EFFECTS OF COMPUTER-ASSISTED INSTRUCTION ON ACADEMIC ACHIEVEMENT AMONG NCE PHYSICS STUDENTS OF DIFFERENT ABILITIES IN NIGER STATE, NIGERIA.

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DECLARATION

I hereby declare that this thesis tiled EFFECTS OF COMPUTER-ASSISTED INSTRUCTION ON ACADEMIC ACHIEVEMENT AMONG NCE PHYSICS STUDENTS OF DIFFERENT ABILITIES IN NIGER STATE, NIGERIA is a collection of my original work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

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Alhaji Bida, DANJUMA Date

DEDICATION

This work is dedicated to the blessed memory of my late father Alhaji Yahaya Tetengi, my mother and step mother late Hajiya Aishatu Yahaya Tetengi and late Hajiya Hauwawu Cheko Yahaya Tetengi respectively, my uncle late Alhaji Muhammad Kudu and the entire members of Alhaji Yahaya Tetengi's family.

CERTIFICATION

The thesis;"EFFECTS OF COMPUTER-ASSISTED INSTRUCTION ON ACADEMIC ACHIEVEMENT AMONG NCE PHYSICS STUDENTS OF DIFFERENT ABILITIES IN NIGER STATE, NIGERIA" by Alhaji Bida DANJUMA, (M.ED/EDUC/3507/2009-2010) of Ahmadu Bello University, Zaria which is approved for its contribution to scientific knowledge and literary presentation.

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ABBREVIATIONS

CAI-	Computer- Assisted Instruction.
COE-	College of Education
FCE-	Federal College of Education
FME-	Federal Ministry of Education.
FUT-	Federal University of Technology
MPMAT-	Mechanics and Properties of Matter Achievement Test
NCCE-	National Commission for Colleges of Education
NCE-	Nigerian Certificate in Education
NECO-	National Examination Council
NERC`	National Educational Research Council
NIP-	National Institute of Physics
NTFTEP-	National Task Force on Teacher Education in Physics
PSI-	Personalized System of Instruction
RBITT-	Research Base Information on Timely Topics
STAN-	Science Teacher Association of Nigeria
WAEC-	West African Examination Council

OPERATIONAL DEFINITION OF TERMS

Computer Assisted Instruction: Is an interactive instructional technique whereby a computer is used to present the instructional material and monitor the learning that takes place.

Lecture Method: Is a traditional method of talk and chalk method of teaching in which the teacher does most of the talk, while students listen and write note.

Academic Achievement: Something has been accomplished by superior ability; special effort; Great courage; or a great or heroic deed; it is the art of achieving; attainment or accomplishment.

Low Ability Students: They are the group of students who performed poorly in tests, examinations and are easily distracted and less able to set about tasks in an organized manner, less able to control their own basic impulses and their destines.

Medium Ability Students: These are group of students who can only record an average achievement, not because they are not capable of doing better, but partly because they cannot put in extra effort to attain better achievement.

High Ability Students: These are students who did not ascribe their fate to luck or to vagaries of chance but rather to their own personal decisions and efforts.

ABSTRACT.

The study investigated the effect of computer- assisted instruction on academic achievement of Nigeria Certificate in Education Physics students of different abilities, in Niger State, Nigeria. Six research questions were raised and six null hypotheses were formulated to guide the study. The study adopted pretest and posttest quasi experimental control group design. Two hundred and eleven (211) NCE II students from the two colleges of education in Niger State were used as research sample. Purposive sampling techniques was used to choose the two schools while balloting method was employed to assign the colleges into experimental and control groups. The researcher developed computer- assisted instructional package on Mechanics and Properties of Matter which was used as treatment instrument for experimental group while control group were exposed to traditional (lecture) teaching method. The instrument for data collection was Mechanics and Properties of Matter Achievement Test (MPMAT) which was validated by experts in science education. A 40- items multiple choice objective type achievement test covering six topics in Mechanics and Properties of Matter was used to collect data for both pretest and posttest. A reliability coefficient of 0.78 was obtained using the data collected from pilot test and analyzed using Pearson's Product Moment Correlation Coefficient (r). The data of the first five hypotheses were analyzed using t- test and the sixth hypothesis was analyzed using one way Analysis Of Variance (ANOVA) statistics. The findings of this study revealed that experimental group performed better than the control group, no statistically significant difference in the performances of both male and female students taught using CAI which implies that it is gender friendly and there is no significant difference in the academic achievement among low, medium and high abilities taught using CAI. It was recommended among others, that Physics Lecturers should use computer software in teaching physics in order to enhance student's achievement in physics and Physics Lecturers should acquire computer literacy, so that he/she can develop any computer assisted instruction package.

CHAPTER ONE

THE PROBLEM

1.1 Introduction

The world is becoming more sophisticated technologically. The industrial age gave way to information age, an info-tech era which is as vital as the water we drink because this has brought positive changes to the society, business, education and other facets of human life. In fact, the educational sector is not exempted from the benefit of participation in an information-rich computerized society. To keep to date with the emerging technological changes at the national, regional and global environments, our present educational system is continuously upgrading its resources through the modernization of the various elements of the system. Modernization can be pursed through the introduction of modern instructional aides and materials such as multimedia gadgets like computers, CD-ROM, TV, internet among others (Caday, 2004). Linn (2003) stated that information and communication technology had had a convoluted but ultimately advantageous impact on science teaching.

Computers offer exciting approaches to teaching that were not even dreamt of two decades ago, but the extent to which the educational potential of computer technology will be realized remains to be seen (Amara, 2006). Computer technology has caught the attention of many researchers and educators and computer-based instructional applications are considered effective alternative to traditional teaching method (Yushau, 2006). Research findings explicitly reported that science education and computer technology had created a meaningful partnership over the century (Flick & Bell, 2000). Thomas (2001) argued that very little was known about the use of computer in science classrooms and its effects on students' learning. It is obvious that

the current trends in research all over the world involve the use of computer facilities and resources to enhance students' learning. This may be the reason why Handelsman, Ebert-May, Beichner, Bruns, Chang, Detloan, Gentile, Lauffer, Stewart, Tilghman and Wood (2004: 521) opined that "many exercises that depart from traditional method are now readily accessible on the web", even though teachers did not use these facilities. They further showed that the interactive approaches to teaching significantly enhanced learning. Computer and Science are inseparable transformational tool for increased productivity, income generation and security awareness.

Physics, which is one of the science subjects, is highly needed for our nation's technological breakthrough (Agommouoh & Nzewi, 2003). According to Okeke (1997), Physics is the heart of science and the hub of all technological activities. For a nation to develop a sound basis for modern technology, the study of Physics enhances an understanding of the inter-play of forces in nature and forms a veritable amour against superstition which muddles technological advancement anywhere (Agommuoh & Nzewi, 2003). In addition, Danjuma (2008) stated that Physics as the soul of science plays a vital role in all human endeavour and serves as a pre-requisite for courses such as medicine, geology, computer engineering, forestry, space navigation, agricultural science, pharmacy, among others.

Research findings of Bunkure (2007) indicated that CAI enhanced students' achievement in physics but teachers did not often use it. Rather they used lecture methods and thus, there is the need to try a new teaching strategy in line with global trends of using CAI, especially for science teaching. Advancement in science and technology has recently changed the education

systems in societies. The increasing importance of skilled persons not only as users of knowledge but producers of knowledge puts additional responsibilities on the educators of science, (Gonen, Kocakaya & Inan, 2006). In the same vein, Kadıoglu, 1996; Ayas & Ozmen, 1998; Ozmen, İbrahimoglu and Ayas (2000) stated that physics, chemistry and biology have many theoretical concepts that are difficult to understand by students, and if not properly taught, students will encounter a lot of misconceptions that may alter learning. It is also known that students do not or rarely link the knowledge gained from those sciences to their daily lives. In a related development, Şahin and Parim, (2002); Saka and Cerrah, (2004) stated that in education and learning process, traditional education and the existing educational materials neither helped to solve the existing problems nor assisted in the development of conceptual learning.

However, the researcher observed that the use of CAI instruction creates and sustains students' attention and curiosity in the learning process. The use of CAI is also likely to enhance the learning of Physics concepts. In addition, with the use of computers in education most of the knowledge which is related to natural phenomena is now available in the computer environment. This is why teachers should use computers as a teaching tool in order to give the students the ability to visualize in a three-dimensional form, the physical phenomena of some concepts (Soylu & İbiş, 1998).

Gender roles can be referred to as the roles and relationships between men and women in a given situation. On the issue of gender on students' achievement in science subjects, Shaibu and Mari (1994) found that there was no statistically significant difference between boys and girls' ability to solve problems requiring their understanding of process skills. Also James (2000), Olorukooba (2001) and Bichi (2002) in their various studies found that there was no statistically significant difference between boys' and girls'achievement in science with reference

to their exposure to activity-based method of instruction in science. Therefore, this study investigated the effect of CAI on gender among different ability levels of NCE Physics students in Niger State.

Lecture method is the teacher-centered method, which is seen as the traditional talk-chalk method of teaching. Here the teacher does the talking while students serve as receiver only by listening and taking down notes. Obeka (2009) described lecture method as a teacher-centered method. He further stressed that the method enhances acquisition of subject matter pre-dominantly under the memorization and close supervision of the students by the teacher. Lecture method is one of science teaching instructions that encourage rote learning and regurgitation of information without necessarily facilitating understanding, and this does not enhance academic achievement in science (James, 2000, Bichi, 2002 &Usman, 2008). Though this method has some disadvantages, teachers often use it. Therefore, there is need to try an alternative teaching strategy such as CAI in line with global trends.

There are students with different academic ability levels, which are categorized as low, medium and high ability levels. Students with marks from 0% to 39% are low-level ability; those with 40% to 69% are middle-level ability and those with 70% and above are high-level ability (Ofonime, 2007). According to Hummel andSprinthal, (1965) and Ashilley (2001), low level ability students are said to be the group of students who perform poorly in tests and examinations, are easily distracted, less able to set about tasks in an organized manner and less able to control their own basic impulses and their destines. Ofonime (2007) also described the low-level ability students as students whose academic potentials are judged below class average while their achievement is described as poor. On the other hand, the high-level ability students were referred to by Collia (2002) as those students who did not ascribe their fate to luck or to

vagaries of chance but rather to their own personal decisions and efforts. Ofonime (2007) further stressed that the high-level ability students as whose academic potentials are above class average and their achievement described as good. Some studies were carried out on teaching strategy on academic achievement without considering ability level on how CAI would enhance students' achievement at NCE level while other studies were focussed on SSS. The Computer-Assisted Instruction (CAI) was used in this study to see whether it would improve the academic achievement of NCE physics students of different ability levels.

1.1.1 Theoretical Framework

The theoretical basis that guided this study on the effect of computer-assisted instruction on academic achievement among NCE Physics students of different ability levels is the constructivism theory of learning. Constructivism which means the ability of an individual to construct ideas can be applied to the use of computers to enable the students learn some concepts like the structure of atom, wave formation and many other related concepts. Thus, students can learn best when they actively construct through their own understanding. In fact, CAI can help students to build meaningful relation between what they know and what they are setting out to learn. Constructivists consider learning to be a result of mental construction although students learn by fitting new information together with what they already know. However, Vygotskii (1978) observed that we can distinguish between "Cognitive Constructivism" which is about how the individual learner understands things, in terms of developmental stages and learning styles, and "Social Constructivism" which emphasizes how meanings and understanding grow out of social encounters. Thus, Constructivism can be described as a dynamic and interactive conception of human learning which essentially holds the view that scientific knowledge is

personally constructed and reconstructed by the learners, based on their experiences. This is because learners bring to the class ideas which affect new information they receive and what they learn. Therefore, learning results from interaction between their previous knowledge and what is experienced during learning. Thus, in the constructivist model of instruction, students redefine, reorganize, elaborate and change their initials concepts through interaction among themselves and their environment (Nwosu, 2003). The experiences involved in CAI require that students redefine, reorganize, elaborate and change their initial concepts through interaction with computers which agree with the constructivist theory.

Therefore, the researcher used Computer-Assisted Instruction (CAI) to investigate its effect on the academic achievement of Physics students of different ability levels at NCE in Niger State, Nigeria.

1.2 Statement of the Problem

Generally, poor achievement of students in the science subjects has been a subject of concern to many stakeholders in education (Olorundare, 1993 & Olatoye, 2002). According to West African Examinations Council's (WAEC 2006, 2007 & 2008) examiners reported low enrolment and poor achievement of secondary school students in science subjects. In addition, most of the Physics teachers at secondary school levels were NCE teachers. The achievement of Physics students in the external examinations conducted by WAEC or NECO were largely disappointing as revealed in the reports of WAEC chief Examiners often (Ogunneye, 2003).

Available evidence shows that not much work has been done on the effect of using Computer-Assisted Instruction (CAI) on academic achievement in science with regard to the ability levels of students. And therefore, without considering ability levels of students, poor

academic achievement in Physics may still persist. Many studies in published literature indicated that there was a strong relationship between the use of computers and students' academic achievements in teaching and learning processes (Altun, Yigit & Alev, 2007). For instance, Yigit (2005) found in his study that computer-assisted instruction had positive impact on students' perception about computer-supported instruction as well as on to their academic achievement. Therefore, the problem of this study is to look at the effect of Computer-Assisted Instruction (CAI) on the academic achievement of NCE Physics students in relation to their ability levels in Niger State, Nigeria.

1.3 Objectives of the Study

The study was designed to determine:

1 Whether there is any difference in academic achievement of Physics students taught with CAI and those taught with lecture method at NCE level.

2 If there is any difference in academic achievement between low ability level Physics students taught with CAI and those taught with lecture method at NCE level.

3 Whether there is any difference in academic achievement between medium ability level Physics students taught with CAI and those taught with lecture method at NCE level.

4 If there is any difference in academic achievement between high ability level Physics students taught with CAI and those taught with lecture method at NCE level.

5 If there is gender difference in academic achievement between Physics students taught using CAI at NCE level.

6 Whether there is any difference in academic achievement among Low Ability (LA), Medium Ability (MA) and High Ability (HA) level Physics students taught with CAIat NCE level.

1.4 Research Questions

The following research questions were set for answering;

(1) What is the difference between academic achievement of Physics students taught using CAI and those taught using lecture method at NCE leve?

(2) Is there any difference in academic achievement between low ability level Physics students taught using CAI and those taught using lecture method at NCE level?

(3) What is the difference in the academic achievement between medium ability Physics students taught with CAI and those taught with Lecture method at NCE level?

(4) Is there any difference in the academic achievement between high ability Physics students taught with CAI and those taught with Lecture method at NCE level?

(5) What is the difference in the academic achievement between male and female Physics students taught with CAI at NCE level?

(6) Is there any difference in the academic achievement among low ability (LA), medium ability (MA) and high ability (HA) level students taught with CAI at NCE level?

1.5 Hypotheses

The following hypotheses were formulated at 0.5 level of significance to answer the stated research questions,

H_{01}: There is no significant difference in the academic achievement between Physics students taught using CAI and those taught using Lecture method in Physics at NCE level.

H_{02}: There is no significant difference in the academic achievement between low ability students taught using CAI and those taught using Lecture method in Physics at NCE level.

H_{03}: There is no significant difference in the academic achievement between medium ability students taught using CAI and those taught using Lecture method in Physics at NCE level.

H_{04}: There is no significant difference in the academic achievement between high ability students taught using CAI and those taught using Lecture method in Physics at NCE level.

H_{05}: There is no significant difference in the academic achievement between male and female students taught using CAI in Physics at NCE level.

H_{06}: There is no significant difference in the academic achievement among low ability, medium ability and high abilitystudents taught using CAI in Physics at NCE level

1.6 Significance of the Study

The findings of the study would hopefully uplift the standard of Physics education in the following ways:

The study would contribute to the improvement of teaching and learning of Physics in Nigeria's institutions of learning. That is to say it would help to improve teacher effectiveness and confidence in the classroom during instruction and hence improve students' achievement in Physics concepts.

It would promote further research. For example National Institute of Physics (NIP), National Educational Research Council (NERC), Science Teacher Association of Nigeria (STAN) and private individuals that carry out research, discuss and disseminate research findings might wish to consider the result of this research work with a view to using the CAI to promote further research.

It would encourage active participation of the students in teaching and learning of Physics which would lead to meaningful learning outcomes, to stimulate the curriculum developers and administrators to encourage lecturers in all subject areas to acquire skills and attitude for developing CAI instructional materials for teaching, to enable administrators of higher institutions to organize and sponsor workshops, seminars and in-service trainings for their lecturers with a view to making use of CAI as one of the methods of teaching at NCE level.

Learning difficulties may be reduced using CAI and this will help to remove the abstractness of some concepts. Fellow researchers will benefit from the findings of this study by gaining access to recent literature and to be acquainted with present solutions of using CAI in teaching Physics at NCE level. This study would also serve as a foundation for further studies in the teaching of Physics.

1.7 Delimitation of the Study

The study was delimited to two colleges of education in Niger State i.e. Federal College of Education, Kontagora and Niger State College of Education, Minna, because they are the only Colleges of Education in the state. The Colleges selected were accredited by National Commission for Colleges of Education (NCCE) and were similar in terms of academic activities, quality of staff and infrastructure. The study was limited to Physics students in NCE II (200

Level) of the two Colleges of Education under study.The study was also limited to Mechanics and Properties of Matter with the following concepts: Inertial of Rigid body, Energy and Gyration of Rigid body, Angular Momentum, Gravitation, Surface Tension and Oscillatory and Circular Motion.

1.8 Basic Assumptions

For the purpose of this study, the following assumptions were made:

1. Computer Assisted Instruction is not used in teaching physics in the selected schools.
2. The study sample i.e NCE II students of different ability levels have been taught by qualified physics teachers.
3. The concept under study have been taught using NCCE minimum standard syllabus.
4. The Colleges are homogenous in the area of provision of equipment, instructional materials, staff qualification, motivation and students enrolment.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This study aimed at assessing the effects of Computer-Assisted Instruction on the academic achievement of different ability levels in Nigeria Certificate in Education Physics students in Niger State. In this chapter, the researcher reviewed related literature to the study undertaken under the following sub-headings.

- Physics as a Teaching Subject at Secondary School Level.
- Science Teaching Strategies.
- Science Teaching Strategies and Academic Achievement in Science
- Computer - Assisted Instruction (CAI)
- Conventional Lecture Method.
- Concept of Ability Levels
- Ability Levels and Students Academic Achievement in Science.
- Gender and Academic Achievement in Science.
- Overview of Similar Studies on CAI and Academic Achievement in Physics.
- Implications of Literature Reviewed on the Present Study

2.2 Physics as a Teaching Subject at Secondary School

Physics is a physical science that deals with the study of matter in relationship with energy. It has many branches that include mechanics, optics, heat, electricity, magnetism, nuclear physics, solar energy, plasma physics to mention but few. There is a very close association between physics and the four basic needs of man, which includes food, shelter, medical services

and security (KanKia, 2007). Ogunniyi in Olugbenga and Atadoga, (2007) stated that the objectives of teaching physics in Nigerian secondary included: the development of the spirit of inquiry, the understanding or holding valid view of the nature of science, imparting of scientific literacy, the transformation of the environment and production of individuals who are self-reliant. These objectives also enable students to acquire sufficient proficiency in Physics education to enable them to progress as effectively as possible in all subjects in the school curriculum.

Adeyanju (2006) asserted that Physics maintains a leading position among other educational disciplines because knowledge and good achievements at it are necessary for a study in information communication and technology, which is much sought after the world over. Physics is also a prerequisite for studying any discipline in science (pure and applied), engineering and the environment. These among others underscore the importance of this subject. Olugbenga and Atadoga (2007) said that Physics is one of the important science subjects for further career development in science related disciplines. The wholistic educational development of our children will be crippled by their inability to pass Physics.

According to Leake (1982), in Nigeria as well as in most developing countries, Physics is considered an important subject and is taught during the last three years of the secondary school level, as a single subject. Notwithstanding the importance of physics to technological development, students in secondary schools tend to show a negative (poor) attitude towards it. Ayuba (2010) stated that Physics is the bedrock for scientific and technological advancement, the development of manpower in the country and it will be impossible to have a sound knowledge of

the subject if it is not properly taught and learnt in the nation's secondary schools. The National Task Force on Teacher Education in Physics (NTFTEP) 2010 notes that without a strong Physics education, differences in middle school science achievement between students in the U.S and in other industrialized nations cannot be bridged easily during the high school years especially in view of our anaemic production of well qualified Physics teachers. The need to study Physics as expressed by Owolabi (1999) is that the secondary school Physics curriculum was developed to improve understanding of concepts, functionality and application of Physics concept to everyday life.

In *National Policy on Education* (FME, 2004), the objectives of teaching Physics at the secondary school level as expressed in the curriculum are to:

- provide basic literacy in Physics for functional living in the society,
- acquire basic concept and principles of Physics as a preparation for further studies,
- acquire essential scientific skills and attitudes as a preparation for the technological applications of Physics, and
- stimulate and enhance creativity.

Apart from the acquisition of basic concepts and principles of Physics as a preparation for further studies, which is meant for people pursing science-related discipliners, other objectives cover every aspect of human endeavour.

Ogunneye (2003) noted that the study of Physics has been and will continue to be of tremendous importance to humanity for its ability to explain natural phenomena and everyday occurrences as well as its central role in the world's current technological development. Atadoga (2001) observed that Physics is an aspect of science that helps to explain the cause-effect relationships of matter and energy, and their application to natural phenomena. Physics helps to

transform the world. Physics draws awe and respect from people because of its contribution to knowledge, growth and development of individuals in particular and the society in general. The numerous applications to which Physics concepts are being put to improve man's environment make it occupy a unique position among other science subjects (Grant, 1998).Though, the subject (Physics) contributes much to man's existence, it enjoys the least popularity among secondary school students, mostly because it involves calculations which most students do not like (Ogunneye 2003).

Agommuoh and Nzewi (2003) observed that the present mode of teaching Physics in secondary schools whereby teachers mostly adopt the lecture method does not in any way provide for systematic learning experiences. Ogunleye (1993) observed that the heavy dependence of the subject on mathematics makes Physics a subject that is dreaded by many students in the secondary school system. Abdullahi (2004) observed that the difficulty in the understanding of Physics concepts centres around such factors as poor comprehension of Physics textbooks which is the major source of information on the subject, abstract nature of the subject and the method employed in teaching it. Abott (2000) observed that a major cause of difficulty in learning Physics concepts at ordinary level (secondary school) was the teaching methods employed during instruction. Researchers observed that Nigeria cannot develop scientifically and technologically or sustain it present level of development if she kills and buries Physics at the secondary school level.

According to Atadoga (2001) science and other sources of knowledge are built upon the foundation laid at the primary and secondary education levels. It is expected that it is from

among the students at these levels that future scientists, doctors, engineers, technologist etc would emerge. But if the foundation is weak at the primary and secondary levels, then the entire system is likely to collapse. Mankilik and Inyang (2009) in their survey on the attitude of secondary schools students towards Physics in some schools in Zaria, Kaduna state found out that students generally considered Physics a difficult subject. Among other handicaps that force them to drop the subject eventually is their lack of understanding of the subject because of the way it is taught. This study, therefore, set out to investigate the effect of Computer-Assisted Instruction (CAI) on Academic achievement of different ability levels of Nigeria Certificate in Education Physics students to see whether it would improve on the teaching of physics at secondary school level.

2.3 Science Teaching Methods

For any meaningful learning and teaching to take place, there should be suitable means of presenting the content to the learners at all levels of education. The means or strategies of presenting the content to the learners depend on the familiarity with the basic principle of effective teaching method in science. Bichi (2009) stated that the basic principles of effective pedagogy in science teaching include mastery of science contents, wise use of instructional methods, knowing the psychology of the students, teacher's knowledge about himself and conducive environment for learning. He further stated that basic principles to note are: the more child-centred a method is, the better is the learning outcome; the more teacher-centred a method is the less effective learning outcome is. Teaching methods on a continuum are lecture method, demonstration method, discussion method, project method, laboratory activity method, inquiry method, discovery method, process method, and problem solving.

The Demonstration Method can be used in teaching various subjects like science, religion, mathematics and others. The teacher is to teach a subject by demonstration while his students follow the procedure. Questions can be entertained after the demonstration excise (Bichi, 2009). Demonstration supplements the effort of the teacher; where he talks less, he can only demonstrate and instruct his students to do the same. In some cases, the teacher can invite a specialist to give practical demonstration. Gbamanja (1989) described the demonstration method of teaching as a technique or a method used to assist students to discover the concept of metal where the teacher needs to demonstrate the physical and chemical properties of several different metals. In addition, in the laboratory for example, the teacher needs to demonstrate the use of a microscope to the class before letting the students use it to discover things themselves. When a science teacher shows the action of carbon dioxide on a piece of moist blue litmus paper, he or she is presenting a demonstration. Likewise a teacher may demonstrate the dissection of a toad or of a rabbit to the students in the laboratory or classroom before students do it themselves.

The Project Method is a teaching approach which allows students to identify and choose a piece of work, topic or a problem to investigate. Here, students are allowed to go out to obtain relevant information for the purpose of the project. The Project method is entirely student-centred and students could either work individually or in groups. The teacher's role is to monitor how the project is being executed, give encouragement and offer assistance when necessary. At the end of the project, students are expected to write their report. It is important that students' reports are discussed in class. Since this method enables them to carry out an investigation on their own, it leads students to develop science process skills, stimulate the development of scientific attitude and of course facilitate meaningful learning of science.

The Inquiry Method is seen by Author & Robert (1975), who identified three types of inquiry methods of teaching science. They are the teacher guided inquiry, the modified inquiry and the free inquiry. The teacher guided inquiry is a method of inquiry in which instruction is carried out through the teacher's guide. The following are some of the advantages of inquiry-orientated approach to teaching as outlined by (Author & Robert, 1975).

i. Instruction becomes student-centred. This is because students carry out investigation themselves.

ii. Students develop more interest in the lesson because they are actively involved.

iii. Inquiry learning builds in students self concept. That is, students are willing to take explore, tolerate minor failures and learn science.

The Guided Discovery Method is an approach in science teaching which was postulated by Brunner (1961). The approach enables students to get firsthand experience in getting facts, concepts, principles and processes by using mental process and manipulating scientific equipment and materials. Brunner believed that a child who is exposed to the guided discovery gets four (4) benefits. These are:

i. There is a shift from extrinsic to intrinsic motivation.

ii. There will be an increase in intellectual attainment.

iii. The learning of the discoveries is valuable to students' investigation processes.

iv. Discovery learning and memory of the child.

Cronbach (1963) said discovery learning is mental assimilation by which the individual grasps a concept or principle resulting from physical and mental activity. In this method, the teacher ensures that the students have a chance to form concepts by studying objects leading the student to make generalizations. In guided discovery method of teaching, concept formation is

the main purpose. The Guided Discovery Method is applicable to virtually all areas of teaching and the types of activities in which the students are involved, vary from topic to topic and with the age and ability of the student. The amount of guidance the students receive from the teacher also varies but is never excessive. Guided discovery is a method of teaching that encourages mental skills development of students as well as their observing, measuring, classifying ability and so forth (James, 2000 & Usman, 2000).

The Problem-solving Method is an instructional strategy in which problems (scientific in nature or related to the real world) are carefully formulated and presented to students (Bichi, 2002). In the process of solving problems, students interact with one another using instructional materials and ultimately construct knowledge and acquire the process of science. The Problem-solving method is a way of helping students to see the personal relevance and the applicability of the science they learn. Bichi (2002) said that problem-solving provides opportunities for student to work as scientists, investigating phenomena in a systematic way and finding solutions to scientific problems. Problem-solving promotes investigative thinking in children (Awodi, 1984) and it enables the learner to experience new ideas (Schwaab, 1962). Problem-solving process is interesting, challenging and therefore motivating (Oyedokun, 1998).

The Laboratory Activity Method is an activity performed by an individual or group of students for the purpose of making personal observations or processes, products or events. It has been used in teaching science as:

i. a means of verifying principles, laws or theories,

ii. practising one or more cognitive skills such as ability to observe, classify, measure, interpret data, etc and

iii. To determine the relationship between causes and effects, (Abdullahi, 1982).

These science teaching strategies provide the prospective science teachers with necessary experiences in classroom setting to develop scientific skills in students.

Discussion method is a two-way interaction method. To a large extent, it is student-centred since students participate actively. The learner should take a moment to list some of the positive outcomes he has achieved by using discussion in class. It increases curiosity about the subject, enhances a more positive perception of students about the value of the subject. To get information on what to contribute during discussion, students need to spend more time reading. Students seem to attend classes regularly if they enjoy the lessons especially when they are less formal. Discussion facilitates higher levels of thinking, accommodates conflict, negotiation and consensus, and enhances learning and longer retention (Bichi, 2009). Although the discussion method is effective, it could be time consuming and the classroom could appear noisy. If discussion is not well moderated by the teacher the discussion could be dominated by a few outspoken ones and sometimes the teacher may want to impose his own ideas on the class. The objectives of a discussion can only be achieved if the teacher plays his role as a moderator effectively.

The Questioning Technique is an act of making statements which require respondents to make responses. In teaching and learning, questions are used to determine students' readiness to learn skills and concepts. When questions are appropriately used in the Physics classroom, they encourage the learners to be at alert and active, to think and seek alternatives to responses. Basically there are two types of questions adopted in teaching and learning process, which are narrow and broad questions. Examples of narrow questions are: (i) how many colour has a rain bow? (ii) what is the S.I. unit of mass? An example of broad questions, on the other hand, is: give a scientific explanation to the saying that what goes up must come down (Bichi, 2009).

These strategies promote meaningful teaching and learning of sciences in our schools. One of the strategies is the Computer-Assisted Instruction (CAI) which this study compared with traditional (lecture) method of teaching at NCE level among physics students of different abilities in Niger State.

2.4 Science Teaching Strategies and Academic Achievement in Science

Several studies have been carried out on teaching strategies and academic achievement in science. Yusuf andAfolabi (2010) observed from their research on the effects of Computer-Assisted Instruction (CAI) on secondary school students achievement in Biology that the achievement of students exposed to CAI either individually or co-operatively were better than their counterparts exposed to the conventional classroom instruction. Kolawole (2003) observed that concept-mapping instructional strategy could enhance students' achievement in the sciences. Chemistry students exposed to concept-mapping instructional strategy performed better than those who were exposed to analogies instructional strategy while those exposed to expository teaching method performed the least (Kolawole, 2003).

Owolabi (2007) worked on the use of analogy as a vehicle for achieving effective Physics delivery in some selected senior secondary schools in Lagos. The study sample consisted of 112 senior secondary school (two) Physics students drawn from two randomly selected secondary schools in Lagos, Nigeria. He used questions adopted from Owaseye (2000). The test was to find out specific information regarding the concepts of mirror and lenses which many students often confuse or use interchangeably. The result showed that the experimental group performed significantly better then the control group after a posttest. It showed that there was statistically

significant difference between the mean scores of experimental and control groups. This is an indication that there was a significant influence of analogy on students' achievement in Physics. The findings of this study are relevant and a useful guide to the present study.

James (1991) studied the effectiveness of the inquiry verse lecture method of teaching Biology in secondary schools. The result of the study showed that the inquiry method can enhance students' academic achievements better than lecture method. Lagoke (1992) studied the analogical concept attainment by secondary school students using a constructivist framework. The result showed that analogical linkage improved students' academic attainment in Biology. Ali (1982) studied discovery and expository task presentation by students in elementary mathematics. The result showed that poor teaching method led to poor academic achievement. In this study, the researcher carried out an investigation to see whether the CAI method would enhance the academic achievement of NCE Physics students with different ability levels at better than the lecture method in Niger State.

2.5 Computer-Assisted Instruction

Computer-Assisted Instruction (CAI) is an interactive instructional technique whereby a computer is used to present the instructional materials and monitor the learning that takes place. It uses a combination of text, graphics, sound and video in the learning process (Onasanya, Daramola & Asuquo, 2006). Computer-based learning has the potential to facilitate development of students' decision-making and problem-solving skills, data-processing skills, and communication capabilities. By using computer, students can gain access to expansive knowledge links and broaden their exposure to diverse people and perspectives (Bakac, Kartal & Akbay, 2011). Many studies in the published literature indicate that there is a strong relationship

between the use of computers and students' academic achievements in teaching and learning processes (Altun, Yigit & Alev, 2007). For instance, Yigit (2005) found in his study that computer-assisted instruction has had a positive impact on students' perception about computer supported instruction as well as on their academic achievement.

Computer Assisted Instruction (CAI) can refer to virtually any kind of computer use in educational settings including drill and practice, tutorials, simulations, instructional management, supplementary exercises, programming, database development, writing using word processors, and other applications (Cotton, 2001). The Association of Education Communications and Technology (1977) has defined Computer Assisted Instruction (CAI) as a method of instruction in which the computer is used to instruct the student and where the computer contains the instruction which is designed to teach, guide and test the students until a desired level of proficiency is attained.

Mills (2001) revealed that CAI was found to be as effective as classroom instruction for fact-based learning, but not as effective for topics requiring critical thinking or mathematical problem-solving. In addition, the time required by learners to use CAI was overall higher than conventional classroom instruction. Students taught using CAI performed better than students taught using traditional instruction in a college setting (Akour, 2006). Similarly, college students taught statistics using lecture-plus-CAI obtained higher averages at midterm and final examinations than students taught using lecture method only (Bastrurk, 2005). Chang (2000) reported a significant increase in scores on a measure of academic achievement when CAI on arithmetic was used to teach addition and subtraction. These studies indicated that CAI could

have a positive effect on secondary students' skills and achievement. In the first study, Stern and Repa (2000) showed that CAI was successfully used to teach social skills to teens enrolled in a behaviour modification programme. In the second study, Dunn (2002) found that school freshmen in the CAI treatment group scored significantly higher than the control group on a measure of reading comprehension.

Some studies (Springer, 2002) further support the effects of CAI on academic achievement in delivering metric CAI (as a proctored tutorial) to pre-service teachers and found that those individuals who received the CAI performed significantly better on a metric posttest than those students who received no CAI instruction. Jenks (2002) in comparing paging text and scrolling text versions of a linear metric CAI module, found with both the paging and scrolling treatments, that the pre-service teachers who scored low on the pretest had a much larger mean improvement on the posttest than did the students who scored high on pretest. This could indicate the linear metric CAI was effective as a remedial tool. Many studies showed that during the teaching process, computer assisted applications aided the consolidation of attitudes and the restructuring of the knowledge by students themselves (Baki 2002; Saka & Akdenize, 2006).

Computer-Assisted Instruction has been found to enhance students' achievement than the conventional instructional method in counsellor education (Karper, Robinson & Casado-kehoe 2005). Onasanya, Daramola and Asuquo (2006) stated that studies conducted by U.S. Department of Education showed that CAI used in schools in the U.S.A had helped in increasing the rate at which students learnt. Students receiving computer-based instructions tended to learn more and faster. Their gains exceeded those in schools using the traditional method. Students

receiving CAI based instruction also enjoyed their classes more and had better attitudes towards computer. Studies have shown that students who went through active-engagement computer-based activities did better than students who went through traditional instruction (Steinberg, 2000). Venkataiah (2004) observed that Computer-Assisted Instruction (CAI) is an interaction between a student, a computer and a software programme guided by the teacher for the purpose of enhancing learning outcomes. Even though CAI was expensive and mechanical, it was considered to be a better teaching machine because of its flexibility and versatility. Furthermore, it provided integrated experiences which varied from abstract to concrete; helped the teacher to reduce repetition of words; improved students manipulative skills; improved visual perceptions and retention of information by the learner.

Computer-Assisted Instruction (CAI) is used to indicate the application of the computer in the teaching and learning process. Tabassum (2004) indicated that it is the approach where the computer acts as a tutor teaching new skills or concepts or providing practice for learners. Thomas (2001) in Owusu (2009) indicated that when a new technology appears in market, various arguments are made to indicate how that technology will enhance learning. In the light of this, Tabassum (2004) stated that advocates of CAI had high expectations for the computer as an instrument for identifying and meeting individual needs.

Ives and Barron (as cited in Owusu, 2009) reported significant learning increases when pre-service teacher worked in a paired condition using computer-based instruction that was designed for learning. Chang (2001) produced mixed results, while the CAI group performed better generally than the traditional (lecture) approach group. Nonetheless, the traditional

approach group performed better on test items involving computer application. Thus, while the CAI group did well on knowledge and comprehension level items, the traditional approach group did better on computer application level items. Imhanlahimi and Imhanlahimi (2008) found out that the traditional method of instruction proved to be superior to computer-assisted instruction.

Agommuoh and Nzewi (2003) carried out a study on effects of videotaped instruction on the secondary school students' achievement in Physics. Their investigation revealed that the achievement of students in Physics greatly improved with the use of videotaped instruction. Computer-based instructional applications were considered an effective alternative to traditional teaching methods (Leigh, 1996; Larkin, 2003). Kolawole (2003) reported that the use of concept and vee-mapping strategies were more effective in teaching Organic Chemistry than the conventional method of teaching and therefore charged that it was essential for Chemistry teachers to utilize both instructional strategies in teaching Chemistry.

Tabassum (2004) revealed that the overall achievement of students taught by conventional approach supplemented by CAI was higher than those taught by conventional approach only. She also found out that both high achievers and low achievers in the CAI supplemented group performed better than low achievers in that same group. She therefore concluded that CAI supplemented by conventional teaching proved to be more effective for high achievement level students. However, Cotton (2001) in Owusu (2009) indicated that comparisons between low-achieving and high-achieving students show that CAI was more effective with lower-achieving students than with higher-achieving ones. She indicated that the greater benefits experienced by lower-achieving students were largely due to the need these

groups had for elements common to the majority of CAI programme-extensive drill and practice, privacy, and immediate feedback and reinforcement. In this study, Computer-Assisted Instruction (CAI) teaching strategy was employed to find its effectiveness on achievement of physics students with different ability levels at NCE level.

2.6 Conventional Lecture Method

Lecture Method is teacher-centred method, which is seen as the traditional talk – chalk method of teaching. Here, teacher does the talking while students serve as receiver only by listening and taking down notes. Obeka (2009) described lecture method as a teacher-centred method. Several studies (Aminu, 1979; Balogun, 1982; Abdullahi; 1982 Akpan, 1983; Olarewaju and Balogun, 1984; Gbamanja, 1991; Odubunmi, 1993; Okonkwo, 1999 and Ajeyalemi, 2002) have shown that the teaching method used mostly in the teaching of science in our schools is the lecture method. Gbamanja (1991) observed that in using lecture method, the teacher talks about science while the students read about science. This lead to a classroom- teaching environment, which is teacher dominated, didactic, textbook bound and examination-oriented.

Lecture method is a popular method of teaching whereby the teacher dominates the period by doing the talking and student sitting and listening to him. Kelly (2009) affirmed that lecture method, sometimes called the traditional method or expository method of teaching involves the teacher using verbal presentation of ideas or concepts. In this method, the teacher does much of the activity in form of talking and writing on the board while the students listen. The effectiveness of this method is that it requires clear and good command of language, good ability to write and allows for easy coverage of syllabus. On the alternative, it does not promote meaningful learning. It appeals to the sense of hearing and seeing, which the learner can easily forget. Lecture method is used to describe teaching in which a large part, or possibly the whole,

of the lesson is occupied by the teachers in exposition and by the students in listening or taking notes.

Paiko (2004) defined lecture method as a verbal presentation of subject matter content. Similarly, he described lecture method as a strategy which involves the teacher talking, using the chalkboard, questioning and explaining the required concepts. This implies that lecture method is a way of imparting knowledge. No doubt the method is teacher-centred rather than child-centred since it is the teacher that dominates the lesson with much talking. Garba (2004) stated that lecture method is either called speech or lecture method for the fact that it is usually a formal talk, prepared and organized in advance. However, lecture method is simply defined as the most traditional and common form of teaching at higher levels of schooling. It is often over used, and it has been criticized as an ineffective method of instruction. Lecture method is one a science teaching method of instruction that encourages rote learning and regurgitation of information without necessarily aiding understanding, and this does not enhance academic achievement in science as observed by James (2000), Bichi (2002) and Usman (2008). Gbamanja (1991) observed that in using the lecture method, the teacher talks about science while the students read about science. This leads to a classroom-teaching environment, which is teacher dominated, didactic, textbook bound and examination oriented. Therefore, in this study the researcher intend to compare the lecture method with the Computer-Assisted Instruction method in teaching of NCE physics students of different ability levels in Niger State.

A lecture is oral presentations intended to present information or teach people about a particular subject, for example by a university or college teacher. Lectures are used to convey

critical information, history, background, theories and equations. A politician's speech, a minister's sermon, or even a businessman's sales presentation may be similar in form to a lecture. Usually, the lecturer would stand at the front of the room and recite information relevant to the lecture's content.

2.7 Concept of Ability Levels

Students of all mental abilities are found mixed in a classroom (Egelson, 1996). They are given the same assignments and are required and indeed expected to do the same work. Ability levels are of different types. Ability level is the degree of the exhibited capability of a student to learn and comprehend a concept as well as solve problems in it (Peterson, 1980). Research Base Information on Timely Topics magazine (RBITT, 2002) referred to two common forms of ability grouping:

(1) within- class ability grouping, which refers to teachers' practice of dividing students of similar ability in small group, and

(2) the between-class grouping, which refers to schools' practice of separating students into different classes, courses or course sequences or curricula tracks based on their achievement.

Students within-class grouping are by ability said to be homogeneously grouped, while students of different ability lump or mixed together in ability classes are said to be heterogeneously grouped. RBITT (2002) reported that within-class ability grouping consistently produces larger gain than the mixed ability group and that the positive effects are slightly greater for low achievers than the average or above average achievers. It is also reported that the cross-grade ability grouping where students are regrouped for teaching across grade levels and the

nongraded plan, where children are divided by achievement rather than age, produced greater gain in achievement than the mixed-ability group class.

Collia (2002) identified three types of ability levels, via the high ability level, the middle (average) ability level and low (under) ability levels. The high ability levels according to Ofonime (2007) described the high ability level students as students whose academic potentials are above class average and their achievement described as good. James (1991) ascribed the high achievers as those students who perform well in test, assignments and examinations. Middle (average) achievers, these are the group of students who according to Taylor (1999), Eledea (2002) and Awe (2003) can only record an average achievement, not because they are not capable of doing better, but partly because they cannot put in extra effort to attain better achievement. They are, therefore, contented to remain average. For this reason, they content themselves with the classroom learning without trying to access other information.

The low achievers (underachievers) as described by Hummel and Sprinthal (1965) and Ashilley (2001) is the group of students who perform poorly in tests, examinations and also are easily distracted and less able to set about tasks in an organized manner. They further stressed that these students are less able to control their own basic impulses and their destines. Ofonime (2007) also described the under-Achievers as students whose academic potentials are judged below class average while their achievement is described as poor. Ayeremoi (2001) contended that the underachievers (low achievers) need constant study, evaluation and help so as to reverse their condition. Chadau (2002) identified the problem of the underachieving students to be one of the more tragic dilemmas in education. Cotton (2001) in Owusu (2009) attributed the

achievement of low achievers, after being introduced to CAI, to some characteristics of CAI – the exercises, privacy and the ability of students to learn at their own pace, the immediate feedback and the ability to read over the material again. This gives the indication that CAI holds great promise to low achieving students, teachers and parents. It implies that CAI can be used to aid low achieving students to improve their achievement. In this study the researcher sought to find out if the use of CAI would improve the academic achievement of NCE physics students with different ability levels in Niger State.

2.8 Ability Levels and Students' Academic Achievement in Science

The high–ability students maintain interest in their studies in a homogeneous group but they languished when grouped with the slow learners while opponent of ability grouping contend that ability grouping not only fails to benefit any student as it also channels poor and minority students to low tracks where they receive a lower quality of instruction than their groups and contributes to a widening of the achievement gap. Emily, Robert, and Michael (2003) studies revealed that if students are grouped homogeneously, there is the fear that low-ability students will be deprived of opportunities to learn and be unmotivated to learn because of peer, personal and teachers' expectations of poor achievement. On the other hand Collia (2002) opined that it is unethical to retard the achievement of high-ability students by assigning them to heterogeneous group class settings where they might spend their time instructing other group members rather than learning information they did not already know.

Afolabi and Akinbobola (2009) were of the view that physics students with low ability level taught with problem-based learning technique performed significantly better than those

taught with lecture teaching method. Also, student taught with problem-based learning technique performed significantly better than those taught with lecture method. Adesoji (1995, 1997) discovered that problem-solving strategies were effective in teaching students of different ability levels. Okebukola (1992) confirmed that the use of appropriate instructional strategies could influence the achievements of low achieving students.

Nwana (2008) pointed out that CAI is used to present instructional programmes to students through interactive process and the students learn at their own pace. In the case of the low learners, they are not rushed neither are the fast learners inhibited. In other words, individualized instruction is enhanced. The findings of this study are relevant and serve as a guide to the present study. Okebukola (1992) affirmed that the use of appropriate instructional strategies could influence the low ability level students. It was discovered from the studies of intellectual abilities by Alant (2004) that students of varying ability levels performed differently depending on the type of method of instruction. Afolabi and Akinbobola (2009) submitted that the ability levels of the students were found to actually influence the students' academic achievement. In this study therefore, the researcher carried out an investigation to see how the use of CAI affect the academic achievement of physics students with different ability levels at NCE level in Niger State.

2.9 Gender and Academic Achievement in Science

Gender is one of the factors interacting with achievement and studies on it have been unresolved in their conclusions (Nussbaum, 2000). Some researchers found that male students have a higher achievement than female students (Novak & Mosunda, 1991; Danmole, 1998).

Usman (2000), reported that boys performed significantly better than girls in SSCE Physics examination. Other studies confirmed the superiority of female students' achievement over male students (Mari, 1994 and Shaibu& Mari, 1997). Other researchers found no significant difference between male and female achievement (Price, 1993; Bello, 1996; Nussbaum, 2000; Danmole & Adebayo, 2004; Danmole & Femi-Adeoye, 2004).

Furthermore, there have been researches on the issue of gender and its effects on performance of students. Many studies on gender have suggested that male achieved better results in science than their female counterparts (Ojiaku and Woye, 2003). Etukudo (2002) in his studies revealed that there was no significant gender difference in performance of junior secondary school students when taught mathematics with the help of computer. Similarly, Odok and Ablam (2006) found that there was no significant relationship between gender and achievement in number and numeration, statistics and algebra, but a weak relationship between gender achievement in geometry and trigonometry. In addition, Amelink (2009) indicated that male students performed better in geometry and measurement, while female students performed better in numbers and operations. Alhassan (2012) observed that there was significant difference in the performance of male and female students when taught with CAI. He found out that the male students performed better in geometry than the female students when taught with CAI. Salahudeen (2012) observed that there was no significant difference in the performances of male and female taught longitude and latitude using CAI at secondary schools in Minna Metropolis. Hence, this study investigated the effect of computer-assisted instruction on academic achievement of different ability levels in Nigeria Certificate in Education Physics students in Niger State, Nigeria.

2.10 Overview of Similar Studies on CAI and AcademicAchievement

Owusu (2009) worked on effects of computer-assisted instruction on senior high school students' achievement in Biology in Ghana. The study used 75 senior high school (SHS) students and adopted pretest, posttest quasi-experimental design. The findings revealed that the students that were instructed by the conventional approach performed better on the pretest than those instructed with the use of CAI. Also, the performance of low achievers within the experimental group improved after they were instructed by the CAI and the CAI group did not perform better than the conventional approach group, but the students in the CAI group showed positive attitudes towards CAI when they were interviewed. This study is relevant to the present study for the fact that the study was on ability levels and it used the CAI in Ghana, African country. This study is on effect of computer assisted instruction on academic achievement among physics students of different abilities in Niger State, Nigeria.

Tekbiyik, Konur and Pirasa (2008) conducted their study of effects of computer assisted instruction on students' attitudes towards science courses in Turkey using 125 students for the study. They explained that an average student's attitude towards science course moved from the 50^{th} percentile to the 75^{th} percentile when computer assisted instruction was used. In other words, a student's attitude towards science improved after the student was exposed to CAI. The study used CAI which is similar to the present study.

Owolabi (2007) worked on the use of analogy as vehicle for achieving effective Physics delivery in some selected senior secondary schools in Lagos. The study sample consisted of 112 senior secondary school (two) Physics students drawn from two randomly selected secondary schools in Lagos, Nigeria. He used questions adopted from Owaseye (2000) to find out specific information regarding the concepts of mirror and lenses which many students often confused or

used interchangeably. The result showed that the experimental group performed significantly better and retained more of the concepts than the control group after a posttest. It showed that there was statistically significant difference between the mean scores of the experimental and control groups. There was significant influence of analogy on students' performance in physics. The findings of this study were relevance to the present study; it will save as guide to the present study.

Salahudeen (2012) investigated the effects of Computer-Assisted Instructional package on Learning of Longitude and Latitude among Secondary School Students in Minnna Metropolis. The study used 120 Senior Secondary School (SSS) Students and adopted the pretest and posttest quasi experimental control group design. The result revealed that the experimental group performed better than the control group. Gender and age differences were found to have no significant effect on the mean achievement of the experimental group. This study is relevant to the present study in terms of instrument (CAI), gender and location and would serve as guide to the present work.

In the recent study of Alhassan (2012) on effects of computer assisted instructional package on achievement and retention in geometry among Junior Secondary School Students in Minna Metropolis, the study used 80 Junior Secondary School (JSS) Students and adopted the pretest, posttest quasi experimental–control group design. The finding revealed that the experimental group performed better than the control group and male students performed better than female students when taught geometry using computer. This study is relevant to the present study that is the subjects are Nigerlites and CAI is used. The study also tried to see the effect of computer assisted instruction on academic achievement of students similar to the present study.

2.11 Implication of Literature Reviewed on the Present Study

Owusu (2009) investigated the effects of computer assisted instruction on Senior High School Students' achievement in Biology at Ghana. This study tried to see the effects of computer assisted instruction on academic achievement of students. Owusu's study is similar to the present study, in the sense that it looks at the effects of computer assisted instruction on academic achievement of students. This work was done at Secondary School level in Ghana, while the current study is looking at such effects at college of education level in Niger State, Nigeria. Owolabi (2007) studied the use of analogy as a vehicle for achieving effective Physics delivery in some selected senior secondary schools in Lagos. This study is similar to the current study, though it was on Physics students at secondary school in Nigeria, while the present study is also working on Physics students but at NCE level in Niger State, Nigeria.

The studies of Alhassan (2012) and Salahudeen (2012) examined the effects of computer assisted instruction on the academic achievement among secondary school students in Minna Metropolis. They also made use of computer assisted instruction and their work is at Niger State, which is similar to the present study. The reviewed showed that academic ability had played an important influence on the academic achievement of students. Gender difference in some studies had an influence on academic achievement while in some other studies, gender difference had no influence on academic achievement. It was observed that many of the studies were focussed on some part of science education, mathematics and social studies. Not many researchers have looked into the effect of computer assisted instruction on academic achievement of different abilities of Physics students in mechanics and properties of matters. In addition, most studies did not examine students of colleges of education but focused on secondary school students.

Furthermore, there are areas of differences between the literature reviewed in previous works and that of the present study: Such differences include geographical scope of the study, sample size, subject areas, instructional strategies, computer software and method of statistical analysis. To the best knowledge of the researcher, most of the studies were conducted in countries like Ghana, Turkey but few in Nigeria, while those in Niger State were not at NCE level. This study therefore, examined the effects of computer assisted instruction on academic achievement among Physics students of different abilities in Niger State, Nigeria.

CHAPTER THREE

METHODOLOGY

3.1 Introduction.

This study investigated the effects of computer-assisted instruction on students' academic achievement of different ability level in mechanics and properties of matter among NCE 200 level Physics students in two colleges of education in Niger State. The chapter incorporated a description of the following sub-headings.

- Research Design.
- Population.
- Sample and Sampling Techniques.
- Selection of Topics for the Study.
- Instrumentation.
- Mechanics and Properties of Matter Achievement Test (MPMAT).
- Validity of the Research Instrument.
- Pilot Testing.
- Reliability of Research Instrument.
- Item Analysis.
- CAI as a Teaching Strategy.
- Administration of Treatment.
- Control Group.
- Data Collection Procedure.
- Data Analysis.

3.2 Research Design.

The study adopted pretest, posttest quasi-experimental control group design as recommended by Kerlinger (1973). Two groups, experimental and control groups were used in the study. The two groups were pretested using Mechanics and Properties of Matter Achievement Test (MPMAT) before treatment in order to determine the entry level equivalence in ability of the two groups. The experimental group was taught using Computer-Assisted Instruction (CAI) (X_1) while the control group was taught using lecture method (X_2). After the treatment, Posttest was administered to the subjects of the two groups to determine the efficacy on the use of Computer-Assisted Instruction compared to Lecture Method employed in the teaching of the concepts. The same test was administered as pretest, and as posttest. The design of the study shown in Fig. 3.1.

Research Design illustration.

Group 1: $\mathbf{E} \longrightarrow \mathbf{O_1}^{\mathbf{LM}}{}_{\mathbf{H}} \longrightarrow \mathbf{X_1} \longrightarrow \mathbf{O_2}^{\mathbf{LM}}{}_{\mathbf{H}}$

Group 2: $\mathbf{C} \longrightarrow \mathbf{O_1}^{\mathbf{LM}}{}_{\mathbf{H}} \longrightarrow \mathbf{X_2} \longrightarrow \mathbf{O_2}^{\mathbf{LM}}{}_{\mathbf{H}}$

Group 1 = Experimental group.

Group 2 = Control group.

X_1 = Use of Computer-Assisted Instruction (CAI) (Treatment)

X_2 = Lecture method (Control)

O_1= Pretest Administration.

O_2= Posttest Administration.

E = Experimental (Those exposed to treatment)

C = Control (not exposed to treatment)

L = Low ability Level Students.

M = Medium ability Level Students.

H = High ability Level Students

Fig 3.1: Research Design Illustration.

3.3 Population.

The target population for this study consisted of all N.C.E 200 level Physics students of the two Colleges of Education in Niger state. There are two Colleges of Education in the state, a state owned College and Federal owned.

The total Physics students' population in the two colleges at the time of the study is 211 students, consisting of 129 male and 82 female students. The colleges are co-educational and offer Mechanics and Properties of Matter as courses in Physics (PHY 213). The breakdown of the selected students used for the study is presented in Table 3.1.

Table 3.1: Population of the Study

INSTITUTION	No of Physics Students		Total No of Students
	Male	Female	
FCE Kontagora	**61**	**37**	**98**
COE Minna	**68**	**45**	**113**
Total	**129**	**82**	**211**

Source: Examination Offices in both FCE Kontagora and COE Minna (2012)

The colleges were accredited by the National Commission for Colleges of Education (NCCE). The colleges were similar in terms of the curriculum used, manpower, and quality of staff. The average age of students in the population was 20 years.

3.4 Sample and Sampling Procedure

The population was same as sample because there were only two colleges of education in the state with a few students of Physics Education. The sampling technique used was the balloting method (the first school picked was the control group and the second school picked served as the experimental group). The technique was used to assign the colleges into experimental and control groups, which were used for the study. The details of the sampling is presented in Table 3.2

Table 3.2: Sample for the Study.

INSTITUTION	No of Physics Students		Total No of Students
	Male	Female	
FCE Kontagora	**61**	**37**	**98**
COE Minna	**68**	**45**	**113**
Total	**129**	**82**	**211**

Source: Examination Offices in both FCE Kontagora and COE Minna (2012)

3.5 Selected Topics for the Study

The topics to be taught were drawn from Mechanics and Properties of Matters course in Physics (PHY 213) of the NCCE Minimum Standard (2010 revised version). The contents wrere as follows:

- Inertia of rigid body.
- Gravitation.
- Surface Tension.
- Fluid Motion.
- Harmonic Motion.

These topics were selected for the following reasons:

- To maintain continuity and objective of the NCCE minimum standards for the NCE students.
- The topics constituted the areas students perceived to be difficult. (External Moderator's report 2012)

3.6 Instrumentation

The instrument used for data collection on this study was the Mechanics and Properties of Matter Achievement Test (MPMAT).

3.7 Mechanics and Properties of Matter Achievement Test (MPMAT)

Mechanics and Properties of Matter Achievement Test (MPMAT) was developed by the researcher. Mechanics and Properties of Matter Achievement Test was used for the pretest and posttest. The MPMAT test items were made up of 40 multiple choice questions with four

options, to choose the correct option. Only one option was correct the remaining three options served as destructors. The items covered the units taught.

Table of items Specified in Achievement Test

S/N	Topics	Total number of Questions	The questions
1.	Inertial of Rigid body	6	1, 2, 14, 15, 26, 27.
2.	Energy and Gyration of Rigid body	6	3, 12, 13, 31, 32, 33
3.	Angular Momentum	8	4,5,6,21,37,38,39,40
4.	Gravitation	7	7,18,19,20,34,35,36.
5.	Surface Tension	8	10,11,16,17,25,28,29,30
6.	Oscillatory and Circular Motion	5	8, 9, 22, 23, 24.
Total		**40**	**40**

The disparity in the number of questions from the each topic was baesd on the volume of each topic.

3.8 Validation of the Instrument (MPMAT)

The MPMAT instrument with the marking scheme was validated by two senior lecturers with minimum qualification of PhD from Department of Science and Science Education of Federal University of Technology (FUT) Minna and two senior lecturers with minimum qualification of PhD from Department of Science Education, Ahmadu Bello University Zaria

respectively. They evaluated the instrument for its face and content validity for accuracy, clarity and level of phrasing of the test items.

The experts validated the MPMAT instrument to ensure it was in consonance with the NCE Physics syllabus. The instrument was also validated to ensure that it was appropriate and served the purpose for which it was designed. The fifty (50) items instrument was validated for the appropriateness of the questions in relation to the content of Mechanics and Properties of Matter II covered in the MPMAT. All the inputs and corrections were harmonised and used in the production of the instruments for the study. Face validation was undertaken to determine whether the MPMAT was appropriate or not. Face validity pertained to whether the test was valid to the examinee who would take it. Content validation was similarly undertaken to see whether the MPMAT instrument was in consonance with the syllabus.

3.9 Pilot Testing

During the pilot testing, two tests (Pre-Test and Post-Test) were carried out. NCE II Physics students of College of Education Zuba were used for pilot-testing of the instrument. The aim of pilot study was to determine the characteristics of the test items which included their facility and discrimination indices and the reliability coefficient. Fifty students participated in the pilot study. The groups were mixed sexes.The result of the pilot study was used to:

i. determine the number of weeks that would be suitable for conducting the study and adequate time allocation for the test;
ii. assess the clarity of the items of the MPMAT;
iii. calculate the reliability coefficient of the MPMAT. Also the facility and difficult indices were determined using the scores of the students.

Pearson's Product Moment-Correlation Coefficient was used to compute the reliability coefficient which was calculated to be approximately 0.78.

3.9.1 Pretest Administration

Pretest was carried out using the instrument of the study, i.e. Mechanics and Properties of Matter Achievement Test (MPMAT). The pretest was done to determine if the two groups were not significantly different in their ability level. Also, the result was used to categorise the study subjects as low, medium and high ability levels.

3.9.2 Reliability of the Instrument

The scores that were obtained from the pilot study were used to determine the reliability coefficient of the MPMAT. The study employed test retest method on the scores obtained from the Pilot study. After the first test, two weeks interval MPMAT was given for the second test which is retest. This is in line with Tuckman (1978) in Atadoga's (2001) recommendation.

On the basis of the data obtained from the pilot testing of achievement test, the instrument used for this study was found to have a reliability coefficient of 0.78. This shows that the instrument was reliable and used for this study.

3.10 Item Analysis of MPMAT

Item analysis was carried out on the scores obtained from the pilot study to determine the facility and the difficulty indices of the items in MPMAT.

3.11 Facility Indices.

The facility index (F_1) of a test according to wood (1990) in Jiya (2011) is the percentage of the students that got an item right. It was determined by using the formula.

$$\boldsymbol{F_1 = \frac{R}{T} \times \frac{100}{1}}$$

Where R = number of correct responses

T = Total number of study

Furst (1958) in Atadoga (2001) recommended values within the range of 0.30 to 0.70 for good test item values in assessing achievement. For the present study 0.30 to 0.70 was chosen for the study.

3.12 Discrimination Indices.

The discrimination index/indices is the discriminating power of each of the test items or is the ability to sort or separate between high and low ranking students in the whole test. The calculation was done using scores of the top twenty seven percent (27%) and bottom twenty-seven percent (27%) of the total respondents. This was calculated using the formula given by (Furst (1958) in Atadoga 2001).

$$\boldsymbol{D_1 = \frac{R_u - R_i}{1/2\, N}}$$

Where D = discrimination index

R_u = Number among upper 27% of respondents.

R_i = Number among lower 27% of respondents.

N = total number of respondents.

The discrimination index with a range between 0.30 and 0.70 was regarded as moderately positive and was accepted for the present study. This was used in selecting the final items of the test MPMAT. Details of computation is given in Appendix C

3.13 Administration of Treatment

Before the treatment, pretest was administered to both experimental and control groups. The experimental group was taught Mechanics and Properties of Matters using CAI while the control group was taught the same topics using lecture method. A lesson plan prepared was used to teach the study subjects based on the topic selected as specified in selection 3.5 of chapter 3.

The CAI package was developed with the assistance of a computer programmer. The need for the researcher-made computer package was based on the fact that the commercially produced computer assisted instructional packages might not suit the objectives of the study.

The CAI package consisted of the same topics as in lecture method. The CAI package was written in "Macromedia flash" that utilized the script symbolic instructional code (language) animation and could accommodate interactive instructional process. The main menu consisted of introduction instructional section, the topic and exit. The drill practice modes of the computer-assisted instruction were adopted. It was an individualized programme in which the individuals who reacted to the computer would have to make some entries. The terminology used in the package was not different from those that the researcher used in the classroom, since this could cause real problems of the terminologies differed (Andrews & Collins 1993). The format of CAI tutorial was that concepts were presented, questions asked and students were encouraged to progress.

3.14 Control Group

During the treatment, Lecture Method was used for the control group as their treatment factor and the results collected after the treatment through Mechanics and Properties of Matter Achievement Test (MPMAT) were analyzed using t-test and one way ANOVA statistic.

3.15 Data Collection Procedure.

The response of the subjects to Mechanics and Properties of Matter Achievement Test was scored using the marking scheme. Each correct response was scored one point with a maximum score of 40 marks. The scores were collected and recorded based on each research question, hypotheses and ability levels.

3.16 Data Analysis

The scores that were obtained from MPMAT were used for testing stated hypotheses 1 – 6. The statistical analysis was done as follows:

H_{01}: There is no significant difference in the academic achievement between Physics students taught using CAI and those taught using Lecture Method in Physics at NCE level.

H_{02}: There is no significant difference in the academic achievement between low ability students taught using CAI and those taught using Lecture Method in Physics at NCE level.

H_{03}: There is no significant difference in the academic achievement between medium ability students taught using CAI and those taught using Lecture Method in Physics at NCE level.

H_{04}: There is no significant difference in the academic achievement between high ability

students taught using CAI and those taught using Lecture Method in Physics at NCE level.

H_{05}: There is no significant difference in the academic achievement between male and female students taught using CAI in Physics at NCE level.

H_{06}: There is no significant difference in the academic achievement among low ability, medium ability and high ability level students taught using CAI in Physics at NCE level.

The first five null hypotheses stated were analyzed using t-test statistic to determine the effect (if any) between the experimental and control groups and the sixth null hypothesis stated was analyzed using one way ANOVA statistic. Significant level at$P \leq 0.05$ was used to reject or retain the stated hypotheses.

CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This study was carried out to investigate the effect of computer-assisted instruction on academic achievement of different ability levels of Nigeria Certificate in Education (NCE) Physics Students in Niger state. The analyses and results of the data collected and their discussions are presented in this chapter. The data collected were analyzed using the Statistical Package for Social Science (SPSS) and the level of significance adopted for decision taken on the stated hypotheses at $p \leq 0.05$.

4.2 Data Analysis and Results

The instrument used for the data collection was Mechanics and Properties of Matter Achievement Test (MPMAT) which was used to measure the students' performance in the pretest and posttest for both experimental and control groups. The data that were obtained in the course of the study were:

i. performance scores from pretest for both the experimental and control groups

ii. Performance scores from posttest for both experimental and control groups

4.2.1 Answers to Research Questions

The result is presented as follows:

Research Question 1: What is the difference between academic achievement of Physics students taught using CAI and those taught using Lecture Method at NCE?

The descriptive statistics such as mean and standard deviation was used to test this research question and the summary of the results is presented in Table 4.2.1. The mean and standard deviation of Pre-test result discussion is in Appendix E.

Table 4.2.1 Means and Standard Deviation of Post-test of the Experimental (CAI) and Control (Lecture) Groups in Mechanics and Properties of Matters Achievement Test (MPMAT).

Variable	N	Mean	SD	MD
Experimental group	113	66.22	14.26	30.04
Control group	98	36.18	8.17	

Based on Table 4.2.1, the answer to question one which states: "What is the difference between academic achievement of Physics students taught using CAI and those taught using lecture method?" is that the mean score for the experimental group was 66.22 and that of the control group was 36.18. This indicates that there is significant difference between the mean scores of the experimental group (66.22) and the control group (36.18). The mean difference is 30.04 in favour of experimental group. Therefore, the answer to the research question one is that there exist significant differences in favour of experimental group. To test whether there was a significant difference or not in the mean score of the experimental and control groups, HO_1 was used.

Research Questions 2: Is there any difference in academic achievement between low ability level Physics students taught using CAI and those taught using Lecture Method at NCE?

A descriptive statistics such as mean and standard deviation was used to test this research question and the summary of the results is presented in Table 4.2.2. The mean and standard deviation of Pre-test result discussion is in Appendix E.

Table 4.2.2 Means and Standard Deviation of Post-test of Low Ability Students of the Experimental and Control groups in Mechanics and Properties of Matter Achievement Test (MPMAT).

Variable	N	Mean	SD	MD
Experimental group	28	57.93	17.03	22.73
Control group	15	35.20	7.82	

Based on Table 4.2.2, the answer to question two which states: "Is there any difference in academic achievement between low ability level Physics students taught using CAI and those taught using lecture method?" is that the mean score for the experimental group was 57.93 and that of the control group was 35.20. The mean difference is 22.73 in favour of experimental group. The low ability students exposed to CAI had a higher mean score, an indication that the students performed better on exposure to CAI. This implies that the treatment had an impact on the experimental group. Therefore, the answer to the research question two is that there exist significant differences in favour of the experimental group. To test whether there was a significant difference or not in the mean score of the experimental and control groups, $H0_2$ was used.

Research Questions 3: What is the difference in the academic achievement between medium ability Physics students taught with CAI and those taught with Lecture Method at NCE?

The descriptive statistics such as mean and standard deviation was used to test this research question and the summary of the results is presented in Table 4.2.3. The mean and standard deviation of Pre-test result discussion is in Appendix E.

Table 4.2.3 Means and Standard Deviation of Post-test of Medium Ability Students of the Experimental and Control groups in Mechanics and Properties of Matter Achievement Test (MPMAT).

Variable	N	Mean	SD	MD
Experimental group	61	68.59	12.45	33.94
Control group	54	34.65	7.58	

Based on Table 4.2.3, the answer to question three which states: "What is the difference in academic achievement of medium ability level Physics students taught using CAI and those taught using lecture method?" is that the mean score for the experimental group was 68.59 and that of the control group was 34.65. This indicates that there is significant difference between the mean score of the experimental group (68.59) and the control group (34.65).The mean difference is 33.94 in favour of experimental group. Therefore, the answer to the research question three is that there exists significant difference in favour of experimental group. This shows the effect of the treatment on the experimental group. To test whether there was a significant difference or not in the mean score of the experimental and control groups, $H0_3$ was used.

Research Questions 4: Is there any difference in the academic achievement between high ability Physics students taught with CAI and those taught with Lecture Method at NCE?

The descriptive statistics such as mean and standard deviation was used to test this research question and the summary of the results is presented in Table 4.2.4. The mean and standard deviation of Pre-test result discussion is in Appendix E.

Table 4.2.4 Means and Standard Deviation of Post-test of High Ability Students of the Experimental and Control groups in Mechanics and Properties of Matter Achievement Test (MPMAT).

Variable	N	Mean	SD	MD
Experimental group	24	69.88	11.54	30.60
Control group	29	39.28	8.49	

Based on Table 4.2.4, the answer to question four which states: " Is there any difference in academic achievement of high ability level Physics students taught using CAI and those taught using Lecture Method?" is that the mean score for the experimental group was 69.88 and that of the control group was 39.28. This indicates that there is statistically significant difference between the mean score of the experimental group (69.88) and the control group (39.28).The mean difference is 30.60 in favour of experimental group. Therefore, the answer to the research question four is that there exists significant difference in favour of experimental group. This shows the effect of the treatment on the experimental group. To test whether there was a significant difference or not in the mean score of the experimental and control groups, $H0_4$ was used.

Research Questions 5: What is the difference in the academic achievement between male and female Physics students taught with CAI at NCE?

The descriptive statistics such as mean and standard deviation was used to test this research question and the summary of the results is presented in Table 4.2.5. The mean and standard deviation of Pre-test result discussion is in Appendix E.

Table 4.2.5 Means and Standard Deviation of Post-test of Male and Female Physics Students taught using CAI.

Gender	N	Mean	SD	MD
Male	68	67.29	14.53	2.69
Female	45	64.60	13.85	

Based on Table 4.2.5, the answer to question five which states: "What is the difference in academic achievement of male and female physics students taught using CAI?" is that the mean score for the male was 67.29 and that of the female was 64.60. This indicates that there is no significant difference between the mean score of the male (67.29) and the female (64.60). The mean difference is 2.69 in favour of the male. Therefore, the answer to research question five is that there exists significant difference in favour of the male. To test whether there was a significant difference or not in the mean score of the male and female, $H0_5$ was used.

Research Questions 6: Is there any difference in the academic achievement among Low Ability (LA), Medium Ability (MA) and High Ability (HA) level students taught with CAI at NCE?

The descriptive statistics such as mean and standard deviation was used to test this research question and the summary of the results is presented in Table 4.2.6.

Table 4.2.6 Means and Standard Deviation of Post-test of Low Ability, Medium Ability and High Ability Levels Students taught using CAI

Source	Sum of Square	DF	Mean	SD	MD
Between Groups	2588.23	2	35.97	17.99	22.42
Within Group	20193.24	110	13.55	6.77	
Totals	22781.47	112			

Based on Table 4.2.6, the answer to question six which states: "What is the difference in academic achievement among low ability, medium ability and high ability level Physics students taught using CAI?" is that the mean score for the between group was 35.97 and that of the within group was 13.55. This indicates that there is statistically significant difference between the mean score of the between group (35.97) and the within group (13.55).The mean difference is 22.42. Therefore, the answer to the research question six is that there exists significant difference among the groups. This implies that there is significant difference in the academic achievement among low ability, medium ability and high ability level students taught using CAI. To test whether there was a significant difference or not in the mean score of the experimental and control groups, $H0_6$ was used.

4.2.2 Hypotheses Testing

The results are presented in Tables 4.2.7 - 4.2.13

4.2.3 Test for Academic Achievement of Physics Students taught using CAI and those taught using Lecture Method in their Mean Scores in Experimental and Control Groups.

Null Hypothesis I

$H0_1$: There is no significant difference in the academic achievement between Physics students taught using CAI and those taught using Lecture method in physics at NCE level.

This hypothesis was tested by selecting the scores of the experimental group who were subjected to the treatment and the score of the control group to a two sample t-test after the experiment. The result of the test is summarized in Table 4.2.7.

Table 4.2.7: Two Sample t-test on Achievement Score in Physics by Experimental and Control Groups.

Type	N	Mean	Std. Deviation	Std. Error	t-value	DF	MD	P	Remark
Experimental	113	66.22	14.26	1.34	18.40	209	30.04	.0001	Sig.
Control	98	36.18	8.17	0.83					

*Significant at $p \leq 0.05$

The result in Table 4.2.7 revealed that students who were exposed to the CAI significantly performed better in their achievement when compared to students in the control group who were not exposed to the treatment. Moreover, the level of significance obtained for the test is 0.0001 ($p \leq 0.05$). Therefore, the null hypothesis that there is no significant difference in the academic achievement between Physics students taught using CAI and those taught using Lecture method in Physics at NCE level is rejected. The result is a clear indication that students

exposed to the Computer-Assisted Instruction (CAI) method were better in their performance than those exposed to Lecture Method.

4.2.4 Test for Academic Achievement of Low Ability Students taught using CAI and those taught using Lecture Methods in there Mean Scores in Experimental and Control Groups.

Null Hypothesis II

$H0_2$: There is no significant difference in the academic achievement between low ability students taught using CAI and those taught using Lecture Method in Physics at NCE level.

To test this hypothesis, the posttest mean scores of the students in the experimental and control groups were compared using t-test statistics. The result is shown in Table 4.2.8

Table 4.2.8: t-test on Scores of Low Ability Students in Experimental and Control Groups after Treatment.

Type	N	Mean	Std. Deviation	Std. Error	t-value	DF	MD	P	Remark
Experimental	28	57.93	17.03	3.22	4.88	41	22.73	.0001	Sig.
Control	15	35.20	7.82	2.02					

*Significant at $p \leq 0.05$

From the result in Table 4.2.8 the p-valve obtained is 0.000 which is less than $p \leq 0.05$. Since p-value 0.0001 obtained is smaller than $p \leq 0.05$, this shows that students who were exposed to the CAI significantly performed better in their achievement when compared to students in the control group who were not exposed to the treatment. The null hypothesis of no significant difference between the academic achievement of the experimental and control group is rejected. The result shows that the Computer-Assisted Instruction is better at improving

students' academic achievement in Mechanics and Properties of Matter than the lecture method. As revealed in the Table 4.2.8, the mean scores of experimental group is 57.93 and the control group is 35.20 which clearly shows that students exposed to the Computer-Assisted Instruction (CAI) method were better in their performance than those exposed to lecture method.

4.2.5 Test for Academic Achievement of Medium Ability Students taught using CAI and those taught using Lecture Methods in there Mean Scores in Experimental and Control Groups.

Null Hypothesis III

$H0_3$: There is no significant difference between the academic achievement of medium Ability students taught using CAI and those taught using Lecture Method in Physics at NCE level.

To test this hypothesis, the posttest mean scores of the achievement test of the experimental and control groups who were categorized in the medium ability were selected for comparison to test the effect of the Computer-Assisted Instruction (CAI) method. The summary of the two sample t-test used for the hypothesis is shown in Table 4.2.9.

Table 4.2.9: t-test on Scores of Medium Ability Students in Experimental and Control Groups after Treatment.

Type	N	Mean	Std. Deviation	Std. Error	t-value	DF	MD	P	Remark
Experimental	61	68.59	12.45	1.60	17.37	113	33.94	.0001	Sig.
Control	54	34.65	7.58	1.03					

*Significant at $p \leq 0.05$

From the mean score in Table 4.2.9, the students who were exposed to the Computer-Assisted Instruction were significantly enhanced in their performance after the

treatment when compared with their counterparts who were in the control group that were not exposed to the treatment. The p-valve obtained from the test as indicated in the table is 0.0001 which is less than the p-value of $p \leq 0.05$. Thus the null hypothesis that there is no significant difference in the academic achievement of medium ability students taught using CAI and those taught using Lecture Method in Physics at NCE level was rejected. Students taught using CAI had their academic performance in Physics significantly enhanced compared to students in the control group who were taught with the conventional Lecture Method.

4.2.6 The Effect of Academic Achievement between High Ability Level Students taught using CAI and those taught using Lecture Method

Null Hypothesis IV

$H0_4$: There is no significant difference in the academic achievement between high ability students taught using CAI and those taught using Lecture Method in Physics at NCE level.

To test this hypothesis, the posttest mean scores of the achievement test of the experimental and control groups in the high ability category were selected and subjected to a two sample t-test procedure. The result is summarised in Table 4.2.10

Table 4.2.10:Two Sample t- test on Scores of High Ability Students in Experimental and Control Groups after Treatment.

Type	N	Mean	Std. Deviation	Std. Error	t-value	DF	MD	P	Remark
Experimental	24	69.88	11.54	2.36	11.11	51	30.60	.0001	Sig.
Control	29	39.28	8.49	1.58					

*Significant at $p \leq 0.05$.

The result in the Table 4.2.10 revealed that the two groups differed significantly in their performances. The p-valve obtained from the test as indicated in the table is 0.0001 which is less than the p-value of $p \leq 0.05$. Thus the null hypothesis that there is no significant difference in the academic achievement of high ability students taught using CAI and those taught using Lecture Method in Physics at NCE level is rejected. From the mean scores, students who were exposed to the Computer-Assisted Instruction have higher performance than those taught using Lecture Method.

4.2.7 Test for Academic Achievement of Male and Female Students taught using CAI in there Means Scores in Experimental Group.

Null Hypothesis V

$H0_5$: There is no significant difference in the academic achievement between male and female students taught using CAI in Physics at NCE level.

To test this hypothesis, the posttest mean scores of the male and female students who were exposed to the computer-assisted instruction method after the treatment were used as the dependent variable. The result of the two sample t-test used to compare their differences in the performance is summarized in Table 4.2.11.

Table 4.2.11: Two Sample t-teston Scores of Male and Female Students in Experimental Group.

Gender	N	Mean	Std. Deviation	Std. Error	t-value	DF	MD	P	Remark
Male	68	67.29	14.53	1.76	0.98	111	2.69	0.328	NS
Female	45	64.60	13.85	2.06					

*Significant at $p \leq 0.05$

The result in the Table 4.2.11 did not reveal significant difference between the male and female students who were exposed to the computer-assisted instruction method in their academic

achievement. The p-value obtained from the test as indicated in the table is 0.328 which is greater than p-value of $p \leq 0.05$. Therefore, the null hypothesis that there is no significant difference in the academic achievement between the male and female students taught using CAI in Physics at NCE level is not rejected.The result showed that the treatment had equal enhancement on the performances of the male and female students who were exposed to it. Therefore, the CAI is gender friendly.

4.2.8 Test for Academic Achievement of Low Ability, Medium Ability and High Ability Level Students Taught Using CAI.

Null Hypothesis VI

$H0_6$: There is no significant difference in the academic achievement among low ability, medium ability and high ability level students taught using CAI in Physics at NCE level.

To test this hypothesis, the posttest mean scores of the achievement test of the experimental groups for the three categorized abilities were subjected to one way ANOVA procedure. The result for the analysis of variance model is summarized in Table 4.2.12

Table 4.2.12: One way ANOVA Analyses of the Mean Scores of Low Ability, Medium Ability and High Ability Levels in Experimental Groups in the Posttest.

Source	Sum of Square	DF	Mean Square	Critical Value	F	Sig.
Between Groups	2588.23	2	1294.12	3.00	7.05	0.001
Within Group	20193.24	110	183.58			
Totals	22781.47	112				

*Significant at $p \leq 0.05$

The result in Table 4.2.12 shows that the groups differ significantly in their performances from each other. The observed F-value (7.05) is higher than the 3.00 for the critical value at the 2, 110 degree of freedom (DF). The observed level of significance is 0.001 ($p \leq 0.05$). This means that the null hypothesis that there is no significant difference in academic achievement among low ability, medium ability and high ability level students taught using CAI in Physics at NCE level is therefore rejected.

To establish the category of the ability level that was significantly different from the other, a post hoc mean separation test was carried out on the mean scores. The Scheffe procedure was used for this purpose and the result is summarized in Table 4.2.13.

Table 4.2.13: Result of the Scheffe Test on the Mean Scores

(I) Ability	(J) Ability	Mean Difference (I-J)	Std. Error	Sig.	Rmk
Low	Medium	-10.66159(*)	3.09284	0.004	S
	High	-11.94643(*)	3.76898	0.008	S
Medium	Low	10.66159(*)	3.09284	0.004	S
	High	-1.28484	3.26472	0.926	NS
High	Low	11.94643(*)	3.76898	0.008	S
	Medium	1.28484	3.26472	0.926	NS

***The mean difference is significant at the .05 level.

The result in Table 4.2.13 reveals that low ability students compared to medium ability students with p-value of 0.004 which is less than p-value of $p \leq 0.05$ implies that there is significant difference in their academic achievement. Also, low ability students compared to high ability students with p-value of 0.008 which is less than p-value of $p \leq 0.05$shows that there is significant difference in their academic achievement.The result further reveals that medium ability students compared to low ability students with p-value of 0.004 which is less than p-value of $p \leq 0.05$, indicates that there is significant difference in their academic achievement. The medium ability students compared to high ability students have p-value of 0.926 which is greater than p-value of $p \leq 0.05$ implies that there is no significant difference in their academic achievement. Similarly,

high ability students compared to low ability student having p-value of 0.008, which is less than p-value of $p \leq 0.05$, implies that there is significant difference in their academic achievement. Furthermore, the high ability students compared to medium ability students have p-value of 0.926 which is greater than p-value of $p \leq 0.05$, implies that there is no significance difference in their academic achievement.

4.3 Summary of Findings

The findings of the study are as follows:

1. There is a significant difference between the academic performance of students who were exposed to CAI and those who were exposed to lecture method. Students who were exposed to CAI achieved higher in Physics.
2. The low ability level students taught using CAI (experimental group) performed better than their counterparts (control group) taught using lecture method, which indicates the viability of CAI on low ability students.
3. The medium ability level students taught using CAI performed better than their control counterparts taught using lecture method. Therefore, null hypothesis three is rejected.
4. The high ability level students taught using CAI performed better than their counterparts taught using lecture method. Therefore, null hypothesis four is rejected.
5. The result of the study reveals that there is no significant difference between the mean scores of male and female students exposed to computer-assisted instruction. Therefore, null hypothesis five is accepted.

6. There is significant difference in the academic achievement among low ability, medium ability and high ability students taught using CAI.

4.4 Discussion of the Results

The objective of this study was to investigate the effects of the use of computer-assisted instruction on academic achievement of Nigeria Certificate in Educationof Physics students of different ability levels in Niger State. The data collected were analyzed by employing t-test statistics and one way ANOVA at $p \leq 0.05$ levels of significance.

The test for Hypothesis I reveals that students exposed to the use of the CAI were found to be significantly better in their performance than those who were taught with the conventional lecture method. The implication of this finding is that the use of the CAI enhances students' performance in Physics than the use of the lecture method. The result supports the findings of Akour (2006); Orisebiyi (2007) and Yusuf and Afolabi (2010) who reported a significant difference in the performance of students taught using CAI. The result is however, not in agreement with the previous findings of Huxford (as cited by Jenks and Springer, 2002), Imhanlahimi and Imhanlahimi (2008) and Owusu (2009) who discovered that those taught using conventional method performed better than those exposed to CAI. The result shows that the treatment given to the experimental group had a positive effect on them as it shown by the higher mean score. This might be due to change in mode of instruction that is from teacher-centred (i.e. lecture method) to student-centred (i.e. computer-assisted instruction).

Hypothesis II which states that: "there is no significant difference in the academic achievement between low ability students taught using CAI and those taught using Lecture Method in Physics at NCE level" was tested using t-test statistics. The result reveals that students

exposed to the use of CAI were significantly better than their counterparts taught using the Lecture Method. This implies that Null Hypothesis II is rejected. The result indicates a better achievement in favour of low ability students taught using CAI. The finding is related to the findings of Gambari (2003) who observed that Computer Assisted Instruction (CAI) enhances academic achievement of Physics students in senior secondary schools. Also the result is in agreement with those of Kara and Yakar (2008) who reported that students taught Newton's Law of Motion by use of Computer-Assisted Instruction had their performance enhanced. Owusu (2009) in his finding stated that Computer-Assisted Instruction enhance the performance of the low achievers than the high achievers in Biology in Ghana. Also, Salahudeen (2012) in his study found that Computer-Assisted Instruction enhances learning of longitude and latitude among secondary school students in Minna Metropolis. In the same way, Hassan (2012) in his work revealed that Computer Assisted Instruction enhances pupils' academic achievement taught Mathematics in Nupe language. But the finding is in contrast to Tabassum (2004) who indicated that CAI is more effective for high achievement level students than low achievement level students. This implied that the treatment had impact on the experimental group. The CAI enhanced the performance of the low ability level students because it encouraged individualised learning activity. The students' learning yield positive and immediate results. Besides, the students could learn at their own pace.

Hypothesis III, "There is no significant difference between the academic achievement of medium ability students taught using CAI and those taught using Lecture method in Physics at NCE level" was tested using t-test statistics. The result reveals that there is significant difference in the posttest mean scores of medium ability level in the experimental group. This implies that

Null Hypothesis III is rejected. The experimental group has higher academic achievement than the control group.

The result indicats a better achievement in favour of medium ability students taught using CAI. The result is in agreement with the findings of Tabassum (2004), who found that Computer-Assisted Instruction enhances student achievement in science. Also Orisebiyi (2007), in his study found that Instructional Video Tape package improved senior secondary school students' performances in Biology in Fidit:. In the same vein, Alhassan (2012) in his work also found that Computer-Assisted Instruction enhances academic achievement in Geometry among junior secondary school students in Minna Metropolis. While, the finding is not in agreement with Imhanlahimi and Imhanlahimi (2008) and Owusu (2009) whose findings revealed that conventional method approach group performed better than the CAI group. The result indicates the efficacy of Computer-Assisted Instruction in enhancing acquisition of concepts of Mechanics and Properties of Matter. This is because the instruction allowed new materials, especially abstract concepts, to be more easily assimilated with the students' prior knowledge, enabling them to develop a more scientific understanding of the concepts.

Hypothesis IV, "There is no significant difference in the academic achievement between high ability students taught using CAI and those taught using Lecture Method in Physics at NCE level"was tested using t-test statistics. The results reveals that there is a significant difference in the mean scores of high ability students taught using CAI and those taught using Lecture Method as shown in the test of Hypothesis IV. This implies that Null Hypothesis IV is rejected. Those taught using CAI have a higher academic achievement than those taught not using CAI. The result indicats a better performance in favour of high ability students taught using CAI. The result agrees with the finding of Owusu (2009) which revealed

that those students who received Computer-Assisted Instruction showed a greater increase in their academic achievement scores in multiplication and subtraction than students who received traditional mathematical instruction. The finding of Hassan (2012) also agreed with the findings of this study. His finding reveals that pupils taught mathematics with the use of Computer-Assisted Instruction package in Nupe Language performed better than those taught mathematics using conventional teaching method. The result showed that the treatment given to the experimental group had a positive effect on them as it shown by the higher mean score. This might be due to change in mode of instruction, that is, from teacher-centred (i.e. lecture method) to student-centred which is hand-on and mind-on instruction (i.e. computer-assisted instruction).

Hypothesis V which states that "There is no significant difference in the academic achievement between male and female students taught using CAI in physics at NCE level"was tested using t-test statistics. The result reveals that there is no significant difference in the academic achievement of male and female students. This implies that Null Hypothesis V is accepted. The result is not in agreement with the findings of Hassan (2012) andSalahudeen (2012). They reported significant difference between the performances of male and female students in favour of females. But the finding is in agreement with the findings of Yusuf and Afolabi (2010), Bello (1996) in Achuonye (2011), who stated that gender has no influence on performance of male and female pupils exposed to CAI.

Hypothesis VI which states that "there is no significant difference in the academic achievement among low ability, medium ability and high ability level students taught using CAI in Physics at NCE level" was tested using one way ANOVA statistics. The result reveals a significant difference in the ability groups of the experimental group after the experiment. Though, the variability was found to be significan the significance was only between the students

with low ability group and the rest of the two (high and medium abilities). Between the medium ability and the high ability group, no significance difference was observed. The Null Hypothesis was therefore rejected. A post hoc mean separation test was carried out on the mean scores, using Scheffe procedure to establish the category of the ability level that was significantly different. From Table 4.2.7, it was revealed that low ability students were significantly different in their performances from the medium and high ability students. But there was no significant difference between medium and high ability students in their academic achievement. The result of this finding is in agreement with the findings of Fagbemi (2003) which revealed that there was significant difference in the achievement scores of pupils of different ages taught Social Studies using a computer based package, but in disagreement with Salahudeen (2012) whose finding revealed that there was no significant difference in the academic achievement of students taught mathematics using CAI package in respect of their age group.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The study was an investigation into the use of computer-assisted instruction on academic achievement of different ability levels of Nigeria Certificate in Education Physics students in Niger State. The data collected were analysed using mean and t-test statistical tools. This chapter is presented under the following sub-headings:

- Summary of the Study
- Summary of Major Findings
- Contribution of the Study to Knowledge.
- Conclusion
- Recommendations
- Limitations
- Suggestions for Further Study

5.2 Summary of the Study

This study is an investigation into the use of computer-assisted instruction on academic achievement of different ability levels of Nigeria Certificate in Education Physics students in Niger State. Computer-Assisted Instruction (CAI) was used to enhance the students' academic achievement in Mechanics and Properties of Matter. Two hundred and eleven (211) students were used for the study. The study involved teaching using computer-assisted instruction as the treatment in an attempt to compare the academic achievement in Mechanics and Properties of Matter and Lecture Method was used as control.

The concepts selected for the study were Inertia of rigid body, Gravitation, Surface Tension, Fluid Motion and Harmonic Motion. Six null hypotheses were stated and tested at $p \leq 0.05$ levels of significant. Mechanics and Properties of Matter Achievement Test (MPMAT) made up of 40 multiple choice questions was used to measure academic achievement of the students after treatment.

The data collected from the achievement test were analysed using t-test and one way ANOVA statistics to test the stated hypotheses. The results and discussion are reported in Chapter Four.

The findings revealed the following:

i There is a significant difference in the academic achievement of students who were exposed to Computer-Assisted Instruction (CAI) and those who were not exposed to Computer-Assisted Instruction (CAI). Students who were exposed have higher achievement.

ii There is a significant difference in the mean academic achievement score of low ability level students taught using Computer-Assisted Instruction compared to those taught using Lecture Method of instruction in Mechanics and Properties of Matter in favour of the experimental group (i.e. Computer-Assisted Instruction).

iii. There is a significant difference in the mean academic achievement score of medium ability level students taught using Computer-Assisted Instruction compared to those taught using Lecture Method of instruction in Mechanics and Properties of Matter in favour of the experimental group.

iv. There is a significant difference in the mean academic achievement score of high ability level students taught using Computer-Assisted Instruction compared to those taught using Lecture Method of instruction in Mechanics and Properties of Matter in favour of the experimental group.

v. There is no significant difference in the mean academic achievement scores of male and female students taught using Computer-Assisted Instruction in Mechanics and Properties of Matter in the experimental group as instruction is gender friendly.

vi. There is significant difference in the academic achievement among low ability, medium ability and high ability level students taught with CAI, in favour of low ability level students.

5.3 Summary of Major Findings

i Those students who were exposed to the CAI performed better in their academic achievement than their counterpart who were taught using lecture method, hence the null hypothesis I is rejected.

ii The low ability level students taught using CAI (experimental group) performed better than their counterparts (control group) taught using lecture method, hence the null hypothesis II is rejected.

iii There is a significant difference in the posttest mean scores of the experimental group of high ability level.

iv There is a significant difference in the mean scores of medium ability level in experimental group.

v There is no significant difference in the mean scores of males and females as instruction is gender friendly.

vi There is significant difference in the academic achievement among low ability, medium ability and high ability students taught using CAI.

5.4 Conclusion

The findings of this study have shown that academic achievement on mechanics and properties of matters among physics students of different abilities at NCE level enhanced by usage of Computer-Assisted Instructional package. The used of CAI package does not discriminate between genders in academic achievement thus, CAI is gender friendly at NCE level. It was generally observed that Computer-Assisted Instruction (CAI) has the potential of enhancing NCE students' academic achievement in Mechanics and Properties of Matters concepts, and this may be because it is based on both hands-on and minds-on strategies.

5.5 Contribution of the Study to Knowledge.

This study contributed to the knowledge in the following ways:

1. The other researches on CAI are mainly on secondary schools while this study is on tertiary education, the NCE level.

2. The study is concerned with all the three abilities level at NCE level which is unique. Therefore, all ability levels can always be helped through CAI.

3. The study is on Mechanics and Properties of Matter II at NCE level in Niger State for the first time.

4. Nobody is a drop-out with the use of CAI in teaching and learning Physics concepts in Mechanics.

5. It has added to the existing literature in CAI.

5.6 Recommendations

From the findings of this study, the following recommendations are made:

(1) The use of Computer-Assisted Instruction (CAI) should be encouraged by NCE Physics teachers in teaching Mechanics and Properties of Matters concepts because it enhance the performances of the students.

(2). Teaching and learning materials such as computers should be provided by government agencies such as State Governments, Federal Ministry of Education, and National Commission for Colleges of Education (NCCE) for effective utilization of Computer-Assisted Instruction (CAI) in teaching/learning Mechanics and Properties of Matters concept at NCE level.

(3). Computer-Assisted Instruction (CAI) enhances visualization and reorganization of science facts in the learners' cognitive structure. It should therefore be encouraged for teaching in the science classroom.

(4). Professional associations like Science Teachers Association (STAN), Mathematics Association of Nigeria (MAN) and research centres like Nigerian Educational and Research Development Council (NERDC) should incorporate Computer-Assisted Instruction (CAI) in their science curricula at the junior and senior secondary school levels to encourage the use of the instructional materials among teachers. Workshops may be needed for this by STAN.

(5). Science teachers should be trained in computer programming to help them in designing software packages for various courses at NCE level.

(6). Individual Physics lecturers should be computer literate so that they can develop appropriate computer-assisted instruction software.

(7). The Computer-Assisted Instruction (CAI) should be incorporated into teacher education curriculum and be taught as other teaching methods since it is a relatively new technique with many stages for its successful implementation.

5.7 Limitations of the Study

The following limitations influence the findings of this study:

1. Unstable electricity supply during the research experiment which made the researcher to have a stand-by generator may have had effect on the result of the study.
2. Limited time and fund available to carry out this study.
3. Small sample of only two colleges.

4. Making one College experimental and the other control.

5.8 Suggestions for Further Studies

(i). Only two methods of instruction for teaching/learning of Mechanics and Properties of Matters concepts in NCE were investigated. There is need to carry out a similar research using other activity-based methods of instruction.

(ii). This type of study could be extended to other institutions, universities, polytechnics in various disciplines to see what the results would be.

(iii). The results obtained in this research are for Physics. The method can therefore be tried out in other courses such as Chemistry, Biology, Integrated Science and Mathematics at NCE level.

(iv) This type of study could be extended to other states and federal colleges of education in Nigeria for widening and generalizing the scope of the findings of such studies.

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APPENDIX A

MECHANICS AND PROPERTIES OF MATTER ACHIEVEMENT TEST (MPMAT)

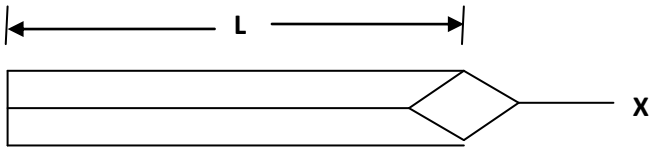
PHY 213

TIME: 80 minutes

INSTRUCTIONS: Answer all by TICKING the correct option.

1. An object or system of particle s in which the distances between particles are fixed and remain constant is termed.
   (A) Frictional force (B) Surface tension (C) Rigid body (D) Moment of inertia
2. The rotational inertia about the natural axis can be expressed as
   (A) M^2R (B) MR (c) MR^2 (D) $M^2 R^2$
3. The Kinetic energy of rotation is given by
   (A) $\frac{1}{2}I^2W$ (B) $\frac{1}{2}IW^2$ (C) $\frac{1}{2}IW$ (D) $\frac{1}{2}1^2W^2$
4. The angular momentum L of the particle relative to the Origin O, is defined to be the,
   (A). Sum of r and P (B) Quotient of r and P
   (C) Dot product of r and P (D) Cross product of r and P,
5.. A car of mass 1200kg moves counter clockwise in a circle of radius 20m with speed 15m/s. Calculate its angular momentum about the origin
   (A) 3.6 x 10^4 kg m^2/s k (B) 3.6 x 10^5 kg m^2/s k
   (C) 3.0 x 10^5 kg m^2/s k (D) 3.0 x 10^4 kg m^2/s k
6. If the same in (no. 5) above moves with velocity V = - (15m/s)i along the line $y=y_0=20$m parallel to the axis. Find the angular momentum about the origin
   (A) 3.0 x 10^5 kg m^2/s k (B) 3.6 x 10^4 kg m^2/s k
   (C) 3.0 x 10^4 kg m^2/s k (D) 3.6 x 10^5 kg m^2/s k
7. The Universal Gravitational constant is given by:
   (A) 6.67 x $10^{11}Nm^2/kg^2$ (B) 6.00 x $10^{11}Nm^2/kg^2$
   (C) 5.90 x $10^{12}Nm^2/kg^2$ (D) 6.67 x $10^{12}Nm^2/kg^2$
8. The resolution of the work done in stretching the spring, if $U(x) = \int_0^x Kxdx$ is given as;
   (A) Kx^2 (B) $\frac{1}{2}Kx$
   (C) $\frac{1}{2}Kx^2$ (D) 2Kx.
9. The number of cycles that takes place per unit time is
   (A) Amplitude (B) Frequency
   (C) Wavelength (D) Period.
10. The surface tension in the film γ, is expressed as:
    (A) $\gamma = {}^{F}/_{2L}$ (B) $\gamma = \frac{2L}{F}$ (C) γ = 2LF (D) $\gamma = \frac{L}{2F}$
11. The attractive force exerted on a liquid molecule by the neighboring liquid molecule is termed:
    (A) Frictional force (B) Cohesive force
    (C) Gravitational force (D) Adhesive force

12. What would be the value of 3000 rev/min in rad/sec?
    (A) 25 rad/sec (B) 50 rad/sec (C) 100 rad/sec (D) 314 rad/sec
13. The parallel axis theorem states that;
    (A) I = Icm +Mh (B) I = Icm + M^2h (C) I = Icm + Mh^2 (D) I = Icm + M^2h^2
14. Find the rotational inentia of a thin uniform circular disc with radius R, mass M and surface density $\rho = \frac{m}{\pi R^2}$ about an axis through its, center and perpendicular to the plane of the disc.
    (A) MR^2 (B) ½MR (c) ½M^2R (D) ½MR^2



Given the length L and mass, M about an axis perpendicular to the stick and through one end, assume that the stick has negligible thickness.

15. The moment of inertia is given by the integral
    (A) $\int_o^L X^2 dm$ (B)$\frac{1}{3}\int_o^L X^3 dm$ (C) $\frac{1}{2}\int_o^L X^2 dm$ (D) $\int_o^L X dm$
16. The attractive force exerted on a liquid molecule by the molecule in the surface of the solid is
    (A) Frictional force (B) Cohesive force
    (C) Gravitational force (D) Adhesive force

17. If the adhesive force is small, compared with the cohesive force, the liquid surface is pulled away from the wall and the meniscus is:
    (A) Plano convex (B) Convex
    (C) Plano Concave (D) Concave
18. One of Kepler's law State that $T^2 = Cr^3$, which of the law's stated that?
    (A) First law (B) Second law (C) Third law (D) Fourth law
19. The Magnitude of the gravitational force exerted by a particle of mass M_1 on another particle of mass M_2 and a distance r, away is given by:
    (A) $F = \frac{GM_1M_2}{r}$(B) $F = \frac{GM_1M_2}{r^2}$(C) $F = \frac{GM_1}{M_2r}$ (D) $F = GM_1M_2r^2$
20. Newton published his theory of gravitation in……,
    (A) 1866 (B) 1686 (C) 1668 (D) 1985
21. If a disk in the xy plane of radius 20m and mass 1200kg rotated at 0.75 rad/sec about its axis which is the z – axis. What would be the angular momentum about the origin?
    (A) 1.8 x 10^5 kg m^2/s k (B) 1.5 x 10^2 kg m^2/s k
    (C) 1.8 x 10^2 kg m^2/s k (D) 3.6 x 10^5 kg m^2/s k

22. If an oscillatory motion exactly repeats itself after each time interval T = 0.5 sec. What is its frequency?

(A) 50 HZ (B) 30 HZ

(C) 40 HZ (D) 20HZ

Use the information below to answer questions 23 and 24.

A spring stretches by 4.0 cm from its relaxed length when a force of 7.0 N is Applied. A particle with a mass of 0.5 kg is attached to the free end of the spring, Which is then compressed horizontally by 6.0 cm from its relaxed length and released from rest at t = 0.

23. Find its angular frequency

(A) 18.71 rad/sec (B) 27. 38 rad/sec

(C) 22.37 rad/sec. (D) 18.00 rad/sec.

24. Find its periods.

(A) 0.357 sec. (B) 0.280 sec.

(C) 0.336 sec (D) 0.226 sec.

25. Calculate the excels pressure inside a drop of mercury of diameter 4mm at 20^0C (take mercury $\gamma = 465 \times 10^{-3}$Nm^{-1}

(A) 5.0×10^{-2}atm (B) 2.5×10^{-3}atm

(C) 5.0×10^{-3}atm (D) 2.5×10^{-2}atm

26. If given $\rho = \frac{M}{L}$, write dm in terms of the mass density ρ and dx.

(A) $dm = \frac{M}{L}dx$ (B) $dm = MLdx$ (C) $dm = \frac{1}{2}MLdx$ (D) $dm = ML^2dx$

27. Find the Moment of inertia of the uniform stick

(A) $\frac{1}{3}ML^3$ (B) $\frac{1}{3}ML^2$ (C) ML^3 (D) $\frac{1}{2}ML^2$

28. The angle of contact is defined as:

(A) the angle between the solid surface and the tangent plane to the liquid surface at the point where it touches the solid

(B) the angle between the solid surface and the tangent plane to the solid surface at the point where is touches the solid

(C) the angle between the liquid surface and the tangent plane to the solid surface at the point where it touches the liquid.

(D) the angle between the liquid surface and the tangent plane to the liquid surface at the point where it touches the liquid.

29. The angle of contact between water and clean glass is
(A) 45^0(B) 90^0(C) 0^0 (D) 137^0

30. What angle of liquid in contact Suffers capillary depression?
(A) less than 90^0 (B) Equal 90^0
(C) Greater than 90^0 (D) Zero

31. The radius of Gyration can be calculated as
(A) $r^2 = \frac{1}{m}\int_m r^2 dm$ (B) $r^2 = \int_m r^2 dm$ (C) $r^2 = m\int_m r^2 dm$
(D) $r^2 = \int_m r dm$

32. The velocity of the centre of mass relative to any point on the axis of rotaton is
(A) Vcm = h^2w (B) Vcm = hw (C) Vcm = hw^2 (D) Vcm=h^2w^2

33. The rotational inertia of uniform disk about a perpendicular axis through its center is
(A) I = ½(MR) (B) I = ½(MR^2) (C) I = ½$(MR)^2$ (D) I = ½(M^2R)

34. The first experiment from which a reasonable accurate value for G could be obtained was carried out by the English Chemist Henry Cavendish and reported his result to the royal society in ……..
(A) 1978 (B) 187900 (C) 1789 (D) 1798

35. If an object is projected upward from the earth with some initial kinetic energy then;
(A) the P.E decreases and the K.E increases as the object rises
(B) the K.E decreases and the P.E increases as the object rises
(C) the K.E increases and the P.E decreases as the object rises
(D) the P.E increases and the K.E decreases as the object rises

36. The speed required for an object to escape from the earth is:
(A) Uniform velocity (B) Escape velocity
(C) Gravitational force (D) moment of inertia

37. Which is the correct statement about Torque?
(A) $\tau = r.F$ (B) $\tau = r + F$ (C) $\tau = r - F$ (D) $\tau = r \times F$

38 The net external torque on a system equals to the
(A) rate of change of velocity with time
(B) rate of change of angular momentum of the system
(C) rate of change of angular acceleration
(D) rate of change of rotational inertia

39. Which law states that 'If the net external torque acting on a system is zero the total angular momentum of the system is constant.'
(A) law of angular momentum (B) law of conservation of energy
(C) law of inertia (D) law of conservation of angular momentum

40. Torque can also be referred to as
(A) Moment of force (B) Angular moment
(C) Angular speed (D) Angular acceleration

APPENDIX B
MARKING SCHEME

1. C
2. C
3. B
4. D
5. B
6. D
7. A
8. A
9. B
10. A
11. B
12. D
13. C
14. D
15. A
16. D
17. B
18. C
19. B
20. B
21. A
22. D
23. A
24. C
25. C
26. A
27. B
28. A
29. C
30. B
31. A
32. C
33. B
34. D
35. B
36. B
37. D
38. B
39. D
40. A

APPENDIX C

Facility Indices

S/NO	X(Score)	F =R/T	Y(Score)	F=R/T
1	14	0.29	20	0.41
2	8	0.16	18	0.37
3	10	0.20	22	0.45
4	9	0.18	23	0.47
5	14	0.29	26	0.53
6	7	0.14	20	0.41
7	15	0.31	25	0.51
8	11	0.22	23	0.47
9	16	0.33	24	0.49
10	6	0.12	20	0.41
11	11	0.22	25	0.51
12	14	0.29	26	0.53
13	12	0.24	22	0.45
14	15	0.31	28	0.57
15	10	0.20	23	0.47
16	13	0.27	28	0.57
17	22	0.45	32	0.65
18	18	0.37	29	0.59
19	19	0.39	28	0.57
20	19	0.39	29	0.59
21	10	0.20	22	0.45
22	21	0.43	31	0.63
23	19	0.39	28	0.57
24	16	0.33	25	0.51
25	16	0.33	26	0.53
26	16	0.33	30	0.61
27	13	0.27	27	0.55
28	22	0.45	35	0.71
29	18	0.37	25	0.51
30	19	0.39	28	0.57
31	16	0.33	25	0.51
32	21	0.43	33	0.67
33	15	0.31	26	0.53
34	10	0.20	20	0.41
35	13	0.27	23	0.47
36	12	0.24	22	0.45
37	11	0.22	20	0.41

38	13	0.27	25	0.51
39	13	0.27	26	0.53
40	13	0.27	28	0.57
41	13	0.27	29	0.59
42	12	0.24	20	0.41
43	11	0.22	21	0.43
44	12	0.24	22	0.45
45	13	0.27	23	0.47
46	11	0.22	21	0.43
47	13	0.27	22	0.45
48	13	0.27	23	0.47
49	14	0.29	28	0.57

APPENDIX D

Reliability Coefficient

S/N	Score X	Score Y	X^2	Y^2	XY
1	14	20	196	400	280
2	8	18	64	324	144
3	10	22	100	484	220
4	9	23	81	529	207
5	14	26	196	676	364
6	7	20	49	400	140
7	15	25	225	625	375
8	11	23	121	529	253
9	16	24	256	576	384
10	6	20	36	400	120
11	11	25	121	625	275
12	14	26	196	676	364
13	12	22	144	484	264
14	15	28	225	784	420
15	10	23	100	529	230
16	13	28	169	784	364
17	22	32	484	1024	704
18	18	29	324	841	522
19	19	28	361	784	532
20	19	29	361	841	551
21	10	22	100	484	220
22	21	31	441	961	651
23	19	28	361	784	532
24	16	25	256	625	400
25	16	26	256	676	416
26	16	30	256	900	480
27	13	27	169	729	351
28	22	35	484	1225	770
29	18	25	324	625	450
30	19	28	361	784	532
31	16	25	256	625	400

32	21	33	441	1089	693
33	15	36	225	1296	540
34	10	20	100	400	200
35	13	23	169	529	299
36	12	22	144	484	264
37	11	20	121	400	220
38	13	25	169	625	325
39	13	26	169	676	338
40	13	28	169	784	364
41	13	29	169	841	377
42	12	20	144	400	240
43	11	21	121	441	231
44	12	22	144	484	264
45	13	23	169	529	299
46	11	21	121	441	231
47	13	22	169	484	286
48	13	23	169	529	299
49	14	28	196	784	392
SUM	**682**	**1235**	**10182**	**31949**	**17777**



$\sum X$ $\sum Y$ $\sum X^2$ $\sum Y^2$ $\sum XY$

Use the following equation to calculate Pearson's coefficient:

$$r = \frac{\sum XY - \frac{\sum X \sum Y}{N}}{\sqrt{\left(\sum X^2 - \frac{(\sum X)^2}{N}\right)\left(\sum Y^2 - \frac{(\sum Y)^2}{N}\right)}}$$

Substitute the values obtained from the table into the equation:

$$r = \frac{17777 - \frac{682 \text{ x } 1235}{49}}{\sqrt{\left(10182 - \frac{682^2}{49}\right)\left(31949 - \frac{1235^2}{49}\right)}}$$

Simplify the equation:

$$r = \frac{17777 - 17189.184}{\sqrt{(10182 - 9492.327)\ (31949 - 31127.041)}}$$

$$r = \frac{587.816}{\sqrt{(689.673)\ (821.959)}}$$

$$r = \frac{587.816}{\sqrt{566882.929}}$$

$$r = \frac{587.816}{752.916}$$

$$r = 0.781$$

Therefore, Pearson's Product Moment Correlation Coefficient is 0.781

APPENDIX E

Table E.1 Means and Standard Deviation of Pre-test of the Experimental (CAI) and Control (Lecture) groups in Mechanics and Properties of Matters Achievement Test (MPMAT)

Variable	N	Mean	SD	MD
Experimental group	113	45.84	10.33	2.69
Control group	98	48.53	8.37	

From the result in Table E.1, the mean and standard deviation of Pre-test scores for the experimental group were 45.84 and 10.33 and that of the control group were 48.53 and 8.37 respectively. This indicates that there is significant difference between the mean scores of the experimental group (45.84) and the control group (48.53). The mean difference is 2.69 which mean that students in both groups were not equivalent with respect to their prior knowledge of the concept of mechanics and properties of matter II in Physics before treatment.

Table E.2 Means and Standard Deviation of Pre-test of Low Ability Students of the Experimental and Control groups in Mechanics and Properties of Matters Achievement Test (MPMAT)

Variable	N	Mean	SD	MD
Experimental group	28	31.64	4.82	4.24
Control group	16	35.88	1.86	

From the result in Table E.2, the mean and standard deviation of Pre-test scores for the experimental group were 31.64 and 4.82 and that of the control group were 35.88 and 1.86 respectively. This indicates that there is significant difference between the mean scores of the experimental group (31.64) and the control group (35.88). The mean difference is 4.24 which mean that students in both groups were not equivalent with respect to their prior knowledge of mechanics and properties of matter II in Physics before treatment.

Table E.3 Means and Standard Deviation of Pre-test of Medium Ability Students of the Experimental and Control groups in Mechanics and Properties of Matters Achievement Test (MPMAT)

Variable	N	Mean	SD	MD
Experimental group	61	47.15	4.27	0.18
Control group	55	47.33	4.26	

From the result in Table E.3, the mean and standard deviation of Pre-test scores for the experimental group were 47.15 and 4.27 and that of the control group were 47.33 and 4.26 respectively. This indicates that there is significant difference between the mean scores of the experimental group (47.15) and the control group (47.33). The mean difference is 0.18 which mean that students in both groups were not equivalent with respect to their prior knowledge of the concept of mechanics and properties of matter II in Physics before treatment.

Table E.4 Means and Standard Deviation of Pre-test of High Ability Students of the Experimental and Control groups in Mechanics and Properties of Matters Achievement Test (MPMAT)

Variable	N	Mean	SD	MD
Experimental group	24	59.08	3.43	0.58
Control group	28	58.50	3.67	

From the result in Table E.4, the mean and standard deviation of Pre-test scores for the experimental group were 45.84 and 10.33 and that of the control group were 48.53 and 8.37 respectively. This indicates that there is significant difference between the mean scores of the experimental group (45.84) and the control group (48.53). The mean difference is 2.69 which mean that students in both groups were not equivalent with respect to their prior knowledge of the concept of mechanics and properties of matter II in physics before treatment.

Table E.5 Means and Standard Deviation of Pre-test of Male and Female Physics Students of the Experimental groups

Variable	N	Mean	SD	MD
Male	68	66.67	13.72	3.52
Female	45	63.15	13.45	

From the result in Table E.5, the mean ans standard deviation scores for the male were 66.67 and 13.72 and that of the female were 63.15 and 13.45 respectively. This indicates that there is significant difference between the mean scores of the male (66.67) and the female (63.15). The mean difference is 3.52 thatmean the students both male and female were equivalent with respect to their prior knowledge of the mechanics and properties of matter II in Physics before treatment.

APPENDIX F

COMPUTER-ASSISTED INSTRUCTION (CAI) LESSON PLANS

Topic: Inertia of Rigid Body.

Time: 2 hrs

Instructional Aids: Chalk, Chalkboard, Textbook, and Computer-Assisted Instruction Software.

Instructional Objective: By the end of the lesson, students should be able to:

i) Define rigid body
ii) Explain how to determine Rotational inertia
iii) Determine the rotational inertia of thin uniform, solid sphere and uniform stick.

Content Development	Teachers Activities	Students Activities	Strategies
Entry Behaviour	Step one: The teacher allows students some seconds to settle down and ask them to LOGIN	The students then LOGIN and the topic of the research work appears on the screen.	Listening and watching.
	Step two: The teacher ask them to click the next botton to proceed	On clicking the screen displays the list of the lesson topics.	Note taking and questioning
	Step three: He told the students to click on lesson one to start and they should learn about the topic on their own using the CAI.	The students click on lesson one and they listern and watch to take note on their own.	Listening, watching and note taking
	Step four: The teacher then ask the students to have group discussion on what they've learnt.	They form groups and discuss on what they've seen and learnt.	Free discussion on the lesson learnt.
	Step five: He then evaluate by asking the following questions i) Define rigid body ii) Explain how you will determine rotational inertia.	They respond to the questions and take corrections	Answering the questions and seeking clearification on what they don't understand.

EFFECTS OF COMPUTER – ASSISTED INSTRUCTION ON ACADEMIC ACHIEVEMENT AMONG PHYSICS STUDENTS OF DIFFERENT ABILITIES, IN NIGER STATE, NIGERIA

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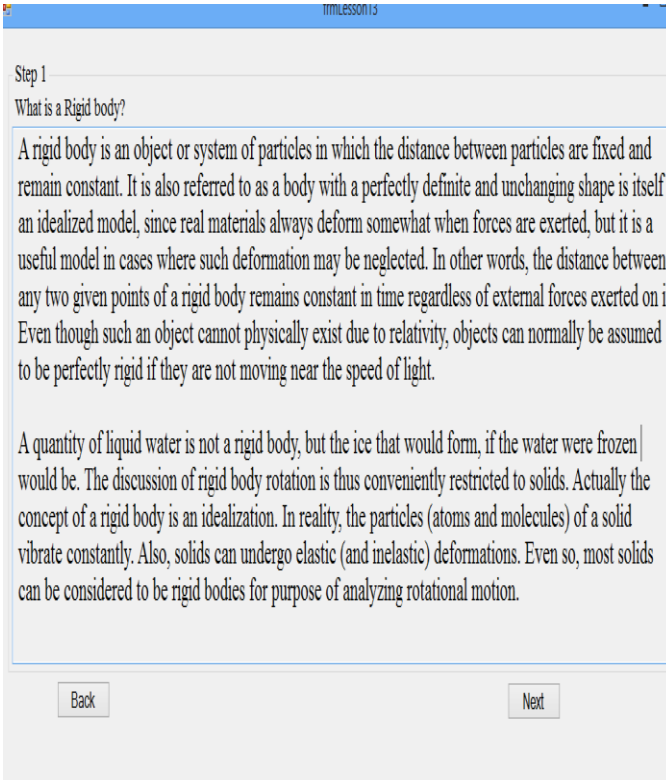


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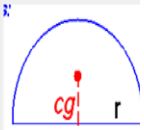


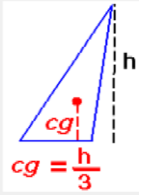
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Step 2

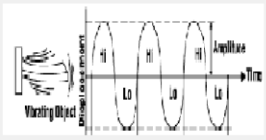
What is Center of Gravity?

The center of gravity is a geometric property of any object. The center of gravity is the average location of the weight of an object. We can completely describe the motion of any object through space in terms of the translation of the center of gravity of the object from one place to another, and the rotation of the object about its center of gravity if it is free to rotate. If the object is confined to rotate about some other point, like a hinge, we can still describe its motion. In flight, both airplanes and rockets rotate about their centers of gravity. A kite, on the other hand, rotates about the bridle point. But the trim of a kite still depends on the location of the center of gravity relative to the bridle point, because for every object the weight always acts through the center of gravity.





A vibrating object moves back and forth from its normal stationary position. A complete cycle of vibration occurs when the object moves from one extreme position to the other extreme, and back again. The number of cycles that a vibrating object completes in one second is called frequency. The unit of frequency is hertz (Hz). One hertz equals one cycle per second.

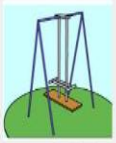


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Step 3

Difference between Translational and Rotational Motion.





Translational motion (also called linear) is simply an increment of distance dS traveled over an increment of time dT. As dS is a straight line over this small increment, there is no angular momentum. That is, there is no rotation or revolution of the object with the linear motion.

Rotational motion (also called spin) is where the object travels an increment of angle dTheta over an increment of time dT. The angle Theta is measured from some starting point (usually at time T = 0) and wraps around the spin axis, which is something like the hub of a wheel.

Step 4

How to determine Rotational Inertia.

As the determination of the rotational inertia for an object with a complicated shape involves a tedious calculation, or the value must be obtained by experiment. Fortunately, the calculation of the rotational inertia for homogenous objects with simple geometric shapes is relatively straight forward. For example, a thin-walled cylinder or ring with mass M and radius R has all of its mass at a distance r = R from the natural (or symmetry) axis of the cylinder. Consequently, the rotational inertia about this axis is

$I = MR^2$;



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Step 5

Exercise

Find the rotational inertia (or moment of inertia) of a thin uniform circular disc with radius R, mass M and surface density $\rho = M/\pi R^2$; about an axis through its center and perpendicular to the plane of the disc.

Solution:

Divide the disc into rings of differential width dr and area $(2\pi r)dr$. Each ring thus has differential mass

$dm = \rho (2\pi r)dr$

Then from rotational inertia

$I = \int_m r^2 \, dm$

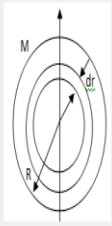
We have

$I_z = \int_0^R r^2 \rho (2\pi r)dr$

$= 2\pi\rho \int^R r^3 \, dr$

$= \frac{1}{2} \pi\rho R^4$

$= \frac{1}{2} MR^2$



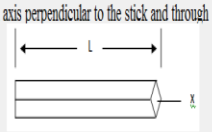
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Step 6

Exercise 2:

Find the moment of inertia of a uniform stick of length L and mass M about an axis perpendicular to the stick and through one end in fig below. Assume that the stick has negligible thickness.



Solution:

$I = \int_0^L x^2 \, dm$

Writing dm in terms of the mass density, ρ and dx

$dm = \rho \, dx = \frac{M}{L} dx.$

Substituting the above and integrating, we have.

$I_y = \int_0^L x^2 dm$

$= \int_0^L x^2 \frac{M}{L} dx$

$= \frac{M}{L} \frac{1}{3} x^3 \Big|_0^L$

$= \frac{M}{L} \frac{L^3}{3}$

$= \frac{1}{3} ML^2$

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THIS IS THE END OF LESSON ONE

OK

Lesson two - Energy and Gyration of a Rigid Body

Topic:Energy and Gyration of a Rigid Body

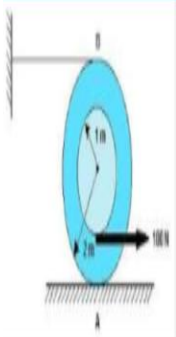
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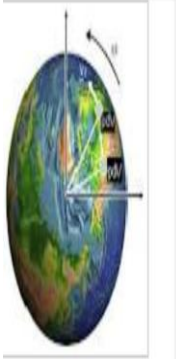
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ENERGY AND GYRATION OF A BODY.











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Step 1

What is Kinectic Energy of Rotation?

kinetic energy of rotation is the sum of the kinetic energies of the individual particles in the object. The kinetic energy of rotation of a rigid body is obtained by first dividing it up into a collection of smaller masses, and then summing up the kinetic energies due to the tangential velocities of the individual masses making up that rigid body.
To obtain the Rotational kinectic Energy of a body we have

$K = \frac{1}{2} m_i V_i^2$ ..... (1)

Summing over all the elements and using $V_i = r_i\omega$ gives

$K_{rot} = \sum_i \frac{1}{2} m_i v_i 2 = \sum_i \frac{1}{2} m_i (r_i \omega)$

$= \frac{1}{2} (\sum_i m_i r_i 2)\omega 2$

The term in the second set of parentheses is the moment of inertia I relative to the axis of rotation. The kinetic energy is thus

$K_{rot} = \frac{1}{2} I\omega^2$ ..... (2)

Equation (2) is the rotational analog of $K = \frac{1}{2} mV^2$ for linear motion.

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Step 2

Exercise on Rotational Kinetic Energy.

A fly wheel used for storing energy consist of a uniform disk of mass 1.5exp5 and radius 2.2m that rotates at 3000 rev/min about its center of mass. Find its kinetic energy.

Solution:

The kinetic energy is calculated directly from $K = \frac{1}{2} I\omega^2$. To obtain K in joules, we must express the angular velocity in radians per second.

The kinetic energy of rotation is $K_{rot} = \frac{1}{2} I\omega^2$.

Now let calculate the moment of inertia of the disk.

$I = \frac{1}{2} MR^2 = \frac{1}{2} (1.5 \times 10^5 kg)(2.2m)^2$

$= 3.63 \times 10^5 kg.m^2$

We then convert ω to rad/s

$\omega = \frac{3000\ rev}{60s} \times \frac{2\pi\ rad}{1\ rev} = 314\ rad/s$

Substitute these values to find the kinetic energy

$K_{rot} = \frac{1}{2} I\omega^2 = \frac{1}{2} (3.63 \times 10^5 kg.m^2)(314 rad/s)^2$

$= 1.79 \times 10^{10} J.$

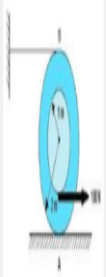
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Step 3

What is Radius of Gyration?

Radius of Gyration is regardless of the shape of an object, we can always find a radial distance from the axis of rotation at which the concentration of the entire mass M of the object would produce the same rotational inertia as that of the extended object itself. Then, the rotational inertia is equal to the value for a particle with a mass M at a distance , namely, $I = Mr^2$. We refer to this distance as the Radius of Gyration for the object about the particular axis, thus $r^2 = \frac{I}{M} = \frac{1}{M}\int_m r^2 dm$



For a planar distribution of mass rotating about some axis in the plane of the mass, the radius of gyration is the distance from the axis that all mass can be concentrated to obtain the same mass moment of inertia. Thus, the radius of gyration is the ``equivalent distance" of the mass from the axis of rotation. In this context, gyration can be defined as rotation of a planar region about some axis lying in the plane.



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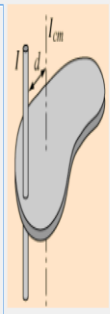
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Step 4

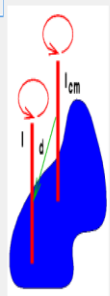
Parallel Axis Theorem

The parallel axis theorem can be used to determine the second moment of area or the mass moment of inertia of a rigid body about any axis, given the body's moment of inertia about a parallel axis through the object's centre of mass and the perpendicular distance (r) between the axes.

Parallel Axis theorem states that the moment of inertia of any object about an axis through its center of mass is the minimum moment of inertia for an axis in that direction in space. The moment of inertia about any axis parallel to that axis through the center of mass is given by:



$$I_{parallel\ axis} = I_{cm} + Md^2$$



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Step 5

How to prove the Parallel-axis Theorem step by step.

We can prove the parallel-axis theorem using the result: $K = \frac{1}{2} MV^2 + K_{rel}$

That is the kinetic energy of a system of particles is the sum of the kinetic energy of the motion of the center of mass plus the kinetic energy of the motion relative to the center of mass.

But the kinetic energy of this relative motion is: $K_{rel} = \frac{1}{2} I_{cm} \omega^2$

The velocity of the center of mass relative to any point on the axis of rotation is Vcm¬ = hω. The kinetic energy of the motion of the center of mass is thus.

$\frac{1}{2} MV_{cm}^2 = \frac{1}{2} M(h\omega)^2 = \frac{1}{2} M\omega^2 h^2$

$K = \frac{1}{2} M\omega^2 h^2 + \frac{1}{2} I_{cm}\omega^2$

$= \frac{1}{2} (Mh^2 + I_{cm})\omega^2$

$= \frac{1}{2} I\omega^2$

with

$I = Mh^2 + I_{cm}$ Which is the Parallel Axis Theorem

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Step 6

Exercise 1

Determine the moment of inertia of uniform Disk about a perpendicular axis through its center.

Solution:

For the case of a uniform disk, we expect that I (moment of inertia) will be smaller than MR^2, since the mass is uniformly distributed from r = 0 to r = R rather than being concentrated at r = R as it is in a hoop. In fig. below, each mass element is a hoop of radius r and thickness dr. The moment of inertia of any given mass element is r^2dm. Since the area of each element is r^2dm. Since the area of each element is $dA = 2\pi r dr$, the mass of each element is

$$dm = \frac{M_E}{A_E} d_A$$

$$= \frac{M}{A} 2\pi r dr$$

Where $A = \pi R^2$ is the area of the disk. We thus have

$$I = \int r^2 dm$$

$$= \int_0^R r^2 \frac{M}{A} 2\pi r dr$$

$$= 2\pi M / 2\pi R^2 \int_0^R r^3 dr$$

$$= 2M/R^2 [R^4/4]$$

$$= \frac{1}{2} MR^2$$

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Lesson Three- Angular momentum

Topic: ANGULAR MOMENTUM

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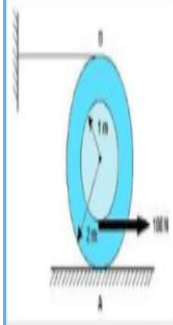
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ENERGY AND GYRATION OF A BODY.









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Step 1

What is Kinectic Energy of Rotation?

kinetic energy of rotation is the sum of the kinetic energies of the individual particles in the object. The kinetic energy of rotation of a rigid body is obtained by first dividing it up into a collection of smaller masses, and then summing up the kinetic energies due to the tangential velocities of the individual masses making up that rigid body.

To obtain the Rotational kinectic Energy of a body we have:

$K = \frac{1}{2} m_i V_i^2$ ..... (1)

Summing over all the elements and using $V_i = r_i\omega$ gives

$K_{rot} = \sum_i \frac{1}{2} mivi2 = \sum_i \frac{1}{2} mi\,(ri\omega)$

$= \frac{1}{2} (\sum_i mi\ ri2)\omega 2$

The term in the second set of parentheses is the moment of inertia I relative to the axis of rotation. The kinetic energy is thus

$K_{rot} = \frac{1}{2} I\omega^2$ ..... (2)

Equation (2) is the rotational analog of $K = \frac{1}{2} mV^2$ for linear motion.

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Step 2

Exercise on Rotational Kinetic Energy.

A fly wheel used for storing energy consist of a uniform disk of mass 1.5exp5 and radius 2.2m that rotates at 3000 rev/min about its center of mass. Find its kinetic energy.

Solution:

The kinetic energy is calculated directly from $K = \frac{1}{2} I\omega^2$. To obtain K in joules, we must express the angular velocity in radians per second.

The kinetic energy of rotation is $K_{rot} = \frac{1}{2} I\omega^2$.

Now let calculate the moment of inertia of the disk.

$I = \frac{1}{2} MR^2 = \frac{1}{2} (1.5 \times 10^5 kg)(2.2m)^2$

$= 3.63 \times 10^5 kg\ m^2$

We then convert ω to rad/s

$\omega = \frac{3000\ rev}{60s} \times \frac{2\pi\ rad}{1\ rev} = 314\ rad/s$

Substitute these values to find the kinetic energy

$K_{rot} = \frac{1}{2} I\omega^2 = \frac{1}{2} (3.63 \times 10^5 kg.m^2)(314 rad/s)^2$

$= 1.79 \times 10^{10} J.$

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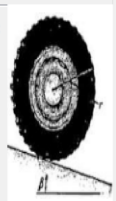
Step 3

What is Radius of Gyration?

Radius of Gyration is regardless of the shape of an object, we can always find a radial distance from the axis of rotation at which the concentration of the entire mass M of the object would produce the same rotational inertia as that of the extended object itself. Then, the rotational inertia is equal to the value for a particle with a mass M at a distance , namely, $I = Mr^2$. We refer to this distance as the Radius of Gyration for the object about the particular axis, thus $r^2 = \frac{I}{M} = \frac{1}{M}\int_m r^2 dm$



For a planar distribution of mass rotating about some axis in the plane of the mass, the radius of gyration is the distance from the axis that all mass can be concentrated to obtain the same mass moment of inertia. Thus, the radius of gyration is the ``equivalent distance" of the mass from the axis of rotation. In this context, gyration can be defined as rotation of a planar region about some axis lying in the plane.



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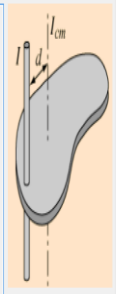
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Step 4

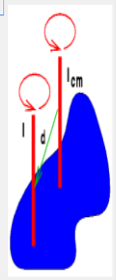
Parallel Axis Theorem

The parallel axis theorem can be used to determine the second moment of area or the mass moment of inertia of a rigid body about any axis, given the body's moment of inertia about a parallel axis through the object's centre of mass and the perpendicular distance (r) between the axes.

Parallel Axis theorem states that the moment of inertia of any object about an axis through its center of mass is the minimum moment of inertia for an axis in that direction in space. The moment of inertia about any axis parallel to that axis through the center of mass is given by:



$$I_{parallel\ axis} = I_{cm} + Md^2$$



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Step 5

How to prove the Parallel-axis Theorem step by step.

We can prove the parallel-axis theorem using the result: $K = \frac{1}{2}MV^2 + K_{rel}$

That is the kinetic energy of a system of particles is the sum of the kinetic energy of the motion of the center of mass plus the kinetic energy of the motion relative to the center of mass.

But the kinetic energy of this relative motion is: $K_{rel} = \frac{1}{2} I_{cm} \omega^2$

The velocity of the center of mass relative to any point on the axis of rotation is $V_{cm} = h\omega$. The kinetic energy of the motion of the center of mass is thus.

$\frac{1}{2} MV_{cm}^2 = \frac{1}{2} M (h\omega)^2 = \frac{1}{2} M\omega^2 h^2$

$K = \frac{1}{2} M\omega^2 h^2 + \frac{1}{2} I_{cm}\omega^2$

$= \frac{1}{2} (Mh^2 + I_{cm})\omega^2$

$= \frac{1}{2} I\omega^2$

with

$I = Mh^2 + I_{cm}$ Which is the Parallel Axis Theorem

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Step 6

Exercise 1

Determine the moment of inertia of uniform Disk about a perpendicular axis through its center.

Solution:

For the case of a uniform disk, we expect that I (moment of inertia) will be smaller than MR^2, since the mass is uniformly distributed from r = 0 to r = R rather than being concentrated at r = R as it is in a hoop. In fig. below, each mass element is a hoop of radius r and thickness dr. The moment of inertia of any given mass element is $r^2 dm$. Since the area of each element is $r^2 dm$. Since the area of each element is $dA = 2\pi r dr$, the mass of each element is

$dm = \frac{M_R}{r_R} d_A$

$= \frac{M}{A} 2\pi r dr$

Where $A = \pi R^2$ is the area of the disk. We thus have

$I = \int r^2 dm$

$= \int_0^R r^2 \frac{M}{A} 2\pi r dr$

$= 2\pi M/2\pi R^2 \int_0^R r^3 dr$

$= 2M/R^2 [R^4/4]$

$= \frac{1}{2} MR^2$

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THIS IS THE END OF LESSON TWO

OK

Lesson Three- Angular momentum

Topic: ANGULAR MOMENTUM

BY

DANJUMA, ALHAJI BIDA

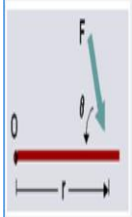
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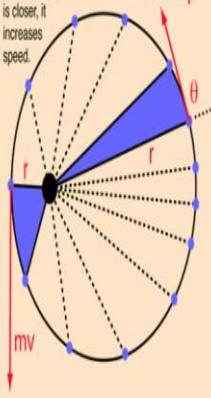


ANGULAR MOMENTUM AND TORQUE

Angular Momentum of a Particle



The angular momentum is the same at every point on an orbit. When it is closer, it increases speed.



The angular momentum of a particle of mass m with respect to a chosen origin is given by

$$L = mvr \sin\theta$$

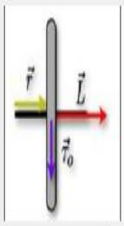
or more formally by the vector product

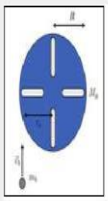
$$L = r \times p$$

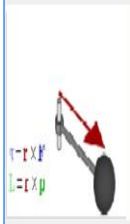
The direction is given by the right hand rule which would give L the direction out of the diagram. For an orbit, angular momentum is conserved, and this leads to one of Kepler's laws. For a circular orbit, L becomes

$$L = mvr$$









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Step 1

What is an Angular Momentum?

An Angular momentum is the cross product of position vector and momentum. L = r x p. Objects executing motion around a point possess a quantity called angular momentum. This is an important physical quantity because all experimental evidence indicates that angular momentum is rigorously conserved in our Universe: it can be transferred, but it cannot be created or destroyed. For the simple case of a small mass executing uniform circular motion around a much larger mass (so that we can neglect the effect of the center of mass) the amount of angular momentum takes a simple form. As the adjacent figure illustrates the magnitude of the angular momentum in this case is L = mvr, where L is the angular momentum, m is the mass of the small object, v is the magnitude of its velocity, and r is the separation between the objects..



Angular momentum is conserved in a system where there is no net external torque, and its conservation helps explain many diverse phenomena. For example, the increase in rotational speed of a spinning figure skater as the skater's arms are contracted is a consequence of conservation of angular momentum. The very high rotational rates of neutron stars can also be explained in terms of angular momentum conservation. Moreover, angular momentum conservation has numerous applications in physics and engineering (e.g. the gyrocompass)



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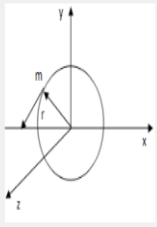
Step 2

Example:

Find the angular momentum about the origin for the following situation. (a) A car of mass 1200 kg moves counter clockwise in a circle radius 20m with speed15 m/s. (b) The same car moves with velocity V = - (15m/s)i along the line y = yo = 20 m parallel to the axis. (c) A disk in the x y plane of radius 20m and mass 1200 kg rotated at 0.75 rad/s about its axis which is the z axis.

Solution:

(a) r and p are perpendicular and r x p is in the z direction



$L = r \times p = mvk$

$= (20m)(1200kg)(15m/s)\,k$

$= 3.6 \times 10^5 kg\,m^2/s\,k$

(b) i. For the same car moving to the left along the line, we express r and p in terms of unit

$y = y_0 = 20m,$

$r = xi + yj$

$= xi + y_0 j$

$P = mV = -pi$

ii. Now compute r x p

$L = r \times p$

$= (xi + y_0 j) \times (-pi)$

$= -xp\,(i \times i) - y_0 p\,(j \times i)$

$= -xp\,(0) - y_0 p\,(-k)$

$= y_0 pk$

$= (20m)(1200kg)(15m/s)\,k$

$= 3.6 \times 10^5 kg\,m^2/s\,k$

(c). Use $L = I\omega$

$= I\omega k$

$= (\frac{1}{2} MR^2)\,\omega k$

$= (1/2\,(1200kg)\,(20m)^2)\,(0.75rad/s)$

$= 1.8 \times 10^5 kg\,m^2/s\,k$

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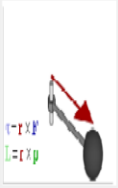
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Step 3

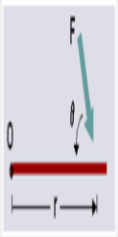
What is a Torque?

It is a common experience that an object can be set into rotation by a force that is applied off center. For example, a tangential push on the rim of a wheel will cause rotation, but a similar push along a line through the axis will not. The tendency for a force to produce rotation is proportional to the magnitude of the force and to the distance from the point of application to the center of rotation. The quantitative measure of this rotation tendency is in terms of the TORQUE produce by the force.



We can also simply define Torque as a measure of how much a force acting on an object causes that object to rotate. The object rotates about an axis, which we will call the pivot point, and will label 'O'. We will call the force 'F'. The distance from the pivot point to the point where the force acts is called the moment arm, and is denoted by 'r'. Note that this distance, 'r', is also a vector, and points from the axis of rotation to the point where the force acts. (Refer to Figure beside for a pictoral representation of these definitions.)

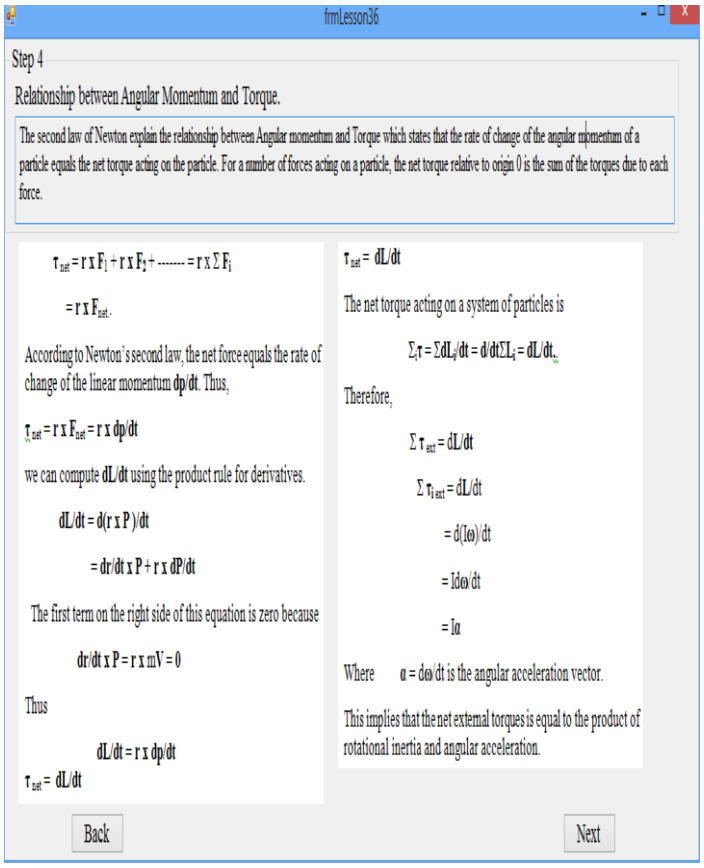
It can also be said to be the product of the magnitude of a force and its force arm. Any vector can be express in terms of its component vectors. Therefore, a force F that is applied to a particle m, as in last figure below can be expressed in terms of component F⊥1 perpendicular to the position vector r and a component FII parallel to r. Only the component F1 can produce a torque about the point 0. The magnitude of the torque produced by F about 0 is defined to be $\tau = r F_1 = r f \sin\theta$

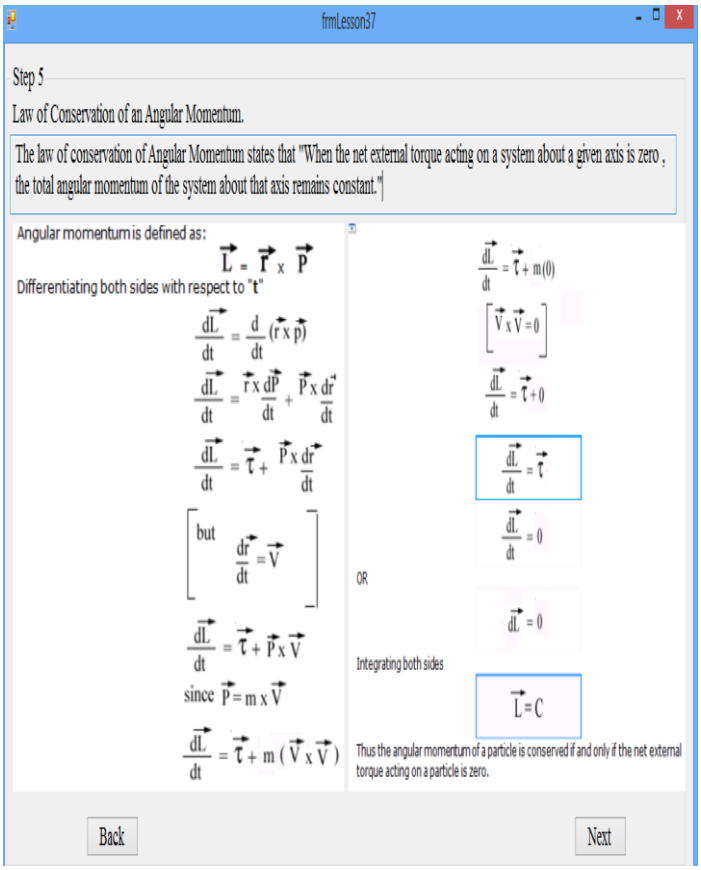


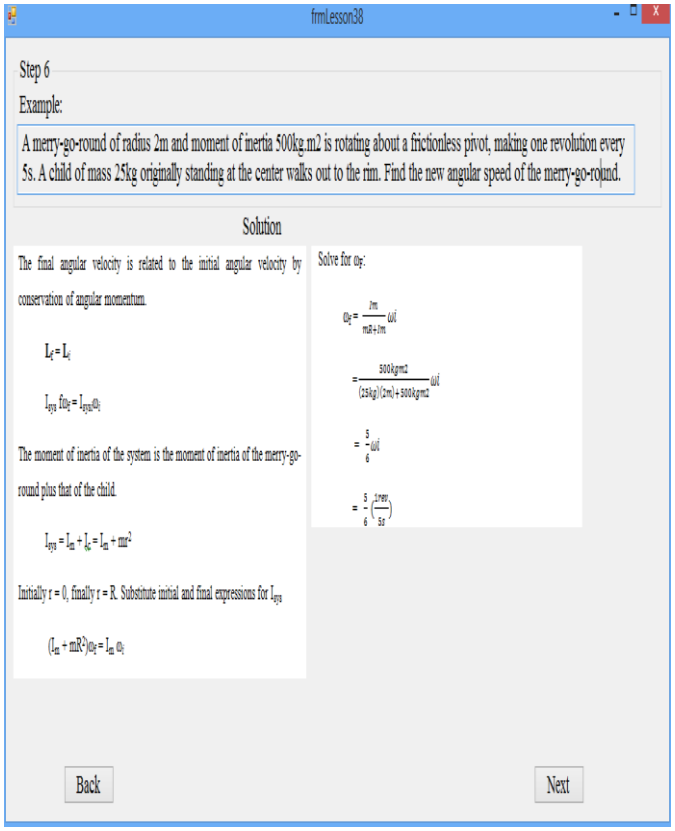
Where θ is the smaller angle between the positive directions of r and F. using vector notation, we can write, in analogy with the definition of angular momentum:

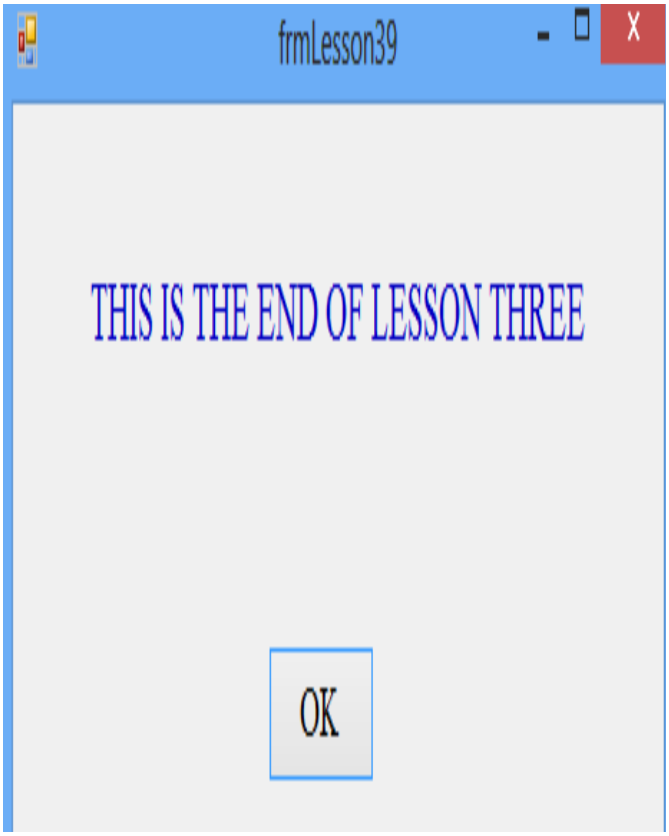
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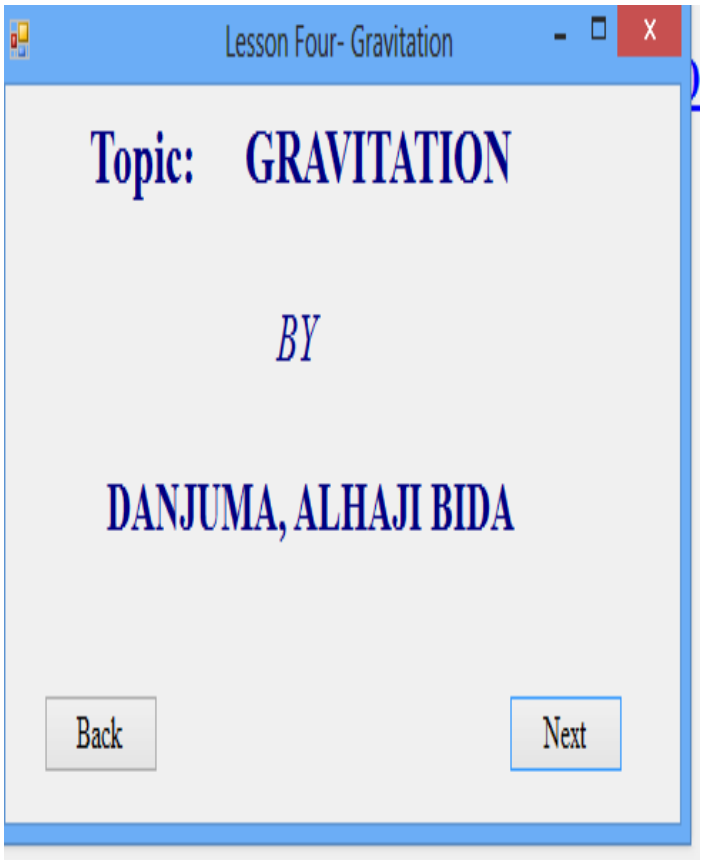
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Step 4
Relationship between Angular Momentum and Torque.
The second law of Newton explain the relationship between Angular momentum and Torque which states that the rate of change of the angular momentum of a particle equals the net torque acting on the particle. For a number of forces acting on a particle, the net torque relative to origin 0 is the sum of the torques due to each force.
$\tau_{net} = r \times F_1 + r \times F_2 + \cdots\cdots = r \times \Sigma F_i$
$= r \times F_{net}.$
According to Newton's second law, the net force equals the rate of change of the linear momentum dp/dt. Thus,
$\tau_{net} = r \times F_{net} = r \times dp/dt$
we can compute dL/dt using the product rule for derivatives.
$dL/dt = d(r \times P)/dt$
$= dr/dt \times P + r \times dP/dt$
The first term on the right side of this equation is zero because
$dr/dt \times P = r \times mV = 0$
Thus
$dL/dt = r \times dp/dt$
$\tau_{net} = dL/dt$
$\tau_{net} = dL/dt$
The net torque acting on a system of particles is
$\Sigma\tau = \Sigma dL_i/dt = d/dt \Sigma L_i = dL/dt.$
Therefore,
$\Sigma \tau_{ext} = dL/dt$
$\Sigma \tau_{i\,ext} = dL/dt$
$= d(I\omega)/dt$
$= Id\omega/dt$
$= I\alpha$
Where $\alpha = d\omega/dt$ is the angular acceleration vector.
This implies that the net external torques is equal to the product of rotational inertia and angular acceleration.
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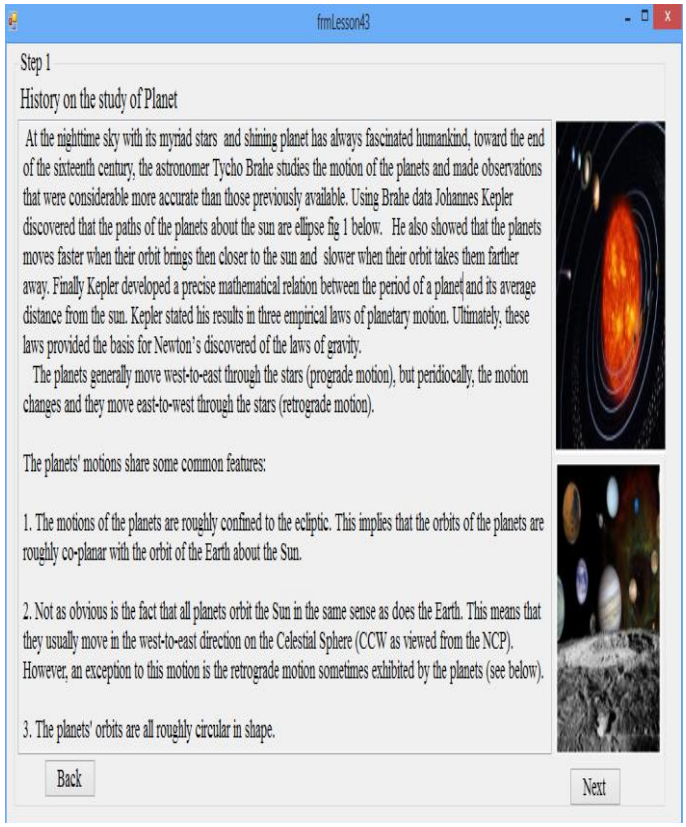

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Step 5
Law of Conservation of an Angular Momentum.
The law of conservation of Angular Momentum states that "When the net external torque acting on a system about a given axis is zero , the total angular momentum of the system about that axis remains constant."
Angular momentum is defined as:
$\vec{L} = \vec{r} \times \vec{P}$
Differentiating both sides with respect to "t"
$\frac{d\vec{L}}{dt} = \frac{d}{dt}(\vec{r} \times \vec{p})$
$\frac{d\vec{L}}{dt} = \vec{r} \times \frac{d\vec{P}}{dt} + \vec{P} \times \frac{d\vec{r}}{dt}$
$\frac{d\vec{L}}{dt} = \vec{\tau} + \vec{P} \times \frac{d\vec{r}}{dt}$
but $\frac{d\vec{r}}{dt} = \vec{V}$
$\frac{d\vec{L}}{dt} = \vec{\tau} + \vec{P} \times \vec{V}$
since $\vec{P} = m \times \vec{V}$
$\frac{d\vec{L}}{dt} = \vec{\tau} + m(\vec{V} \times \vec{V})$
$\frac{d\vec{L}}{dt} = \vec{\tau} + m(0)$
$[\vec{V} \times \vec{V} = 0]$
$\frac{d\vec{L}}{dt} = \vec{\tau} + 0$
$\frac{d\vec{L}}{dt} = \vec{\tau}$
$\frac{d\vec{L}}{dt} = 0$
OR
$d\vec{L} = 0$
Integrating both sides
$\vec{L} = C$
Thus the angular momentum of a particle is conserved if and only if the net external torque acting on a particle is zero.
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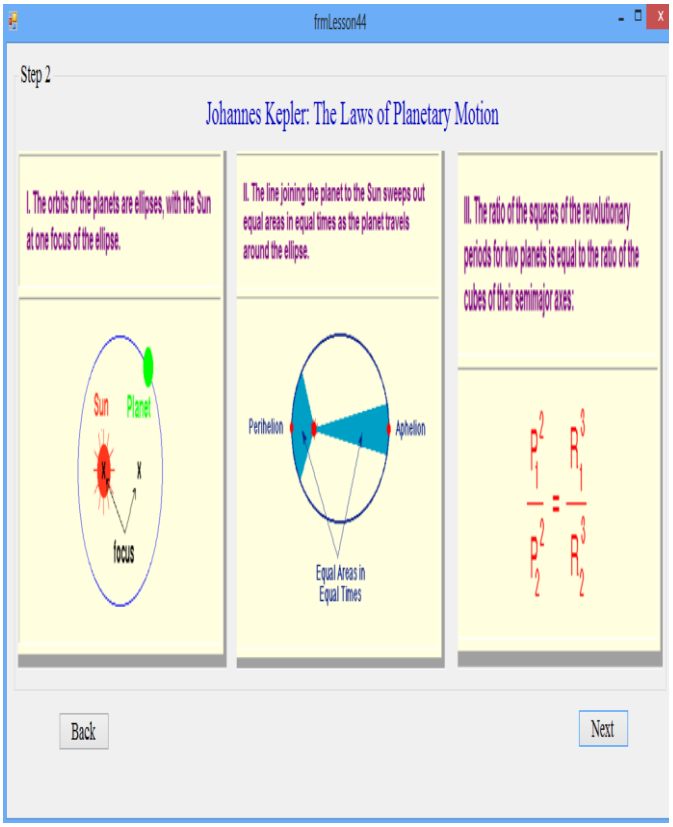

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Step 6
Example:
A merry-go-round of radius 2m and moment of inertia 500kg.m2 is rotating about a frictionless pivot, making one revolution every 5s. A child of mass 25kg originally standing at the center walks out to the rim. Find the new angular speed of the merry-go-round.
Solution
The final angular velocity is related to the initial angular velocity by conservation of angular momentum.
$L_f = L_i$
$I_{sys}\,\omega_f = I_{sys}\omega_i$
The moment of inertia of the system is the moment of inertia of the merry-go-round plus that of the child.
$I_{sys} = I_m + I_c = I_m + mr^2$
Initially r = 0, finally r = R. Substitute initial and final expressions for I_{sys}
$(I_m + mR^2)\omega_f = I_m \omega_i$
Solve for ω_f:
$\omega_f = \frac{I_m}{mR^2 + I_m}\omega_i$
$= \frac{500\,kg.m2}{(25kg)(2m)^2 + 500\,kg.m2}\omega_i$
$= \frac{5}{6}\omega_i$
$= \frac{5}{6}\left(\frac{1\,rev}{5s}\right)$
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THIS IS THE END OF LESSON THREE
OK


Lesson Four- Gravitation
Topic: GRAVITATION
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DANJUMA, ALHAJI BIDA
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GRAVITATION AND KEPLER'S LAW
Orbit Eccentricity
Newton's Law of Gravitation
Pluto
Uranus
Neptune
Jupiter
Saturn
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Step 1
History on the study of Planet
At the nighttime sky with its myriad stars and shining planet has always fascinated humankind, toward the end of the sixteenth century, the astronomer Tycho Brahe studies the motion of the planets and made observations that were considerable more accurate than those previously available. Using Brahe data Johannes Kepler discovered that the paths of the planets about the sun are ellipse fig 1 below. He also showed that the planets moves faster when their orbit brings then closer to the sun and slower when their orbit takes them farther away. Finally Kepler developed a precise mathematical relation between the period of a planet and its average distance from the sun. Kepler stated his results in three empirical laws of planetary motion. Ultimately, these laws provided the basis for Newton's discovered of the laws of gravity.
The planets generally move west-to-east through the stars (prograde motion), but peridiocally, the motion changes and they move east-to-west through the stars (retrograde motion).
The planets' motions share some common features:
1. The motions of the planets are roughly confined to the ecliptic. This implies that the orbits of the planets are roughly co-planar with the orbit of the Earth about the Sun.
2. Not as obvious is the fact that all planets orbit the Sun in the same sense as does the Earth. This means that they usually move in the west-to-east direction on the Celestial Sphere (CCW as viewed from the NCP). However, an exception to this motion is the retrograde motion sometimes exhibited by the planets (see below).
3. The planets' orbits are all roughly circular in shape.
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Step 2
Johannes Kepler: The Laws of Planetary Motion
I. The orbits of the planets are ellipses, with the Sun at one focus of the ellipse.
II. The line joining the planet to the Sun sweeps out equal areas in equal times as the planet travels around the ellipse.
III. The ratio of the squares of the revolutionary periods for two planets is equal to the ratio of the cubes of their semimajor axes:
Sun
Planet
focus
Perihelion
Aphelion
Equal Areas in Equal Times
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Step 3

What is an Ellipse?

An ellipse is the locus of points for which the sum of the distance from two foci F is constant, as show in the nearly circular, with the distance to the sun at perihelion (closest point) being 1.48 x 10 11m, and at a phelion (farthest point) being 1.52×10^{11} m . The semiMajor axis equals the average of these diagram beside, a planet following an elliptical path with the sun at one focus. The earth's orbit is distances, which in 1.52×10^{11} m (93million miles) for earth's orbit. The mean earth- sun distance define the Astronomical unit (AU)

$$1\ AU = 1.50 \times 10^{11}\ m = 93.0 \times 10^{6}\ mi$$

The AU is used frequently in problems dealing with solar system. A planet moves faster when it is closer to the sun than when it is further away, so that the area swept out by the radius vector in a given time interval is the same throughout the orbit. The law of equal area is related to the conservation of angular momentum.

kepler's third law relates the period of any planet to its mean distance from the sun, which equals the semimajor axis of its elliptical path. In algebraic form, if r is the mean distance between a planet and the sun and T is the planet's period of revolution, kepler's third law states that $T^2 = Cr^3$

Where the constant C has the same value for all the planets. This law is a consequence of the fact the force exerted by the sun on a planet varies inversely with the square or the distance from the sun to the planet.

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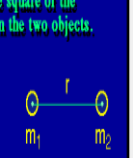
Step 4

Newton's Law of Universal Gravitation

Law of Universal Gravitation

Every object in the Universe attracts every other object with a force directed along the line of centers for the two objects that is proportional to the product of their masses and inversely proportional to the square of the separation between the two objects.

$$F_g = G\frac{m_1 m_2}{r^2}$$



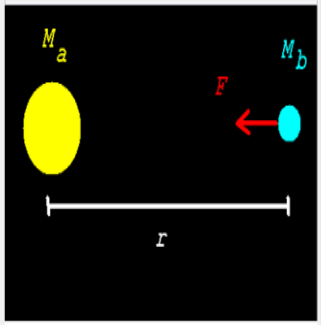
F_g is the gravitational force
m_1 & m_2 are the masses of the two objects
r is the separation between the objects
G is the universal gravitational constant

The constant of proportionality G is known as the universal gravitational constant. It is termed a "universal constant"

Each object in the universe attracts each other body.

If object A has mass Ma and object B has mass Mb, then the force F on object A is directed toward object B and has magnitude

$$F = G M_a M_b / r^2$$



$$F = G\frac{M_a M_b}{r^2}$$

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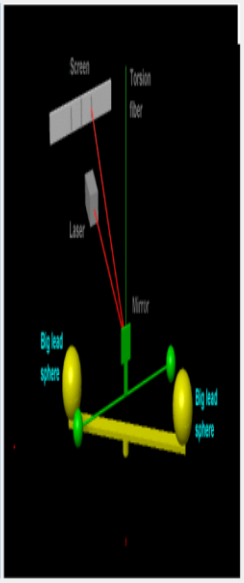
frmLesson47

Step 5

How to Determine Gravitational Constant.

The value of the gravitational constant G can be determined by measuring the force between a pair of objects with known masses that are separated by a known distance. The first experiment from which a reasonably accurate value for G could be obtained was carried out by the English chemist Henry Cavendish (1731-1810), who reported his result to the royal society in 1798. For his measurement, Carvendish used on instrument called a torsion balance that was similar to the one invented independently by Charles coulomb and used by him in studies of electric and magnetic forces. The type of torsion balance used by Cavendish consist of a thin rod that carries two small balls with masses 1 and 2 .The rod is attached to the lower end of a wire that is suspended from a fixed support. The apparatus is allowed to come to rest with the large balls M1 and M2 ,some distance away. This equilibrium position is measured by directing a light beam from a stationary source onto a minor that is attached to the suspension wire, the point at which the reflected beam is seen on the scale is recorded. Next, the large balls are moved close to the small balls.

Because m1 attracts m2 and m2 attracts m1, a torques is exerted on the rod. It rotates through a small angle until the restoring torque due to the torsional force in the twisted wire just balances the gravitational torque. The angular displacement of the rod is determined by noting the new position of the light spot on the scale. The force necessary to twist the wire by a certain amount (the so-called torsion constant) is related to the period of oscillation of the system, which can be measured in a separate experience. In this way Cavendish measured the gravitational force between known masses separated by a known distance. The value of G obtained from Cavendish is data is only 1 percent different from the value now accepted.



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Step 6

Gravitational Potential Energy

Gravitational Potential Energy

The general expression for gravitational potential energy arises from the law of gravity and is equal to the work done against gravity to bring a mass to a given point in space. Because of the inverse square nature of the gravity force, the force approaches zero for large distances, and it makes sense to choose the zero of gravitational potential energy at an infinite distance away. The gravitational potential energy near a planet is then negative, since gravity does positive work as the mass approaches. This negative potential is indicative of a "bound state"; once a mass is near a large body, it is trapped until something can provide enough energy to allow it to escape. The general form of the gravitational potential energy of mass m is:

$$U = \frac{-GMm}{r}$$ Show

where G is the gravitation constant, M is the mass of the attracting body, and r is the distance between their centers.

This is the form for the gravitational potential energy which is most useful for calculating the escape velocity from the earth's gravity.

$$U_i = -\int_r^{\infty} \mathbf{F} \cdot d\mathbf{s}$$

$$U_i = -\int_{\infty}^{r} \frac{Gm_1m_2}{r^2}dr$$

$$U_i = -Gm_1m_2\left[\frac{1}{r} - \frac{1}{\infty}\right]$$

and here it is ...

$$U_i = -\frac{Gm_1m_2}{r}$$

where ...

U_i=gravitational potential energy
m_1m_2=masses of any two objects
r=separation between their centers
G=universal gravitational constant (6.67×10^{-11} Nm²/kg²)

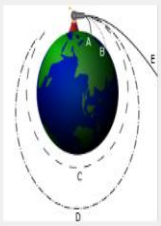
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Step 7

What is an Escape Velocity?

"Escape velocity" is the initial speed required to go from an initial point in a gravitational potential field to infinity with a residual velocity of zero, with all speeds and velocities measured with respect to the field. Additionally, the escape velocity at a point in space is equal to the speed that an object would have if it started at rest from an infinite distance and was pulled by gravity to that point. In common usage, the initial point is on the surface of a planet or moon.



It is derive by setting the total energy at the surface of the earth equal to zero.

$E = K + U = 0.$

$\frac{1}{2}(mV_e^2) - GM_Em/R_E = 0$

$V_e = \sqrt{(2GM_E/R_E)} = \sqrt{(2gR_E)}$

Using $g = 9.81\ m/s^2$ and $R_E = 6.37 \times 10^6 m$, we obtain

$V_e = \sqrt{[2(9.81 m/s^2)(6.37 \times 10^6 m)]}$

$= 11.2 km/s$

This is about 6.95 mi/s or 25,000 mi/h.

Escape Velocity

If the kinetic energy of an object launched from the Earth were equal in magnitude to the potential energy, then in the absence of friction resistance it could escape from the Earth.

$v_{escape} = 11.2\ km/s$



Escape velocity from the Earth

$\frac{1}{2}mv^2 = \frac{GMm}{r}$

$v_{escape} = \sqrt{\frac{2GM}{r}}$

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Assignment

(i) Explain Briefly how to determine Gravitational constant G.

(ii) Explain Briefly how to determine escape velocity.

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THIS IS THE END OF LESSON FOUR

OK

Lesson five-Surface Tension.

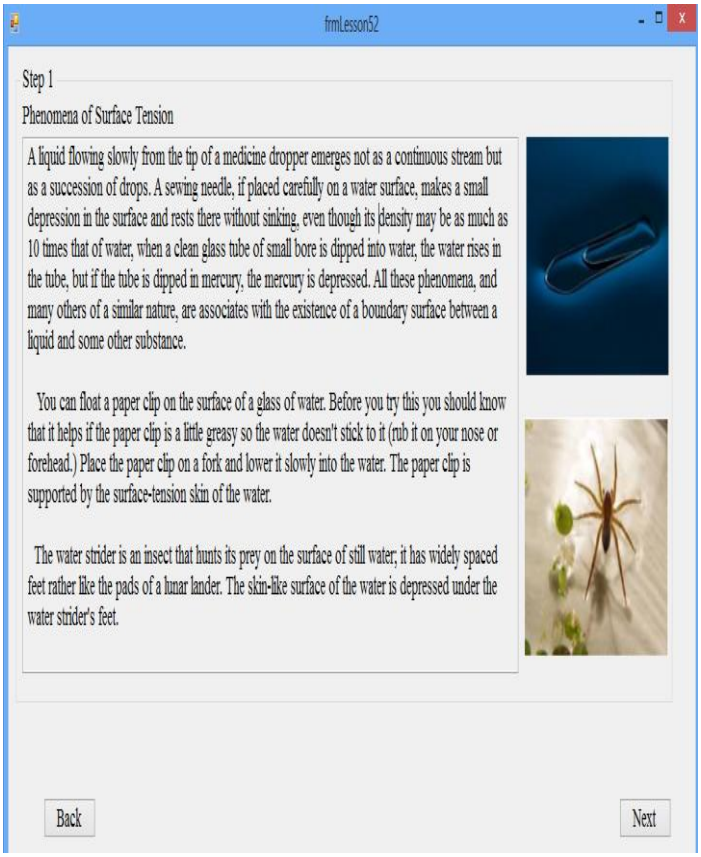
Topic: SURFACE TENSION

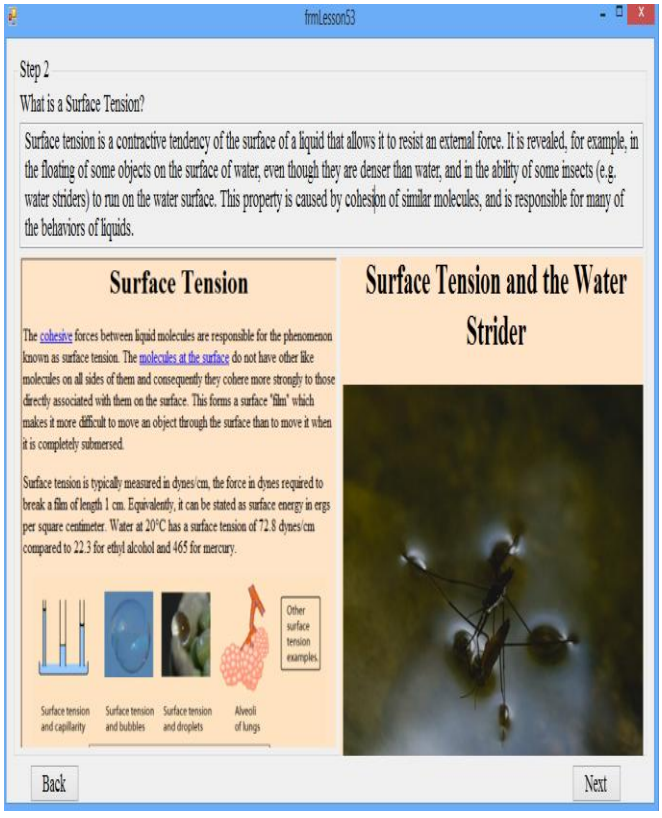
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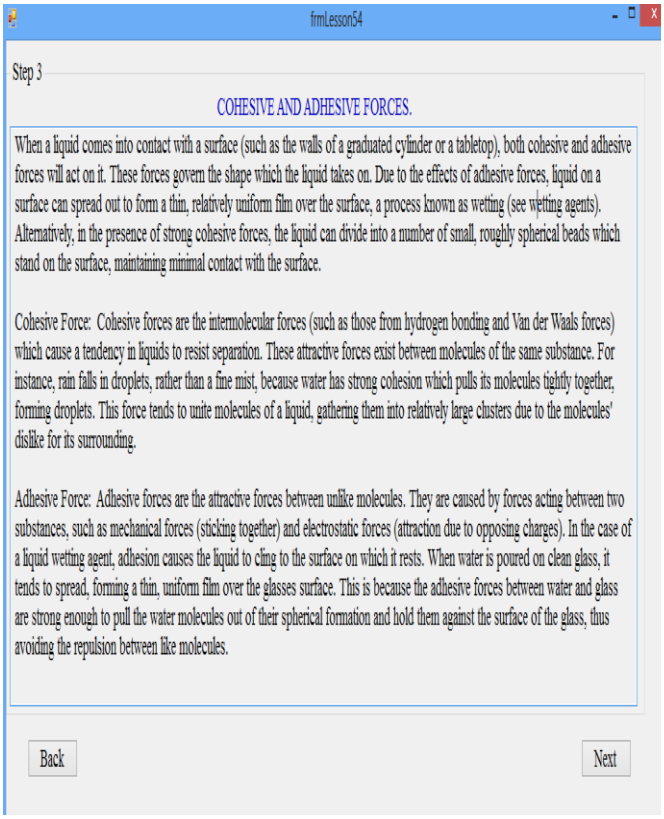
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Step 1
Phenomena of Surface Tension
A liquid flowing slowly from the tip of a medicine dropper emerges not as a continuous stream but as a succession of drops. A sewing needle, if placed carefully on a water surface, makes a small depression in the surface and rests there without sinking, even though its density may be as much as 10 times that of water, when a clean glass tube of small bore is dipped into water, the water rises in the tube, but if the tube is dipped in mercury, the mercury is depressed. All these phenomena, and many others of a similar nature, are associates with the existence of a boundary surface between a liquid and some other substance.
You can float a paper clip on the surface of a glass of water. Before you try this you should know that it helps if the paper clip is a little greasy so the water doesn't stick to it (rub it on your nose or forehead.) Place the paper clip on a fork and lower it slowly into the water. The paper clip is supported by the surface-tension skin of the water.
The water strider is an insect that hunts its prey on the surface of still water; it has widely spaced feet rather like the pads of a lunar lander. The skin-like surface of the water is depressed under the water strider's feet.
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Step 2
What is a Surface Tension?
Surface tension is a contractive tendency of the surface of a liquid that allows it to resist an external force. It is revealed, for example, in the floating of some objects on the surface of water, even though they are denser than water, and in the ability of some insects (e.g. water striders) to run on the water surface. This property is caused by cohesion of similar molecules, and is responsible for many of the behaviors of liquids.
Surface Tension
The cohesive forces between liquid molecules are responsible for the phenomenon known as surface tension. The molecules at the surface do not have other like molecules on all sides of them and consequently they cohere more strongly to those directly associated with them on the surface. This forms a surface "film" which makes it more difficult to move an object through the surface than to move it when it is completely submersed.
Surface tension is typically measured in dynes/cm, the force in dynes required to break a film of length 1 cm. Equivalently, it can be stated as surface energy in ergs per square centimeter. Water at 20°C has a surface tension of 72.8 dynes/cm compared to 22.3 for ethyl alcohol and 465 for mercury.
Other surface tension examples.
Surface tension and capillarity
Surface tension and bubbles
Surface tension and droplets
Alveoli of lungs
Surface Tension and the Water Strider
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Step 3
COHESIVE AND ADHESIVE FORCES.
When a liquid comes into contact with a surface (such as the walls of a graduated cylinder or a tabletop), both cohesive and adhesive forces will act on it. These forces govern the shape which the liquid takes on. Due to the effects of adhesive forces, liquid on a surface can spread out to form a thin, relatively uniform film over the surface, a process known as wetting (see wetting agents). Alternatively, in the presence of strong cohesive forces, the liquid can divide into a number of small, roughly spherical beads which stand on the surface, maintaining minimal contact with the surface.
Cohesive Force: Cohesive forces are the intermolecular forces (such as those from hydrogen bonding and Van der Waals forces) which cause a tendency in liquids to resist separation. These attractive forces exist between molecules of the same substance. For instance, rain falls in droplets, rather than a fine mist, because water has strong cohesion which pulls its molecules tightly together, forming droplets. This force tends to unite molecules of a liquid, gathering them into relatively large clusters due to the molecules' dislike for its surrounding.
Adhesive Force: Adhesive forces are the attractive forces between unlike molecules. They are caused by forces acting between two substances, such as mechanical forces (sticking together) and electrostatic forces (attraction due to opposing charges). In the case of a liquid wetting agent, adhesion causes the liquid to cling to the surface on which it rests. When water is poured on clean glass, it tends to spread, forming a thin, uniform film over the glasses surface. This is because the adhesive forces between water and glass are strong enough to pull the water molecules out of their spherical formation and hold them against the surface of the glass, thus avoiding the repulsion between like molecules.
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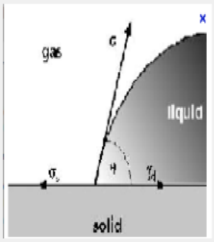
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Step 4

Angle of a Contact.

The angle of contact θ is defined as the angle between the solid surface and the tangent plane to the liquid surface at the point where it touches the solid; the angle is measured through the liquid. It can be seen from Fig. 3 above, that the meniscus is concave when θ in less than 90 degree and is convex when θ is greater than 90 degree. A liquid is said to "wet" a surface with which its angle of contact is less than 90 degree. The angle of contact between water and clean glass is zero, that between mercury and clean glass is 137 degree. Thus water "wets" clean glass, mercury does not.

The zero angle of contact between water and clean glass is due to the adhesive force between water and glass being very much larger than the cohesive force between the water molecules themselves. This explains why water tends to spread into a thin continuous film when splashed on a horizontal clean glass surface. Mercury, on the other hand, forms into little drops; water on the roof of a freshly waxed car behaves in a similar fashion. The addition of a detergent to a liquid lowers its surface tension and reduces the contact angle. Water- proofing agents have the opposite effect.



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Step 5

PRESSURE DIFFERENCES ACROSS A SURFACE FILMS

A soap bubble consists of two spherical surface films very close together, with liquid between surface tension makes the films tends to contact, but as the bubble contacts it compresses the inside air, increasing the interior pressure to a point which prevents further contraction. To obtain a relation between surface tension and this excess pressure we apply the principles of statics to one-half of the bubbles. As a preliminary, consider first a small element ΔA of the surface. Suppose the air pressure on the left of this element is P and that on the right is Pa. The force normal to the element is therefore (P - Pa) ΔA. The component of this force in the X- direction is (P - Pa) ΔAcosθ

But ΔAcosθ is the area projected on a plane perpendicular to the X - axis. The force in the X- direction is therefore the difference of pressure multipled by the projected area in the X- direction. Now consider the half- bubble the other half exerts a force to the left equal to twice the left equal to twice the surface tension times the perimeter or

$F \text{ (to the left)} = (2\gamma)(2\pi R)$

Since the half- bubble is in equilibrium.

$$(P - P_a)\pi R^2 = 4\pi R\gamma$$

$$P - P_a = \frac{4\gamma}{R}$$

For a liquid drop, which has only one surface film, the difference between pressure of the liquid and that of the outside air is half that for a soap bubble.

$$P - P_a = \frac{2\gamma}{R}$$

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Step 6

How to measure Surface Tension Using Capillary rise.

Water in a capillary tube rises above the level of the water outside. The effect is known as capillary rise and is most marked with narrow tubes. The ability of blotting paper to soak up ink is due to the same effect; the spaces between the fibers act as fine capillary tubes. A liquid whose angle of contact is greater than 90 degree suffers capillary depression. Both capillary rise and capillary depression are caused by surface tension and provide a means by which the surface tension "γ" "of a liquid may be measured.

Suppose that a capillary tube is held vertically in a liquid which has a concave meniscus. Surface tension forces cause the liquid to exert or downward directed force on the walls of the tube. In accordance with Newton's third law, the tube exerts an equal and opposite force on the liquid and it rises in the tube. At equilibrium the weight of the liquid which has been lifted up is equal to the vertical component of the force exerted by the tube. The mass of the raised liquid is the product of its density ρ and its volume $\pi r^2 h$ and therefore its weight is

$\rho\pi r^2 hg$

The length of the liquid surface in contact with the tube is equal to the circumference $2\pi r$ of the tube; and therefore the vertical component of the force exerted by the tube is

$2\pi r\gamma\cos\theta$

Therefore at equilibrium.

$$2\pi r\gamma\cos\theta = \rho\pi r^2 hg$$

i.e $\gamma = \frac{\rho r h g}{2\cos\theta}$

From which γ can be determined.

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THIS IS THE END OF LESSON FIVE

OK

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Topic: OSCILLATORY AND CIRCULAR MOTION.

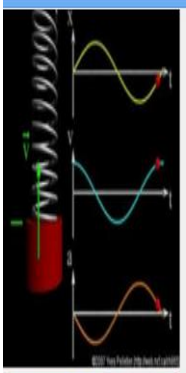
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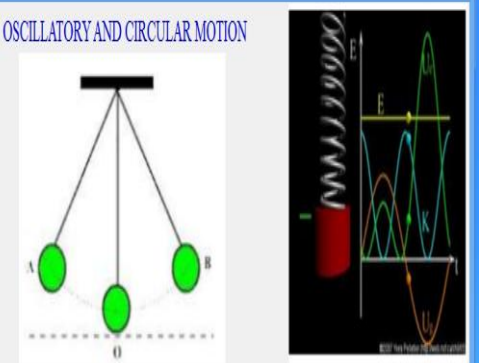
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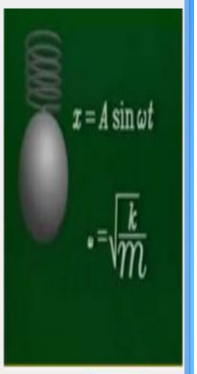
OSCILLATORY AND CIRCULAR MOTION











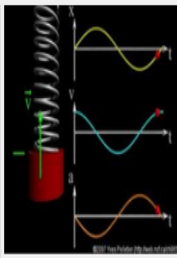
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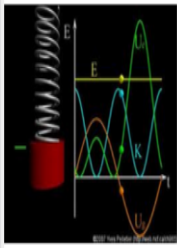
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Step 1

SIMPLE HARMONIC MOTION

simple harmonic motion is a type of periodic motion where the restoring force is directly proportional to the displacement. It can serve as a mathematical model of a variety of motions, such as the oscillation of a spring. In addition, other phenomena can be approximated by simple harmonic motion, including the motion of a simple pendulum as well as molecular vibration. Simple harmonic motion is typified by the motion of a mass on a spring when it is subject to the linear elastic restoring force given by Hooke's Law. The motion is sinusoidal in time and demonstrates a single resonant frequency. In order for simple harmonic motion to take place, the net force of the object at the end of the pendulum must be porportional to the displacement.





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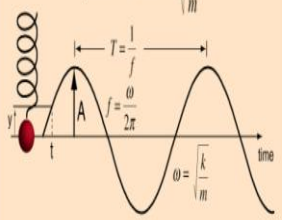
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Step 2

Simple Harmonic Motion

Simple harmonic motion is typified by the motion of a mass on a spring when it is subject to the linear elastic restoring force given by Hooke's Law. The motion is simusoidal in time and demonstrates a single resonant frequency.

$$y = A\sin\omega t = A\sin\sqrt{\frac{k}{m}}t$$



Simple Harmonic Motion Equations

The motion equation for simple harmonic motion contains a complete description of the motion, and other parameters of the motion can be calculated from it.



$$y = A\sin\omega t = A\sin\sqrt{\frac{k}{m}}t$$

The velocity and acceleration are given by



$$v = \omega A\cos\omega t$$

$$a = -\omega^2 A\sin\omega t = -\omega^2 y$$

The total energy for an undamped oscillator is the sum of its kinetic energy and potential energy, which is constant at

$$E = KE + PE = \frac{1}{2}kA^2$$

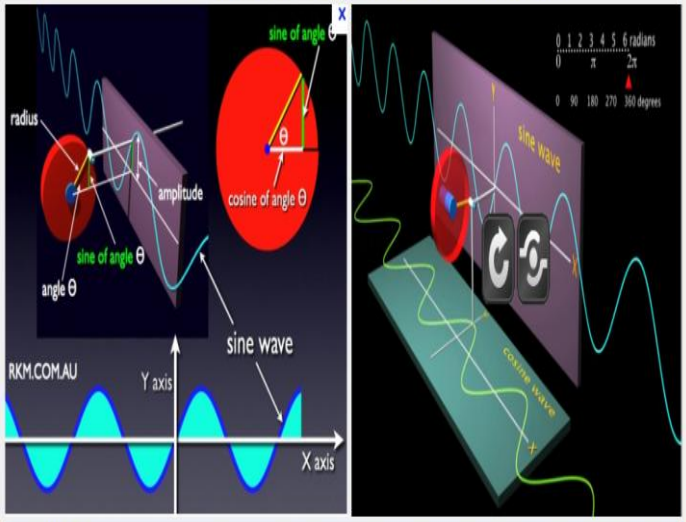
Energy transformation in periodic motion

Basic conditions to execute simple harmonic motion:

1. There must be an elastic restoring force acting on the system.
2. The system must have inertia.
3. The acceleration of the system should be directly proportional to its displacement and is always directed to mean position

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IDENTIFYING THE GRAPHICAL REPRESENTATION OF SINUSOIDAL WAVE



SINE WAVES (y = sin x) are ubiquitous. They represent the behaviour of a simple oscillator. This animation illustrates the relationship between a circle (the wheel in this diagram) and the phase (stage) of the sine wave. As the wheel rotates the attached horizontal pointer traces out a sine wave on the purplish screen. The maximum amplitude of the wave is the same as the radius of the circle (wheel in this case). The height of the wave at any point depends on the sine of the angle that the radius of the circle (yellow line) makes with a horizontal plane.

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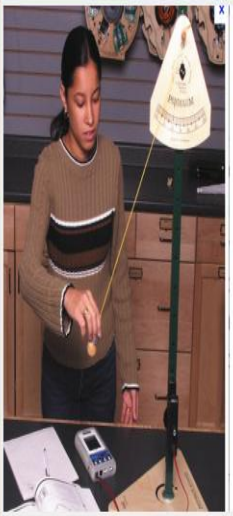
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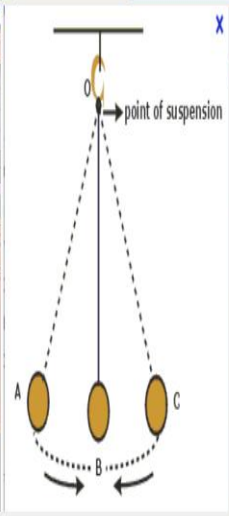
Step 4

SIMPLE PENDULUM

A simple pendulum is one which can be considered to be a point mass suspended from a string or rod of negligible mass. It is a resonant system with a single resonant frequency. For small amplitudes, the period of such a pendulum can be approximated by:

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{L}{g}}.$$





Pendulum Motion

The motion of a simple pendulum is like simple harmonic motion in that the equation for the angular displacement is

$$\theta = \theta_{max}\sin\sqrt{\frac{g}{L}}t$$ Show

which is the same form as the motion of a mass on a spring:

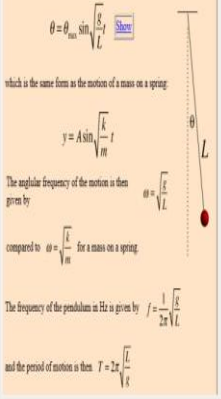
$$y = A\sin\sqrt{\frac{k}{m}}t$$

The angular frequency of the motion is then given by $\omega = \sqrt{\frac{g}{L}}$

compared to $\omega = \sqrt{\frac{k}{m}}$ for a mass on a spring.

The frequency of the pendulum in Hz is given by $f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$

and the period of motion is then $T = 2\pi\sqrt{\frac{L}{g}}$



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Step 5

PHYSICAL PENDULUM

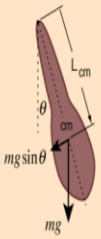
A physical pendulum is simply a rigid object which swings freely about some pivot point. The physical pendulum may be compared with a simple pendulum, which consists of a small mass suspended by a (ideally massless) string. In this lab, the physical pendulum is a meter stick with length L = 1m, and it pivots about a fixed point a distance r from the center of mass. The period T of physical pendulum is given by

$$T = 2\pi\sqrt{\frac{I_{support}}{mgL_{cm}}}$$

Physical Pendulum

Hanging objects may be made to oscillate in a manner similar to a simple pendulum. The motion can be described by "Newton's 2nd law for rotation":

$$\tau = I_{support}\alpha$$



where the torque is

$$\tau = -mgL_{cm}\sin\theta$$

and the relevant moment of inertia is that about the point of suspension. The resulting equation of motion is:

$$\alpha \approx \frac{mgL_{cm}}{I_{support}}\theta$$

for small angles where $\sin\theta \approx \theta$ Show

This is identical in form to the equation for the simple pendulum and yields a period:

$$T = 2\pi\sqrt{\frac{I_{support}}{mgL_{cm}}}$$

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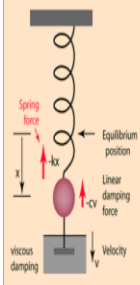
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Damped Harmonic Oscillator

The Newton's 2nd Law motion equation is

$$ma + cv + kx = 0$$

$$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = 0$$



This is in the form of a homogeneous second order differential equation and has a solution of the form

$$x = e^{\lambda t}$$

Substituting this form gives an auxiliary equation for λ

$$m\lambda^2 + c\lambda + k = 0$$

The roots of the quadratic auxiliary equation are

$$\lambda = \frac{-c \pm \sqrt{c^2 - 4mk}}{2m}$$

The three resulting cases for the damped oscillator are

$c^2 - 4mk > 0$ Overdamped

$c^2 - 4mk = 0$ Critical damping

$c^2 - 4mk < 0$ Underdamped

Damping Coefficient

When a damped oscillator is subject to a damping force which is linearly dependent upon the velocity, such as viscous damping, the oscillation will have exponential decay terms which depend upon a damping coefficient. If the damping force is of the form

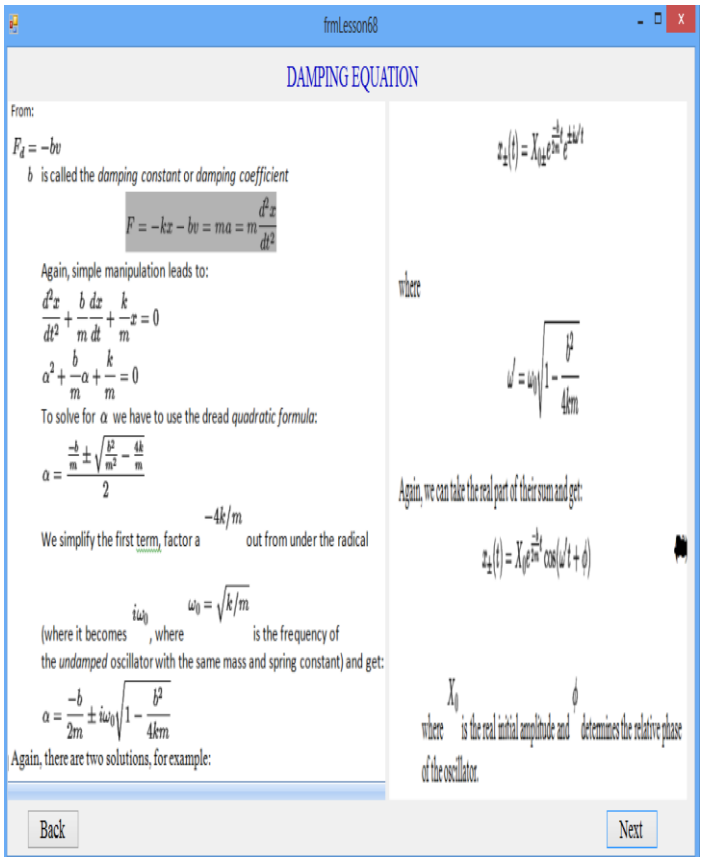
$$F_{damping} = -cv$$

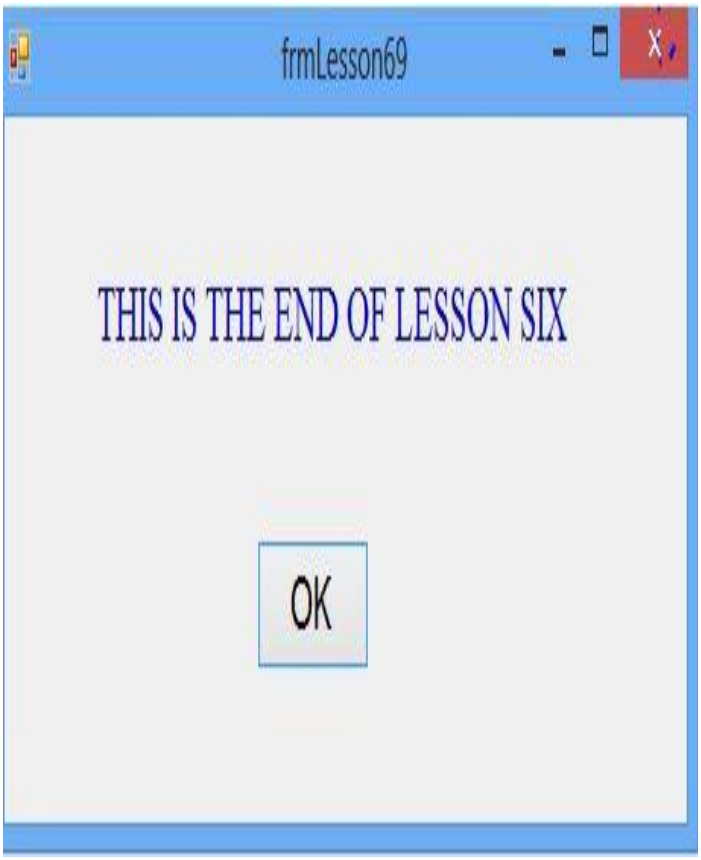
then the damping coefficient is given by

$$\gamma = \frac{c}{2m}$$

This will seem logical when you note that the damping force is proportional to c, but its influence inversely proportional to the mass of the oscillator.

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DAMPING EQUATION
From:
$F_d = -bv$
b is called the *damping constant* or *damping coefficient*
$F = -kx - bv = ma = m\frac{d^2x}{dt^2}$
Again, simple manipulation leads to:
$\frac{d^2x}{dt^2} + \frac{b}{m}\frac{dx}{dt} + \frac{k}{m}x = 0$
$\alpha^2 + \frac{b}{m}\alpha + \frac{k}{m} = 0$
To solve for α we have to use the dread *quadratic formula*:
$\alpha = \frac{-\frac{b}{m} \pm \sqrt{\frac{b^2}{m^2} - \frac{4k}{m}}}{2}$
We simplify the first term, factor a $-4k/m$ out from under the radical
(where it becomes $i\omega_0$, where $\omega_0 = \sqrt{k/m}$ is the frequency of the *undamped* oscillator with the same mass and spring constant) and get:
$\alpha = \frac{-b}{2m} \pm i\omega_0\sqrt{1 - \frac{b^2}{4km}}$
Again, there are two solutions, for example:
$z_\pm(t) = X_0 e^{\frac{-b}{2m}t} e^{\pm i\omega' t}$
where
$\omega' = \omega_0\sqrt{1 - \frac{b^2}{4km}}$
Again, we can take the real part of their sum and get:
$z_\pm(t) = X_0 e^{\frac{-b}{2m}t} \cos(\omega' t + \phi)$
X_0 ϕ
where is the real initial amplitude and determines the relative phase of the oscillator.
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frmLesson69
THIS IS THE END OF LESSON SIX
OK

APPENDIX G

LECTURE METHOD LESSON PLANS.

LESSON 1

NAME: DAJUMA ALHAJI BIDA

MATRIC NO: M.ED/EDUC/3507/2009 – 2010

SCHOOL: FEDERAL COLLEGE OF EDUCATION, KONTAGORA

LEVEL: 200 LEVELS

COURSE: PHYS 213 (MECHANICS AND PROPERTIES OF MATTER)

AGE: 17 – 21 YEARS

METHOD: LECTURE METHOD

TOPIC: INERTIA OF RIGID BODY

DURATION: TWO (2) HOURS.

BEHAVIORAL OBJECTIVE: By the end of the lesson the students should be able to:-

i. define rigid body;
ii. explain how to determine Rotational inertia;
iii. determine the rotational inertia of thin uniform, uniform solid sphere and uniform stick.

INTRODUCTION:- The teacher introduce the lesson by explaining to the students that; In the dynamics of translational motion we recognize that a solid object if it is not too large compared with the scale of its trajectory will behave as a point like particle. Also we knew that motion of an object can be represented by a particle located at its center of mass. Rotation, or spinning, was not considered in the motions of objects because a particle, a point mass, has no physical dimensions. Rotational motion becomes relevant when we analyze the motion of solid extended objects or rigid bodies.

PRESENTATION: - The teacher present his lesson as follows:-

STEP I. The teacher define the term rigid body as: - A rigid body is an object or system of particles in which the distance between particles are fixed and remain constant. It is also referred to as a body with a perfectly definite and unchanging shape is itself an idealized model, since real materials always deform somewhat when

forces are exerted, but it is a useful model in cases where such deformation may be neglected.

STEP II. The teacher then explains more about rigid body; A quantity of liquid water is not a rigid body, but the ice that would form, if the water were frozen would be. The discussion of rigid body rotation is thus conveniently restricted to solids. Actually the concept of a rigid body is an idealization. In reality, the particles (atoms and molecules) of a solid vibrate constantly. Also, solids can undergo elastic (and inelastic) deformations. Even so, most solids can be considered to be rigid bodies for purpose of analyzing rotational motion.

STEP III. He further says objects in the real world, however, are not point like particles. A real object has a mass distribution associated with its size and shape, and the motion of a real object usually involves both translation and rotation. This type of combined translational and rotational motion occurs, for example, when a ball or a cylinder or a wheel rolls on a flat surface.

STEP IV. The teacher then explain to the students how to determine Rotational inertia, as the determination of the rotational inertia for an object with a complicated shape involves a tedious calculation, or the value must be obtained by experiment. Fortunately, the calculation of the rotational inertia for homogenous objects with simple geometric shapes is relatively straight forward. For example, a thin-walled cylinder or ring with mass M and radius R has all of its mass at a distance r = R from the natural (or symmetry) axis of the cylinder. Consequently, the rotational inertia about this axis is

$$I = MR^2, \qquad \text{ring about symmetry axis.}$$

STEP V. The teacher worked example on a thin uniform circular disc.

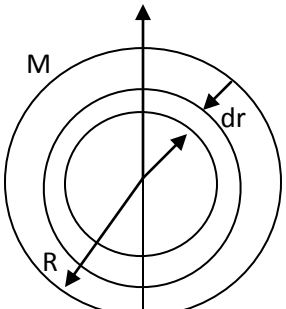
Find the rotational inertia (or moment of inertia) of a thin uniform circular disc with radius R, mass M and surface density $\rho = M/\pi R^2$, about an axis through its center and perpendicular to the plane of the disc.

Solution

Divide the disc into rings of differential width dr and area $(2\pi r)$dr. Each ring thus has differential mass

$dm = \rho\,(2\pi r)dr$

Then from rotational inertia



$$I = \int_m r^2 dm$$

We have

$$I_z = \int_o^R r^2 \rho\, (2\pi r) dr$$

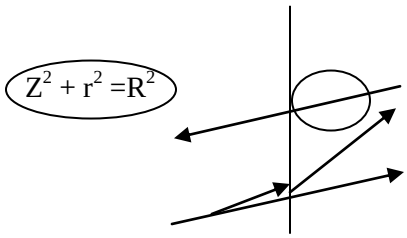
$$= 2\pi\rho \int^R r^3 dr$$

$$= \tfrac{1}{2}\pi\rho R^4$$

$$= \tfrac{1}{2}\, MR^2$$

STEP VI. The teacher add to the students more example.

Determine the rotational inertia of a uniform solid sphere with radius R, mass M and density $\frac{M}{4/3\pi R^3}$ about an axis through its center.



Solution

By taking advantage of the cylindrical symmetry, the rotational inertia can be evaluated with a single integration. Divide the solid sphere into discs with differential thickness dz and radius r. Then the volume of each disc $\pi r^2 dz$ and its differential mass is $dm = \pi r^2 \rho dz$. According to the result of Example 1 above, the rotational inertia of a disc about its axis is $Iz = \tfrac{1}{2} MR^2$ Therefore, we can write,

$$dI_Z = \tfrac{1}{2} r^2 dm = \tfrac{1}{2}\, \pi\, r^4 \rho\, dz.$$

Now, $z^2 + r^2 = R^2$, so we have $r^4 = (R^2 - Z^2)^2$, which can be substituted in the preceding equation and integrated to find I_z

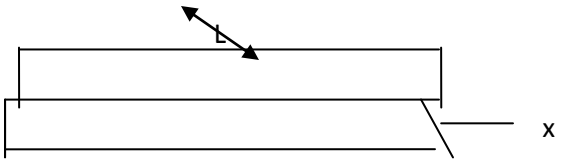
$$I = \int dI_z = \tfrac{1}{2}\, \pi\, \rho \int_{-R}^{+R} (R^2 - Z^2)^2 dz$$

$$\tfrac{1}{2}\, \pi\rho\, [R^4 z - {}^2/_3\, R^2\, Z^3 + {}^1/_5\, Z^2]_{-R}^{+R}$$

$= {}^{8}/_{15}\pi\rho\, R^5$

$= {}^{2}/_{5}\, MR^2$

STEP VII Find the moment of inertia of a uniform stick of length L and mass M about an axis perpendicular to the stick and through one end in fig below. Assume that the stick has negligible thickness.



Solution:-

Let the stick lie along the x-axis with its end at the origin. To calculate I_y about the y-axis since the total mass M is uniformly distributed along the length L, the mass per unit length (linear mass density) is $\rho = M/L$

The moment of inertia is given by the integral

$$I = \int_0^L x^2 dm$$

Writing dm in terms of the mass density, ρ and dx

$$dm = \rho\, dx = \frac{M}{L}\, dx.$$

Substituting the above and integrating, we have.

$$I_y = \int_0^L x^2 dm$$

$$= \int_0^L x^2 \frac{M}{L}\, dx$$

$$= \frac{M}{L}\, {}^{1}/_{3}\, x^3 \,l_0^L$$

$$= \frac{M}{L}\, \frac{L3}{3}$$

$$= {}^{1}/_{3} ML^2$$

That is the moment of inertia about the z-axis is also ${}^{1}/_{3}\, ML^2$ and that about the x-axis is zero, assuming that all of the mass is right on the x-axis.

SUMMARY:-

The teacher summarizes the lesson by defining the term rigid body as an object or system of particles in which the distance between particles are fixed and remain constant.

Rotational inertia is the determination of the rotational inertial for an object with a complicated shape involves a tedious calculations or the value must be obtained by experiment. ($I = MR^2$). The rotational inertia of a thin uniform circular disc with radius R, mass M and surface density $\rho = M/\pi R^2$ is $\frac{1}{2} MR^2$

The rotational inertia of a uniform solid sphere with radius R, mass M and density $\rho = \frac{M}{\frac{4}{3}\pi R^3}$ about an axis through its centre is $\frac{2}{5} MR^2$

The moment of inertia of a uniform stick of length L and mass M, about an axis perpendicular to the stick and through one and is $\frac{1}{3} ML^2$

EVALUATION:-

The teacher evaluate s his lesson by asking students questions based on what he thought.

i. Define rigid body.

ii. Explain briefly how to determine the rotational inertia

iii. State the rotational inertia of thin uniform circular disc with radius R, mass M and surface density $\rho = \frac{M}{\pi R^2}$

iv. State the moment of inertia of a uniform stick of length L and mass M, about an axis perpendicular to the stick and through one end.

LECTURE METHOD

LESSON 2

SCHOOL:- Federal College of Education, Kontagora

LEVEL:- 200

COURSE:- PHY 213

CREDIT UNIT:- 2

TOPIC:- Inertia of Rigid Body

SUB TOPIC:- Energy and Gyration of a Rigid Body

DURATION:- 2 hours

BEHAVIORAL OBJECTIVES:- By the end of the lesson students should be able to:

i. define Kinetic Energy of rotation;
ii. solve some numerical examples on kinetic energy;
iii. explain Radius of Gyration;
iv. state parallel-axis theorem;
v. determine the inertia of uniform disk about a perpendicular axis through its center.

ENTRY BEHAVIOR:- The student had some knowledge about kinetic energy and rotational inertia or moment of inertia.

INTRODUCTION:- The teacher introduces his lesson by explaining the term kinetic energy of rotation as the sum of the kinetic energies of the individual particles in the object. The rotational inertia is the determination of the rotational inertia for an object with a complicated shape involves a tedious calculations or the value must be obtained by experiment ($I = MR^2$).

PRESENTATION:-The teacher presents the lesson to the students as follows:

STEP I. The kinetic energy of a mass element m_i is

$$K = \tfrac{1}{2} m_i V_i^2 \text{ ……} \quad \textbf{(1)}$$

Summing over all the elements and using $V_i = r_i\omega$ gives

$$K_{rot} = \sum_i \frac{1}{2} mivi2 = \sum_i \frac{1}{2} mi(ri\omega)2$$

$$= \tfrac{1}{2} (\sum mi\, ri2)\omega 2$$

The term in the second set of parentheses is the moment of inertia I relative to the axis of rotation. The kinetic energy is thus

$$K_{rot} = \frac{1}{2} I\omega^2 \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Equation (2) is the rotational analog of $K = \frac{1}{2} mV^2$ for linear motion.

STEP II. The teacher call on a student to solve the below example,

A fly wheel used for storing energy consist of a uniform disk of mass $1.5x10^5$kg and radius 2.2m that rotates at 3000 rev/min about its center of mass. Find its kinetic energy.

SOLUTION

The kinetic energy is calculated directly from $K = \frac{1}{2} I\omega^2$. To obtain K in joules, we must express the angular velocity in radians per second.

The kinetic energy of rotation is $K_{rot} = \frac{1}{2} I\omega^2$.

Now let calculate the moment of inertia of the disk.

$$I = \frac{1}{2} MR^2 = \frac{1}{2} (1.5 \times 10^5 kg) (2.2m)^2$$

$$= 3.63 \times 10^5 kg .m^2$$

We then convert ω to rad/s

$$\omega = \frac{3000\, rev}{60 s} \times \frac{2\pi rad}{1\, rev} = 314 \text{ rad/s}$$

Substitute these values to find the kinetic energy

$$K_{rot} = \frac{1}{2} I\omega^2 = \frac{1}{2} (3.63 \times 10^5 kg.m^2) (314 rad/s)^2$$

$$= 1.79 \times 10^{10} J.$$

STEP III. The teacher explain the term Radius of Gyration as regardless of the shape of an object, we can always find a radial distance Γ from the axis of rotation at which the concentration of the entire mass M of the object would produce the same rotational inertia as that of the extended object itself. Then, the rotational inertia is equal to the value for a particle with a mass M at a distance Γ, namely, $I = M\Gamma^2$. We refer to this distance as the Radius of Gyration for the object about the particular axis, thus

$$\Gamma^2 = \frac{I}{M} = \frac{1}{M}\int_m r^2 dm \qquad \text{…….. (3)}$$

STEP IV. The teacher state the parallel-axis theorem for the student as

Let I_{cm} be the moment of inertia about an axis through the center of mass of an object of

total mass M, and let I be that about a parallel axis distance h away. The parallel-axis

theorem states that

$$I = I_{cm} + Mh^2 \qquad \text{……} \qquad (4)$$

STEP V The teacher then shows the students how to prove the parallel-axis theorem step by step.

We can prove the parallel-axis theorem using the result

$$K = \tfrac{1}{2} MV^2 + K_{rel} \qquad \text{……} \qquad (5)$$

That is the kinetic energy of a system of particles is the sum of the kinetic energy of the motion of the center of mass plus the kinetic energy of the motion relative to the center of mass.

Consider a rigid object rotating with an angular velocity ω about an axis a distance h from a parallel axis through the center of mass as shown in fig below. When the body rotates through an angle dθ measured about any axis of rotation, it rotates through the same angle dθ measured about any other parallel axis. The motion of the object relative to the center of mass is thus a rotation about the center-of-mass axis with the same angular velocity ω. The kinetic energy of this relative motion is

$$K_{rel} = \tfrac{1}{2} I_{cm} \omega^2$$

The velocity of the center of mass relative to any point on the axis of rotation is $V_{cm} = h\omega$. The kinetic energy of the motion of the center of mass is thus.

$$\tfrac{1}{2} MV_{cm}^2 = \tfrac{1}{2} M (h\,\omega)^2 = \tfrac{1}{2} M\, \omega^2 h^2$$

The relative energy is $\tfrac{1}{2} I\, \omega^2$ Equation (4) then becomes

$$K = \tfrac{1}{2} M\, \omega^2 h^2 + \tfrac{1}{2} I_{cm} \omega^2$$

$$= \tfrac{1}{2} (Mh^2 = I_{cm})\, \omega^2$$

$$= \tfrac{1}{2} I\, \omega^2$$

with

$$I = Mh^2 + I_{cm} \quad \ldots\ldots\ldots \quad (6)$$

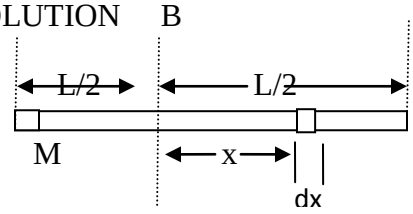
Which is the parallel-axis theorem?

STEP VI. The teacher called a student to solve the example on the chalk board under his guidance.

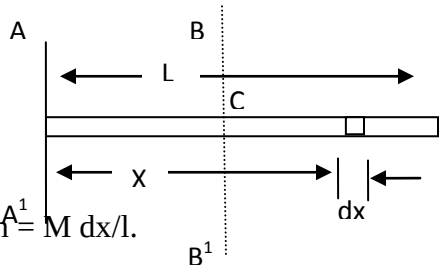
Determine the rotational inertia of a thin uniform rod

(a) about a perpendicular axis through its center and
(b) about a perpendicular through one end

SOLUTION B



B dm= M dx/L



dm = M dx/l.

Fig a.

(a) Figure (a) shows the rotation the perpendicular axis BB^1 through the center. The rotation inertia is

$$I_c = {}^{M}/_{L}\, x^2\, dx$$

$$= M/3L\, [x^3]_{-L/2}^{+L/2}$$

$$= M/3L\, [(+L/2)^3 - (-L/2)^3]$$

$$= M/3L\, [{}^{L3}/_{8} + {}^{L3}/_{8}]$$

$$= M/3L\, [L^3/4]$$

$$= ML^2/12$$

(b) The rotational inertia about a perpendicular axis AA^1 through one end of the rod can be calculated by using the geometry of fig (b) we find

$$I_A = M/L \int {}^{L}{}_{0} x^2\, dx$$

$$= M/3L\, [x^3]_0^L$$

$$I_A = M/3L\, [L^3 - 0]$$

$$= M\, L^2\, /3$$

OR. Using the parallel-axis theorem and the result of (a)

$I_A = I_c + M (L/2)^2$

$= 1/12 [ML^2] + ¼ [ML^2]$

$= \frac{ML^2 + 3ML^2}{12}$

$= \frac{4}{12} ML^2$

$= \frac{1}{3} ML^2$

STEP VII. The teacher explains to the students how the hoop about a perpendicular axis through its center look like, that is assumed that a hoop has mass M and radius R. (fig. below). The axis of rotation is the axis of the hoop, which is perpendicular to the plane of the hoop. All the mass is at a distance r = R, and the moment of inertia is

$I = \int r^2 dm$

$= R^2 \int dm$

$= MR^2$

STEP VIII. The teacher asks the students to solve the problem.

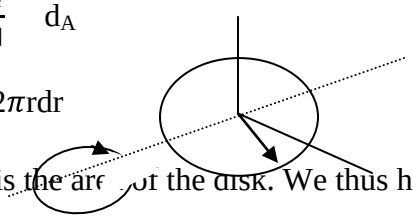
Determine the moment of inertia of uniform Disk about a perpendicular axis through its center.

Solution

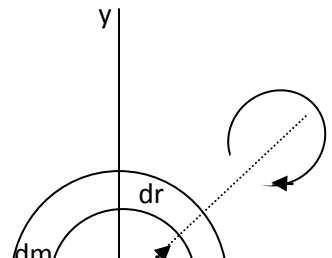
For the case of a uniform disk, we expect that I (moment of inertia) will be smaller than MR^2 , since the mass is uniformly distributed from r = 0 to r = R rather than being concentrated at r = R as it is in a hoop. In fig. below, each mass element is a hoop of radius r and thickness dr. The moment of inertia of any given mass element is r^2dm. Since the area of each element is r^2dm. Since the area of each element is $d_A = 2\pi rdr$, the mass of each element is

$dm = \frac{M}{A} d_A$

$= \frac{M}{A} 2\pi rdr$



Where $A = \pi R^2$ is the area of the disk. We thus have



$I = \int r^2 dm$

$= \int_0^R r^2 \frac{M}{A} 2\pi r dr$

$= 2\pi M/2\pi R^2 \int_0^R r^3 dr$

$=2M/R^2 [R^4/4]$

$= ½ MR^2$

SUMMARY:- The teacher summarized the lesson by stating that kinetic energy of rotation is

$K_{rot} = ½ I\omega^2$,

Radius of Gyration is

$\Gamma^2 = I/M = 1/M\int_m r^2 dm.$

The parallel-axis theorem is stated that

$I = I_{cm} + Mh^2$

The rotational inertia of a thin uniform rod about a perpendicular axis through its center is $I = M L^2/12$.

The rotational inertia of a thin uniform rod about a perpendicular axis through one end is

$I = M L^2/3$.

The rotational inertia of hoop about a perpendicular axis through its center is

$I = MR^2$.

The rotational inertia of uniform disk about a perpendicular axis through its center is

$I = ½[MR^2]$.

EVALUATION:- The teacher evaluates is lesson as

i) Define kinetic energy of rotation.
ii) Explain radius of Gyration.
iii) State parallel – axis theorem.
iv) Determine the inertia of uniform disk about a perpendicular axis

v)

vi) through its center

LECTURE METHOD

LESSON 3

NAME: **DAJUMA ALHAJI BIDA**

MATRIC NO: **M.ED/EDUC/3507/2009 – 2010**

SCHOOL: **FEDERAL COLLEGE OF EDUCATION KONTAGORA**

LEVEL: **200 LEVEL**

COURSE: **PHYS 213 (MECHANICS AND PROPERTIES OF MATTER II)**

AGE: **17 – 21 YEARS**

METHOD: **LECTURE METHOD**

TOPIC: **ANGULAR MOMENTUM**

DURATION: 2 HOURS

BEHAVIORAL OBJECTIVE: By the end of the lesson the students should be able to:-

i. define Angular Momentum;
ii. apply the angular momentum equation to solve some questions;
iii. explain the term torque;
iv. explain the relationship of Torque and Angular momentum;
v. state conversation of Angular Momentum;
vi. solve problems based on angular momentum, angular speed.

ENTRY BEHAVIOR: - The students had some knowledge about angular momentum, torque and momentum.

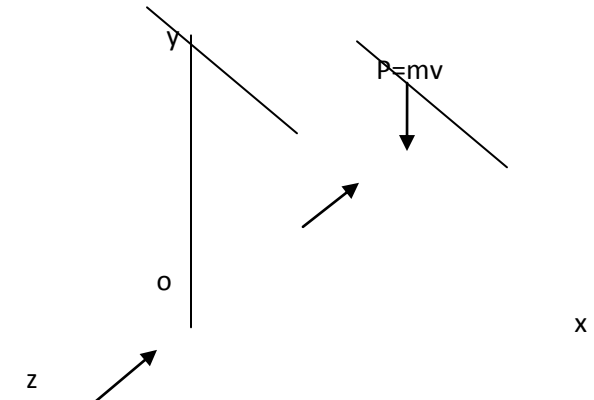
INTRODUCTION:- The teacher introduces his lesson by explaining the term Angular momentum as the cross product of position vector and momentum. $\mathbf{L} = \mathbf{r} \times \mathbf{p}$.

PRESENTATION: - The teacher presents his lesson as follows:

STEP I. The figure (1) below show a particle of mass M moving with a velocity **V** at a position **r** relative to the origin O. The linear momentum of the particle is $\mathbf{p} = m\mathbf{V}$. The angular momentum **L** of the particle relative to the origin O is defined to be the cross product of **r** and **p**.

$$\mathbf{L} = \mathbf{r} \times \mathbf{p}. \quad \ldots\ldots\ldots \quad (1)$$

If **r** and **p** are in xy plane, as in figure (1) below, then L is along the z axis and is given by **L** = **r** x **p**. = MVrSinø**k**. Like torque, angular momentum is defined relative to a point in space.



L= r x p

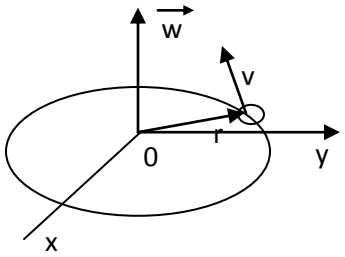
Fig (2) shows a particle moving in a circle in xy plane with the center of the circle at the origin. The speed V of the particle and the magnitude of its angular velocity ω are related by V = rω. The angular momentum of the particle relative to the centre of the circle is **L = r x p** = **r** x m**V**

= rmV $\sin 90^0$**k**

= rmV**k**

= $mr^2\omega$ k

= mr^2**ω**



The angular momentum is in the same direction as the angular velocity. Since mr^2 is the momentum of the inertia for a single particle about z axis we have:

I = mr^2**ω**

= I**ω** ……. (2)

STEP II. The teacher solved example for the students.

Find the angular momentum about the origin for the following situation. (a) A car of mass 1200 kg moves counter clockwise in a circle of radius 20m with speed15 m/s. (b) The same car moves with velocity **V** = - (15m/s)***i*** along the line y = y_o = 20 m parallel to the axis. (c) A disk in the x y plane of radius 20m and mass 1200 kg rotated at 0.75 rad/s about its axis which is the z axis.

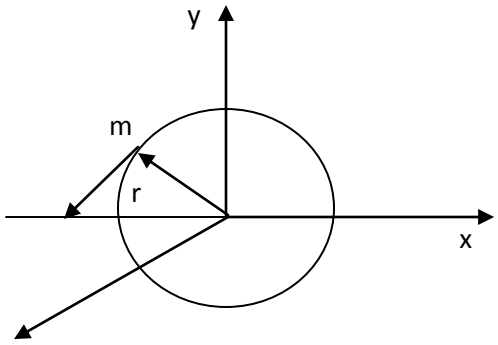
SOLUTION

(a) **r** and **p** are perpendicular and **r x p** is in the z direction

L = **r x p** = rmv***k***

= (20m) (1200kg) (15m/s) k

= 3.6 x 10^5kg m^2/s k



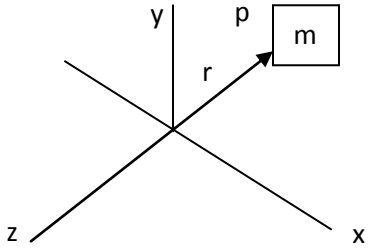
(b)i. For the same car moving to the left along the line

y = y_0 = 20m, we express **r** and **p** in terms of unit vectors

r = x ***i*** + y ***j***

= x ***i***+ y_0***j***

P = m**V** = -p***i***



ii. Now compute **r x p**

L = r x p

= (x ***i*** +y_0***j***) x (-p***i***)

= -xp (***i***x ***i***) – y_op (***j*** x ***i***)

= -xp (0) – y_0p (-***k***)

= y_0p***k***

= (20m) (1200kg) (15m/s) ***k***

= 3.6 x 10^5kg m^2/s ***k***

(c). Use **L** = I **ω**

= I ω***k***

= (½ MR^2)ω***k***

= {1/2 (1200kg) $(20m)^2$} (0.75rad/s)

= 1.8 x 10^5kg m^2/s ***k***

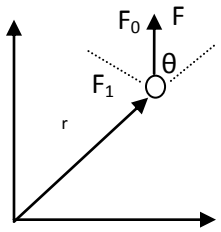
STEP III. The teacher explain the torque as: it is a common experience that an object can be set into rotation by a force that is applied off center. For example, a tangential push on the rim of a wheel will cause rotation, but a similar push along a line through the axis will not. The tendency for a force to produce rotation is proportional to the magnitude of the force and to the distance from the point of application to the center of rotation. The quantitative measure of this rotation tendency is in terms of the TORQUE produce by the force.

STEP IV. The teacher then defines the term torque as the product of the magnitude of a force and its force arm. Any vector can be express in terms of its component vectors. Therefore, a force **F** that is applied to a particle m, as in fig 5 below can be expressed in terms of component $\mathbf{F}_1$ perpendicular to the position vector **r** and a component $\mathbf{F}_{II}$ parallel to **r**. Only the component $\mathbf{F}_1$ can produce a torque about the point 0. The magnitude of the torque produced by **F** about 0 is defined to be

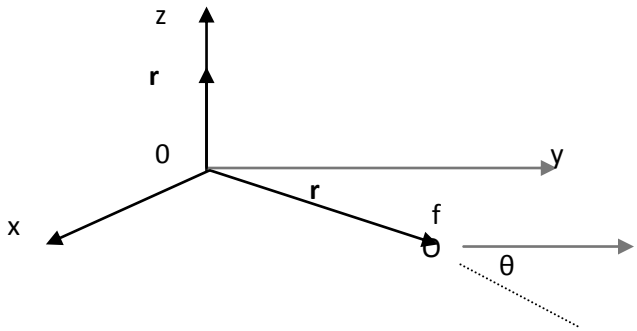
$$\tau = r F_1 = r f \sin\theta \qquad \ldots\ldots\ldots\ldots \qquad (3)$$

Where θ is the smaller angle between the positive directions of **r** and **F.** using vector notation, we can write, in analogy with the definition of angular momentum:

$$\boldsymbol{\tau = r \times F} \qquad \ldots\ldots\ldots \quad (4)$$



Torque is also referred to as moment of force. Note that the vector **τ**, which results from the cross product of two vectors, is perpendicular to the plane containing **r** and **F**, with a direction sense given by the right-hand rule, fig 6.



STEP V. The teacher further explains to the students the relation between torque and angular momentum.

We will now show that Newton's second law implies that the rate of change of the angular momentum of a particle equals the net torque acting on the particle. For a number of forces acting on a particle, the net torque relative to origin 0 is the sum of the torques due to each force.

$$\boldsymbol{\tau}_{net} = \mathbf{r} \times \mathbf{F}_1 + \mathbf{r} \times \mathbf{F}_2 + \text{-------} = \mathbf{r} \times \Sigma \mathbf{F}_i$$

$$= \mathbf{r} \times \mathbf{F}_{net.}.$$

According to Newton's second law, the net force equals the rate of change of the linear momentum **dp/dt**. Thus,

$$\boldsymbol{\tau}_{net} = \mathbf{r} \times \mathbf{F}_{net} = \mathbf{r} \times \mathbf{dp/dt} \quad \text{……} (5)$$

We now compare this with rate of change of the angular momentum; we can compute **dL/dt** using the product rule for derivatives.

$$\mathbf{dL/dt} = \mathbf{d(r \times P)/dt}$$

$$= \mathbf{dr/dt \times P + r \times dP/dt}$$

The first term on the right side of this equation is zero because

$$\mathbf{dr/dt \times P = r \times} m\mathbf{V = 0}$$

Thus

$$\mathbf{dL/dt = r \times dp/dt} \quad \text{……} (6)$$

Comparing this result i.e. equation (6) with equation (5) gives

$$\boldsymbol{\tau}_{net} = \mathbf{dL/dt} \text{----------} (7)$$

The net torque acting on a system of particles is the sum of the individual torques. The generalization of equation (7) to a system of particle is then.

$$\Sigma_i \boldsymbol{\tau} = \Sigma \mathbf{dL_i/dt} = \mathbf{d/dt} \Sigma \mathbf{L_i} = \mathbf{dL/dt.}$$

In this equation, the sum of the torques may include internal as well as external torques. We've seen earlier that the sum of the internal torques must be zero.

Therefore,

$$\Sigma \boldsymbol{\tau}_{ext} = d\mathbf{L/dt} \text{-------} (8)$$

The net external torque acting on a system equals the rate of change of the angular momentum of the system. For a rigid body rotating about a fixed axis, the momentum of inertia is constant and equation (8) becomes

$$\Sigma\boldsymbol{\tau}_{i\text{ext}} = d\mathbf{L}/dt$$

$$= d(I\boldsymbol{\omega})/dt$$

$$= Id\boldsymbol{\omega}/dt$$

$$= I\boldsymbol{\alpha} \text{ ------- } (9)$$

Where $\boldsymbol{\alpha} = d\boldsymbol{\omega}/dt$ is the angular acceleration vector.

This implies that the net external torques is equal to the product of rotational inertia and angular acceleration.

STEP VI. The teacher explains to the student on how the law of conservation of angular momentum is obtained and state the law for the students.

When the net external torque acting on a system is zero, we have

$d\mathbf{L}/dt = \mathbf{0}$

Or $\mathbf{L} = \text{constant}$ …….. (10)

Equation (10) is a statement of the law of conservation of angular momentum.

The statement is "If the net external torque acting on a system is zero, the total angular momentum of the system is constant".

STEP VII. The teacher solved some examples for the students

Q1. A merry-go-round of radius 2m and moment of inertia 500kg.m^2 is rotating about a frictionless pivot, making one revolution every 5s. A child of mass 25kg originally standing at the center walks out to the rim. Find the new angular speed of the merry-go-round.

SOLUTION

The final angular velocity is related to the initial angular velocity by conservation of angular momentum.

$$\mathbf{L}_f = \mathbf{L}_i$$

$$I_{sys}f\omega_f = I_{sysi}\omega_i$$

The moment of inertia of the system is the moment of inertia of the merry-go-round plus that of the child.

$I_{sys} = I_m + I_c = I_m + mr^2$

Initially r = 0, finally r = R. Substitute initial and final expressions for I_{sys}

$(I_m + mR^2)\omega_f = I_m\omega_i$

Solve for ω_F:

$$\omega_f = \frac{Im}{mR+Im}\omega i$$

$$= \frac{500kgm2}{(25kg)(2m)+500kgm2}\omega i$$

$$= \frac{5}{6}\omega i$$

$$= \frac{5}{6}\left(\frac{1rev}{5s}\right)$$

$$= \frac{1rev}{6s}$$

SUMMARY: The teacher summarizes his lesson as, Angular momentum as the cross product of position vector and momentum. **L = r x P**

Torque is the product of the magnitude of force and its force arm. $\boldsymbol{\tau}$ **= r x F**

The net external torque acting on a system equals the rate of change of the angular momentum of the system. $\Sigma \boldsymbol{\tau}_{ext} = d\mathbf{L}/\mathbf{dt}$

The net external torques is equal to the product of rotational inertia and angular acceleration. $\Sigma\boldsymbol{\tau}_{iext} = I\boldsymbol{\alpha}$.

Law of Conservation of angular momentum is stated as "If the net external torque acting on a system is zero, the total angular momentum of the system is constant."

EVALUATION; The teacher evaluates his lesson as follows:

(i) define angular momentum?
(ii) Explain the term torque.
(iii) State the law of conservation of angular momentum.

LECTURE METHOD

LESSON 4

School:- Federal college of education kotangora

Level :- 200level

Course:- Phys 213 (mechanics and properties of matter)

Average:- Age:- 17-21- year

Method:- Lecture method

Topic:- Gravitation

Duration:- Two hours

BehavioralObjective:- By the end of the lesson the students should be able to:

i. state the three laws of kepler;
ii. state the Newton's law of gravity;
iii. determine G;
iv. explain gravitational potential energy;
v. determine escape velocity.

Entry Behavior:- The student had some knowledge about Newton laws, potential energy and escape velocity

Introduction:- The teacher introduces his lesson by explaining the term ellipse as the locus of points for which the sum of the distance from two foci F is constant.

Presentation:- The teacher present his lesson as follow

Step I The teacher give short history about the study of planet as:- at the nighttime sky with its myriad stars and shining planet has always fascinated humankind, toward the end of the sixteenth century, the astronomer Tycho Brahe studies the motion of the planets and made observations that were considerable more accurate than those previously available.

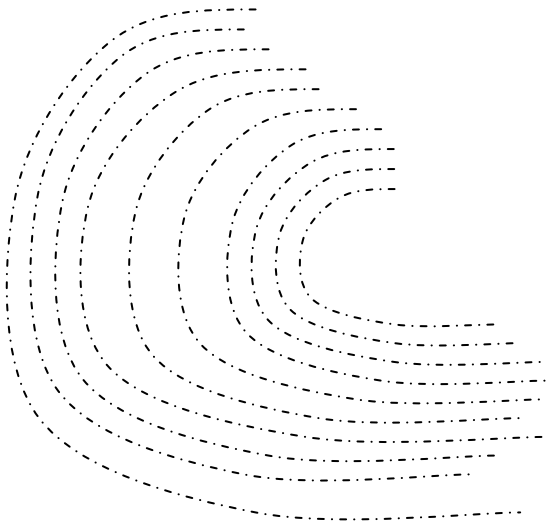
Using Brahe data Johannes Kepler discovered that the paths of the planets about the sun are ellipse fig 1 below. He also showed that the planets moves faster when their

orbit brings then closer to the sun and slower when their orbit takes them farther away.

Finally Kepler developed a precise mathematical relation between the period of a planet and its average distance from the sun. Kepler stated his results in three empirical laws of planetary motion. Ultimately, these laws provided the basis for Newton's discovered of the laws of gravity.

Kepler's three laws are.

1. All planets moves in elliptical orbits with the sun at one focus
2. A line joining any planet to the sun sweeps out equal areas in equal times.
3. The square of the period of any planet is proportional to the cube of the semimajor axis of its orbit



Step II. Teacher explains the term ellipse as the locus of points for which the sum of the distance from two foci F is constant, as show in fig 2. Fig 3 below show a planet following an elliptical path with the sun at one focus. The earth's orbit is nearly circular, with the distance to the sun at perihelion (closest point) being 1.48 x 10^{11}m, and at a phelion (farthest point) being 1.52x 10^{11} m. The semiMajor axis equals the average of these distances, which in 1.50x10^{11}m (93million miles) for earth's orbit. The mean earth- sun distance define the astronomical unit (AU)

$$1 \text{ AU} = 1.50 \times 10^{11} \text{ m} = 93.0 \times 10^{6} \text{ mi.} \qquad -(1)$$

The AU is used frequently in problems dealing with solar system. Fig. (3) illustrateskepler's second law, the law of equal areas. A planet moves faster when it is closer to the sun than when

it is further away, so that the area swept out by the radius vector in a given time interval is the same throughout the orbit. The law of equal area is related to the conservation of angular momentum.

kepler's third law relates the period of any planet to its mean distance from the sun, which equals the semimajor axis of its elliptical path. In algebraic form, if r is the mean distance between a planet and the sun and T is the planet's period of revolution, kepler's third law states that

$$T^2 = C\, r^3 \qquad \text{---- (2)}$$

Where the constant C has the same value for all the planets. This law is a consequence of the fact the force exerted by the sun on a planet varies inversely with the square or the distance from the sun to the planet.

Step III:- the teacher explain to the students on how Newton's law of gravity was founded:- Although kepler's laws were an important first step in understanding the motion of planets, they were still just empirical rules obtained from the astronomical observations of Brahe: It remained for Newton to take the next giant step by attributing the acceleration of a planet in its orbit to a specific force exerted on it by the sun. Newton proved that a force that varies inversely with the square of the distance between the sun and a planet result in elliptical orbits, as observed by kepler. He then made the bold assumption that this force acts between any two objects in the universe. Before Newton, it was not even generally accepted that the laws of physics observed on earth were applicable to the heavenly bodies. Newton's law of gravity postulates that there is a force of attraction between each pair of objects that is proportional to the product of the masses of the objects and inversely proportional to the square of the distance separating them. The magnitude of the gravitational force exerted by a particle of mass m_1 on another particle of mass m_2 and a distance r away is thus given by

$F = Gm_1m_2/r^2$---------(3)

Where G is the universal gravitational constant, which has the value G = 6.67 $x10^{11}$ N. m^2 /Kg^2

Newton published his theory of gravitation is 1686 but it was not until a century latter that an accurate experimental determination of G was made by Cavendish.

Step IV the teacher further explain how gravitational constant G is determine: the value of the gravitational constant G can be determined by measuring the force between a pair of objects with known masses that are separated by a known distance. The first experiment from which a reasonably accurate value for G could be obtained was carried out by the English chemist Henry Cavendish (1731-1810), who reported his result to the royal society in 1798. For his measurement, Carvendish used on instrument called a torsion balance that was similar to the one

invented independently by Charles coulomb and used by him in studies of electric and magnetic forces. The type of torsion balance used by Cavendish consist of a thin rod that carries two small balls with masses m_1 and m_2 .The rod is attached to the lower end of a wire that is suspended from a fixed support. The apparatus is allowed to come to rest with the large balls M_1 and M_2 ,some distance away. This equilibrium position is measured by directing a light beam from a stationary source onto a minor that is attached to the suspension wire, the point at which the reflected beam is seen on the scale is recorded. Next, the large balls are moved close to the small balls.

Because m_1 attracts $m_1$and m_2 attracts m_2, a torques is exerted on the rod. It rotates through a small angle until the restoring torque due to the torsional force in the twisted wire just balances the gravitational torque. The angular displacement of the rod is determined by noting the new position of the light spot on the scale. The force necessary to twist the wire by a certain amount (the so-called torsion constant) is related to the period of oscillation of the system, which can be measured in a separate experience. In this way Cavendish measured the gravitational force between known masses separated by a known distance. The value of G obtained from Cavendish is data is only 1 percent different from the value now accepted.

STEP V. The teacher explain to the student what gravitational potential energy is; near the surface of the earth, the gravitational force exerted by the earth on an object is constant because the distance to the centre of the earth $r = R_E + h$ is always approximately R_E for $h << R_E$. The potential energy of an object near the earth's surface is $mg(r - R_E) = mgh$, where we have chosen $U = o$ at the earth's surface, $r = R_E$. When we are far from the surface of the earth, we must take into account the fact that the gravitational force exerted by the earth is not uniform but decreases as $1\backslash r^2$. The general definition of potential energy gives.

$d\mathbf{u} = -\mathbf{F} \cdot \mathbf{ds}$ _____ (4),

Where **F** is the force on a particle and **ds** is a general displacement of the particle. For the radial gravitational `force **F** given by

$\mathbf{du} = -\mathbf{F}.\mathbf{ds} = -F_r dr = -(-GM_E m/r^2)dr = +(GM_E m/r^2)\,dr$ – (5)

Integrating both sides of this equation we obtain.

$$U = -GM_E m/r + U_0 \quad \text{____ (6)}$$

Where Uo is a constant of integration. Since only charges in potential energy are important, we can choose the potential energy to be zero at any position. The earth's surface is a good choice for many energy day problems, but it is not always a convenient choice. For example, when considering the potential energy associated with a planet and the sun, there is no reason to want the potential energy to be zero at the surface of the sun. In fact, it is nearly always more

convenient to choose the gravitational potential energy of a two – object system to be zero when the separation of the objects is infinite. Thus, Uo = 0 is often a convenient choice. Then

$$U(r) = - GMm/r, \quad U = o \text{ at } r = \infty \qquad ____ (7)$$

Figure (5) is a plot of U(r) verse r

for this choice of U = o at r = ∞ for $E_2>0$

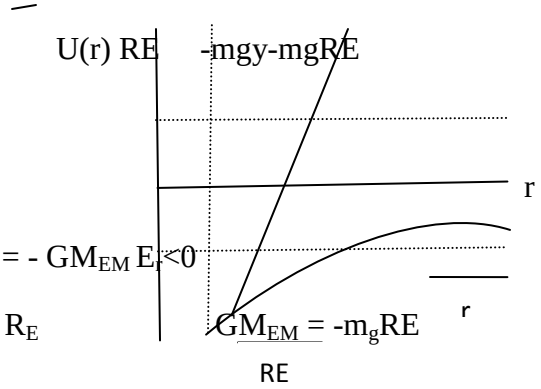
an object of mass m and the earth

of mass M_E, this function begins at $u(r) = - GM_{EM}$ $E_r<0$

the negative value $U = - GM_Em \setminus R_E = - mg R_E$ $GM_{EM} = -m_gRE$

at the earth's surface and increases as r increases,

approaching zero at infinite r.



Step VI The term escape velocity was explained to the student by the teacher as:- in the past few decades, the idea of escaping from the earth's gravity has changed from fantasy to reality. Space probes have been sent out to the far reaches of the solar system. Some of these probes are expected to orbit the sun; others will leave the solar system and drift into outer space. We will see that there is a minimum initial speed, called the ESCAPE VELOCITY that is speed required for an object to escape from the earth.

If we project an object upward from the earth with some initial kinetic energy, the kinetic energy decreases and the potential energy increases as the object rises. The maximum increase in potential energy is GM_Em/R_E as can be seen from figure (6).

Therefore, this is the most that the kinetic energy can decrease. If the initial kinetic energy is greater than $G M_Em/R_E$, the total energy E will be greater than zero (E_2 in fig. 6), and the object will still have some kinetic energy when r is very great (or even when r is infinite). Thus, the object will escape from the earth if the initial kinetic energy is greater than $GM_E m/R_E$,. Since the potential energy at the earth's surface is $– GM_E m/R_E$, the total energy E = K+U must be greater than or equal to zero for the object to escape. The speed near the earth's surface corresponding to zero total energy is called the escaped velocity V_e. It is found by setting the total energy at the surface of the earth equal to zero.

$$E = K+U =0.$$

$$½(mV_e^2) - GM_Em/R_E = 0$$

$$V_e = \sqrt{(2GM_E/R_E)} = \sqrt{(2gR_E)} \qquad \text{--------- (8)}$$

Using g = 9.81 m/s^2 and R_E = 6.37 x 10^6m, we obtain

$V_e = \sqrt{[2(9.81 m/s^2)(6.37 \times 10^6 m)]}$

= 11.2km/s

This is about 6.95 mi/s or 25,000 mi/h.

An object with this speed will just escape the earth.

Summary: - the teacher summaries his lesson by stating the three laws of kepler, that is

- all planets moves in elliptical orbits with the sun at one focus.
- A line joining any planet to the sun sweeps out equal areas in equal times.
- The square of the period of any planet is proportional to the cube of the semimajor axis of its orbits.

Also by stating Newton's law of gravity as there is a force of attractive between each pair of objects that is proportional to the product of the masses of the objects and inversely proportional to the square of the distance supporting them.

$F = GM_1M_2/r^2$

where G is the universal gravitational constant = 6.67 x 10^{11} $N.m^2/kg^2$.

Escape velocity is the speed or velocity required for an object to escape from the earth.

$V_e = \sqrt{(2gR_E)}$.

Evaluation: - the teacher evaluates his lesson by asking the students the following **question**.

(i) state the three laws of kepler.

(ii) state the Newton's law of gravity

Assignment.

i. Explain briefly how to determine universal gravitation constant G.
ii. Explain how to determine escape velocity.

LECTURE METHOD

LESSON 5

School:- Federal College of Education, Kontagora.

Level:- 200 Level.

Course: - Physics 213 (Mechanics and Properties of Matters)

Average: - 17 – 21 years.

Method: - Lecture Method.

Topic:- Surface Tension.

Duration: - Two Hours.

Behavioralobjective: By the end of the lesson the students should be able: -

i. explain surface tension;
ii. identify angle of contact;
iii. explain capillary rise;
iv. determine the pressure difference across a surface film;
v. solve problems on surface tension.

Entry Behavior: - The students had some knowledge about surface tension.

Introduction: - The teacher introduce his lesson by explaining the phenomena of surface, that is to say Surface phenomena indicate that surface of a liquid can be considered to be in a state of stress such that, for any line lying in or bounding the surface, the material on either side of the line exerts a pull on the material on the other side.

Presentation: - The teacher presents his lesson as follows.

Step I: - The teacher explains the phenomena of surface as: a liquid flowing slowly from the tip of a medicine dropper emerges not as a continuous stream but as a succession of drops. A sewing needle, if placed carefully on a water surface, makes a small depression in the surface and rests there without sinking, even though its density may be as much as 10 times that of water, when a clean glass tube of small bore is dipped into water, the water rises in the tube, but if the tube is dipped in mercury, the mercury is depressed. All these phenomena, and many others of a similar nature, are associates with the existence of a boundary surface between a liquid and some other substance.

Step II The teacher further explain on how to demonstrate the effect of surface that is to say, in the fig. 1 below a piece of wire in bent into the shape of a U and a second piece of wire is used as a slider. When the apparatus is dipped in a soap solution and removed, the slider (if its weight W_1, is not too great) is quickly pulled up to the top of the U. It may be held in equilibrium by adding a second weight W_2. Surprisingly, the same total force $F = W_1 + W_2$ will hold the slider at rest in any position will hold the slider at rest in any position, regardless of the area of the liquid film, provided, the film remains at constant temperature. That is, the force does not increase as the surface is stretched further. That is, very different from the elastic behavior of a sheet of rubber, for which the force would be greater as the sheet was stretched.

Although a soap film like that in fig 1 is very thin, its thickness is still enormous compared with the size of a molecule. Hence it can be considered as made up chiefly of bulk liquid, bounded by two surface layers a few molecules thick. When the cross bar in fig. 1 is pulled down and the area of the film is increased, molecules formerly in the main body of the liquid more into the surface layers. That is, these layers are not "stretched" as a rubber sheet would be; move surface is created by molecules, moving from the bulk liquid.

Step III the teacher define surface tension for the students. Let L be the length of the wire slider. Since the films have two surfaced the total length along which the surface force act is 2l. The surface tension in the film, γ, in defined as the ratio of the surface force to the length (perpendicular to the force) along which the force acts. Hence in this case,

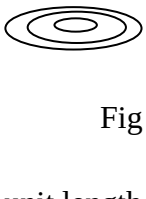
$$\gamma = F/2l \qquad \text{-------} (1)$$

The mks unit of surface tension is the newton per meter ($1Nm^{-1}$). This unit is not in common use, the usual unit is the cgs unit, the dyre per centimeter ($1 \text{ dyn } cm^{-1}$).

$$1Nm^{-1} = 1000 \text{ dyn } cm^{-1}.$$

Another example is shown in the figure 2 below. A circular wire of circumference l is lifted out from the body of a liquid . The additional force F needed to balance the surface force 2 γ l due to

the two surface films on each side is measured either by the stretch of a delicate spring or by the twist of a tension wire. The surface tension is ten given by

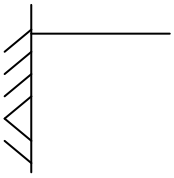


$$\gamma = \frac{f}{2l}$$

Fig 2.

In nut shell, surface tension is a force per unit length acting at right- angle to one side of a line down in the surface. OR it is the surface of a liquid act like skin covering the liquid.

Step IV:- the teacher explain the term angle of contact for the students: - the surface of a liquid is usually curved where it is in contact with a solid. The particular form that this curvature takes is determined by the relative strengths of what are called cohesive and adhesive forces. The cohesive force is the attractive force exerted on a liquid molecule by the neighboring liquid molecules. The adhesive force is the attractive force exerted on a liquid molecule by the molecules in the surface of the solid. Consider a liquid in a container with vertical sides. If the adhesive force is large compared with the cohesive force, the liquid tends to stick to the wall and so has a concave meniscus figure 3a., on the other hand, if the adhesive force is small compared with the cohesive force, the liquid surface is pulled away from the wall and the meniscus is convex fig. 3b.whether the meniscus is concave or convex depends on the liquid concerned and on the solid with which it is in contact. For example, water has a concave meniscus when in contact with glass and a convex meniscus when in contact with wax; mercury has a convex meniscus with (clean) glass.



The angle of contact θ is defined as the angle between the solid surface and the tangent plane to the liquid surface at the point where it touches the solid; the angle is measured through the liquid. It can be seen from Fig. 3 above, that the meniscus is concave when θ in less than 90^0 and is convex when θ is greater than 90^0. A liquid is said to "wet" a surface with which its angle of contact is less than 90^0. The angle of contact between water and clean glass is zero that between mercury and clean glass is 137^0. Thus water "wets" clean glass, mercury does not.

The zero angle of contact between water and clean glass is due to the adhesive force between water and glass being very much larger than the cohesive force between the water molecules themselves. This explains why water tends to spread into a thin continuous film when splashed on a horizontal clean glass surface. Mercury, on the other hand, forms into little drops; water on the roof of a freshly waxed car behaves in a similar fashion. The addition of a detergent to a liquid lowers its surface tension and reduces the contact angle. Water- proofing agents have the opposite effect.

Step V: The teacher explain to the students how surface tensionγ is measured, using a capillary rise.

Water in a capillary tube rises above the level of the water outside. The effect is known as capillary rise and is most marked with narrow tubes. The ability of blotting paper to soak up ink is due to the same effect; the spaces between the fibers act as fine capillary tubes. A liquid whose angle of contact is greater than 90^0 suffers capillary depression. Both capillary rise and capillary depression are caused by surface tension and provide a means by which the surface tension "γ" "of a liquid may be measured.

Suppose that a capillary tube is held vertically in a liquid which has a concave meniscus fig. 4 below. Surface tension forces cause the liquid to exert or downward directed force on the walls of the tube. In accordance with Newton's third law, the tube exerts an equal and opposite force on the liquid and it rises in the tube. At equilibrium the weight of the liquid which has been lifted up is equal to the vertical component of the force exerted by the tube. The mass of the raised liquid is the product of its density ρ and its volume πr^2h, and therefore its weight is

$\rho\pi r^2hg$ ---------- (2)

The length of the liquid surface in contact with the tube is equal to the circumference $2\pi r$ of the tube; and therefore the vertical component of the force exerted by the tube is

$2\pi r\gamma cos\theta$ ---------- (3)

Therefore at equilibrium

$2\pi r\gamma cos\theta = \rho\pi r^2hg$ ---------- (4)

i.e $\gamma = \frac{\rho rhg}{2cos\theta}$ ---------- (5)

From which γ can be determined.

NOTE.

i. The weight of the small quantity of liquid in the meniscus has seen ignored in deriving Eqn (5)

ii. h and r are normally measured with a travelling microscope. The tube should be broken at the level of the meniscus in order to measure r.

iii. θ and ρ are found from tables or measured in separate experiments.

iv. Equilibrium (5) also holds for capillary depression.

Step VI: the teacher further explain for the students, the pressure differences across a surface films

A soap bubble consists of two spherical surface films very close together, with liquid between surface tension makes the films tends to contact, but as the bubble contacts it compresses the inside air, increasing the interior pressure to a point which prevents further contraction. To obtain a relation between surface tension and this excess pressure we apply the principles of statics to one- half of the bubbles. As a preliminary, consider first a small element ΔA of the surface, shown in fig. (5). Suppose the air

pressure on the left of this element is P and that on the right is Pa. The force normal to the element is therefore (P - Pa) ΔA. The component of this force in the X- direction is

(P - Pa) ΔAcosθ ------ (6)

But ΔAcosθ is the area projected on a plane perpendicular to the X – axis. The force in the X- direction is therefore the difference of pressure multipled by the projected area in the X- direction.

Now consider the half- bubble shown in fig. (6) the other half exerts a force to the left equal to twice the left equal to twice the surface tension times the perimeter or

F (to the left) = (2γ) $(2\pi R)$ ---------- (7)

Fig.6

Since the half- bubble is in equilibrium.

$(P - P_a)\ \pi R^2 = 4\pi R\gamma$ ---------- (8)

$P - P_a = \frac{4\gamma}{R}$ ---------- (9)

If the surface tension remains constant (this means constant temperature), the pressure difference is greater for small bubbles than for large ones. If two bubbles are blown at opposite ends of a pipe, the smaller of the two will force air into the larger, the smaller one will increase in size.

For a liquid drop, which has only one surface film, the difference between pressure of the liquid and that of the outside air is half that for a soap bubble.

$P - P_a = \frac{2\gamma}{R}$ ---------- (10)

Step VII the teacher solved an worked example for the students. calculate the excels pressure

insidea drop of mercury of diameter 4mm at 20^oc.

Solution

$\gamma mercury = 465\ x\ 10^{-3}\ Nm^{-1}$, R = 0.002m

$P - P_a = \frac{2\gamma}{R}$

$=2(465 \times 10^{-3} NM^{-1})/0.002m$

$= 465\ Nm^{-2} = 0.005atm$

Summary: The teacher summaries his lesson by defining surface tension as:

The ratio of the surface force to the length perpendicular to the force along which the force acts. Also angle of contact as the angle between the solid surface and the tangent plane to the liquid surface at the point where it touches the solid.

Evaluation: The teacher evaluate his lesson by asking the students some questions.

i. Explain briefly the term surface tension
ii. Differentiate between cohesive and adhesive forces.
iii. Define angle of contact

Assignment:

i. Explain how to determine surface tension γ using capillary rise

ii. Explain how to determine the pressure difference across a surface film

LECTURE METHOD

LESSON 6

Name: - **DANJUMA ALHAJI BIDA**
Matric No: - **M.ED/EDUC/3507/2009 – 2010**
School: - **Federal College of Education, Kontagora**
Level: - **200 Level**
Course: - **PHY213 (MECHANIC AND PROPERTIES OF MATTERII)**
Age: - **17-21 years**
Method: - **Lecture Method**
Topic: - **Oscillatory and circular motions.**
Duration: - **TWO (2) HOURS**

Behavior objectives: - By the end of the lesson the student be able to: -

(i) define simple harmonic motion;
(ii) state conditions for simple harmonic motion, in terms of acceleration;
(iii) identify graphical representation of sinosodial wave;
(iv) explain some example of simple harmonic motion such as simple pendulum physical pendulum;
(v) explain damped oscillations;
(vi) solve some problems on simple harmonic motion and damped oscillation.

Introduction: - Oscillation occurs when a system is distributed from a position of stable equilibrium. There are many familiar example such as boats bob up and down, clock pendulums swing back and forth, and the strings and needs of musical instrument vibrate. Other, less familiar example are the oscillations of air molecules in a second wave and the oscillations of electric current in radios and television sets.

Presentation: - The teachers present his lesson as follows: -

Step I: The teacher explain the term simple harmonic motion as a common and very important kind of oscillations motion as simple harmonic motion, such as the motion of an object attached to a spring figure (1) below.

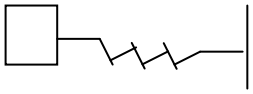


Figure 1.

Motion described by sines and cosines of single frequency is referred to as a Single Harmonic Motion (SHM) and the associated system is called a Simple Harmonic Oscillator. In equilibrium, the spring exerts a force – kx, as given by Hooke's law:

$$F_X = -Kx \qquad (1)$$

Where k is the force constant of the spring, a measure of the springs stiffness.

The minus sign indicates that the force is a restoring force; that is, it is opposite to the direction of the displacement. Combing equation (1) with Newton's Second law, we have

$$F_X = ma_x$$

$$-Kx = m\frac{d^2x}{dt^2}$$

or $$a = \frac{d^2x}{dt^2} = -\frac{K}{m}x \qquad (2)$$

The acceleration is proportional to the displacement and is oppositely directed. This is a general characteristic of simple harmonic motion and can be used to identify systems that will exhibit it.

Step II. The teach state the condition for Simple Harmonic Motion in terms of acceleration as "whenever the acceleration of an object is proportional to its displacement and is oppositely directed, the object will move with Simple Harmonic Motion.

Since the acceleration is proportional to the net force, whenever the act force on an object is proportional to its displacement and is oppositely directed, the object will move with Simple Harmonic Motion.

Step III:- the teacher then define some term such an

Period (T):- is the time taken by a displacement object to make a complete oscillation back and forth about its equilibrium position (unit in second)

Frequency (f) is the number of oscillation per second, which is the reciprocal of the period.

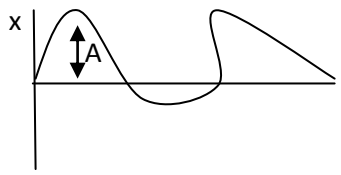
F = $\frac{1}{T}$…….. (3)

The unit of frequency is the reciprocal of second (5^{-1}), which is called a hart 3 (HZ).

Amplitude:- is the maximum displacement from equilibrium.

Step IV:- the teacher teach the students how to drive or obtain the general equation for wave.

Fig below shows how we can experimentally obtain x versus t for a mass on a spring.



X = A cos (wt+ δ) ……. (4)

Where A, w and δ are constant. The maximum displacement from equilibrium is called the amplitude A. the argument of the consine function, wt + δ is called the phase of the motion, and the constant δ is called the phase constant. The phase constant depends on the choice of t = 0. If we have just one oscillating system, we can always choose t = 0 such that δ = 0. If we have two systems oscillarating weith the same amplitude and frequency bat different phase, we can choose δ = 0 for one of them. The equations for the two systems are then

x_1 = A cos wtAnd$x_{2=A\cos(wt+\delta)}$

If the phase difference δ is 0 or an integer times 2π, then $x_2 = x_1$ and the systems are said to be in phase. If the phase difference δ in π or an odd integer times π, then x $x_2 = -x_1$ and the systems are said to be out of phase.

We can show that equ (4) is a solution of equ (2) by differentiating x twice respect to time. The first derivative of x gives the velocity V

$v = \frac{dx}{dt} = -Aw\sin(wt + \delta)$ ... ... (5)

Differentiating the velocity with respect to time gives the acceleration:

$a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = -w^2A\cos(wt + \delta)$ ... ...(6)

Or $a = -w^2 x$ ... .(7)

Comparing $a = -w^2 x$ with $a = -\left(\frac{k}{m}\right) x$ $(equ\ 2)$, we see that x = A Cos (wt + δ) is a solution of $\frac{d^2x}{dt^2} = a = -\left(\frac{k}{m}\right) x\ if\ w = \sqrt{\frac{k}{m}}$ ... ... (8).

The amplitude A and the phase constant δ can be determined from the initial position x_0 and the initial velocity v_o of the system setting t = 0 in x = cos (wt +) gives $x_{o=A\cos\delta}$..... (9).

Similarly, setting

t = 0 in V = $\frac{dx}{dt} = -Aw\sin(wt + \delta)\ gives\ V_o = -Aw\sin\delta$ ....(10)

these equations can be solved for A and δ in terms of x_o and V_o the period T is the time after which x repeats. Then x (t) = x (t + T)

$A\ Cos\ (wt + \delta) = A\ Cos\ [w\ (t + T) + \delta] = A\ Cos\ (wt + \delta + wT)$

The cosine (and sine) function repeats in value when the phase increases by 2π, so.

wT = 2π or w = $\frac{2\pi}{T}$.

The constant w is called the angular frequency. It has units of radians per second and dimensions of inverse time, the same as angular velocity, which is also designated by w. the frequency is the reciprocal of the period.

$f = \frac{1}{T} = \frac{w}{2\pi}$ ... ... (11)

Since $w = \sqrt{\frac{k}{m}}$, the frequency and period of an object on a spring are related to the force constant k and the mass m by

$f = \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \ldots\ldots\ldots\ldots\ldots\ldots (12)$

The frequency increases with increasing k (spring stiffness) and decreases with increasing mass m.

Step V the teacher worked an example for the students that is Q. you are on a boat that is bobbing up and down. The boat's vertical displacement of is given by

$$y = (1.2m)\, Cos\left(\frac{t}{25} + \frac{\pi}{6}\right).$$

(a) find the amplitude, angular frequency, phase constant, frequency, and period of the motion; (b) where is the boat at t = 1 s? (c) find the velocity and acceleration at any time t (d) find the initial position, velocity, and acceleration of the boat.

Solution.

(a) compare the equation for the boat's vertical displacement with equation (4) y =A cos (wt + 8) to get A, w and f.

Y = (1.2m) cos ($\frac{t}{25}\frac{\pi}{6}$).

ie A = 1.2m, w =$\frac{1}{2}$ rad/s, s =$\frac{\pi}{6}$ rad.

2. The frequency and period are found from w.

F= $\frac{w}{2\pi} = \frac{0.5\ rad/s}{2 \times \frac{22}{7}} = \frac{7 \times 0.5}{44}$ = 0.0796HZ.

T = $\frac{1}{f} = \frac{1}{0.796}$ = 12.65.

(b) set t = 1s to find the boat's position

$y = (1.2m)\cos\left[\frac{1}{25}(1s) + \frac{\pi}{6}\right] = 0.624m$

(c) The velocity and acceleration are obtained from the position by differentiation with respect to time.

$v_y = \frac{dy}{dt} = -(1.2m)\sin\left(\frac{1}{25}t + \frac{\pi}{6}\right)\frac{d\,(t/_{25})}{dt}$

$= -(0.6m/s)\sin\left(\frac{1}{25}t + \frac{\pi}{6}\right).$

(d) set t = o to find $y_{o,} v_{yo,}$ and $a_{yo.}$

$ay = \frac{dvy}{dx} = -(0.6\ m/s)\cos\left(\frac{1}{25}t + \frac{\pi}{6}\right)\frac{d\left(t/_{25}\right).}{dt}$

$ay = \frac{dvy}{dt} = -\left(0.3\frac{m^2}{s}\right)\cos\left(\frac{t}{25}t + \frac{\pi}{6}\right).$

$y_o = (1.2m)\cos\frac{\pi}{6} = 1.04m$

$v_{yo} = -(0.6m/s)\sin\frac{\pi}{6} = -\frac{0.300m}{s}$.

$a_{yo} = -(0.3m/s^2)\cos\frac{\pi}{6} = -0.260m/s^2$

NB:- The frequency and period of simple harmonic motion are independent of the aptitude.

Step IV the teacher, demonstratne to the student on how graphical represent of sin of social wave in. when the phase constant in $\delta = 0$, equations (4),(5)and (6) them become.

X = A coswt ___ 13a

V= - WA sinwt __13b.

And a = $-w^2$ A sin wt __13c.

These functions are plotted on below.

Step VII :- the teacher further explain the example of simple harmonic motion, ie.

Simple pendulum:- consider a particle (the pendulum bob) that has a mass m and is suspended from a fixed support by a string of length L. this system in equilibrium when the bob hangs directly below the support point. A displacement away from this equilibrium position is conveniently measurement in terms of the angle $\emptyset$, as shown above.

The free-body diagram for the bob shows the two forces that are acting. (we now use s for the tension, reserving T for the period).

We now apply Newton's second law to the tangential component of the motion of the bob. The tangential acceleration is

$$a = \frac{d^2s}{dt^2} = \frac{d^2(c\,\theta)}{dt^2} = L\left(d^2\theta/dt^2\right).$$

So we have

- Mg $\sin\theta = mL\,\frac{d^2\theta}{dt^2}$ _____ (14).

The general solution of an equation of thin type in complicated however, of the motion of the pendulum in restricted to angles sufficiently small than sin θ may be replaced by θ, the solution is readily obtained.

In thin event, we have .

$\frac{d^2\theta}{dt^2} = \frac{-g}{L}$ _____(15).

This equation has the same form as equation $\frac{d^2x}{dt^2} = \frac{-k}{m}\,x$, so we have a case of S.H.M. involving the angular co-ordinate θ, of Q represent the amplitude of the angular motion, we can immediately write the solution as $\theta\,(t) = Q\sin(wt + \emptyset)$ ___(16)

Where $w_o = \sqrt{\frac{g}{L}}$ ____(17).

The period of the motion is

$T = \frac{2\pi}{w_o} = 2\pi\sqrt{\frac{L}{g}}$ _____(18)

NOTE that the period of the pendulum depends only on its length and not on the mass of the bob.

Be certain that you understand the distinction between the angular co-ordination $\theta(t)$, which describes the position of the bob and is confirmed to the relatively narrow range, - Q≤ $\theta \leq$ + Q, and the phase angle, $Q_{0,}$ which increase without limit as t increase.

The solution to the pendulum problem contained in equation (16) through (18) is only approximately; the expression are useful only when the amplitude Q is sufficiently small.

Step VIIb The physical pendulum:- A Rigid object pivoted about a point other than its center of mass will oscillate when displace from equilibrium. Such a system is called a**PHYSICAL PENDULUM**. Consider a plane figurepivote about a point a distance D from its center of mass and displaced from equilibrium by the angle ∅ shown below, the torque about the pivot has a magnitude Mg D ∅ and tends to decrease∅. Newton's second law applied to rotation is

$\boldsymbol{\tau = I \propto = I\frac{d^2\phi}{dt^2}}$

Where ∝ is the angular acceleration, and I is pivot the moment of inertial about the pivot. Substituting –My D sin ∅ for the net torque

$$-mg\ D \sin = I\ \frac{d^2\phi}{dt^2}$$

$$or\ \ \frac{d^2\phi}{dt^2} = -\frac{M_{g^D}}{I}\sin\phi \ldots\ldots\ldots (19)$$

Again, the motion is approximately simple Harmonic if the angular displacement are small, so the approximation sin ∅ = ∅ holds. In thin case, we have

$$\frac{d^2\phi}{dt^2} = -\frac{M_{g^D}}{I}\ \phi = -w^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

Where $w^2 = {}^{M_{g^D}}/_{I}$. the period or therefore

$T = \frac{2\pi}{w} = 2\pi\sqrt{\frac{I}{M_{g^D}}}$ …… (21).

Step VIII. The teacher explains about damped oscillations for the students.

Left to itself, a spring or a pendulum eventually stops oscillating because the mechanical energy is dissipated by frictional forces. Such motion is said damped.

If damping is small, the system oscillates with amplitude that decreases slowly with time as in fig below.

Both the amplitude and the energy which is proportional to the square of the amplitude, decrease by a constant percentage in time interval. This type of decrease is called exponential decrease. The force extorted on a damped oscillator can be represented by the empirical expression.

$$f_{d=-bv.}$$

Where is a constant. Since the damping force is opposite the direction of motion, tit dose negative work and courses the mechanical energy of the system to decrease. The motion of a damped system can be obtained from newt ion's second law. For an objective of massm on a spring of force constant k the net force in –kx-b d^{2x/dt^2}, are obtain

$$f_{x=m_{ax.}}$$

$$\text{-kx - b}\frac{dx}{dt} = \text{m}\,\frac{d^{2x}}{dt^2} \quad \text{___ (22).}$$

The exact solution of thin equation can be found using standard method for solving differential equations. The solution for the case of small damping is

$$\text{X}=A_O\, e^{-(b/2m)t} \cos(wt+\delta) = A_{o^{e^{-t/2T}}} \cos(wt+\delta)$$

whereA_o is the maximum amplitude, and $__(23)\tau = \frac{m}{b}$ $__$ (24) is called the decsy time or time constant. The frequency w^i is given by

$$w^1 = \sqrt{w_{0^2 - (b/2m)^2=}}\, w_0 \sqrt{1 - \left(b/2mw_0\right)2_{.....}}$$

Where w_0 is the frequency with no damping ($w_0 = \sqrt{k/m}$ for a mass on a spring).For small damping, $b/2mw_0 \ll 1$ and w^1 is nearly equal to w_0. The dashed curved in above figure correspond to x = A and x = - A where A is given by

$$A = A_O e^{-(b/2m)t} = A_o e^{-t/2\tau} _____ (26)$$

If the damping constant is gradually increased, the angular frequency w' decrease until it becomes zero at the critical value

$$b_c = 2mw_o$$

If when b is greater than or equal to b_c' the system does not oscillate. If b = bc, the system is said to be critically damped; it returns to equilibrium with no oscillation in the shortest time possible. When b is greater that bc, the system is over damped. Figure below shws plots of the displacement verses time for a critical damped and on over damped oscillator,

The energy of an oscillator is proportional to the square of the amplitude, the energy of an under damped oscillator (average) over a cycle) also decrease exponentially with time.

$$E = \frac{1}{2}mw^{2}{}_{A} = \frac{1}{2}mw^{2}\left(A_{o}e^{-t/2\tau}\right)2 = E_{o}e^{-t/\tau}$$

Where $E_0 = \frac{1}{2}mw^{2}{}_{A_0^2}$. We see that the decay tire in the time for the energy to decrease to e^{-1} times its original value.

A damped oscillator in often described by its Q factor (for quality factor).

$Q = w_o\,\tau = \frac{w_o m}{b}$ ……. (29)

We can relat Q to the fractional energy loss per cycle. Differentiating equation (28) given

$$dE = -\frac{1}{\tau}E_{o}e^{-t/\tau}\,dt = -\frac{1}{\tau}Edt.$$

If the energy loss per period in small we can replace dE by DE, and dt by the period T. then $\Delta E/_E$ in one period is given by

$\frac{\Delta E}{E} = \frac{T}{\tau} = \frac{2\pi}{w_o\tau} = \frac{2\pi}{Q}$ ……. (30)

Or $Q = \frac{2\pi}{\left(\Delta E/_E\right)}\ cycle$

Q is this inversely proportional to the fractional energy loss per cycle.

SUMMARY:- the teacher summaries the lesson by defining simple harmonic motion as the motion described by sins and cosines of a dingle frequency.

Condition for simple harmonic motion in terms of acceleration is whenever the acceleration of an object is proportional to its displacement and is oppositely directed, the object with move with simple harmonic motion.

State some examples simple harmonic motion as simple pendulum with the pendulum of the motion $T = 2\pi\sqrt{\frac{L}{g}}$. and physical pendulum with the period of motion $T = 2\pi\sqrt{\frac{I}{m_g D}}$. damped oscillators an either critical or over damped.

Evolution: the teacher evaluates his lesson by assing the student some question

(i) define simple harmonic motion

(ii) sketch graphically the representation of wave

(iii) differentiate between critical and over dying

Assignment: -(i) state the condition for SHM in terms of acceleration

(ii) explain the following terms

(a) simple pendulum

(b) Physical pendulum.

(iii) explain the term damped oscillations