UNIVERSITY OF EDUCATION, WINNEBA

# COMPARATIVE EFFECT OF COOPERATIVE LEARNING AND COOPERATIVE LEARNING WITH INSTRUCTIONAL MANUAL ON STUDENTS' PERFORMANCE IN MECHANICS CONCEPTS

APPIAH-TWUMASI ERIC

2016

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APPIAH-TWUMASI ERIC

8140130001

A THESIS IN THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF SCIENCE EDUCATION, SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, UNIVERSITY OF EDUCATION, WINNEBA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF PHILOSOPHY (SCIENCE EDUCATION) DEGREE.

AUGUST, 2016

# DECLARATION

**Student's Declaration**

I, **APPIAH-TWUMASI ERIC**, declare that this Thesis, with the exception of quotations and references contained in published works which have all been identified and acknowledged, is entirely my own original work and it has not been submitted, either in part or whole, for any other degree elsewhere.

**Sign** ……………………………………**Date**……………………………….

**Supervisors' Declaration**

We hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines set for thesis laid down by the University of Education, Winneba.

**Sign** …………………………….... **Date**……………………………….

Dr. Ishmael K. Anderson

(Principal Supervisor)

**Sign**………………………….. **Date**………………………………

Prof. Mawuadem Koku Amedeker

(Supervisor)

## ACKNOWLEDGEMENTS

I am neither the first nor will be the last to complete a thesis of this nature. As those before me, I could not have completed a work such as this so successfully without the support, insight, and dedication of my mentors, family, friends and colleagues.

First and foremost, my sincere gratitude goes to my principal supervisor, Dr. I. K. Anderson, for his guidance, valuable comments, suggestions and advice given to me during the period of this work. I am also grateful to my co-supervisor, Professor Mawuadem Koku Amedeker.

Furthermore, my thanks go to Mr. and Mrs. Twumasi-Ankrah, Mr. Richard Acheampong and Mr. Charles Badu for their support and encouragement. Also, without exceptional support of Mr. Philip Dorsah, my coursemate this body of work wouldn‟t have existed. Finally, I would like to acknowledge the contribution of my other course mates and friends who contributed immensely to the successful completion of the work.

# DEDICATION

This work is dedicated to my wife Asuma Rita and children: Appiah-Twumasi Shulammite and Appiah-Twumasi Ataf.

# TABLE OF CONTENTS

**Content** **Page**

**CHAPTER TWO: LITERATURE REVIEW**

**CHAPTER FIVE: DISCUSSION OF DATA, SUMMARY, CONCLUSION AND RECOMMENDATIONS**

# LIST OF TABLES

**Table** **Page**

# LIST OF FIGURES

**Figure** **Page**

# LIST OF APPENDICES

# ABSTRACT

The study examined the effect of cooperative learning strategy with instructional manual as against cooperative learning strategy only on SHS students‟ performance in Mechanics concepts in Physics in Berekum Municipality, Brong Ahafo Region. The research design employed in this study was the quasi-experimental using pretest and posttest equivalent control group design. Samples of ninety three (93) SHS 2 students drawn from two intact classes were used for the study. An instrument known as Mechanics Concepts Test (MCT) was used to gather data for the study. Mean, standard deviation, mean gain and effect size analysis were used to answer the research questions, while independent sample t-test was used to test the hypotheses. The results revealed that students taught using cooperative learning strategy with instructional manual performed better on the Mechanics Concepts Test (MCT) than those taught using cooperative learning strategy only. There was no gender difference in performance on the use of cooperative learning strategy with instructional manual. Based on the result obtained, it was therefore recommended that teachers must be encouraged to use cooperative learning strategy guided by instructional manual to teach physics and other science subjects at the SHS.

# CHAPTER ONE

# INTRODUCTION

## 1.0 Overview

This chapter discusses the background of the study and statement of the problem. It also throws light on the purpose of the study, objectives of the study, research questions and research hypotheses formulated for the study. Furthermore, the chapter presents the significance of the study, delimitation as well as the limitation of the study. The chapter ends with abbreviations of terms used for the study and theorganisation of the study.

## 1.1 Background to the Study

The environment, science and technology, can be recognised as pillars of economic prosperity and social development which can provide tools and solutions to address global challenges. Hence, it must be seen as crucial for Ghana to move in the direction of science and technology in order to improve on its economy and also play an active role in the global economy. Furthermore, Ghanaians must make best use of the natural resources within their environment and conduct research in the areas of science and technology. All these would be effective if they are hinged on a quality education for its citizenry. In a developing world such as Ghana, improvement in the quality of education for its citizenry must be considered a priority, especially in science subjects. This is because of its apparent potential to provide a foundation for scientific and technological development.

Governments all over the world spend greater chunk of their resources on education. For example, a study conducted in 2015 shows that Ghana government spends over six percent of its Gross Domestic Product (G.D.P.) on education annually (Afful, 2015). In spite of all the investments made by government of Ghana in education, performances over the years in science education in particular, have been relatively low. Anamuah-Mensah and Asabere-Ameyaw (2007) noted that Ghana introduced science and mathematics education in the sixties but it appears Ghana has not benefited much from it.

A clear manifestation is in the regular and the annual abysmal performance in science by students in both W.A.S.S.C.E. and B.E.C.E. examinations. For example, WAEC reported that in the 2006 WASSCE, only twelve point five percent (12.5%) of the total candidates obtained grades between A1 to C6 in Physics. In that of 2014 examination, the percentage was twenty eight point one percent (28.1%) (The West Africa Examination Council [WAEC], 2006; 2012).

Some of the causes of the low performance of science students at these levels may be attributed to the kind of learning environment, interaction, and teaching methods utilised by science teachers. According to Kizlik (2016), the instructional method which is right for a particular lesson depends on many factors such as the age and cognitive development of the students, what the students already know, and what they need to know to succeed in the subject, the subject matter, students interest and the objective of the lesson. Kizlik (2016) further added that other factors are time, space, materials and resources available, and the kind of interaction between students in the classroom.

Johnson and Johnson (2010) are of the opinion that learning environments reflect the overall structure of the learning goals, which in turn largely determines the daily routines, the social and emotional atmosphere. They added that learning environments also reflect moment-to-moment interaction among the teacher and students and among the students themselves.

Teaching basically has two dimensions or views that reflect on the kind of interaction, the kind of activity, and the kind of teaching method used by teachers in the classroom. The interaction could be traditional view of teaching and teaching as a bi-polar process; where teachers and students involve in all the aspects of the teaching and learning processes (Boison, Fosu & Mensah, 2009).

In the traditional views of teaching, the teacher is a dispenser of information, and a fount of all knowledge (Boison, Fosu & Mensah, 2009). In this view, they suggested a picture of students sitting in rows in front of the teacher who is talking and passing information to students with the aid of a blackboard as the students either listening passively, or taking down notes. Teachers or educators who hold this view appear to see the child‟s mind as "*tabula rasa*'' or empty slate to be filled with teacher‟s information. Thus students are considered as a container and the teacher is the holder of knowledge, the teacher has knowledge about what dose of knowledge the child needs. The teacher makes all the decisions and direction of the teaching and learning process.

In the traditional instructed physics classroom, teachers teach Physics concepts through discussion and lecturing. Teacher describes and defines those concepts and writes related equation and keywords on the chalkboard. Students take notes and after the teacher‟s explanations, the concepts are discussed through teacher-directed questions. Consequently, students in this classroom situation are likely to be passive learners instead of active learners. In this sense of teaching, the teacher may also be seen to be teaching and yet may be doing very little teaching in a more practical sense. The students may not be learning and even if they are seen learning, they may be learning pre-digested material which may fail to develop their growing mental faculty.

Current dimension of teaching may be seen as a bi- polar process, between the teacher and the students. Teachers in this classroom interaction are to be seen as facilitators, and coaches, a person who assists students to learn for themselves. Students are likely to be put in groups, all doing something different, some doing practical tasks, some writing, some not even in the room but in another part of the building using specialized equipment or looking up something in the library. All of the students might well be at different stages in their learning and in consequence, the learning is individualized to suit the learners individual requirements and abilities (Boison, Fosu &Mensah, 2009). The importance of this is that students become active in the teaching and learning processes instead of being passive as in the case of the traditional view of teaching.

According to Pickering, Marzano and Pollock (2001), active or participatory learning by the students is the effective, efficient, and superior instruction for teaching and learning. An example of active learning is student-centered learning.

Felder and Brent (2009) noted that student-centered teaching methods comprise cooperative learning in which students work in teams on problems and projects under conditions that assure both positive interdependence and individual accountability. Students-centered teaching also includes inductive teaching and learning, in which students are first presented with challenges (questions or problems) and learn the course material in the context of addressing the challenges. Inductive methods include inquiry-based learning, case-based instruction, problem-based learning, project-bases learning, and discovery learning.

According to Douglas and Jaquit (2009), student-centered learning (also called child-centered learning) is an approach to education focusing on the needs of the students rather than those involved in the educational process such as teachers and administrators. This approach has many implications for the design of the curriculum, the course content, and the interactivity of courses. For example, student-centered methods have repeatedly been shown to be superior to the traditional teacher-centered approaches to instruction (Felder & Brent, 2007). The authors concluded that student-centered lessons promote short-term mastery, long-term retention, or depth of understanding of course material, acquisition of critical thinking or creative problem-solving skills, formation of positive attitudes toward the subject being taught, or level of confidence in knowledge or skills.

Kpangban and Ajaja (2007) believe that science teaching and learning today is focused on activities by which the learner acquires facts, rules, actions and sequences. They further suggested that the panacea for learners to acquire facts, rules and actions and sequences is through student-centered teaching and learning activities.

In a student-centered instructional approach like cooperative learning, harnessing student ideas means bringing student experiences, points of view, feelings, and problems into the lesson by making the student the primary point of reference. A completely student oriented lesson is always initiated by asking students questions and assigning specific roles to them on the content to be taught, and their answers and dispositions would become the focus of the lesson (Ajaja & Eravwoke,2010).

Active learning or student-centered learning, an engagement form of educating students where the teacher creates conditions so that students can take control of their own learning, ginger the learner beyond the function of inactive listener and note taker. Prince (2004) said that any instructional method that engages students in the learning process is an active learning. Active learning includes a variety of teaching methods such as small group discussion, cooperative learning, role playing, hands-on projects, and teacher driven questioning. Simmons and DiStasi (2008) explain active learning activities that require students to use a diversity of learning techniques, promote retention of huge amounts of information, and encourage greater social interaction via peer discussion.

Haack (2008) was of the opinion that more recent views of learning have encouraged the use of active learning strategies to enhance the quality of student learning through students" creation of meaning rather than rote memorization of facts, merely taking part in activities may not be enough to achieve deep learning.

Basically, there are three ways in which the learning goals may be achieved. These are cooperative, competitive, and individualistic. Cooperative learning is the instructional use of small groups so that students work together to maximize their own and each others" learning. Within cooperative situations, individuals seek outcomes that are beneficial to themselves and beneficial to all other group members. Cooperative learning is important in helping learners acquire from the curriculum the basic cooperative attitudes and values they need to think independently inside and outside of the classroom (Borich, 2004).

Cooperative learning activities instill in learners important behaviour that prepare them to reason and perform in an adult world. Concluding from the attributes of cooperative learning, the pattern of teacher-student interaction during cooperative learning has greater effects on the teaching and learning of physics and subsequently improving students" performance in mechanics topics. The major purpose of teacher-student interaction during cooperative learning is to promote independent thinking. The exchanges between the teacher and students in the cooperative classroom focus on getting learners to think for themselves. This implies that science teachers must model their instructions to enforce teamwork with students since cooperative learning occurs in groups that share a common purpose and task. Again, it also implies that the science teacher must broaden interactions to fit the zone of maximum response opportunity that is common to most group members in his classroom (Ajaja & Eravwoke, 2010).

Competitive learning is students working against each other to achieve an academic goal such as a grade of "A" that only one or a few students can attain (Johnson & Johnson, 2013). According to them, within competitive situations, individuals seek outcomes that are beneficial to themselves but detrimental to all other group members. Individualistic learning is students working by themselves to accomplish learning goals unrelated to those of the other students. Although there are restrictions on when and how teachers may utilise competitive and individualistic classroom interaction appropriately, teachers can structure and utilise any learning task in any subject area of any curriculum using cooperative interactive approach.

Attitudes and values of students are generated through social interaction in the classroom, during the teaching and learning process. Borich (2004) noted that most of our attitudes and values are formed by discussing what we know or think with others.

Continuing in this manner, we exchange our information and knowledge with that of others who have acquired their knowledge in different ways. This exchange shapes our views and perspectives (Ajaja & Eravwoke, 2010). Our attitudes and values are among the most important outcomes of schooling. They provide the framework for guiding our actions outside the classroom.

It is based on this background that the Researcher decided to use cooperative learning strategy with a self-prepared instructional manual with the hope to enhance students‟ performance in some mechanics concepts in physics.

## 1.2 Statement of the Problem

Physics can be recognised as an important academic subject to every society. The reason for this is due to the fundamental role it plays in modern scientific and technological developments. Despite this, students‟ performance in the subject at the national and internal examinations has been relatively low. For example, W.A.E.C. reported that in the 2006 W.A.S.S.C.E. examination, only twelve point five percent (12.5%) of the total candidates obtained grades between A1 to C6 in Physics. In 2012 and in a similar examination also, the percentage was twenty eight point one percent (28.1%) (The West Africa Examination Council ([WAEC.], 2006; 2012).

In the executive summary of the T.I.M.S.S. for 2007 by Anamuah-Mensah, Mireku and Gharty-Ampiah (2008) noted the following in the study of science in Ghana:

- The overall performance of the Ghanaian JHS2 students on the science test was very low.

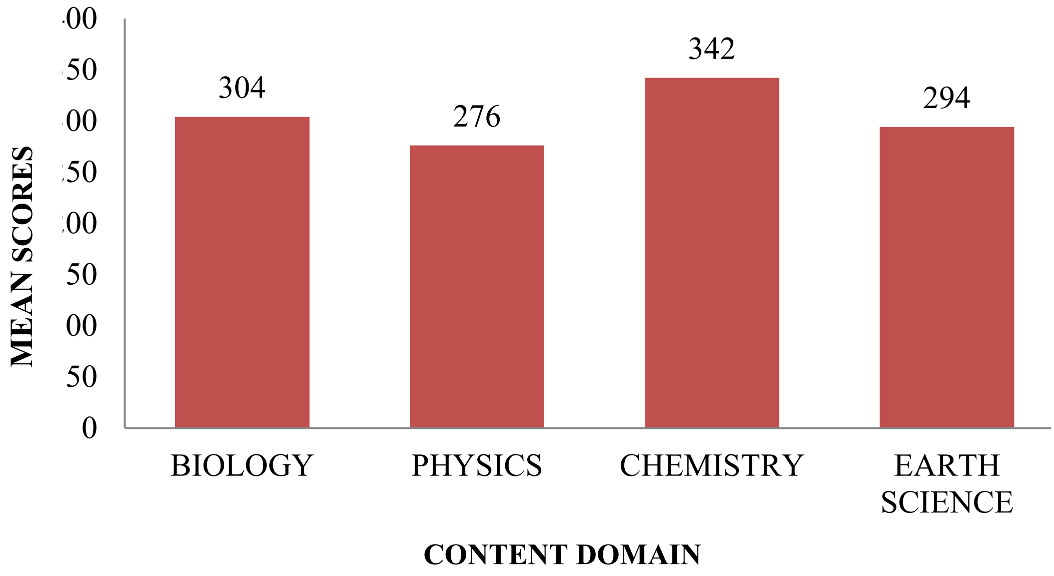


**Figure 1.0: Ghanaian JHS 2 Students Content Mean Performance of Science Domain (TIMSS, 2007)**

- In all the four science content domains as indicated in figure 1.0, the Ghanaian JHS 2 students‟ performance was statistically significantly below the T.I.M.S.S. scale average of 500, indicating that they were very weak in all the four domains.
- The mean score of 276 in physics was the least performed among the Ghanaian JHS2 students in all the domains.
- On average, the performance of boys was statistically better than girls by 29 scale points difference.

Analysis of the W.A.S.S.C.E. results of science and technical students over the years showed that students‟ performance in physics in Berekum Municipality confirmed the national and internal abysmal performance in physics. A field survey conducted in 2016 by the Researcher showed that Baidan Methodist Senior High Technical School students‟ performance in the W.A.S.S.C.E. was not different from the national abysmal trend. This is having negative effect on the teaching and learning of physics in the Municipality.

Admittedly, some physics concepts and theories are perceived to be abstract and therefore appear difficult for students to comprehend. This perception might be a contributing factor to students‟ low performance and low interest in the subject. However, studies show that cooperative learning strategies have the potential to improve upon students‟ performance in any science subject including physics (Ho & Boo, 2007; Akinbobola, 2009; Zakaria, Chin & Daud, 2010). This informed the Researcher to use cooperative leaning strategy and instructional manual with the mind to improve upon students‟ performance in physics.

## 1.3 Purpose of the Study

The purpose of this study was to investigate the effect of the use of cooperative learning strategy and instructional manual on students‟ performance in physics. The study was also designed to find out whether there is significant difference between students instructed with cooperative learning strategy only and those instructed with cooperative learning strategy with instructional manual.

## 1.4 Objectives of the Study

The specific objectives for the study were to:

i) Determine the effect of using cooperative learning strategy only to teach mechanics concepts in physics.

ii) Determine the effect of using cooperative learning strategy with instructional manual to teach mechanics concepts in physics.

iii) Determine the differential effect of cooperative learning strategy only and cooperative learning with instructional manual on mechanics concepts test in physics.

## 1.5 Research Questions

The following research questions guided the study.

1. What is the effect of the use of cooperative learning strategy only on students" performance in mechanics concepts?
2. What is the effect of the use of cooperative learning strategy with instructional manual on students" performance in mechanics concepts?
3. What is the difference in performance of students instructed using cooperative learning strategy only and cooperative learning strategy with instructional manual?

## 1.6 Research Hypotheses

From the research questions raised, two research hypotheses were formulated.

**$H_{01}$:** There is no significant difference in the performance between students instructed using cooperative learning strategy only and those instructed using cooperative learning strategy with instructional manual.

## 1.7 Significance of the Study

The effects of cooperative teaching strategies and instructional manual on students" academic performance of the subjects (sample) would inform physics teachers in the school about the need to tackle their students" poor performance in physics from the perspective of classroom interaction. The results of this study would also inform physics teachers and other teachers in the school the need to prepare comprehensive instructional manual for their students to guide their studies. Consequently shifting from the traditional method of teaching physics in school and adopting the bi-polar perspective of teaching Physics such as student-centered method through cooperative learning strategy would help the students to improve their performance in Physics.

Furthermore, results of this study would help Physics students in the school to improve upon their performance in Physics through the use of cooperative learning and instructional manual.

## 1.8 Justification of the Study

Cooperative learning strategy has been researched into and its effect on performance noted in many findings. However, including instructional manual is lacking in many of studies concerning cooperative learning strategy. Hence, the justification for this study.

## 1.9 Delimitation of the Study

According to Simon and Goes (2011), the delimitations of a study are those characteristics that arise from limitations in the scope of the study. Delimitation defines the boundaries and by the conscious exclusionary and inclusionary decisions made during the development of the study plan. Examples of these exclusionary and inclusionary decisions are the choice of objectives and research question(s), variables of interest, the choice of theoretical perspectives that will be used, the methodology, and the choice of participants. Hence, there are many methods of teaching physics, but for the purpose and direction of this study, cooperative learning strategy only and cooperative learning with instructional manual were selected for the study. The study was also restricted to Form Two Science and Technical Two Students because the mechanics topics under consideration in this study are in their syllabus. Lastly, the topics considered are under mechanics topics, just an aspect of entire physics topics at the S.H.S level.

## 1.9 Limitation of the Study

The main limitation of this study was that there were possibilities of the students in the two groups interacting with each other outside the classroom which could affect the results of the study.

Other limitation of the study was absenteeism on the part the students. Some research participants were sometimes absent from school due to truancy. Others were also driven from class for not being able to settle their school fees. All of these hindrances were beyond the reach of the Researcher.

## 1.10 Abbreviation

| | | |
|---|---|---|
| **W.A.S.S.C.E.** | : | West African Senior School Certificate Examination |
| **W.A.E.C.** | : | West African Examinations Council |
| **S.H.S.** | : | Senior High School |
| **B.E.C.E.** | : | Basic Education Certificate Examination |
| **J.H.S.** | : | Junior High School |
| **C.L.S.O.** | : | Cooperative Learning Strategies Only |
| **C.L.W.I.M.** | : | Cooperative Learning with Instructional Manual |
| **Z.P.D.** | : | Zone of proximal development |
| **M.C.T.** | : | Mechanics concept test. |
| **T.I.M.S.S.** | : | Trends in International Mathematics and Science Study |
| **N.H.T** | : | Numbered Heads Together |

## 1.11 Organisation of the Study

The study was organised into five chapters. Chapter one deals with the introduction which comprises background of the study, statement of the problem, purpose and objectives of the study, research questions, research hypotheses, significance of the study, delimitation of the study, limitation of the study and the organisation of the study. Chapter two reviews the literature under specific themes. It discusses the theoretical and conceptual frameworks which serve as a guide towards data collection. Again, issues like empirical evidence of cooperative learning and gender differences in cooperative learning strategy are discussed in this chapter.

Chapter three, the methodology section, contains subsections consisting of research design, population and sample size, data collection instruments, data collection procedures and data analysis. Chapter four presents the findings of the study with regards to the specific objectives which are effect of cooperative learning strategy and instructional manual on student performance in mechanics concepts and gender difference in performance when using cooperative learning strategy with instructional manual method of teaching mechanics concepts. The chapter ends with the discussion of results as presented in the previous chapter in the light of the scientific literature. Chapter five presents the summary of the findings and outlines the conclusion and recommendations based on the findings as well as issues for further research in this dimension.

# CHAPTER TWO

## LITERATURE REVIEW

### 2.0 Overview

This chapter presents a review of literature that relates this study. For effective presentation of the review, the chapter was organised under headings such as: cooperative learning, theoretical basis of cooperative learning, relationship between zone of proximal development, types of cooperative learning, critical aspects of effective cooperative and key to successful group processes in cooperative learning.

Additionally cooperative learning structure and techniques, conceptual framework of the study, implementation challenges of cooperative learning, empirical evidence of cooperative learning, gender related issues in cooperative learning and instructional manual and its importance are reviewed. The chapter ends with summary of issues arising from the review.

### 2.1 Cooperative Learning

One learning strategy that really enhances learners‟ understanding of science and by implication physics is cooperative instructional learning. This strategy is completely different from the self-centered learning, which focuses mainly on individual learners‟ learning independently. Cooperative learning is a successful instructional strategy in which small groups, each with students of diverse ability levels using a variety of learning activities to improve student learning experiences (Arra, Antonio, & Antonio, 2011).

According to Wendy (2005), cooperative learning is the umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together. It requires a small number of students to work together on a common task, supporting and encouraging one another to improve their learning through interdependence and cooperation with one another (Larry & Hartman, 2002).

According to Abass (2008), cooperative learning is a method of teaching and learning in which students work together to explore a significant question or create a meaningful project. Felder and Brent (2007) also defined cooperative learning as students working in teams on an assignment or project under a condition in which certain criteria are satisfied, including that the team members are held individually accountable for the complete content of the assignment or project. Cooperative learning group formation usually comprises two to five students in a group that allows everyone to participate in a clearly designed task (Wendy, 2005; Sarah & Cassidy, 2006).

In cooperative learning, students must be responsible for their own learning and for the success of other group members" learning (Slavin, 2011). In other words, students must ensure that each member in the group completes the tasks or assignment and achieves the academic outcomes. Johnson and Johnson (2008a) noted that the lesson will not be cooperative structured if students do not "swim together" in the group during the learning processes and activities. In cooperative learning, if team members are not dependent on each other and fail to have mutual interest in working together to complete the tasks, the success of the team will decrease. Hence, if any group member fails to complete his or her learning task, all the other group members will suffer the effect of that member"s action.

Borich (2004, p. 86) asked, "What good are critical thinking, reasoning, and problem-solving skills if your learners cannot apply them in interaction with others?" These implies that students with high critical thinking abilities or skills, high reasoning abilities and are ingenious problem-solvers become baseless if students with such high mental abilities cannot share with others. Borich"s statement above offers an explanation why students" confidence levels increase in small groups and also expresses idea that supports cooperative learning in that, many minds are better than one.

The social aspect of cooperative learning is what gives it power and usefulness. However, not all groups are cooperative. Johnson and Johnson (2009a) stated that placing students in the same group in the classroom, seating students together, telling them that they are a group, does not mean they will cooperate effectively.

Woolfolk (2001) stated that the terms group learning and cooperative learning are often used as if they meant the same. Woolfolk (2001) further added that, group work is simply several students working together. They may or may not be cooperating. Woolfolk (2001) concluded that cooperative learning is an arrangement in which students work in mixed ability groups and are rewarded on the basis of the success of the group.

From the attributes of cooperative learning above, cooperative learning includes any form of instruction in which students work for a purpose. Furthermore, the more any activity or instruction requires mutual interdependence, group problem solving, and striving for a common goal, the likelihood that the full benefits of cooperative learning would be achieved.

## 2.2 Theoretical Basis of Cooperative Learning

Dat-Tran (2013) stated that the theoretical roots of cooperative learning are social interdependence theory, cognitive development perspective, social learning theory, constructivist learning theory. However, this research adopts social learning theory, social interdependent theory and cognitive developmental perspective as the theoretical basis of this research.

### 2.2.1 Social Learning Theory

Albert Bandura introduced social learning theory to integrate behavioural and cognitive learning theories by taking into considerations how imitable behaviour is affected by cognitive constructs, such as attention, retention, production and motivation. Bandura (1977), the founder of social learning theory, acknowledged that much learning occurs by observing, modeling and imitation models. Schunk (2007) also stated that social learning theory places human behaviour within a framework of three reciprocal interactions. These are person, behaviour and environment. Schunk further noted that the major premise of social learning theory is that learners can improve their knowledge and retention by observing and modeling the desired behaviour, attitudes and reactions of others, and human thought processes are central to understanding personality.

In the context of social learning theory, most learning take place in a social environment, in which learners obtain knowledge, rules, skills, strategies, beliefs, and attitudes by observing others. In the social learning theory, reciprocal interaction among the students‟ personal factors, environmental variables, and behaviours are significant constructs found in the cooperative learning (Schunk, 2007; Johnson, Daigle & Rustamov, 2010).

### 2.2.2 Social Interdependence Theory

The social interdependence theory is relevant when each individual"s goals are accomplished under the influence of others (Johnson & Johnson, 2005). According to Slavin (2011), this theoretical perspective holds that students help each other"s learning because it is about the group and its members, and comes to derive self-identity benefits from membership. Social interdependence theory views cooperation as resulting from positive interdependence among individuals' goals. In social interdependence theory, groups are considered as a "dynamic wholes"" in which a modification in the state of any member or subgroup alters the state of the other members. Consequently, social interdependence exists when the accomplishment of each individual"s goal is affected by the actions of others (Johnson & Johnson, 2010).

Social interdependence may be differentiated from social dependent, independence and helplessness. According to Johnson and Johnson (2010), social dependence exists when the goal achievement of person A is affected by person B"s actions, but reverse is not true. Social independence exists when the goal achievement of person A is not affected by person B"s actions and vice versa. Social helplessness exists when neither the person nor any other can influence goal achievement.

Deutsch (1949) developed Levin"s social interdependence theory by discussing the relationship between the goals of two or more individuals. According to Deutsch (1949), social interdependence may be both positive and negative. It may be positive when individuals work cooperatively to attain their shared goals, and it may be negative when individuals compete to claim who attained the goals. In cooperative situation as argued by Deutsch (1949), the psychological processes associated with substitutability; the degree to which actions of one person substitutes for the actions of another person, inducibility; the openness to being influenced and to influencing others, and positive cathexis, the investment of psychological energy in objects outside of oneself, such as friends, family, and work. Deutsch (1949) added that in competitive situations, the opposite psychological processes are highlighted, namely non-substitutability, negative cathexis and resistance to being influenced by others. A lack of social interdependence detaches an individual from others, thereby creating non-substitutability, cathexis only to one"s own actions, and no inducibility, or resistance to completely shared goals. Deutsch (1949) stated that the basic premise of the social interdependence theory is that the way in which goals are structured determines how individuals interact, and interaction patterns create outcomes.

Johnson and Johnson (2008b) believe that positive interdependence may result in promotive interaction, negative interdependence may result in oppositional interaction, and no interdependence may result in no-interaction. Promotive interaction is when individuals encourage and facilitate each other"s efforts to complete tasks, and accomplish the group"s goals. It is made up of variables such as mutual help and assistance, exchange of needed resources, effective communication, mutual influence, trust, and constructive management of conflict.

Positive interdependence exists when there is a positive connection among individuals" goal accomplishment. Individuals perceive that they can achieve their goal if and only if the other individuals with whom they are cooperatively associated attain their goals. Oppositional interaction is when individual student discourages and obstructs each other"s efforts to complete tasks or assignment(s) and accomplish their goals. It comprises such variables as obstruction of each other"s goal achievement efforts, tactics of threat and coercion, ineffective and misleading communication, distrust, and striving to win conflicts (Johnson & Johnson, 2010).

No interaction is when individuals act independently without any exchange with each other while they work to accomplish their goals; individuals focus only on increasing their own productivity and achievement and ignore as irrelevant the efforts of others (Dat-Tran, 2013). Each type of interdependence results in certain psychological processes and interaction patterns which in turn determine the outcomes of the situation, including the moral socialisation and education of individuals involved (Johnson & Johnson, 2009b).

### 2.2.3 Cognitive Development Theory

Dat-Tran (2013) noted that the cognitive development perspective arose from the work of Piaget and Vygotsky. A basic assumption of the cognitive development perspective driven by their theories, together with those of their colleagues, is that reciprocal interaction among children around suitable academic tasks creates growth in the knowledge of concepts and critical skills (Slavin, 2011). To further explain the context of students" interaction in teaching and learning processes, Vygotsky (1978) stated that what a child can do with assistance today, the child will be able to do tomorrow.

Cognitive-developmental theory views cooperation as a vital requirement for cognitive development. It argues from the harmonisation of perspectives as individuals work to accomplish mutual goals. Mutually, Piaget and Vygotsky emphasized the importance of social interactions in cognitive development, but Piaget saw a different role for interaction. Piaget said that interaction encourages development by creating disequilibrium-cognitive conflict that motivated change.

Thus, Piaget believed that the most helpful interactions were those between peers, because peers are on an equal basis and can challenge each other‟s thinking. Vygotsky (1978), on the other hand, suggested that children‟s cognitive development is fostered by interactions with people who are more capable or advanced in their thinking. Hence, students can learn from both adults and peers. However unlike Piagetian theory, where a child would be just influenced by the society, Vygotsky sought to explain the development of a child through a transformative collaborative practice which involved cultural influences, cultural tools, and individuals (Vianna& Statesenko, 2006). The individuals here refers to assistance provided by more capable others; parents, teachers, peers, experts, and coaches.

Paterson (2015) also noted that the theoretical perspective outlined by Vygotsky can be understood in terms of three general themes that run throughout Vygotsky writings which are;

- the use of genetic, or developmental method;
- the claim that higher mental functioning in the individual emerges out of social processes; and
- the claim that human social and psychological processes are fundamentally shaped by cultural tools, or meditational means.

Hence to Vygotsky, the child‟s cognitive development is the function of the genetic, social interactions and psychological factors. Thus, higher mental processes first are co- constructed during shared activities between the child and another person. Then the processes are internalised by the child and become part of that child‟s cognitive development (Woolfolk, 2007). Subsequently, Vygotsky produced some famous concepts like internalisation and the zone of proximal development which is the phase at which a child can master a task if given the appropriate help and support.

### 2.2.4 Relationship between Zone of Proximal Development (Z.P.D.) and Cooperative Learning

Vygotsky‟s concept of the Z.P.D. is meaningful and vital to teaching and learning processes in subjects including science. Vygotsky (1978) defines the Z.P.D. as the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. Figure 2.0 illustrate the Z.P.D

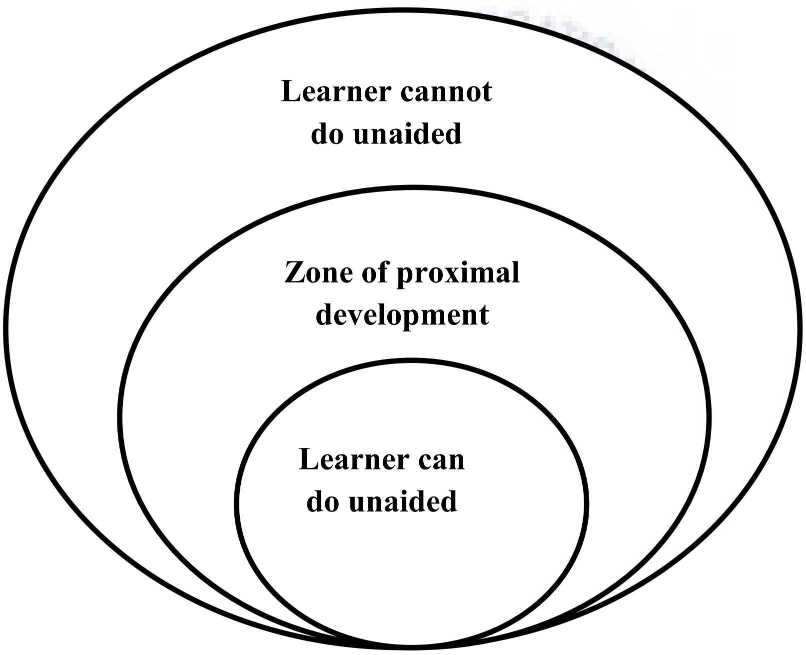


**Figure2.0: An Illustration of the Zone of Proximal Development (ZPD)**

Vygotsky viewed the Z.P.D. as the gab between where the learner currently has reached in relation to problem solving processes and the learner‟s potential for development. This gap as illustrated in Figure 2.0 indicates that there is a gap between what the learner cannot do alone and what he can with the aid of more capable people (peers, teachers etc). In the middle circle, representing the zone of proximal development, students cannot complete tasks unaided, but can complete them with guidance from more capable peers. This is the zone where teaching and learning can be successful, because real learning is possible at this point.

Breger (2006) also called this area the "magic middle"; somewhere between what the students already know and what students are not ready to learn. Breger (2006) added that the zone of the proximal development is the teaching space between the boring and the impossible. In this space, scaffolding from the teacher or a peer can support teaching and learning. This reinforces how important social interaction in the classroom is an essential factor in any teaching and learning context.

Vygotsky highlighted the importance of cooperative activities and pointed out that the development of children is promoted by cooperative activities. In Vygosky"s view, cooperative activities among children promotes growth because children of the same age work in one another"s ZPD and model behaviour, which is more effective than children working individually (Slavin, 2011).

## 2.3 Types of Cooperative Learning

According to Johnson, Johnson and Holubec (2008), there are three types of cooperative learning. They are formal, informal and cooperative based groups. Detailed explanations of the types of cooperative learning and guidelines to implement them based on the Johnson, Johnson and Holubec (2008) model are as follows:

### 2.3.1 Formal Cooperative Learning

Formal cooperative learning consists of students working together, for one class period to several weeks, to achieve shared learning goals and complete jointly specific tasks and assignments They are structured through pre-instruction decision, setting the task, and the cooperative structure, monitoring the group while they work, intervening to improve teamwork, evaluating students learning, and processing group functioning.

### 2.3.2 Informal Cooperative Learning

Informal cooperative learning consists of having students work together to achieve a joint learning goal in temporary ad-hoc groups that last from a few minutes to one class period (Johnson & Johnson,2008a). During a lecture, demonstration, or film, informal cooperative learning can be used to focus student‟s attention on the material to be learned, set a mood conducive to learning, help set expectations as to what will be covered in a class session, ensure that students cognitively process and rehearse the material being taught, summarise what was learned and proceed to the next session, and provide closure to an instructional session. The teacher‟s role for using informal cooperative learning to keep students more actively engaged intellectually entails having focused discussions before and after the lesson and interspersing pair discussions throughout the lesson. The one-period long work activity designed for conducting any laboratory work in small groups (usually of 3 to 4 students) is an example of an informal cooperative learning group.

### 2.3.3 Cooperative Base Groups

According to Johnson and Johnson (2008a), cooperative base groups are long-term, heterogeneous cooperative learning groups with stable membership. Members‟ primary responsibilities are to: ensure that all members are making good academic progress (i.e., positive goal interdependence), hold each other accountable for striving to learn (i.e., individual accountability), and provide each other with support, encouragement, and assistance in completing assignments (i.e. promotive interaction). The teacher‟s role in using cooperative base groups is to: form heterogeneous groups of (four or three), schedule a time when they will regularly meet (such as beginning and end of each class session or the beginning and end of each week), create specific agendas with concrete tasks that provide a routine for base groups to follow when they meet, ensure that the five basic elements of effective cooperative groups are implemented, and have students periodically process the effectiveness of their base groups.

## 2.4 Critical Aspects of Effective Cooperative Learning

According to Emerson (2013), the basic considerations for structuring cooperative groups include group size, clear learning goals and direct instruction of group procedures, mixed-ability groupings and individual and group accountability.

### 2.4.1 Group Size

Recommended group size varies from two to four students. If the group size is generally small, engagement levels increases. Groups consisting of three students are often difficult to manage because they leave one student out of the dialogue at any given time (Emerson, 2013).

### 2.4.2 Clear Learning Goals and Direct Instruction of Group Procedures

Teachers who get the best outcome from cooperative learning groups directly teach students how to interact prior to the group leading to their own learning. The assignment of roles within the groups also focuses the students on the specified learning goals.

### 2.4.3 Mixed-ability Groupings

Flexible mixed-ability groups (heterogeneous) have advantages over homogeneously grouped students because the higher achieving students can mentor the students who are struggling with a particular skill or concept (Ncube, 2011). Moreover, the students who are more knowledgeable in specific area or aspect expand their own learning by applying higher level thinking skills while supporting others to accomplish task.

### 2.4.4 Individual and Group Accountability

Students need individual as well as group goals to promote cooperation. The need to feel "We sink together!" and the ability to rely on their peers are essential for student learning. Teachers, and eventually peers, need to provide feedback on progress toward group and individual goals. This gradual release of responsibility leads to more engaged and independent learners

## 2.5 Key to Successful Group Processes in Cooperative Learning

Shimazoe and Aldrich (2010) noted that for effective implementation of group processing in cooperative learning class, three essential stages must be followed. These stages are:

**Stage 1: Design and Development Stage**

Stage one is about design and development. In this stage, goals and rewards for group are established with thorough explanation of processes for positive interdependencies. It has a control group composition with optimal diversity and team size. There is also a development of students" social skills through training before classroom activities actually begin with team-building and ideas of positive role model.

**Stage 2: Operation Stage**

Designing tasks and transparent reward systems forms an essential component of this stage. Teachers start with simple assignments and clarify expected outputs form students. It also includes Monitor group performance through peer evaluations and feedback. The teacher must however intervene quickly when problems arise.

**Stage 3: Output and Disbanding Stage**

Stage three is about providing prompt feedback and takes groups‟ outputs seriously and also discusses students‟ output in class. Maintain consistency in the reward system; satisfy individual as well as collective needs are also important part of the stage three.

## 2.6 Cooperative Learning Structure and Techniques

Learning structures and techniques are available for almost any learning situation. Once the objective of the lesson has been determined, the instructor can select a structure or technique that will provide the optimal learning experience for the students. According to Arra, Antonio and Antonio (2011), cooperative learning techniques that relate to the contemporary study are the three-step interview, roundtable technique, Jigsaw, Jigsaw II and numbered head together. These structures or techniques are explained below.

### 2.6.1 Three-step Interview Structure or Technique

The three pair interview can be used as an introductory activity or as a strategy to explore concepts in depth through students‟ roles (Arra, Antonio & Antonio, 2011). In the three- step interview, students interview each other in pairs, first one way, and then the other. Students each share with the group information they learned in the interview. According to Cooperative Learning Center (2000), three pair interview is best Sharing personal information such as hypotheses, reactions to a poem, and conclusions from a unit.

### 2.6.2 Roundtable Technique

This technique is best for content- related team building activity. In this approach, the instructor poses a problem with many possible answers. Each student, in turn, writes one answer as a paper and a pencil are passed around the group. Finally, the group discusses all the possible answers on the sheet (Arra, Antonio & Antonio, 2011). According to Cooperative Learning Center (2000), this structure or technique is suitable for assessing prior knowledge, practicing skills, recalling information, and creating cooperative art.

### 2.6.3 Jigsaw

In Jigsaw students of an average sized class (26 to 33 students) are divided into competency groups of four to six students to research. Individual members of each group then break off to work with the "experts" from other groups, researching a part of the material being studied, after which they return to their starting group in the role of instructor for their sub-category (Adams, 2013).

Jigsaw is a cooperative learning technique that requires everyone"s cooperative effort to produce the final product. In team Jigsaw, students from temporary mastery teams or exert groups with different learning assignments to master (Shafqat, 2008). According to Cooperative Learning Center (2000), this technique is best for acquisition and presentation of new material, review, informed debate, building social interdependence, and status equalization.

### 2.6.4 Jigsaw II

In Jigsaw II, competition occurs among teams that compete for specific group rewards, which are based on individual"s performance (Shafqat, 2008). Points are earned for the team by each student improving his/her performance relative to his/her performance on previous quizzes.

### 2.6.5 Numbered Heads Together (NHT)

According to Baker (2013), this cooperative learning structure may be a productive starting point for a teacher with little experience using cooperative learning due to its simplicity and versatility. He added that, NHT works as follows:

- Students are assigned to heterogeneous groups of four.
- Each student is assigned a number (1, 2, 3, or 4).
- At various times during a lesson, the teacher poses a question and instructs the students to put their heads together.
- Students spend an allotted amount of time discussing the question and formulating a response.
- The teacher calls a number at random. The student with that number in the group is responsible for his or her group"s response. A volunteer with the number called may answer, all students with the number called may answer in unison, or all students with the number called may write a solution to the question (or problem) on a dry erase board.)

NHT is relatively simple and is also suggested by Kagans as a strategy especially useful for checking students" understanding of lesson objectives (Kagan & Kagan, 2009). They added that NHT creates positive interdependence and individual accountability within groups of four students since each individual student is potentially responsible for the success of his or her group if their number is called.

## 2. 7 Conceptual Framework of the Study

The study was guided by the principles of cooperative learning, that are supported by social learning theory, social interdependence theory and cognitive development theory. Social interdependence exists when individual‟s outcomes are affected by the action of others or a situation where the actions of one student substitute for the actions of another student. Such interaction tends to result in a wide range of learning outcome including source of excitement, motivation, enhanced achievement and retention (Gupta & Pasriga, 2013). Informed by these theories, the interaction of research variables were conceptualised as shown in Figure 2.1.

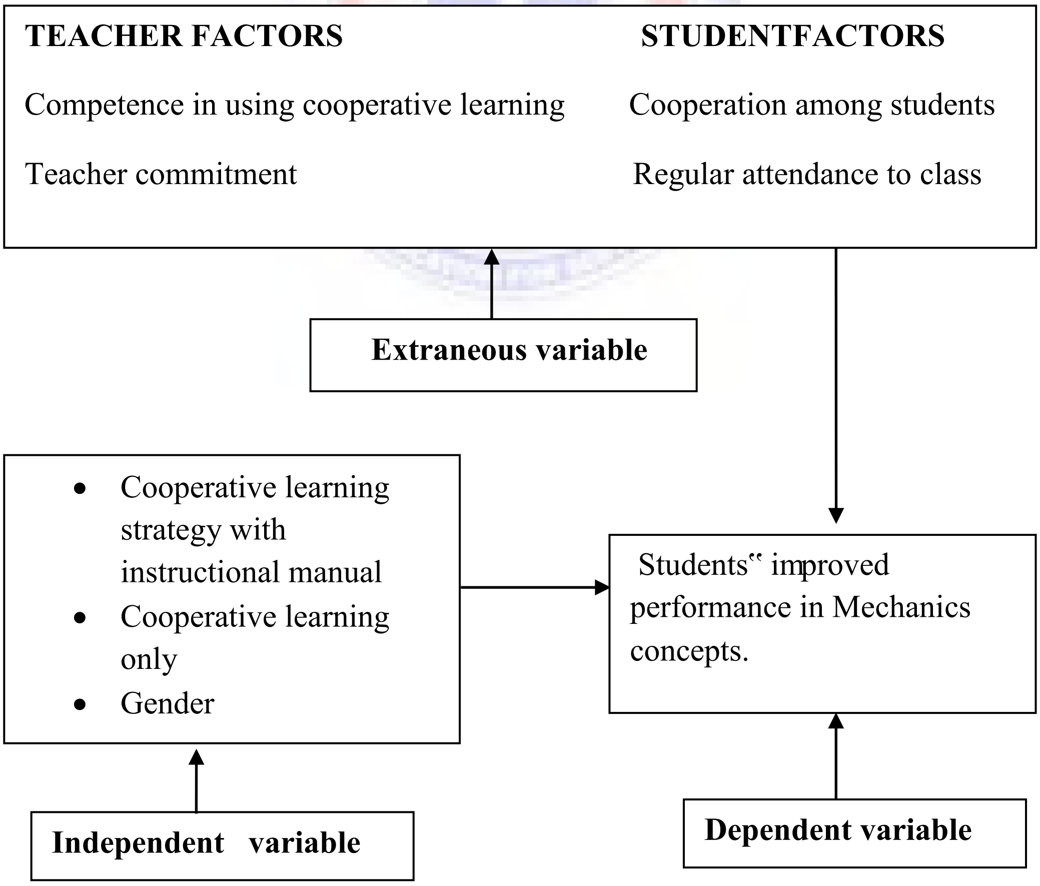


**Figure 2.1: Conceptual Framework of the Study.**

The independent variables were cooperative learning strategy with instructional manual, cooperative learning strategy only and gender. These variables were the factors conceptualised as influencing the dependent variable of the study that is, students" performance in mechanics concept test. The characteristics such as teacher competence in using cooperative learning strategy, teacher commitment and students" characteristics such as cooperation in groups and regular class attendance were the extraneous variables which could influence the teaching and learning process and the performance in mechanics concept as shown in Figure 2.1.

The teacher"s role in Figure2.1 serves as a facilitator. He prepares the instructional design and the instructional content. He also prepares the lesson using the appropriate level of the curriculum content. He also structures the content of the lessons to be learnt and prepares the activities to be undertaken by the learners. The transmission of the content of the lessons to the learners is through instructional strategies designed by the teacher. After designing the strategies, the teacher then implements the strategies and serves as a guide and facilitator in the classroom.

The learners" role in Figure 2.1 is the practice of the learning activities. Students are engaged in the learning activities as structured by the teacher. The practice of cooperative learning is done by the engagement of the students interacting within groups on a task. Group members discuss the task and find solutions to it. Each group does their presentation on the task in the classroom for necessary corrections by the teacher.

## 2.8 Implementation Challenges of Cooperative Learning

The objectives for teaching which employ cooperative learning are not the same as the traditional method of teaching and learning. They are not the same as telling students as much as possible everything they need to know. Incorporating cooperative learning in science classroom is not without challenges. Initially, teachers and students have to face various challenges. Slavin (1995) noted that if activities are not properly constructed, cooperative learning methods can allow "free rider"" effect, in which some group members do all or most of the work ( and learning) while others go alone for the rider. Slavin (1995) added that, the "free rider" effect is most likely to occur when the group has a single task, as when they are asked to hand over a single report, complete a single worksheet, or produce one project as a group. Distribution of responsibility or roles is an additional difficulty. There could be situation where other group members may ignore other students who are perceived to be less skillful or knowledgeable. When each member of the group is made responsible for a unique part of the group"s task, as in the case of Jigsaw, group investigation, and related methods, there is the danger that students may learn a chunk of the task they worked on themselves but not about the rest of the content (Slavin ,1995).

Zakaria and Iksan (2006) also stated that the main problems which arise in using cooperative learning strategies include the following:

- Need to prepare extra materials for class use. The need to prepare materials require a lot of work by the teachers, therefore, it is a burden for them to prepare new materials to cater for all the groups.
- Fear of the loss of content coverage. Cooperative learning methods often take longer time than lectures. Some teachers conclude that it is a waste of time.
- Some teachers do not trust students in acquiring knowledge by themselves. Teachers think they must tell their students what and how to learn. Only the teachers have the knowledge and expertise.

- Lack of familiarity with cooperative learning methods. Cooperative learning is new to some teachers so they need some time to be familiar with the new method. Intensive in-service training can be implemented to overcome the problem.
- Students lack the skills to work in group. Teachers are often concerned with students" participation in group activities. They think that students lack the necessary skills to work in group. To maximise students" participation, teachers should teach the missing skills and/or review and reinforce the skills that students need. Evaluating students" group work can be challenging in the face of students preferences for full control over their individual grade and particularly in the era where institutions heavily rely on individual grading procedures.

However, Pantiz (2003) provided a list of techniques that to some extent address this issue. The techniques are that:

- Teachers should do observations during group work,
- Teachers should use group grading for projects,
- Students grading each other or evaluating the level of contribution made by each member to a team project,
- Teachers should give extra credit when groups exceed their previous average or when individuals within a group exceed their previous performance by a specified amount,
- Teachers should use mastery approach whereby students may retake tests after receiving extra help from their groups or the teacher and
- The use of quizzes, exams, or assignment graded to ensure individual accountability.

## 2.9 Empirical Evidence of Cooperative Learning

In a student-centered instructional approach like cooperative learning, harnessing student ideas means bringing student"s experiences, points of view, feelings, and problems into the lesson by making the student the primary point of reference. A completely student oriented lesson is always initiated by asking students questions and assigning specific roles to them on the content to be taught and their answers and dispositions would become the focus of the lesson (Ajaja & Eravwoke, 2010).Borich (2004) asserted that the surest way to enhance students" interest and to encourage positive attitude and feeling towards the subject is through the use of cooperative learning strategies. Analysis of some of the studies confirms this assertion by Borich (2004).

The impact of cooperative learning on students" academic achievement was investigated by Effandi (2003), cited by Effandi and Zanaton (2006). This study examined how cooperative learning affects students" achievement and problem solving skills. In the study, intact groups compare students" mathematics achievement and problem solving skills. The experimental group was instructed using cooperative learning while the controlled group was instructed using the traditional lecture method. The cooperative learning group instruction showed significant better results in mathematics achievement and problem solving skills. Effandi indicated that, the effect size was moderate and therefore practically meaningful. The study also revealed that, students taught by cooperative learning had favorable response toward group work. Effandi concluded that, utilisation of cooperative learning method is a preferable alternative to traditional instruction.

Schwarz, Neuman and Biezuner (2000) presented a classroom study showing that two students working together can make learning gains even though both students entered the peer learning situation with low levels of competence. Schwarz et al. (2000) further indicated that, the thrust of the research on peer learning shows that when peers engage in dialogues and discussions (even arguments) that are relevant to both the task at hand and to initial misconceptions, cognitive gains can result from the peer interactions.

Also a study was conducted by Ajaja and Eravwoke (2010) to test the effect of cooperative learning on students" performance. They reported that there was a significant higher achievement test scores of students in cooperative learning group than those in traditional classroom; a significant higher attitude scores of students in cooperative learning group than those in traditional classroom; a significant higher achievement test scores of all students of varying abilities in cooperative group than those in traditional classroom; a non-significant difference in achievement test scores between the male and female students in the cooperative learning group and non–significant interaction effect between sex and ability, sex and method, ability and method and among method, sex and ability on achievement. Igboanugo (2013) also revealed positive attributes of cooperative interaction among students as follows: more students learn more materials when they work together cooperatively; more students are motivated to learn the material when they work together cooperatively than when they compete with one another, and also, students develop more positive attitudes to science when they work together cooperatively than when they work alone.

Research on cooperative learning conducted by Johnson, Johnson and Stanne (2000) also indicated that individual student"s performance was better when cooperative methods were used as against competitive or individualistic methods. The variables measured include knowledge acquisition, retention, accuracy, creativity in problem solving, and higher-level reasoning. They added that students taught cooperatively viewed the team work as a positive force in their learning, and they also valued the interactions for promoting a sense of community in the classroom.

Felder and Brent (2007) also indicated that cooperative learning is superior for promoting metacognitive thought, persistence in working toward a goal, transfer of learning from one setting to another, time on task, and intrinsic motivation. They concluded that students who score in the 50$^{th}$ percentile when learning competitively would score in the 69$^{th}$ percentile when taught cooperatively. Affective outcomes were also improved by the use of cooperative learning. Relative to students involved in individual or competitive learning environments, cooperatively taught students exhibited better social skills and higher self-esteem.

In the study conducted by Johnson and Johnson (2013), they found out that sample engaged in cooperatively spent considerably more time on task than did competitors (effect size = 0.76) or students working individualistically (effect size = 1.17).In addition, they indicated that students working cooperatively tended to be more involved in activities and tasks, attach greater importance to success, and engage in more on-task behaviour and less apathetic, off-task, disruptive behaivour. They added that cooperative experiences, compared with competitive and individualistic ones, have been found to promote more positive attitudes toward the task and the experience of working on the task (effect-sizes = 0.57 and 0.4 respectively).

Also a meta-analysis of the effects of face-to face cooperative learning conducted by Kyndt, Raes, Cascallar, Timmers and Dochy (2013) reported that effect size of cooperative learning strategy on achievement; attitudes and perception were 0.54, 0.15 and 0.18 respectively. Caper and Terim (2015) also compiled experimental studies from 1988 to 2010 to examine the influence of cooperative learning method as compared with that of traditional methods on mathematics achievement. A total of 26 studies (n=36) were considered in their meta-analysis. The effect size for cooperative learning on academic achievement was found to be *d*= 0.59 (95% CL: Between 0.38 and 0.80).

Ho and Boo (2007) in their study to explore the effectiveness of cooperative learning in physics classroom, concluded that in spite of the limitations of their study, cooperative learning does increase students' academic achievement, helps students to achieve a better understanding of physics concepts and increases students' motivation to learn. They added that both the teacher and students gained much from this study. The significance of these findings is that a student engaged in cooperative learning promotes more insight into content matter and use of higher-level cognitive and moral reasoning strategies than competitive or individualistic methods. Cooperation among students also tends to promote more accurate perspective thinking than do competitive or individualistic efforts.

Zakaria, Chin and Daud (2010) also conducted a study on effect of cooperative learning on students‟ achievement. The purpose of their study was to determine the effects of cooperative learning on students‟ mathematics achievement in secondary school students in Pekanbaru, Indonesia. The results showed that there was a significant difference of mean in students‟ mathematics achievement between the cooperative group and the traditional group. Content analysis data revealed that students in the cooperative group were able to increase their understanding and to develop their self-confidence (Zakaria et al. 2010).

Also, the study conducted in Nigeria by Akinbobola (2009) showed that cooperative learning strategy is more powerful in enhancing students‟ attitude towards physics than competitive and individualistic learning strategies. He concluded that, utilization of cooperative learning will enable the students to understand, enjoy and create more positive attitude towards physics, so that teaching it becomes more rewarding to teachers. He concluded that, cooperative learning does not discriminate against sexes.

## 2.10 Instructional Manual and its' Importance

It is a book or booklet of instructions, designed to improve the quality of a performed task. An instructional manual (also called course manual) may form an important part of a formal training or learning in the classroom. For example, it may help ensure consistency in presentation and the delivery of content. It may also ensure that all training information on skills, processes, and other information necessary to perform tasks are together in one place. According to Amedeker and Taale (2011) course manual helps students to approach their learning with the appropriate strategies, give students resources or materials that will help them prepare well ahead of lessons, challenge students to improve their ability to research for information, and to think critically.

## 2.11 Summary of Literature Review

The literature search showed that, cooperative learning strategy as teaching strategy has its roots in the creation of social interdependence, cognitive-developmental, behavioral learning theories, social learning theory, and constructivist learning theory (Dat-Tran, 2013). The scientific literature that has been reviewed also pointed out that, cooperative learning defies a single definition (Felder & Brent, 2007; Abass 2008; Arra, Antonio, & Antonio 2011). However, the literature showed that, the lesson will not be cooperative structured if students do not "swim together" in the group during the learning processes and activities (Johnson & Johnson, 2008a). Notwithstanding, the search pointed out that, positive interdependence, individual accountability, promotive interaction, the appropriate use of social skills, and group processing are the key elements of cooperative learning. In the context of research focus, the discussions have indicated that cooperative learning improves students" performance, persistence in working towards a goal, enhances transfer of learnt materials, higher self-esteem, better social skills and metacognitive thought (Johnson, Johnson & Stanne, 2000 ; Felder & Brent, 2007; Johnson & Johnson, 2013).

The search also pointed out that, implementation of cooperative learning in the classroom is not without challenges. Some of the challenges the search highlighted are the need to prepare extra materials for class use, teacher"s fear of the loss of content coverage, and some teachers do not trust students in acquiring knowledge by themselves. Moreover, the search also pointed out that, some teachers lack the knowledge and skills to use cooperative learning (Zakaria & Iksan, 2006). The search also pointed out that instructional manual or course manual helps students approach their learning with the appropriate strategies, give students resources or materials that will help them prepare well ahead of lessons, challenge students to improve your ability to research for information, and to think critically (Amedeker & Taale, 2011.)

# CHAPTER THERE

# METHODOLOGY

## 3.0 Overview

This chapter describes the study area of the research. It also describes the research design which is quasi-experimental approach to collect data for the study. The chapter further outlines population, participants, sample and sampling techniques used to select the sample size for the study.

This chapter also gives detailed description of research instruments used to collect data for the study. Validity and reliability of the research instruments are also discussed in this chapter. The chapter ends with data collection procedure and how the data generated was analysed.

## 3.1 Study Area

The pilot-test and the main study were conducted in Berekum Municipality. Geographically, Berekum Municipality can be located in the Brong Ahafo Region. It lies between latitude 7‟15‟ South and 8.00‟ North and longitudes 2‟25‟ West. The Municipality shares boundaries with Tain District and Jaman District to the Northeast and Northwest respectively, Dormaa East District to the South and Sunyani West District to the East. Berekum, the Municipal capital, is 32km North West of Sunyani which is the regional capital and 437 km from Accra, the national capital respectively. Its total area constitutes about 0.7 percent of the entire 233,588km$^2$ of Ghana, (1,635km$^2$) (Berekum Municipal Assembly, 2006).

The main occupation of the inhabitants is farming. The Municipality is also relatively closer to Cote d‟ Ivoire and it promotes economic and commercial activities between the Municipality and Cote d‟ Ivoire (Berekum Municipal Assembly, 2006). The Municipality has four public SHS and two private SHS. It also has about seventy-three (73) JHS comprising both public and private JHS.

### 3.2 Research Design

A research design may be considered as an arrangement or outline that specifies how data relating to a given problem should be collected and analysed. There by giving comprehensive steps in the study and providing guideline for an organised data collection. Burns and Grove (2003) define a research design as a blueprint for conducting a study with maximum control over factors that may interfere with the validity of the findings. Amedahe (2002) noted that in every research study, the choice of a particular research design must be appropriate to the subject under investigation, and that the various designs in research have specific advantages and disadvantages.

Like randomised experiment, quasi-experiments aim to demonstrate causality between an intervention and outcome. Quasi-experimental usually tests the causal consequences of long-lasting treatments outside of the laboratory. But unlike "true" experiments where treatment assignment is at random, assignment in quasi-experiments is by self-selection or administrator judgment (Cook, 2015). Quasi-experimental research designs include, but are not limited to the one group posttest only design; the one- group pretest posttest design; the removed treatment design; the case-control design; the non-equivalent control group design; the interrupted time-series design and the regression discontinuity design (Shadish, Cook & Campbell, 2002).

According to Harris, Bradham, Baumgarten, Zuckerman, Fink, and Perencevich (2004), quasi-experimental studies encompass a broad range of non-randomised intervention studies. They further noted that these designs are frequently used when it is not logistically feasible or not ethical to conduct a randomised, controlled trail; the "golden standard" of causal research design.

This study employed quasi-experimental, non-randomised pretest-intervention-posttest study design with two equivalent intact classes using formal cooperative learning. This design was used because of the following reasons. This design was appropriate because students prior to the study had some knowledge about the aspect of the mechanics concepts to be treated in the study. This was realised during the pilot-testing of the research instrument. Hence the pretest was used to assess this prior knowledge.

The choice of quasi-experimental design was also informed by the facts that at the S.H.S. level students are put into specific classes to do specific programmes. Hence intact classes were used in order not to disorganise classes assigned to students through randomisation of students for this research. Another reason to use quasi-experimental design with pretest and posttest was that quasi-experimental designs seek to demonstrate causality between an intervention and outcome (Cook, 2015). Hence analyses and comparisons of results of pretest and posttest established the causality among instructional manual, cooperative learning strategy, students" performance in M.C.T. and gender differences in performance in the experimental group.

The quasi-experimental design divided the sample into two instructional groups where group one instructed using cooperative learning only (C.L.O.) and the other group using cooperative learning with instructional manual (C.L.W.I.M.). The utilisation of cooperative learning served as a fixed or constant study variable within the two groups. The main independent variables were cooperative learning strategies, instructional manual and gender. However, the dependent variable was students‟ performance in M.C.T.

## 3.3 Population

Population is the entire aggregation of cases that meet a designated set of criteria. Population always comprises the entire aggregation of elements in which the researcher is interested. According to Creswell (2008), a population is a group of individual or objects who have the same characteristics. Population can be small or large and a researcher needs to decide what group the researcher would like to study. Basically, the larger group is the target population and the smaller group is the accessible population. The target population is the aggregate of cases or elements about which the researcher would like to make generalisation.

According to Creswell (2008), a target population is a group of individual with some common defining characteristic that the researcher can identify and study. He added that within the target population, researchers then select a sample for the study. The accessible population is the aggregate of cases or elements that conform to the designated criteria that are accessible to the researcher as a pool of subjects or participants for the study. The accessible population is the group that a researcher actually can measure. Because of time and budgetary constraints, for example, often limit the number of subjects or participants a researcher can study, making the experimentally accessible population much smaller than the target population. Moreover, physical limitations also often compel a researcher to study groups that are smaller than the target population. For example, interviewing every subject or participant spread across a large area often not feasible; hence a researcher must select a smaller group for study.

The target population for the study comprised all the Science and Technical students in the Berekum Municipality in Brong Ahafo Region. The accessible population for the study however, comprised of Berekum SHS and Biadan Methodist Secondary and Technical schools, both located in the Berekum Municipality. The two schools included in the study were chosen based on their performance in the WASSCE; the willingness of the heads of the schools and elective physics teachers to participate in the study; the proximity of the schools to the Researcher and last but not least, the students" of the two schools had fair idea of the mechanics concepts prior to the study.

### 3. 4 Participants

A total of 93 students which comprised male and female 2nd year Science and Technical students of Berekum SHS and Baidan Methodist S.H.S, all in Berekum Municipality. The subjects or participants were between 15 to 20 years old and were composed into two groups. The first group of 48 students was the experimental group whereas the second group of 45 students was the control group. Participants in the study were all of similar educational background as they had all passed the Basic Education Certificate Examination (BECE) at the Junior High School (JHS) level. Also, they had some basic knowledge of the concepts of the mechanics topics considered as they had been introduced to it at SHS one.

### 3. 5 Sample and Sampling Technique

According to Kothari (2004), a sample consists of a carefully selected subset of the units that comprise the population. In most cases researchers opt for an incomplete coverage and study only a small proportion of the population (Asamoah-Gyima & Doudu, 2007). This proportion of the population is the sample. According to Creswell (2008), a sample must be a true representation of the population from which it was selected or a subgroup of the target population that the researcher plans to study for generalising about the target population.

The process of selecting the sample is called sampling. There are two sampling strategies that are used in educational research which are probability and non-probability samples (Cohen, Manion& Morrison, 2008). Cohen et al. (2008) are of the opinion that probability sampling is useful if the researcher wishes to make generalisation, because it seeks representativeness of the wider population. They also added that probability sampling is used when two-tailed tests are to be administered in statistical analysis of quantitative data. In non-probability sampling, elements or subjects are selected by non-random methods. Usually, not every element or subject in the population has a chance of being selected. This method is less strict and makes no claim for representativeness.

According to Cohen et al. (2008), there are many types of non-probability sampling. These are the convenience sampling, quota sampling, and dimensional sampling, snowballing sampling, volunteer sampling, theoretical sampling, and purposive sampling. They added that purposive sampling is often a feature of qualitative research, in which the researchers handpick the cases to be included in the sample on the basis of their judgment of their typicality or possession of the particular characteristics being sought.

This study employed purposive sampling for the selection of the classes for the study. The samples for the study were two intact classes of second year students of Berekum SHS (control group) and Biadan Methodist SHS (experimental group), all in Berekum Municipality, in the Brong Ahafo Region. Second years students were purposively selected for the study because mechanics concepts considered are taught during the second year of the SHS science programme as it forms part of the SHS 2 elective physics syllabus.

The total sample size for study was 93 (ninety three) students. The cooperative learning strategy with instructional manual group (C.L. S.W.I.M) or the experimental group, was made up of forty eighty (48) students. Out of the forty eighty (48) students, twelve (12) were girls and remaining thirty six (36) were males. The cooperative learning strategy only (C.L.S.O) group was also made up of forty five (45). Thirty four (34) of these students were males while eleven (11) students were females. Within the C.L. S.W.I.M. (i.e. experimental group), 12 small mixed ability and heterogeneous (i.e. male and female) grouping were formed. There were four (4) members in each small group formed. These groups were maintained throughout the seven weeks of the treatment period. They were instructed using cooperative learning strategies coupled with instructional manual.

Within the C.L.S.O (i.e. control group), 11 small mixed ability and heterogeneous groups were formed. There were four (4) members with exception of only one of the groups in the control group which had five members and these were also maintained throughout the treatment period. In each group (control and experimental), simple random method was used in signing males to groups. However, for the purpose of heterogeneity, the females were ceded to make sure each group had a female.

### 3.6 Research Instruments

Research instruments are tools used to collect data to answer the research questions. There are various procedures of data collection. According to Zohrabi (2013), some of them are questionnaire, interview, classroom observation and test.

For the purpose and direction of this research, two research instruments were used to collect data for study. The two instruments used were instructional manual and Mechanics concept test (MCT.) These instruments were prepared by the Researcher and were field or pilot-tested to assess the reliability and validity of the instruments.

#### 3.6.1 Instructional Manual

This self-prepared instructional manual was useful interventional instrument in the research data collection. For example, the instructional manual ensured consistency in presentation and the delivery of teaching and learning process in the experimental group. It also ensured that all instructional information on skills, processes, and other information (like reference books) necessary to perform tasks were together on one place for the students. The instructional manual guided the students about what to do before and after every lesson. It consisted of seven weekly activities designed to take participants through in the intervention phase of the research. See Appendix A for the instructional manual.

### 3.6.2. Mechanics Concept Test (MCT)

The MCT was a self-constructed test instrument. The MCT comprised three main topics in mechanics. These are the circular motion, oscillatory motion and gravitational force. Similar set of questions was used as pretest and posttest. The pretest was used to assess students‟ prior knowledge concerning those mechanics concepts under consideration. The posttest was also used to collect data for the study to measure the effectiveness of the instructional manual and cooperative learning strategies variables for the study.

The questions were made up of two parts. The first part consisted of the students‟ bio-data such as students‟ school, age, class of participant, and gender. The second part provided the general information on both section A and section B. The test consisted of 20 items. The mechanics concept test was made up of 18 multiple-choice and two theory questions. See Appendix B for the MCT. Table 3.0 shows the structure of the MCT.

**Table 3.0: Mechanics Concept Test (MCT) Content and Question Selection.**

| Concept | Question(s) |
|---|---|
| **A. Circular motion** | |
| Angular velocity | (17), 1a, 1d |
| Linear velocity | 2a (i) |
| Centripetal force | 2, 3, 14 |
| Banking of roads | 12, (2b) |
| Relationship between ***v, r, w*** | 7, 1c |
| Relationship between **a, r, w** | 9 |
| Maximum acceleration | (5) |
| **B. Oscillatory motion** | |
| Simple pendulum | 1, 8, (13) |
| Period of oscillation | 10, 11, 1b, 2a (ii) |
| **C. Gravitational force** | |
| Newton law of gravitation | 4, 11, 16 |
| Escape velocity | 6 |
| Geostationary Satellites | 15 |

****v= Linear velocity, r = radius, a = linear acceleration and w = angular velocity***

***# Parenthesis means that other components are significantly involved in the Question***

### 3.7 Validity of the Instrument

According to Patton (2005), validity of a research instrument is how well it measures what it is intended to measure. Bell (2004) also argued that validity of any instrument is important because it determines whether an item measures or describes what is intended to measure or describe.

The self-designed MCT was given to some experienced physics teachers for their comments and suggestions. The purpose of this was to assess each item"s content validity, accuracy and format. After this, the self-designed test items were pilot- tested in mini study.

### 3.8 Reliability of the Instruments

Joppe (2000) defined reliability as the extent to which results are consistent over time. It implies that if the results of a study can be reproduced under a similar methodology, then the research instrument of the study can be considered as being reliable. Reliability concerns with the degree to which an experiment, test or any measuring procedure yields the same results on repeated trials (Patton, 2007). To determine the reliability of the instruments for the study, the test items were field pilot-tested at Berekum Presbyterian Senior High located in the same study area with fifteen (15) students. The reliability analysis of the instruments was performed statistically and Cronbach alpha coefficient of 0.75 was obtained. The Cronbach alpha coefficient of 0.75 was higher than the 0.70 that is generally accepted in social science research. This means that the coefficient level was higher for the instrument to be used. For that reason internal consistency of the instruments was thus reliable.

## 3.9 Data Collection Procedure

### Phase 1: Pre-Intervention phase

Formal permission was sought from the Headmasters of the two schools selected for the study (See Appendix C). The Physics teachers in these schools were also duly notified. The pilot-study or the mini study was conducted at Berekum Presbyterian SHS which is located within the study area. Fifteen (15) students were used in the pilot-study or the mini study. It was very useful because it helped in the adjustment of some items in research instruments to make it more effective.

In order to ensure the effective use of cooperative learning, and instructional manual among students, the researcher explained why he wanted to use cooperative learning and instructional manual in teaching mechanics and described the benefits to the students. To facilitate this explanation, the researcher distributed papers that described cooperative learning skills needed for effective cooperation. The researcher also took students through the instructional manual and how it would be used and the benefits they would derive from the usage of the instructional manual.

The next stage of the pre-interventions phase was the formation of heterogeneous cooperative base groups. Groups were formed by putting students together to share common strengths and interests. Once the groups were formed, students were given one week to go through the instructional manual and locate the reference books stated in the instructional manual. The researcher also made photocopies of portions of books stated in the reference section on the instructional manual which were not in the libraries to the groups. The last stage of the pre-intervention was administering the pre-intervention test.

**Phase 2: Intervention Phase**

After all the preparations, it was time to apply the intervention. Throughout the intervention phase for both experimental and control groups, the students played active role. Some of their roles at this point were for them to work together or cooperative with each other through listening to one another, questioning one another, keeping records of their work and the progress, as well as assuming personal responsibility of being involved in the group.

The two groups were taught by the Researcher for the seven weeks of the interventional phase. To ensure uniformity in the teaching and learning process, the Researcher used same teaching notes, same exercises and assignments for the two groups.

The steps involved in the intervention phase of the experimental group (CLWIM) are shown in Table 3.1.

**Table 3.1 Intervention Phase Processes for the Experimental Group**

| PHASE | TEACHER / STUDENTS ACTIVITIES |
|---|---|
| **Phase-1**<br>Teacher clarified goals and motivated students | Teacher went over goals for the lesson and established learning set |
| **Phase-2**<br>Teacher presented information and/or materials | Teacher presented lesson in the form of lecture, illustrations , and discussion on each week"s activities reflecting on the instructional manual and the lesson notes |
| **Phase – 3**<br>Assessment | Teacher gave end of lesson quizzes/ assignments and exercises after every lesson to the groups |
| **Phase – 4**<br>Supervision | Teacher supervised students to answer the questions. |
| **Phase – 5**<br>Evaluation | Teacher assessed each member"s performance, marked and graded and did corrections with students. |
| **Phase – 6**<br>Conclusion | 1. Teacher concluded the lesson by summing up the main points using N.H.T. cooperative learning technique.<br>2. Teacher directed students to follow the instructional manual for the next lesson. |

The steps involved in the intervention phase of the control group (CLO) are shown in the Table 3.2.

**Table 3.2: Intervention Phase Processes for the Control Group (CLO)**

| PHASE | TEACHER / STUDENTS ACTIVITIES |
|---|---|
| **Phase-1**<br>Teacher clarified goals | Teacher went over goals for the lesson and established learning set |
| **Phase-2**<br>Teacher presented information and/or materials | Teacher presented lesson in the form of lecture, illustrations, and discussion on each week‟s activities reflecting the teaching notes. |
| **Phase – 3**<br>Evaluation/ assessment | Teacher gave end of lesson quizzes/ assignments and exercises after every lesson to the groups. |
| **Phase-4**<br>Supervision | The teacher supervised students to answer the questions. |
| **Phase – 5**<br>Evaluation/ assessment | Teacher assessed each member‟s performance. marked, graded and did correction with students |
| **Phase – 6**<br>Conclusion | Teacher concluded the lesson by summing up the main points using N.H.T. cooperative learning technique |

**Phase 3: Post- Intervention Phase**

The seventh or the last week was used for the administration of the post-intervention test. During this phase, the researcher with the help of the Physics teachers in the selected schools administered the post-intervention test to both the experimental and the control groups. The Researcher marked and scored the students scripts. Progress in the students‟ lesson was observed and monitored.

### 3.10. Data Analysis Procedure

The study was quasi-experimental with quantitative approach. The data, source, and instruments of the study is presented in Table 3.3

**Table 3.3: Matrix of Data Source and Instrumentation**

| Type of data | Data source | Instrument |
|---|---|---|
| Students‟ performance | Pretest and post-test results of the two groups | M.C.T |

Data analysis was carried out step by step from the beginning of the study to the end of the study. The collected data was then analysed quantitatively. The results from the MCT were analysed using S.P.S.S., version 16.0 for Windows and Microsoft Excel. According to Awanta and Asiedu-Addo (2008), the statistical Package for Social Science (S.P.S.S.) is by far one of the best known and widely used software for the statistical analysis of social data in educational research. Descriptive statistics, *t*- test and Cronbach‟s reliability test were conducted on the data. Descriptive statistics such as mean, standard deviation, percentages and graphical representation were carried out to measure the effect of cooperative learning strategies and instructional manual on the two groups.

T-test was used to explore the statistically differences between the performances of the two groups prior to study. The accepted $p<.05$ level of probability was used as the basis to report whether significant differences between the performances of students in the two groups existed after exposure to the cooperative learning and instructional manual as well as any gender differences in the experimental group.

Effect size analysis was also used to investigate how the two different types of teaching strategies affected students" performances on mechanics concepts. According to the definition of Cohen (1988), as cited by Kai-Ti and Tzu-Hua (2012), Cohen"s *d* less than 0.2 means „small" effect size, between 0.2 and 0.5 means „small to middle" effect size, between 0.5 and 0.8 means „middle to large" effect size, while larger than 0.8 means „larger" effect size. Appendix D shows how the treatment effect of the instructional manual was measured.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

## 4.0 Overview

This chapter presents the demographic characteristics of the respondents, results and findings of the study. The results are presented based on the research questions and research hypotheses. The information collected during the research interventions have been analysed in terms of descriptive and inferential statistics. Statistical analysis was carried out using S.P.S.S (Statistical Package for Social Science), version 16 for Windows and also Microsoft Excel. A number of tables have been constructed for easy presentation of data. T-test assuming equal variances was used for testing the hypotheses at 0.05% level of significance. The results are presented based on the following research questions:

1. What is the effect of the use of cooperative learning strategy only on students‟ performance in mechanics concepts?
2. What is the effect of the use of cooperative learning strategy with instructional manual on students‟ performance in mechanics concepts?
3. What is the difference in the performance of students instructed using cooperative learning strategy only and cooperative learning strategy with instructional manual?

## 4.1 Demographic Characteristics of Students

This section discussed the demographic characteristics of the respondents. The parameters discussed included group equivalence analysis before intervention, age, and gender of students.

### 4.1.1 Groups Entry Characteristic Analysis

The experimental group (N=48) and control group (N= 45) were constituted from two equivalent intact classes in accordance to pre-test results of the students. T-test was used to determine whether there is a significant difference between the experimental and control groups prior to the introduction of the intervention. The results of the entry characteristics test (See Appendix E) of the groups are presented in Table 4.0.

**Table 4.0: Entry Characteristics on Performance for the Groups**

| Groups | *N* | *Mean* | *SD* | *t-value* | *p-value* |
|---|---|---|---|---|---|
| **Experimental** | 48 | 4.46 | 1.30 | 0.22 | 0.82* |
| **Control** | 45 | 4.40 | 1.19 | | |

*not significant, p> .05

In table 4.0, the mean and standard deviation scores of the experimental group were determined as 4.46 and 1.30 respectively in entry characteristics test conducted before the intervention. In the control group, the mean and standard deviation scores were determined as 4.40 and 1.19 respectively in the same entry characteristics test conducted before intervention. No statistically significant difference [t (91) =0.22, p=0.82, p>0.05)] was observed in the independent-samples t-test conducted on performance in baseline test conducted for the two groups before the intervention.

According to this result, the mean score of the experimental group is almost within the same standard deviation range as the mean score of the control group. This indicates that both the experimental and control groups were equivalent in performance standard before the intervention. Hence any change in groups‟ performance in MCT after the intervention may be attributed to the intervention used.

### 4.1.2 Gender and Age Distribution of Respondents

It is observed from Table 4.1 that the respondents have a higher male population than female population. Out of a total number of ninety-three (93) respondents, 70 (75.27%) were males while their female counterparts were 23 (24.73%).

**Table 4.1: Gender Distribution of Respondents**

| | Variable | Frequency | Percentage |
|---|---|---|---|
| **Sex** | Male | 70 | 75.27% |
| | Female | 23 | 24.73 |
| | **Total** | **93** | **100.00%** |
| **Groups** | Experimental | 48 | 51.61% |
| | Control | 45 | 48.39% |
| | **Total** | **93** | **100.00%** |

Table 4.2 shows the descriptive statistics of age of students for the experimental group and control group. The age for the experimental group ranged from 15 to 20 (M= 16.98, SD = 1.48). However, the age for the control group ranged from 16 to 20 (M= 17.13, SD= 1.54). The analysis showed that the highest mean age was observed in the control group.

**Table 4.2: Age of Respondents**

| Group | *Min. Age* | *Max. Age* | *Mean Age* |
|---|---|---|---|
| **Experimental** | 15 | 20 | 16.98(1.48) |
| **Control** | 16 | 20 | 17.13(1.54) |

*standard deviation in parenthesis

**Results**

As already indicated, the results and analysis of the data collected were done along the research questions.

**Analysis with Respect to Research Question One**

**RQ 1:** *What is the effect of the use of cooperative learning strategy only on students?' performance in mechanics concepts?*

The effect of cooperative learning on students" performance in mechanics concepts were determined using descriptive statistics of the pretest and posttest scores of the control groups performance in the M.C.T. Table 4.3 shows the mean, standard deviation and mean gain for control group in the M.C.T. conducted before and after the introduction of the intervention.

**Table 4.3: Pretest and Posttest Mean Scores for the Control Group**

| Group | N | Pretest Mean | Posttest Mean | Mean Gain |
|---|---|---|---|---|
| **Control** | 45 | 22.87(6.75) | 26.84(5.59) | 3.97 |

*standard deviation in parenthesis

Table 4.3 shows that control group had pretest and posttest mean scores of 22.87 (SD = 6.75) and 26.84 (SD = 5.59) respectively after exposed to cooperative learning strategy only. Table 4.3 also shows performance mean gain of 3.97 after using cooperative learning strategy only to teach the control group. Achieving a group average of 26.84 in the post-intervention test compared with 22.78 in the pre-intervention test confirms a clear improvement in the control group. Also smaller standard deviation (SD =5.59) in the post-intervention test compared with standard deviation (SD = 6.75) in the pre-intervention test shows smaller variability in the scores of the individual students in the control performance in the MCT. Therefore by these results cooperative learning strategy only had real positive effect on the students" performance in the mechanics concepts.

**Analysis with Respect to Research Question Two**

**RQ 2:** *What is the effect of the use of cooperative learning strategy with instructional manual on students' performance in mechanics concepts?*

The effect of cooperative learning strategy on students" performance in mechanics concepts were determined using descriptive statistics of the pretest and posttest scores of the experimental groups. Table 4.4 shows the mean, standard deviation and mean gain of the experimental group in the MCT conducted before and after the introduction of the interventions (i.e. cooperative learning and instructional manual).

**Table 4.4: Pretest and Posttest Mean Scores for Experimental Group.**

| Group | N | Pretest Mean | Posttest Mean | Mean Gain |
|---|---|---|---|---|
| **Experimental** | 48 | 22.97(6.66) | 30.17(6.81) | 7.20 |

*standard deviation in parenthesis

Table 4.4 shows that experimental group had pretest and posttest means scores of 22.97 (SD = 6.66) and 30.17 (SD = 6.81) respectively after exposed to cooperative learning strategy through instructional manual. Table 4.4 also shows performance mean gain of 7.20 after using cooperative learning strategies with instructional to teach the experimental group. Achieving a group average of 30.17 in the post-intervention test compared with 22.97 in the pre-intervention test confirms a clear improvement in the experimental group performance after using cooperative learning through instructional manual. However, relative bigger standard deviation (SD =

6.81) in the post-intervention test compared with standard deviation (SD = 6.66) shows relatively bigger variability in the scores of the individual students in the experimental group performance in the MCT after using cooperative learning strategy with instructional manual.

**Analysis with Respect to Research Question Three**

**RQ 3:** *What is the difference in the performance of students instructed using cooperative learning strategy only and cooperative learning strategy with instructional manual?*

To find out the difference in the performance of students taught using cooperative learning strategy only and students taught using cooperative learning through instructional manual, descriptive statistics were computed and used to determine the difference in the performance between the control group and the experimental group. Table 4.5 shows the mean, standard deviation, mean gains and mean difference of control group and the experimental group in the MCT conducted before and after the introduction of the interventions.

**Table 4.5: Pretest and Posttest Mean Scores for the Two Groups**

| Groups | N | Pretest Mean | Posttest Mean | Mean Gain |
|---|---|---|---|---|
| **Experimental** | 48 | 22.97(6.66) | 30.17(6.18) | 7.20 |
| **Control** | 45 | 22.87(6.75) | 26.84(5.59) | 3.97 |
| **Mean difference** | | 0.1 | 3.33 | |

*standard deviation in parenthesis

Table 4.5shows that the experimental group pretest and posttest mean scores were 22.97 (SD = 6.66) and 30.17 (SD = 6.81) respectively. Also, the control group had pretest and posttest scores of 22.87 (SD = 6.75) and 26.84 (SD = 5.59) respectively. The mean gain for the experimental group was 7.20 whereas the mean gain for the control group was 3.97. These results as presented in the Table 4.5 revealed that students taught using cooperative learning strategy with instructional manual performed better in the mechanics concepts test than those taught using only cooperative strategy only.

To estimate the extent of difference between the two groups an effect size analysis was carried out using Cohen‟s (*d*) index. This involves comparing the mean scores of the two groups and dividing them by the standard deviation. Depending on the statistical figures available, researchers could choose from a number of several formulae for estimation of effect size. Appropriate for this study is the one indicated in Appendix F. The results of *d*are presented in the Table 4.6.

**Table 4.6**: **Magnitude of Effect for the Treatments**

| Group | Posttest Mean($M_2$) | Pretest Mean($M_1$) | Mean Diff. ($M_2$-$M_1$) | *d* |
|---|---|---|---|---|
| **Experimental** | 30.17(6.81) | 22.97(6.66) | 7.2 | 1.07 |
| **Control** | 26.84(5.59) | 22.89(6.75) | 3.97 | 0.64 |

*standard deviation in parenthesis

From Table 4.6, the effect size of the experimental group was 1.07. This represents large effect size comparing to Cohen‟s *d* indexes in Appendix E. Also, effect size estimated for the control group was 0.64. This also represents medium effect size comparing.

According to Magnusson (2014), Cohen"s *d* of 1.1 means 86% of the treatment group will be above the mean score of the control group, 58% of the two groups will overlap and there is a 78% chance that a person picked at random from the treatment group will have higher score than a person picked at random from the control group.

Using Magnusson"s interpretation, 1.07 Cohen *d* obtained for the C.L.S.W.I.M. means that, about 86% of the students taught using C.L.W.I.M. mean score will be above student taught using C.L.S.O. Moreover, there is about 78% chance that a student picked at random from the C.L.S.W.I. group will have higher score than a student picked at random from the C.L.S.O group. The results indicate that, using cooperative learning strategies through instructional manual (d=1.07) has greater effect on students" performance as compared to using cooperative learning strategies only (d=0.64). This signifies that there is a substantial difference in the two methods of teaching.

**Testing of Hypothesis with Respect to Research Question Three**

To determine whether the difference in the performance between the experimental group and the control group were statistically significant, research question three was formulated into a null hypothesis and tested. It was hypothesised that:

**$H_{01}$:** *There is no significant difference in the performance between students instructed using cooperative learning strategy only and those instructed using cooperative learning strategy with instructional manual*

To test this hypothesis, an independent sample *t*-test was performed and the results are presented in Table 4.7.

**Table 4.7 Inferential Statistics for Groups Mean Score Difference for the Posttest**

| Groups | N | Mean | SD | t-value | p-value |
|---|---|---|---|---|---|
| **Experimental** | 48 | 30.17 | 6.81 | 2.54 | 0.012* |
| **Control** | 45 | 26.84 | 5.59 | | |

*significant, p<.05

The results showed that there is significant difference between the post-intervention test scores of students instructed using cooperative learning strategy with instructional manual (M=30.17, SD= 6.81) and those instructed using cooperative learning strategy only (M= 26.84, SD= 5.59). [t= (91) 2.54, p= .012]. Hence the null hypothesis was rejected.

## 4.2 Discussion of Findings

**Research Question 1:**

*What is the effect of the use of cooperative learning strategy only on students' performance in mechanics concepts?*

The purpose of this study was to use cooperative learning teaching strategy and instructional manual to help Science and Technical Students to improve upon their performance in mechanics concepts in physics. In the control group, the treatment (Cooperative learning strategy) was found to have significant effect on the students" performance in the test instrument used (MCT). Students in the control group after exposed to cooperative learning strategy only performed relative better in post-intervention test used compared with the pre-intervention test results of the same test.

The higher level of performance observed in the cooperative learning based instruction agrees with findings of Schwarz et al. (2000). Schwarz et al. (2000)

concluded that two students working together can make learning gains even though both students entered the peer learning situation with low levels of competence. Schwarz et al. (2000) further indicated that, the thrust of the research on peer learning shows that when peers engage in dialogues and discussions (even arguments) that are relevant to both the task at hand and to initial misconceptions, cognitive gains can result from the peer interactions. By extension, this study confirms these attributes of cooperative learning highlighted by (Schwarz et al. (2000).

The findings also confirm a study conducted by Ajaja and Eravwoke (2010) that tested the effect of cooperative learning on students‟ performance. They reported that there was a significant higher achievement test scores of students in cooperative learning group than those in traditional classroom, a significant higher attitude scores of students in cooperative learning group than those in traditional classroom and significant higher achievement test scores of all students of varying abilities in cooperative group than those in traditional.

Cooperative learning strategy also provided the students with a forum where they could raise questions and get answers, a good platform to inspire students to think more creatively. In addition some students believed that cooperative learning pushed them to work harder and had opportunity to approach a problem from multiple angles from their peers.

The findings have equally lent weight to the campaign of shifting from traditional ways of teaching and embrace the bi-polar nature of teaching method such as cooperative learning strategy. Importance of this is that students become active in the teaching and learning processes; with its associated benefits as highlighted by the results of the present study.

**Research Question 2:**

*What is the effect of the used of cooperative learning strategy with instructional manual on students' performance in mechanics concepts?*

Findings with respect to research question two were positive in that, performance of students in the experimental group exposed to cooperative learning strategy through instructional manual was better than their counterparts exposed to cooperative learning strategy only.

Analysis of the research literature (Amedeker & Taale, 2011.) suggested that course manual (instructional manual) helps students to approach their learning with the appropriate strategies, give students resources or materials that will help them prepare well ahead of lessons, challenge students to improve their ability to research for information, and to think critically. Based on the above literature, instructional manual was added to the cooperative learning strategy to teach the experimental group. This saw the experimental group students" performance in the MCT from 22.97 to 30.17, representing 7.20 (23.89%) mean gain as compared with the control group students" performance from 22.87 to 26.84, representing 3.97 (14.79%) mean gain where only cooperative learning strategy was used.

**Research Question 3:**

*What is the difference in the performance of students instructed using cooperative learning strategy only and cooperative learning strategy with instructional manual*?

Findings with respect to research question three showed that there was a substantial difference between students instructed using cooperative learning strategy only and those instructed using cooperative learning strategy with instructional manual. The findings thus not support the research hypothesis that there is no significant difference in the performance between students taught using cooperative learning strategy only and those instructed using cooperative learning strategy with instructional manual

Using Magnusson (2014) interpretation, 1.07 Cohen *d* obtained for the C.L.S.W.I.M. means that, about 86% of the students taught using C.L.W.I.M. mean performance will be above student taught using C.L.S.O. Moreover, there is about 78% chance that a student picked at random from the C.L.S.W.I. group will have higher score than a student picked at random from the C.L.S.O group. This shows superiority of C.L.S.W.I.M. (experimental group) over C.L.S.O. (control group).

Effect size analysis result of the control group (*d*=0.64, representing moderate effect size) confirms study conducted by Johnson and Johnson (2013) who reported *d*= 0.76, representing moderate effect size for students engage in cooperative learning as against competitors learning. The findings also confirm the effect size reported by Kyndt et al. (2013) who reported that effect size of cooperative learning strategy on achievement; attitudes and perception were 0.54, 0.15 and 0.18 respectively. The result is also in congruent with Caper and Terim (2015) study also compiled experimental studies from 1988 to 2010 to examine the influence of cooperative learning method as compared with that of traditional methods on mathematics achievement and reported effect size of 0.59 (95% CL: Between 0.38 and 0.80) for cooperative learning on academic achievement.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.0 Overview

In this chapter the summaries of the findings of the study have been documented. There were three major findings that emerged out of the intervention used. Conclusions, recommendations and suggestions were made based on the findings for further research work.

## 5.1 Summary

The study investigated the effect of cooperative learning strategy and instructional manual use on science and technical students in the Berekum Municipality performance in Mechanics concepts in physics. Population of 93 students, constituted from two equivalent intact classes was used for the study. The duration for interventional activities with the students was seven (7) weeks.

The main focus was to measure control group performance in M.C.T. and experimental group performance in the same test before and after the interventions administered. The control group students were taught using cooperative learning strategy only while the experimental group was taught using cooperative learning through instructional manual. Hence, cooperative learning strategy was a fixed study variable in the two groups. Two research instruments were used to collect dada for the study.

The study revealed that cooperative learning strategy had positive effect on the students‟ performance in the mechanics concepts. The results showed that using cooperative learning strategy on the participants, the mean score of the control group rose from 22.87 to 26.84, Also the mean score of the experimental group rose from 22.97 to 30.17. This indicates that cooperative learning strategy had positive effect on the students" performance in the mechanics concepts.

However, post hoc analyses revealed that experimental group performance exceeded their counterpart in the control group where students were instructed using cooperative learning strategy only.

## 5.2 Conclusion

Cooperative learning strategy used had proven to be effective approach to Physics studies at the S.H.S. level. Within the limitations of the study, the interventional instruments designed to improve upon students" abysmal performance in mechanics concepts yielded positive results. The study showed that students learn more materials when they work together cooperatively; more students are motivated to learn the material when they work together or cooperatively. Also, students develop more positive attitudes to Physics studies when they work together cooperatively than when they work alone. Cooperative learning helps students to achieve better understanding of Physics concepts and increases student"s motivation to spend more time on their studies.

Moreover, per the analyses of the posttest results of the two groups, it is right to conclude that, cooperative learning strategy through instructional manual had more positive effects than the cooperative learning strategy only. Also, it is right to conclude from the findings of the study that, in enhancing the performance of students in Physics concepts, both the teacher and the students have unique roles to play. Teachers should be seen as facilitators, and coaches; a person who assists students to learn for themselves. However, teachers should not assume that students" mind is "*tabula rasa''* or empty slate that should be filled with teacher‟s information. Hence students must be fully involved in the teaching and process from the beginning to the end of the lesson.

## 5.3 Recommendation

Based on the major findings of the study and conclusions drawn, some recommendations are made here for consideration.

1. Physics teachers should develop interest in the use of cooperative learning and instructional manual. They should develop the cooperative learning skills and knowledge in order to enhance their use in S.H.S. and break from the old traditional belief underlying the teaching and learning of Physics.
2. Teachers should be encouraged to use cooperative instructional strategy and instructional manual to teach other science related subjects and the social sciences since it has the potential to improve upon performance at the S.H.S. level.
3. Students should be empowered by their teachers to assume responsibility for their own studies while the teacher becomes a facilitator or a coach in the learning process. This can be done when teachers adopt instructional strategy which is bi-polar in nature such as cooperative learning strategy.
4. The effects of the instructional manual as heighted by the study cannot be overlooked. Consequently, teachers should be encouraged to use instructional manual at the S.H.S. to serve as research and study guide for their students at this level.
5. Head teachers and other educational authorities could also advocate for the use of the cooperative learning and instructional use in schools under their

jurisdiction to improve upon students" performance in sciences and social sciences subjects.

6. In service training in the form of workshops, conferences, seminars should be organised by governments to prepare teachers to incorporate cooperative learning instructional strategy and instructional manual in their teaching at the S.H.S. level.
7. Science educators and curriculum planners should integrate innovative pedagogical strategies like cooperative learning instructional strategy into their various teacher education programmes.

## 5.4 Suggestions for further research

Based on the findings of this study, the following suggestions for further research are made:

1. It is suggested that the study should be replicated using cooperative learning with instructional manual on other physics concepts. This would also provide a basis for greater generalisation of the conclusion drawn from the analysis.
2. Moreover, empirical studies should be carried out on the use of cooperative learning strategy and instructional manual in other science subjects and at different schools to provide sound basis for the integration of instructional manual at the S.H.S. level.
3. Additionally, it is suggested that the study should be replicated using large sample size to provide a basis for more generalisation of the conclusion drawn from the findings of the study about the effectiveness of cooperative learning and instructional manual use in teaching physics.

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# APPENDIX A

# INSTRUCTIONAL MANUAL FOR MECHANICS CONCEPTS AT SHS

**UNIVERSITY OF EDUCATION, WINNEBA**

**FACULTY OF SCIENCE EDUCATION**

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**NAME OF FACILITATOR:** Appiah-Twumasi Eric

**TEL:** 0205766130/0240403605

**INTRODUCTION**:

You are most welcome to the mechanics class. You have already covered the various types of motion, laws which govern them and their application at SHS 1. Moreover, you have already covered the various forms in which force affect the state of a body and their application at SHS one. In the following lessons, we will discuss circular motion, gravitation and oscillation motion. These topics form part of the mechanics topics at SHS-2 syllabus.

**SUBJECT CONTENT/TOPICS**

***Circular motion***: Angular speed, angular acceleration, tangential acceleration, centripetal force, angular momentum, rounding a bend (banking of road) centrifuge, simple harmonic motion, simple pendulum and oscillation in spring –mass system

***Gravitation:*** Newton"s law of gravitation, earth"s gravitational field, earth satellite, parking orbits gravitation potential and velocity of escape

Basically, this instructional manual is planned to:

- help students to approach their learning with the appropriate strategies.
- give students resources that will help them prepare well ahead of lesson.
- challenge students to search for your information in relation to the topics.
- help students work cooperatively with their group members.

**Reading List**

**Compulsory study texts:**


i. Nelkon, M& Parker, P. (1995) *Advanced level physics* (7th ed.). New Delhi, India: Heinemann Publishers (Oxford) Ltd

*ii.* Asiedu, P. &Baah-Yeboah, H.A. (2006). *Physics for Senior High Schools in West Africa*. Ghana: Aki- Ola Publications.

*iii.* Mohammed, A.S. (2012). *Physics for Senior High Schools in West Africa – The Entire Syllabus*. Ghana: Alhaji Publications

iv. Young, P. L., Anyankoha, M. W., &Okeke, P. N. (2002). *University Physics*. Onitsha, Nigeria: Africana-FEP *Publishers* Limited.

v. Ministry of Education (2010).*Teaching Syllabus for Physics- Senior High School (1-3).* Accra, Ghana: CRDD.


**Supplementary Reading List:**


Young, D. H., Freedman, A. R., & Ford, A. L. (2008).*University Physics* (12th ed.). Sansome St., San Francisco: Person Addiso-Wesley.


**Type of Teaching and Learning Activities**

**i. Group Work**

It is where a number of students considered together or belonging together to perform task(s). Instructor leads students to form mixed ability groups of three (3) members in each group. Each group should write their members names and submit to the instructor (teacher). The group formed will present any assignment which requires students to do in groups. Group work will:

- Promote team work
- Peer teaching
- Promote tolerance and accommodation of other students" views
- help students to do private studies before and after the lesson
- encourage students to support group members to learn
- Make students active in the teaching and learning processes

**ii. Discussion**

It is talk between two or more people about a subject, usually to exchange ideas or reach conclusion. Discussion method is a means of

- getting insight to what students know
- revealing students misconceptions and misunderstandings
- involving all in the class

**iii. Demonstration**

Classroom demonstrations will be employed to help students concretize scientific concepts. It will help students to picture mentally and understand some of these abstract concepts in more realistic manner than you can imagine

**iv. Question and Answer**

- To get to what students know

- To reveal students alternative conceptions or misconceptions
- To involve the reserved or isolated students / students.

v. **Feedback / Assignments**

Reading of texts, notes and other materials will help students revise and to acquire knowledge and concepts taught in class. Students are encouraged and advised to present their assignment or exercises on time for marking. Students would be advised to do correction(s) where it is necessary.

## LESSON SCHEDULE

| Week | Learning Objectives | Preparation to do before class | Teaching and learning activities | Post- lesson assignments |
|---|---|---|---|---|
| 1 **15/04/16** | Revision on motion | Groups read on Alhaji Series pp. 20-36 and Aki-Ola pp.31-38 | (i). Demonstrate to groups the different types of motion (ii) Lead students to distinguish be the following terms: (a) distance (b)displacement (c) velocity (d) acceleration | (i) State four (4) types of motion. (ii) Define the following terms: distance displacement velocity uniform velocity acceleration uniform acceleration |
| 2 **22/04 /16** | Explain the ff terms: angular displacement angular velocity angular acceleration | Read Young, Anyankoha and Okeke pp.150. Alhaji series pp.86-87. Aki- Ola pp. 111-113. | Teacher leads groups to bring out the definition of angular displacement, angular velocity, and angular acceleration. | Define the following terms: angular displacement, velocity and acceleration |

| | | | | |
|---|---|---|---|---|
| | Work examples on angular displacement, angular velocity and angular acceleration | Read Young, Anyankoha and Okeke pp.150. Alhaji series pp.86-87 Aki- Ola pp. 111-113 | Teacher leads groups to work questions on angular displacement, angular velocity And angular acceleration | Solve Q2 on pp 87 from Alhaji series. Solve Q2 & Q3 from Aki-Ola pp.113 |
| 3 **29/04/16** | Explain centripetal acceleration and centripetal force. | Read Young, Anyankoha and Okeke pp.150. Aki-Ola pp.113-114 Alhaji series pp.88 | Teacher guides groups to state Centripetal acceleration and relate it to Centripetal force | Show that $F=\frac{mv^2}{r}$ Solve Q6 on pp.90 from Alhaji series And Q4 from Aki-Ola pp. 115 |
| 4 **06/05/16** | Explain the applications of circular motion | Read Alhaji series pp 91-94, and Aki-Ola pp.116-118 Nelkon& Parker 7th pp.65 | Teacher discusses applications of circular motion with students | Explain the uses of the following. Banking of roads and centrifuge. |
| 5 **13/05/16** | Gravitational field Newton‟s Universal law of gravitation | Read Alhaji series pp.110-111, Aki-Ola pp.129-130 | Teacher discusses gravitational | Distinguish between universal gravitational |

| | | | | |
|---|---|---|---|---|
| | | Young, Anyankoha &Okeke pp.200-204 | field with students, Newton"s law of gravitation and relationship between ***g*** and ***G*** | constant and acceleration due to gravity. Deduce the dimension of ***G*** |
| **6** **20/05/16** | Explain the term satellites and distinguish between artificial and natural satellites. | Read Alhaji series pp.112-113, Aki-Ola pp.131-132 Young, Anyankoha & Okeke pp.206 | Discuss to bring out the meaning of satellites. Compare artificial and natural satellites. Discuss the period of revolution and the speed of a satellite. Outline the uses of artificial satellites | Outline some uses of artificial satellites. Define the following terms: i. artificial satellites ii. parking orbit iii. period of a satellite |

| | | | | |
|---|---|---|---|---|
| **7** **27/05/16** | Describe oscillatory motion. Describe and illustrate simple harmonic motion (SHM). | Read Alhaji series pp.97-98, Aki-Ola pp.119-127 Young, Anyankoha & Okeke pp.243-259 | Discuss oscillatory motion. Define and describe simple harmonic motion and give examples as listed in content | (i).Define simple harmonic motion amplitude and frequency. ii. Solve Q 13 pp. 89 from Nelkon& Parker |

# APPENDIX B

## MECHANICS CONCEPTS TEST

**UNIVERSITY OF EDUCATION, WINNEBA**

**DEPARTMENT OF SCIENCE EDUCATION**

**MECHANICS CONCEPT TEST (MCT)**

**School** : ...............................................................

**Age** : ...............................................................

**Class** : ...............................................................

**Gender:** **Male** ☐ **Female** ☐

**GENERAL INSTRUCTIONS:** This test contains twenty four (20) questions grouped in two (2) sections, namely section A and section B. Please answer ***all*** questions in ***all*** the two (2) sections of the test.

**DURATION: 45 MINUTES.**

## SECTION A

## MULTIPLE CHOICE QUESTIONS

**INSTRUCTIONS:** *The following questions are followed by four (4) lettered to D. Select the correct option and circle A, B, C or D to indicate your answer.*

1. In simple pendulum experiment, the length $l$ is varied and the period $T$ is measured. To find acceleration due to gravity, it is best to plot.

   A. $l$ against $T$

B. $l$ against $T^2$

C. $1/l$ against $T$

D. $l^{1/2}$ against $T^2$

2. If a car moves round a circular road of radius $r$ at a constant speed $v$

**A.** its velocity changes and acceleration is $\frac{v}{r^2}$

**B.** there is no force on the car since its speed is constant

**C.** there is no velocity change since the speed is constant

**D.** the force of the car is towards the centre and is $\frac{mv^2}{r}$

3. When the stone mass, ***m***at the end of a string is whirled in a vertical circle at a constant speed,

**A.** the tension (force) in the string is always constant

**B.** the tension is at least when the stone reaches the bottom of the circle

**C.** the tension is always the centripetal force

**D.** the weight, **mg** is always the centripetal force

4 Which of the following relations between the force **F** and the distance **r** satisfies the law of gravitation?

**A.** F α r

**B.** F α $\frac{1}{r^2}$

**C.** F α $\frac{1}{r}$

**D.** F α $r^2$

5 The amplitude of a particle executing simple harmonic motion is 5cm while it angular frequency is 10rads$^{-1}$. Calculate the magnitude of the maximum acceleration of the particle.

**A.** 0.25ms$^{-1}$

**B.** 0.50ms$^{-1}$

**C.** 2.00ms$^{-1}$

**D.** 5.00ms$^{-1}$

6 When the satellite is launched with the escape velocity, it

**A.** leaves the earth gravitational field

**B.** is launched into parking orbit

**C.** has an acceleration equal to that of gravity

**D.** has zero gravity

7 If the linear velocity of a body, ***w*** is its angular velocity and *r* is the radius of the circle it describes, the relation between ***v, r*** and ***w*** is

**A.** $v = \frac{r^2}{w}$

**B.** $v = rw$

**C.** $v = \frac{r}{w}$

**D.** $v = w^2 r$

8 Which of the following systems cannot be used to demonstrate simple harmonic motion?

**A.** meter rule clamped to a table at one end

**B.** simple pendulum

**C.** mass on a spring

**D.** tennis ball thrown against a vertical wall

9 The correct relationship between the linear acceleration , ***a*** and linear velocity ***v*** of a body executing simple harmonic motion at a distance, ***r*** from fixed point is

**A.** $a = \frac{v}{r}$

**B.** $a = \frac{v^2}{r}$

**C.** $a = \frac{v}{r^2}$

**D.** $a = \frac{v^2}{r^2}$

10 A simple pendulum makes 50 oscillations in one minute. What is its period of oscillation?

**A.** 0.02s

**B.** 0.20s

**C.** 0.83s

**D.** 1.20s

11 The equation $GM = gR^2$, with the symbols having their usual meaning, expresses the fact that

**A.** Newton‟s law of gravitation holds under every condition.

**B.** The weight of a body is equal to the force of attraction between it and the earth

**C.** A body at a distance, R above the earth‟s surface experiences weightlessness

**D.** Acceleration of the fall varies with latitude

12 Roads are banked round curves

**A.** so that the centre of gravity of the vehicle will be low

**B.** to prevent the vehicle from skidding off the road

**C.** to reduce the centripetal force

**D.** to prevent the tyres from wearing away too fast

13 Which of the following are correct about uniform circular motion and simple harmonic motion?

i. Acceleration is directed towards a fixed time

ii. Motion has periodic time

iii. Acceleration is constant

**A.** I and II only

**B.** I and III only

**C.** II and III only

**D.** I,II and III

14 . A small mass of 0.2kg is whirled round in a horizontal circle at the end of a string of length 0.5m at a constant angular speed of 4 rads$^{-1}$. The tension( force) in the string in N is

**A.** 0.4

**B.** 0.6

**C.** 0.8

**D.** 1.6

15 A *geostationary* satellite is one that

**A.** moves at the same speed as the speed of rotation of the earth

**B.** has it"s distance from the earth twice the radius of the earth

**C.** moves at twice the speed of the rotation of the earth

**D.** has an orbit radius equal to the radius of the earth.

16 If $M_1$ and $M_2$ are masses of two bodies in space separated by a distance, ***R*** between their centers, the force of attraction, F between them is proportional to

**A.** $\frac{M_1 R^2}{M_2}$

**B**. $M_1 M_2 R^2$

**C.** $\frac{M_1}{M_2} R$

**D.** $\frac{M_1 M_2}{R^2}$

17. An object moves in a horizontal circular path of radius 3.0m with a constant speed of 45km $h^{-1}$. Calculate its angular speed

A. 25 rad $s^{-1}$

B. 6.25 rad $s^{-1}$

C. 4.17 rad $s^{-1}$

D. 2.50 rad $s^{-1}$

18. With the usual notations, the period of oscillations of a simple pendulum is given by the equation

**A.** $T = 2\pi\sqrt{\frac{g}{l}}$

**B.** $T = \frac{1}{2}\pi\sqrt{\frac{l}{g}}$

**C.** $T = 2\pi\sqrt{\frac{l}{g}}$

**D.** $T = \frac{1}{2}\pi\sqrt{\frac{g}{l}}$

## SECTION B

## ESSAY QUESTIONS

**INSTRUCTION:** Answer ***all*** the questions in this section

1. A model car moves round a circular track of radius 0.3m at 2 resolutions per second. What is

**a)** the angular speed *w,*

**b)** the period $T$

**c)** the speed *v* of the car?

**d)** find also the angular speed of the car if it moves with a uniform speed of $2ms^{-1}$ in a circle of radius 0.4m

2. (a) A stone of mass 0.6kg attached to a string of length 0.5m, which is whirled in a horizontal circle at a constant speed. If the maximum tension (force) in the string is 30N before it breaks, calculate

**(i)** the maximum speed of the stone,

**(ii)** the maximum number of revolution per second it can make

(**b**) Show that $\tan \Theta = \frac{v^2}{rg}$, where the symbol have their usual meaning.

# APPENDIX C

## LETTER OF INTRODUCTION

**UNIVERSITY OF EDUCATION, WINNEBA**

**DEPARTMENT OF SCIENCE EDUCATION**

**P.O BOX 25, WINNEBA-TEL. NO. 0202041079**

December 7, 2015.

Dear Sir,

**TO WHOM IT MAY CONCERN**

**INTRODUCTORY LETTER**

The bearer of this letter, APPIAH-TWUMASI, ERIC with index Number **8140130001** is a Student offering Master of Philosophy in Science Education in the Department of Science Education in the above University.

He is conducting a research on „*'Comparative Effect of Cooperative Learning and Cooperative Learning with Instructional Manual on Performance in Mechanics Concepts''*.

Your school has been selected as part of his sampling area.

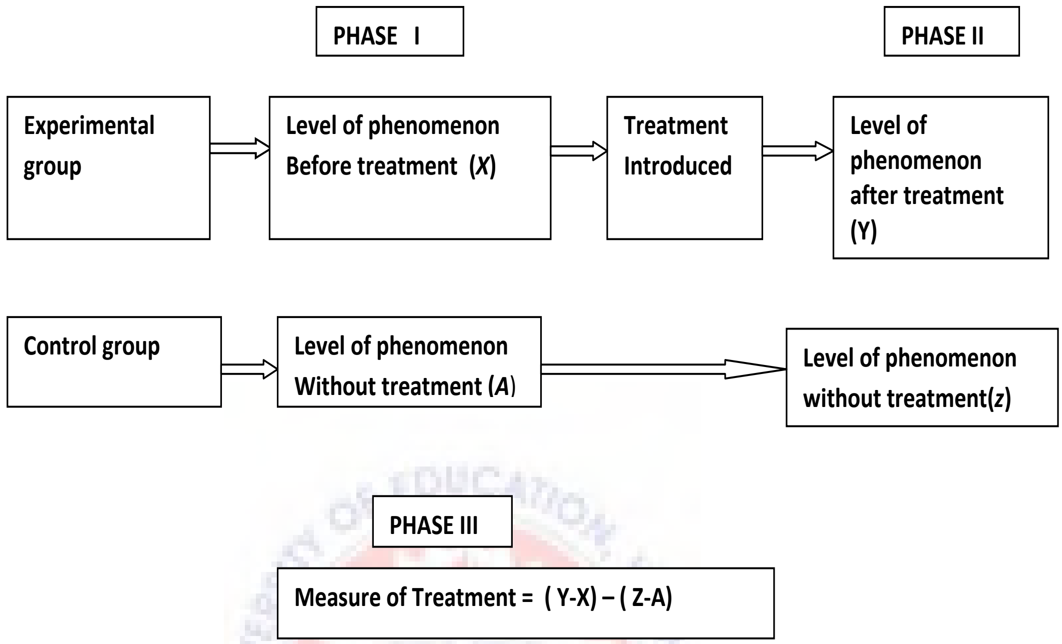
I hope you would assist him to do a good thesis write-up.

Thank you.

VICTOR ANTWI, PHD.
Head of Department

# APPENDIX D

## Measure of Treatment Effect




**Source :**Adopted from Kothari (2004).

# APPENDIX E

## ENTRY CHARACTERISTICS TEST

.**INSTRUCTIONS:** *The following questions are followed by four (4) lettered  to D. Select the correct option and circle A, B, C or D to indicate your answer.*

1. Which of the following is a scalar quantity
   A. Momentum
   B. Acceleration
   C. Displacement
   D. Distance
2. The slope of the straight line displacement time graph indicates
   A. distance travelled
   B. uniform velocity
   C. uniform acceleration
   D. uniform acceleration at instant
3. The tendency of a body to remain at rest when a force is applied to it is called
   A. Impulse
   B. Momentum
   C. Inertia
   D. Friction
4. A centripetal force is one that
   A. Acts in the direction of motion
   B. Keeps an object moving in a circular track
   C. Acts tangentially to a circular track
   D. Accelerates an object in the direction of motion

5. A net force of 15N acts upon a body of mass 3kg for 5s, calculate the chance in speed of the body
   A. 25.0m/s
   B. 9.0m/s
   C. 2.5m/s
   D. 1.0m/s
6. How far will a body move in 4 seconds if the uniformly accelerates from rest at the rate of $2ms^{-2}$
   A. 32m
   B. 24m
   C. 16m
   D. 12m
7. A body accelerates uniformly from rest at $2ms^{-2}$. Calculate its velocity after travelling 9m
   A. 36.00m/s
   B. 18.00m/s
   C. 6.00m/s
   D. 4.5m/s
8. An orange at rest falls freely from a height of 10.0m to the ground. Calculate the time taken to reach the round. ($g=10\ ms^{-2}$)
   A. 100.0s B. 10.0s C. 1.4 D. 1.0s

# APPENDIX F

## Cohen's *d* and Cohen's *d* Indexes

***Figure 4.1: Cohen's d formula***

$$d = \frac{M_1 - M_2}{\sqrt{\frac{S_1^2 + S_2^2}{2}}}$$

*Where*

| | | |
|---|---|---|
| $\mathbf{M_1}$ | = | Mean of post- test |
| $\mathbf{M_2}$ | = | Mean of pre-test |
| $S_2^2$ | = | Standard deviation of post- test |
| $S_1^2$ | = | Standard deviation of pre-test |
| $d$ | = | Calculated Cohen"s d |
| $r$ | = | Calculated effect size coefficient |

***Cohen's d Indexes***

| **Effect Size** | **Interpretation** |
|---|---|
| $\leq 0.2$ | Small |
| $\leq 0.5$ | Medium |
| $\geq 0.8$ | Large |

**Source:** Cohen (1988) as cited in Kai-Ti and Tzu-Hua (2012)

# APPENDIX G

## SAMPLES OF STUDENTS' PERFORMNCEIN MCT (PRETEST)

UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION
MECHANICS CONCEPT TEST (MCT)
PRETEST

School : Bexekum Senior high
Age : 18
Class : 2A1

Gender: Male [ ] Female [✓]

GENERAL INSTRUCTIONS: This test contains twenty four (24) questions arranged in two (2) sections, namely section A and section B. Please answer all questions in all the two (2) sections of this test.
DURATION: 45 MINUTES.

SECTION A

MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: The following questions are followed by four (4) lettered A to D. Select the correct option and circle A, B, C or D to indicate your answer.

1. In simple pendulum experiment, the length *l* is varied and the period *T* is measured. To find acceleration due to gravity *g*, it is best to plot
   A. *l* against *T*
   (B.) *l* against $T^2$
   C. 1/*l* against *T*
   D. $l^2$ against $T^2$

2. If a car moves round a circular road of radius *r* at a constant speed *v*
   A. its velocity changes and acceleration is $\frac{v}{r}$
   B. there is no force on the car since its speed is constant
   C. there is no velocity change since the speed is constant
   (D.) the force of the car is towards the centre and is $\frac{mv^2}{r}$

3. When the stone mass *m* at the end of a string is whirled in a vertical circle at a constant speed,
   (A) the tension (force) in the string is always constant
   B. the tension is at least when the stone reaches the bottom of the circle
   C. the tension is always the centripetal force
   D. the weight of the string is always the centripetal force

4. Which of the following relations between the force F and the distance r satisfies the law of gravitation?

A. $F \alpha r$ (B) $F \alpha \frac{1}{r^2}$ C. $F \alpha \frac{1}{r}$ D. $F \alpha r^2$

5. The amplitude of a particle executing simple harmonic motion is 5cm while it angular frequency is $10rads^{-1}$. Calculate the magnitude of the maximum acceleration of the particle

A. $0.25ms^{-2}$ B. $0.50ms^{-2}$ C. $2.00ms^{-2}$ (D) $\pm 5.00ms^{-2}$

6. When the satellite is launched with the escape velocity, it

A. leaves the earth gravitational field
B. is launched into parking orbit
(C) has an acceleration equal to that of gravity
D. has zero gravity

7. If the linear velocity of a body, w is its angular velocity and r is the radius of the circle it describes, the relation between v, r and w is

A. [illegible] B. [illegible] C. $v = \frac{r}{w}$ (D) [illegible]

8. Which of the following system cannot be used to demonstrate simple harmonic motion?

A. meter rule clamped to a table at one end
B. simple pendulum
C. mass on a spring
(D) tennis ball thrown against a vertical wall

9. The correct relationship between the linear acceleration, a and linear velocity v of a body executing simple harmonic motion at a distance, r from fixed point is

(A) [illegible] B. [illegible] C. [illegible] D. [illegible]

10. A simple pendulum makes 50 oscillations in one minute. What is its period of oscillation?

A. 0.02s B. 0.20s (C) 0.83s D. 1.20s

11. The equation $GM = gR^2$, with the symbols having their usual meaning, expresses the fact that

A. Newton's law of gravitation holds under every condition.
(B) The weight of a body is equal to the force of attraction between it and the earth
C. A body a distance, R above the earth's surface experiences weightlessness
D. Acceleration of the fall varies with latitude

12 Roads are banked round curves

A. so that the centre of gravity of the vehicle will be low
B. to prevent the vehicle from skidding off the road
C. to reduce the centripetal force
D. to prevent the tyres from wearing away too fast

13 Which of the following are correct about uniform circular motion and simple harmonic motion?

i. Acceleration is directed towards a fixed time
ii. Motion has periodic time
iii. Acceleration is constant

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

14 . A small mass of 0.2kg is whirled round in a horizontal circle at the end of a string of length 0.5m at a constant angular speed of 4 rad/s. The tension (force) in the string in N is

A. 0.4 B. 0.6 C. [illegible] D. 1.6

15 A *geostationary* satellite is one that

A. moves at the same speed as the speed of rotation of the earth
B. has a distance from the earth twice the radius of the earth
C. moves at twice the speed of the rotation of the earth
D. has an orbit radius equal to the radius of the earth

16 If $M_1$ and $M_2$ are masses of two bodies in space separated by a distance, $R$ between their centers, the force of attraction, F between them is proportional to

A. $\frac{M_1 R^2}{M_2}$ B. $M_1 M_2 R^2$ C. $\frac{M_1}{M_2} R$ D. $\frac{M_1 M_2}{R^2}$

17. An object moves in a horizontal circular path of radius 5.0m with a constant speed of $45 km h^{-1}$. Calculate the it's angular speed

A. $25 rad s^{-1}$ B. [illegible] C. $4.17 rad s^{-1}$ D. $2.50 rad s^{-1}$

18. With the usual notations, the period of oscillations of a simple pendulum is given by the equation

A. $T=2\pi\sqrt{\frac{g}{l}}$ B. $T=\frac{1}{2}\pi\sqrt{\frac{l}{g}}$ C. $T=2\pi\sqrt{\frac{l}{g}}$ D. $T=\frac{1}{2}\pi\sqrt{\frac{g}{l}}$

5

## SECTION B

## ESSAY QUESTIONS

**INSTRUCTION:** Answer *all* the questions in this section.

1. A model car moves round a circular track of radius 0.5m at 2 revolutions per second. What is

   a) the angular speed $\omega$
   b) the period $T$
   c) the speed $v$ of the car?
   d) find also the angular speed of the car if it moves with a uniform speed of $2ms^{-1}$ in a circle of radius 0.4m

2. (a) A stone of mass 0.6kg attached to a string of length 0.5m, which is whirled in a horizontal circle at a constant speed. If the maximum tension (force) in the string is 30N before it breaks, calculate

   (i) the maximum speed of the stone,
   (ii) the maximum number of revolution per second it can make

   (b) Show that $\tan\theta = \frac{v^2}{rg}$, where the symbol have their usual meaning.

3

**THANK YOU**

4

① $r = 0.3m$

$d\theta = 2 \times 2\pi$

$dt = 1s$

a. Angular Speed $= \frac{d\theta}{dt}$

$= \frac{2 \times 2\pi}{1}$

$= 12.57 \, rad/s$

b. period $T = 2\pi\sqrt{\frac{L}{g}}$

$= 2\pi\sqrt{\frac{0.3}{10}}$

$= 1.09 sec$

c. $v = r\omega$

$= 0.3 \times 12.57$

$= 3.77 m/s$

d. $v = r\omega$

$\omega = \frac{v}{r}$

$\frac{2}{0.4} = 5 \, rad/s$

10

(a) i. maximum speed = $\frac{2\pi}{T}$

= 0.21 rads⁻¹

ii. $\omega = \frac{d\theta}{dt}$

$d\theta = \omega \times dt$

= 0.21 × 0.6

0.126.

$T = \frac{mv^2}{r + m(g)}$

$30 = \frac{0.6 \times v^2}{0.5 + 0.6(\times 10)}$

$5.5 \times 30 = 0.6v^2$

$\frac{165}{0.6} = \frac{0.6v^2}{0.6}$

$v = \sqrt{275}$

$v = 16.58$ m/s.

(b) for horizontal equilibrium

$R\sin\theta = mv^2/r$ — ①

for vertical equilibrium

$R\cos\theta = mg$ — ②

eqn ① ÷ ②

$\frac{R\sin\theta}{R\cos\theta} = \frac{mv^2/r}{mg}$

$\tan\theta = v^2/rg$

14

50

# UNIVERSITY OF EDUCATION, WINNEBA
# DEPARTMENT OF SCIENCE EDUCATION
## MECHANICS CONCEPT TEST (MCT)

PRETEST

School : MEC TECH

Age : 17 years

Class : 2T

Gender: Male [✓] Female [ ]

**GENERAL INSTRUCTIONS:** This test contains twenty four (24) questions grouped in two (2) sections namely section A and section B. Please answer *all* questions in *all* the two (2) sections of the test.
**DURATION: 45 MINUTES.**

### SECTION A

### MULTIPLE CHOICE QUESTIONS

**INSTRUCTIONS:** The following questions are followed by four (4) lettered A to D. Select the correct option and circle A, B, C or D to indicate your answer.

1. In simple pendulum experiment, the length $l$ is varied and the period $T$ is measured. To find acceleration due to gravity $g$, it is best to plot
   A. $l$ against $T$
   (B) $l$ against $T^2$
   C. $1/l$ against $T$
   D. $l^2$ against $T^2$

2. If a car moves round a circular road of radius $r$ at a constant speed $v$
   A. its velocity changes and acceleration is $\frac{v}{r}$
   B. there is no force on the car since its speed is constant
   (C) there is no velocity change since the speed is constant
   D. the force of the car is towards the centre and is $\frac{mv^2}{r}$

3. When the stone mass, $m$ at the end of a string is whirled in a vertical circle at a constant speed
   A. the tension (force) in the string is always constant
   B. the tension is at least when the stone reaches the bottom of the circle
   C. the tension is always the centripetal force
   (D) the weight acting is always the centripetal force

1

4 Which of the following relations between the force F and the distance r satisfies the law of gravitation?

A. $F \alpha r$ B. $F \alpha \frac{1}{r^2}$ C. $F \alpha \frac{1}{r}$ D. $F \alpha r^2$

5 The amplitude of a particle executing simple harmonic motion is 5cm while it angular frequency is 10rads⁻¹. Calculate the magnitude of the maximum acceleration of the particle.

A. $0.25ms^{-2}$ B. $0.50ms^{-2}$ C. $2.00ms^{-2}$ D. $5.00ms^{-2}$

6 When the satellite is launched with the escape velocity, it

A. leaves the earth gravitational field
B. is launched into parking orbit
C. has an acceleration equal to that of gravity
D. has zero gravity

7 If the linear velocity of a body, $w$ is its angular velocity and $r$ is the radius of the circle it describes, the relation between $v$, $r$ and $w$ is

A. $v = \frac{r^2}{w}$ B. $v = rw$ C. $v = \frac{r}{w}$ D. $v = w^2 r$

8 Which of the following system cannot be used to demonstrate simple harmonic motion?

A. meter rule clamped to a table at one end
B. simple pendulum
C. mass on a spring
D. tennis ball thrown against a vertical wall

9 The correct relationship between the linear acceleration, $a$ and linear velocity $v$ of a body executing simple harmonic motion at a distance $r$ from fixed point is

A. $a = \frac{v}{r}$ B. $a = \frac{v^2}{r}$ C. $a = \frac{v}{r^2}$ D. $a = \frac{v^2}{r^2}$

10 A simple pendulum makes 50 oscillations in one minute. What is its period of oscillation?

A. 0.02s B. 0.20s C. 0.83s D. 1.20s

11 The equation $GM = gR^2$, with the symbols having their usual meaning, expresses the fact that

A. Newton's law of gravitation holds under every condition.
B. The weight of a body is equal to the force of attraction between it and the earth
C. A body a distance, R above the earth's surface experiences weightlessness
D. Acceleration of the fall varies with latitude

12. Roads are banked round curves

A. so that the centre of gravity of the vehicle will be low
B. to prevent the vehicle from skidding off the road
C. to reduce the centripetal force
D. to prevent the tyres from wearing away too fast

13. Which of the following are correct about uniform circular motion and simple harmonic motion?

i. Acceleration is directed towards a fixed point
ii. Motion has periodic time
iii. Acceleration is constant

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

14. A small mass of 0.2kg is whirled round in a horizontal circle at the end of a string of length 0.[illegible] at a constant angular speed of 4 rads$^{-1}$. The tension (force) in the string in N is

A. 0.4 B. 0.6 C. 0.8 D. 1.6

15. A *geostationary* satellite is one that

A. moves at the same speed as the speed of rotation of the earth
B. has a distance from the earth twice the radius of the earth
C. moves at twice the speed of the rotation of the earth
D. has an orbit radius equal to the radius of the earth

16. If $M_1$ and $M_2$ are masses of two bodies in space separated by a distance, $R$ between their centers, the force of attraction, F between them is proportional to

A. $\frac{M_1 R^2}{M_2}$ B. $M_1 M_2 R^2$ C. $\frac{M_1}{M_2} R$ D. $\frac{M_1 M_2}{R^2}$

17. An object moves in a horizontal circular path of radius [illegible] with a constant speed of 45kmh$^{-1}$. Calculate the it's angular speed.

A. [illegible] rad s$^{-1}$ B. 6.25 rad s$^{-1}$ C. 4.[illegible] rad s$^{-1}$ D. [illegible] rad s$^{-1}$

18. With the usual notations, the period of oscillations of a simple pendulum is given by the equation

A. $T=2\pi\sqrt{\frac{g}{l}}$ B. $T=\frac{1}{2}\pi\sqrt{\frac{l}{g}}$ C. $T=2\pi\sqrt{\frac{l}{g}}$ D. $T=\frac{1}{2\pi}\sqrt{\frac{g}{l}}$

## SECTION B

## ESSAY QUESTIONS

**INSTRUCTION:** Answer *all* the questions in this section

1. A model car moves round a circular track of radius 0.3m at 2 revolutions per second. What is

   a) the angular speed $w$,
   b) the period $T$
   c) the speed $v$ of the car?
   d) Find also the angular speed of the car if it moves with a uniform speed of $2\ ms^{-1}$ in a circle of radius 0.4m

2. (a) A stone of mass 0.6kg attached to a string of length 0.5m, which is whirled in a horizontal circle at a constant speed. If the maximum tension (force) in the string is 20N before it breaks, calculate

   (i) the maximum speed of the stone,
   (ii) the maximum number of revolution per second it can make

   (b) Show that $\tan\Theta = \frac{v^2}{rg}$, where the symbol have their usual meaning.

**THANK YOU**

1 $r = 0.3m$

(a) $\omega = 2\pi \times 2$

$= 12.57 rads^{-1}$

(b) $\omega = \frac{2\pi}{T}$

$T = \frac{2\pi}{\omega}$

$T = \frac{2\pi}{12.57}$

$T = 0.5s$

(c) $v = \omega r$

$v = 12.57 \times 0.7$

$v = 3.771 ms^{-1}$

(d) $v = 2 ms^{-1}$

$\omega = \frac{v}{r}$

$\omega = \frac{2}{0.4}$

$\omega = 5 rads^{-1}$

(i) mass of stone = 0.6 kg

length of string = 0.5m

$F = 30N$ $r = 0.5$

$F = \frac{mv^2}{r}$

$v^2 = \frac{Fr}{m}$

$v^2 = \frac{30 \times 0.5}{0.6}$

$\sqrt{v^2} = \sqrt{25}$

$v = 5 ms^{-1}$

(ii) $F = m\omega^2 r$

$30N = 0.6 \times \omega^2 \times 0.5$

$30 = \omega^2 \times 0.3$

$\frac{30}{0.3} = \frac{0.3\omega^2}{0.3}$

$\sqrt{100} = \sqrt{\omega^2}$

$\omega = 10 rads^{-1}$

1 rev = $2\pi$ rad

$= \frac{10 rad}{2\pi rad} \times 1$

$= 1.45 revs^{-1}$

**UNIVERSITY OF EDUCATION, WINNEBA**
**DEPARTMENT OF SCIENCE EDUCATION**
**MECHANICS CONCEPT TEST (MCT)**
POST TEST

School : Berekum Senior High School
Age : 16
Class : 2A1

Gender: Male [✓] Female [ ]

**GENERAL INSTRUCTIONS:** This test contains twenty four (20) questions grouped in two (2) sections namely section A and section B. Please answer *all* questions in *all* the two (2) sections of the test.
**DURATION: 45 MINUTES.**

**SECTION A**

**MULTIPLE CHOICE QUESTIONS**

**INSTRUCTIONS:** The following questions are followed by four (4) lettered A to D. Select the correct option and circle A, B, C or D to indicate your answer.

1. In simple pendulum experiment, the length $l$ is varied and the period $T$ is measured. To find acceleration due to gravity g , it is best to plot
   A. $l$ against $T$
   B. $l$ against $T^2$
   C. $1/l$ against $T$
   D. $l^2$ against $T^2$

2. If a car moves round a circular road of radius $r$ at a constant speed $v$

   A. its velocity changes and acceleration is $\frac{v}{r^2}$
   B. there is no force on the car since its speed is constant
   C. there is no velocity change since the speed is constant
   D. the force of the car is towards the centre and is $\frac{mv^2}{r}$

3. When the stone mass, $m$ at the end of a string is whirled in a vertical circle at a constant speed;

   A. the tension (force) in the string is always constant
   B. the tension is at least when the stone reaches the bottom of the circle
   C. the tension is always the centripetal force
   D. the weight, mg is always the centripetal force

1

4. Which of the following relations between the force F and the distance r satisfies the law of gravitation?

   A. $F \alpha r$ B. $F \alpha \frac{1}{r^2}$ C. $F \alpha \frac{1}{r}$ D. $F \alpha r^2$

5. The amplitude of a particle executing simple harmonic motion is 5cm while it angular frequency is 10rads$^{-1}$. Calculate the magnitude of the maximum acceleration of the particle

   A. 0.25ms$^{-2}$ B. 0.50ms$^{-2}$ C. 2.00ms$^{-2}$ D. 5.00ms$^{-2}$

6. When the satellite is launched with the escape velocity it

   A. leaves the earth gravitational field
   B. is launched into parking orbit
   C. has an acceleration equal to that of gravity
   D. has zero gravity

7. If the linear velocity of a body, w is its angular velocity and r is the radius of the circle it describes, the relation between v, r and w is

   A. $v = \frac{r^2}{w}$ B. $v = rw$ C. $v = \frac{r}{\omega}$ D. $v = \omega^2 r$

8. Which of the following system cannot be used to demonstrate simple harmonic motion?

   A. meter rule clamped to a table at one end
   B. simple pendulum
   C. mass on a spring
   D. tennis ball thrown against a vertical wall

9. The correct relationship between the linear acceleration, a and linear velocity v of a body executing simple harmonic motion at a distance, r from fixed point is

   A. $a = \frac{v}{r}$ B. $a = \frac{v^2}{r}$ C. $a = \frac{v}{r^2}$ D. $a = \frac{v^2}{r^2}$

10. A simple pendulum makes 50 oscillations in one minute. What is its period of oscillation?

   A. 0.02s B. 0.20s C. 0.83s D. 1.20s

11. The equation $GM = gR^2$, with the symbols having their usual meaning, expresses the fact that

   A. Newton's law of gravitation holds under every condition.
   B. The weight of a body is equal to the force of attraction between it and the earth
   C. A body a distance, R above the earth's surface experiences weightlessness
   D. Acceleration of the fall varies with latitude

12 Roads are banked round curves

(A.) so that the centre of gravity of the vehicle will be low
B. to prevent the vehicle from skidding off the road
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i. Acceleration is directed towards a fixed time
ii. Motion has periodic time
iii. Acceleration is constant
A. I and II only
B. I and III only
(C.) II and III only
D. I, II and III

14 A small mass of 0.2kg is whirled round in a horizontal circle at the end of a string of length 0.5m at a constant angular speed of 4 rads$^{-1}$. The tension( force) in the string in N is

(A.) 0.4 B. 0.6 C. 0.8 D. 1.6

15 A *geostationary* satellite is one that

(A.) moves at the same speed as the speed of rotation of the earth
B. has it distance from the earth twice the radius of the earth
C. moves at twice the speed of the rotation of the earth
D. has an orbit radius equal to the radius of the earth.

16 If $M_1$ and $M_2$ are masses of two bodies in space separated by a distance, $R$ between their centers, the force of attraction, F between them is proportional to

A. $\frac{M_1R^2}{M_2}$ B. $M_1M_2R^2$ C. $\frac{M_1}{M_2}R$ (D.) $\frac{M_1M_2}{R^2}$

17 An object moves in a horizontal circular path of radius 3.0m with a constant speed of $15 km h^{-1}$. Calculate the it's angular speed

A. 25 rad $s^{-1}$ (B.) 6.39 rad $s^{-1}$ C. 4.17 rad $s^{-1}$ D. 2.50 rad $s^{-1}$

18. With the usual notations, the period of oscillations of a simple pendulum is given by the equation

A. $T=2\pi\sqrt{\frac{g}{l}}$ B. $T=\frac{1}{2}\pi\sqrt{\frac{l}{g}}$ (C.) $T=2\pi\sqrt{\frac{l}{g}}$ D. $T=\frac{1}{2}\pi\sqrt{\frac{g}{l}}$

3

## SECTION B

## ESSAY QUESTIONS

**INSTRUCTION:** Answer *all* the questions in this section

1. A model car moves round a circular track of radius 0.3m at 2 revolutions per second. What is

   a) the angular speed $w$,
   b) the period $T$
   c) the speed $v$ of the car?
   d) find also the angular speed of the car if it moves with a uniform speed of $2ms^{-1}$ in a circle of radius 0.4m

2. (a) A stone of mass 0.6kg attached to a string of length 0.5 m, which is whirled in a horizontal circle at a constant speed. If the maximum tension (force) in the string is 30N before it breaks, calculate

   (i) the maximum speed of the stone,
   (ii) the maximum number of revolutions per second it can make

   (b) Show that $\tan \theta = \frac{v^2}{rg}$, where the symbol have their usual meaning.

**THANK YOU**

① (a) $\theta = 2\pi$ rad (360)
$W = 2 \times 2\pi$
$= 4\pi\, rad\, s^{-1}$
$= 4 \times 3.142$
$= 12.57\, rad\, s^{-1}$

(b) $T = \frac{2\pi}{\omega}$, but $\omega = 12.57\, rad\, s^{-1}$
$= \frac{2 \times 3.142}{12.57}$
$= \frac{6.284}{12.57}$
$= 0.5$
$T = \frac{1}{f} = \frac{1}{2} = 0.5s$

(c) $v = r\omega$ but $r = 0.3\,m$ and $\omega = 12.57\, rad\, s^{-1}$
$= 0.3 \times 12.57$
$= 3.8\, m s^{-1}$

(d) $v = r\omega$, $v = 2 m s^{-1}$ and $r = 0.4\,m$
$\omega = \frac{v}{r}$
$= \frac{2\, m/s}{0.9\, m}$
$= 0.8\, rad\, s^{-1}$

4

(2) 9(i) $m = 0.6kg$, $r = 0.5$, $F = 30N$

$F = \frac{mv^2}{r}$

$Fr = \frac{mv^2}{m}$

$v^2 = \frac{Fr}{m} = \frac{30 \times 0.5}{0.6} = v^2 = \sqrt{25} = 5ms^{-1}$

$T = \frac{2\pi r}{v}$, $v = 5ms^{-1}$

(ii) $T = \frac{2 \times 3.142 \times 0.5}{5}$

$= 0.6280$

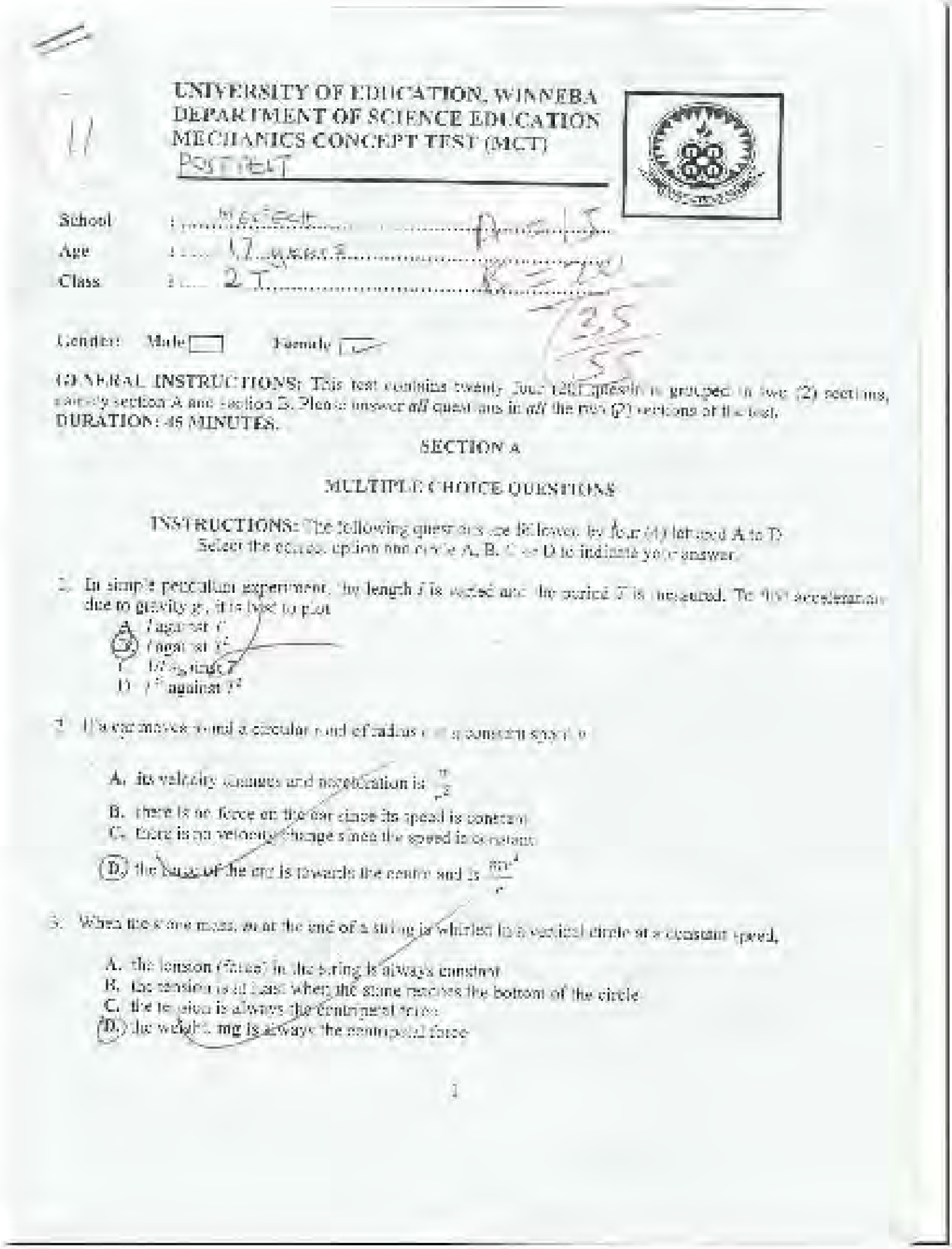
Revs per second $= \frac{1}{T}$

$= \frac{1}{0.628}$

$= 0.59$

24

## SAMPLES OF STUDENTS' PERFORMNCE IN MCT (POSTEST)



UNIVERSITY OF EDUCATION, WINNEBA
DEPARTMENT OF SCIENCE EDUCATION
MECHANICS CONCEPT TEST (MCT)
POSTTEST

School : ..........................................
Age : ...... 17 years ..........................
Class : ...... 2 T ..............................

Gender: Male [ ] Female [✓]

GENERAL INSTRUCTIONS: This test contains twenty four (24) questions grouped in two (2) sections, namely section A and section B. Please answer *all* questions in *all* the two (2) sections of the test.
DURATION: 45 MINUTES.

SECTION A

MULTIPLE CHOICE QUESTIONS

INSTRUCTIONS: The following questions are followed by *four (4)* lettered A to D. Select the correct option and circle A, B, C or D to indicate your answer.

1. In simple pendulum experiment, the length $l$ is varied and the period $T$ is measured. To find acceleration due to gravity $g$, it is best to plot
   A. $T$ against $l$
   B. $l$ against $T^2$
   C. $1/T$ against $T$
   D. $l^2$ against $T^2$

2. If a car moves round a circular road of radius $r$ at a constant speed $v$
   A. its velocity changes and acceleration is $\frac{v}{r^2}$
   B. there is no force on the car since its speed is constant
   C. there is no velocity change since the speed is constant
   D. the force of the car is towards the centre and is $\frac{mv^2}{r}$

3. When the stone mass, $m$ at the end of a string is whirled in a vertical circle at a constant speed,
   A. the tension (force) in the string is always constant
   B. the tension is at least when the stone reaches the bottom of the circle
   C. the tension is always the centripetal force
   D. the weight, mg is always the centripetal force

1

4 Which of the following relations between the force F and the distance r satisfies the law of gravitation?

A. $F \propto r$ B. $F \propto \frac{1}{r^2}$ C. $F \propto \frac{1}{r}$ D. $F \propto r^2$

5 The amplitude of a particle executing simple harmonic motion is 5cm while it angular frequency is $10 rads^{-1}$. Calculate the magnitude of the maximum acceleration of the particle.

A. $0.25ms^{-2}$ B. $0.50ms^{-2}$ C. $2.00ms^{-2}$ D. $5.00ms^{-2}$

6 When the satellite is launched with the escape velocity, it

A. leaves the earth gravitational field
B. is launched into parking orbit
C. has an acceleration equal to that of gravity
D. has zero gravity

7 If the linear velocity of a body, $w$ is its angular velocity and $r$ is the radius of the circle it describes, the relation between $v$, $r$ and $w$ is

A. $v = \frac{r^2}{w}$ B. $v = rw$ C. $v = \frac{r}{w}$ D. $v = w^2r$

8 Which of the following system cannot be used to demonstrate simple harmonic motion?

A. meter rule clamped to a table at one end
B. simple pendulum
C. mass on a spring
D. tennis ball thrown against a vertical wall

9 The correct relationship between the linear acceleration, $a$ and linear velocity $v$ of a body executing simple harmonic motion at a distance $r$ from fixed point is

A. $a = \frac{v}{r}$ B. $a = \frac{v^2}{r}$ C. $a = \frac{v}{r^2}$ D. $a = \frac{v^2}{r^2}$

10 A simple pendulum makes 50 oscillations in one minute. What is its period of oscillation?

A. 0.02s B. 0.20s C. 0.83s D. 1.20s

11 The equation $GM = gR^2$, with the symbols having their usual meaning, expresses the fact that

A. Newton's law of gravitation holds under every condition.
B. The weight of a body is equal to the force of attraction between it and the earth
C. A body a distance, R above the earth's surface experiences weightlessness
D. Acceleration of the fall varies with latitude

12 Roads are banked round curves

A. so that the centre of gravity of the vehicle will be low
B. to prevent the vehicle from skidding off the road
C. to reduce the centripetal force
D. to prevent the tyres from wearing away too fast

13 Which of the following are correct about uniform circular motion and simple harmonic motion?

i. Acceleration is directed towards a fixed time
ii. Motion has periodic time
iii. Acceleration is constant

A. I and II only
B. I and III only
C. II and III only
D. I, II and III

15

14 . A small mass of 0.2kg is whirled round in a horizontal circle at the end of a string of length 0.5m at a constant angular speed of 4 $rads^{-1}$. The tension (force) in the string in N is

A. 0.4 B. 0.6 C. 0.8 D. 1.6

15 A *geostationary satellite* is one that

A. moves at the same speed as the speed of rotation of the earth
B. has it distance from the earth twice the radius of the earth
C. moves at twice the speed of the rotation of the earth
D. has an orbit radius equal to the radius of the earth.

16 If $M_1$ and $M_2$ are masses of two bodies in space separated by a distance, $R$ between their centers, the force of attraction, F between them is proportional to

A. $\frac{M_1R^2}{M_2}$ B. $M_1M_2R^2$ C. $\frac{M_1}{M_2}R$ D. $\frac{M_1M_2}{R^2}$

17. An object moves in a horizontal circular path of radius 3.0m with a constant speed of $45km\,h^{-1}$. Calculate the it's angular speed

A. 25 $rad\,s^{-1}$ B. 6.25 $rad\,s^{-1}$ C. 4.17 $rad\,s^{-1}$ D. 8.50 $rad\,s^{-1}$

18. With the usual notations, the period of oscillations of a simple pendulum is given by the equation

A. $T=2\pi\sqrt{\frac{g}{l}}$ B. $T=\frac{1}{2}\pi\sqrt{\frac{l}{g}}$ C. $T=2\pi\sqrt{\frac{l}{g}}$ D. $T=\frac{1}{2}\pi\sqrt{\frac{g}{l}}$

3

P.T.O

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A. $\frac{M_1R^2}{M_2}$ B. $M_1M_2R^2$ C. $\frac{M_1}{M_2}R$ D. $\frac{M_1M_2}{R^2}$

17. An object moves in a horizontal circular path of radius 3.0m with a constant speed of 45km $h^{-1}$. Calculate the it's angular speed

A. 25 rad $s^{-1}$ B. 6.25 rad $s^{-1}$ C. 4.17 rad $s^{-1}$ D. 8.50 rad $s^{-1}$

18. With the usual notations, the period of oscillations of a simple pendulum is given by the equation

A. $T = 2\pi\sqrt{\frac{g}{l}}$ B. $T = \frac{1}{2}\pi\sqrt{\frac{l}{g}}$ C. $T = 2\pi\sqrt{\frac{l}{g}}$ D. $T = \frac{1}{2}\pi\sqrt{\frac{g}{l}}$

3

P.T.O

## SECTION B

### ESSAY QUESTIONS

**INSTRUCTION:** Answer *all* the questions in this section

1. A model car moves round a circular track of radius 0.3m at 2 revolutions per second. What is

   a) the angular speed $w$,
   b) the period $T$
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   d) find also the angular speed of the car if it moves with a uniform speed of $2ms^{-1}$ in a circle of radius 0.4m

2. (a) A stone of mass 0.6kg attached to a string of length 0.5m, which is whirled in a horizontal circle at a constant speed. If the maximum tension (force) in the string is 30N before it breaks, calculate
   (i) the maximum speed of the stone,
   (ii) the maximum number of revolution per second it can make

   (b) Show that $\tan \theta = \frac{v^2}{rg}$, where the symbol have their usual meaning.

**THANK YOU**

Q1

(a) $r = 0.3m$
1rev = 2
$\therefore \omega = 2\pi rev \times r$
$= 4\pi \times 2 \times 0.3$
$= 7.54$ rad/s

(b) $T = \frac{2\pi}{\omega} = \frac{2\pi}{7.54}$
$T = 0.833s$

(c) $v = \omega r$
$v = 7.54 \times 0.3$
$v = 2.262$ m/s

(d) $\omega = \frac{v}{r}$
$\omega = \frac{2}{0.4} = 5$ rad/s

1rev = $2\pi$ rad = 360°
2rev = $4\pi$ rad

(ii) $\omega = \frac{v}{r} = \frac{5}{0.5} = 10$ rad/s

1rev = $2\pi$ rad
$\pi = 1$
but $2\pi = 6.28$
1rev = 6.28
$\frac{10}{6.28} \times 1$
= 1.59 rev

Q2

(a) $m = 0.6$ kg
$r = 0.5$ m
$f = 30N$
$F = \frac{mv^2}{r}$
$30 = \frac{0.6v^2}{0.5}$
$30 \times 0.5 = 0.6v^2$
$\frac{15}{0.6} = \frac{0.6v^2}{0.6}$
$v^2 = 25$
$v = \sqrt{25}$
$v = 5$ m/s

(b) $f = N\sin\theta$ but $f = \frac{mv^2}{r}$
$\frac{mv^2}{r} = N\sin\theta$ —(1)
Resolving Vertically
$N\cos\theta = mg$ —(2)
(1) ÷ (2)
$\frac{\frac{mv^2}{r}}{mg} = \frac{N\sin\theta}{N\cos\theta}$
$\frac{mv^2}{rmg} = \tan\theta$
$\frac{v^2}{rg} = \tan\theta$

where v is the speed of the Vehicle r is the radius of the Vehicle and g is the gravity of the Vehicle