A MULTIMEDIA LEARNING SYSTEM FOR SELECTED TOPICS OF PHYSICS.

By

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Certification

AFRICAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, ABUJA-NIGERIA
DEPARTMENT OF COMPUTER SCIENCE

This is to certify that the work described in this thesis entitled **A Multimedia Learning System for Selected Topics of Physics.**

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Was carried out in the Department of Computer Science under the supervision of:

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Prof. Mohamed Hamada

Date____________________________

Dedication

I dedicate this work to the Almighty God,

Creator of the entire Universe for granting me the strength,

Wisdom and grace required to take this work to completion,

And to my lovely mom and dad who encouraged me to get

my Master's degree.

Thank you!

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Abstract

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The usage of computers in Physics Instruction began in the seventies and ever since then, lots of research efforts have been devoted to studying various emerging technologies and their impact on the learning process. Multimedia Learning Systems provide flexibility as well as a collaborative approach to learning, decreased cost of education for learners and proper time usage for instructors. It provides a major benefit over the traditional approach to Physics Instruction.

This Thesis is the analysis, design and implementation of a Multimedia Learning System for Selected Topics of Physics. A first implementation of our Environment for a Newtonian Mechanics course which happens to be one of the first areas of Physics introduced to undergraduate level Science Students is presented here. The technology used for this system is the Java 2D Technology of Sun Microsystems.

The system is portable, web-based enabled, machine-independent and easy-to-use. It can be used as a stand-alone application or run as an applet in any one of the major web-browsers. It is designed to meet the active learning preferences of Physics learners and can also be used as a supporting tool for other courses.

Keywords: Computer uses in education, computer-mediated instruction, multimedia learning systems.

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ABBREVIATIONS

MOODLE-Modular Object-Oriented Dynamic Learning Environment

PHP-PHP Hypertext Preprocessor

VLE-Virtual Learning Environment

IE- Integrated Environment

SLOODLE- Simulation Linked Object-Oriented Dynamic Learning Environment

MUD- Multi User Domains

ILS- Integrated Learning Systems

VRML- Virtual Reality Markup Language

MLS- Multimedia Learning System

IDE- Integrated Development Environment

Chapter 1

Introduction

1.1 Background

Nowadays, our world functioning is largely based on Information Technology. The usage of computers in Physics instruction began in the seventies [1]. Since then, lots of research efforts have been devoted to studying various emerging technologies and their impact on the learning process. Learning systems (also known as Virtual Learning Environments or VLEs) are being developed for use in the educational as well as corporate sectors. Over the years various contributions have been made from the commercial as well as open-source communities. Today there are a good number of learning systems in existence. Some of which are open source while a good number of them are commercially available. In a certain study [30] of ninth grade students in Pittsburgh, Pennsylvania, an intelligent-tutor software program was used as part of the regular curriculum for ninth-grade algebra, to support a curriculum focusing on mathematical analysis of real-world situations and the use of computational tools. On average, the 470 students in the experimental classes using the software outperformed students in comparison classes by 15% on standardized tests and 100% on tests targeting the curriculum-focused objectives.

Some of these systems are also being used by numerous blue chip companies to deliver training to employees and customers via web conferencing and applications such as WebEx (created by Communications Inc. and acquired by Cisco in 2007). We also have the Blackboard Learning System which is a web-based server platform and also an established leader in the commercial learning systems platform market supporting as many as 3200 global customers. Among the many Universities that make use of the Blackboard Learning suite are Heriot-Watt University, University of Antwerp, Trent University, University of Ulster just to name a few. Its main purposes are to add online elements to courses traditionally delivered face-to-face and to develop completely online courses with few or no face-to-face meetings. Moodle which stands for Modular Object-Oriented Dynamic Learning Environment is a free and open-source e-learning software platform built using PHP (a server-side scripting language) and created by Martin Dougiamas in 2003 as part of a research project. Since then it has become extremely popular, having as of 31 August, 2011, a user-base of 55,110 registered sites with 44,966,541 users in 4,763,446 courses in 214 countries and in more than 75 languages [2].Also heavy 3D immersive worlds have emerged such as SLOODLE (an Open Source project which integrates the multi-user virtual environment of Second Life with the Moodle learning management system) that integrates course management and virtual worlds) which supports active and collaborative learning. There is also UMGUMBO, which is a 3D Virtual Learning Environment set in Newtonian simulation of the solar system [3].

A Virtual Learning Environment (VLE) is a computer program that facilitates education via computer-mediated communication. They have increased in popularity over the years amongst Universities and other institutions of higher and further education. [4] Learning science research indicates that engineering and science students tend to have active and sensing learning preferences, and related educators are recognizing the need for more active and collaborative learning pedagogy. Many students entering college today, even some of those identified as among the brightest and highest achievers have been trained to associate learning physics with rote memorization and application of memorized laws in narrowly defined situations [5]. This has led many able students who could have become excellent research physicists to change their majors because they see physics as routine, abstract and boring. Some concepts are indeed abstract in nature for example, Quantum Mechanics and hence used to be taught by a traditional lecture-driven style. However, this manner of approach is more suitable for learners with reflective preferences. Since engineering and science learners tend to have strong active preferences, a lecture-driven teaching style is less motivating for them [4]. Since physics is a science whose results are continually tested and evaluated against the real world, a physicist needs experimental skills (provided by simulations in VLEs) as well as theoretical ones (provided as text in VLEs). This has led to the development of Integrated Environments (IE) for learning also known as Virtual Learning Environments (VLEs) designed to tackle the above-mentioned issues.

There has been extensive research regarding the creation of VLEs for education in general and for topics of physics in particular. The advantages put forth by this educational tool that raises its popularity daily includes but are not limited to;

- The constructivist theory employed in the creation of these learning systems where students are no longer merely passive consumers of information but rather active producers in control of their own learning is a major advantage.

- It provides flexibility in learning i.e. no longer is learning dependent on classroom availability as in the traditional learning approach but rather becomes ubiquitous in nature.

- It also provides an environment where students can interact in real-time with their instructors and get feedback on assignments and quizzes as well as engage collaboratively with their peers in solving lab exercises, homework's and other activities.

- Learning is no longer limited to scheduled groups as in the traditional "chalk and talk" approach but is now available at any time.

- It provides an avenue for the lecturers themselves to spend more time engaged in active research and other administrative duties rather than preparing lesson notes for students since the center of focus is now shifted from the lecturer to the student.

However, there are still some draw backs associated with learning systems in general. The authors in [6] state that very few learning systems lay emphasis on the importance of motivation for students and lecturers alike, in the sense that their non-user friendly and hectic environments reduces motivation of both the students and lecturers. E-learning can be both highly interactive and simultaneously isolating because of the inherent difficulties of developing cohesiveness and true connectedness among students (Sauer, 2001). Heinze and Procter in [7] discuss the lack of social interaction as one of the major draw backs in the use of learning systems to assist the educational process. This creates a special need to motivate the less independent student as all students don’t have the same learning preferences.

1.2 Aims and Objectives

This Thesis aims to tackle the above mentioned problems associated with the design and implementation of learning systems in general and for topics of physics in particular of which Newtonian Mechanics is our topic of choice, to meet the active learning preferences for learners. This topic was chosen because in most introductory physics courses mechanics usually is the first area of physics that is discussed. Newton's laws of motion, which describe how massive objects respond to forces, are central to the study of mechanics. Newton arrived at his three laws of motion from an extensive study of empirical data including many astronomical observations. An active learning approach to physics instruction is very useful since as the famous adage says, “*I see and I forget, I hear and I remember, I do and I understand.*” The approach will be used as a supporting tool for active learning not only for physics topics, but can also be implemented for other related courses. It focuses on the following issues;

1. Detailed literature study of “state of the art” in learning systems for science education and physics in particular.
2. Brief background on the usage of computers in physics instruction.
3. Problems associated with the design of a Multimedia Learning System for selected topics of Physics with emphasis on Newtonian Mechanics.
4. Proposal of a better Multimedia Learning System for Newtonian Mechanics course.

1.3 Research Questions

Q1: How can students (particularly of African descent) be motivated to study an important but difficult subject as Physics?

In addition to this, we can't fully answer our main research question without answering the following related questions:

Q2: What is it that we want our students to learn?

Q3: In what ways is the current approach to introductory physics instruction inadequate?

Q4: What is the implication of using learning systems?

1.4 Thesis Structure

Chapter 2- Gives a brief background of the state of Physics Education in the 21st Century, the usage of computers in Physics instruction and the motivation for choosing to develop a Multimedia Learning System for selected topics of Physics in this work.

Chapter 3- Is associated with the detailed study of the "state of the art" of learning systems for Physics Education in general and Newtonian Mechanics in particular.

Chapter 4- Depicts the problems associated with the design of Multimedia Learning Systems for selected topics of Physics with emphasis on Newtonian Mechanics in particular as well as a detailed analysis of the previous proposals to answering the research problem discussed in this thesis.

Chapter 5- Presents our proposed solution to the problem stated in Chapter 4 coupled with the design principles employed, their implementation, and results. Also contains a detailed description of our Integrated Environment and its various components.

Chapter 6- Finishes up with Conclusions, Summary of Contributions, Difficulties Encountered and Future Research.

1.5 Expected Contributions

This work is expected to make the following contributions to new knowledge;

- The research presented here is a contribution to the question, “How can we effectively motivate African students to study Physics?” It provides the necessary basic knowledge still lacking in many African schools for using the computer as a teaching aid.

- The creation of an environment to encourage Physics learners to acquire knowledge in self-regulated, self-motivated ways, and according to their own unique learning preferences.

- A new approach to computer-based learning within an active and collaborative instruction-led process.

Chapter 2

Brief Review of the State of Physics Education in the 21st Century.

Since this work cuts across two major disciplines which are Physics and Computer Science hence making it interdisciplinary in nature it behooves us to provide a brief review of the state of Physics Education in the 21st Century for a better understanding on our work flow.

2.1 Background

Introductory level physics taught at the Undergraduate level of every University constitutes the bedrock or foundation in the educational life as well as professional career of every Science and Engineering major. As a norm, students enrolled on any Science degree track such as Physics, Biochemistry, Microbiology, Chemistry, Botany, Zoology, and even Medicine are mandated to take a minimum of two general or introductory level physics courses, (with the exception of Physics majors who take other higher level courses during the course of their program) one in the first semester and other in the second semester. Often these general level physics courses are centered on Newton's laws of motion, work and energy, one-particle dynamics, pulley systems, inclined planes and so on. Generally these courses provide the students with a broad foundation as to the basic applications of physics within the context of their everyday lives. For example why an object thrown up in free space will always come down and not keep going up or how ships and planes with their seemingly huge sizes can be used to transport a lot of goods and great numbers of people by water and air respectively without sinking or come crashing down. They also provide salient concepts upon which the students build concrete understanding during their years of specialization.

However, the methods employed in teaching these courses to such a diverse group of learners with different learning preferences are not the best. Only the most inspiring and dedicated teachers are able to get the students to feel not only the creativity that the field possesses but also that they themselves can actually perform innovative investigative physics. This has often left many beginning students feeling dry and poorly motivated. The end results have often amounted to a significant number of students taking these courses for re-sits two or more times before finally validating them. Some resort to changing majors after a year or more of failing to validate these introductory courses while others even spend an extra year because of these courses. Many faculty have begun to question themselves as to whether the students actually finally learn the core concepts of physics after finally succeeding introductory courses. The answer to this question in some cases has been a strong feeling of failure. International comparison tests in some countries have shown how their students, coming from theoretically more advanced countries, perform worse than the average. But what has really contributed in raising the eye brows of many in the community has been the long-lasting decline on the figures of enrollment of physics majors [8]. Fewer physics Ph.D.'s are granted today than two decades ago. In the following sub-section, we go on to advance a couple of reasons for this decline as revealed by the literature.

2.1.1Reasons for decline in enrollment of Physics Majors.

2.1.1.1 Problems with the traditional Physics curriculum.

A common observable trend in some Universities today reveals that there is a lack in the robustness of the school curricular to keep up to speed with the ever-growing and advancing trends in technology, research and innovation being witnessed globally today. Ground breaking discoveries are made in various disciplines on a daily basis hence pushing the frontiers of formal education which need to conform to these new standards thus enabling our students to be at the forefront, riding on the waves of discovery in this digital age. However, this most at times turns out not to be the case. Some Universities continue to use outdated curricular prepared twenty to thirty years back and blended with the traditional “chalk and talk” approaches to instruct today’s students. How can that be? Some University lecturers even go ahead to boast to their students about their lecture notes which happened to be their own notes taken at that particular level when they were still in school. Failing to develop robust curricular which are being updated as the time advances often leads to the production of graduates who are completely clueless as to where the “knowledge puck” has been, where it is at the moment and where next it will be headed to. It also fails to groom young scientists and researchers who will push the frontiers of research making earth-shattering contributions of new knowledge which is an essential ingredient to the growth of any economy.

This might not be a problem actually if physics was a static field. But as you would have it, it is not. In the past thirty years, we have seen an explosion in a variety of subfields of physics ranging from mesoscopic physics which deals with materials of an intermediate length scale to the clustering of galaxies. We are also seeing a lot of work being done in Quantum mechanics towards the creation of the world's first Quantum Computer. There are also major breakthroughs in fields long thought to be understood. Current developments in Newtonian Mechanics are evolving into a theory of non-linear systems and chaotic behaviour that may produce profound changes in the way we think of physics. A critical element in the study of physics both experimental and theoretical is about "getting the physics right". Physics is not an exact Science but rather a science in which we believe in the accuracy of our approximations [5]. Because introductory students often come with the notion that they are working with laws and problems that have exact answers, they often fall on the wrong side of the divide and miss the fundamental aspect of the discipline.

2.1.1.2 Change in the overall perception as regarding the usefulness of Physics.

Today there is a general perception in a good number of communities that studying Physics is a major waste of time, energy and money. In fact some categorically call it, "a bad investment". This has also been a major contributor to the growing disinterest in physics and to make matters worse apart from the general public views even the scientifically educated public, no longer perceive physics as a vital discipline making ground-breaking discoveries. Also, Industries driven by global competition, and governments inspired by the change in global political situation and the more stable state of the oil industry have undertaken big cuts in basic research programs on which physics played an important role [9].

2.1.1.3 A change in the students.

Finally, there has also been a change in the students themselves leading to their disinterest in physics education. With the growing desire to "make it before I turn 25" many students have lost the patience with any form of instruction they believe does not prepare them for the job market. With the so many changes taking place in the job market today, students prefer to position themselves in sectors where they feel would be relatively easier to get a good job and a huge salary. Many more students with their parents backing them up are going for more specialized courses such as Accounting, Marketing, Banking and Finance, or prefer to shoot for the certifications out there in the market place which promise better financial rewards like Cisco, Oracle, SAP just to name a few. As a result of this and with the staggering nature of the economy, the "job security first" mindset has led a lot of would-have-been excellent research physicists to drift away from physics into anyone of these so-called promising career paths. Since they wonder what the future will hold after an advanced degree in Physics.

In addition to this growing up in a very digitally advanced age with computers having a lot of capability to do tremendous things that even the best of humans can't do, our students have found themselves entangled in a web of laziness relying on their computers to do everything for them. The aftermath of this is that they have become less conversant with printed material and even their mathematical skills have also suffered. They have gotten so accustomed to easy success so much so that disciplines like physics which require some level mathematical sophistication and rigor are considered not worth the stress [10].

2.2 Usage of Computers in Physics Education.

There has been an extensive debate about the influence of computer-assisted education in Physics courses. One standard reason for using computers in the science class is the need to visualize or simulate dynamic processes, which are otherwise difficult to handle in the classroom [11]. Some authors consider that computational Physics provides a broader and more flexible education in Physics than a traditional Physics course. Moreover they consider that teaching Physics as a scientific problem-solving paradigm is more effective than using the traditional approach [12]. Before the extensive use of computers in physics instruction began, the traditional “chalk and talk” approach was very much in use. Here students were passive recipients of knowledge while the teachers acted as the transmitters of that knowledge.

Sessions were usually conducted in scheduled groups which were largely dependent on classroom availability. [13] Assessment too was often of the recitation type were students basically regurgitated exactly what they had been “spoon-fed” like little robots. In the wake of 1981, a group of pioneers [14] announced that: “We are at the onset of a major revolution in education, a revolution of the printing press. The computer will be the instrument of this revolution…By year 2000, the major way of learning at all levels in almost all subject areas will be through the interactive use of computers”. Even though this assertion still awaits fulfillment, researchers began to find new ways of using computers and new technologies to create learning environments that would extend the traditional methods of teaching (blackboard, books, chalk…). This also led to creation of b-learning (blended learning) which is simply leverage on technology to enhance the traditional teaching scheme (face-to-face lessons, lab sessions, and tutorials) by providing a series of online activities that are carried out by the student on a fixed schedule or in a more flexible way [1].

Soon more educators began to complain that the former curricular were “a mile wide and an inch deep” [15]. And as a side-effect of this, the general cry was that students end up not getting the right kind of training they ought to get resulting in a lack of motivation and interest. In order to solve this problem, a group of physicists conducted a thorough study on how students learn physics which was widely adopted and has become the basis for the design of new science curricular [16]. This brought about an enormous rise in the amount of educational physics software to be used for instructional purposes. A key reason for this paradigm shift is the PCs ability to help students understand various representations of physical phenomena. The many possible representations of a single phenomenon is often a central part of a physics lesson. For instance, a lesson in the oscillatory motion of a mass on a spring might include a physical demonstration, a graphical representation on a microcomputer, a simplified diagrammatic model, a mathematical representation, and a graphical representation of the mathematical model. In Chapter 3 we provide a detailed review of the literature on related works carried out in this area.

2.3 Motivation for choosing to develop a Multimedia Learning System for Newtonian Mechanics in this work.

2.3.1 Popularity of Newton’s Laws.

One of the most talked about concepts in Physics when dealing with the classical limits happens to be the famous Newton’s Laws of motion. Sir Isaac Newton (1642-1727), an English Scientist and Mathematician famous for his discovery of the law of gravity also discovered what is today widely known as Newton's Laws of motion which he published in his book Philosophiae Naturalis Principia Mathematica (Mathematical principles of philosophy) in 1687. Introductory physics which mostly happens to be a superficial view of general concepts in physics never goes beyond the classical limit. More advanced notions like special relativity and quantum mechanics are not seen at this level. This implies that students taking general physics first and second semester courses at the undergraduate level from any of the science inclined disciplines can easily relate to Newton's laws, as well as other basic concepts. This therefore has been one of the leading motivations why we chose to develop a Multimedia Learning System for Newtonian Mechanics out of the so many branches of Physics that we have. They find their application in almost every thing happening around us from the launching of rockets into outer space to the mere pushing of an object which lay at rest on a horizontal surface.

2.3.2 Common misconceptions from beginning students

In as much as Newton's laws are so popular and widely known they are not as clearly understood as they ought to be by a good majority of beginning students. This is so because Newton's Laws by themselves were not engraved on stone tablets as the Ultimate law of Physics. No, they have their own limitations. And it is these limitations that throw so many off who come with preconceived ideas about the Newtonian world as they were in taught in High School. In High School, Newton's laws do of course pass the "litmus test" as the students are not introduced into deeper things so as not to get them more confused with concepts such as inertial and non-inertial frames of reference, relativistic speeds, quantum mechanics which are mostly of the abstract type and need some level of maturity and reasoning in order to be understood properly. So why bother these young lads? However, when this preconceived “one-size-fits-all” ideology about the Newtonian world is carried along into undergraduate studies of physics, the student is bound to have a lot of misconceptions about Newtonian Mechanics. As an example Newton's First Law, also known as the law of inertia, states that, in an inertial frame, a body at rest will remain at rest and that a body moving at constant velocity will continue to move with the same velocity unless a net force acts on the body. Many students hold the misconception that a net force is required to keep a body moving at constant velocity. They know that to slide a book across a table a "push" has to be exerted on the book. However, they fail to take into account that there is more than one force acting on the book when it is being pushed across the table at constant velocity. In addition to the "push" being exerted, there also is a frictional force in the opposite direction acting on the book from the tabletop. When the book moves at constant velocity those two forces balance out (add vectorially) to produce a net force of zero. In an active learning environment students might experiment with objects in an environment that has almost no friction, for example a block moving on an almost frictionless air table. There they would find that if they start the block moving at constant speed, it continues to move at constant speed without the need for a constant "push". It is hoped that exercises of this nature will help students to overcome their preconceived ideas about motion.

Also Newtonian mechanics does not apply to all situations. For example, If the speeds of the interacting bodies are very large – an appreciable fraction of the speed of light–we must replace Newtonian mechanics with Einstein’s special theory of relativity, which holds at any speed, including those near the speed of light. Also if the interacting bodies are on the scale of atomic structure (for example, they might be electrons in an atom), we must replace Newtonian mechanics with Quantum Mechanics. Physicists now view Newtonian mechanics as a special case of these two more comprehensive theories.

Still, it is a very important special case because it applies to motion of objects ranging in size from the very small (almost on the scale of atomic structure) to astronomical (galaxies and clusters of galaxies). This makes an excellent case for wanting to study it more thoroughly and also to eliminate any faulty preconceived notions of the Newtonian World by providing appropriate examples backed by sound theory and pedagogical methods.

Chapter 3

State of the Art of Learning Systems for Physics Education in General and Newtonian Mechanics in Particular.

As described in section 2.2, the onset of the computer revolution also ushered in a lot of changes in the way teaching and learning began to be carried out in the classroom. It brought about a change in the curricular of many Institutions of learning and the introduction of various technologies to aid in the dissemination of knowledge. This change in curricular and methods of dissemination of knowledge coupled with technological advances resulted in the creation of specialized kinds of instruction vehicles or knowledge portals called Integrated Learning Systems (ILS) used for educational purposes. These systems play an important role in enhancing the learning experience for students of physics who by nature tend to have more active and collaborative learning preferences.

Several models have been developed which make use of the increasing role Information and Communication Technologies play in the instruction of physics to introductory university students. In an attempt to give an overview of these related works, we will provide a rough classification of these learning systems according to their principles of use.

3.1 Tools for Data Acquisition and Manipulation

This is one of the most known conventional methods of instruction in Physics education. Spread Sheets and other information gathering tools were used in collecting data from various sources for analysis e.g. laboratory experiments carried out by the students and later the data was analyzed using computer programs. From the simulations the behaviour of the systems were studied and graphs were plotted. In this way the learner got a “hands-on” experience as they went through the experiments by themselves with close supervision for the first two trials from their lecturers. Simulations especially for a course perceived to be difficult like Physics provides a means for learners to get a more comprehensive view of the concepts being taught and most importantly understanding the underlying Physics behind them. Students were sometimes required to learn programming languages like MATLAB, FORTRAN for courses which required some basic programming skills like Computational Physics. They wrote programs for example to simulate fluid flow through a hose, or use the Navier-Stokes equations in the numerical modeling of wakes when studying the aerodynamics of wind turbines. This approach to learning has it merits also in that it provides the learners with deep analytical thinking skills as they go through the process of observation, data collection, analysis and drawing conclusions.

3.2 Open-access Educational websites.

This form of instruction came with the advent of the World Wide Web and internet technologies. It is based on hypermedia which is a computer-based information retrieval system that enables a user to gain or provide access to text, audio and video recordings, photographs and computer graphics related to a particular subject. From the time of its inception, one of the aims of the World Wide Web was to open up access to information and break down the barriers between content creators and content consumers. Hypermedia can be contrasted with the much broader term, multimedia in that it takes a rather non-linear approach to the presentation of information whereas multimedia is a descriptive term for non-interactive linear presentations as well as hypermedia. With the changes that began to take place within the classroom environment at the onset of the computer revolution, some teachers began to enhance the learning experience of their students by providing not only "face-to-face" sessions within allotted periods to scheduled groups but also made available their course notes on personalized static webpages which could be accessed by the students from any computer as long as they had an internet connection.

Assignments and tutorials were also added to these personalized webpages to be done by the students and returned when they were due. Advocates for the use of hypermedia in enhancing the learning process justified their view point with the fact that the human brain processes information by free association in an intrinsically non-linear way [17]. Over time institutions began to adopt this strategy of information dissemination and knowledge sharing as a means of reaching a wider range of learners thus breaking barriers of geographical limitation. Then the OpenCourseWare (OCW) consortium, which is basically a worldwide community of hundreds of universities and associated organizations committed to advancing global education, was born. The Massachusetts Institute of Technology was the originator of OCW with the launch of MITOpenCourseWare in 2002. Shortly after similar approaches for OCW began to be adopted in China, Japan which were the events that led to the creation of the OCW consortium. OpenCourseWare is simply a term applied to course materials in a Virtual Learning Environment created by Universities and shared freely with the world via the internet. Today there are so many educational websites and blogs for Physics education with open access to a diverse group of people all over the world.

Physics students in Nigeria or any part of the world can follow up video lectures at Stanford University by live streaming or even get to download them for free from their website for offline viewing. Anybody with an interest in Physics or any other discipline can take free courses online from the MITOpenCourseWare website. All this help to eliminate travel expenses, costs of living and fees which many African students are not able to afford in order to make the trip to study at these places. There are other wonderful open-access educational websites that are used for Physics instruction such as the famous Khan Academy with various video lectures on mechanics, projectile motion, electricity and magnetism. It was born out of the educator Salman Khan's frustration with the traditional methods of instruction which were more teacher-centered than student-centered. Open-access educational websites provide the opportunity for learners to learn whenever they want in whatever environment they find themselves as long as they have an internet connection. This makes learning ubiquitous and provides material which would have been rather hard to get, open to all learners with an interest in a particular discipline. Students don't need to travel to the source to get information because the source has now been made available "open" to all.

3.3 Integrated VLEs and Microworlds

With the passage of time and the fast pace of evolution in technology, more comprehensive approaches began to be adopted towards enhancing the learning experience of students in the study of Introductory Physics courses. A good number of Institutions especially in Africa don't have the financial power to equip laboratories with all the equipment needed by the students to carry out their work effectively. The end result of this is the production of so many graduates with a sound mastery of the theory but very poor background when it comes to experimentation. From the use of tools for acquiring data for analysis to the application of hypermedia approaches for Physics instruction, it became clear that there could be better ways of making the overall learning experience of Physics a more formidable one by the integration of other approaches into a "*one-stop-shop experience*" kind of learning system. A system that could provide all-in-one, combining various technologies and delivering a unique learning experience would be best-fit for such a difficult course as Physics was the prevalent thought amongst researchers. Integrated Learning Systems which have now become popularly known as Virtual Learning Environments then began to come to the surface. These systems combined multimedia, hypermedia (in which graphics, audio, video, plain text and hyperlinks intertwine to create a generally non-linear medium of information), and also simulators into one integrated system which made provision for active and collaborative learning.

Several models have been developed to make use of growth within internet-based technologies. For example in [5], the authors realized an open environment called M.U.P.P.E.T. utilities based on Pascal, which provides a flexible and powerful computing environment that permits introductory Physics students to add programming to their tools for solving physics problems. It has a host of libraries, one of which contains a variety of routines for solving Newton's second law in one and two dimensions. The Utilities include tools for graphing, building data input screens and menus, parsing, and simple animation. They later on in [18] proposed a more advanced system to bring together in a single unified computer environment some of the successful attempts at enhancing the learning experience of introductory Physics students. The proposed system called the CUPLE system which is a multitasking, windowing, graphic environment for learning physics that combines hypertext materials, computational physics tools, video from videodisc, videotape, or other sources, and computer data acquisition. It is designed to be used in lecture, laboratory, recitation, homework, workshop, or independent study situations. It also makes available the following; Instructional text, Microcomputer based labs (MBL), Computer simulation tools, Interactive video laboratories, and Extensive reference material (including video).

Herman Härtel [19] presents a simulation program named xyZET which offers a rich and complex User Interface and allows for the development in 3D-space of numerous experiments in basic mechanics and electricity. A special learner mode in which the learner can interact with java applets embedded in web pages is also made available. By clicking active buttons communication with the simulation program is established using TCP/IP protocol. This allows the learner to concentrate fully on the topic and frees him or her from any control activity which might divert attention from the underlying science. Another application presented in [1] is based on ADOBE FLASH and java implementation of a physics course within a MOODLE learning environment. Test and quizzes are evaluated automatically and the result is reported to the MOODLE platform. The selection of questions by the system is randomized so that students can't memorize the answers. It also provides an opportunity for teachers to make suggestions and comments about the students work or respond to questions via the personal message utility or simply email. This shifts the role of the teacher from merely delivering information to mentoring students.

Mohamed Hamada's environment [4] integrates a set of visual tools to support interactive and collaborative learning in the theory of computation course. This environment provides a single interface, web-based, all-in-one, stand-alone application based on Java 2D technology of Sun Microsystems [20] which can be adapted for similar courses including Physics. More recently Awodele O. et al [6] studied the integration of e-learning in the Nigerian Education System. In their work, they proposed a web-based system called CITADEL e-learning system based on HTML, ADOBE FIREWORKS, PHP, JAVASCRIPT and MySQL. The proposed system provides functionality that caters for visual, sensing and active learning preference types. Courses from any discipline can be implemented on the platform by the lecturer as well as student and course progress monitored from a standard administrative report. While [21] presents a family of small flexible java applets called Physlets which are interactive animations or animations representing physical situations, like Brownian motion. They are created and controlled with JavaScript implying that they can be customized by the teacher and used as part of any curriculum with any teaching style. They can also be embedded in html documents and interact with the learner thus employing the Interactive Engagement approach to learning Physics.

Also due to the importance of virtual reality, heavy 3D immersive Microworlds have been developed [22] as a means of providing enhanced social interaction amongst learners which is essential in the learning process. In these microworlds (which are basically 3D VLEs), the presence of learners by proxy is made possible through avatars which are controlled in real-time by the learners. These environments are equipped with tools such as whiteboards for internal group discussions as well as chats and other means of communication. Common place technologies such as Java 3D and VRML (Virtual Reality Markup Language) are used in the development process. Motivated by these works and most especially Mohamed Hamada's approach, the present study proposes a Multimedia Learning System for selected topics of Physics. The proposed system is designed to tackle the problems associated with the systems presented in this section as well provide sufficient motivation for African students to want to study Physics. The related works presented above will be analyzed in the following Chapter of this work and the problem statement justified.

Chapter 4

Problem Statement: How does one effectively motivate students (African) to study Physics?

In Chapter 3, we reviewed the literature as concerns the state of the art for Multimedia Learning Systems for Physics Instruction. This work seeks to address the problems associated with Multimedia Learning System design and the motivation of the African Student towards the study of Physics which is often perceived as abstract, difficult and worse still boring. It is assumed that learner's success in improving factual knowledge and deeper understanding not only depends on the mode of presentation and the degree of self-regulation but also on the learner's motivation [11]. Learners not only need to know which steps are right to take to be successful in the learning process, it also requires motivation to be a successful learner. We saw in the previous chapters, that one of the major reasons for the decline in the enrollment of students at the University for degrees in Physics was because of the traditional methods employed in the instruction of Physics which were mostly teacher-centered than student-centered. This resulted in a great lack of motivation on the part of the student towards the study of Physics. The question therefore that remains to be answered is, "*How do we effectively motivate students (especially of African descent) in areas which lack even the most basic laboratories to study Physics and do the approaches previously presented in Chapter 3 not suffice to answer this research question?*"

This Chapter is divided into three main sections. Firstly, we will restate and briefly discuss the main research question (as given in section 1.3) that this thesis intends to answer. Secondly, we will provide our justification by direct reference to Chapter 3, to show that the question previously posed still remains unanswered and also that we are not re-inventing the wheel. And finally we conclude this Chapter with discussions on the importance of answering this question and demonstration of its worth.

4.1 Issues facing the use of Multimedia Learning Systems as a tool for Physics Instruction.

From the onset of the computer revolution during which certain pioneers made the prediction that the major way of learning at all levels in almost all subject areas was going to be through the interactive use of computers, many have been skeptical about the use of these systems as a means of enhancing the learning experience for learners. Such skepticism stems from a myriad of ways in which computer-mediated instruction has been viewed by many over the past years. We will discuss these views in detail here.

4.1.1. Computer acting as master over student instead of the reverse.

It is without doubt that computers have played a major role in improving human life today from the way we learn, do business, play, and a whole host of other things that would never have been achievable otherwise. From the time of their inception computer manufacturers have been working tirelessly to increase the overall capabilities of these devices while reducing their sizes a great deal as well as cost implication. Over time they have moved from large mainframes (which occupied large rooms) to miniaturized versions (the size of your wallet) which we can easily carry around without any hassles. More power is packed into a desktop computer the size of a breadbox than was available in mainframes thirty years ago. These devices have become a force to reckon with so much so that even little children can differentiate a real one from a toy one when asked to. We can carry our electronic books (e-books) around in them and don't necessarily have to wait for a friend to return a book to the school library before we can borrow it. No longer is it obligatory for people have to sit in a particular environment with a white or blackboard and some chalk in order to learn. All of that can now be done using your computer from anywhere at any time (even while flying on a plane for a short trip overseas).

Early studies soon showed that the predictions that were made by these pioneers concerning the interactive use of computers becoming the major way of learning at all levels in almost all subject areas were somehow a little over the top. Computers showed a great potential to enhance student achievement, but only if they were used appropriately, as part of a coherent education approach [23]. One of the reasons advanced by those who were slow to adopt the use of Multimedia Learning Systems in the instruction process for education was that they feared that Instructional software designers are bound to forget that the student is supposed to run the computer, not the other way round [5]. The computer in other words must become a powerful servant to the student, not a master. These fears were very legitimate in that the over reliance by students on the computer to be able to perform all their tasks would result in the students becoming very lazy with underdeveloped math and physics skills which constitute the basic foundation in the life of every professional Physicist. Thus instructional software designers had to take into consideration this very serious risk involved in the use of Instructional software for Physics Instruction.

4.1.2 Lack of full Intellectual Engagement on the part of the Student.

A second problem that instructional software designers faced in the development of Multimedia Learning Systems for Physics Instruction was that of becoming the unintentional creator of a video game. With some of the sophisticated learning environments that were being developed without any consistent instruction-led design models or learning workflows to promote more effective learning, students were left to muddle through these complicated systems like a child would when given a new toy car without reading the user's manual. These successive sessions of trial and error only ended up in the students not acquiring the full intellectual engagement for which the learning environments were built in the first place. The students would end up messing around with the system all in a bid to understand how it works because of their complex interfaces and usually wound up being frustrated at the system and discouraged in the overall learning process. The learning system which was thus built to act as a motivator ended up being a major distraction and de-motivator to these students. In other cases much richer user interfaces some of which included heavily immersive 3D environments with avatars representing real people controlled by humans in real-time on the outside, complete virtual worlds which were more socially constructive were only seen by some students not as learning tools but just another Multi-player video game like SecondLife, Alpha Worlds, and many others.

Instead of grasping the underlying concepts, which are key to understanding the subject matter, the animations and attractive displays get the student lost in the amazement of what they see and as a direct consequence of this; they miss out on the Physics behind it. In this way the original intention is downplayed completely and instead an unintentional video game becomes the end-product. The student equally fails to acquire the requisite skills of experimentation, observation and analysis which were the original focus of the system to begin with. This all happens due to the absence of a clear workflow of learning activities that can guide the new learner on how and where to start using the system. A proper learning design model must be integrated during the design phase of instructional software such that it fulfills the purpose for which it was originally designed.

4.1.3 Replacing the former methods of instruction with the computer.

A third reason for which critics rejected the use of computers for physics instruction was the fear that computers would completely replace everything in the current environment such as textbooks, the teacher and the laboratory. These people had seen the representations of this various instruments of learning such as the textbooks in the virtual space could be the content developed in any form, the teacher could be the student who is now in charge of his own learning and the laboratory which could be constructed as virtual labs with simulators which the students could interact with by changing various parameters to get desired results. As a result of this changes taking place the general fear was that the extensive usage of these learning systems would render the former entities redundant or even useless in the new approach. This also created a major divide which had to be taken care of in the design of learning systems for instruction. Instructional software designers had to be wary of the fact that computers were not meant to replace textbooks and neither were they meant to replace the teacher or laboratories. The design models had to clearly capture this so that they could work in sync with each other and not otherwise.

4.1.4 Forgetting the students' point of view in favor of designers.

Lastly, another major challenge that surrounded the design of Multimedia Learning Systems for Physics instruction was the possibility for instructional software designers to easily forget the students' point of view in favor theirs in the design process. It is true that computers make it possible to approach topics from a perspective different to the traditional approach and certainly much more exciting. Due to the differences in the mental models between the learner and the designer, the propensity for the designer to produce something which may be intellectual engaging to him and a rip off to the student is very high. Presentations that enthrall the designer who is an expert may bewilder the novice [24], simply because of a difference in their mental models.

In addition to that it is not enough to use the computer to illustrate examples from the current curriculum. The entire curriculum must be redesigned from ground up, now assuming the availability of the computer. Educators now have to ask themselves one very important question, "What can we teach with the computer now that we couldn't do before?" This will bring about a complete restructuring of the curriculum to include new approaches to learning that extend the possibilities of old technologies (books, blackboard, and laboratories) instead of acting as a replacement to them.

4.2 Analysis of related works on Multimedia Learning Systems for physics instruction.

In Chapter 3, we presented a detailed review of the literature on Multimedia Learning Systems for selected topics of Physics. Following our previous section, we have underscored that the goal of this work is to propose a Multimedia Learning System for selected topics of Physics (in our case Newtonian Mechanics) that meets the learning preferences of students in Africa and serves as an effective motivator in aspiring them to want to go higher in the field of Physics and its associated branches. We have seen in the previous section 4.1 the problems that instructional software designers faced in the development of learning environments for Physics instruction. The proposals that were made in Chapter 3, were all geared towards answering our main research question for this work which is “How can we effectively motivate students (African) to study Physics?” The related works carried out in this area to enhance the learning of Physics topics were presented according to their principle of use. However, most of them suffer from one or more flaws that make them a less effective tool for the instruction of Physics to introductory level students.

The approach presented in section 3.1 based on the use of tools for data acquisition and manipulation has its weakness in that at some point, a pre-knowledge of some programming languages like FORTRAN and MATLAB are required early on in the learning process as a prerequisite to understanding some of the more advanced concepts being taught. This places the students who are novices in the area of programming at the far end of the learning spectrum which eventually might result in a complete disinterest on the part of the student. Section 3.2, discusses the use of hypermedia as a vehicle for information dissemination. This also has its shortcoming in that the web is a very vast resource with so much information and web pages indexed on the various search engines we have today. Looking for the right information in the midst of this spaghetti of html codes can be very daunting. There is a lack of teacher to student guidance which is very necessary in shaping the students ideas in any introductory course. It could also be argued that online courses hosted in a website whose usage is restricted to registered users, limits the accessibility to information since it is not available to the general public. Also the lack of social interaction when using hypermedia based educational websites is a major problem as it doesn't favor collaborative learning or Problem-based learning which is present in the classroom environment.

The MUPPET utility presented in section 3.3 is a machine dependent environment as it was built using Pascal which reduces its flexibility and portability entirely as an effective learning environment. The CUPLE system lacks a precise workflow of learning activities that instruct the new learner on how and where to start using the system so that they can progressively build their understanding from ground up.

The xyZET environment has a very complex user interface which provides a poor user experience for the less advanced learner thus giving room for trial and error which in most cases produces undesirable results. This makes it difficult for new students to navigate the system. The learner tends to gamble with his/her way through the system in an attempt to understand how it works with no real depth of understanding of the subject matter or concepts underpinning the simulations.

4.3 Justification of research question.

From our analysis of the reviewed literature, we see that the importance of our research question cannot be overemphasized. This question still remains unanswered and that is the purpose of this work. Since it is now obvious that we are not re-inventing the wheel, a learning environment which will be machine independent, web-based, easy to use and easy to learn for new users with a clear workflow of learning activities is paramount. This will provide an environment which can be used for introductory Physics instruction in schools in Africa especially areas in which there are no laboratories or the traditional methods of instruction have been maxed out with no significant results. Thus this questions still remains a very important question to be answered. In the next Chapter we will propose our own solution in an attempt to answer this very important question.

Chapter 5

A new approach to Physics Instruction: A Multimedia Learning System for Newtonian Mechanics.

5.1 Why a Multimedia Learning System for Newtonian Mechanics?

Before choosing Newtonian Mechanics as the topic to be studied in this work, a small survey was conducted on a group of students who had read Physics at the Undergraduate level and earned their bachelor's degrees in record time from the University in Buea in Cameroon. When asked the question, "If you were to retake your Bachelor's degree all over again, and this time for your introductory level courses a system provided to help in visualizing those concepts which seemed very abstract to you, what three topics (listed in order of preference) will be your choice for this activity as a freshman or freshwoman?"

The results were indeed amazing. Feelings of excitement were poured out over the development of such a system that would enhance the learning process for introductory level Physics students as well as past feelings of disgruntlement were expressed over those courses which they felt were validated with no proper understanding of the concepts due to the lack of laboratories and poor teaching methodologies. The survey registered the percentages for the following three topics in order of preference;

Total number of people interviewed- 60 people

- Newtonian Mechanics- 80%
- Electromagnetism-15%
- Wave and Optics- 5%

See pie chart below in Fig.1 for graphical display.

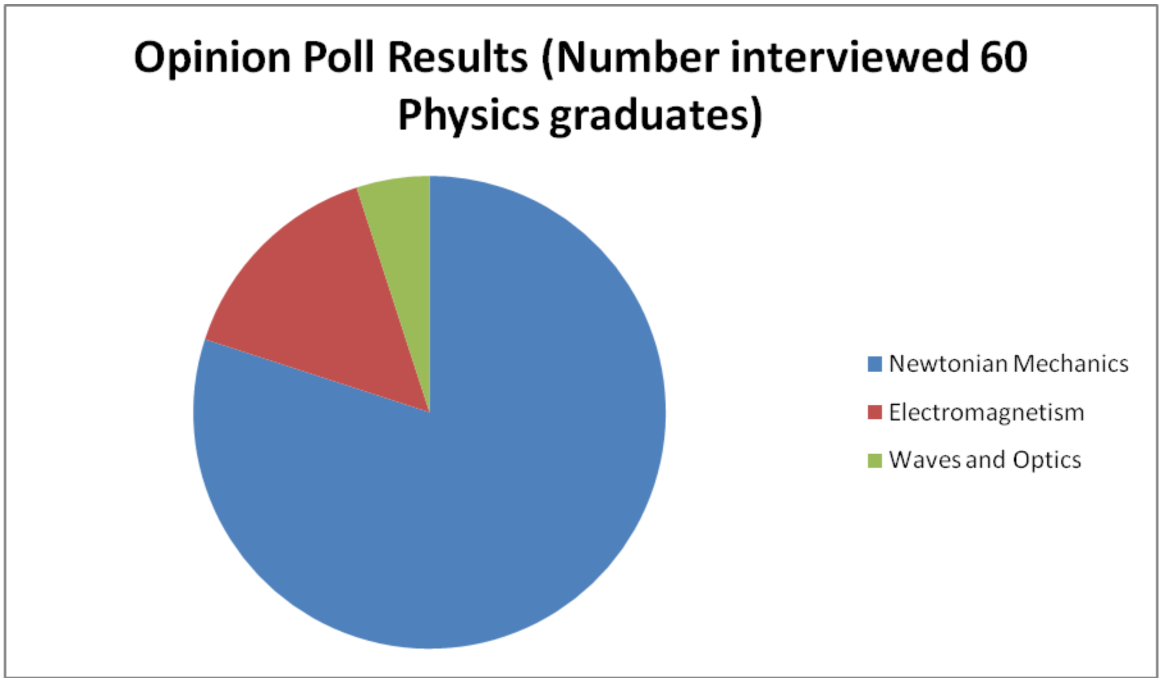

Fig.1: Opinion Poll results conducted on a group of Physics graduates for topic of choice to be simulated using Multimedia Learning Environment.

Looking at the percentages it became clear that many more students had problems with the Newtonian Mechanics course which forms the foundation from which the other courses branch out. And a shaky foundation would imply a weak structure. For this reason we chose to develop a Multimedia Learning System for Newtonian Mechanics as our first topic of choice. However, the principles applied here can be done for any others like Electricity and Magnetism, Thermodynamics, Wave and Optics, and even Quantum mechanics. In section 1.3, we presented our main research question and the associated questions that must also be answered in order to have fully answered it. Question 3 was answered in section 2.1 of this work and Question 4 in section 1.1. Now we answer Question 2 which says “What is it we want our students to learn?”

5.1.1 Skill Analysis

The development of a Learning System for Introductory level Physics students in order to motivate them to actively participate in the learning process of related subjects and to seek more knowledge on their own without a proper understanding of the general skill set required of every Physics student would be more or less like giving a gun to a child. We must therefore design our learning system bearing in mind the general process skills students of Physics are required to have. Our system captures this in the design phase. These skills set are categorized as follows;

1. Basic skills
    - A scientific framework
    - Number awareness

2. Theoretical skills
    - Analytic skills
    - Estimation and natural scales
    - Approximation skills
    - Numerical skills

3. Experimental skills
    - Error and analysis

- Mechanical skills
- Device experience
- Empathy for the apparatus

4. General skills

- Intuition
- Large-problem skills
- Communication skills

We discuss briefly each set.

5.1.1.1 Basic Skills

Two basic skills are defined as a must for Physics students: The first is having a scientific framework and the second is number awareness. By having a scientific framework we mean that the student must understand the “story-line” of science which entails observation, hypothesis, analysis, and testing against observation. By number awareness, we mean that the student must understand that aspects of the real world may be quantified by measurements and that the results of our mathematical analysis can tell us about what is happening (or will happen) in the real world. Number awareness is thus stressed in some introductory level Physics courses.

5.1.1.2 Theoretical Skills

The next set is the theoretical or modeling skills. The first of which is the analytical skills which requires students to be able to write equations from word problems, to solve a variety of equations and to interpret results in terms of the physical world. Others in this category include estimation, approximation and numerical skills. They are essential in learning to model physical systems and to understand the implications of models built by others. They help in knowing what physical laws to apply under what circumstances and what additional complicating factors can be safely neglected. This is called “getting the physics right”. Yet these skills though critically important are often ignored by most traditional courses.

5.1.1.3 Experimental Skills

Since Physics is a science whose results are continually tested and evaluated against the real world, a physicist needs experimental skills as well as theoretical ones. Majors are often trained in error analysis, mechanical skills and given experience with a variety of devices. Another often overlooked skill which must be thought to our students is the “empathy for the apparatus”. This simply means an understanding of what is happening in an experiment, what is being measured, and where the information lies.

5.1.1.4 General Skills

Finally, there are a number of general skills that all physicists must develop. They must build an intuition for their field which is the ability to understand which tools apply in which circumstances and to have a complex network of internal checks that let them look at a wrong answer and have it not “feel” right. They must learn large problem skills; the ability to take a significant problem and break it down into component, solvable parts in an appropriate manner while keeping track of the overall goal. They must also build communication skills. In physics, as well as in any other field, it does not suffice to do brilliant work in a notebook or in your head. Physics, as is any field is a social agreement of what it is we know. A physicist needs to be able to present his or her results in oral and written form in a clear and compelling fashion. However, these skills too are neglected at the introductory level until they begin research in the second year of graduate school.

5.2 Learner Preferences

In our proposed system, we considered the various learning preferences common to science and engineering students. Not all students have the same learning preferences. In fact, different people have different mental models which accounts for the differences in the way they ingest and process information. This is not any different for Physics students. Several learning models have been developed so far for the realization of learning preferences of learners. However, our proposed system takes root in Felder and Silverman [25] model which is simpler and easier to implement. It classifies engineering learners into four axes:

- Active versus Reflective learners.
- Sensing versus Intuitive learners.
- Visual versus Verbal learners.
- Sequential versus Global learners.

We discuss each of them very briefly;

5.2.1 Active versus Reflective learners

Active learners gain information through a learn-by-doing style, while Reflective learners gain information by thinking about it.

5.2.2 Sensing versus Intuitive learners

Sensing learners tend to learn facts through their senses, while Intuitive learners prefer discovering possibilities and relationships.

5.2.3 Visual versus Verbal learners

Visual learners prefer images, diagrams, tables, movies, and demos, while Verbal learners prefer written and spoken words.

5.2.4 Sequential versus Global learners

Sequential learners gain understanding from details and logical sequential steps, while Global learners tend to learn a whole concept in large jumps.

A study of the above model [4] revealed that Science and Engineering learners tend to have strong active, sensing, visual and sequential learning preferences. So with the broad skill set required of Physics students as well as the differences in learning preferences amongst learners, our proposed solution is designed taking all this key requirements into consideration.

5.3 Design Principles.

The following design principles were considered in the design of our proposed Multimedia Learning System for Physics Instruction which adheres to an active construction learning model.

5.3.1 Teachers as facilitators not as knowledge transmitters.

The ultimate goal of education is to prepare students to become competent adults and life-long learners. The former traditional "chalk and talk" approaches to learning were more teacher-centered. Here the teacher was the center of focus in the learning process. Students had to sit down passively receiving the knowledge transmitted by the teachers. They contributed very little to the construction of their own learning process. This approach only fostered regurgitation and rote memorization on the part of the student. Material retention was low as the active engagement in the learning process by the student was lacking. This is buttressed by the famous adage which says that, "*I see and I forget, I hear and I remember, I do and I understand.*" In our environment students no longer play a passive role in the learning process, they enter the game. They participate actively in the construction of their own learning.

5.3.2 Learning must take place in a collaborative environment.

Critics who oppose the use of virtual learning environments argue that some of the key elements which are vital to the learning process that are lost when we move from a real classroom experience in which students actively collaborate with each other to virtual learning environments are;

- Facial expression.
- Body gestures.
- Voice intonation.

These elements are very vital components that enhance the quality of the learning experience of every learner. We adopt the social constructivist approach to learning systems design which hinges on Interactive Engagement. Interactive Engagement is simply a brand name for teaching methods that are designed to promote conceptual understanding through interactive engagement of students in heads-on (always) and hands-on (usually) activities that yield immediate feedback through discussions with peers and/or instructors. According to the Russian Psychologist Lev Vygotsky, for most individuals, learning is most effectively carried out via social interaction [27]. It is for this reason that our MLS fosters a collaborative environment in which learners can actively engage in the learning process.

5.3.3 Active involvement of learners is key.

According to the work of Jean Piaget who proposed the constructivist account of learning in the first half of the 20th Century, science students must engage in active construction of their own extant scientific knowledge [28]. In order to motivate learners and get them actively involved in this knowledge construction, learning activities should be centered on real world problems that inspire learners. In this way students are no longer restricted simply to the consumption of information but rather they become information producers. They become not only members but contributors to the social and information space.

5.3.4 Modularization of learning content.

Our system comprises of separate modules. The modularization of learning content into smaller topics that each follows a consistent learning model, sequencing through an introduction, presentation, practice and review model greatly helps in material retention and a proper understanding of the content on the part of the learner. Also an intuitive interface and easy navigation through the different modules helps to speed up the learning process significantly while reducing the learning curve.

5.3.5 Proper procedures for assessment.

Assessment procedures should be embedded in the learning process and should consider learners' individual orientations such as an objective-driven quiz pool which can be evaluated automatically and results displayed to the learner immediately.

5.4 Implementation

The various components of our MLS were written in java and then integrated into the Java 2D backbone of Sun Microsystems. Our system is web-based enabled, machine independent and portable. It can be used as a standalone, all-in-one application or be run as an applet in any one of the major web-browsers such as Mozilla Firefox, Internet Explorer, Opera, Safari and Google Chrome. This makes it a useful tool as interactive collaborative environment. During the design phase a prototype of how the system will look and feel was developed and visualized on PowerPoint. When the validation of this phase was complete and the required functionality properly captured, actual development then begun. The Introduction component was done using HTML in a power point fashion for easy navigation and understanding. The IDE Netbeans was used for the coding of the various components in java because of its well-defined drag and drop utility. Details of our prototype which was done in PowerPoint prior to the finished work as well as the source code for the Newton's Second Law Simulator can be found in the Appendix section of this work.

5.5 Detailed description of our MLS

In this section, we describe fully our MLS environment as well as each of its various components. Our environment contains four components which have been integrated into a single unit giving it a much more intuitive user-interface and a richer overall user-experience. This cannot be equaled with the use of simple independent java applets with no coherent flow of instruction for the learners to appropriately follow the course. The components include the following: an animated (movie-like) welcome component, a hypertext introduction to Newtonian

Mechanics, a Newton's second law simulator, self-assessment exercises, and visual examples of Forces and Motion.

The welcome and Introduction components use plain and animated texts (properly structured), which are suitable for learners with sequential learning preferences. The simulator and visual examples are best suited for learners with active and sensing learning preferences which are come to most Physics learners. In the following sub-section, we will describe each of the following components of our MLS.

5.5.1 Welcome Screen and Introduction component.

The first two components of our environment are;

- An animated (movie-like) welcome component.
- A hypertext introduction to Newtonian Mechanics.

The first component presents a short movie-like introduction that welcomes the learners to the topic. While the other is a rich hypertext introduction to the basic course content delivered in a power point fashion for easy readability and understanding. Learners can navigate through the components and learn about the basic concepts of forces and motion, friction, drag and all the topics treated therein. The interfaces of these two components are shown in Figs. 2 and 3. The interface is a rather intuitive one which favors easy navigation through the presentations thus enhancing the overall user experience of the learner. The presentation is made using white ink on background which is clear enough to eliminate any form of distraction as a result of blurred texts and enables the student to focus on the core content. Pictures are also used within the presentation to illustrate certain concepts which might be suitable for visual learners. As is often said, “A single picture speaks more than a thousand words”. A brief biography and picture of Sir Isaac Newton, the creator of the famous Newton’s laws of motion is provided within the Introduction component so as to inspire confidence in the learner and eliminate any feelings of dealing with the abstract since it will be clear to them that these laws were formulated by a real personality like themselves. The text is also presented in English with translations in French to be included as well in order to make the system Bilingual.

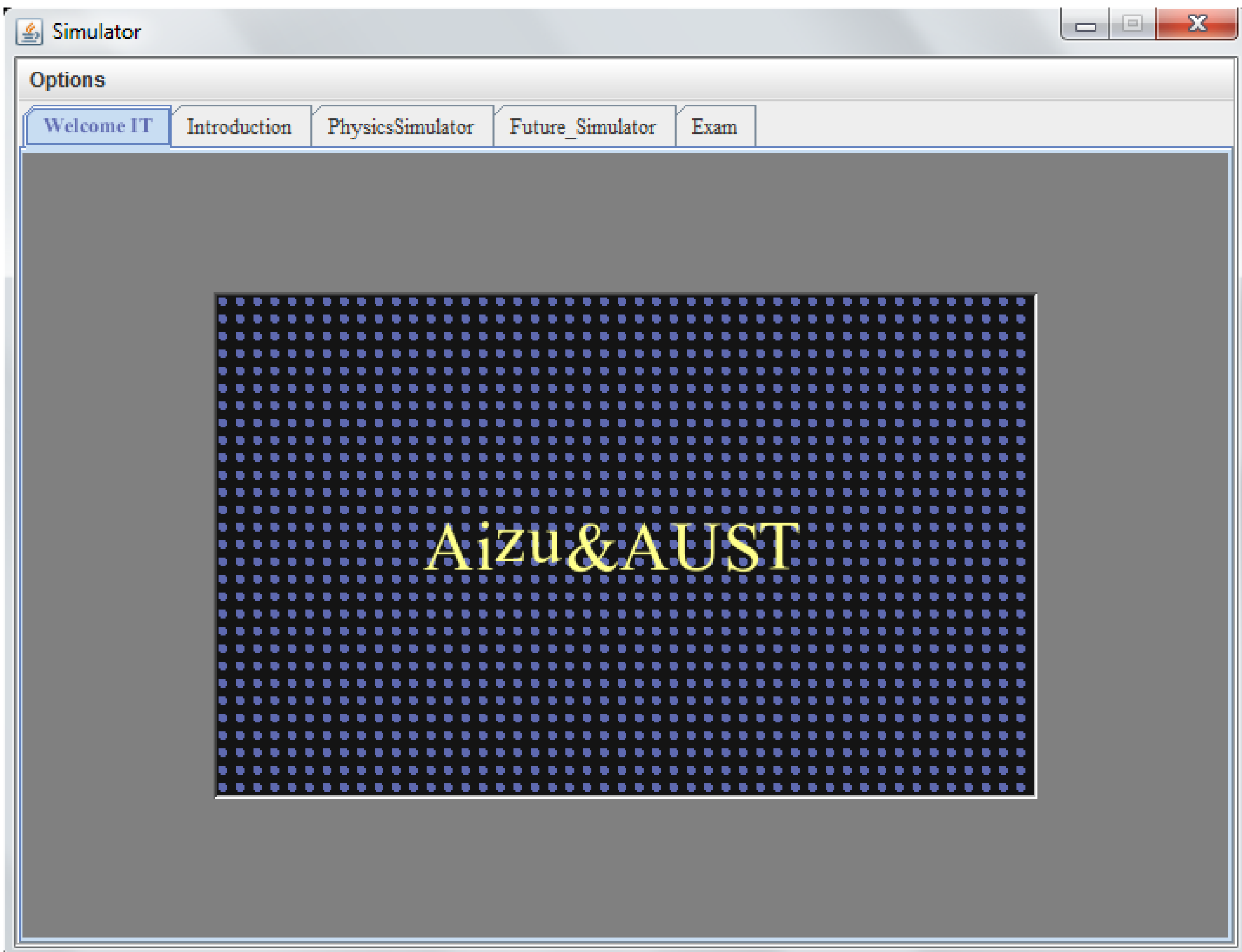

Fig.2. A short movie-like welcome component in the MLS

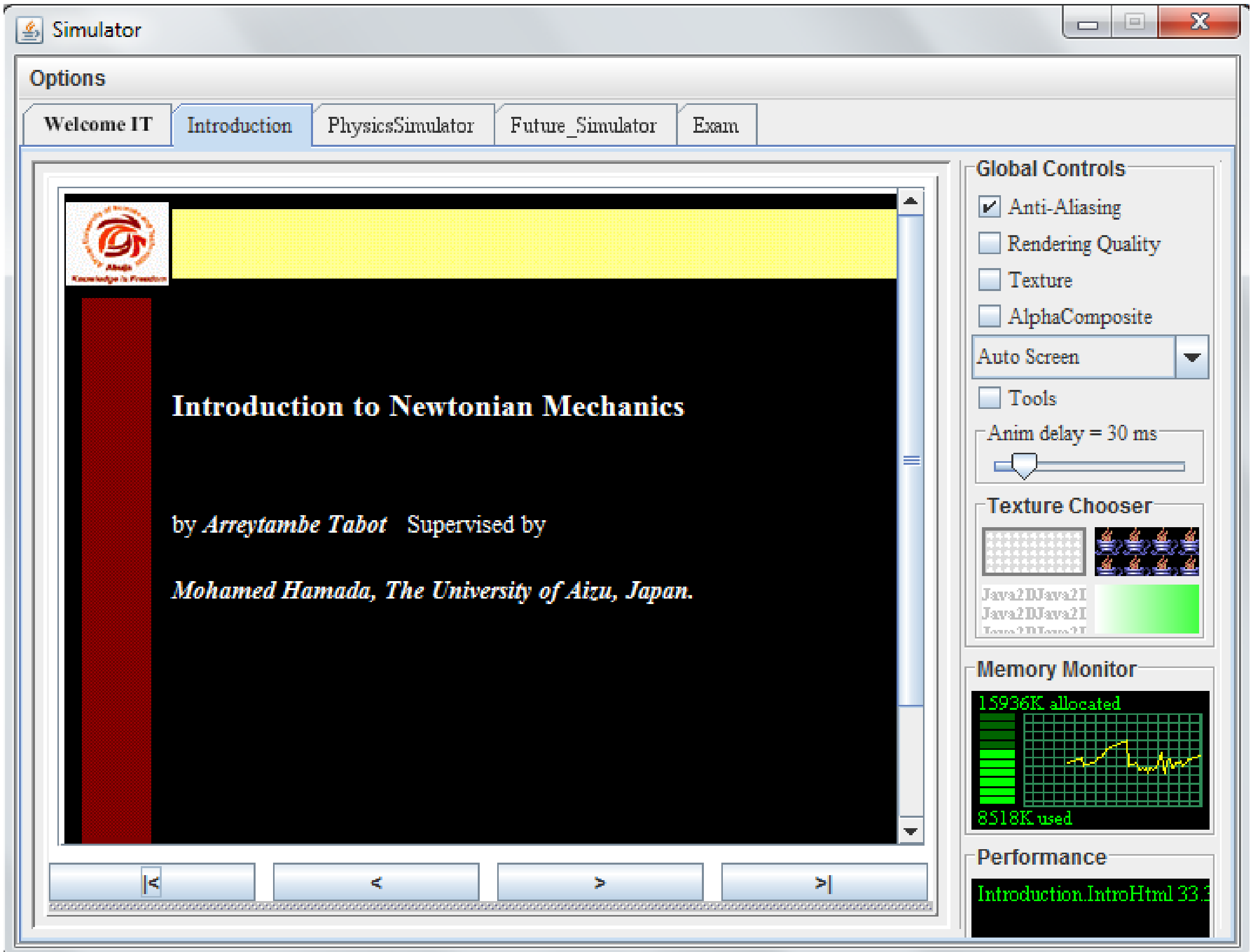

Fig.3. The topics introduction component in the MLS

5.5.2. Newton's Second Law Simulator (N2 Simulator)

The N2 Simulator was developed as a separate java application and integrated as a basic component of the MLS. It allows the learner to simulate and visualize the concept behind Newton's second Law of motion which states that,

"The net force on a body is equal to the product of its mass and acceleration, or F = ma."

Here a very user-friendly and intuitive interface implemented in java is provided for the user with parameters for the force, mass and acceleration. The learner can conveniently vary the force and mass using the sliders and watch the car move with the desired acceleration. This increases the level of understanding of this concept on the part of the learner because of the interactive approach employed were the learner carries out the simulation by themselves. The numerical skills of the learner are also built in this way as they carry out the calculation of force divided mass to get the value of the acceleration just to ensure that it is the right value displayed in the simulator textfield. Such an interactive approach between the learner and the application is necessary in promoting a positive attitude towards the subject matter as well as increasing the motivation of the learner. Also guidance on how to use the simulator is provided by the use of menus. A help menu is provided which clearly outlines the procedure the learner must use in order to get the best out of the learning process. This eliminates any form of trial and error on the part of the learner by presenting a clear workflow of the learning activities. The simulator interface is shown in Fig.4.

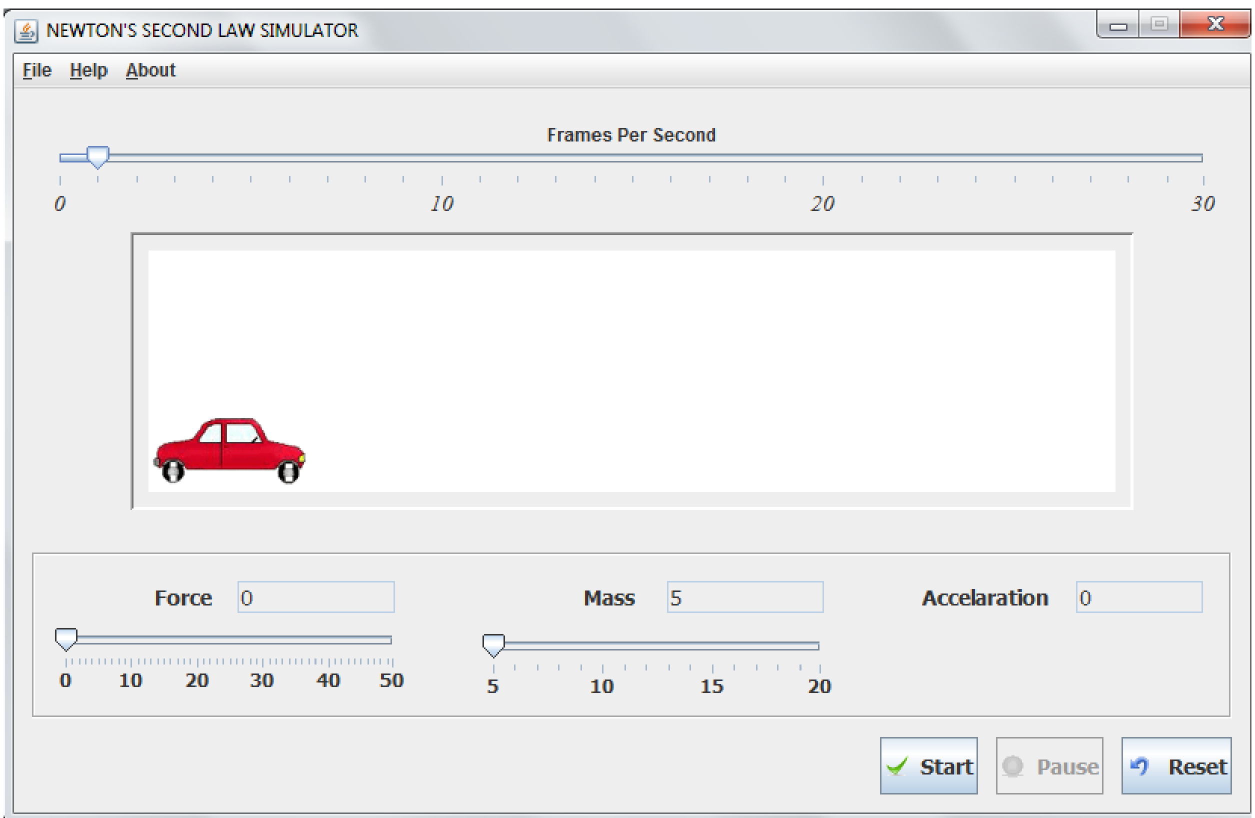

Fig.4. The N2 Simulator interface presented as standalone component.

5.5.3 Visual Examples

In our MLS, a set of visual examples are introduced with the aim of motivating learners in this course and closely related ones. The examples chosen represent useful daily life issues. We prototyped a set of different visual examples for our MLS, each of which is intended to have a desired effect on the learner. Some of the examples we prototyped are; a Force puzzle, a launching rocket and two tankers in combat. All of these examples strongly underpin concepts taught in the introduction component and just serve as reinforcement to them. In this sub-section however, we will describe those components which we have already been integrated into our MLS.

5.5.3.1 Self-Assessment

A set of exercises with different levels is also integrated with the environment. A multiple choice quiz format was chosen for ease of evaluation. The questions span across the entire curriculum already presented to the learner in the introduction component. Learners can perform a pre-assessment, in-assessment or a post-assessment. In the way the learner can easily evaluate his/her performance as they go through the learning process. The assessment interface is shown in Fig.5. First, the learner selects an exercise at the upper left corner of the window and then a description and evaluation method will be shown in the main window. Learners can freely navigate between quizzes by using the navigation buttons. They can equally check their score at any time by clicking on the “score” button. Learners gain a lot in this model, since they can freely go back and forth to the introduction component to read up on things they had forgotten while taking the quiz.

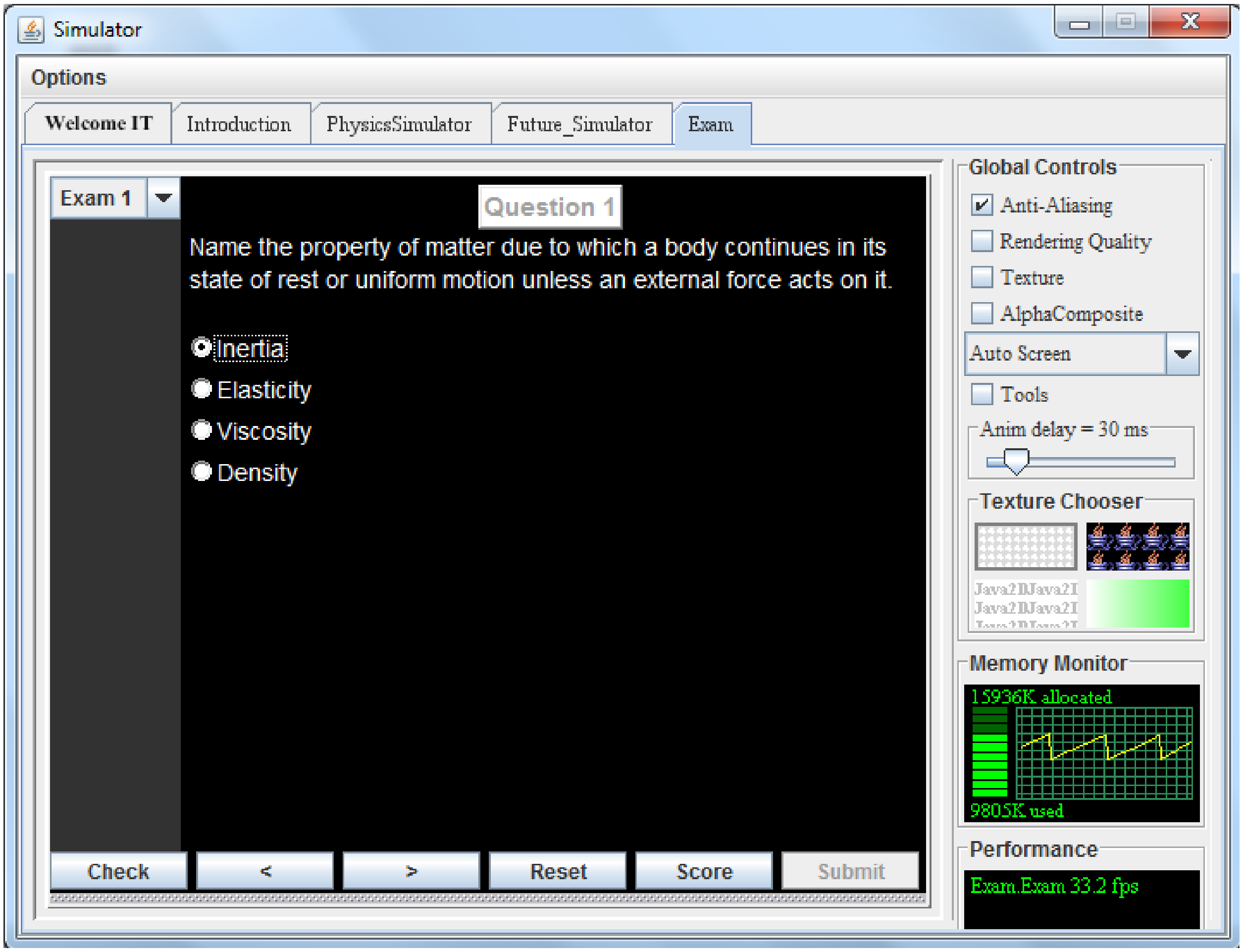

Fig.5 The self-assessment component interface in the MLS.

5.6 Evaluation

Due to the broad scope of this work and the limited time available, at the time of this defense, our MLS has not been tested (statistically) to evaluate the effect of using the system on students' performance. However, we were able to divide the evaluation phase into two different but related stages:

Stage 1: Evaluation of our MLS against a sound theoretical framework, applicable principles and recommendations by Physics Education Research for good instructional software.

Stage 2: Statistical evaluation of the effectiveness of our MLS in improving students' motivation based on Keller's ARCS motivation model [29] as well as student's performance.

So far we were able to carry out the first stage of the evaluation process with great success as our MLS was built ground up to conform with the findings and recommendations of Physics Education Research. As for the second stage of evaluation, two Universities have been earmarked for this process, Katsina State University in Nigeria and the University of Buea in Cameroonian. The target population will be the level 100 students in KSU and 200 students in UB all from the Physics stream. Detailed information about the research results and the impact of our MLS on the learners will be made available for public consumption.

Chapter 6

Conclusion

6.1 Summary of work and results

The overall research has been conducted in a well-organized way as defined in chapter 5. Research questions 1 and 2 defined in chapter 1, sections 1.3 are answered through Chapters 4 and 5. Research question 3 is answered in Chapter 2, sub-section 2.1.1.1.

In this work, we have proposed a Multimedia Learning System for selected topics of Physics with a first implementation on an introductory Newtonian Mechanics course which happens to be the first area of Physics that is discussed at that level. The system is portable, web-based enabled, machine-independent and easy-to-use. The interface is a rather intuitive one and help menus are provided for guidance on how to use components. It can be used as a stand-alone application or run as an applet in any one of the major web-browsers such as Mozilla Firefox, Internet Explorer, Opera, Safari and Google Chrome.

Our Environment supports interactive and collaborative learning in the Newtonian Mechanics course. It can also be used for other courses such as thermodynamics, waves and optics and electromagnetism. It meets the learner preferences of Physics learners which are mostly active, visual, sensing and reflective. Being java based, our MLS can also be integrated with third party applications and Learning Management Systems such as MOODLE.

6.2 Challenges

We faced the following challenges in the course of this work;

- The Newton's 2^{nd} Law simulator was a bit of a hassle and indeed received more attention than had originally been anticipated, being the most important component of our MLS. More coding hours were spent on it that would have been given to the development of one other component for the visual example.

- Due to the fact that we finished course work a little later than expected, the scope of our work and time limitations added a lot of stress that would probably have been significantly reduced had we started on time. It also resulted in us being unable to do a second stage evaluation (statistical) to evaluate the effect of our MLS on student performance.

- Some important research material could not be accessed while others were no longer available in print or online.

- Persistent power outages on campus greatly affected project timelines and deliverables.

6.3 Future Work

In the future work, we plan to enhance our visual tools by adding more features and more visual examples as shown in our initial prototype in the appendix section. We also plan to do a second stage statistical evaluation of our MLS in two Universities, one in Nigeria and the other in Cameroon. We will add more exercises for better performance evaluation as well as an online chatting tool which we left out due to time constraint. The chat tool will enhance online collaborative learning amongst students in discussing questions and solving exercises in real-time. We are also developing other simulators for example a Newton's Third Law (N3) simulator to simulate other physical phenomena such as action and reaction which is a much widely misunderstood concept amongst introductory level University students. We are also planning on developing a mobile version of the tools that can run on devices such as mobile phones, and tablet PCs which are becoming increasingly popular amongst students today.

Chapter 7

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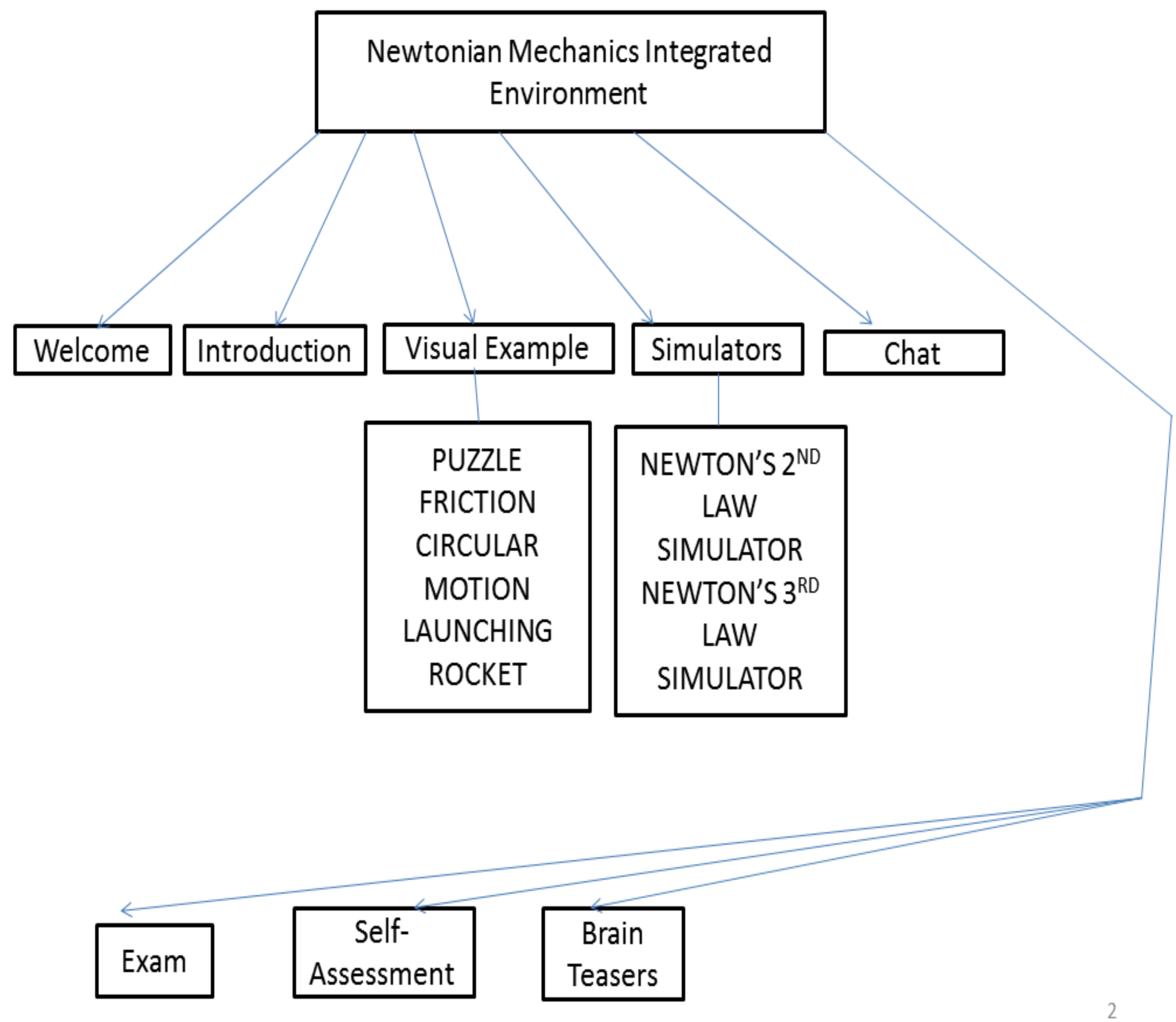
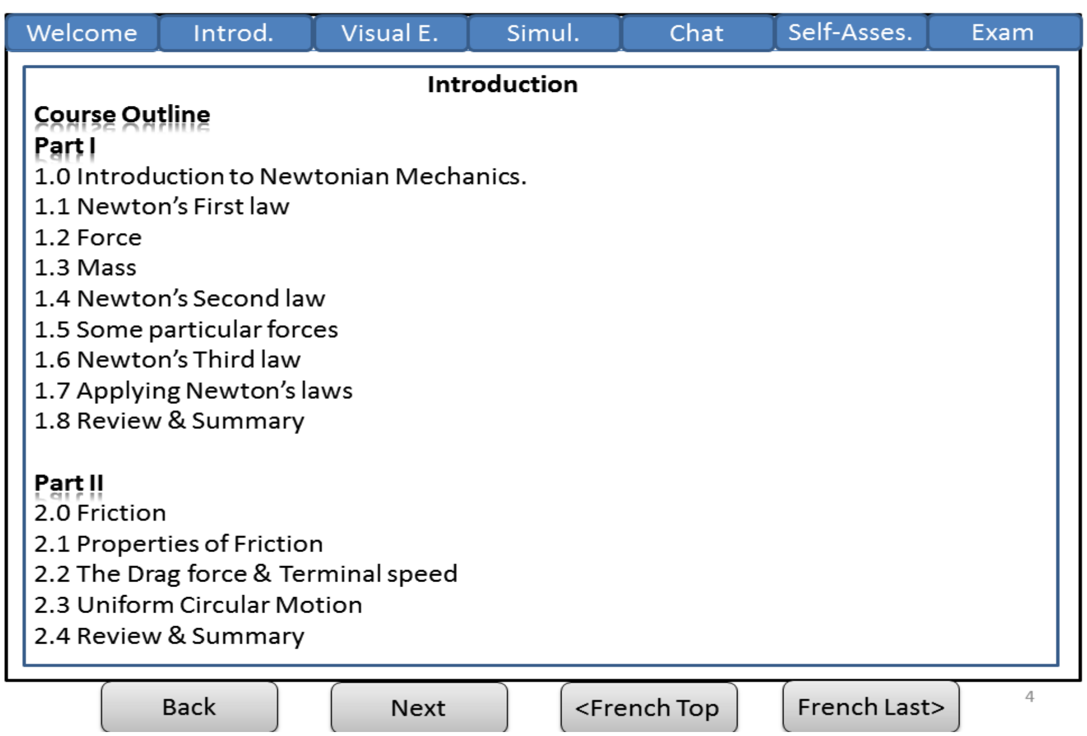
Chapter 8

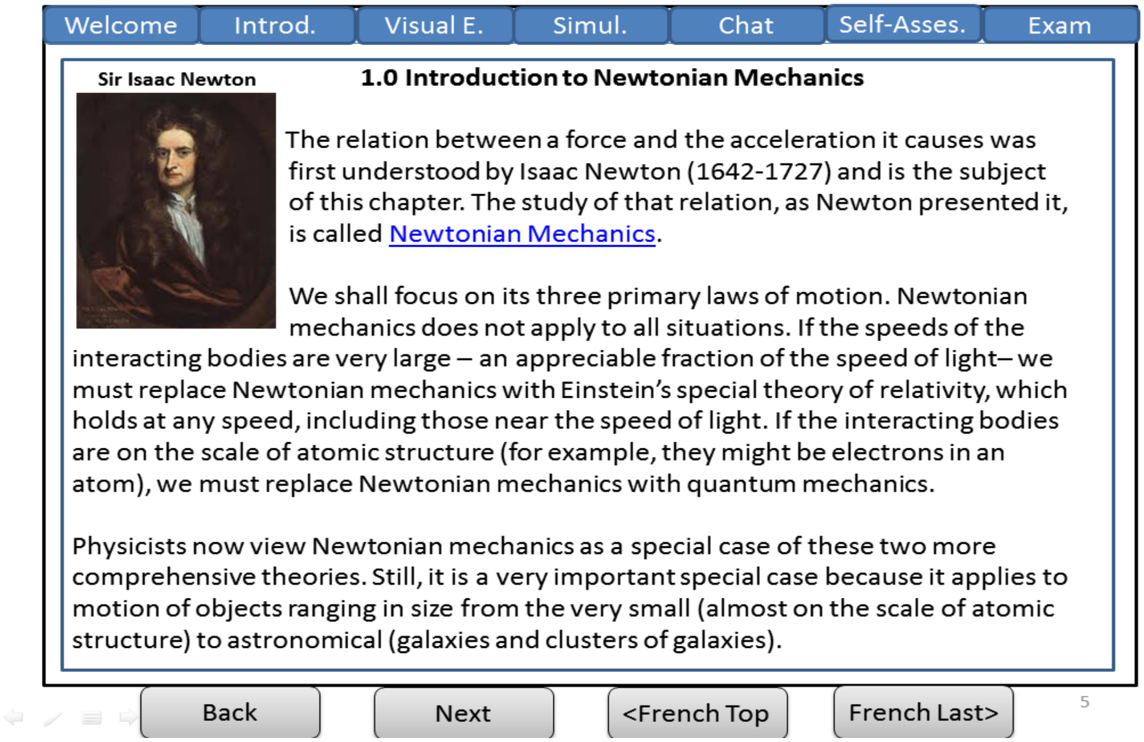
Appendix A

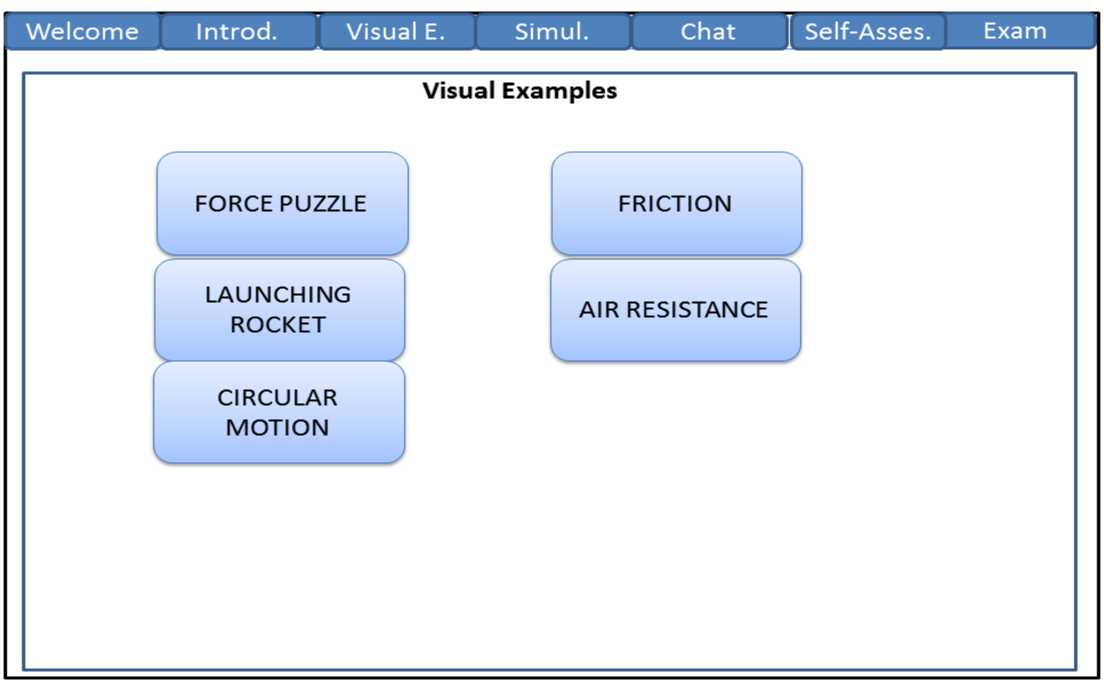
Prototype of MLS done in PowerPoint before actual design

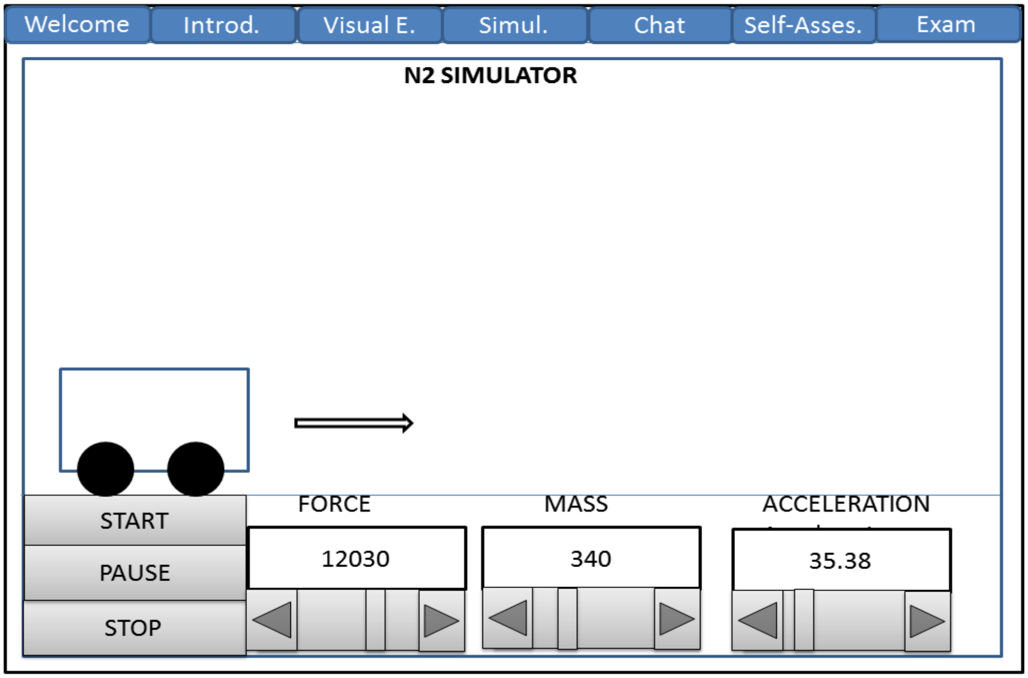



Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
Welcome Screen
Welcome Dear Friend,
"Learning can be much fun when done in the right way"
Arreytambe Tabot.
Enjoy
Newtonian Mechanics.
Next
3

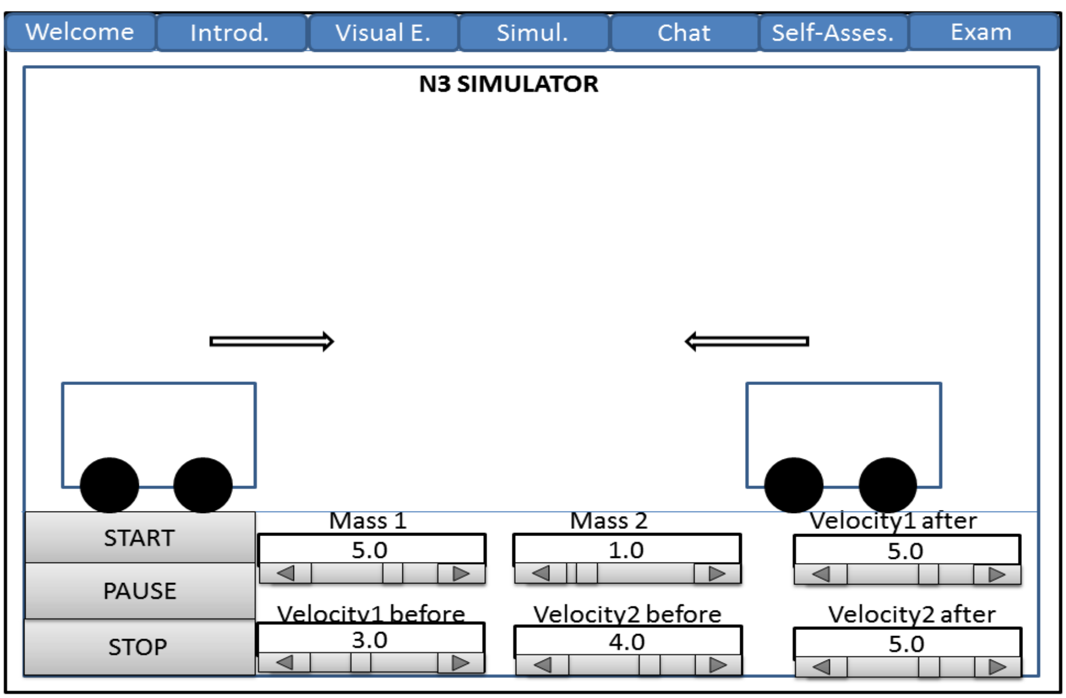

Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
Introduction
Course Outline
Part I
1.0 Introduction to Newtonian Mechanics.
1.1 Newton's First law
1.2 Force
1.3 Mass
1.4 Newton's Second law
1.5 Some particular forces
1.6 Newton's Third law
1.7 Applying Newton's laws
1.8 Review & Summary
Part II
2.0 Friction
2.1 Properties of Friction
2.2 The Drag force & Terminal speed
2.3 Uniform Circular Motion
2.4 Review & Summary
Back
Next
<French Top
French Last>
4


Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
Sir Isaac Newton
1.0 Introduction to Newtonian Mechanics
The relation between a force and the acceleration it causes was first understood by Isaac Newton (1642-1727) and is the subject of this chapter. The study of that relation, as Newton presented it, is called Newtonian Mechanics.
We shall focus on its three primary laws of motion. Newtonian mechanics does not apply to all situations. If the speeds of the interacting bodies are very large – an appreciable fraction of the speed of light– we must replace Newtonian mechanics with Einstein's special theory of relativity, which holds at any speed, including those near the speed of light. If the interacting bodies are on the scale of atomic structure (for example, they might be electrons in an atom), we must replace Newtonian mechanics with quantum mechanics.
Physicists now view Newtonian mechanics as a special case of these two more comprehensive theories. Still, it is a very important special case because it applies to motion of objects ranging in size from the very small (almost on the scale of atomic structure) to astronomical (galaxies and clusters of galaxies).
Back
Next
<French Top
French Last>
5

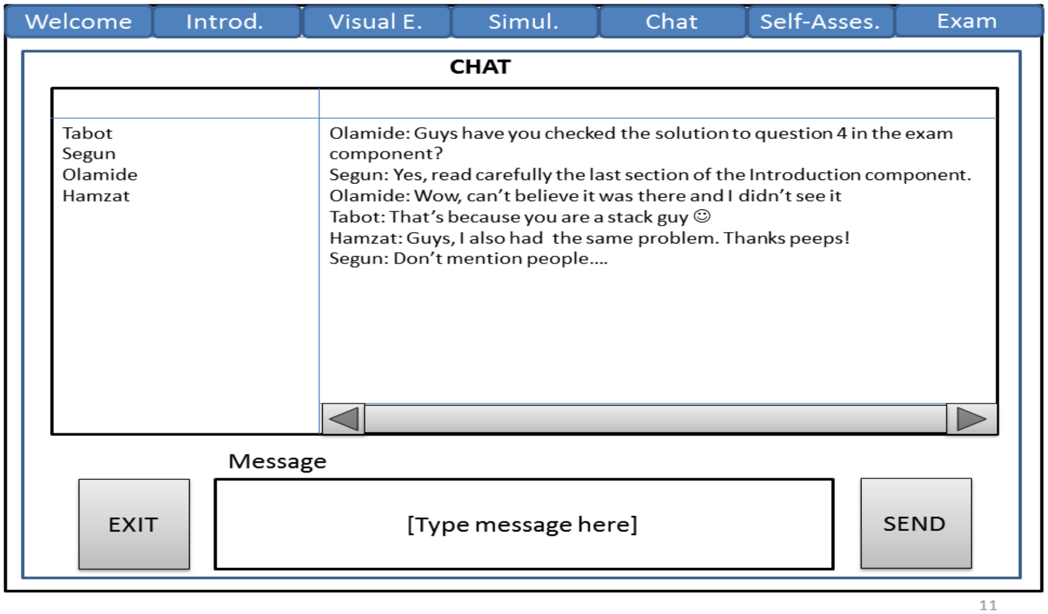

Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
Visual Examples
FORCE PUZZLE
FRICTION
LAUNCHING ROCKET
AIR RESISTANCE
CIRCULAR MOTION
6

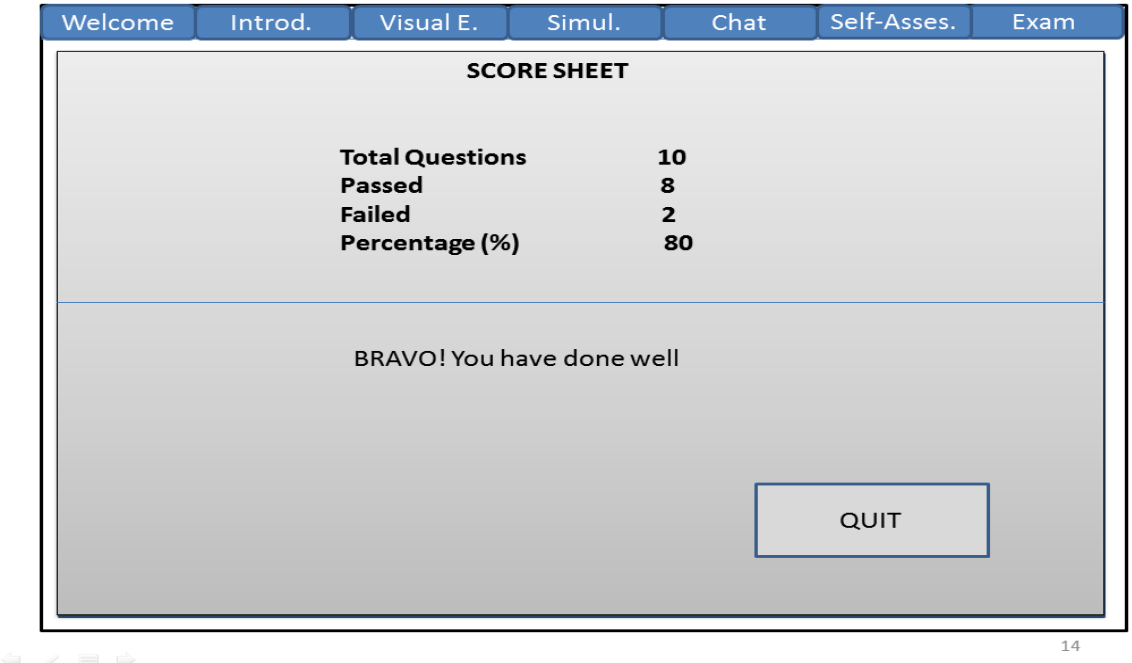

Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
N2 SIMULATOR
START
PAUSE
STOP
FORCE
12030
MASS
340
ACCELERATION
35.38

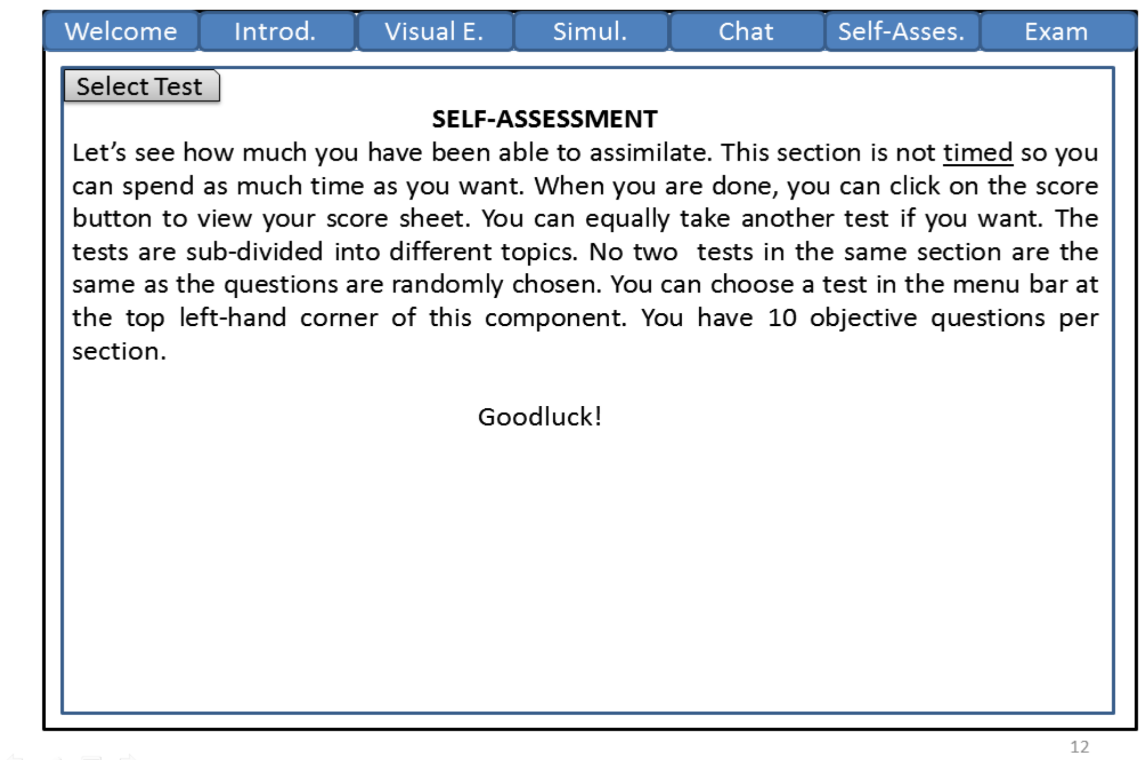
9

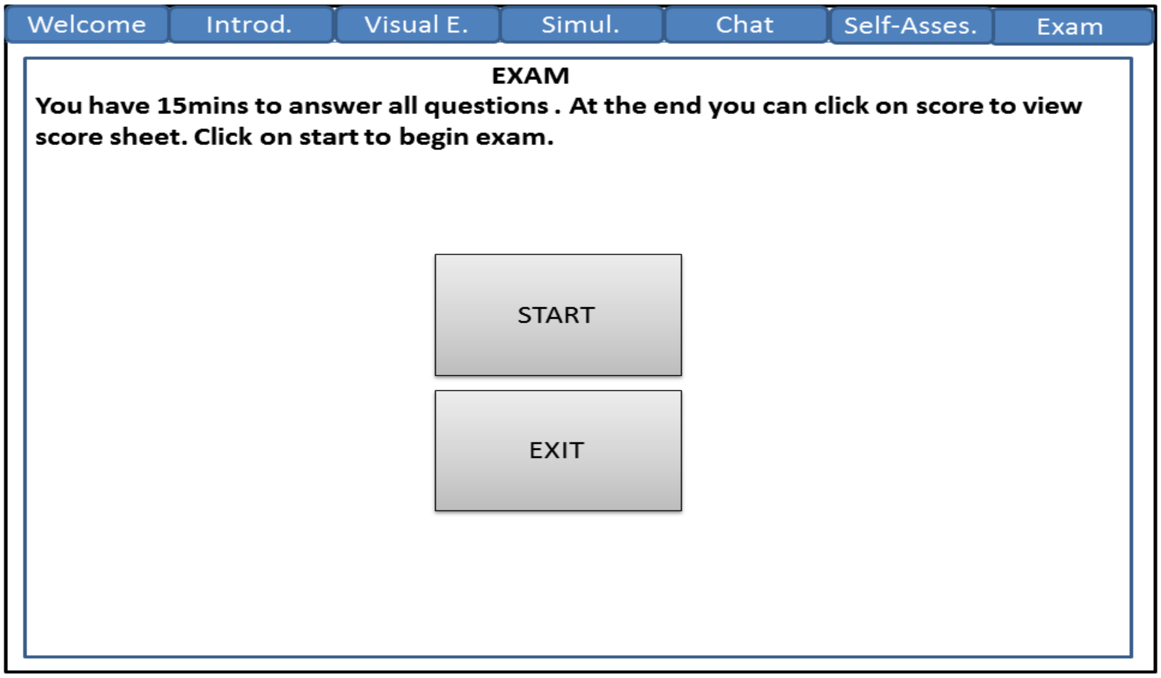

Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
N3 SIMULATOR
START
PAUSE
STOP
Mass 1
5.0
Mass 2
1.0
Velocity1 after
5.0
Velocity1 before
3.0
Velocity2 before
4.0
Velocity2 after
5.0

10

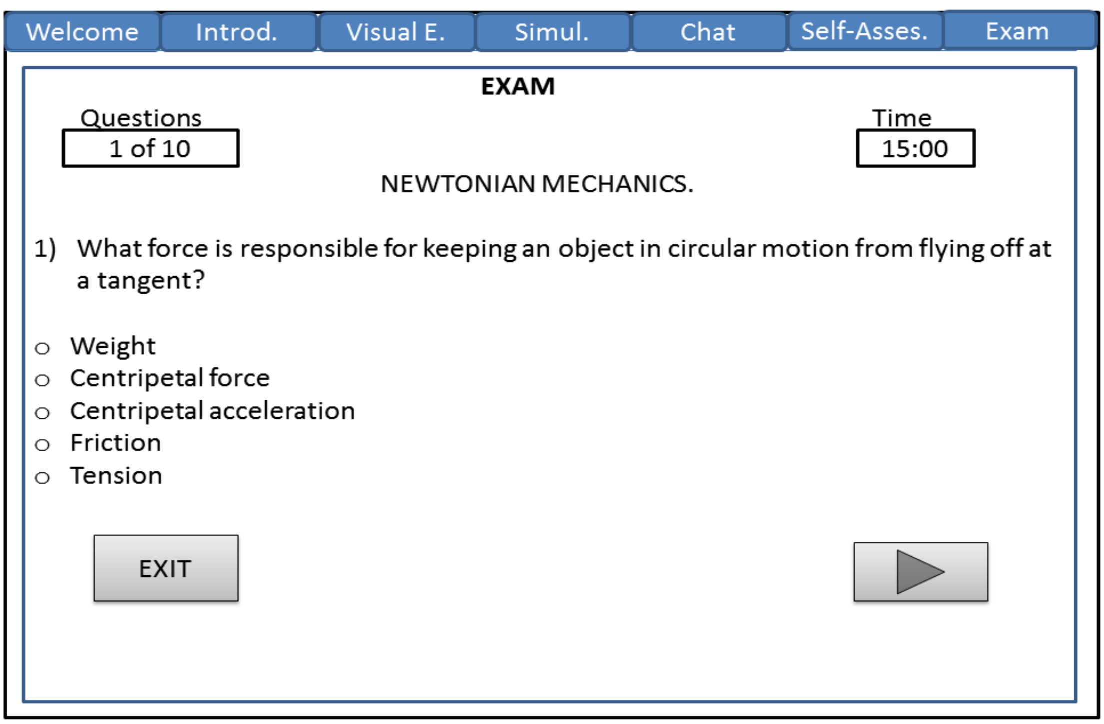

Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
CHAT
Tabot
Segun
Olamide
Hamzat
Olamide: Guys have you checked the solution to question 4 in the exam component?
Segun: Yes, read carefully the last section of the Introduction component.
Olamide: Wow, can't believe it was there and I didn't see it
Tabot: That's because you are a stack guy ☺
Hamzat: Guys, I also had the same problem. Thanks peeps!
Segun: Don't mention people….
Message
EXIT
[Type message here]
SEND
11


Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
SCORE SHEET
Total Questions 10
Passed 8
Failed 2
Percentage (%) 80
BRAVO! You have done well
QUIT
14


Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
Select Test
SELF-ASSESSMENT
Let's see how much you have been able to assimilate. This section is not timed so you can spend as much time as you want. When you are done, you can click on the score button to view your score sheet. You can equally take another test if you want. The tests are sub-divided into different topics. No two tests in the same section are the same as the questions are randomly chosen. You can choose a test in the menu bar at the top left-hand corner of this component. You have 10 objective questions per section.
Goodluck!
12


Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
EXAM
You have 15mins to answer all questions . At the end you can click on score to view score sheet. Click on start to begin exam.
START
EXIT

15


Welcome
Introd.
Visual E.
Simul.
Chat
Self-Asses.
Exam
EXAM
Questions
1 of 10
Time
15:00
NEWTONIAN MECHANICS.
1) What force is responsible for keeping an object in circular motion from flying off at a tangent?
Weight
Centripetal force
Centripetal acceleration
Friction
Tension
EXIT

16

Welcome | Introd. | Visual E. | Simul. | Chat | Self-Asses. | Exam

SCORE SHEET

Total Questions	**10**
Passed	**6**
Failed	**4**
Percentage (%)	**60**

Good, but you can do even better. Would you like to take another test?

Take another test | QUIT

17

Welcome | Introd. | Visual E. | Simul. | Chat | Exam | Self-Asses.

BRAIN TEASERS

THESE ARE QUESTIONS DESIGNED TO HELP THE LEARNER REFLECT ON THE APPLICATIONS OF WHAT HAS BEEN DONE IN EXPLAINING NATURAL PHENOMENA. **GROUP DISCUSSIONS ARE HIGHLY ENCOURAGED.**

1. The Great Pyramid, built about 4500 years ago, consists of about 2300000 stone blocks, most with a mass of 2000 to 3000kg. How did the engineers and workers manage to lift the stones into place to construct this pyramid, which is over 140m high?

18

Appendix B

Source Code for N2 Simulator

```
/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */
package newtonsforcesim;
/**
 *
 * @author Tabot
 */
public class Main {

    /**
     * @paramargs the command line arguments
     */
    public static void main(String[] args) {
        // Start the main frame application
java.awt.EventQueue.invokeLater(new Runnable() {
            public void run() {
AnimationPanel.createAndShowGUI();
            }
        });
```

```
    }

}

/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */

/*
 * MainFrame.java
 *
 * Created on 10-Nov-2011, 17:07:17
 */

package newtonsforcesim;

import javax.swing.JOptionPane;

/**
 *
 * @author Tabot
 */
```

```
public class MainFrame extends javax.swing.JFrame{



    /** Creates new form MainFrame */
    public MainFrame() {
initComponents();
    }

    /** This method is called from within the constructor to
     * initialize the form.
     * WARNING: Do NOT modify this code. The content of this method is
     * always regenerated by the Form Editor.
     */
    @SuppressWarnings("unchecked")
    // <editor-fold defaultstate="collapsed" desc="Generated Code">
    private void initComponents() {

panDisplay = new javax.swing.JPanel();
panNewtonVariables = new javax.swing.JPanel();
        jLabel1 = new javax.swing.JLabel();
txtForce = new javax.swing.JTextField();
sdrForce = new javax.swing.JSlider();
txtMass = new javax.swing.JTextField();
```

```
sdrMass = new javax.swing.JSlider();
        jLabel2 = new javax.swing.JLabel();
        jLabel5 = new javax.swing.JLabel();
txtAcceleration = new javax.swing.JTextField();
btnStart = new javax.swing.JButton();
btnStop = new javax.swing.JButton();
btnReset = new javax.swing.JButton();
        jMenuBar1 = new javax.swing.JMenuBar();
mnuFile = new javax.swing.JMenu();
mnuItemStart = new javax.swing.JMenuItem();
mnuItemStop = new javax.swing.JMenuItem();
mnuItemReset = new javax.swing.JMenuItem();
        jSeparator1 = new javax.swing.JPopupMenu.Separator();
mnuItemExit = new javax.swing.JMenuItem();
mnuHelp = new javax.swing.JMenu();
mnuItemHelp = new javax.swing.JMenuItem();
mnuAbout = new javax.swing.JMenu();
mnuItemAbout = new javax.swing.JMenuItem();

        setDefaultCloseOperation(javax.swing.WindowConstants.DO_NOTHING_ON_CLOSE);
setTitle("NEWTON'S SECOND LAW SIMULATOR");
setResizable(false);
addWindowListener(new java.awt.event.WindowAdapter() {
```

```
        public void windowClosing(java.awt.event.WindowEventevt) {
formWindowClosing(evt);
        }
      });

panDisplay.setLayout(null);

      panNewtonVariables.setBorder(javax.swing.BorderFactory.createEtchedBorder());

      jLabel1.setFont(new java.awt.Font("Tahoma", 1, 14));
      jLabel1.setText("Force");

txtForce.setEditable(false);
txtForce.setFont(new java.awt.Font("Tahoma", 0, 14));
txtForce.setText("0");

sdrForce.setFont(new java.awt.Font("Tahoma", 1, 12));
sdrForce.setMajorTickSpacing(10);
sdrForce.setMaximum(50);
sdrForce.setMinorTickSpacing(1);
sdrForce.setPaintLabels(true);
sdrForce.setPaintTicks(true);
sdrForce.setValue(0);
```

```
sdrForce.addChangeListener(new javax.swing.event.ChangeListener() {
        public void stateChanged(javax.swing.event.ChangeEventevt) {
sdrForceStateChanged(evt);
        }
    });


txtMass.setEditable(false);
txtMass.setFont(new java.awt.Font("Tahoma", 0, 14));
txtMass.setText("5");


sdrMass.setFont(new java.awt.Font("Tahoma", 1, 12));
sdrMass.setMajorTickSpacing(5);
sdrMass.setMaximum(20);
sdrMass.setMinimum(5);
sdrMass.setMinorTickSpacing(1);
sdrMass.setPaintLabels(true);
sdrMass.setPaintTicks(true);
sdrMass.setValue(5);
sdrMass.addChangeListener(new javax.swing.event.ChangeListener() {
        public void stateChanged(javax.swing.event.ChangeEventevt) {
sdrMassStateChanged(evt);
        }
    });
```

```
    jLabel2.setFont(new java.awt.Font("Tahoma", 1, 14));
    jLabel2.setText("Mass");

    jLabel5.setFont(new java.awt.Font("Tahoma", 1, 14));
    jLabel5.setText("Accelaration");

txtAcceleration.setEditable(false);
txtAcceleration.setFont(new java.awt.Font("Tahoma", 0, 14)); // NOI18N
txtAcceleration.setText("0");

javax.swing.GroupLayoutpanNewtonVariablesLayout = new
javax.swing.GroupLayout(panNewtonVariables);
panNewtonVariables.setLayout(panNewtonVariablesLayout);
panNewtonVariablesLayout.setHorizontalGroup(

panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADIN
G)
        .addGroup(panNewtonVariablesLayout.createSequentialGroup()

.addGroup(panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignme
nt.LEADING)
              .addGroup(panNewtonVariablesLayout.createSequentialGroup()
```

```
.addGap(79, 79, 79)
.addComponent(jLabel1, javax.swing.GroupLayout.PREFERRED_SIZE, 43,
javax.swing.GroupLayout.PREFERRED_SIZE)
.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
.addComponent(txtForce, javax.swing.GroupLayout.PREFERRED_SIZE, 90,
javax.swing.GroupLayout.PREFERRED_SIZE)
.addGap(57, 57, 57)

.addGroup(panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignme
nt.LEADING)
.addGroup(panNewtonVariablesLayout.createSequentialGroup()
.addGap(68, 68, 68)
.addComponent(jLabel2, javax.swing.GroupLayout.PREFERRED_SIZE, 43,
javax.swing.GroupLayout.PREFERRED_SIZE)

.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
.addComponent(txtMass, javax.swing.GroupLayout.PREFERRED_SIZE,
104, javax.swing.GroupLayout.PREFERRED_SIZE)

.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED, 65,
Short.MAX_VALUE)
.addComponent(jLabel5)
```

```
.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
        .addComponent(txtAcceleration,
javax.swing.GroupLayout.PREFERRED_SIZE, 84,
javax.swing.GroupLayout.PREFERRED_SIZE)
        .addGap(17, 17, 17))
      .addGroup(panNewtonVariablesLayout.createSequentialGroup()
        .addComponent(sdrMass, javax.swing.GroupLayout.PREFERRED_SIZE,
233, javax.swing.GroupLayout.PREFERRED_SIZE)

.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED, 229,
Short.MAX_VALUE))))
    .addGroup(panNewtonVariablesLayout.createSequentialGroup()
      .addContainerGap()
      .addComponent(sdrForce, javax.swing.GroupLayout.PREFERRED_SIZE, 233,
javax.swing.GroupLayout.PREFERRED_SIZE)))
    .addContainerGap())
  );

  panNewtonVariablesLayout.linkSize(javax.swing.SwingConstants.HORIZONTAL, new
java.awt.Component[] {txtForce, txtMass});
```

```
panNewtonVariablesLayout.linkSize(javax.swing.SwingConstants.HORIZONTAL, new java.awt.Component[] {jLabel1, jLabel2});

panNewtonVariablesLayout.linkSize(javax.swing.SwingConstants.HORIZONTAL, new java.awt.Component[] {sdrForce, sdrMass});

panNewtonVariablesLayout.setVerticalGroup(

panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
        .addGroup(panNewtonVariablesLayout.createSequentialGroup()
            .addContainerGap()

.addGroup(panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)

.addGroup(panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
                .addGroup(panNewtonVariablesLayout.createSequentialGroup()

.addGroup(panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
```

```
.addComponent(txtMass, javax.swing.GroupLayout.PREFERRED_SIZE, javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
.addComponent(jLabel2, javax.swing.GroupLayout.PREFERRED_SIZE, 30, javax.swing.GroupLayout.PREFERRED_SIZE)
.addComponent(jLabel5, javax.swing.GroupLayout.PREFERRED_SIZE, 30, javax.swing.GroupLayout.PREFERRED_SIZE)
.addComponent(txtAcceleration, javax.swing.GroupLayout.PREFERRED_SIZE, javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE))
.addGap(52, 52, 52))
.addGroup(javax.swing.GroupLayout.Alignment.TRAILING, panNewtonVariablesLayout.createSequentialGroup()
.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED, 36, javax.swing.GroupLayout.PREFERRED_SIZE)
.addComponent(sdrMass, javax.swing.GroupLayout.PREFERRED_SIZE, javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)))
.addGroup(panNewtonVariablesLayout.createSequentialGroup()

.addGroup(panNewtonVariablesLayout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE)
.addComponent(txtForce, javax.swing.GroupLayout.PREFERRED_SIZE, javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
```

```
                .addComponent(jLabel1, javax.swing.GroupLayout.PREFERRED_SIZE, 30,
javax.swing.GroupLayout.PREFERRED_SIZE))
              .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.RELATED)
              .addComponent(sdrForce, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)))
          .addContainerGap(javax.swing.GroupLayout.DEFAULT_SIZE,
Short.MAX_VALUE))
    );

btnStart.setFont(new java.awt.Font("Tahoma", 1, 14));
btnStart.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/tick.png"))); // NOI18N
btnStart.setText("Start");
btnStart.setIconTextGap(8);
btnStart.addActionListener(new java.awt.event.ActionListener() {
      public void actionPerformed(java.awt.event.ActionEventevt) {
btnStartActionPerformed(evt);
      }
    });

btnStop.setFont(new java.awt.Font("Tahoma", 1, 14));
btnStop.setIcon(new javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/icon-16-
cpanel.png"))); // NOI18N
```

```
btnStop.setText("Pause");
btnStop.setEnabled(false);
btnStop.setIconTextGap(8);
btnStop.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEventevt) {
btnStopActionPerformed(evt);
        }
    });

btnReset.setFont(new java.awt.Font("Tahoma", 1, 14));
btnReset.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/undo.gif"))); // NOI18N
btnReset.setText("Reset");
btnReset.setIconTextGap(8);
btnReset.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEventevt) {
btnResetActionPerformed(evt);
        }
    });

mnuFile.setMnemonic('F');
mnuFile.setText("File");
```

```
mnuItemStart.setAccelerator(javax.swing.KeyStroke.getKeyStroke(java.awt.event.KeyEvent.VK
_S, java.awt.event.InputEvent.CTRL_MASK));
mnuItemStart.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/tick.png"))); // NOI18N
mnuItemStart.setMnemonic('S');
mnuItemStart.setText("Start");
mnuFile.add(mnuItemStart);


mnuItemStop.setAccelerator(javax.swing.KeyStroke.getKeyStroke(java.awt.event.KeyEvent.VK
_X, java.awt.event.InputEvent.CTRL_MASK));
mnuItemStop.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/icon-16-cpanel.png")));        //
NOI18N
mnuItemStop.setMnemonic('t');
mnuItemStop.setText("Stop");
mnuFile.add(mnuItemStop);


mnuItemReset.setAccelerator(javax.swing.KeyStroke.getKeyStroke(java.awt.event.KeyEvent.V
K_R, java.awt.event.InputEvent.CTRL_MASK));
```

```
mnuItemReset.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/undo.gif"))); // NOI18N
mnuItemReset.setMnemonic('R');
mnuItemReset.setText("Reset");
mnuFile.add(mnuItemReset);
mnuFile.add(jSeparator1);

mnuItemExit.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/remove.png"))); // NOI18N
mnuItemExit.setMnemonic('x');
mnuItemExit.setText("Exit");
mnuItemExit.addActionListener(new java.awt.event.ActionListener() {
            public void actionPerformed(java.awt.event.ActionEventevt) {
mnuItemExitActionPerformed(evt);
            }
        });
mnuFile.add(mnuItemExit);

        jMenuBar1.add(mnuFile);

mnuHelp.setMnemonic('H');
mnuHelp.setText("Help");
```

```
mnuItemHelp.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/question-icon.gif")));          //
NOI18N
mnuItemHelp.setMnemonic('V');
mnuItemHelp.setText("View Help");
mnuItemHelp.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEventevt) {
mnuItemHelpActionPerformed(evt);
        }
    });
mnuHelp.add(mnuItemHelp);

    jMenuBar1.add(mnuHelp);

mnuAbout.setMnemonic('A');
mnuAbout.setText("About");

mnuItemAbout.setIcon(new
javax.swing.ImageIcon(getClass().getResource("/newtonsforcesim/question.gif"))); // NOI18N
mnuItemAbout.setMnemonic('N');
mnuItemAbout.setText("N2 Simulator");
mnuItemAbout.addActionListener(new java.awt.event.ActionListener() {
        public void actionPerformed(java.awt.event.ActionEventevt) {
```

```
mnuItemAboutActionPerformed(evt);
            }
        });
mnuAbout.add(mnuItemAbout);

        jMenuBar1.add(mnuAbout);

setJMenuBar(jMenuBar1);

javax.swing.GroupLayout layout = new javax.swing.GroupLayout(getContentPane());
getContentPane().setLayout(layout);
layout.setHorizontalGroup(
            layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
            .addGroup(javax.swing.GroupLayout.Alignment.TRAILING,
layout.createSequentialGroup()
                .addContainerGap()

.addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.TRAILING)
                    .addComponent(panDisplay,          javax.swing.GroupLayout.Alignment.LEADING,
javax.swing.GroupLayout.DEFAULT_SIZE, 770, Short.MAX_VALUE)
                    .addGroup(layout.createSequentialGroup()
                        .addComponent(btnStart)
```

```
.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                    .addComponent(btnStop)

.addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)
                    .addComponent(btnReset))
                .addComponent(panNewtonVariables, javax.swing.GroupLayout.DEFAULT_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, Short.MAX_VALUE))
            .addContainerGap())
    );
layout.setVerticalGroup(
        layout.createParallelGroup(javax.swing.GroupLayout.Alignment.LEADING)
        .addGroup(javax.swing.GroupLayout.Alignment.TRAILING,
layout.createSequentialGroup()
            .addContainerGap()
            .addComponent(panDisplay, javax.swing.GroupLayout.DEFAULT_SIZE, 232,
Short.MAX_VALUE)
            .addGap(18, 18, 18)
            .addComponent(panNewtonVariables, javax.swing.GroupLayout.PREFERRED_SIZE,
javax.swing.GroupLayout.DEFAULT_SIZE, javax.swing.GroupLayout.PREFERRED_SIZE)
            .addPreferredGap(javax.swing.LayoutStyle.ComponentPlacement.UNRELATED)

.addGroup(layout.createParallelGroup(javax.swing.GroupLayout.Alignment.BASELINE, false)
```

```
                .addComponent(btnReset, javax.swing.GroupLayout.PREFERRED_SIZE, 27, javax.swing.GroupLayout.PREFERRED_SIZE)
                .addComponent(btnStop)
                .addComponent(btnStart, javax.swing.GroupLayout.PREFERRED_SIZE, 38, javax.swing.GroupLayout.PREFERRED_SIZE))
            .addContainerGap())
        );

layout.linkSize(javax.swing.SwingConstants.VERTICAL, new java.awt.Component[] {btnReset, btnStart, btnStop});

java.awt.DimensionscreenSize = java.awt.Toolkit.getDefaultToolkit().getScreenSize();
setBounds((screenSize.width-806)/2, (screenSize.height-488)/2, 806, 488);
    }// </editor-fold>

    private void formWindowClosing(java.awt.event.WindowEventevt) {
        // Exit frame
int reply = JOptionPane.showConfirmDialog(this, "Do you really want to quit?", "Quit", JOptionPane.YES_NO_OPTION, JOptionPane.QUESTION_MESSAGE);
        if(reply == JOptionPane.YES_OPTION){System.exit(0);}
    }

    private void mnuItemExitActionPerformed(java.awt.event.ActionEventevt) {
```

```
        // Exit frame
int reply = JOptionPane.showConfirmDialog(this, "Do you really want to quit?", "Quit", JOptionPane.YES_NO_OPTION, JOptionPane.QUESTION_MESSAGE);
        if(reply == JOptionPane.YES_OPTION){System.exit(0);}
    }

    private void mnuItemHelpActionPerformed(java.awt.event.ActionEventevt) {
        // show help dialog
JOptionPane.showMessageDialog(this, "To simulate Newton's Second Law do the following simple instructions:" +
                                    "\n-Use the sliders to select the force and mass of the car.\n-Click on start to run the simulator." +
                                    "\n-View the acceleration as you change the force and mass." +
                                    "\n-Click stop to end simulation and pause to keep simulation on hold." +
                                    "\n-Enjoy!",                    "Instructions", JOptionPane.INFORMATION_MESSAGE);
    }

    private void mnuItemAboutActionPerformed(java.awt.event.ActionEventevt) {
        // show about dialog
```

```
JOptionPane.showMessageDialog(null, "This simulator has been built to help learners understand by simulation" +
                                    "\nthe working of Newton's Second Law of Motion. The simulator was designed\nand built using Java. It is a simple tool" +
                                    " that will provide a deeper understanding \nof Newtonian Mechanics.", "About Simulator", JOptionPane.INFORMATION_MESSAGE);
    }

    private void sdrForceStateChanged(javax.swing.event.ChangeEventevt) {
        // syncronize the value of the slider with force textfield
        String strForce = Integer.toString(sdrForce.getValue());
txtForce.setText(strForce);
    }

    private void sdrMassStateChanged(javax.swing.event.ChangeEventevt) {
        // syncronize the value of the slider with mass textfield
        String strMass = Integer.toString(sdrMass.getValue());
txtMass.setText(strMass);
    }

    private void btnStartActionPerformed(java.awt.event.ActionEventevt) {
        // Initialize the start procedure
        try{
```

```
intiAccl = (sdrForce.getValue()/sdrMass.getValue());
            String strAccl = Integer.toString(iAccl);
txtAcceleration.setText(strAccl);
            if(iAccl != 0){
btnStart.setEnabled(false);
AnimationPanel.getAnimator().framesPerSecond.setValue(iAccl);
AnimationPanel.getAnimator().startAnimation();
btnStop.setEnabled(true);
            }else{
JOptionPane.showMessageDialog(this, "Please select a value for Force", "Error", JOptionPane.ERROR_MESSAGE);
            }
        }catch(Exception ex){
JOptionPane.showMessageDialog(this, ex.toString(), "Error", JOptionPane.ERROR_MESSAGE);
        }
    }

    private void btnStopActionPerformed(java.awt.event.ActionEventevt) {
        // Initialize the stop procedure
AnimationPanel.getAnimator().stopAnimation();
btnStop.setEnabled(false);
btnStart.setEnabled(true);
```

```
    }


    private void btnResetActionPerformed(java.awt.event.ActionEventevt) {
        // Initialize the reset procedure
sdrForce.setValue(0);
sdrMass.setValue(5);
txtAcceleration.setText("0");
this.btnStopActionPerformed(evt);
AnimationPanel.getAnimator().framesPerSecond.setValue(0);
        AnimationPanel.getAnimator().picture.setIcon(AnimationPanel.getAnimator().images[0]);
    }



    // Variables declaration - do not modify
    private javax.swing.JButtonbtnReset;
    private javax.swing.JButtonbtnStart;
    private javax.swing.JButtonbtnStop;
    private javax.swing.JLabel jLabel1;
    private javax.swing.JLabel jLabel2;
    private javax.swing.JLabel jLabel5;
    private javax.swing.JMenuBar jMenuBar1;
    private javax.swing.JPopupMenu.Separator jSeparator1;
    private javax.swing.JMenumnuAbout;
```

```
    private javax.swing.JMenumnuFile;
    private javax.swing.JMenumnuHelp;
    private javax.swing.JMenuItemmnuItemAbout;
    private javax.swing.JMenuItemmnuItemExit;
    private javax.swing.JMenuItemmnuItemHelp;
    private javax.swing.JMenuItemmnuItemReset;
    private javax.swing.JMenuItemmnuItemStart;
    private javax.swing.JMenuItemmnuItemStop;
    public static javax.swing.JPanelpanDisplay;
    private javax.swing.JPanelpanNewtonVariables;
    private javax.swing.JSlidersdrForce;
    private javax.swing.JSlidersdrMass;
    public javax.swing.JTextFieldtxtAcceleration;
    private javax.swing.JTextFieldtxtForce;
    private javax.swing.JTextFieldtxtMass;
    // End of variables declaration

}

/*
 * To change this template, choose Tools | Templates
 * and open the template in the editor.
 */
```

```
package newtonsforcesim;


/**
 *
 * @author Tabot
 * Animation class
 */


import java.awt.*;
import java.awt.event.*;
import javax.swing.*;
import javax.swing.event.*;


public class AnimationPanel extends JPanel
                        implements ActionListener,
WindowListener,
ChangeListener {
    //Set up animation parameters.
    static final int FPS_MIN = 0;
    static final int FPS_MAX = 30;
    static final int FPS_INIT = 1;    //initial frames per second
```

```
    /**
     * @return the animator
     */
    public static AnimationPanelgetAnimator() {
        return animator;
    }

    /**
     * @paramaAnimator the animator to set
     */
    public static void setAnimator(AnimationPanelaAnimator) {
        animator = aAnimator;
    }
intframeNumber = 0;
int NUM_FRAMES = 75;
ImageIcon[] images = new ImageIcon[NUM_FRAMES];
int delay;
    Timer timer;
boolean frozen = false;
JSliderframesPerSecond;
   private static AnimationPanel animator;

    //This label uses ImageIcon to show the doggy pictures.
```

```
JLabel picture;
MainFramemfr = null;

  public AnimationPanel() {
setLayout(new BoxLayout(this, BoxLayout.PAGE_AXIS));

    delay = 1000 / FPS_INIT;

    //Create the label.
JLabelsliderLabel = new JLabel("Frames Per Second", JLabel.CENTER);
sliderLabel.setAlignmentX(Component.CENTER_ALIGNMENT);

    //Create the slider.
framesPerSecond = new JSlider(JSlider.HORIZONTAL,
                                        FPS_MIN, FPS_MAX, FPS_INIT);


framesPerSecond.addChangeListener(this);

    //Turn on labels at major tick marks.

framesPerSecond.setMajorTickSpacing(10);
framesPerSecond.setMinorTickSpacing(1);
```

```
framesPerSecond.setPaintTicks(true);
framesPerSecond.setPaintLabels(true);
framesPerSecond.setBorder(
BorderFactory.createEmptyBorder(0,0,10,0));
    Font font = new Font("Serif", Font.ITALIC, 15);
framesPerSecond.setFont(font);

    //Create the label that displays the animation.
    picture = new JLabel();
picture.setHorizontalAlignment(JLabel.CENTER);
picture.setAlignmentX(Component.CENTER_ALIGNMENT);
picture.setBorder(BorderFactory.createCompoundBorder(
BorderFactory.createLoweredBevelBorder(),
BorderFactory.createEmptyBorder(10,10,10,10)));
updatePicture(0); //display first frame

    //Put everything together.
setPreferredSize(new java.awt.Dimension(643, 384));
    add(sliderLabel);
    add(framesPerSecond);
    add(picture);
setBorder(BorderFactory.createEmptyBorder(10,10,10,10));
```

```
        //Set up a timer that calls this object's action handler.
        timer = new Timer(delay, this);
        //timer.setInitialDelay(delay * 7); //We pause animation twice per cycle
                                          //by restarting the timer
timer.setCoalesce(true);
sliderLabel.setVisible(false);
framesPerSecond.setVisible(false);
    }

    /** Add a listener for window events. */
    void addWindowListener(Window w) {
w.addWindowListener(this);
    }

    //React to window events.
    public void windowIconified(WindowEvent e) {
stopAnimation();
    }
    public void windowDeiconified(WindowEvent e) {
startAnimation();
    }
    public void windowOpened(WindowEvent e) {}
    public void windowClosing(WindowEvent e) {}
```

```
    public void windowClosed(WindowEvent e) {}

    public void windowActivated(WindowEvent e) {}

    public void windowDeactivated(WindowEvent e) {}


    /** Listen to the slider. */

    public void stateChanged(ChangeEvent e) {

JSlider source = (JSlider)e.getSource();

        if (!source.getValueIsAdjusting()) {

int fps = (int)source.getValue();

            if (fps == 0) {

                if (!frozen) stopAnimation();

            } else {

                delay = 1000 / fps;

timer.setDelay(delay);

timer.setInitialDelay(delay * 10);

                if (frozen) startAnimation();

            }

        }

    }


    public void startAnimation() {

        //Start (or restart) animating!

timer.start();
```

```
        frozen = false;
    }

    public void stopAnimation() {
        //Stop the animating thread.
timer.stop();
        frozen = true;
    }

    //Called when the Timer fires.
    public void actionPerformed(ActionEvent e) {
        //Advance the animation frame.
        if (frameNumber == (NUM_FRAMES - 1)) {
frameNumber = 0;
        } else {
frameNumber++;
        }

updatePicture(frameNumber); //display the next picture

        if ( frameNumber==(NUM_FRAMES - 1)
          || frameNumber==(NUM_FRAMES/2 - 1) ) {
timer.restart();
```

```
        }
    }

    /** Update the label to display the image for the current frame. */
    protected void updatePicture(intframeNum) {
        //Get the image if we haven't already.
        if (images[frameNumber] == null) {
            images[frameNumber] = createImageIcon("car"
                                             + frameNumber
                                             + ".gif");
        }

        //Set the image.
        if (images[frameNumber] != null) {
picture.setIcon(images[frameNumber]);
        } else { //image not found
picture.setText("image #" + frameNumber + " not found");
        }
    }

    /** Returns an ImageIcon, or null if the path was invalid. */
    protected static ImageIconcreateImageIcon(String path) {
        java.net.URL imgURL = AnimationPanel.class.getResource(path);
```

```
        if (imgURL != null) {
            return new ImageIcon(imgURL);
        } else {
System.err.println("Couldn't find file: " + path);
            return null;
        }
    }
    /**
     * Create the GUI and show it.  For thread safety,
     * this method should be invoked from the
     * event-dispatching thread.
     */
    public static void createAndShowGUI() {
        //Create and set up the window.
MainFrame frame = new MainFrame();
setAnimator(new AnimationPanel());

        //Add content to the window.
MainFrame.panDisplay.setLayout(new java.awt.BorderLayout());
MainFrame.panDisplay.add(getAnimator(), BorderLayout.CENTER);
MainFrame.panDisplay.validate();
MainFrame.panDisplay.repaint();
```

```
    //Display the window.
frame.pack();
frame.setVisible(true);
  }
}
```