
0.96875	0.03125	0.1875
0.96875	0.03125	0.1875
0.96875	0.03125	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
1	0.0625	0.15625
0.9375	0.0625	0.15625
1	0.0625	0.15625
1	0.0625	0.15625
0.96875	0.0625	0.15625
1	0.0625	0.15625
1	0.03125	0.15625
1	0.03125	0.15625
1	0.03125	0.15625
1	0.0625	0.15625
1	0.0625	0.15625
1	0.03125	0.15625
1	0.0625	0.15625
1	0.0625	0.1875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875

Experiment 6

KNEE JOINT	HEAD	HIP JOINT
0	0	0
0.9375	0.09375	0.15625
0.96875	0.09375	0.15625
0.96875	0.09375	0.15625
0.96875	0.125	0.15625
0.9375	0.125	0.15625
0.96875	0.125	0.15625
0.96875	0.125	0.15625
0.96875	0.125	0.15625
0.96875	0.125	0.15625
0.9375	0.125	0.15625
0.96875	0.125	0.15625
0.96875	0.125	0.15625
0.96875	0.125	0.15625
0.96875	0.125	0.1875
1	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.125	0.1875
0.96875	0.09375	0.1875
0.96875	0.0625	0.1875
0.9375	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.21875
0.96875	0.0625	0.21875
0.96875	0.0625	0.21875
0.96875	0.0625	0.21875
0.96875	0.0625	0.21875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
1	0.0625	0.21875
0.96875	0.09375	0.1875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875
0.96875	0.09375	0.21875

0.96875	0.0625	0.1875
0.96875	0.09375	0.1875
0.96875	0.0625	0.1875
0.96875	0.09375	0.1875
0.96875	0.0625	0.1875
1	0.0625	0.1875
1	0.09375	0.21875
1	0.0625	0.1875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
0.96875	0.0625	0.21875
0.96875	0.0625	0.21875
0.96875	0.09375	0.1875
0.96875	0.09375	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.0625	0.1875
0.96875	0.09375	0.1875
0.96875	0.0625	0.1875
1	0.09375	0.1875
1	0.0625	0.21875
1	0.0625	0.1875
1	0.0625	0.25
1	0.0625	0.25
1	0.09375	0.28125
0.96875	0.09375	0.34375
0.96875	0.09375	0.375
0.96875	0.125	0.40625
0.96875	0.125	0.5
0.96875	0.1875	0.53125
0.96875	0.21875	0.65625
0.90625	0.40625	0.6875
0.75	0.5625	0.71875
0.6875	0.8125	0.96875
0.78125	0.96875	1.0625
0.84375	1.0625	1.15625
0.84375	1.1875	1.25
0.84375	1.4375	1.21875

1	0.09375	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.0625	0.21875
1	0.09375	0.1875
1	0.09375	0.1875
1	0.09375	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.09375	0.21875
1	0.09375	0.21875
1	0.09375	0.21875
0.96875	0.09375	0.21875
1	0.0625	0.1875
1	0.0625	0.1875
1	0.0625	0.1875
0.96875	0.125	0.1875
1	0.09375	0.1875
1	0.09375	0.1875
1.03125	0.125	0.21875
1	0.125	0.21875
1	0.125	0.21875
1	0.09375	0.21875
1.03125	0.09375	0.21875
1	0.125	0.21875
1.03125	0.0625	0.21875
1	0.09375	0.1875
1	0.09375	0.21875
0.96875	0.09375	0.25
1	0.09375	0.28125
1	0.09375	0.28125
1	0.09375	0.25
1	0.09375	0.25
1	0.09375	0.25
1	0.125	0.25
1	0.09375	0.25
0.96875	0.125	0.25
1	0.09375	0.25
1.03125	0.09375	0.25
1	0.09375	0.25
1	0.125	0.25
1.03125	0.09375	0.25
1	0.09375	0.28125

0.6875	1.6875	1.34375	1	0.125	0.25
0.75	1.875	1.21875	0.96875	0.125	0.25
0.75	1.84375	1.09375	1	0.125	0.28125
0.71875	1	0.96875	1	0.09375	0.28125
0.9375	0.71875	1.15625	1	0.09375	0.28125
1	0.8125	0.96875	1.03125	0.0625	0.28125
0.875	0.46875	0.8125	1.03125	0.0625	0.25
0.90625	0.8125	0.78125	1	0.0625	0.21875
0.84375	1.5	0.625	1	0.0625	0.25
0.84375	0.96875	0.59375	1	0.0625	0.25
0.84375	0.3125	0.625	1	0.09375	0.21875
0.875	0.25	0.53125	1	0.09375	0.25
0.75	0.125	0.4375	1.03125	0.125	0.28125
1	0.125	0.5	1	0.125	0.28125
1.5	0.9375	0.53125	1	0.125	0.28125
1.1875	1.15625	-0.03125	1	0.125	0.28125
0.90625	-0.03125	0.28125	1	0.09375	0.28125
0.65625	-0.25	0.625	1	0.0625	0.25
0.84375	0.5	0.5	1.03125	0.0625	0.4375
0.8125	0.21875	0.34375	1	0.09375	0.34375
0.96875	0.3125	0.21875	1.03125	0.09375	0.21875
1.125	0.46875	0.375	1	0.09375	0.375
1.09375	0.34375	0.4375	1	0.125	0.59375
1	0.1875	0.4375	1	0.09375	0.4375
0.78125	0.15625	0.65625	1	0.125	0.6875
0.84375	0.71875	0.875	1	0.09375	0.875
1.03125	1.375	0.5	1	0.09375	0.5
0.65625	1	0.4375	1	0.09375	0.375
0.6875	0.53125	0.625	1	0.09375	0.875
1.15625	0.8125	0.90625	1	0.09375	0.90625
1.09375	0.625	0.625	1	0.09375	0.65625
1.03125	0.75	0.9375	1.03125	0.125	1.09375
0.6875	0.9375	0.4375	1	0.15625	0.4375
0.59375	0.65625	0.625	1	0.1875	0.5
0.71875	0.375	1.03125	1.03125	0.21875	1.03125
1.03125	1	0.78125	1.03125	0.25	0.8125
1.15625	0.8125	0.5	1.0625	0.28125	0.625
1.125	1.125	0.125	1.09375	0.4375	0.125
0.96875	0.875	0.21875	1.0625	0.53125	0.21875
0.71875	0.125	0.34375	1.03125	0.65625	0.46875
0.5	-0.15625	0.21875	1	0.71875	0.25
0.75	0.1875	-0.21875	1	0.75	-0.21875
1.25	-0.1875	-0.3125	1	0.8125	-0.3125
1.53125	-0.125	0.375	0.96875	0.96875	0.3125
1.28125	0	0.21875	0.96875	1.25	0.25

1.3125	-0.125	0.4375	0.9375	1.34375	0.4375
0.96875	-0.0625	0.5625	1	1.59375	0.65625
0.5	0.53125	-0.65625	1.0625	1.6875	-0.65625
0.8125	-0.5625	0.5	1.09375	1.8125	0.5625
0.65625	-0.3125	0.25	0.96875	1.78125	0.25
1.15625	0.375	-0.25	0.9375	1.46875	-0.25
1.21875	-0.5625	0.5625	0.9375	1.40625	0.5
1.46875	0.40625	-0.15625	0.90625	1.375	-0.15625
1.25	0.40625	-0.03125	1.03125	-0.0625	-0.03125
0.875	0.3125	-0.15625	1.03125	-0.0625	-0.15625
0.875	0.21875	-0.5625	1.09375	0.6875	-0.1875
0.96875	-0.09375	0.46875	1.3125	0.59375	0.46875
0.96875	0.15625	0.15625	1	0.4375	0.15625
0.96875	0.125	-0.0625	0.8125	0.25	-0.09375
0.8125	0.0625	-0.03125	1.21875	0.78125	-0.03125
0.71875	0.53125	-0.53125	1.25	1.1875	-0.53125
-3.0625	-3.03125	3.71875	0.90625	0.25	2.1875
0.90625	2.875	3.4375	0.78125	-0.125	1.9375
1.21875	2.15625	-1.125	1	0.4375	-1.4375
1.03125	1.90625	0.71875	1.1875	0.46875	0.71875
0	-1.375	0.90625	1.15625	0.9375	0.84375
1.09375	-1.65625	0.96875	1.125	0.40625	0.96875
-0.03125	-1.34375	1.09375	0.9375	0	1.4375
0.4375	-1.375	0.65625	1.1875	0.46875	0.625
0.4375	-1.21875	1.03125	0.90625	0.4375	1.0625
0.84375	-1.25	0.28125	0.78125	1.09375	0.28125
0.5625	-0.8125	0.375	1.0625	1.5	0.34375
0.71875	-0.84375	0.59375	1.09375	0.9375	0.59375
0.5	-0.78125	0.3125	1.1875	0.4375	0.53125
1.96875	2.375	1.875	1.25	0.75	1.71875
-1.625	-0.3125	-1.71875	0.8125	0.75	-1.71875
3.6875	3.03125	-1.15625	0.59375	0.53125	-1.15625
1.71875	2.59375	1	0.78125	0.40625	0.625
0.09375	-1.625	-2.65625	1.25	1.0625	-2.5
0.125	2.1875	-0.8125	1.3125	0.9375	-0.75
0.46875	1.125	-2.03125	1.1875	1.65625	-2.03125
-0.21875	0.25	-0.875	0.84375	1.78125	-0.9375
0.4375	0.0625	0.25	0.4375	0.90625	0.25
2.125	-0.09375	-0.0625	0.625	0.5625	-0.0625
-3.34375	1.5625	-2.46875	0.90625	0.0625	-2.3125
2.34375	-2.59375	0.1875	1.125	0	0.1875
0.75	3.0625	-2.375	1.5625	-0.09375	-2.3125
0.59375	1.21875	-0.78125	1.15625	0	-0.6875
-0.28125	-0.09375	-0.125	1.0625	-0.21875	-0.1875
-0.15625	0.46875	-0.59375	1.1875	-0.03125	-0.78125

0.21875	-0.34375	-0.3125	0.9375	0.1875	-0.3125
0.4375	-0.1875	-0.125	1.1875	-0.375	-0.125
-3.6875	-0.9375	2.03125	0.5	-0.9375	1.71875
-3.3125	1.5625	-1.03125	0.625	0	-1.03125
1.6875	0.15625	-0.34375	1.21875	0.09375	-0.375
0.59375	-1.25	-1.15625	1.59375	-0.21875	-1.21875
-0.59375	-1.5	0.25	1.6875	0	0.0625
-0.28125	-0.90625	0.03125	1.625	0.21875	3.8125
0.3125	-0.84375	0.96875	0.625	0.03125	3.21875
0.09375	-0.1875	-0.03125	0.65625	0.28125	-0.03125
0.5	0.375	-0.5	1	0.15625	-0.5
0.75	0.6875	-0.375	1.0625	0.21875	-0.6875
0.84375	-0.09375	-0.21875	0.90625	0.28125	-0.21875
0.59375	-0.65625	-0.15625	0.625	0.21875	-0.15625
-0.46875	-1.875	-0.625	0.375	0.46875	-0.625
0.65625	0.21875	-0.9375	2.0625	3.03125	-0.9375
0.9375	1.3125	-0.125	1.0625	2.9375	-0.09375
0.40625	-0.5	-0.65625	0.71875	2.46875	-0.65625
-3.53125	-1.15625	-0.3125	0.25	1.875	-0.3125
1.25	-0.4375	-0.4375	0.5	1.46875	-0.4375
0.15625	-0.03125	-0.65625	0.46875	-1	-0.65625
0.65625	0.21875	-0.3125	0.28125	-1	-0.34375
0.78125	0.625	-0.46875	0.3125	-1.46875	-0.5
0.75	0.34375	-0.53125	2.875	1	-0.59375
0.90625	0.125	-0.53125	-0.34375	-0.75	-0.59375
1.71875	0	-0.46875	0.75	-0.40625	-0.46875
0.65625	0	-0.5	3.75	-0.625	-0.5625
0.84375	-0.0625	-0.5625	2.625	0.3125	-0.5625
0.9375	-0.21875	-0.625	3.4375	0.25	-0.65625
1.03125	-0.1875	-0.53125	1.09375	0.46875	-0.53125
0.9375	0.0625	-0.53125	-3.75	0.59375	-0.5
0.96875	0.0625	-0.46875	0.9375	-3.21875	-0.5625
0.90625	0.09375	-0.53125	-0.0625	-2.8125	-0.53125
0.9375	0	-0.5625	1.90625	0.28125	-0.5625
0.96875	0.03125	-0.53125	1.59375	0.25	-0.53125
0.84375	-0.03125	-0.46875	0.625	0.15625	-0.5
0.84375	-0.09375	-0.53125	0.75	0.8125	-0.53125
0.90625	-0.09375	-0.53125	1.4375	0.09375	-0.5
0.875	0.03125	-0.53125	-0.03125	-0.875	-0.53125
0.9375	0.0625	-0.5	1.3125	-0.5	-0.5
0.90625	0.03125	-0.53125	1.5	-0.8125	-0.5
0.875	0	-0.5	0.9375	-1.03125	-0.5
0.90625	-0.0625	-0.53125	0.375	-0.8125	-0.5625
0.875	0	-0.53125	0.84375	-0.5625	-0.53125
0.90625	0.03125	-0.5	0.65625	-1	-0.5

0.9375	0.0625	-0.53125
0.90625	0	-0.5
0.90625	0	-0.4375
0.90625	0.03125	-0.5
0.875	0.03125	-0.5
0.90625	0.03125	-0.5
0.90625	0.03125	-0.53125
0.90625	0.03125	-0.5
0.90625	0.03125	-0.5625
0.90625	0	-0.53125
0.875	0	-0.53125
0.875	0	-0.53125
0.875	0	-0.53125
0.875	0	-0.53125
0.875	0.03125	-0.53125
0.875	0.03125	-0.53125
0.875	0.03125	-0.5
0.875	0.03125	-0.5
0.875	0.03125	-0.53125
0.875	0.03125	-0.53125
0.875	0	-0.53125
0.90625	0	-0.53125
0.90625	0	-0.53125
0.90625	0.03125	-0.53125
0.90625	0.03125	-0.53125
0.90625	0.03125	-0.53125
0.90625	0.03125	-0.53125
0.90625	0.03125	-0.5
0.90625	-0.03125	-0.5
0.90625	0	-0.53125
0.90625	0	-0.53125
0.90625	0.03125	-0.53125
0.90625	0	-0.53125
0.90625	0.03125	-0.53125
0.90625	0	-0.53125
0.90625	0	-0.53125
0.90625	0.03125	-0.53125
0.90625	0	-0.53125
0.875	0	-0.53125
0.875	0.03125	-0.53125
0.875	0	-0.53125
0.875	0.03125	-0.53125
0.875	0	-0.5
0.875	0.03125	-0.5
0.875	0	-0.5

-0.3125	-0.875	-0.53125
1.09375	-1.03125	-0.53125
0.9375	-0.875	-0.53125
0.90625	-1.5625	-0.53125
0.9375	-0.75	-0.53125
-0.5	-0.375	-0.53125
1.375	-2.4375	-0.53125
0.9375	-2.625	-0.5
2.03125	3.0625	-0.5625
0.4375	0.96875	-0.53125
0.53125	0.625	-0.53125
0.84375	2.09375	-0.53125
0.59375	-0.1875	-0.53125
1.125	-0.5	-0.53125
2.3125	1.5625	-0.53125
1.78125	0.75	-0.53125
1.1875	-0.90625	-0.53125
0.3125	-1.96875	-0.53125
0.09375	0.71875	-0.53125
-0.0625	-0.28125	-0.5
-1.71875	-1.15625	-0.5
1.125	0.28125	-0.53125
0.53125	-0.71875	-0.53125
0.78125	-0.28125	-0.53125
0.3125	0.125	-0.5
1.125	-0.5625	-0.53125
1.46875	-0.0625	-0.53125
0.78125	0.0625	-0.5
0.84375	0.21875	-0.5
0.9375	-0.25	-0.5
1.03125	0	-0.5
0.96875	-0.3125	-0.5
0.9375	-0.25	-0.5
0.90625	-0.375	-0.5
0.9375	-0.4375	-0.5
0.96875	-0.1875	-0.53125
1	-0.21875	-0.53125
1	-0.1875	-0.53125
1	-0.15625	-0.53125
0.96875	-0.28125	-0.53125
0.96875	-0.25	-0.53125
0.96875	-0.28125	-0.53125
0.96875	-0.25	-0.53125
0.96875	-0.21875	-0.5
1	-0.1875	-0.5

0.90625	0	-0.5	0.96875	-0.21875	-0.5
0.90625	0	-0.5	0.96875	-0.1875	-0.5
0.90625	0.03125	-0.5	0.96875	-0.21875	-0.5
0.90625	0	-0.5	1	-0.1875	-0.5
0.90625	0	-0.5	0.9375	-0.21875	-0.5
0.90625	0.03125	-0.5	0.9375	-0.25	-0.5
0.90625	0	-0.5	0.9375	-0.25	-0.5
0.90625	0	-0.5	0.9375	-0.21875	-0.5
0.90625	0.03125	-0.5	0.9375	-0.1875	-0.5
0.90625	0	-0.53125	0.9375	-0.1875	-0.53125
0.90625	0	-0.53125	0.9375	-0.1875	-0.53125
0.90625	0	-0.53125	0.9375	-0.1875	-0.53125
0.90625	0.03125	-0.53125	0.96875	-0.1875	-0.53125
0.90625	0	-0.53125	0.96875	-0.1875	-0.53125
0.90625	0	-0.53125	0.96875	-0.1875	-0.53125
0.90625	0	-0.53125	0.96875	-0.21875	-0.53125
0.90625	0	-0.5625	0.96875	-0.1875	-0.5625
0.90625	0	-0.5625	0.96875	-0.1875	-0.53125
0.90625	0	-0.5625	0.96875	-0.21875	-0.53125
0.90625	0	-0.5625	0.96875	-0.1875	-0.5625
0.90625	0	-0.5625	0.9375	-0.1875	-0.53125
0.90625	0	-0.5625	0.9375	-0.1875	-0.53125
0.90625	0	-0.5625	0.9375	-0.21875	-0.53125
0.9375	0	-0.5625	0.9375	-0.25	-0.5
0.9375	0	-0.5625	0.9375	-0.21875	-0.5
0.9375	0	-0.5625	0.9375	-0.21875	-0.5
0.9375	0	-0.5625	0.9375	-0.21875	-0.5
0.90625	0	-0.5625	0.9375	-0.21875	-0.5
0.90625	0	-0.53125	0.9375	-0.1875	-0.5
0.90625	0	-0.53125	0.9375	-0.21875	-0.5
0.90625	0	-0.53125	0.9375	-0.21875	-0.5

EXP 7	EXP 8	EXP 9
0	0	0
0.15625	0.125	0.15625
0.15625	0.125	0.15625
0.15625	0.125	0.15625
0.15625	0.125	0.15625
0.15625	0.125	0.15625
0.15625	0.125	0.15625
0.15625	0.125	0.15625
0.125	0.125	0.15625
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0.125	0.125	0.15625
0.125	0.125	0.15625
0.15625	0.15625	0.15625
0.125	0.125	0.125
0.15625	0.15625	0.15625
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0.15625	0.15625	0.15625
0.15625	0.15625	0.15625
0.125	0.125	0.125
0.15625	0.15625	0.15625
0.125	0.125	0.15625
0.125	0.125	0.15625
0.125	0.125	0.15625
0.125	0.125	0.15625
0.15625	0.15625	0.15625
0.15625	0.15625	0.15625
0.1875	0.15625	0.15625
0.1875	0.15625	0.15625
0.1875	0.15625	0.15625
0.15625	0.15625	0.15625
0.15625	0.15625	0.15625
0.125	0.15625	0.15625
0.125	0.15625	0.15625
0.125	0.125	0.15625
0.125	0.125	0.15625
0.125	0.125	0.15625
0.125	0.125	0.15625
0.15625	0.15625	0.15625
0.15625	0.15625	0.15625
0.1875	0.1875	0.1875
0.21875	0.21875	0.21875
0.1875	0.21875	0.1875
0.1875	0.1875	0.1875
0.15625	0.15625	0.15625

0.15625	0.15625	0.15625
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.15625	0.15625	0.15625
0.1875	0.15625	0.1875
0.1875	0.15625	0.1875
0.1875	0.15625	0.1875
0.1875	0.15625	0.1875
0.15625	0.15625	0.15625
0.15625	0.15625	0.15625
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.15625	0.15625	0.125
0.15625	0.15625	0.125
0.15625	0.15625	0.125
0.1875	0.1875	0.125
0.1875	0.1875	0.125
0.1875	0.1875	0.125
0.15625	0.15625	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.125	0.125	0.125
0.15625	0.15625	0.15625
0.125	0.125	0.125
0.125	0.125	0.125
0.09375	0.09375	0.09375
0.09375	0.09375	0.09375
0.0625	0.0625	0.0625
0.03125	0.03125	0.03125
0.03125	0.03125	0.03125
0.125	0.125	0.125
0.0625	0.0625	0.0625
0.09375	0.09375	0.09375
0.21875	0.21875	0.21875
0.25	0.25	0.25
0.3125	0.28125	0.3125
0.40625	0.34375	0.40625
0.25	0.25	0.25

0.15625	0.15625	0.15625
0.21875	0.21875	0.21875
0.25	0.25	0.25
0.25	0.25	0.25
0.28125	0.28125	0.28125
0.21875	0.21875	0.21875
-0.1875	-0.1875	-0.1875
-0.15625	-0.15625	-0.15625
-0.125	-0.125	-0.125
-0.125	-0.125	-0.125
-0.0625	-0.0625	-0.0625
0.03125	0.03125	0.03125
-0.125	-0.125	-0.125
-0.34375	-0.40625	-0.34375
-3.125	-3.1875	-2.8125
-1.09375	-1.09375	-1.09375
2.84375	2.84375	2.84375
-1.53125	-1.53125	-1.5625
-2.84375	-2.84375	-2.84375
-1.78125	-1.78125	-1.78125
0.90625	0.9375	0.90625
2.125	2.125	2.125
0.03125	0.03125	0.09375
-0.53125	-0.53125	-0.53125
3.6875	3.71875	3.75
-0.375	-0.375	-0.375
-0.1875	-0.1875	-0.1875
-0.625	-0.625	-0.625
-0.78125	-0.78125	-0.78125
-0.78125	-0.78125	-0.78125
-0.9375	-0.9375	-0.9375
-0.78125	-0.625	-0.875
-0.21875	-0.21875	-0.21875
-0.5	-0.5	-0.5
-0.65625	-0.65625	-0.65625
-1.03125	-1.03125	-1.03125
-0.625	-0.625	-0.625
-0.25	-0.25	-0.3125
-0.71875	-0.6875	-0.71875
-1	-1	-1
-0.46875	-0.46875	-0.46875
0.375	0.375	0.375
0.40625	0.40625	0.40625
0.4375	0.4375	0.4375
0.34375	0.40625	0.40625
0.4375	0.4375	0.4375
0.125	0.125	0.125
-1	-1	-1

0	0	0
0.15625	0.15625	0.1875
0.03125	0.0625	0.03125
0.09375	0.09375	0.09375
-0.65625	-0.65625	-0.65625
-0.4375	-0.375	-0.4375
-0.65625	-0.65625	-0.65625
-0.0625	-0.0625	-0.0625
0.25	0.25	0.375
0.125	0.125	0.125
-0.71875	-0.71875	-0.71875
-1.71875	-1.71875	-1.71875
-1.34375	-1.34375	-0.46875
-1.53125	-1.53125	-1.53125
0.34375	0.375	0.34375
-0.5625	-0.5625	-0.5625
-0.40625	-0.40625	-0.40625
0.53125	0.53125	0.59375
0.09375	0.09375	0.09375
-0.34375	-0.375	-0.34375
0.0625	0.0625	0.0625
0.1875	0.1875	0.1875
0.25	0.25	0.3125
0.0625	0.0625	0.0625
0.15625	0.25	0.15625
0.34375	0.34375	0.34375
-0.21875	-0.21875	-0.21875
0.1875	0.1875	0.1875
-4	-3.96875	-4.0625
-2.125	-2.125	-2.125
1.65625	1.65625	1.625
-1.4375	-1.4375	-1.4375
3.71875	3.625	3.75
-0.4375	-0.4375	-0.4375
0.375	0.375	0.375
0.4375	0.4375	0.5
0.59375	0.59375	0.59375
0.6875	0.6875	0.6875
1.53125	1.53125	1.53125
0.375	0.375	0.375
0.65625	0.65625	0.6875
0.84375	0.84375	0.84375
0.8125	0.8125	0.8125
0.15625	0.15625	0.15625
0.75	0.75	0.75
0.90625	0.9375	0.90625
1	1	0.96875
1.1875	1.1875	1.1875

0.96875	0.96875	0.96875
0.84375	0.84375	0.84375
0.84375	0.84375	0.84375
0.84375	0.90625	0.84375
1.0625	1.0625	1.0625
0.9375	0.9375	0.9375
0.90625	0.90625	0.90625
0.90625	0.90625	0.90625
0.9375	0.9375	0.9375
0.96875	0.96875	0.96875
0.96875	0.9375	0.96875
0.9375	0.9375	0.9375
0.9375	0.9375	0.9375
0.90625	0.90625	0.90625
0.90625	0.90625	0.90625
0.875	0.875	0.875
0.875	0.875	0.875
0.90625	0.90625	0.90625
0.90625	0.90625	0.90625
0.90625	0.90625	0.90625
1	0.96875	0.90625
1.03125	1.03125	0.90625
1	1	1
0.96875	0.96875	0.96875
0.90625	0.90625	0.90625
0.9375	0.9375	0.9375
0.96875	0.96875	0.96875
1	1	1
1	1.03125	1
1	1	1
0.84375	0.84375	0.84375
1.25	1.25	1.09375
0.96875	0.96875	0.96875
1	1	1
1.03125	1.03125	1.03125
0.96875	0.96875	0.96875
0.96875	1	0.96875
0.96875	0.96875	0.96875
0.9375	0.9375	0.9375
0.96875	0.96875	0.96875
0.96875	0.96875	1
1	1	1
0.96875	0.96875	0.96875
0.96875	0.96875	0.96875
0.96875	0.96875	0.96875
1	1	1
1	1	1
1	1	1

1.03125	1	1.03125
1	1	1
1	1	1
0.96875	1	0.96875
0.96875	1	0.96875
0.96875	1	0.96875
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0.96875	1	0.96875
0.9375	1	0.9375
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0.9375	0.9375	0.9375
0.9375	0.9375	0.90625
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0.96875	0.96875	0.90625
0.9375	0.96875	0.90625