PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS

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DECLARATION

I, **SHYMA USMAN ABDULLA**, do hereby declare that this dissertation entitled **PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS** has not been submitted by me for the award of any Degree, Diploma, Title or Recognition before.

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CERTIFICATE

I, **Dr. MUMTHAS N. S.**, do hereby certify that the dissertation titled, **PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS**, is a record of bonafide study and research carried out by **SHYMA USMAN ABDULLA** under my supervision and guidance, has not been submitted by her for the award of any Degree, Diploma, Title or Recognition before.

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From the days of very ancient stone-age, human race have reached its supremacy by upgrading gradually to the maximum heights of luxury. From the discovery of fire to the invention of tools and to the latest leaps in the field of communication; there has been a lengthy list of enormous success and advancements. Today in the twenty-first century, men have enough reasons to be proud for their remarkable achievements and accomplishments. But uneasy people's mind has still enough desire for even greater accomplishments.

Globalization is no more a current phenomenon in the world's socio-economic system which has a multi-dimensional influence on the system of education. Education has played the most important role in the social, economic and political transformations in the society, by integrating the mankind with values that led to social cohesion and national identity. Only a well-educated population, full-fledged with relevant knowledge, attitudes and skills can thrive towards the nation's development.

"Recognizing the importance of education in national development, the Twelfth Plan places an unprecedented focus on the expansion of education, on significantly improving the quality of education imparted and on ensuring that educational opportunities are available to all segments of the society" (Planning Commission, Government of India, 2013). It is only through upgrading the educational footing of a society that the multi-faceted progress of its people can be ensured.

Presently, the pursuit for knowledge is limitless. There are no barriers and hurdles that cannot be jumped over in the long journey of enriching oneself with knowledge. Consequently to the availability and expansion of knowledge of Science and Technology, there has been the inflation of the competitive instinctual drive of the humans for the attainment of success.

Dissemination of Science Education has played a vital role in accelerating the pace of scientific progress and still continues to do so. Science Education imparts good standards for the mass and leads to cultural advancement, boosting the development of potential scientific and technological manpower.

“The dominating feature of the contemporary world is the intense cultivation of Science on a large scale, and its application to meet the country’s requirements” (Ministry of Science and Technology, Government of India, 1958). Thus, the production of citizens who are better consumers of scientific products by imparting science literature and development of a spirit of inquiry are not possible without Science Education.

The scientific streams of knowledge have contributed the bulk of progress that men have achieved and thus deserve a place of importance in the field of education. The spirit of scientific inquiry is what drives the thirst for improvement and development in any sphere of life. In order to cultivate this spirit, a strong educational background in Science is necessary.

Need and Significance

Science is a universal discipline. It was after long years of vigorous and constant efforts that its need in the school curriculum was identified. “Science and Technology must become essential components in any educational enterprise; they must be incorporated into all educational activity intended for children, young people and adults” (UNESCO, 1996).

In India, through the efforts of National Council of Educational Research and Training (NCERT), Science has been made a compulsory subject throughout the school stage. The Secondary Education Commission (1952-53) had also recommended that every secondary school pupil should study General Science as a compulsory subject, so that he gains a basic quantum of scientific knowledge as a part of his General Education (Ministry of Education, Government of India, 1953).

By the incorporation of Science in the field of education, the realm of human life has been reshaped and Science has proved essential for his existence. People today live in an ‘Era of Science’ perhaps needs no explanation to include Science in the school curriculum. Science had been arbitrarily split into different ‘streams’ when the amount of information we had started to increase beyond the limits where it could be considered as a single subject. But education being a comprehensive and co-ordinated process, various streams has to be correlated and transacted to attain the aim of ‘unification of knowledge’.

There is the need of deliberate effort to be laden to integrate various disciplines and to teach them as a synthetic whole. The shift of dissemination of unified, integrated and meaningful knowledge to the limelight was as the result of the child's psychological build-up which wants to receive learning experiences in an integrated manner. An example would be that of Mathematics and Physics. Mathematics as the science of patterns and relationship, is considered to be 'pure' and 'abstract', dealing with 'concepts' rather than actual real world situations (American Association for the Advancement of Science, 2013). Physics, on the other hand, is considered to be a 'down-to-earth' stream that deals with the reality of the world based on 'hard provable facts' (Greene, 1969; Buch, 1974; Munene, 2014).

In reality, one of the most extensive application of Mathematics is in Physics (Embeywa 1985; Redish, 2005). The bond between these two streams of Science is a very strong one (Hutchings, 1973). In fact, some topics in Physics appear exactly the way they are in Mathematics (Munene, 2014). Mathematics is a principal tool of Physics (Greene, 1969). So, it is clear that learning Physics requires mathematical knowledge (Redish, 2005; Bing, 2008; Ataide & Greca, 2013; Vinitsky-Pinsky & Galili, 2014).

The Ministry of Education, Government of India (1966), had laid great prominence of Science in the school curriculum and had recommended that Science and Mathematics should be taught on a mandatory basis to all students as a part of General Education during the first ten years of schooling.

In the Twelfth Five-year Plan (2012-17), Science and Mathematics are identified to be the disciplines that need extra noteworthy attention in the part of educational administrators. "Poor Science and Mathematics Education accounts for 80 percent of total students who fail in Tenth Board Examination. The transition rate from X to XI in Science is very small as indicated by less than 12 percentage share of students in UG Science stream. This low enrolment in Science stream at higher secondary level and poor quality education is a constraint in development of scientific manpower in the country" (Planning Commission, Government of India, 2013).

"Physics is crucial to understand the world around us, the world inside us, and the world beyond us. It is the most basic and fundamental Science" (American Physical Society). The important purpose of teaching Physics in secondary schools is to enable pupils to grasp the basic knowledge of Physics systematically which is essential for further study of modern Science and Technology and to perceive its applications. In addition, it would assist them to attain experimental skills and the ability to think and use Mathematics to solve physical problems.

Physics is considered to be a particularly difficult school discipline due to the difficulty faced by the students in integrating the concepts of Mathematics and Physics (Tuminaro, 2004; Pietrocola, 2008; Vinitsky-Pinsky & Galili, 2014; Mwangala & Shumba, 2016). This can be observed in student difficulty in setting up an appropriate calculation and also in interpreting the results of the calculation in the context of a Physics problem (Tuminaro & Redish, 2007).

The researcher herself had felt the difficulty to apply Mathematics while solving Physics problems at the school level. Moreover, the investigator had witnessed that the students are reluctant to attend problem based Physics questions during the examination, as compared to the theoretical and descriptive items. So, it is important to investigate the categories and the extent of difficulties of students to identify, combine and apply Physics and mathematical concepts so as to make the transaction of the content and reproduction of the comprehended knowledge effectively.

Statement of the Problem

The present study is entitled as ‘PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS’.

This study provides insights into Higher Secondary School Students’ Physico-mathematical Conceptual Difficulties when solving Physics problems involving the application of mathematical concepts.

Definition of Key Terms

Physico-mathematical Conceptual Difficulties

Physico-mathematical Concepts are concepts that involve the use of both Physics and Mathematics principles to define, derive or solve a Physics problem. (Uhden, Karam, Pietrocola & Pospiech, 2012; Vinitsky-Pinsky & Galili , 2014).

For the present study, Physico-mathematical Concepts are operationally defined as the basic concepts in Physics at higher secondary level which involves mathematical applications.

Physico-mathematical Conceptual Difficulties are the difficulties of higher secondary students to identify, combine and apply Physics and mathematical concepts and laws to solve Physics problems.

Higher Secondary School Students

Higher Secondary School Students are those who pursue the level of education which comes after the completion of ten year of schooling. Usually it refers to those students who are attending the two year course, XI and XII standards, which lead to the entry into an undergraduate course.

For this study, the students of XI standard are taken into consideration.

Variable

The only variable involved in the study is Physico-mathematical Conceptual Difficulties.

Objectives

The major objective of the study is to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. This is achieved through the following minor objectives.

1. To find out the extent of Conceptual Difficulty in Physics among Higher Secondary School Students.
2. To rank the Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students.
3. To find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students.
4. To rank the concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students.

5. To find out the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
    a) Creating or Identifying the Formula
    b) Extracting Information from Diagrams or Graphs
    c) Creating Schematic Diagrams or Graphs
    d) Application of Mathematics
6. To rank the concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
    a) Creating or Identifying the Formula
    b) Extracting Information from Diagrams or Graphs
    c) Creating Schematic Diagrams or Graphs
    d) Application of Mathematics

Research Questions

In order to clarify the objectives of the study, the objectives are reframed as the following research questions.

1. What is the extent of Conceptual Difficulty in Physics among Higher Secondary School Students?
2. What is the relative position of Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students?
3. What is the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?

4. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?

5. What is the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in

    a) Creating or Identifying the Formula?

    b) Extracting Information from Diagrams or Graphs?

    c) Creating Schematic Diagrams or Graphs?

    d) Application of Mathematics?

6. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in

    a) Creating or Identifying the Formula?

    b) Extracting Information from Diagrams or Graphs?

    c) Creating Schematic Diagrams or Graphs?

    d) Application of Mathematics?

Methodology

Method of Study

Methodology deals with the precise description of method used to realize the objectives of the study. Survey method is employed in the present study.

Sample

The study is conducted on a sample of 880 students from XI standard drawn from three districts namely Malappuram, Thrissur and Palakkad using stratified sampling technique.

Tool Used for Data Collection

The tool used for data collection by the investigator for the present study is 'Physico-mathematical Conceptual Test'.

Physico-mathematical Conceptual Difficulties are identified and analyzed using a test with multiple choice questions based on the basic concepts from Physics at higher secondary level.

Statistical Techniques

Percentage analysis is used to analyze the collected data.

Scope and Limitations

The present study is aimed to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. This study tries to explore the types of difficulties that students face while dealing with Physics problems involving mathematical applications. The main focus is on the troubles that students have in identifying, combining and applying Physics and mathematical concepts and laws to solve Physics problems. By incorporating the review of related studies and by gathering the opinion from higher secondary Physics teachers, the investigator found that Physico-mathematical Conceptual Difficulties fell into four major categories, viz., Creating or Identifying the Formula, Extracting Information from Diagrams or Graphs, Creating Schematic Diagrams or Graphs and Application of Mathematics. For the purpose of finding out their extent, the researcher constructed 'Physico-mathematical Conceptual Test', consisting of multiple choice test items from the topic 'Motion', by providing due weightage to each category of Physico-mathematical Conceptual Difficulties. The data for the study was pooled from a sample of 880 Higher Secondary School Students drawn from three districts namely Malappuram, Thrissur and Palakkad, using stratified sampling technique.

The investigator earnestly believes that the conclusions of the study can enlarge the vision of teachers and teacher educators to suggest remedial strategies for rectifying the difficulties in solving mathematical problems in Physics.

Even though the present study was organized with sincerity and maximum possible care with respect to the ability of the investigator, certain limitations which could hardly be avoided, have crept in to the study. They are

- The study aimed at finding out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. But the investigation was carried out using a test prepared only on the select concepts from 'Motion', which itself was a vast topic with enough scope to measure all the four categories of Physico-mathematical Conceptual Difficulties. So, the researcher had to neglect other Physico-mathematical concepts dealt in higher secondary classes.
- The limited time and inconveniences forced the investigator to restrict the sample chosen from three districts, viz., Malappuram, Thrissur and Palakkad.

- The sample is collected from Higher Secondary Schools working under State Board only. Other streams were not considered.

In spite of all the above limitations, the investigator hopes that the results to be valid and dependable and will render to modifications in educational process.

Organization of the Report

The report has been divided into five chapters.

Chapter 1 includes a brief introduction, need and significance of the study, statement of the problem, definition of key terms, objectives, research questions, methodology, scope and limitations of the study and organization of the report.

Chapter 2 incorporates a brief conceptual overview of the variable under study, survey of studies related to Physico-mathematical Conceptual Difficulties and a conclusion of review of related literature.

Chapter 3 describes methodology of the study in detail with description of tool used for measurement, sample selected for the study, data collection procedure and the statistical techniques used for analysis.

Chapter 4 includes details of the major statistical analysis of the data, interpretation and the major findings of the study.

Chapter 5 includes study in retrospect, conclusion of the study, educational implications and suggestions for further research in the area.

CHAPTER II

REVIEW OF RELATED LITERATURE

- *Conceptual Overview of Physico-mathematical Conceptual Difficulties*
- *Review of Related Studies*
- *Conclusion*

REVIEW OF RELATED LITERATURE

The review of related literature is an inevitable aspect of any research study. Any purposeful study in any sphere of knowledge needs an ample acquaintanceship with the work which has already been done in the same field. Hence, it is very important that a researcher has to review carefully the research journals, dissertations, thesis and other sources of information on the problem. As Best and Kahn (2014) underpins, "Since effective research is based upon past knowledge, a review of related literature helps to eliminate the duplication of what has been done and provides useful hypotheses and helpful suggestion for significant investigation".

It is the review of related literature that provides the researcher with better understanding of the problem by unfolding new insights and to construct new approaches to the related problem. It enables to apprehend the limitations of the previous works and enables us to refine our own exploration and conduct the research study very fruitfully. It helps the investigator to delimit and define his problem. The knowledge of related studies provides the investigator up-to-date information regarding the work which others have done in the domain of his problem and thus guides to state the objectives clearly and concisely.

Thus a deep examination of the related literature will enable an investigator to understand the relevance of the present study and to build a new approach to the same.

The present study is about the Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. To understand the essence of the study, the researcher has reviewed the relevant literature in this area.

The review is presented under the following heads.

- Conceptual Overview
- Review of Related Studies

Conceptual Overview

As the main purpose of the current study is to explore the extent of Physico-mathematical Conceptual Difficulties, the investigator has undergone in-depth review into the related studies, and has identified the various domains of Physics Education Research and the predominant roles played by Mathematics in Physics Education.

Domains of Physics Education Research

Various studies on Physics Education have been conducted with the common purpose of finding out the variables that are related with or are considered good forecasters of performance in the field of Science. One of the important aims of Physics Education Research is the identification or determination of potential barriers to student learning, and how to tackle those barriers in a way that would result in successful learning. The barriers include various aspects that arise during instruction such as instructional procedure and techniques as well as those that are associated with pupils' pre-instructional preparation like Mathematics and English disciplines in relation to their performance in Physics (Lacambra, 2016).

Some projects in the field of Physics Education Research focus on outlining new curricula for Physics classes. Investigators work to diagnose particular hurdles Physics pupils have in conventionally taught Physics courses and then propose new laboratory activities, lecture presentations, instructional worksheets, so as to tackle these difficulties. Some other studies are about modeling how Physics students think. Researchers concentrate on discovering the best frameworks and vocabulary to narrate what goes on internally in the minds of learners. Ideally, studies on how pupils think informs the curriculum design researches (Bing, 2008).

According to Sadaghiani (2005), generally, the areas of Physics Education Research falls into three different categories. The first category aims at studying the learner's conceptual understanding of physical phenomena and diagnosing the probable misapprehended and misinterpreted concepts in various topics. The second category discusses the design of instructional materials including seminars, tutorials and computer software, which would enable the students to comprehend complex ideas. The third category focuses upon curriculum development for the purpose of intercepting or curbing these difficulties.

Relation between Physics and Mathematics

Nowadays, physicists and mathematicians consider the relationship between Mathematics and Physics as noteworthy (Al-Omari & Miqdadi, 2014). Many proponents in both the fields have well acknowledged the fact that Physics and Mathematics are deeply intertwined (Karam, Pospiech & Pietrocola, 2011). The physicists have admitted the essentiality of Mathematics in Physics.

The outbreak of mathematization in Physics is often dated back to the 17th century (Pospiech, 2015). Galileo (1854) noted that the universe is written in mathematical language and Einstein (1934) held the opinion that the actual creative principle in Physics lies in Mathematics. Feynman (1992) stated that it is impossible to explain honestly the beauties of the laws of nature in a way that people can feel, without their deep understanding of Mathematics.

Tzanakis (2002) explained the two important ways in which Physics and Mathematics are tied-up. The first pinpoints the application of mathematical techniques and procedures in Physics which stipulates the role of Mathematics in interpreting the content and sense of concepts in Physics. The second explains that the utilization of Physics concepts, theories and justifications in enhancing mathematical competency and thinking.

The idea of interrelationship between Physics and Mathematics was also stated by Redish (2005), as the latter being the language in which the Physics theories are built up by blending with mathematical symbols in a way that has an important influence on the use and interpretation of equations.

According to Ataide and Greca (2013), the relationship goes in three aspects:

1. Mathematics is used to explain measurement of physical operations in the real world, and is employed to elucidate geometrical terminology and structures.
2. Physics determines how the real world functions, and Mathematics is the language that describes this reality.

3. Mathematics leads to physical knowledge, constructing physical laws and concepts.

The role of Mathematics in Physics has different dimensions, viz., it acts as a tool (pragmatic perspective), it serves as a language (communicative function) and it gives a logical and structural framework to Physics theories and concepts (Krey, 2012). Pospiech (2015) explains the concept of Krey as follows:

- **Mathematics as a Technical Tool**

According to the perception of Physics learners and researchers, the role as a technical tool is the most important. Mathematics provides many structures e.g. functions or equations, differential equations and algorithms, which contribute to the precise formulation of physical laws and therefore allow calculating numerical results and hence quantitative predictions.

- **Structural Role of Mathematics**

Mathematics builds the skeleton of physical theories and gives valuable general theorems allowing to proceed into the unknown. In these theories often Mathematics is needed as a guide even for conceptual explanations or reasoning.

- **Communicative Role of Mathematics**

Mathematics provides possibilities that help in representing physical relations in a symbolic and at the same time precise way. These representational means - numbers, graphs, algebraic forms and geometrical objects - contribute to its communicative role.

These different roles have to be considered also in teaching Physics and its mathematization.

Redish's Model of Mathematics in Physics

According to Redish (2005), a model describing the use of Mathematics in Physics is shown in Figure 1.

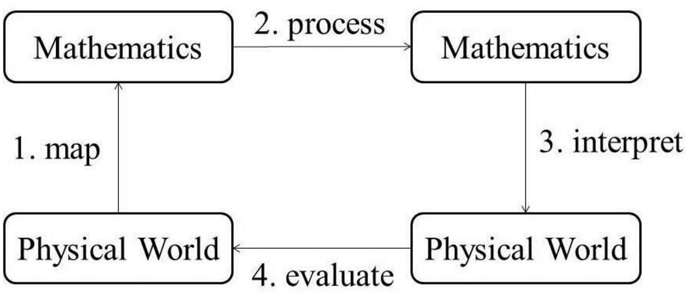


Figure 1. A model for the use of mathematics in physics

We start from the lower left corner by opting for a physical system which we want to describe. Within this box, the decision regarding what characteristics of the system have to paid attention to and what have to be ignored. Redish explains this as the important step and is where much of the skill or "art" in doing Physics lies.

Once the decision of what to be considered is made, we can proceed to 'step 1: map'. This step involves the mapping of the physical structures into mathematical ones, i.e., the creation of a mathematical model. To perform this step, it is necessary to understand what mathematical structures are available and what aspects of them are relevant to the physical characteristics we are trying to model.

After mathematizing the physical system, we can proceed to 'step 2: process'. In this step, the technology linked with the math structures can be used. It may be solving an equation or deriving new ones.

The next is the ‘step 3: interpret’, which involves the seeing of what the results tell about the system in physical terms. Then do ‘step 4: evaluate’, in which the evaluation of whether the results adequately describe the physical system or whether the model have to be modified further, is done.

Relevance of Mathematics in Physics Performance

Many researches in education have been conducted to know the relationship between Mathematical Skills and Physics Achievement of students. As a result, there has been the mushrooming of the notion that establishes a positive correlation of Mathematical Ability and Performance in Physics (Delialioglu & Ashkar, 1999).

Some of the early educational researches conducted had proved that pupils’ mathematical scores and Physics scores had high correlation (Cohen, Hillman & Agne, 1978; Jiar & Long, 2014; Lacambra, 2016). Uhden and Pospiech (2011) explains that strong interlink between Physics and Mathematics is an important factor that determines the success of Physical Science. A student who is outstanding in Mathematics is anticipated to be outstanding in Physics as well (Jiar & Long, 2014). “A student’s development as a physicist entails, in no small part, becoming increasingly comfortable with Mathematics” (Bing & Redish, 2009).

Therefore, an important indication of Physics students’ performance is their ability to blend the principles of Mathematics with their physical knowledge and imagination (Bing & Redish, 2007). It also becomes obvious that the interplay between Physics and Mathematics should be made an important and essential component of Science Teaching (Uhden & Pospiech, 2010).

Physics as a Challenging Discipline

The extent of comprehension of the pertinence or applicability of Mathematics in Physics Education is highly influenced by the age of the learners (Pospiech, 2015). While dealing with university level Physics courses, Mathematics is considered to be an inevitable part of teaching and this deep relationship is treated with due consideration. But at senior secondary school level, only the superficial use of Mathematics as a technical tool is required, not so much of the structural role (Schoppmeier, Borowski & Fischer, 2012). There is even lesser regard for Mathematics in Physics education at lower secondary school.

Inspite of being the backbone of Physics, the power of Mathematics in Physics is also the root cause of many of the difficulties faced by pupils (Bing, 2008). Physics is often regarded to be a complex school discipline (Osborne & Collins, 2001; Carlone, 2003;Angell, Guttersrud, Henriksen & Isnes, 2004; Lyons, 2005; Sperandeo- Mineo, Fazio & Tarantino, 2006; Duit, Niedderer & Schecker, 2007; Blickenstaff, 2010; Lin & Singh, 2011). Students usually depict poor performance on mathematical problem solving tasks in Physics (Tuminaro, 2004; Tuminaro & Redish, 2004).

Some of the teachers have the common opinion that most of the pupils lack basic understanding of mathematical concepts (Tuminaro & Redish, 2005; Rebello, Cui, Bennett, Zollman & Ozimek, 2007; Al-Omari & Miqdadi, 2014). As observed by Porter and Masiagila (2000) and Uhden and Pospiech (2010), many of the pupils do not recognize the concepts that lie behind the actions and Mathematics is being viewed as procedures with meaningless mechanical symbols. Especially, realizing the link between formulas and their physical interpretations seems to be challenging for majority of the students (Uhden & Pospiech, 2011). Karam and Pietrocola (2009) opined that failure in relating Mathematics to problems in Physics is the reason why students shy away from learning Physics as an interesting school subject. Some educators also claim that “students can often perform mathematical operations correctly in the context of a math problem, but are unable to perform the same operations in the context of a Physics problem” (Redish, Steinberg & Saul, 1996).

Tuminaro (2004) and Nilsen, Angell and Gronmo (2013) argued that the causes for students finding Physics as a tough subject are

1. students lack the prerequisite mathematical skills needed to solve Physics problem.
2. students do not know how to apply Mathematics to Physics problems.

The first group of difficulties leads to the correlational studies between mathematical competency and Physics performance, while the second group focuses on the deeper studies on the causes of issues with the application of Mathematics in Physics.

This study falls in the second group which aims in exploring the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students.

Physico-mathematical Conceptual Difficulties

Physics is considered to be a particularly difficult school discipline due to the difficulty faced by the students in integrating the concepts of Mathematics and Physics (Tuminaro, 2004; Pietrocola, 2008; Vinitsky-Pinsky & Galili, 2014; Mwangala & Shumba, 2016).

Physico-mathematical Concepts are concepts that involve the use of both Physics and Mathematics principles to define, derive or solve a Physics problem (Uhden, Karam, Pietrocola & Pospiech, 2012). For the present study, Physico-mathematical Concepts are operationally defined as the basic concepts in Physics at higher secondary level which involves mathematical applications.

Generally, two types of difficulties are encountered by students while dealing with mathematical problems in Physics. The first one is the Conceptual Difficulty, which refers to the difficulty in identifying, retrieving, recalling, recognizing and selecting the correct concepts from the cues provided. It also includes the difficulty in differentiating or distinguishing one concept from another.

Those students who have no Conceptual Difficulty is supposed to have Physico-mathematical Conceptual Difficulties while solving problems in Physics which involves mathematical applications. Physico-mathematical Conceptual Difficulties are the difficulties of higher secondary students to identify, combine and apply Physics and mathematical concepts and laws to solve Physics problems, even though they are having conceptual understanding.

A brief description of the categories of Physico-mathematical Conceptual Difficulties considered for the present study is given below.

1. **Creating or Identifying the Formula**

   This category refers to the difficulty in creating, identifying, generating, modifying, rearranging and relating the appropriate formula and equations based on Physico-mathematical reasoning that would best represent the situation provided.

2. **Extracting Information from Diagrams or Graphs**

   This category refers to the difficulty in decoding and extracting the correct Physico-mathematical information from the pictorial representations like schematic diagrams and graphs.

3. **Creating Schematic Diagrams or Graphs**

   This category implies the reverse to that of the previous difficulty discussed. This refers to the difficulty in creating, generating, designing and reconstructing the appropriate schematic diagrams or graphs that would best represent and explain the given Physico-mathematical concept.

4. **Application of Mathematics**

   This category refers to the difficulty in applying and understanding operations in Mathematics so as to produce the result and solve the Physics problems completely without leaving the calculations in the half-way.

Review of Related Studies

For the better understanding of Physico-mathematical Conceptual Difficulties, which is the area under present investigation, the researcher reviewed various related studies which are summarized as follows.

Kumaravelu (2018) attempted to study the relationship between information processing skills and academic achievement in Mathematics of higher secondary students. Data were gathered from 260 students using scale and test. The study depicted significant positive relationship between the two variables among higher secondary students.

Abebe and Dirbeba (2017) investigated students' transfer of learning from knowledge of calculus to an introductory Physics course. Interviews and questionnaires were used to assess the extent of transfer of knowledge of university students. The results indicated that students often had difficulty in solving the problem and they needed prompting to connect the calculus knowledge with the Physics problem. It was also observed that students' background knowledge of calculus to be very poor.

Reddy and Panacharoensawad (2017) evaluated the student's problem-solving skills and the factors influencing the problem-solving difficulties in Physics. The study was carried out on 303 graduation students of Physics. The results revealed that poor mathematical skills and lacking of understanding of the problem are the major obstacles in the domain of problem solving skills in Physics.

Tong and Loc (2017) studied students' errors in solving mathematical word problems and ability in identifying errors in wrong solutions. The errors of 160, 3rd grade students in a test were studied. The findings of the study showed that children commit many errors due to many different reasons such as subjectivity, carelessness, wrong application of the calculation rules, incorrect identification of problem kinds and wrong calculation.

Lacambra (2016) examined undergraduate students' mathematics skills and their initial Physics conceptual knowledge as factors that may underlie variations in student learning. The descriptive-correlation method of research was used and the data was collected from 30 undergraduates through test on the major topics: Vectors, Motion, Newton's Laws of Motion, Work and Energy, Momentum, Temperature and Heat. The result indicated that Physics performance of students in the test is affected and found significantly by the students' pre-instruction preparation in Mathematics and English courses. There were problems encountered by the student-respondents that had affected their performance in the Physics achievement test, viz., problems in recalling important concepts, principles and theories, and giving of many assessment works, assignments, projects, and the students' regularity in attending classes.

Makonye and Fakude (2016) studied errors and misconceptions in the learning of addition and subtraction of directed numbers in grade 8. Data were collected from 35 Grade 8 learners' exercise book responses to directed numbers tasks as well as through interviews. The results showed that the students could not easily accommodate negative numbers or the subtraction operation involving negative integers, which is the main source of errors in learning mathematical operations with directed numbers.

Hegde (2015) conducted the study to analyze students' problem solving difficulties and the role of lateral thinking techniques in solving Physics problems. The relevant data was gathered through tests and interview from 300 undergraduates. One of the results of the study showed that the weak association of students' conceptual framework to the physical principles acts as the major restraint in problem solving. The students failed to construct their ideas beyond definitions and statements of laws which showed up in the context of problem solving. Lack of mathematical manipulation skills played a significant role in limiting the problem solving abilities.

Mulwa (2015) conducted a study which sought to review literature pertinent to the difficulties encountered by students in the learning and usage of mathematical terminology. Data analysis involving document review was performed. The study concluded that students have difficulties in using mathematical terms and their related concepts which reflected the student's inadequate grasp of the language of Mathematics.

Al-Omari and Miqdadi (2014) examined the perception of pre-service teachers regarding the nature of the relationship between Physics and Mathematics. The study examined this relationship in reference to their performance in problem solving and strategies they used. The data needed for the study was collected using questionnaire and evaluation activities from 34 pre-service teachers. The results of this empirical study suggested that most participants held a naive epistemological view that considers Mathematics as an instrumental tool for learning Physics. The results indicated that these views could be attributed to failure in Physics problem solving.

Hashemi, Abu, Kashefi and Rahimi (2014) conducted a study to investigate the reasons of difficulties, which students faced in conceptual understanding of derivation. The design of the study was qualitative analysis of open-ended questions, and its subjects consisted of 63 undergraduate students. The findings showed that the students faced serious difficulties in understanding conceptually of derivation due to focusing on symbolic aspect more than embodied aspect and lack of making logical connection between those aspects.

Jacob and Betty (2014) conducted a survey on ability for fundamental mathematical operations among primary school students. The data were collected from 2024 students. The study showed that with respect to the scores for ability for fundamental mathematical operations, majority of the students belonged to 'medium' group. Only a small percentage of students belonged to the group 'high'.

Jiar and Long (2014) studied the relationship between mathematical thinking and Physics achievement of secondary school students in Johor Bahru, Malaysia. A total of 127 form 4 students were selected from 3 cluster schools in Johor Bahru by using cluster sampling. This quantitative study used both test items and questionnaire for data collection. Findings showed significant relationship between all mathematical thinking skills and Physics achievement. However, findings indicated that there was no significant difference in mathematical thinking and Physics achievement by gender.

Kothari and Mistry (2014) carried out a study on learning difficulties in fraction and decimal. A diagnostic test was administered on 553 upper primary school students of Vadodara. The results showed that the students are prevalent to misconceptions regarding multiplication and division of fraction, simplification of two mathematical processes involving fractions, decimal fraction and simple fraction. The students were found weak in the concepts of fractions and decimals which they had learnt earlier. It also showed that students lacked basic mathematical skills and were unable to link the theory with the practical examples.

Minikutty and Krishnan (2014) studied the spacial thinking skills in Mathematics among secondary school students. The study employed a test which was conducted on 100 students from IX standard. The study revealed that secondary school students have a low level of spatial thinking skills and girls are having a significantly high level of spacial thinking skills than boys.

Munene (2014) explored the factors affecting enrolment and performance of students in Physics in Gatundu District, Kenya. The subjects included 8 head of departments, 20 practicing Physics teachers and 144 students from 56 schools in the district, from which data was collected through observation, interview, questionnaires and achievement test. This study found out that the availability and proper use of teaching or learning resources improved achievement in Physics. There was a significant higher enrolment in schools with enough resources compared with those with inadequate resources. Learners who scored good grades in Mathematics had a higher achievement in Physics.

Dhurumraj (2013) identified the causes of poor learner performance in Physical Sciences in grade 12 in the Further Education and Training (FET) phase in public schools in the Pinetown District, KwaZulu-Natal, South Africa. The study employed a quantitative as well as a qualitative approach. Two public schools in the Pinetown District participated in this study. Upon analysis of the results, several contributory factors for poor performance were identified including lack of knowledge of Mathematics and Basic Science concepts.

Erinosho (2013) studied at identifying the areas of Physics that students considered as posing difficulty and what account for this difficulty. A questionnaire was administered to 830 final year students in Science class and 52 Physics teachers from secondary schools. The findings showed that students had difficulty in understanding specific topics in the curriculum that are usually characterized as lacking concrete examples and requiring a lot of mathematical manipulations or visualization. Many also found difficulty in the tasks of solving problems alone and asking questions in class.

Libeeshmon (2013) conducted an investigation on the misconceptions in optics in relation to teaching strategies. The relevant data were gathered from 600 X standard students using test and questionnaire. The conclusions of the study revealed that the students had high misconceptions in the topic 'Power of lenses' followed by 'Properties of light'. Also the results showed that group experiments, IT facilitated and diagrammatic strategies are better for minimizing the high misconceptions.

Luka (2013) investigated errors and misconceptions in algebra among secondary school pupils. The data were collected from 60 students through test and interview. One of the results of the study revealed that the cause of misconception was the inadequate understanding and misuse of the equal sign which hindered solving equations correctly.

Mundia (2012) assessed the math learning difficulties in a primary grade-4 child with high support needs. The investigator used interview and diagnostic test to collect relevant data. The study showed that the difficulties included inability to use the four arithmetic operations (addition, subtraction, multiplication, division) efficiently; not understanding the relationship between units, tens and hundreds; using any two of the four arithmetic processes in combination within one operation and place value problems or wrong alignment of numbers.

Orhun (2012) investigated an overview of specific difficulties based on the graph of derived function. He studied how students find the connections between the graph of derived function and some properties of the original function. The study was conducted on 102 high school students in grade 11. The data collected using diagnostic test and questionnaires were analyzed. The results of the study showed that the students found it difficult to make connections between the graph of derived function and the original function. They did not use the mathematical language to describe the graph of derived function.

Pepper, Chasteen, Pollock and Perkins (2012) studied common difficulties in upper-division electricity and magnetism in the areas of Gauss's law, vector calculus, and electric potential using both quantitative and qualitative evidence. The study was conducted on university students and the data were gathered through student interviews and diagnostic test. The study concluded that students have difficulty in combining Physics ideas with mathematical calculations leading to difficulties in setting up and interpreting calculations. Students do not account for the underlying spatial situation when performing a calculation, and students do not access an appropriate mathematical tool.

Prakash and Sharma (2012) conducted a study to assess the effectiveness of diagnosis-based remediation programme in improving the proportion of students mastering fundamental operation competency (percentage of competency mastered) by the group of V standard students in the selected schools of Shimoga District. A total of 100 students constituted the sample for the study. The result of the experimental study showed that the experimental group had gained significantly higher competencies in fundamental operation competency scores than the control group.

Torigoe (2012) described a framework to explain the difference in performance of introductory Physics students in solving numeric problems and equivalent symbolic problems. Data were collected through interview with 13 students. It was found that the problem solving process in the physical situation is represented in subtly different ways in numeric problems compared to symbolic problems. In almost every respect, the inclusion of numbers makes information more transparent throughout the problem solving process, which resulted in students' better performance in numerical problems compared to symbolic problems.

Uhden, Karam, Pietrocola and Pospiech (2012) developed a new model which can be used for analyzing different levels of mathematical reasoning within

Physics. It also provided a guideline for shifting the attention from technical to structural mathematical skills while teaching Physics and demonstrated its applicability for analyzing physical-mathematical reasoning processes with an example.

Egodawatte (2011) investigated secondary school students’ errors and misconceptions in algebra. An algebra test was conducted on a sample of 11 grade students. One of the major findings of the study was that inadequate understanding of the uses of the equal sign and its properties when it is used in an equation was a major problem that hindered solving equations correctly.

Kushwaha and Srivastava (2011) studied the approaches of children studying in Class V of a CBSE school in Varanasi, to realistic Mathematics word problems and how these approaches are related to their classroom achievement. The study was an exploratory research on 80 students. The data were collected through a test on realistic Mathematics word problems. The analysis of the responses revealed that the children approach the problems in a procedural manner and their school grades are not related to their realistic understanding of the problem.

Lin and Singh (2011) examined introductory Physics students' ability to use analogies in solving problems involving Newton's second law. 597 students enrolled in an algebra-based introductory Physics course were given a solved problem involving tension in a rope and were then asked to solve another problem for which the Physics is very similar but involved a frictional force. They were asked to point out the similarities between the two problems and then use the analogy to solve the friction problem. The study found that a majority of students in an algebra-based introductory Physics course could not exploit the deep analogy between the solved problem and the quiz problem to solve the quiz problem even when explicitly asked to do so because students have no expectation of deep similarities, they resort to memorized formulas.

Mech and Patra (2011) conducted a comparative study of scholastic achievement in Mathematics examination in relation to conceptual understanding and Mathematics ability. The study compared two groups of students of VII and IX classes, each having 290 subjects. The results showed that conceptual understanding and mathematical ability both exhibited positive relationship with scholastic achievements. It was also seen that conceptual understanding and mathematics ability of the students was at a lower level than scholastic achievement. Some common conceptual errors in Mathematics were also discussed.

Narayanan and Benjamin (2011) studied the effectiveness of problem solving strategy in Mathematics at higher secondary level. Data were gathered from 40 students through test. Based on the performance of the problem solving strategy, it was concluded that there is a positive effect while adopting the strategy in Mathematics at higher secondary level.

Uhden and Pospiech (2011) analyzed the difficulties students experienced while dealing with Mathematics in a physical context. Thirty students from IX and X standards from different schools of higher education in Germany were taken as subjects to perform problem solving tasks on the topic- Mechanics. Findings suggested that students focused on the technical use of mathematics. Especially understanding the connection between formulas and physical meaning seemed to be problematic for most students.

Gafoor and Sheela (2010) explored into the difficulties in arithmetic among upper primary students in Kerala. Data from 1509 students were collected through test. The results showed that the pupils of upper primary level are experiencing moderate to high level of difficulties in various arithmetic operations. Gender, type of management and locale does not influence the easier arithmetic tasks. However, gender, type of management and locale influence the higher level arithmetic abilities of upper primary school pupils.

Guttersrud and Angell (2010) conducted a study on upper secondary Physics students' competency to describe phenomena applying mathematical and graphical representations. By using a questionnaire and focus group interviews, students' ideas about their experiences with mathematical and graphical representations in Physics were investigated. The study showed that students have noteworthy weak skills in manipulating algebraic expressions and equations, and that they only to a small extent can deal with fundamental quantitative concept in Physics.

Tarmizi (2010) conducted a study to investigate students' performance in solving calculus problems and further analysed students' difficulties in solving the problems. Twenty undergraduate students participated in this study. It was clear from the interview and protocol analyses that some students require special treatment such as further tutorial session in correcting their misconception. Also the study suggested that the students needed to monitor their steps in problem solving or deriving problem solution and much attention should be directed to fostering students' ability to plan for problem solution.

Uhden and Pospiech (2010) studied the difficulties experienced by students during the translation process between Mathematics and Physics. Data were gathered from the videos of 15 to 16-year old students recorded while solving special diagnostic tasks. The findings of the study suggested that for students, physical meaning and mathematical calculations are two different things. Also severe problems were observed in dealing with units and performing Mathematics with double fractions.

Makgato and Mji (2006), using a non-experimental, exploratory and descriptive method, established learners' and educators' views about factors that contribute to poor performance in Mathematics and Physical Science among grade 11 learners. Results indicated that there were two identifiable factors. The first identified to have a direct influence related to teaching strategies, content knowledge, motivation, laboratory use, and non-completion of the syllabus in a year. The second factor, associated with indirect influences, was attributed to the role played by parents in their children's education, and general language usage together with its understanding in those two subjects.

Redish (2005) conducted a study on problem solving and the use of Mathematics in Physics courses. The study was based on the fact that Mathematics may be the language of Science, but Math-in-Physics is a distinct dialect of that language. This research with university Physics students in classes from algebra-based introductory Physics indicated that the gap between what students think, what they are supposed to be doing and what their instructors expect them to do can cause severe problems.

According to the study conducted by Tuminaro and Redish (2004), there are at least two possible, distinct reasons for algebra-based Physics students' poorly performance on mathematical problem solving tasks in Physics, viz., (1) Students lack the mathematical skills needed to solve problems in Physics, and (2) students do not know how to apply the mathematical skills they have to use in particular problem situations in Physics. The data was gathered through 60 hours of video-taped sessions of groups of students solving problems. The study also presented an instructional strategy that could help students employ the mathematical knowledge they already possess.

Conclusion

Most of the Physics Education Researches are carried out with the main agenda of discovering the factors that are linked with and are regarded to be good influencers of the performance in Physics discipline. The studies try to realize the potential barriers to student learning and to design strategies to overcome these hurdles so that it would produce the outcome of successful learning.

The review of the studies related to the present investigation shows that there exist the issues regarding dealing with mathematical problem solving in Physics among students around the world. A large number of references of recent researches in various perspectives at University level Physics are available, which are carried out abroad.

As far as the researches in Indian context is considered, most of the studies are related to problem-solving ability, attitude towards Physics teaching and learning, correlational studies connecting intelligence, creativity and other psychological variables with achievement in Physics and experimental comparisons of various strategies used for teaching Physics. The investigator found that least number of studies in Kerala focused on diagnosing student difficulties in dealing with Physico-mathematical problems.

The researcher, hence, attempted to conduct the study considering this area to be innovative and with the aim of contributing as the preliminary and grass root level investigation that would render teachers and teacher educators to think about and design strategies to tackle the hurdles in Physics learning at school level due to the application of Mathematics.

CHAPTER III

METHODOLOGY

- *Variable*
- *Objectives*
- *Research Questions*
- *Tool Employed*
- *Selection of Sample*
- *Data Collection Procedure*
- *Scoring and Consolidation of Data*
- *Statistical Techniques Used for Analysis of Data*

METHODOLOGY

Methodology is a process which reveals all the methods and techniques followed by the researcher during the course of research work. The success of any research work depends largely upon the suitability of the methods, tools and techniques followed by the researcher in collecting and processing data. Thus, the role of methodology is to carry out the research work in a scientific and valid manner.

The present study deals with the Physico-mathematical Conceptual Difficulties faced by the Higher Secondary School Students. The methodology of the study is presented below under the following heads, viz.,

- Variable
- Objectives
- Research Questions
- Tool Employed
- Selection of Sample
- Data Collection Procedure, Scoring and Consolidation of data
- Statistical Techniques Used for Analysis of Data

The detailed description of each of the above is given below.

Variable

The variable selected for the study is Physico-mathematical Conceptual Difficulties.

Objectives

The major objective of the study is to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. This is achieved through the following minor objectives.

1. To find out the extent of Conceptual Difficulty in Physics among Higher Secondary School Students.
2. To rank the Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students.
3. To find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students.
4. To rank the concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students.
5. To find out the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
   a) Creating or Identifying the Formula
   b) Extracting Information from Diagrams or Graphs
   c) Creating Schematic Diagrams or Graphs
   d) Application of Mathematics
6. To rank the concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
   a) Creating or Identifying the Formula
   b) Extracting Information from Diagrams or Graphs
   c) Creating Schematic Diagrams or Graphs
   d) Application of Mathematics

Research Questions

In order to clarify the objectives of the study, the objectives are reframed as the following research questions.

1. What is the extent of Conceptual Difficulty in Physics among Higher Secondary School Students?
2. What is the relative position of Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students?
3. What is the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?
4. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?
5. What is the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
    a) Creating or Identifying the Formula?
    b) Extracting Information from Diagrams or Graphs?
    c) Creating Schematic Diagrams or Graphs?
    d) Application of Mathematics?
6. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
    a) Creating or Identifying the Formula?
    b) Extracting Information from Diagrams or Graphs?

c) Creating Schematic Diagrams or Graphs?

d) Application of Mathematics?

Tool Employed

Collection of relevant data is an important aspect of any research work. The selection of suitable tool is of vital importance for a successful research. A research tool is the soul factor in determining sound data and in arriving at perfect conclusions about the problem or study in hand, which ultimately helps in providing appropriate solution to the problem concerned.

For the present study, the investigator used the tool, 'Physico-mathematical Conceptual Test', for pinpointing the difficulties faced by Higher Secondary School Students in solving Physics problems which involves mathematical applications.

The detailed description of the construction of the test is presented under the heads,

1. Planning of the Test
2. Preparation of the Test
3. Tryout of the Test
4. Finalization of the Test

1. Planning of the Test

The first step in the construction of a test is the planning of the test. For the purpose of the study, the investigator planned to prepare a test with multiple choice questions to pinpoint the difficulties faced by Higher Secondary School Students in solving problems in Physics that involves mathematical applications. The researcher also forethought to gather relevant data from school teachers who dealt with Physics regarding the types and extent of issues faced by students in applying mathematical concepts in Physics problems and to know about the topics in which those issues were prevalent.

2. Preparation of the Test

For the purpose of studying the various difficulties faced by the Higher Secondary School Students in dealing with the subject, the investigator collected relevant data from 21 Physics teachers from various districts through informal interview. Most of them were with the view that learners faced issues in identifying the correct mathematical formulae, combining and applying Physics and mathematical concepts and laws, constructing geometrical diagrams from Physics concepts and vice versa and solving numerical equations to solve Physics problems. The teachers also informed the investigator with the topics which the students found tough including Translational and Rotational Motion, Ray Optics, Electricity, Work, Energy, Power etc.

Later, incorporating the review of the Physics Education Research conducted by Mwangala and Shumba (2016), the investigator concluded that the difficulties according to the opinion of teachers fell into five major categories, viz.,

A. Concept
B. Creating or Identifying the Formula
C. Extracting Information from Diagrams or Graphs

D. Creating Schematic Diagrams or Graphs

E. Application of Mathematics

The investigator finalized the concept 'Motion' after considering the majority opinion among 21 higher secondary school Physics teachers. This concept is being introduced to the students in VIII standard and they have the same taught in IX and XI standards in the later years of schooling. So, the teachers were with the opinion that it is supposed that the XI standard students should possess the clear understanding about the preliminary concepts regarding 'Motion' that they had come across in their high school classes.

Based on the five categories of difficulties, the researcher prepared the test titled, 'Physico-mathematical Conceptual Test', with multiple choice test items on the basic Physico-mathematical Concepts that come under 'Motion', viz.,

A. Distance

B. Displacement

C. Speed

D. Velocity

E. Acceleration

F. II Equation of Motion

G. III Equation of Motion

H. Newton's Second Law of Motion

I. The Law of Conservation of Momentum

A brief description of Conceptual Difficulty and the four categories of Physico-mathematical Conceptual Difficulties based on which the test was prepared is given below.

A. Concept

This category refers to the difficulty in identifying, retrieving, recalling, recognizing and selecting the correct Physico-mathematical Concepts from the given cues. It also includes the difficulty in differentiating or distinguishing one concept from another.

Example:

Total length of the path travelled by a moving body (Qn. No. 1)

a) Distance c) Velocity

b) Displacement d) Speed

B. Creating or Identifying the Formula

This category refers to the difficulty in creating, identifying, generating, modifying, rearranging and relating the appropriate formula and equations based on Physico-mathematical reasoning that would best represent the situation provided.

Example:

Orbit of an artificial satellite at distance 42260 km from earth is circular. It completes one revolution around the earth in 24 hrs. Its speed will be …………………. (Qn. No. 32)

a) $[\frac{3.14 \times 42260}{2 \times 24}]$ m/s c) $[\frac{2 \times 3.14 \times 42260}{24}]$ m/s

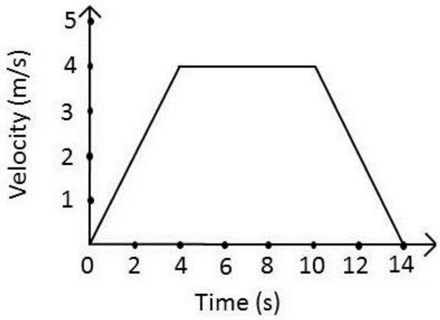
b) $[\frac{3.14 \times 42260}{2 \times 24}]$ km/hr d) $[\frac{2 \times 3.14 \times 42260}{24}]$ km/hr

C. Extracting Information from Diagrams or Graphs

This category refers to the difficulty in decoding and extracting the correct Physico-mathematical information from the pictorial representations like schematic diagrams and graphs.

Example:

Study the given graph and calculate the distance travelled by the body in first 8 secs of the journey graphically (Qn. No. 36).



a) 8m

b) 16m

c) 24m

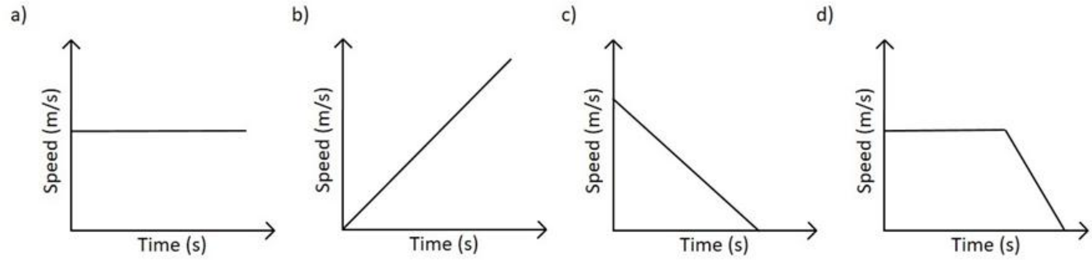
d) 32m

D. Creating Schematic Diagrams or Graphs

This category implies the reverse to that of the previous difficulty discussed. This refers to the difficulty in creating, generating, designing and reconstructing the appropriate schematic diagrams or graphs that would best represent and explain the given Physico-mathematical concept.

Example:

Which of the following graphs show increasing speed with time? (Qn. No. 20)



E. **Application of Mathematics**

This category refers to the difficulty in applying and understanding operations in Mathematics so as to produce the result and solve the Physics problems completely without leaving the calculations in the half-way.

Example:

A car starting from rest moves with a uniform acceleration of 2m/s^2 for 5 min. The final velocity of the car will be (Qn. No. 33)

a) 2.5m/s c) 10m/s

b) 7m/s d) 600m/s

The investigator prepared the 'Physico-mathematical Conceptual Test' with 70 multiple choice test items, with four responses each. With the intention to reduce the influence of students' guesswork on their performance in the test, two test items based on each Physico-mathematical Concept that would assess the same category of difficulty was included.

Scoring Procedure

The 'Physico-mathematical Conceptual Test' consists of 70 multiple choice test items, each having four responses, out of which only one is correct. Four test items have sub-sections. The students have to mark their responses by putting a tick mark (✓) as indicated below on the correct response against each item.

Example: ⓐ ⓑ✓ ⓒ ⓓ where (b) is the correct response.

One mark is assigned for every correct response and zero for every incorrect response. Considering all the test items including sub-sections, the maximum mark obtainable on the test is 78.

3. Try-out of the Test

The try-out of the draft of 'Physico-mathematical Conceptual Test' was administered on 46 higher secondary school students. The main objective of administering the test was to identify misunderstandings and ambiguities among students with the language of test items, if any, and to make a rough estimate of duration of the test, within which the students can answer all the test items provided.

4. Finalization of the Test

Considering the feedback obtained from the try-out of the test, the investigator prepared the 'Physico-mathematical Conceptual Test' consisting of 70 multiple choice test items based on the Physico-mathematical Concepts from 'Motion', covering two items from each concept. The time limit of the test is set to be 100 minutes and the maximum mark for the final test is 78.

The details of the final form of the test is given as Table 1.

Table 1

Details of the 'Physico-mathematical Conceptual Test'

Sl. No.	Categories of Physico-mathematical Conceptual Difficulties	Physico-mathematical Concepts
1.	Concept	Distance Displacement Speed Velocity Acceleration II Equation of Motion III Equation of Motion Newton's second law of motion Law of conservation of momentum
2.	Creating or Identifying the Formula	Distance Displacement Speed Velocity Acceleration II Equation of Motion III Equation of Motion Newton's Second Law of Motion Law of Conservation of momentum
3.	Extracting Information from Diagrams or Graphs	Distance Displacement Speed Velocity Acceleration Newton's Second Law of Motion
4.	Creating Schematic Diagrams or Graphs	Distance Displacement Speed Velocity

		Acceleration Newton's Second Law of Motion
5.	Application of Mathematics	Distance Displacement Speed Velocity Acceleration II Equation of Motion III Equation of Motion Newton's Second Law of Motion Law of Conservation of Momentum

A copy of the final form of the test is appended as Appendix I along with response sheet (Appendix II) and scoring key (Appendix III).

Reliability of the Test

According to Best and Kahn (2014), a test is said to be reliable to the degree that it measures accurately and consistently, yielding comparable results when administered a number of times.

The reliability of the Physico-mathematical Conceptual Test was established by test-retest method. For this, the test was administered to a set of 46 higher secondary school students from the sample. After a time interval of two weeks, the test was re-administered to the same set of students. The scores obtained from the first test were correlated with that of the retest scores using Pearson's product-moment coefficient of correlation method.

The reliability of the Physico-mathematical Conceptual Test was found to be 0.79 which indicated that the test is reliable.

Validity of the Test

According to Best and Kahn (2014), Validity is the quality of a data gathering instrument or procedure that ensures it to measure what is supposed to measure. The validity of the present test was ensured through face validity, content validity and criterion related validity.

A test is said to have face validity when it appears to measure whatever the author had in mind, namely what he thought he was measuring (Garrett, 2005). The instructions and items in the present test were phrased in the least ambiguous way so that the subjects responded to the items accordingly. Hence the test was ensured with face validity.

To ensure content validity, the investigator analyzed the areas of content domains of Physico-mathematical Concepts from ‘Motion’ in the Science textbooks (NCERT and SCERT). The investigator also consulted 10 Physics teachers for the scrutiny of the prepared test items. Enough modifications were brought in the test in accordance with the suggestions received from the teachers and thus, content validity was ensured.

The criterion related validity of the test was ensured by correlating the scores of the ‘Physico-mathematical Conceptual Test’ with that of the first terminal examination scores obtained in Physics conducted in respective schools. The correlation coefficient obtained is 0.65 which indicated that the test is valid to measure Physico-mathematical Conceptual Difficulties.

Selection of Sample

Selection of the sample is an important aspect of any research. A sample is a small proportion of a population selected for observation (Best and Kahn, 2014). The sample for the present study constituted 880 students of XI standard which were selected from 21 secondary schools in Malappuram, Thrissur and Palakkad districts. The sample were selected under stratified sampling technique by giving due representation to the factors like

a) Gender of the pupil
b) Locale of the school
c) Type of the management of the school

The strata considered for selecting the sample and their proportions are described below.

a) Gender of the Pupil

Gender has great influence on findings of the research. Since it has been found that sex difference exists in many of the psychological variables, the investigator decided to give due weightage to male and female students and the proportion taken is approximately equal for boys and girls in the sample.

b) Locale of the School

The number of higher secondary school in rural areas are more than the number of higher secondary schools in urban area. So the investigator decided to give due weightage to the locale of the schools. The ratio of higher secondary schools in rural area to that in urban area is taken to be approximately 2:1.

c) **Type of the Management of the School**

The existing schools in Kerala fall into three broad categories as Government schools, which are directly managed by the government, Aided schools which are managed by private agencies with government aid and Unaided schools which are approved by the government. Since there are more Government schools than Aided and Unaided schools, the investigator decided to give proper weightage to each type of school management. Hence the proportion for government-aided-unaided schools is set as 2:1:1 approximately.

Details of the schools selected for the data collection and number of pupils from each school is given as Appendix IV.

Data Collection Procedure, Scoring and Consolidation of Data

Administration of the Tool

In order to administer the tool and to collect the data required for analysis, necessary copies of the tool and response sheets were printed. After having an idea of the sample to be selected, the investigator personally contacted the heads of the institutions for obtaining permission for data collection. After getting the permission, the investigator met the students and explained the purpose and ensured their co-operation to make the study as successful as possible. After that, copies of the tool were distributed and later collected back after the students have marked their responses.

Scoring and Consolidation of Data

The responses were scored according to the scoring procedure and were consolidated and tabulated for further statistical analysis. While scoring, the incomplete response sheets were rejected and the breakup of the final sample is given in Table 2.

Table 2

Breakup of the Final Sample

Gender		Locale of school		Type of school management		
Male	Female	Rural	Urban	Government	Aided	Un-aided
420	460	597	283	482	233	165
880		880		880		

Data Preparation for Analysis

As the tool ‘Physico-mathematical Conceptual Test’ was prepared by setting two items in each concept under Conceptual Difficulty and the remaining four categories of Physico-mathematical Conceptual Difficulties, viz., Creating or identifying the Formula, Extracting Information from Diagrams or Graphs, Creating Schematic Diagrams or Graphs and Application of Mathematics, the investigator has taken the mean of the obtained scores in the two items as the ‘Average Score’ for the respective difficulty.

Extent of Conceptual Difficulty

The ‘Average Score’ obtained in conceptual items is subtracted from the maximum obtainable average score to get the ‘Index of Conceptual Difficulty’ in that corresponding concept. The Indices of Conceptual Difficulty in all the concepts are summed up to obtain the 'Total Index of Conceptual Difficulty in Physics'. It is then converted to percentage to get 'Percentage Score of Conceptual Difficulty in Physics'.

Extent of Physico-mathematical Conceptual Difficulties

The 'Average Score' obtained in each concept under various categories of Physico-mathematical Conceptual Difficulties is subtracted from the 'Average Score' obtained on the corresponding conceptual item to get the 'Index of Physico-mathematical Conceptual Difficulties' under each category of difficulty in that concept. Only the 'Index of Physico-mathematical Conceptual Difficulties' of the students who have no Conceptual Difficulty is considered for further analysis. The 'Indices of Physico-mathematical Conceptual Difficulties' of all the concepts are summed up to obtain the 'Total Index of Physico-mathematical Conceptual Difficulties'. It is then converted to percentage to get 'Percentage Score of Physico-mathematical Conceptual Difficulties'.

Statistical Techniques Used for Analysis of Data

After the data has been collected, it must be processed and analyzed to draw proper inferences. The raw scores obtained for 880 students were subjected to statistical technique in order to satisfy the objectives of the study. As the investigation was meant to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students, percentage analysis was used for analyzing the data and the proper conclusions were made.

CHAPTER IV

ANALYSIS AND INTERPRETATION

- *Research Questions*
- *Extent of Conceptual Difficulty*
- *Ranking of Concepts based on Conceptual Difficulty*
- *Extent of Physico-mathematical Conceptual Difficulties*
- *Ranking of Concepts based on Physico-mathematical Conceptual Difficulties*
- *Extent of Various Categories of Physico-mathematical Conceptual Difficulty*

ANALYSIS AND INTERPRETATION

Analysis means categorizing, ordering, manipulating and summarizing of data to obtain answer to research questions. The purpose of analysis is to reduce data to interpretable forms so that the relations of research problems can be studied and tested.

The main purpose of the study is to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. The collected data was analyzed statistically and the results have been presented and discussed in this chapter with reference to the research questions of the study.

Research Questions

In order to clarify the objectives of the study, the objectives are reframed as the following research questions.

1. What is the extent of Conceptual Difficulty in Physics among Higher Secondary School Students?
2. What is the relative position of Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students?
3. What is the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?
4. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?

5. What is the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in

    a) Creating or Identifying the Formula?

    b) Extracting Information from Diagrams or Graphs?

    c) Creating Schematic Diagrams or Graphs?

    d) Application of Mathematics?

6. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in

    a) Creating or Identifying the Formula?

    b) Extracting Information from Diagrams or Graphs?

    c) Creating Schematic Diagrams or Graphs?

    d) Application of Mathematics?

The analysis and discussion of the result with regard to the above research questions are described under the following headings.

A. Extent of Conceptual Difficulty in Physics among Higher Secondary School Students

B. Ranking of Select Physico-mathematical Concepts based on the Extent of Conceptual Difficulty among Higher Secondary School Students

C. Extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students

D. Ranking of Select Concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students

E. Extent of various categories of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students in

1) Creating or Identifying the Formula
2) Extracting Information from Diagrams or Graphs
3) Creating Schematic Diagrams or Graphs
4) Application of Mathematics

A. EXTENT OF CONCEPTUAL DIFFICULTY IN PHYSICS AMONG HIGHER SECONDARY SCHOOL STUDENTS

As the study is meant to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students, the investigator calculated the 'Percentage Score of Conceptual Difficulty in Physics' as the preliminary step of analysis.

The greater than smoothed cumulative percentage frequency curve of Conceptual Difficulty in Physics among higher secondary school students is given as Figure 2.

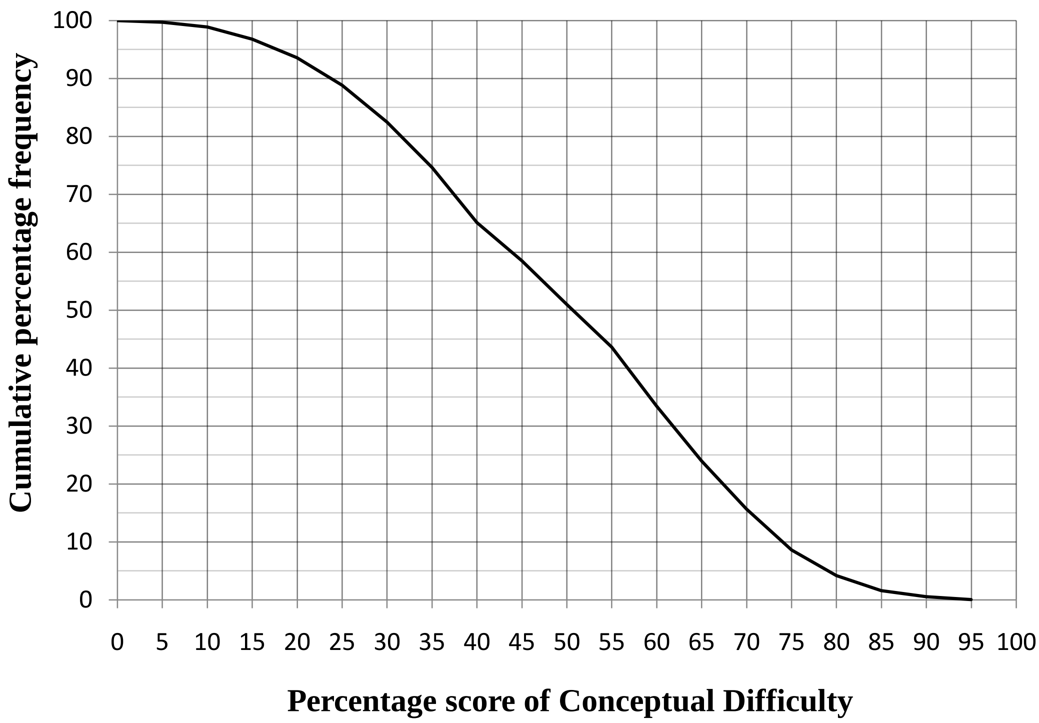


Figure 2. Greater than smoothed cumulative percentage frequency curve of Conceptual Difficulty in physics

Figure 2 shows that one-fourth of the students has 64 percent or more Conceptual Difficulty in Physics. Half of the students have 51 percent or more Conceptual Difficulty in Physics. Three-fourth of the students has 35 percent or more Conceptual Difficulty in Physics.

This means that among the higher secondary school students who have opted science as their main stream, half of them are having 50 percent or more Conceptual Difficulty in Physics. This implies that half of the higher secondary students possess a low level of conceptual understanding in Physics.

B. RANKING OF SELECT PHYSICO-MATHEMATICAL CONCEPTS BASED ON THE EXTENT OF CONCEPTUAL DIFFICULTY AMONG HIGHER SECONDARY SCHOOL STUDENTS

To rank the Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students, the investigator calculated the 'Mean Percentage Score of Conceptual Difficulty' in each select concept from 'Motion'.

The select Physico-mathematical Concepts were listed based on their extent of Conceptual Difficulty among higher secondary school students in Table 3.

Table 3
Mean Percentage Scores of Conceptual Difficulty in Each Select Physico-mathematical Concepts from 'Motion'

Sl. No.	Physico-mathematical Concepts	Mean percentage score of Conceptual Difficulty
1.	III Equation of Motion	73.86
2.	II Equation of Motion	54.20
3.	Law of Conservation of Momentum	53.64
4.	Velocity	52.39
5.	Speed	48.75
6.	Newton's Second Law of Motion	48.01
7.	Distance	42.78
8.	Acceleration	41.48
9.	Displacement	27.95

From Table 3, it is clear that students possess more Conceptual Difficulty in the topic ‘III Equation of Motion’, followed by ‘II Equation of Motion’, ‘Law of Conservation of Momentum’, ‘Velocity’, ‘Speed’, ‘Newton’s Second Law of Motion’, ‘Distance’, ‘Acceleration’ and ‘Displacement’.

For analyzing the extent of Conceptual Difficulty in each concept, the investigator has set the following criteria for interpretation. The Conceptual Difficulty is said to be high if the Percentage Score is greater than 50; it is moderate if the Percentage Score lies between 30 and 50; it is low when the Percentage Score is less than 30.

While considering the topic ‘III Equation of Motion’, the mean percentage score of Conceptual Difficulty obtained by the students is 73.86. This means that students are having a high level of Conceptual Difficulty in ‘III Equation of Motion’. That is, the higher secondary school students who have opted science as their main stream possess only a low level of conceptual understanding in ‘III Equation of Motion’.

As far as the topic ‘II Equation of Motion’ is concerned, the mean percentage score of Conceptual Difficulty obtained by the students is 54.20, which shows that students are having a high level of Conceptual Difficulty in ‘II Equation of Motion’. That is, the higher secondary school students who have opted science as their main stream possess only a low level of conceptual understanding in ‘II Equation of Motion’.

The mean percentage score of Conceptual Difficulty obtained by the students in the topic ‘Law of Conservation of Momentum’ is 53.64. This indicates that students are having a high level of Conceptual Difficulty in ‘Law of Conservation of Momentum’. That is, the higher secondary school students who have opted science as their main stream possess only a low level of conceptual understanding in ‘Law of Conservation of Momentum’.

While considering the topic ‘Velocity’, the mean percentage score of Conceptual Difficulty obtained by the students is 52.39, which denotes that students are having a high level of Conceptual Difficulty in ‘Velocity’. That is, the higher secondary school students who have opted science as their main stream possess only a low level of conceptual understanding in ‘Velocity’.

As far as the topic ‘Speed’ is concerned, the mean percentage score of Conceptual Difficulty obtained by the students is 48.75. This reveals that students are having a moderate level of Conceptual Difficulty in ‘Speed’. That is, the higher secondary school students who have opted science as their main stream possess only a moderate level of conceptual understanding in ‘Speed’.

The mean percentage score of Conceptual Difficulty obtained by the students in the topic ‘Newton’s Second Law of Motion’ is 48.01, which conveys that students are having a moderate level of Conceptual Difficulty in ‘Newton’s Second Law of Motion’. That is, the higher secondary school students who have opted science as their main stream possess only a moderate level of conceptual understanding in ‘Newton’s Second Law of Motion’.

While considering the topic ‘Distance’, the mean percentage score of Conceptual Difficulty obtained by the students is 42.78. This means that students are having a moderate level of Conceptual Difficulty in ‘Distance’. That is, the higher secondary school students who have opted science as their main stream possess only a moderate level of conceptual understanding in ‘Distance’.

As far as the topic ‘Acceleration’ is concerned, the mean percentage score of Conceptual Difficulty obtained by the students is 41.48, which shows that students are having a moderate level of Conceptual Difficulty in ‘Acceleration’. That is, the higher secondary school students who have opted science as their main stream possess only a moderate level of conceptual understanding in ‘Acceleration’.

The mean percentage score of Conceptual Difficulty obtained by the students in the topic ‘Displacement’ is 27.95. This indicates that students are having a low level of Conceptual Difficulty in ‘III Equation of Motion’. That is, the higher secondary school students who have opted science as their main stream possess a high level of conceptual understanding in ‘Displacement’.

For the easy visualization of the extent of Conceptual Difficulty among higher secondary school students in each select Physico-mathematical Concepts from ‘Motion’, Figure 3 is given below.

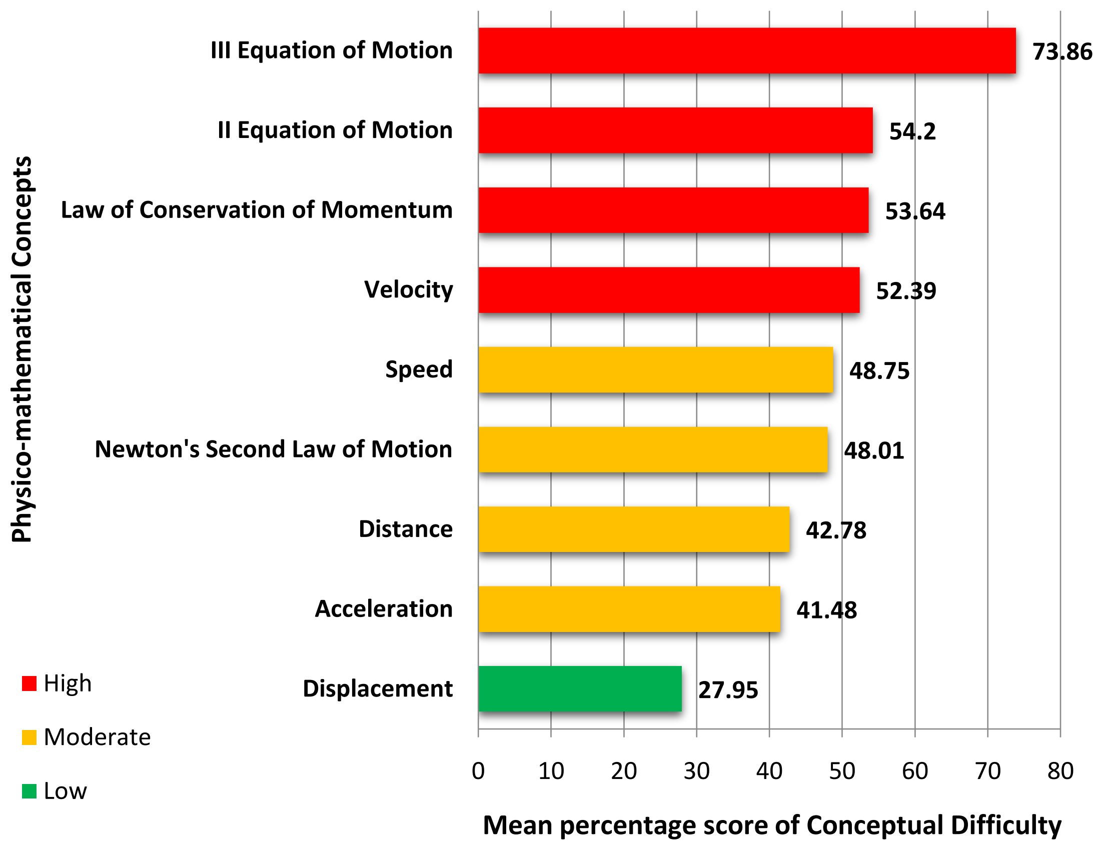


Figure 3. Extent of Conceptual Difficulty in each select Physico-mathematical Concepts from ’motion’

The analysis of Figure 3 reveals that the Conceptual Difficulty is highest with the Physico-mathematical Concept, ‘III Equation of Motion’, which is followed by ‘II Equation of Motion’, ’Law of Conservation of Momentum’, ‘Velocity’, ‘Speed’, ‘Newton’s Second Law of Motion’, ‘Distance’, ‘Acceleration’ and ‘Displacement’.

This reveals that even though the students are from the science stream, they possess high level of Conceptual Difficulty in the topics ‘III Equation of Motion’, ‘II Equation of Motion’, ‘Law of Conservation of Momentum’ and ‘Velocity’;

moderate level of Conceptual Difficulty in the topics ‘Speed’, ‘Newton’s Second Law of Motion’, ‘Distance’ and ‘Acceleration’; low level of Conceptual Difficulty in the topic ‘Displacement’.

Thus, this implies that among the higher secondary school students who have opted science as their main stream, the extent of conceptual understanding is lowest in ‘III Equation of Motion’, ‘II Equation of Motion’, ‘Law of Conservation of Momentum’ and ‘Velocity’; moderate in ‘Speed’, ‘Newton’s Second Law of Motion’, ‘Distance’ and ‘Acceleration’; highest in ‘Displacement’.

C. EXTENT OF PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS

As the study is meant to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students, the investigator calculated the ‘Percentage Score of Physico-mathematical Conceptual Difficulties’.

The greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulties among higher secondary school students is given as Figure 4.

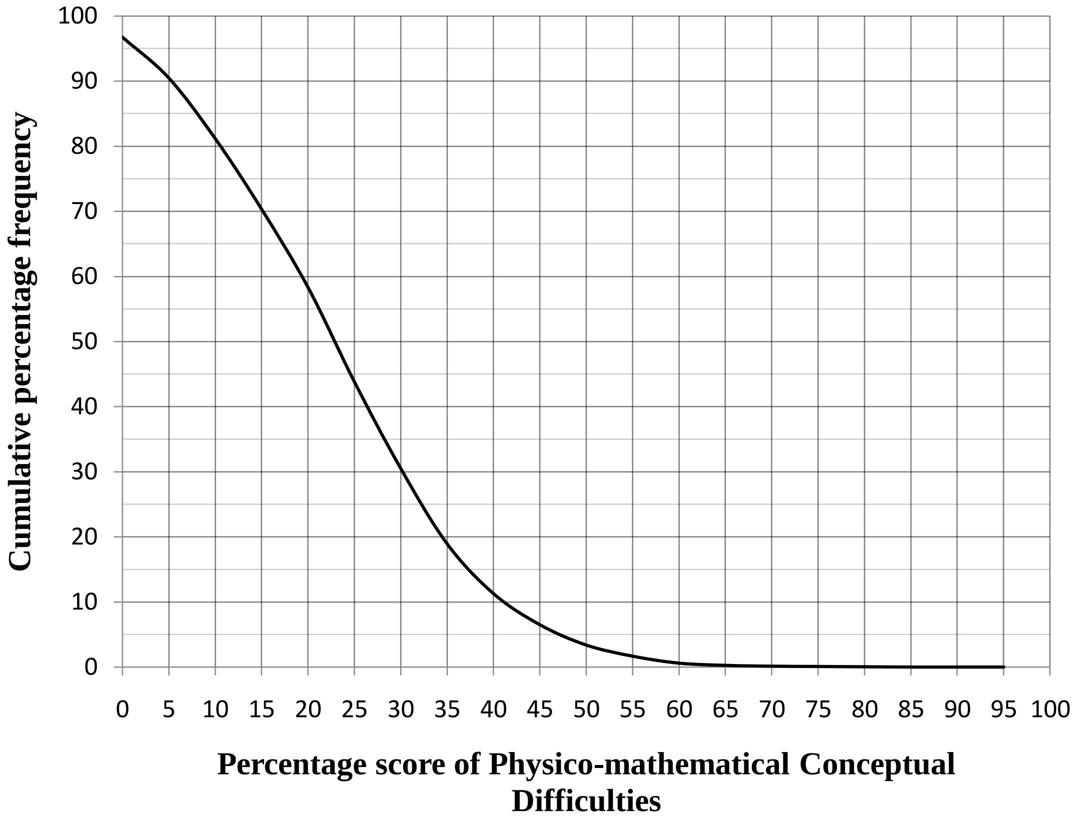


Figure 4. Greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulties

Since the investigator has to analyse the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students having no Conceptual Difficulty, the following criteria were used for interpretation. The Physico-mathematical Conceptual Difficulties is said to be high if the Percentage Score is greater than 30; it is moderate if the Percentage Score lies between 10 and 30; it is low when the Percentage Score is less than 10.

Figure 4 shows that one-fourth of the students has 32.50 percent or more Physico-mathematical Conceptual Difficulties. Half of the students have 22.50

percent or more Physico-mathematical Conceptual Difficulties. Three-fourth of the students has 12.50 percent or more Physico-mathematical Conceptual Difficulties.

This means that among the higher secondary science students who have no Conceptual Difficulty, half of them are having nearly 25 percent or more Physico-mathematical Conceptual Difficulties. This throws light on the fact that even though the students are having conceptual understanding, half of them possess only a moderate level of Physico-mathematical conceptual understanding.

D. RANKING OF SELECT CONCEPTS BASED ON THE EXTENT OF PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS

To rank the select concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students, the investigator calculated the 'Mean Percentage Score of Physico-mathematical Conceptual Difficulties' in each select concepts from 'Motion'.

The select concepts from 'Motion' were listed based on their extent of Physico-mathematical Conceptual Difficulties among higher secondary school students in Table 4.

Table 4

Mean Percentage Scores of Physico-mathematical Conceptual Difficulties in Each Select Concepts from 'Motion'

Sl. No.	Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulties
1.	Displacement	35.34
2.	Acceleration	31.77
3.	II Equation of Motion	29.23
4.	Velocity	25.51
5.	Distance	23.35
6.	Newton's Second Law of Motion	22.78
7.	Law of Conservation of Momentum	22.22
8.	Speed	15.37
9.	III Equation of Motion	2.63

From Table 4, it is clear that students possess more Physico-mathematical Conceptual Difficulties in the topic 'Displacement', followed by 'Acceleration', 'II Equation of Motion', 'Velocity', 'Distance', 'Newton's Second Law of Motion', 'Law of Conservation of Momentum', 'Speed' and 'III Equation of Motion'.

While considering the topic 'Displacement', the mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students is 35.34, which denotes that students are having a high level of Physico-mathematical Conceptual Difficulties in 'Displacement'. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in 'Displacement'.

As far as the topic ‘Acceleration’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students is 31.77. This reveals that students are having a high level of Physico-mathematical Conceptual Difficulties in ‘Acceleration’. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in ‘Acceleration’.

The mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students in the topic, ‘II Equation of Motion’, is 29.23, which conveys that students are having a moderate level of Physico-mathematical Conceptual Difficulties in ‘II Equation of Motion’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in ‘II Equation of Motion’.

While considering the topic ‘Velocity’, the mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students is 25.51. This means that students are having a moderate level of Physico-mathematical Conceptual Difficulties in ‘Velocity’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in ‘Velocity’.

As far as the topic ‘Distance’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students is 23.35, which shows that students are having a moderate level of Physico-mathematical

Conceptual Difficulties in ‘Distance’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in ‘Distance’.

The mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students in the topic ‘Newton’s Second Law of Motion’ is 22.78. This indicates that students are having a moderate level of Physico-mathematical Conceptual Difficulties in ‘Newton’s Second Law of Motion’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in ‘Newton’s Second Law of Motion’.

While considering the topic ‘Law of Conservation of Momentum’, the mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students is 22.22, which denotes that students are having a moderate level of Physico-mathematical Conceptual Difficulties in ‘Law of Conservation of Momentum’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in ‘Law of Conservation of Momentum’.

As far as the topic ‘Speed’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students is 15.37. This reveals that students are having a moderate level of Physico-mathematical Conceptual Difficulties in ‘Speed’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in ‘Speed’.

The mean percentage score of Physico-mathematical Conceptual Difficulties obtained by the students in the topic 'III Equation of Motion' is 2.63, which conveys that students are having a low level of Physico-mathematical Conceptual Difficulties in 'III Equation of Motion'. That is, the higher secondary school students who have opted science as their main stream, possess a high level of Physico-mathematical conceptual understanding in 'III Equation of Motion'.

For the easy visualization of the extent of Physico-mathematical Conceptual Difficulties among higher secondary school students in each select concepts from 'Motion', Figure 5 is given below.

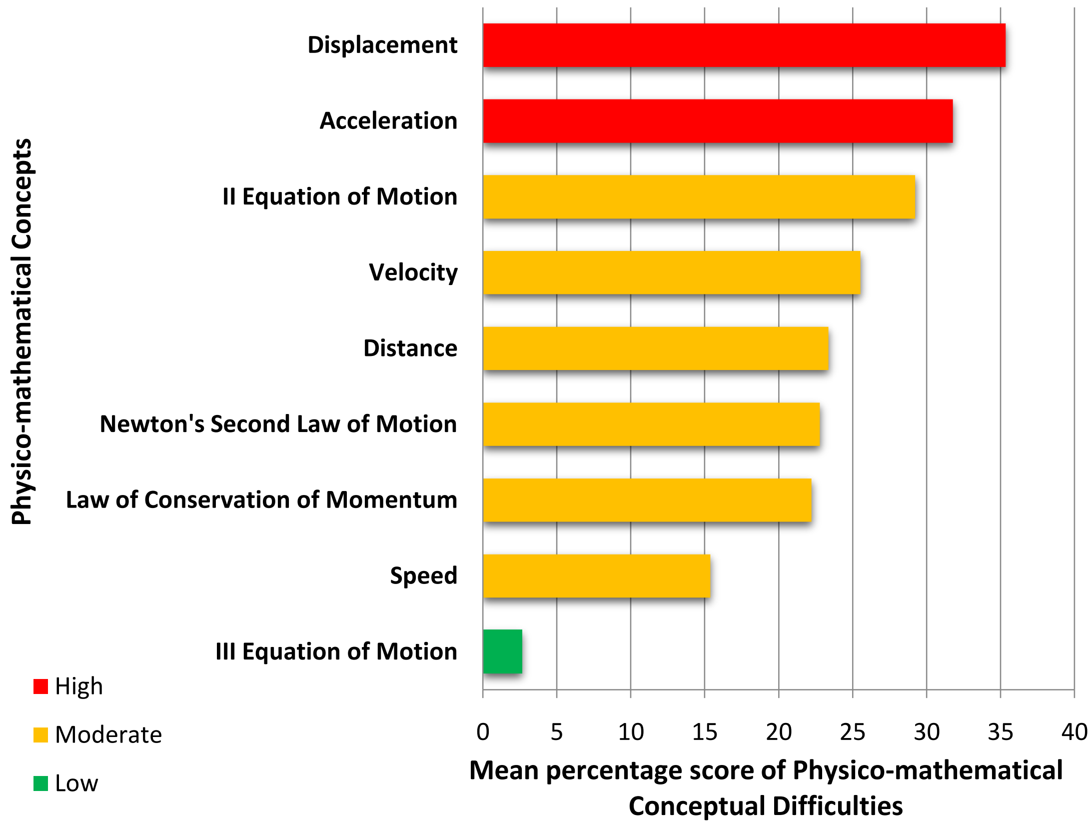


Figure 5. Extent of Physico-mathematical Conceptual Difficulties in each select concepts from 'motion'

The analysis of Figure 5 reveals that the Physico-mathematical Conceptual Difficulties is highest with the concept, 'Displacement', which is followed by 'Acceleration', 'II Equation of Motion', 'Velocity', 'Distance', 'Newton's Second Law of Motion', 'Law of Conservation of Momentum', 'Speed' and 'III Equation of Motion'.

This reveals that even though the students are from the science stream with no Conceptual Difficulty, they possess high level of Physico-mathematical Conceptual Difficulties in the topics 'Displacement' and 'Acceleration'; moderate level of Physico-mathematical Conceptual Difficulties in the topics 'II Equation of Motion', 'Velocity', 'Distance', 'Newton's Second Law of Motion', 'Law of Conservation of Momentum' and 'Speed'; low level of Physico-mathematical Conceptual Difficulties in the topic 'III Equation of Motion'.

Thus, this implies that among the higher secondary school students who have opted science as their main stream, the extent of Physico-mathematical conceptual understanding is lowest in 'Displacement' and 'Acceleration'; moderate in 'II Equation of Motion', 'Velocity', 'Distance', 'Newton's Second Law of Motion', 'Law of Conservation of Momentum' and 'Speed'; highest in 'III Equation of Motion'.

E. EXTENT OF VARIOUS CATEGORIES OF PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS

This analysis is carried out in four subsections, namely,

1. Creating or Identifying the Formula
2. Extracting Information from Diagrams or Graphs
3. Creating Schematic Diagrams or Graphs
4. Application of Mathematics

1. Creating or Identifying the Formula

a) Extent of Physico-mathematical Conceptual Difficulty among higher secondary school students in Creating or Identifying the Formula

To find out the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating or Identifying the Formula, the investigator calculated the 'Percentage Score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula'.

The greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula among higher secondary school students is given as Figure 6.

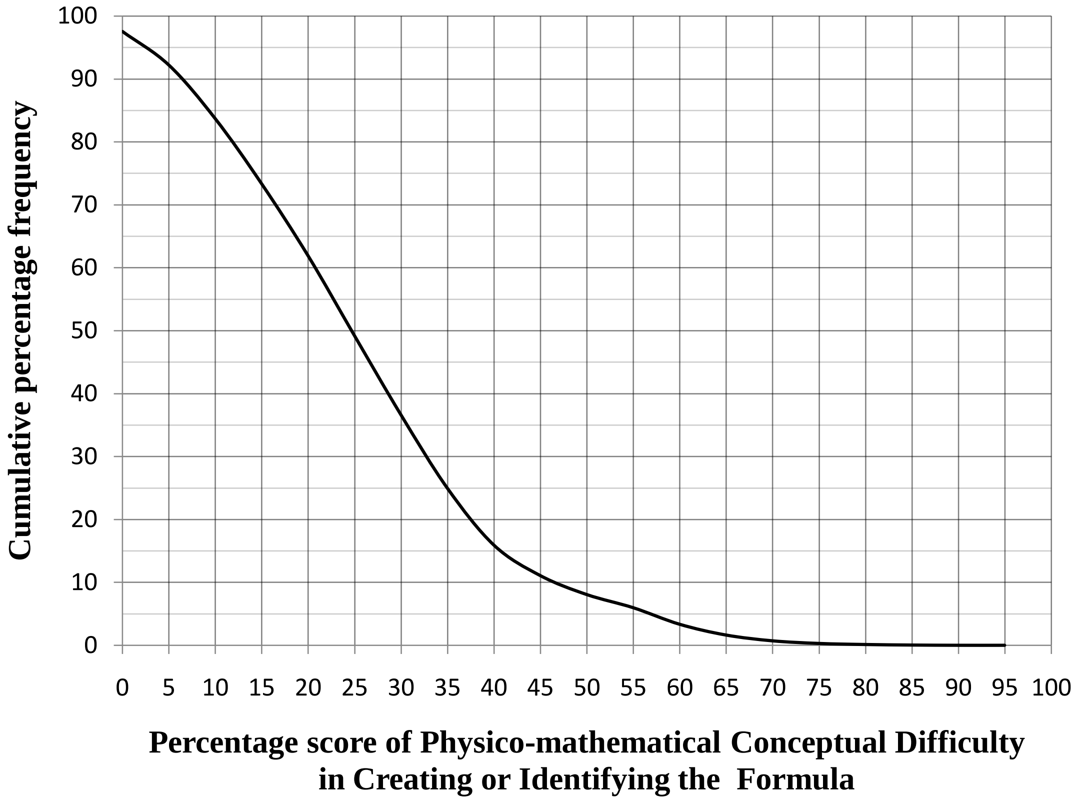


Figure 6. Greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in creating or identifying the formula

Figure 6 shows that one-fourth of the students has 35 percent or more Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula. Half of the students have 25 percent or more Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula. Three-fourth of the students has 14 percent or more Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula.

This means that among the higher secondary science students who have no Conceptual Difficulty, half of them are having 25 percent or more Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula. This throws light on the fact that even though the students are having conceptual understanding, half of the higher secondary science stream students possess only a moderate level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula.

b) Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among higher secondary school students in Creating or Identifying the Formula

To rank the extent of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating or Identifying the Formula, the investigator calculated the 'Mean Percentage Score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula' in each select concepts from 'Motion'.

The select concepts from 'Motion' were listed based on their extent of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula among higher secondary school students in Table 5.

Table 5

Mean Percentage Scores of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in Each Select Concepts from 'Motion'

Sl. No.	Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula
1.	Displacement	44.30
2.	Newton's Second Law of Motion	36.40
3.	Velocity	34.09
4.	Acceleration	27.32
5.	Distance	27.19
6.	II Equation of Motion	22.99
7.	Law of Conservation of Momentum	18.86
8.	Speed	13.41
9.	III Equation of Motion	4.01

From Table 5, it is clear that students possess more Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula with the topic 'Displacement', followed by 'Newton's Second Law of Motion', 'Velocity', 'Acceleration', 'Distance', 'II Equation of Motion', 'Law of Conservation of Momentum', 'Speed' and 'III Equation of Motion'.

While considering the topic 'Displacement', the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula, obtained by the students is 44.30. This means that students are having a high level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in 'Displacement'. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in 'Displacement'.

As far as the topic 'Newton's Second Law of Motion' is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula, obtained by the students is 36.40, which shows that students are having a high level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in 'Newton's Second Law of Motion'. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in 'Newton's Second Law of Motion'.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula, obtained by the students in the topic 'Velocity' is 34.09. This indicates that students are having a high level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in 'Velocity'. That is, the higher secondary school students who have opted science as their main stream, possess only a low level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in 'Velocity'.

While considering the topic 'Acceleration', the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula, obtained by the students is 27.32, which denotes that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the

Formula in ‘Acceleration’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in ‘Acceleration’.

As far as the topic ‘Distance’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula, obtained by the students is 27.19. This reveals that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in ‘Distance’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in ‘Distance’.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula obtained by the students in the topic ‘II Equation of Motion’ is 22.99, which conveys that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in ‘II Equation of Motion’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in ‘II Equation of Motion’.

While considering the topic ‘Law of Conservation of Momentum’, the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula, obtained by the students is 18.86. This means that students are having a moderate level of Physico-mathematical Conceptual Difficulty in

Creating or Identifying the Formula in 'Law of Conservation of Momentum'. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in 'Law of Conservation of Momentum'.

As far as the topic 'Speed' is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula obtained by the students is 13.41, which shows that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in 'Speed'. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in 'Speed'.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula, obtained by the students in the topic 'III Equation of Motion' is 4.01. This indicates that students are having a low level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in 'III Equation of Motion'. That is, the higher secondary school students who have opted science as their main stream, possess a high level of Physico-mathematical conceptual understanding in Creating or Identifying the Formula in 'III Equation of Motion'.

For the easy visualization of the extent of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula among higher secondary school students in each select concepts from 'Motion', Figure 7 is given below.

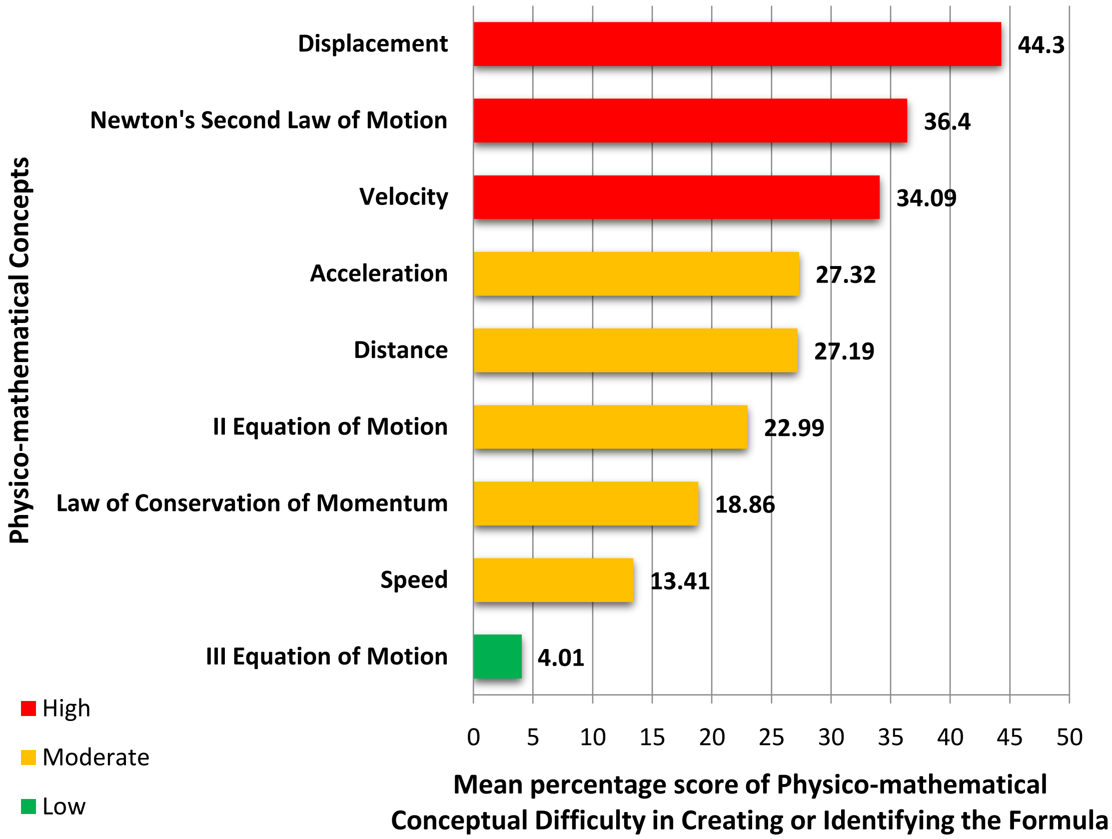


Figure 7. Extent of Physico-mathematical Conceptual Difficulty in creating or identifying the formula in each select concepts from 'motion'

The analysis of Figure 7 reveals that the Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula is highest with the concept, 'Displacement', which is followed by 'Newton's Second Law of Motion', 'Velocity', 'Acceleration', 'Distance', 'II Equation of Motion', 'Law of Conservation of Momentum', 'Speed' and 'III Equation of Motion'.

This reveals that even though the students are from the science stream with no Conceptual Difficulty, they possess high level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in the topics

'Displacement', 'Newton's Second Law of Motion' and 'Velocity'; moderate level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in the topics 'Acceleration', 'Distance', 'II Equation of Motion', 'Law of Conservation of Momentum' and 'Speed'; low level of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula in the topic 'III Equation of Motion'.

Thus, this implies that among the higher secondary school students who have opted science as their main stream, the extent of Physico-mathematical conceptual understanding in Creating or Identifying the Formula is lowest in 'Displacement', 'Newton's Second Law of Motion' and 'Velocity'; moderate in 'Acceleration', 'Distance', 'II Equation of Motion', 'Law of Conservation of Momentum' and 'Speed'; highest in 'III Equation of Motion'.

2. Extracting Information from Diagrams or Graphs

a) Extent of Physico-mathematical Conceptual Difficulty among higher secondary school students in Extracting Information from Diagrams or Graphs

To find out the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Extracting Information from Diagrams or Graphs, the investigator calculated the 'Percentage Score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs'.

The greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs among higher secondary school students is given as Figure 8.

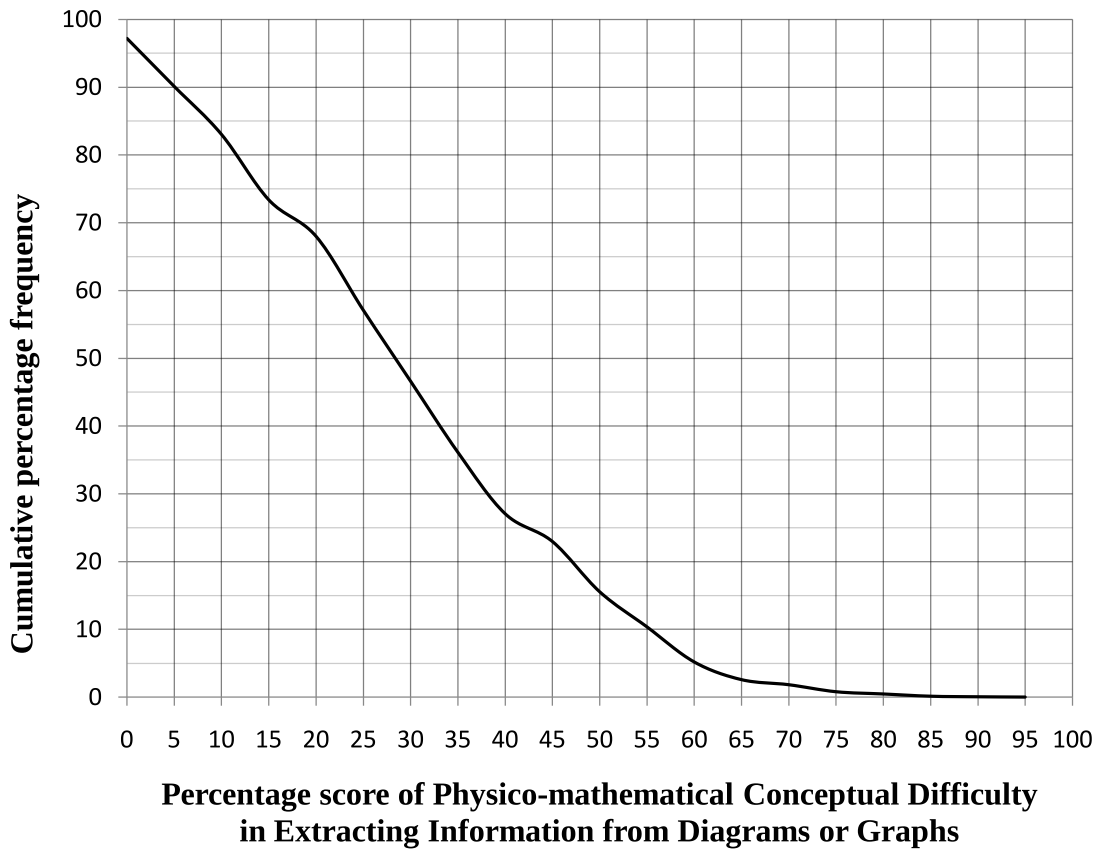


Figure 8. Greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in extracting information from diagrams or graphs

Figure 8 shows that one-fourth of the students has 42.50 percent or more Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs. Half of the students have 28 percent or more Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or

Graphs. Three-fourth of the students has 14 percent or more Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs.

This means that among the higher secondary science students who have no Conceptual Difficulty, half of them are having 28 percent or more Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs. This throws light on the fact that even though the students are having conceptual understanding, half of the higher secondary science stream students possess only a moderate level of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs.

b) Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among higher secondary school students in Extracting Information from Diagrams or Graphs

To rank the select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Extracting Information from Diagrams or Graphs, the investigator calculated the 'Mean Percentage Score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs' in each select concepts from 'Motion'.

The select concepts from 'Motion' were listed based on their extent of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs among higher secondary school students in Table 6.

Table 6

Mean Percentage Scores of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in Each Select Concepts from 'Motion'

Sl. No.	Physico-mathematical Concepts	Mean percentage score of Physico mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs
1.	Acceleration	35.96
2.	Displacement	35.59
3.	Distance	29.32
4.	Speed	26.27
5.	Newton's Second Law of Motion	23.66
6.	Velocity	20.62

From Table 6, it is clear that students possess more Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs with the topic 'Acceleration', followed by 'Displacement', 'Distance', 'Speed', 'Newton's Second Law of Motion' and 'Velocity'.

While considering the topic 'Acceleration', the mean percentage score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs, obtained by the students is 35.96, which denotes that students are having a high level of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in 'Acceleration'. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs in 'Acceleration'.

As far as the topic 'Displacement' is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs, obtained by the students is 35.59. This reveals that students are having a high level of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in 'Displacement'. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs in 'Displacement'.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs, obtained by the students in the topic 'Distance' is 29.32, which conveys that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in 'Distance'. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs in 'Distance'.

While considering the topic 'Speed', the mean percentage score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs, obtained by the students is 26.27. This means that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Extracting

Information from Diagrams or Graphs in 'Speed'. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs in 'Speed'.

As far as the topic 'Newton's Second Law of Motion' is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs, obtained by the students is 23.66, which shows that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in 'Newton's Second Law of Motion'. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs in 'Newton's Second Law of Motion'.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs, obtained by the students in the topic 'Velocity' is 20.62. This indicates that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in 'Velocity'. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs in 'Velocity'.

For the easy visualization of the extent of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs among higher secondary school students in each select Concepts from ‘Motion’, Figure 9 is given below.

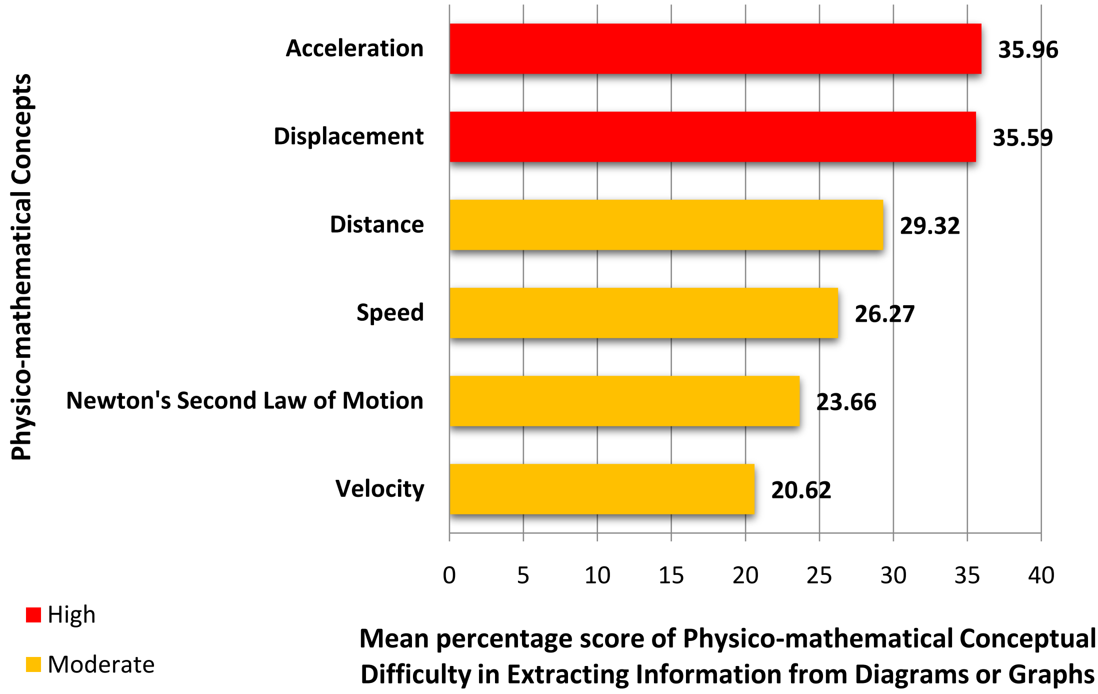


Figure 9. Extent of Physico-mathematical Conceptual Difficulty in extracting information from diagrams or graphs in each select concepts from ’motion’

The analysis of Figure 9 reveals that the Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs is highest with the concept, ‘Acceleration’, which is followed by ‘Displacement’, ‘Distance’, ‘Speed’, ‘Newton’s Second Law of Motion’ and ‘Velocity’.

This reveals that even though the students are from the science stream with no Conceptual Difficulty, they possess high level of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in the topics ‘Acceleration’ and ‘Displacement’ and moderate level of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs in the topics, ‘Distance’, ‘Speed’, ‘Newton’s Second Law of Motion’ and ‘Velocity’.

Thus, this implies that among the higher secondary school students who have opted science as their main stream, the extent of Physico-mathematical conceptual understanding in Extracting Information from Diagrams or Graphs is lowest in ‘Acceleration’ and ‘Displacement’ and moderate in ‘Distance’, ‘Speed’, ‘Newton’s Second Law of Motion’ and ‘Velocity’.

3. Creating Schematic Diagrams or Graphs

a) Extent of Physico-mathematical Conceptual Difficulty among higher secondary school students in Creating Schematic Diagrams or Graphs

To find out the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating Schematic Diagrams or Graphs, the investigator calculated the ‘Percentage Score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs’.

The greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs among higher secondary school students is given as Figure 10.

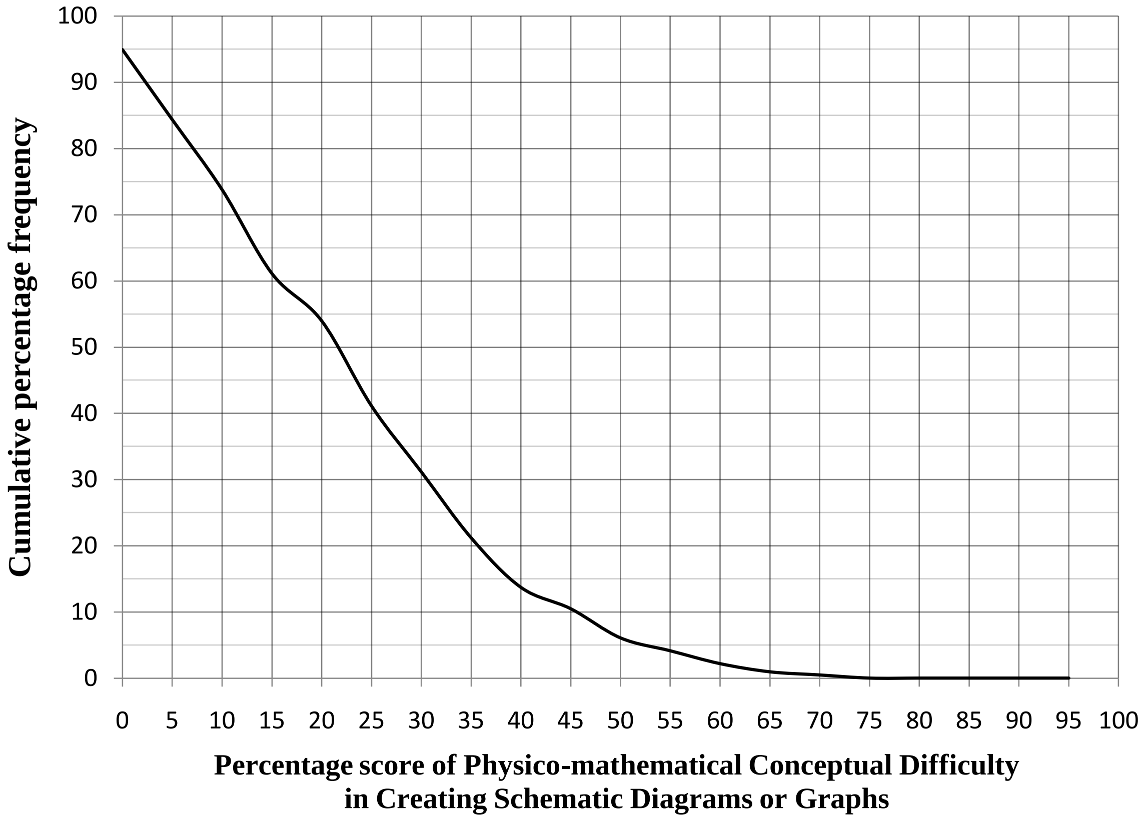


Figure 10. Greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in creating schematic diagrams or graphs

Figure 10 shows that one-fourth of the students has 32.50 percent or more Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs. Half of the students have 22 percent or more Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs. Three-fourth of the students has 9.5 percent or more Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs.

This means that among the higher secondary science students who have no Conceptual Difficulty, half of them are having 22 percent or more Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs. This throws light on the fact that even though the students are having conceptual understanding, half of the higher secondary science stream students possess only a moderate level of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs.

b) Ranking of Select Concepts based on the extent of Physico-mathematical Conceptual Difficulty among higher secondary school students in Creating Schematic Diagrams or Graphs

To rank the select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating Schematic Diagrams or Graphs, the investigator calculated the 'Mean Percentage Score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs' in each select concepts from 'Motion'.

The select concepts from 'Motion' were listed based on their extent of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs among higher secondary school students in Table 7.

Table 7

Mean Percentage Scores of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in Each Select Concepts from 'Motion'

Sl. No.	Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs
1.	Velocity	29.73
2.	Displacement	29.66
3.	Newton's Second Law of Motion	26.81
4.	Acceleration	25.89
5.	Distance	20.48
6.	Speed	3.13

From Table 7, it is clear that students possess more Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs with the topic 'Velocity', followed by 'Displacement', 'Newton's Second Law of Motion', 'Acceleration', 'Distance', and 'Speed'.

While considering the topic 'Velocity', the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs, obtained by the students is 29.73, which denotes that students are having a high level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in 'Velocity'. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs in 'Velocity'.

As far as the topic ‘Displacement’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs, obtained by the students is 29.66. This reveals that students are having a high level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in ‘Displacement’. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs in ‘Displacement’.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs, obtained by the students in the topic ‘Newton’s Second Law of Motion’ is 26.81, which conveys that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in ‘Newton’s Second Law of Motion’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs in ‘Newton’s Second Law of Motion’.

While considering the topic ‘Acceleration’, the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs, obtained by the students is 25.89. This means that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in ‘Acceleration’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs in 'Acceleration'.

As far as the topic 'Distance' is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs, obtained by the students is 20.48, which shows that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in 'Distance'. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs in 'Distance'.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs, obtained by the students in the topic 'Speed' is 3.13. This indicates that students are having a low level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in 'Speed'. That is, the higher secondary school students who have opted science as their main stream, possess a high level of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs in 'Speed'.

For the easy visualization of the extent of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs among higher secondary school students in each select concepts from 'Motion', Figure 11 is given below.

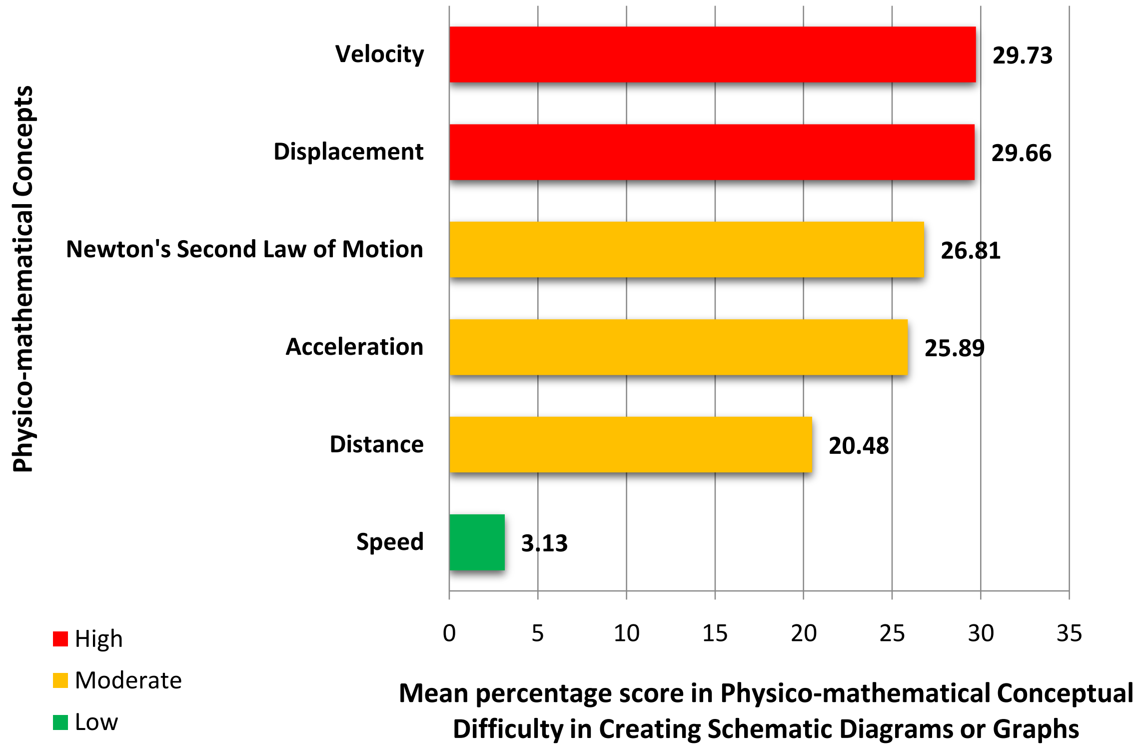


Figure 11. Extent of Physico-mathematical Conceptual Difficulty in creating schematic diagrams or graphs in each select concepts from 'motion'

The analysis of Figure 11 reveals that the Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs is highest with the concept, 'Velocity', which is followed by 'Displacement', 'Newton's Second Law of Motion', 'Acceleration', 'Distance' and 'Speed'.

This reveals that even though the students are from the science stream with no Conceptual Difficulty, they possess high level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in the topics 'Velocity' and 'Displacement'; moderate level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in the topics 'Newton's Second Law of Motion', 'Acceleration' and 'Distance'; low level of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs in the topic ‘Speed’.

Thus, this implies that among the higher secondary school students who have opted science as their main stream, the extent of Physico-mathematical conceptual understanding in Creating Schematic Diagrams or Graphs is lowest in ‘Velocity’ and ‘Displacement’; moderate in ‘Newton’s Second Law of Motion’, ‘Acceleration’ and‘Distance’; highest in ‘Speed’.

4. Application of Mathematics

a) Extent of Physico-mathematical Conceptual Difficulty among higher secondary school students in Application of Mathematics

To find out the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Application of Mathematics, the investigator calculated the ‘Percentage Score of Physico-mathematical Conceptual Difficulty in Application of Mathematics’.

The greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in Application of Mathematics among higher secondary school students is given as Figure 12.

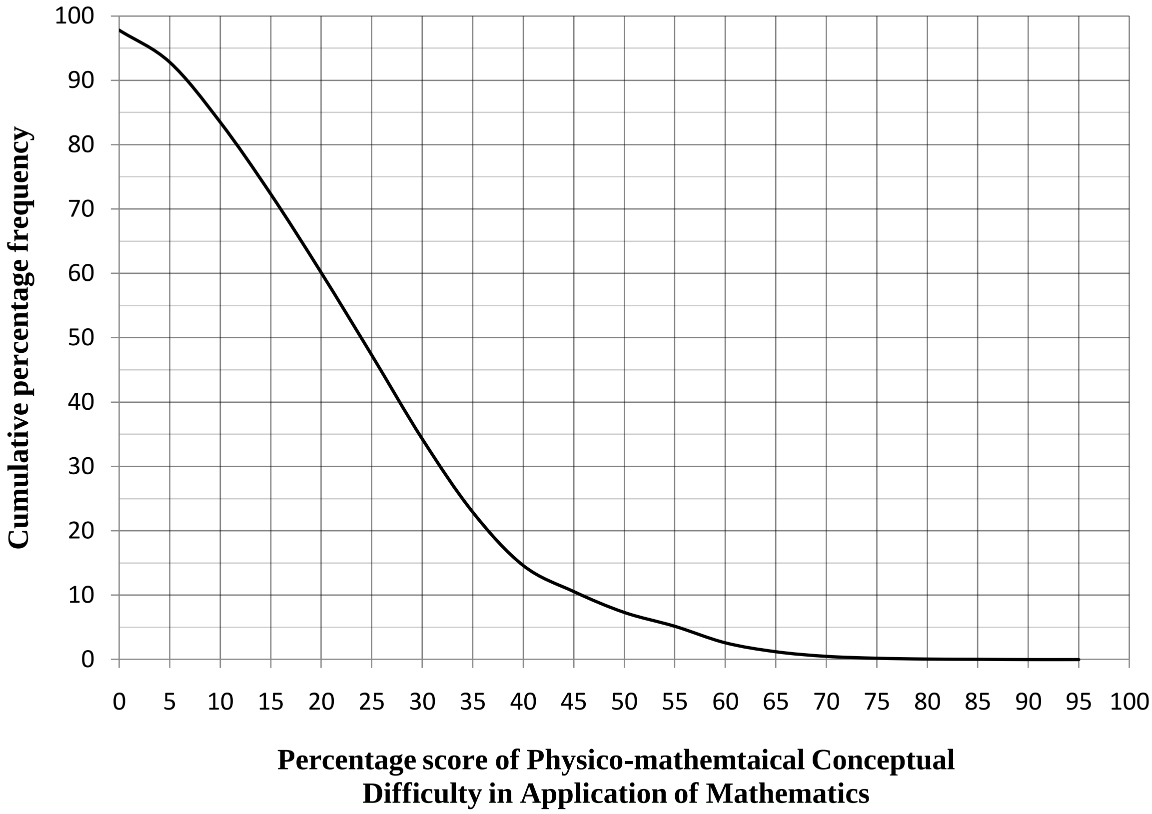


Figure 12. Greater than smoothed cumulative percentage frequency curve of Physico-mathematical Conceptual Difficulty in application of mathematics

Figure 12 shows that one-fourth of the students has 34 percent or more Physico-mathematical Conceptual Difficulty in Application of Mathematics. Half of the students have 24 percent or more Physico-mathematical Conceptual Difficulty in Application of Mathematics. Three-fourth of the students has 14 percent or more Physico-mathematical Conceptual Difficulty in Application of Mathematics.

This means that among the higher secondary science students who have no Conceptual Difficulty, half of them are having 24 percent or more Physico-mathematical Conceptual Difficulty in Application of Mathematics. This throws light on the fact that even though the students are having conceptual understanding, half of the higher secondary science stream students possess only a moderate level of Physico-mathematical conceptual understanding in Application of Mathematics.

b) Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among higher secondary School students in Application of Mathematics

To rank the select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Application of Mathematics, the investigator calculated the 'Mean Percentage Score of Physico-mathematical Conceptual Difficulty in Application of Mathematics' in each select concepts from 'Motion'.

The select concepts from 'Motion' were listed based on their extent of Physico-mathematical Conceptual Difficulty in Application of Mathematics among higher secondary school students in Table 8.

Table 8

Mean Percentage Scores of Physico-mathematical Conceptual Difficulty in Application of Mathematics in Each Select Concepts from 'Motion'

Sl. No.	Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics
1.	Acceleration	41.02
2.	Displacement	35.21
3.	II Equation of Motion	34.51
4.	Speed	29.90
5.	Law of Conservation of Momentum	25.60
6.	Distance	22.63
7.	Velocity	21.11
8.	Newton's Second Law of Motion	10.11
9.	III Equation of Motion	2.34

From Table 8, it is clear that students possess more Physico-mathematical Conceptual Difficulty in Application of Mathematics with the topic 'Acceleration', followed by 'Displacement', 'II Equation of Motion', 'Speed', 'Law of Conservation of Momentum', 'Distance', 'Velocity', 'Newton's Second Law of Motion' and 'III Equation of Motion'.

While considering the topic 'Acceleration', the mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students is 41.02, which denotes that students are having a high level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in 'Acceleration'. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘Acceleration’.

As far as the topic ‘Displacement’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students is 35.21. This reveals that students are having a high level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘Displacement’. That is, the higher secondary school students who have opted science as their main stream and with no Conceptual Difficulty, they possess only a low level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘Displacement’.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students in the topic ‘II Equation of Motion’ is 34.51, which conveys that students are having a high level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘II Equation of Motion’. That is, the higher secondary school students who have opted science as their main stream, possess only a low level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘II Equation of Motion’.

While considering the topic ‘Speed’, the mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students is 29.90. This means that students are having a high level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘Speed’. That is, the higher secondary school students who have opted science as their main stream, possess only a low level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘Speed’.

As far as the topic ‘Law of Conservation of Momentum’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students is 25.60, which shows that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘Law of Conservation of Momentum’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘Law of Conservation of Momentum’.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students in the topic ‘Distance’ is 22.63. This indicates that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘Distance’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘Distance’.

While considering the topic, ‘Velocity’, the mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students is 21.11, which denotes that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘Velocity’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘Velocity’.

As far as the topic ‘Newton’s Second Law of Motion’ is concerned, the mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students is 10.11. This reveals that students are having a moderate level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘Newton’s Second Law of Motion’. That is, the higher secondary school students who have opted science as their main stream, possess only a moderate level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘Newton’s Second Law of Motion’.

The mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics, obtained by the students in the topic ‘III Equation of Motion’ is 2.34, which conveys that students are having a low level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in ‘III Equation of Motion’. That is, the higher secondary school students who have opted science as their main stream, possess a high level of Physico-mathematical conceptual understanding in Application of Mathematics in ‘III Equation of Motion’.

For the easy visualization of the extent of Physico-mathematical Conceptual Difficulty in Application of Mathematics among higher secondary school students in each select concepts from ‘Motion’, Figure 13 is given below.

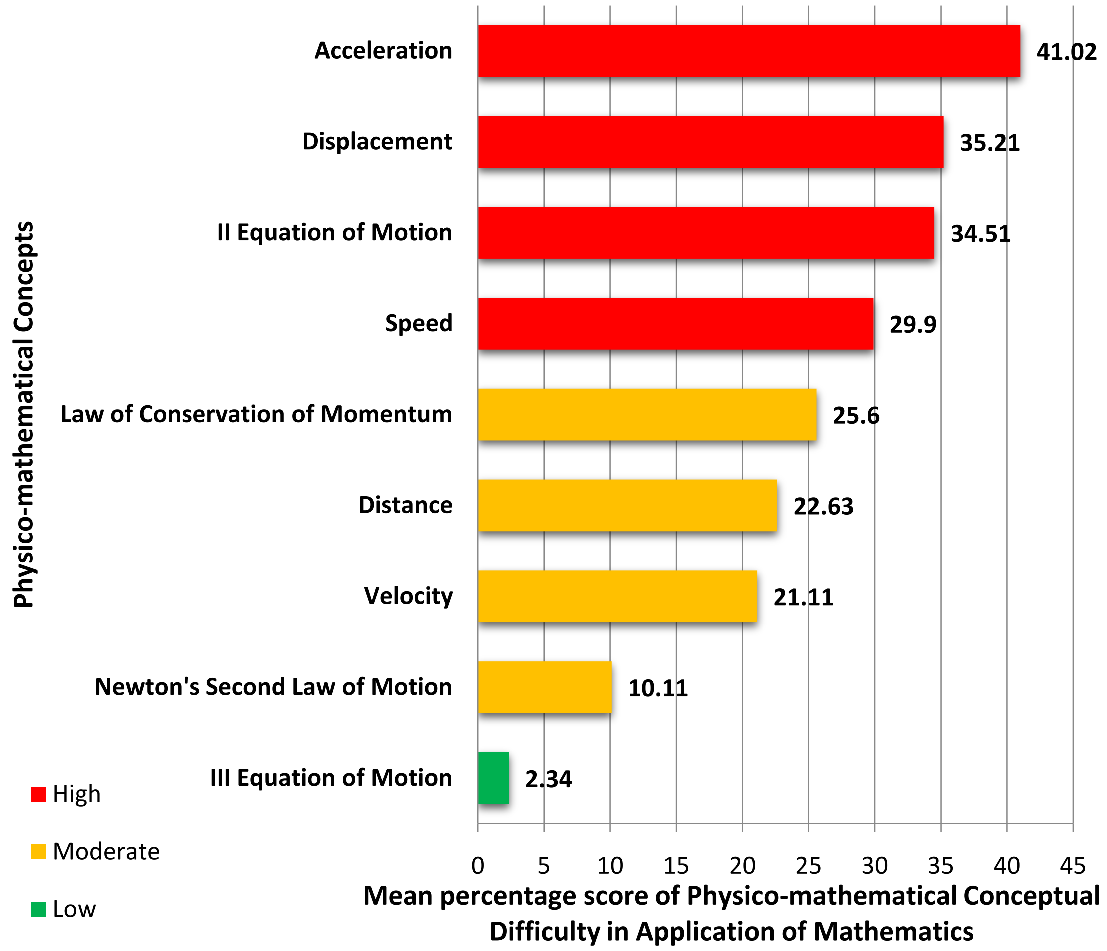


Figure 13. Extent of Physico-mathematical Conceptual Difficulty in application of mathematics in each select concepts from 'motion'

The analysis of Figure 13 reveals that the Physico-mathematical Conceptual Difficulty in Application of Mathematics is highest with the concept, 'Acceleration', which is followed by 'Displacement', 'II Equation of Motion', 'Speed', 'Law of Conservation of Momentum', 'Distance', 'Velocity', 'Newton's Second Law of Motion' and 'II Equation of Motion'.

This reveals that even though the students are from the science stream with no Conceptual Difficulty, they possess high level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in the topics ‘Acceleration’, ‘Displacement’, ‘II Equation of Motion’ and ‘Speed’; moderate level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in the topics ‘Law of Conservation of Momentum’, ‘Distance’, ‘Velocity’ and ‘Newton’s Second Law of Motion’; low level of Physico-mathematical Conceptual Difficulty in Application of Mathematics in the topic ‘III Equation of Motion’.

Thus, this implies that among the higher secondary school students who have opted science as their main stream, the extent of Physico-mathematical conceptual understanding in Application of Mathematics is lowest in ‘Acceleration’, ‘Displacement’, ‘II Equation of Motion’ and ‘Speed’; moderate in ‘Law of Conservation of Momentum’, ‘Distance’, ‘Velocity’ and ‘Newton’s Second Law of Motion’; highest in ‘III Equation of Motion’.

Major Findings

The major findings are summarized as follows.

- The extent of Conceptual Difficulty in Physics among Higher Secondary School Students is high.
- Ranking of Select Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Conceptual Difficulty
III Equation of Motion	73.86
II Equation of Motion	54.20
Law of Conservation of Momentum	53.64
Velocity	52.39
Speed	48.75
Newton’s Second Law of Motion	48.01
Distance	42.78
Acceleration	41.48
Displacement	27.95

- The extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulties
Displacement	35.34
Acceleration	31.77
II Equation of Motion	29.23
Velocity	25.51
Distance	23.35
Newton’s Second Law of Motion	22.78
Law of Conservation of Momentum	22.22
Speed	15.37
III Equation of Motion	2.63

- The extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating or Identifying the Formula is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating or Identifying the Formula is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula
Displacement	44.30
Newton's Second Law of Motion	36.40
Velocity	34.09
Acceleration	27.32
Distance	27.19
II Equation of Motion	22.99
Law of Conservation of Momentum	18.86
Speed	13.41
III Equation of Motion	4.01

- The extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Extracting Information from Diagrams and Graphs is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Extracting Information from Diagrams or Graphs is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs
Acceleration	35.96
Displacement	35.59
Distance	29.32
Speed	26.27
Newton's Second Law of Motion	23.66
Velocity	20.62

- The extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating schematic Diagrams or Graphs is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating Schematic Diagrams or Graphs is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs
Velocity	29.73
Displacement	29.66
Newton's Second Law of Motion	26.81
Acceleration	25.89
Distance	20.48
Speed	3.13

- The extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Application of Mathematics is moderate.
- Ranking of Select Concepts based on the Extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Application of Mathematics is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics
Acceleration	41.02
Displacement	35.21
II Equation of Motion	34.51
Speed	29.90
Law of Conservation of Momentum	25.60
Distance	22.63
Velocity	21.11
Newton's Second Law of Motion	10.11
III Equation of Motion	2.34

Thus, from the major findings, we can reach the conclusion that the higher secondary school students who have opted science as their main stream have a low level of conceptual understanding in Physics. Moreover, while focusing upon the higher secondary science stream students who possess complete conceptual understanding, they fail to solve mathematical problems in Physics due to their Physico-mathematical Conceptual Difficulties in Creating or Identifying the Formula, Extracting Information from Diagrams or Graphs, Creating Schematic Diagrams or Graphs and Application of Mathematics.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSION AND SUGGESTIONS

- *Study in Retrospect*
- *Variable*
- *Objectives*
- *Research Questions*
- *Methodology*
- *Major Findings*
- *Conclusion*
- *Educational Implications*
- *Suggestions for Further Research*

SUMMARY, FINDINGS, CONCLUSION AND SUGGESTIONS

This chapter provides a retrospective view of the study, major findings of the study, educational implications and suggestions for further research.

Study in Retrospect

The present investigation was entitled as PHYSICO-MATHEMATICAL CONCEPTUAL DIFFICULTIES AMONG HIGHER SECONDARY SCHOOL STUDENTS.

Variable

The major variable that was measured and analyzed in the study was Physico-mathematical Conceptual Difficulties.

Objectives

The major objective of the study was to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. This is achieved through the following minor objectives.

1. To find out the extent of Conceptual Difficulty in Physics among Higher Secondary School Students.
2. To rank the Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students.

3. To find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students.
4. To rank the concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students.
5. To find out the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
    a) Creating or Identifying the Formula
    b) Extracting Information from Diagrams or Graphs
    c) Creating Schematic Diagrams or Graphs
    d) Application of Mathematics
6. To rank the concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
    a) Creating or Identifying the Formula
    b) Extracting Information from Diagrams or Graphs
    c) Creating Schematic Diagrams or Graphs
    d) Application of Mathematics

Research Questions

In order to clarify the objectives of the study, the objectives are reframed as the following research questions.

1. What is the extent of Conceptual Difficulty in Physics among Higher Secondary School Students?
2. What is the relative position of Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students?

3. What is the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?
4. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students?
5. What is the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
   a) Creating or Identifying the Formula?
   b) Extracting Information from Diagrams or Graphs?
   c) Creating Schematic Diagrams or Graphs?
   d) Application of Mathematics?
6. What is the relative position of concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in
   a) Creating or Identifying the Formula?
   b) Extracting Information from Diagrams or Graphs?
   c) Creating Schematic Diagrams or Graphs?
   d) Application of Mathematics?

Methodology

Method of Study

Methodology deals with the precise description of method used to realize the objectives of the study. Survey method was employed in the present study.

Sample

The study was conducted on a sample of 880 students from XI standard drawn from three districts namely Malappuram, Thrissur and Palakkad using stratified sampling technique.

Tool Used for Data Collection

The tool used for data collection by the investigator for the present study was 'Physico-mathematical Conceptual Test'.

Physico-mathematical Conceptual Difficulties were identified and analyzed using a test with multiple choice questions based on the basic concepts from Physics at higher secondary level.

Statistical Techniques

The collected data were analyzed using percentage analysis.

Major Findings

The major findings are summarized as follows.

- The extent of Conceptual Difficulty in Physics among Higher Secondary School Students is high.
- Ranking of Select Physico-mathematical Concepts based on the extent of Conceptual Difficulty among Higher Secondary School Students is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Conceptual Difficulty
III Equation of Motion	73.86
II Equation of Motion	54.20
Law of Conservation of Momentum	53.64
Velocity	52.39
Speed	48.75
Newton's Second Law of Motion	48.01
Distance	42.78
Acceleration	41.48
Displacement	27.95

- The extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulties
Displacement	35.34
Acceleration	31.77
II Equation of Motion	29.23
Velocity	25.51
Distance	23.35
Newton's Second Law of Motion	22.78
Law of Conservation of Momentum	22.22
Speed	15.37
III Equation of Motion	2.63

- The extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating or Identifying the Formula is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating or Identifying the Formula is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula
Displacement	44.30
Newton's Second Law of Motion	36.40
Velocity	34.09
Acceleration	27.32
Distance	27.19
II Equation of Motion	22.99
Law of Conservation of Momentum	18.86
Speed	13.41
III Equation of Motion	4.01

- The extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Extracting Information from Diagrams and Graphs is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Extracting Information from Diagrams or Graphs is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico mathematical Conceptual Difficulty in Extracting Information from Diagrams or Graphs
Acceleration	35.96
Displacement	35.59
Distance	29.32
Speed	26.27
Newton’s Second Law of Motion	23.66
Velocity	20.62

- The extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating schematic Diagrams or Graphs is moderate.
- Ranking of select concepts based on the extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Creating Schematic Diagrams or Graphs is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Creating Schematic Diagrams or Graphs
Velocity	29.73
Displacement	29.66
Newton’s Second Law of Motion	26.81
Acceleration	25.89
Distance	20.48
Speed	3.13

- The extend of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Application of Mathematics is moderate.
- Ranking of Select Concepts based on the Extent of Physico-mathematical Conceptual Difficulty among Higher Secondary School Students in Application of Mathematics is obtained as below.

Physico-mathematical Concepts	Mean percentage score of Physico-mathematical Conceptual Difficulty in Application of Mathematics
Acceleration	41.02
Displacement	35.21
II Equation of Motion	34.51
Speed	29.90
Law of Conservation of Momentum	25.60
Distance	22.63
Velocity	21.11
Newton's Second Law of Motion	10.11
III Equation of Motion	2.34

Conclusion

The above findings help us to conclude that higher secondary school students are having Physico-mathematical Conceptual Difficulties, which can be explained as follows.

Among higher secondary school students who have opted science as their main stream, the extent of Conceptual Difficulty in Physics is high. Whereas, the extent of Physico-mathematical Conceptual Difficulties in total and in the categories, viz., Creating or Identifying the Formula, Extracting Information from Diagrams or Graphs, Creating Schematic Diagrams or Graphs and Application of Mathematics, are moderate.

The difficulty faced by higher secondary school students for each concept differ from category to category. For instance, we can see that the Conceptual Difficulty is highest in the topic 'III Equation of Motion', while it is the topic with least Physico-mathematical Conceptual Difficulty in Creating or Identifying the Formula'. For getting the summary of similar results at a glance, the ranking of select concepts based on the extent of Conceptual Difficulty, Physico-mathematical Conceptual Difficulties and its categories is given as Table 9.

Table 9

Ranking of Select Concepts Based on the Extent of Difficulty in Each Category

Conceptual Difficulty	Physico-mathematical Conceptual Difficulties	Difficulties in Creating or Identifying the Formula	Difficulties in Extracting Information from Diagrams or Graphs	Difficulties in Creating Schematic Diagrams or Graphs	Difficulties in Application of Mathematics
1. III Equation of Motion	1. Displacement	1. Displacement	1. Acceleration	1. Velocity	1. Acceleration
2. II Equation of Motion	2. Acceleration	2. Newton's Second Law of Motion	2. Displacement	2. Displacement	2. Displacement
3. Law of Conservation of Momentum	3. II Equation of Motion	3. Velocity	3. Distance	3. Newton's Second Law of Motion	3. II Equation of Motion
4. Velocity	4. Velocity	4. Acceleration	4. Speed	4. Acceleration	4. Speed
5. Speed	5. Distance	5. Distance	5. Newton's Second Law of Motion	5. Distance	5. Law of Conservation of Momentum
6. Newton's Second Law of Motion	6. Newton's Second Law of Motion	6. II Equation of Motion	6. Velocity	6. Speed	6. Distance
7. Distance	7. Law of Conservation of Momentum	7. Law of Conservation of Momentum			7. Velocity
8. Acceleration	8. Speed	8. Speed			8. Newton's Second Law of Motion
9. Displacement	9. III Equation of Motion	9. III Equation of Motion			9. III Equation of Motion

Thus, we can reach the conclusion that the higher secondary school students who have opted science as their main stream have poor level of conceptual understanding in Physics. Moreover, while focusing the higher secondary science stream students who possess a remarkable level of conceptual understanding, they tend to fail in dealing with mathematical problems in Physics due to their Physico-mathematical Conceptual Difficulties in Creating or Identifying the Formula, Extracting Information from Diagrams or Graphs, Creating Schematic Diagrams or Graphs and Application of Mathematics.

Educational Implications

Physics is considered to be one of the difficult disciplines by the school students. This difficulty is even more evident in their low achievement in the subject. Students find the involvement of mathematical principles and operations in Physics as the most likely one among the pool of reasons for their underperformance.

The investigator attempts to find out the extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students. One of the major findings of the study revealed that the extent of Conceptual Difficulty among higher secondary school students who have opted Science as their main stream is high. It is quite pathetic that the students who had encountered with the basic concepts of ‘Motion’ (which the investigator has employed in this study) in their high school Physics, does not possess the basic level of conceptual understanding in those topics even in their higher secondary stage. Also, the fact that these students have opted science stream in spite of this backwardness, cannot be ignored.

This study also highlights that, even if the higher secondary science stream students with complete conceptual understanding are solely taken into consideration, the extent of Physico-mathematical Conceptual Difficulties in all categories, viz., Creating or Identifying the Formula, Extracting Information from Diagrams or Graphs, Creating Schematic Diagrams or Graphs and Application of Mathematics, is moderate. This proves that it is the need of the hour to rethink upon the various aspects regarding the transaction of Physics concept, laws and principles in the secondary and higher secondary stages of schooling.

In short, as far as Physics discipline taught in schools is concerned, it deals mainly with the basic concrete concepts upon which the higher order abstract concepts have to be laden as the student advances to higher classes. So, it is very important to ensure that the footing of conceptual understanding is strong enough to build up the pillars of knowledge and its efficient transfer to various situations of problem solving in life.

Based on the findings of the study, the investigator puts forward following suggestions to improve the Physics teaching and learning in the school level.

Innovative Techniques and Strategies for Transaction of Physics Concepts and its Mathematization

The most important factor that would contribute to reduce the gap between the students' level of performance in Physics and the expected level is to enhance the teaching technique employed by the teachers in the classroom. There is a strong necessity of suitable strategies to cover most of the conceptual difficulties and troubles in problem-solving in Physics learning.

Students develop more understanding of Physics concepts when learning is performed through sensori-motor activities and visual imageries. Especially, in the case of teaching basic Physics concepts in upper primary and high school classes, the teachers should incorporate voice-over simulations and animation softwares. These techniques can have a tight hold upon the attention span of students, better than that of the explanations given by the teachers, as they sets up an environment of virtual reality in the classrooms. Also, it has to be noted that even high-level theoretical concepts can be comprehended with ease in these cases.

The same is the case during transaction of mathematical aspects in Physics. Well-designed instructional approach by incorporating technology for the teaching and learning can inculcate positive impacts on students' mathematical understanding in the subject, specifically like, usage of formulas, graphs, diagrams and solving of equations.

So, efforts have to be made in employing those techniques that will help the students perform experiments or visualize the concepts, which would impart more meaningful and active learning by allowing construction of knowledge by themselves. In this regard, teachers should also make sure that the students enjoy the teaching-learning sessions and ascertain the learning of difficult concepts in Physics.

Interdisciplinary Instructions in Physics and Mathematics

Physics and Mathematics are two deeply interwoven domains in Science. But students are completely unaware about this fact. The students see these two disciplines as poles apart. Therefore, they don't even think about applying the principles, operations and procedures that they have studied in their Mathematics classes into solving Physics problems. So, we need to blend Physics and Mathematics in such a way that it would render to the efficient problem-solving in Physics.

To avoid the isolation of these two disciplines from one another during instructional process, specialization based team teaching can be employed, so that the teachers handling both disciplines can go hand-in-hand and plan instructions which are interdisciplinary in nature. Physics teachers can plan the instructions regarding the conceptual areas in Physics, while the teachers dealing with Mathematics can involve completely in the procedural skills in the discipline such as reading and construction of graphs, mathematical figures and diagrams and simplification of equations. Thus, the best utilization of the available human resources, in terms of subject specialization enables the students to have a better understanding of how topics fit together as well as greater confidence in problem solving.

Life-related Instructional Strategy in Physics

Every concept taught in Physics has to be linked with the real life situations familiar to the students. The teachers also have to make students aware about the significance and need of learning concepts in Physics and where they have to be applied mathematically in their daily life activities. Once the learner identifies the need of learning, they will give upon the habit of memorization of the theories and principles. So, instructions related to everyday activities of the students would render to the development of proper attitude towards these subjects.

Proper Assessment of Entry Behavior of Higher Secondary Students

The entry behavior of higher secondary school students should be properly assessed and appropriate prerequisites have to be set in accordance with the level of the students' capabilities before the execution of instructional process. Physics teachers are meant to identify the basic conceptual foundations which the students possess regarding the topics in high school stage, before teaching the theories and principles in higher secondary Physics. This is applicable to Mathematics teaching also, but in most cases the teachers does not bother to do so.

Failure in adequate assessment of entry behavior and prior knowledge may become unfavorable for the students to learn and may result in teacher's failure in accomplishment of the goals and instructional objectives. Without proper understanding of the past knowledge, it will be difficult for the students to progress ahead, thus, hindering the vertical transfer of knowledge. Hence, it is very well required to clear doubts regarding the past learned related concepts for thorough understanding of the new concepts.

Remedial Assistance

It is clear from the analysis of data in this study that the higher secondary science stream students have poor level of conceptual understanding in Physics. So, special treatments such as further tutorial sessions are required by the students especially to build the understanding of basic concepts, application of laws, theories and principles with main focus on mathematical problem-solving and also in correcting their misconceptions. The weaknesses of the pupil in executing mathematical procedures like solving equations and geometrical problems also have to be pinpointed in the remedial sessions in Mathematics.

Raise the Level of Attention to be laid on Mathematical Problem-solving

Physics teachers in high school usually have the tendency to put sufficiently more effort in transacting the theory portions in the classrooms and smoothly ignore the application level problems in connection with the concepts taught. Their explanation is that the proportion of questions asked during the examinations in high school level from mathematical problem solving is very less compared to that of theory. Consequently, the students misunderstand that their focus should be more on concepts, not on its applications. This results in their downtrodden mathematical skills in dealing with Physics problems.

Therefore, similar to that of concept or theory learning, equal weightage and importance should be laid down in practicing problem based exercises in the classroom, from high school stage onwards so that students become more familiarized with application of Mathematics in Physics problems which is very important for higher education in the discipline.

Provision for Regular Practice on Mathematical Problem-solving

Students are to be provided with enough exposure to mathematical problem-solving in Physics, with regular revision and practice of procedures towards formulation of solution. The translation of Physics concepts to mathematical representations like graphs or diagrams and the drawing out of physical interpretations from mathematical expressions like formulas have to be highlighted, transacted and practiced with utmost care so that the students' difficulties in dealing with mathematical problems in the subject should be brought to an end. Formative assessments must be strengthened by providing more problem-solving drills, exercises, home works and assignments and to maximize the time required to the meet the needs of the students in learning Physics.

Provision for Strict and Systematic Monitoring of Mathematical Problem-solving Activities

Students are to be monitored in each and every step in problem solving so as to derive at the precise solution to the mathematical Physics problems. Sufficient attention should be directed to foster the ability of the student to plan for problem solving and to execute it efficiently. Students should be taught first how to convert the questions to symbolic representations using alphabetical notations and diagrams, and only then to proceed with pure mathematical simplifications and calculations to reach the solution. If this is not done properly in the early stages of Physics education, the pupils tend to become progressively more confused and will fail in dealing with mathematical problem solving experiences in the subject.

Encourage Utilization of Resources at School

Students should be encouraged to utilize the opportunity to read textbooks and references in the library to the maximum extent and to participate in club activities related to science-math quiz contests, open forums, seminars and discussions connecting Mathematics and Physics and similar events. This would enable the students to bridge between the two disciplines in a fruitful manner.

Exposure to Mathematical Problem-solving in Physics through MOODLE

As far as the teaching of Physics at higher secondary level is concerned, it is quite difficult for the teacher to provide individual assistance to students, without singling out even one of them. In the Kerala situation, the higher secondary school teachers are already burdened with the exhaustive subject area to be taught to a wide student group in a comparatively less span of time. In such a circumstance, the distribution of simulations and interactive multimedia packages on the concepts in Physics along with the mathematical practice exercises and worksheets on MOODLE platform will be a boon for all the students who find it difficult to learn solving of problems in a logically systematic way.

Learners are also meant to be encouraged to reflect upon their ability to tackle mathematical problems in Physics, which would help to carry themselves to the outset of self-learning and self-evaluation, which is possible through MOODLE. For this purpose, the students have to be motivated to make proper use of leisure time in exploring higher order mathematical problems and puzzles in Physics which have to be updated constantly by the teacher in this open-source learning platform.

Develop Interest and Attitude towards the Discipline

When teaching, pupils' feelings are very important, since it have a deep effect on the amount of work, the effort to be put forth and the learning that has to be occurred. This reveals that it is the responsibility of teachers to foster interest and positive attitude of the student in learning Physics through deliberate efforts in teaching. This can be ensured by incorporating ICT and multimedia in the process of instruction and evaluation.

Awareness of Parents about the Aptitude of the Learner

Last of all, among the reasons for Physics being tough to learn, there is the lack of interest and aptitude towards Science and Mathematics among learners. As far as Kerala context is taken into consideration, there are enough chances for students being compelled to get enrolled in Science streams by their parents. So, it becomes important to make parents aware about the fact that their wards will be able to perform only in their areas of interest and the learner's aptitude is one of the significant predictors to their achievement in respective subjects.

Suggestions for Further Research

The findings of the study helped the investigator for suggesting the following areas of future research.

- An Investigation on the Factors Affecting Physico-mathematical Conceptual Abilities among Higher Secondary School Students
- A Study on the Adversities faced by Higher Secondary School Teachers in Transaction of Mathematical Problems in Physics
- Preparation of Self-learning Module to Enhance Physico-mathematical Conceptual Understanding in 'Motion' for IX Standard Students
- Preparation of Module on 'Motion' for In-service Teacher Training Programme highlighting the Interrelationship of Physics and Mathematics

- A Comparative Study on the Extent of Physico-mathematical Conceptual Difficulties among Higher Secondary School Students based on Gender and Board of Qualifying Examination

- A Correlational Study on the Attitude of Higher Secondary School Students towards Physics and Mathematics Learning.

- An Exploration into the Factors Affecting Enrolment, Aptitude and Performance in Physics among Higher Secondary School Students

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APPENDICES

APPENDIX - I

FAROOK TRAINING COLLEGE, CALICUT

PHYSICO-MATHEMATICAL CONCEPTUAL TEST

Dr. MUMTHAS N. S.
Associate Professor
Farook Training College

SHYMA USMAN ABDULLA
M. Ed. Student
Farook Training College

…………………………………………………………………………………………

Maximum Marks: 78

INSTRUCTIONS FOR THE CANDIDATE Time: 100 Minutes

This is a test to identify Physico-mathematical Conceptual Difficulties. This test consists of seventy (70) multiple choice type questions, out of which the candidate would be required to answer all the questions. Separate response sheet is provided to mark the answers. Each question has four alternative responses: (a), (b), (c) and (d), out of which only one is correct. The candidates have to mark the response by putting a tick mark (✓) on the correct option against each item. Example: ⓐ ⓑ✓ ⓒ ⓓ where (b) is the correct response. The results of this test will be only used for research purpose.

Note: Question numbers 19, 25, 30, 41 and 61 have sub-sections.

…………………………………………………………………………………………

1. Total length of the path travelled by a moving body.

   a) Distance
   c) Velocity
   b) Displacement
   d) Speed

ചലിക്കുന്ന ഒരു വസ്തു സഞ്ചരിച്ച പാതയുടെ ആകെ നീളം.

a) ദൂരം c) പ്രവേഗം

b) സ്ഥാനാന്തരം d) വേഗത

2. Which of the following statements is true?

   a) Displacement is always same as distance.

   b) The actual length of the path covered by the body is called displacement.

   c) Displacement is either equal to or greater than distance.

   d) Displacement is a vector quantity.

താഴെ കൊടുത്തിരിക്കുന്ന പ്രസ്താവനകളിൽ ശരിയായത് ഏത്?

   a) ദൂരവും സ്ഥാനന്തരവും എപ്പോഴും തുല്യമായിരിക്കും.

   b) ചലിക്കുന്ന ഒരു വസ്തു സഞ്ചരിച്ച പാതയുടെ യഥാർത്ഥ നീളത്തെ സ്ഥാനാന്തരം എന്നു വിളിക്കുന്നു.

   c) സ്ഥാനാന്തരം ദൂരത്തിനു തുല്യമോ അല്ലെങ്കിൽ കൂടുതലോ ആയിരിക്കും.

   d) സ്ഥാനാന്തരം ഒരു സദിശ അളവാണ്.

3. The shortest separation between the initial position and final position of a body in motion.

   a) Distance c) Velocity

   b) Displacement d) Speed

ചലിക്കുന്ന ഒരു വസ്തുവിന്റെ ആദ്യസ്ഥാനവും അന്ത്യസ്ഥാനവും തമ്മിലുള്ള ഏറ്റവും ചെറിയ അകലം.

a) ദൂരം c) പ്രവേഗം

b) സ്ഥാനാന്തരം d) വേഗത

4. Which of the following statements is not true?

   a) Speed is the ratio of distance travelled and the time taken to cover that distance.

   b) In non-uniform motion, speed of an object is not constant.

   c) Speed is the rate of change of displacement.

   d) Speed is a scalar quantity.

താഴെ കൊടുത്ത വിവരണങ്ങളിൽ ശരിയല്ലാത്തത് ഏത്?

a) സഞ്ചരിച്ച ദൂരവും, അതിനെടുത്ത സമയവും തമ്മിലുള്ള പരിമാണമാണ് വേഗത.

b) അസമചലനത്തിൽ വസ്തുവിന് സമവേഗതയല്ല.

c) സ്ഥാനന്തരമാറ്റത്തിന്റെ നിരക്കാണ് വേഗത.

d) വേഗത അദിശ അളവാണ്.

5. Displacement per unit time gives

   a) Speed c) Velocity

   b) Uniform speed d) Acceleration

യൂണിറ്റ് സമയത്തിലുണ്ടായ സ്ഥാനാന്തരമാണ്

a) വേഗത c) പ്രവേഗം

b) സമവേഗത d) ത്വരണം

6. Which of the following statements is not true?

   a) Distance is a scalar quantity.

   b) Distance can be equal to displacement.

   c) Distance is completely dependent on the path covered by the moving body.

   d) The distance-time graph is a straight line parallel to distance axis when the object is at rest.

താഴെ കൊടുത്ത വിവരണങ്ങളിൽ ശരിയല്ലാത്തത് ഏത്?

a) ദൂരം ഒരു അദിശ അളവാണ്.

b) ദൂരം സ്ഥാനാന്തരത്തോട് തുല്യമാവാം.

c) ദൂരം വസ്തു സഞ്ചരിക്കുന്ന പാതയെ മുഴുവനായി ആശ്രയിക്കുന്നു.

d) വസ്തു നിശ്ചലാവസ്ഥയിലായിരിക്കുമ്പോൾ ദൂര-സമയ ഗ്രാഫ് ദൂരത്തിൻറെ അക്ഷത്തിനു സമാന്തരമായിരിക്കും.

7. The rate of change of distance is ……………

   a) Change in distance c) Velocity

   b) Speed d) Change in velocity

ദൂരമാറ്റത്തിന്റെ നിരക്കാണ്

a) ദൂരമാറ്റം
b) വേഗത
c) പ്രവേഗം
d) പ്രവേഗമാറ്റം

8. If the change in velocity of a moving body is equal in equal intervals of time, the body is having

a) Uniform velocity
b) Uniform speed
c) Uniform acceleration
d) Non-uniform acceleration

ചലിക്കുന്ന ഒരു വസ്തുവിന്റെ പ്രവേഗമാറ്റത്തിന്റെ അളവ് തുല്യസമയ ഇടവേളകളിൽ തുല്യമായിരിക്കുമ്പോൾ, ആ വസ്തുവിന് .... ആണ്.

a) സമപ്രവേഗം
b) സമവേഗത
c) സമത്വരണം
d) അസമ ത്വരണം

9. Which of the following statements is true?

a) Velocity is independent of direction of motion.
b) Average velocity of a body is the total distance travelled divided by the total time taken.
c) Distance per unit time gives velocity.
d) SI unit of velocity is same as that of speed.

താഴെ കൊടുത്ത പ്രസ്താവനകളിൽ ശരിയായത് ഏത്?

a) പ്രവേഗം ചലനത്തിന്റെ ദിശയെ ആശ്രയിക്കുന്നില്ല.

b) സഞ്ചരിച്ച ആകെ ദൂരത്തിന്റെയും, സഞ്ചരിക്കാനെടുത്ത ആകെ സമയത്തിന്റെയും ഹരണഫലമാണ് ശരാശരി പ്രവേഗം.

c) യൂണിറ്റ് സമയം കൊണ്ടു സഞ്ചരിച്ച ദൂരമാണ് പ്രവേഗം.

d) പ്രവേഗത്തിന്റെ SI അടിസ്ഥാന യൂണിറ്റ് വേഗതയുടേതിനു തുല്യമാണ്.

10. Which of the following is known as position-time relation?

a) $s + \frac{1}{2}at^2 = ut$

b) $v^2 - u^2 = 2as$

c) $s = ut + \frac{1}{2}at^2$

d) Both (a) and (c)

താഴെ കൊടുത്തിരിക്കുന്നവയിൽ സ്ഥാന-സമയ സമവാക്യം ഏത്?

a) $s + \frac{1}{2}at^2 = ut$

b) $v^2 - u^2 = 2as$

c) $s = ut + \frac{1}{2}at^2$

d) (a)ഉം (c)ഉം

11. The sum of momentum of the two objects before collision is equal to the sum of momentum after the collision provided there is no external unbalanced force acting on them. This is the statement of

a) Newton’s second law of motion

b) Law of conservation of force

c) Law of conservation of force and momentum

d) Law of conservation of momentum

ബാഹ്യബലമില്ലെങ്കിൽ, രണ്ടു വസ്തുക്കൾ ഇടിക്കുന്നതിനു മുമ്പുള്ള ആകെ ആക്കവും ഇടിച്ചതിനു ശേഷമുള്ള ആകെ ആക്കവും തുല്യമാണ്. ഇത് ഏത് നിയമമാണ്?

a) ന്യൂട്ടന്റെ രണ്ടാം ചലനനിയമം

b) ബലസംരക്ഷണനിയമം

c) ബല-ആക്ക സംരക്ഷണനിയമം

d) ആക്കസംരക്ഷണനിയമം

12. What would be the acceleration of a moving body, if the mass were doubled, keeping the force acting upon it the same?

a) Will remain the same
c) Will become zero
b) Will be doubled
d) Will be halved

ഒരു വസ്തുവിൽ പ്രയോഗിക്കപ്പെടുന്ന ബലത്തിൽ മാറ്റം വരുത്താതെ അതിന്റെ മാസിനെ ഇരട്ടിപ്പിച്ചാൽ ത്വരണം എത്രയായിമാറും?

a) മാറ്റം വരില്ല
c) പൂജ്യമാകും
b) ഇരട്ടിക്കും
d) പകുതിയാകും

13. The relation connecting initial velocity, acceleration, the distance covered and the time of motion is

a) Velocity-time relation
c) Velocity-position relation
b) Position-time relation
d) Newton’s second law of motion

ആദ്യപ്രവേഗം, ത്വരണം, ദൂരം, ചലനത്തിനെടുത്ത സമയം എന്നിവയെ ബന്ധിപ്പിക്കുന്ന സമവാക്യം ഏത്?

a) പ്രവേഗ-സമയ സമവാക്യം

b) സ്ഥാന-സമയ സമവാക്യം

c) പ്രവേഗ-സ്ഥാന സമവാക്യം

d) ന്യൂട്ടൺന്റെ രണ്ടാം ചലന നിയമം

14. The rate of change of velocity of an object in motion is known as ………..

a) Displacement

b) Uniform velocity

c) Non-uniform speed

d) Acceleration

ചലിക്കുന്ന ഒരു വസ്തുവിന്റെ പ്രവേഗമാറ്റത്തിന്റെ നിരക്കാണ് ....

a) സ്ഥാനാന്തരം

b) സമപ്രവേഗം

c) അസമപ്രവേഗം

d) ത്വരണം

15. A large truck and a car have a head on collision. Which of the following statements is true?

a) Car will have greater momentum change than truck.

b) Truck will have greater momentum change than car.

c) Both the vehicles experience same momentum change.

d) Acceleration experienced by the truck will be greater than that of the car.

ഒരു വലിയ ട്രക്കും ഒരു കാറും കൂട്ടിയിടിക്കുന്നു. താഴെ കൊടുത്ത വിവരണങ്ങളിൽ ശരിയായത് ഏത്?

a) കാറിന്റെ ആക്കവ്യത്യാസം ട്രക്കിനേക്കാൾ അധികമായിരിക്കും.

b) ട്രക്കിന്റെ ആക്കവ്യത്യാസം കാറിനേക്കാൾ അധികമായിരിക്കും.

c) രണ്ടു വാഹനങ്ങളും ഒരേ ആക്കവ്യത്യാസം അനുഭവപ്പെടും.

d) ട്രക്കിന്റെ ത്വരണം കാറിനേക്കാൾ അധികമായിരിക്കും.

16. Which of the following is known as velocity-position relation?

a) $v^2 - u^2 = 2as$
b) $(v - u)(v + u) = at \times \frac{2s}{t}$
c) $u^2 - v^2 = 2as$
d) Both (a) and (b)

താഴെ കൊടുത്തിരിക്കുന്നവയിൽ പ്രവേഗ-സ്ഥാന സമവാക്യം ഏത്?

a) $v^2 - u^2 = 2as$
b) $(v - u)(v + u) = at \times \frac{2s}{t}$
c) $u^2 - v^2 = 2as$
d) (a)ഉം (b)ഉം

17. Which law states that ‘the rate of change of momentum of a body is directly proportional to the force and takes place in the same direction as force’?

a) Law of conservation of force
b) Newton’s first law of motion
c) Newton’s second law of motion
d) Newton’s third law of motion

‘ഒരു വസ്തുവിലുണ്ടാകുന്ന ആക്കവ്യത്യാസത്തിന്റെ നിരക്ക് ആ വസ്തുവിൽ പ്രയോഗിക്കുന്ന അസന്തുലിത ബാഹ്യബലത്തിന് നേർ അനുപാതത്തിലായിരിക്കും.’ ഇത് ഏത് നിയമമാണ്?

a) ബലസംരക്ഷണനിയമം

b) ന്യൂട്ടന്റെ ഒന്നാം ചലനനിയമം

c) ന്യൂട്ടന്റെ രണ്ടാം ചലന നിയമം

d) ന്യൂട്ടന്റെ മൂന്നാം ചലന നിയമം

18. If the initial velocity of a body is zero, distance covered can be directly calculated from given acceleration and final velocity using ……………………

a) Velocity-time relation

b) Position-time relation

c) Velocity-position relation

d) Combining (b) and (c)

ആദ്യപ്രവേഗം പൂജ്യമായിരിക്കെ, തന്നിരിക്കുന്ന ത്വരണത്തിൽ നിന്നും അന്ത്യപ്രവേഗത്തിൽ നിന്നും സഞ്ചരിച്ച ദൂരം നേരിട്ടു കണക്കാക്കാൻ സഹായിക്കുന്ന സമവാക്യം ഏത്?

a) പ്രവേഗ-സമയ സമവാക്യം

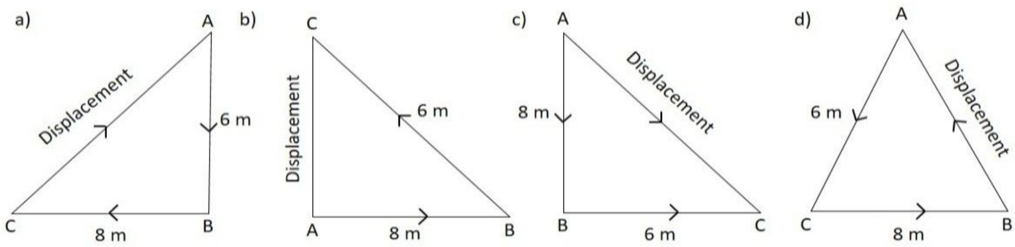
b) സ്ഥാന-സമയ സമവാക്യം

c) പ്രവേഗ-സ്ഥാന സമവാക്യം

d) (b)ഉം (c)ഉം യോജിപ്പിച്ചുകൊണ്ട്

19. A body travels a distance of 8m from A to B and then moves a distance of 6m at right angles to AB.

i. Which of the following diagrams represent the displacement correctly?



ii. Which of the following formulae represent the magnitude of the resultant displacement?

a) $\sqrt{6^2 - 8^2}$ m   c) $(8^2 + 6^2)^{\frac{1}{2}}$ m

b) $\sqrt{8^2 - 6^2}$ m   d) $(8^2 + 6^2)^{\frac{1}{3}}$ m

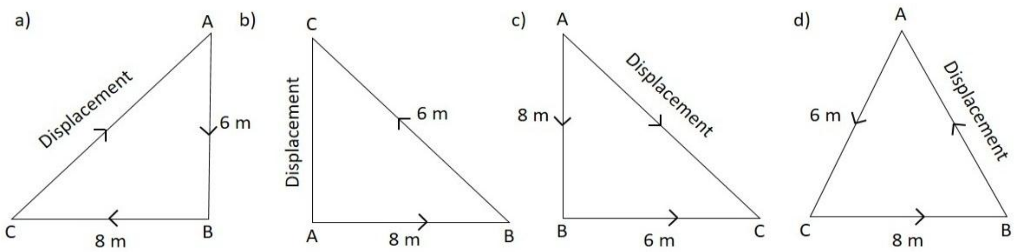
iii. The magnitude of displacement is ………………………

a) 10m   c) 13m

b) 12m   d) 15m

ഒരു വസ്തു A എന്ന ബിന്ദുവിൽ നിന്ന് B എന്ന ബിന്ദുവിലേക്ക് 8m സഞ്ചരിച്ചതിനു ശേഷം 6m AB യിൽ നിന്നും കുത്തനെ സഞ്ചരിക്കുന്നു. എങ്കിൽ

i. താഴെ കൊടുത്ത ചിത്രങ്ങളിൽ സ്ഥാനാന്തരത്തെ ശരിയായി കാണിക്കുന്ന ചിത്രം ഏത്?



ii. സ്ഥാനാന്തരം കണ്ടുപിടിക്കാനുള്ള സൂത്രവാക്യം ഏത്?

a) $\sqrt{6^2 - 8^2}$ m

b) $\sqrt{8^2 - 6^2}$ m

c) $(8^2 + 6^2)^{\frac{1}{2}}$ m

d) $(8^2 + 6^2)^{\frac{1}{3}}$ m

iii. സ്ഥാനാന്തരം എത്ര?

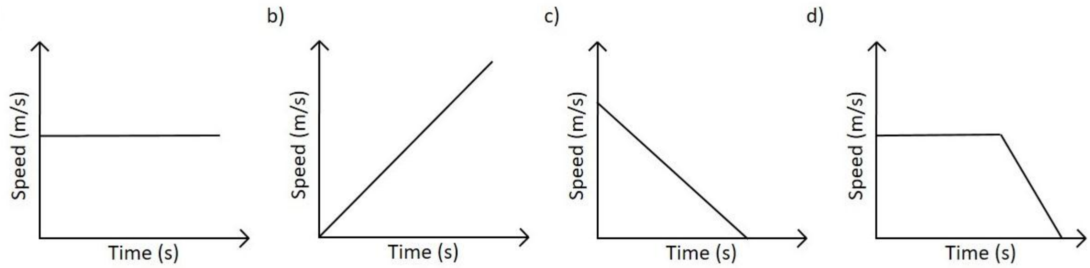
a) 10m

b) 12m

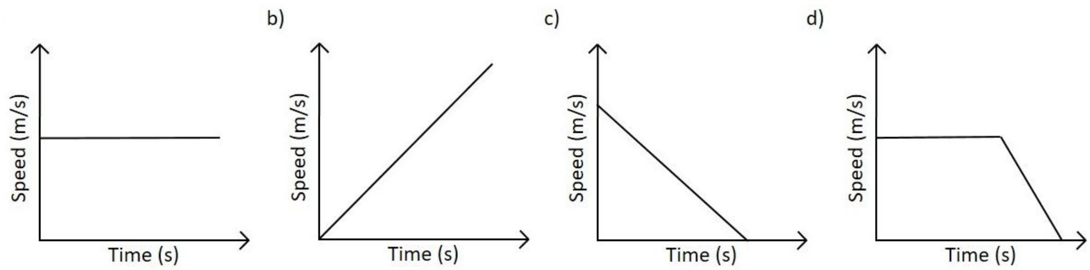
c) 13m

d) 15m

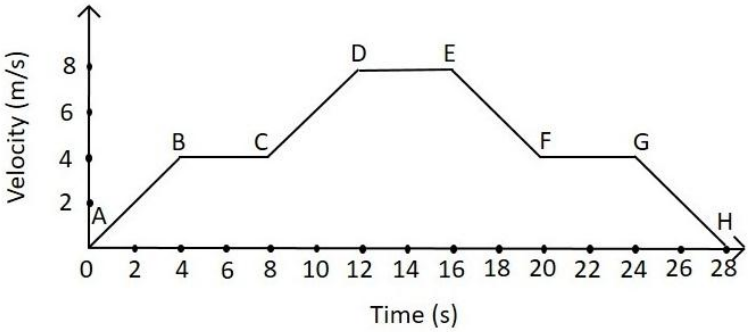
20. Which of the following graphs show increasing speed with time?



സമയത്തിനനുസരിച്ച് കൂടുന്ന വേഗത വിശേഷിപ്പിക്കുന്ന ഗ്രാഫ് ഏത്?



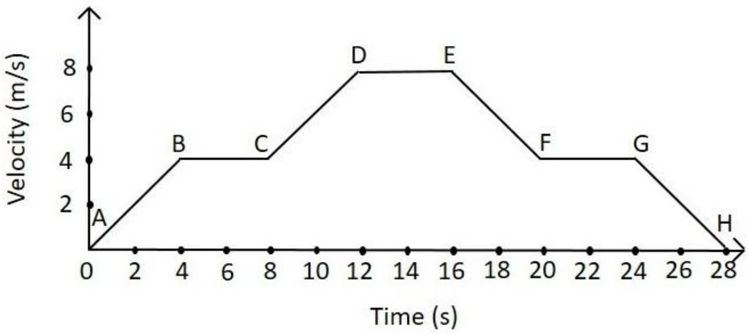
21. Analyze the given graph and choose the best option that represents accelerated motion.



a) A to D   c) E to H

b) CD and GH   d) BC, DE and FG

താഴെ കൊടുത്തിരിക്കുന്ന ഗ്രാഫ് വിശകലനം ചെയ്ത്, തന്നിരിക്കുന്നവയിൽ ഏതാണ് ത്വരണത്തെ വിശേഷിപ്പിക്കുന്ന ഏറ്റവും ഉചിതമായ ഓപ്ഷൻ എന്നു കണ്ടെത്തുക.



a) A തൊട്ടു D വരെ   c) E തൊട്ടു H വരെ

b) CD യും GH ഉം   d) BC, DE, FG

22. A stone is thrown vertically upward with an initial velocity of 40m/s. Find the maximum height reached by the stone.

a) 40m   c) 80m

b) 60m   d) Data is insufficient for the calculation

ഭൂമിയ്ക്ക് ലംബമായി ഒരു കല്ല് മുകളിലേക്ക് എറിയപ്പെടുന്നു. അതിന്റെ ആദ്യ പ്രവേഗം 40m/s ആണെങ്കിൽ ആ കല്ലിനു എത്താൻ കഴിയുന്ന പരമാവധി ഉയരമെത്ര?

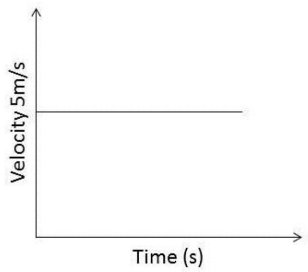
a) 40m

b) 60m

c) 80m

d) തന്നിരിക്കുന്ന വിവരങ്ങൾ അപര്യാപ്തമാണ്

23. Velocity-time graph of a moving particle of mass 2kg is shown below.



What is the force acting on the body?

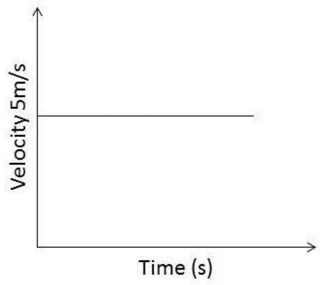
a) 0N

b) 2.5N

c) 10N

d) The force cannot be found out due to inadequate data.

2kg മാസുള്ള ഒരു വസ്തുവിന്റെ പ്രവേഗ-സമയ ഗ്രാഫാണ് താഴെ കൊടുത്തിരിക്കുന്നത്.



വസ്തുവിൽ പ്രയോഗിക്കപ്പെടുന്ന ബലം എത്ര?

a) 0N

b) 2.5N

c) 10N

d) തന്നിരിക്കുന്ന വിവരണങ്ങൾ അപര്യാപ്തമായതിനാൽ ബലം കണ്ടെത്താനാകില്ല.

24. Two objects of masses 1kg and 2kg are moving along the same line and direction with velocities of 2m/s and 1m/s respectively. They collide and after the collision, the first object moves with a velocity of 1.5m/s. Determine the velocity of the second object.

a) (2 + 2 - 1.5) m/s

b) (1.5 – 2+2) m/s

c) [$\frac{2+2-1.5}{2}$] m/s

d) [$\frac{1.5-2+2}{2}$] m/s

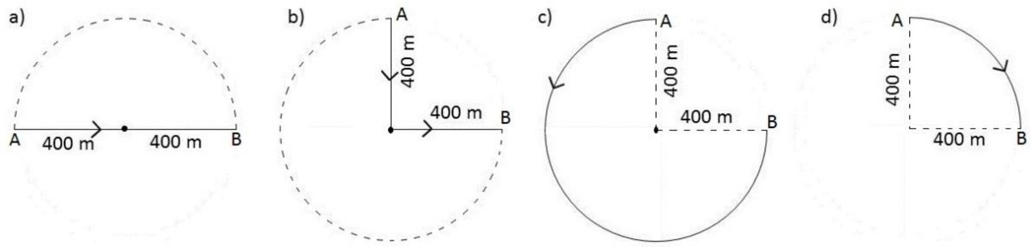
1kg, 2kg മാസുകളുള്ള രണ്ടു വസ്തുക്കൾ യഥാക്രമം 2m/s , 1m/s പ്രവേഗങ്ങളിൽ ഒരേ നേർരേഖയിലും ഒരേ ദിശയിലും സഞ്ചരിച്ചു കൊണ്ടിരിക്കെ കൂട്ടിയിടിക്കുന്നു. അതിനു ശേഷം ഒന്നാമത്തെ വസ്തു 1.5m/s പ്രവേഗത്തിൽ ചലിക്കുന്നുവെങ്കിൽ രണ്ടാമത്തെ വസ്തുവിന്റെ പ്രവേഗം കണക്കാക്കുക.

a) (2 + 2 - 1.5) m/s   c) [$\frac{2+2-1.5}{2}$] m/s

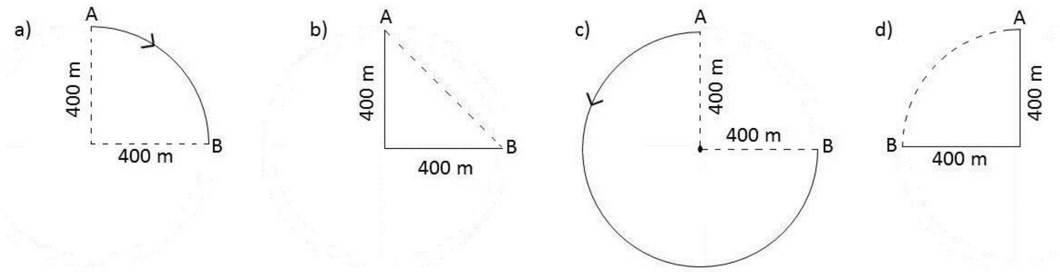
b) (1.5 – 2+2) m/s   d) [$\frac{1.5-2+2}{2}$] m/s

25. A cyclist travels $\frac{3}{4}$ of a circular track from A to B. The radius of the circular track is 400m.

i. If the distance is represented with solid line, which of the following diagrams is correct?



ii. If the displacement is represented with dotted line, which of the following diagrams is correct?



iii. What is the distance travelled by the cyclist?

a) $\frac{3}{4} \times 2 \times \frac{22}{7} \times 400$ m   c) $\frac{1}{4} \times 2 \times \frac{22}{7} \times 400$ m

b) $\frac{3}{4} \times 2 \times \frac{22}{7} \times (400 + 400)$ m   d) $\frac{1}{2} \times 2 \times \frac{22}{7} \times 400$ m

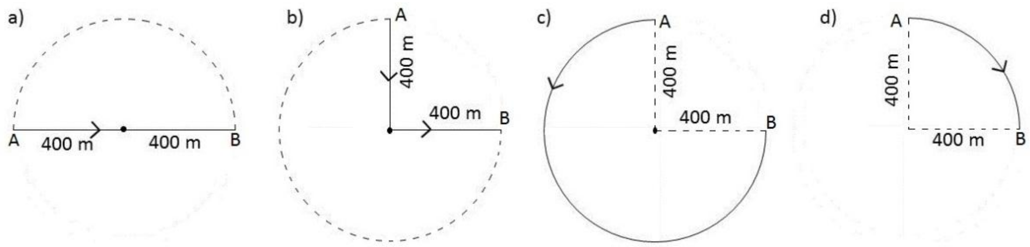
iv. What is the displacement?

a) $\sqrt{800}$ m c) $400\sqrt{2}$ m

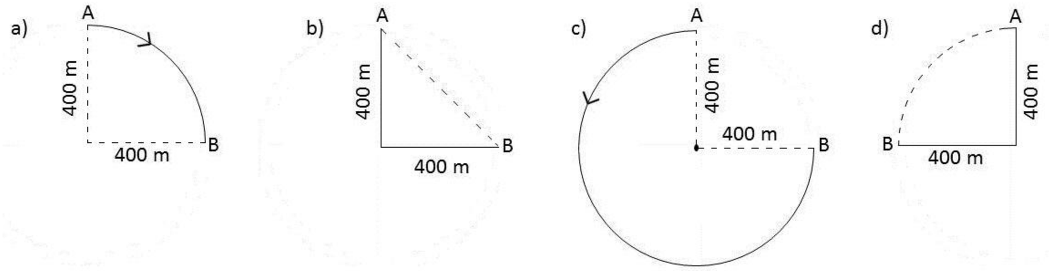
b) $\sqrt{400^2}$ m d) 800 m

ഒരു സൈക്കിൾ യാത്രികൻ വൃത്താകൃതിയിലുള്ള ഒരു പാതയുടെ $\frac{3}{4}$ ഭാഗം (Aയിൽ നിന്ന് Bയിലേക്ക്) സഞ്ചരിക്കുന്നു. പാതയുടെ ആരം 400 m ആണ്.

i. ദൃഢരേഖയിലൂടെ ദൂരത്തെ വിശേഷിപ്പിക്കുകയാണെങ്കിൽ താഴെ കാണിച്ച ചിത്രങ്ങളിൽ ശരിയായത് ഏത്?



ii. ഡോട്ടെട് ലൈൻ ഉപയോഗിച്ച് സ്ഥാനാന്തരത്തെ വിശേഷിപ്പിച്ചിരിക്കുന്നു. എങ്കിൽ താഴെ കാണിച്ച ചിത്രങ്ങളിൽ ശരിയായത് ഏത്?



iii. സൈക്കിൾ യാത്രികൻ സഞ്ചരിച്ച ദൂരമെത്ര?

a) $\frac{3}{4} \times 2 \times \frac{22}{7} \times 400$ m c) $\frac{1}{4} \times 2 \times \frac{22}{7} \times 400$ m

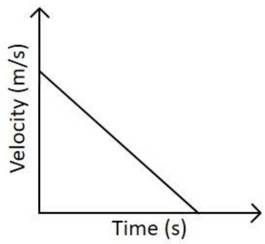
b) $\frac{3}{4} \times 2 \times \frac{22}{7} \times (400 + 400)$ m d) $\frac{1}{2} \times 2 \times \frac{22}{7} \times 400$ m

iv. സ്ഥാനാന്തരം എത്ര?

a) $\sqrt{800}$ m c) $400\sqrt{2}$ m

b) $\sqrt{400^2}$ m d) 800 m

26. The given velocity- time graph represents



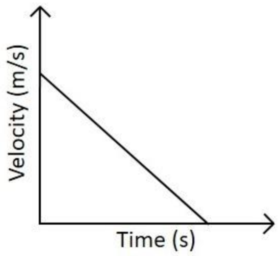
a) Constant Velocity

b) The change in velocity of a body thrown vertically upwards.

c) The change in velocity of a stone dropped from a height.

d) Increasing velocity with time.

തന്നിരിക്കുന്ന പ്രവേഗ-സമയ ഗ്രാഫ് വിശേഷിപ്പിക്കുന്നത്



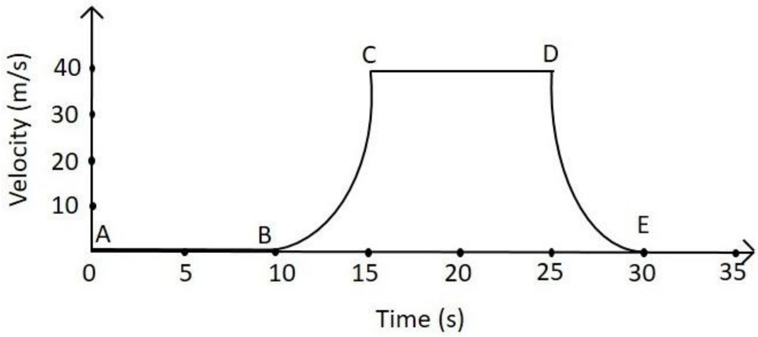
a) സ്ഥിരപ്രവേഗത്തെയാണ്.

b) ലംബമായി മുകളിലേക്ക് എറിയപ്പെട്ട വസ്തുവിന്റെ പ്രവേഗമാറ്റത്തെയാണ്.

c) ഭൂമിയിൽ നിന്ന് ഒരു നിശ്ചയ ഉയരത്തിൽ നിന്നും താഴേക്കു വീഴുന്ന ഒരു കല്ലിന്റെ പ്രവേഗമാറ്റത്തെയാണ്.

d) സമയത്തിനനുസരിച്ചു കൂടുന്ന പ്രവേഗത്തെയാണ്.

27. Identify the part of the graph where the object has zero acceleration.



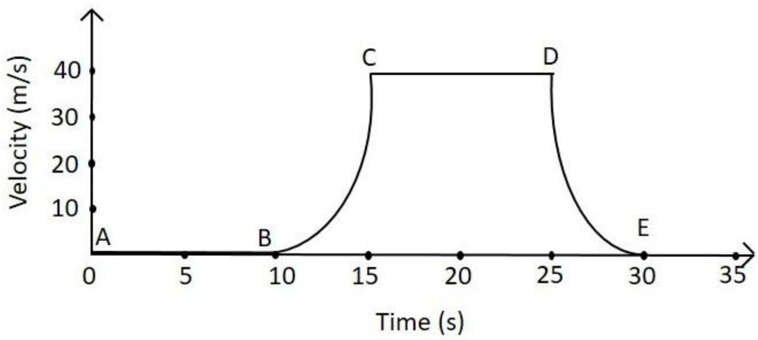
a) CD

b) DE

c) Both AB and CD

d) Both BC and DE

താഴെ കൊടുത്തിരിക്കുന്ന ഗ്രാഫിൽ ഏതു ഭാഗമാണ് വസ്തുവിന്റെ ത്വരണം പൂജ്യമായി കാണിച്ചിട്ടുള്ളത്?



a) CD

b) DE

c) AB യും CD യും

d) BC യും DE യും

28. A cheetah can accelerate from rest at the rate of 4m/s^2. If it attains a velocity of 40m/s in 10s, how far will it travel in this duration?

a) $\frac{40 \times 40}{2 \times 4}$ km

b) (40 × 4 ×10) m

c) $\frac{40^2}{4 \times 10}$ m

d) $\frac{40 \times 40}{2 \times 4}$ m

നിശ്ചലാവസ്ഥയിൽ നിന്നും 4m/s^2 എന്ന നിരക്കിലാണ് പുള്ളിപ്പുലിയുടെ ത്വരണം. 10sec നുള്ളിൽ അതിന്റെ പ്രവേഗം 40m/s ആകുന്നുവെങ്കിൽ, ഈ കാലയളവിൽ അതിന് സഞ്ചരിക്കാവുന്ന ദൂരമെത്ര?

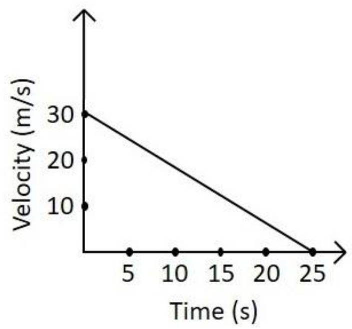
a) $\frac{40 \times 40}{2 \times 4}$ km

b) (40 × 4 ×10) m

c) $\frac{40^2}{4 \times 10}$ m

d) $\frac{40 \times 40}{2 \times 4}$ m

29. Velocity-time graph of a body of 50kg rolling on a floor is given below.



Find the positive force acting on the body.

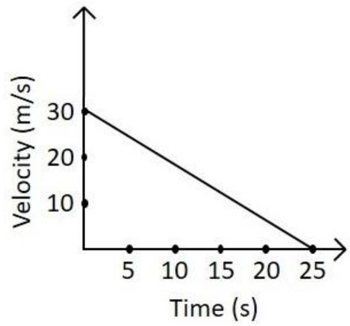
a) The force cannot be found out due to insufficient data.

b) 25N

c) 30N

d) 60N

നിലത്തു ഉരുളുന്ന 50 kg മാസുള്ള ഒരു വസ്തുവിന്റെ പ്രവേഗ-സമയ ഗ്രാഫാണ് താഴെ കൊടുത്തിട്ടുള്ളത്.



വസ്തുവിൽ പ്രയോഗിക്കപ്പെടുന്ന പോസിറ്റീവ് ബലം എത്ര?

a) തന്നിരിക്കുന്ന വിവരണങ്ങൾ അപര്യപ്തമായതിനാൽ ബലം കണ്ടെത്താനാകില്ല.

b) 25N

c) 30N

d) 60N

30. A gun of mass 4kg fires a bullet of 10g with a speed of 100m/s in the forward direction.

i. Find the total momentum of the gun-bullet system.

a) 0kgm/s
c) 2.5kgm/s
b) 0.4kgm/s
d) 25kgm/s

ii. Find the recoil velocity of the gun.

a) [$\frac{10 \times 100}{4}$] m/s
c) [$\frac{4 \times 100}{10}$] m/s
b) [$\frac{0.01 \times 100}{4}$] m/s
d) [$\frac{4 \times 100}{0.01}$] m/s

4kg മാസുള്ള ഒരു തോക്കിൽ നിന്നും 100m/s വേഗതയിൽ 10g മാസുള്ള വെടിയുണ്ട മുൻപിലേക്ക് പായുന്നു.

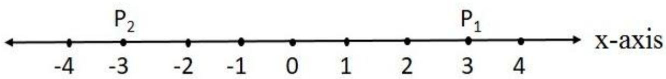
i. വെടിവെക്കുന്നതിനു മുൻപ് തോക്ക്-വെടിയുണ്ട വ്യൂഹത്തിന്റെ ആകെ ആക്കം എത്ര?

a) 0kgm/s
c) 2.5kgm/s
b) 0.4kgm/s
d) 25kgm/s

ii. തോക്കിന്റെ റീകോയിൽ പ്രവേഗം എത്ര?

a) $[\frac{10 \times 100}{4}]$ m/s
c) $[\frac{4 \times 100}{10}]$ m/s
b) $[\frac{0.01 \times 100}{4}]$ m/s
d) $[\frac{4 \times 100}{0.01}]$ m/s

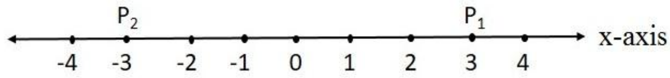
31. Consider the situation shown in figure below:



The x- axis is in metres. Which of the following statements is correct?

a) The position of the particle when it is at P_1 is 3m and when it is at P_2 is -3m.
b) The two positions are not same as they are in different directions.
c) The distances of the particle from the origin in the two positions are same.
d) All the above.

താഴെ കൊടുത്ത ചിത്രം വിശകലനം ചെയ്യുക.



x-അക്ഷം മീറ്ററിലാണ് രേഖപ്പെടുത്തിയിട്ടുള്ളത്. തന്നിരിക്കുന്ന പ്രസ്താവനകളിൽ ശരിയായത് ഏത്?

a) വസ്തുവിന്റെ സ്ഥാനം P_1ൽ 3m ഉം P_2 ൽ -3m ഉം ആണ്.

b) ഇരുദിശകളിലായതിനാൽ രണ്ടു സ്ഥാനങ്ങളും വ്യത്യാസമാണ്.

c) വസ്തുവിന്റെ ദൂരം ആധാരബിന്ദുവിൽ നിന്നു രണ്ടു സ്ഥാനങ്ങളിലേക്കും തുല്യമാണ്.

d) മുകളിൽ പറഞ്ഞവയെല്ലാം.

32. Orbit of an artificial satellite at distance 42260km from earth is circular. It completes one revolution around the earth in 24hrs. Its speed will be ……………..

a) [$\frac{3.14 \times 42260}{2 \times 24}$] m/s c) [$\frac{2 \times 3.14 \times 42260}{24}$] m/s

b) [$\frac{3.14 \times 42260}{2 \times 24}$] km/hr d) [$\frac{2 \times 3.14 \times 42260}{24}$] km/hr

ഭൂമിയിൽ നിന്നു 42260km ദൂരത്തുള്ള കൃത്രിമമായ ഉപഗ്രഹത്തിന്റെ ഭ്രമണപഥം വൃത്താകൃതിയിലാണ്. 24hrs കൊണ്ടു ഒരു പ്രാവശ്യം ഭൂമിയെ വലം വെക്കുകയാണെങ്കിൽ ഉപഗ്രഹത്തിന്റെ വേഗതയെത്ര?

a) [$\frac{3.14 \times 42260}{2 \times 24}$] m/s c) [$\frac{2 \times 3.14 \times 42260}{24}$] m/s

b) [$\frac{3.14 \times 42260}{2 \times 24}$] km/hr d) [$\frac{2 \times 3.14 \times 42260}{24}$] km/hr

33. A car starting from rest moves with a uniform acceleration of 2m/s^2 for 5min. The final velocity of the car will be

a) 2.5m/s c) 10m/s

b) 7m/s d) 600m/s

നിശ്ചലാവസ്ഥയിൽ നിന്നു ഒരു കാർ 2m/s^2 സമത്വരണത്തിൽ 5min നേരത്തേക്ക് സഞ്ചരിക്കുന്നു. കാറിന്റെ അന്ത്യപ്രവേഗം എത്രയെന്ന് കണക്കാക്കുക.

a) 2.5m/s c) 10m/s

b) 7m/s d) 600m/s

34. Find the time within which a car with acceleration of 0.05m/s^2 comes to rest after moving a distance of 100m.

a) $[\frac{2\times100}{0.5}]^{\frac{1}{2}}$ sec c) (2×100×0.5) sec

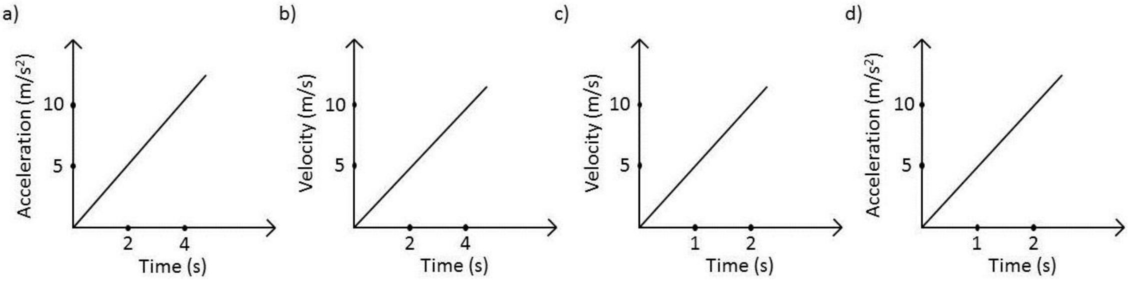
b) $[\frac{100}{2\times0.5}]$ sec d) (100×0.5) sec

0.05m/s^2 ത്വരണത്തിൽ സഞ്ചരിച്ചിരുന്ന കാർ 100m സഞ്ചരിച്ചു കൊണ്ടു നിശ്ചലാവസ്ഥയിലെത്താനെടുത്ത സമയം കണക്കാക്കുക.

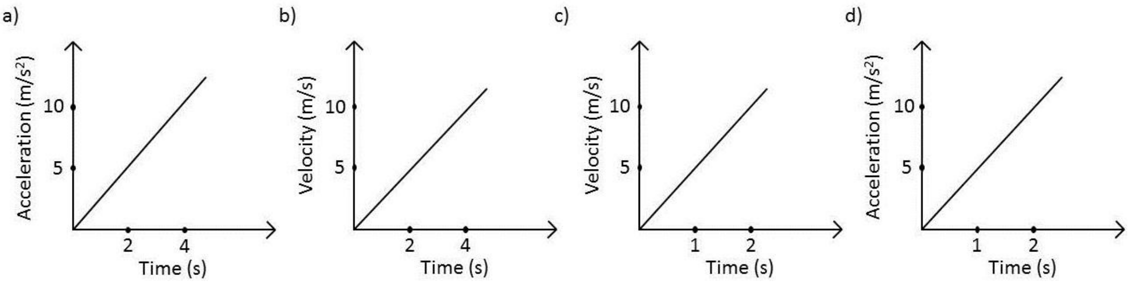
a) $[\frac{2\times100}{0.5}]^{\frac{1}{2}}$ sec c) (2×100×0.5) sec

b) $[\frac{100}{2\times0.5}]$ sec d) (100×0.5) sec

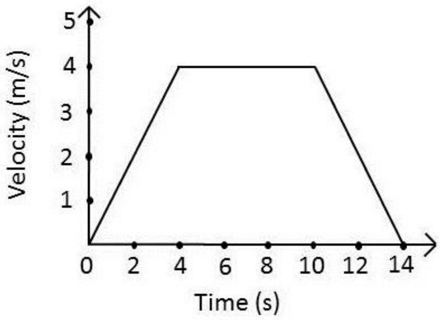
35. Which of the following graphs represent the motion of a body of mass 4kg, if the force acting on it is 10 N.



10N ബലം പ്രയോഗിക്കപ്പെടുമ്പോൾ, 4kg മാസുള്ള ഒരു വസ്തുവിന്റെ ചലനം ശരിയായി കാണിക്കുന്ന ഗ്രാഫ് ഏത്?



36. Study the given graph and calculate the distance travelled by the body in first 8 sec of the journey graphically.



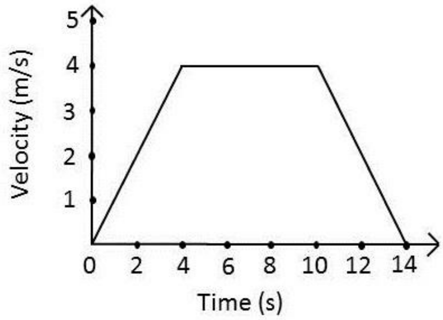
a) 8m

b) 16m

c) 24m

d) 32m

താഴെ കൊടുത്ത ഗ്രാഫ് വിശകലനം ചെയ്തു വസ്തു ആദ്യത്തെ 8sec ൽ സഞ്ചരിച്ച ദൂരം കണ്ടെത്തുക.



a) 8m
b) 16m
c) 24m
d) 32m

37. The distance travelled by a train moving with a speed of 60km/hr in 0.52hrs is

a) $\frac{60}{0.52}$ km
b) (60 × 0.52) m
c) (60 × 0.52) km
d) $\frac{60}{0.52}$ m

0.52hr കൊണ്ട് 60km/hr വേഗതയിലുള്ള തീവണ്ടി സഞ്ചരിച്ച ദൂരം എത്ര?

a) $\frac{60}{0.52}$ km
b) (60 × 0.52)m
c) (60 × 0.52) km
d) $\frac{60}{0.52}$ m

38. The retardation of the train which changes its velocity from 80m/s to 20m/s in 10min will be

a) 0.1m/s^2
b) 0.16m/s^2
c) 6m/s^2
d) 10m/s^2

10 min നുള്ളിൽ പ്രവേഗം 80m/s ൽ നിന്നും 20 m/s ആകുന്ന ഒരു തീവണ്ടിയുടെ മന്ദീകരണം എത്ര?

a) $0.1\text{m}/s^2$ c) $6\text{m}/s^2$

b) $0.16\text{m}/s^2$ d) $10\text{m}/s^2$

39. A ball is gently dropped from a height of 20m. If its velocity increases uniformly at the rate of 10m/s, with what velocity will it strike the ground?

a) $\sqrt{2 \times 10 \times 20}$ m/s c) $\frac{10}{20}$ m/s

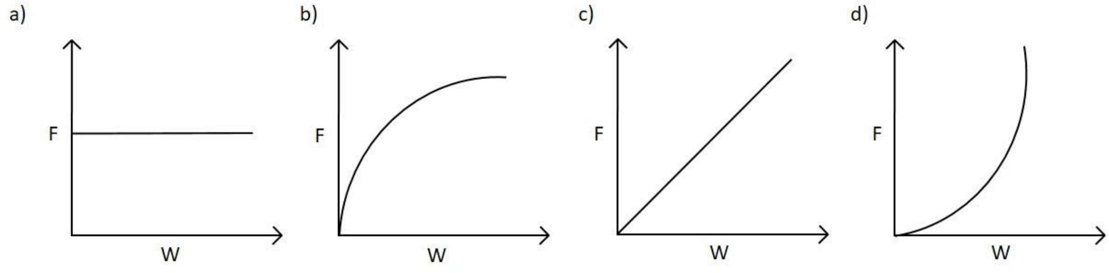
b) $(2 \times 10 \times 20)$m/s d) $(\frac{1}{2} \times \frac{10}{20} \times 20 \times 20)$ m/s

ഭൂപ്രതലത്തിനു 20m ഉയരത്തിൽ നിന്നു ഒരു പന്ത് മൃദുവായി താഴോട്ടു ഇടുന്നു. 10m/s എന്ന നിരക്കിൽ അതിന്റെ പ്രവേഗം ഒരേ പ്രകാരം കൂടുന്നുവെങ്കിൽ, പന്ത് നിലത്ത് പതിക്കുമ്പോൾ അതിന്റെ പ്രവേഗമെത്ര?

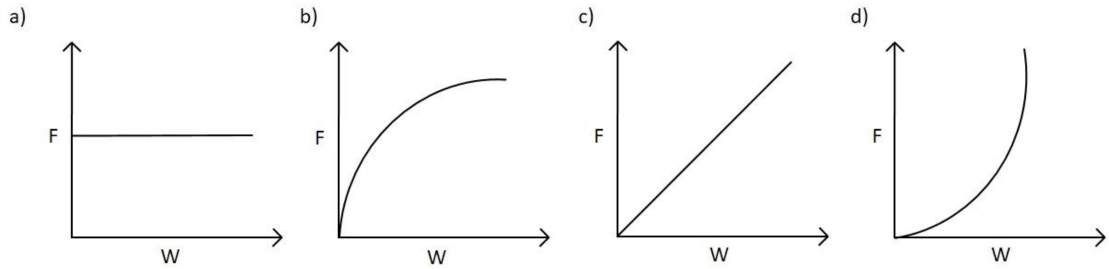
a) $\sqrt{2 \times 10 \times 20}$ m/s c) $\frac{10}{20}$ m/s

b) $(2 \times 10 \times 20)$m/s d) $(\frac{1}{2} \times \frac{10}{20} \times 20 \times 20)$ m/s

40. Weight of a wooden block to be pulled by spring balance is gradually increased and graph is plotted between total weight of block (W) and reading of spring balance (F) to pull it. The shape of the graph is



ഒരു സ്പ്രിംഗ് ത്രാസിൽ തൂക്കിയിട്ട മരക്കട്ടിയുടെ ഭാരം ക്രമേണ വർധിപ്പിച്ചു കൊണ്ടിരിക്കുന്നു. മരക്കട്ടിയുടെ ആകെ ഭാരവും (W) സ്പ്രിംഗ് ത്രാസിലെ അളവും (F) തമ്മിലുള്ള ഗ്രാഫിന്റെ രൂപം എങ്ങനെയായിരിക്കും?



41. A body covers one complete revolution around a circular park of circumference 176m and radius 28m in 4min.

i. The distance covered by the body after 6min is ………………..

a) $3 \times \frac{22}{7} \times 28$ m
c) $2 \times \frac{22}{7} \times 176$ m
b) $2 \times \frac{22}{7} \times 28$ m
d) $2 \times \frac{22}{7} \times (176 + 28)$ m

ii. The displacement of the body after 6min is ……………………

a) (176 + 28) m
c) $3 \times \frac{22}{7} \times 28$ m
b) (2 × 28) m
d) $2 \times 2 \times \frac{22}{7} \times 28$ m

176m വ്യത്തപരിധിയും 28m ആരവുമുള്ള വൃത്താകൃതിയിലുള്ള ഒരു ഉദ്യാനം 4min കൊണ്ട് ഒരു വസ്തു പ്രദക്ഷിണം ചെയ്തു. എങ്കിൽ

i. 6min നുള്ളിൽ ആ വസ്തു സഞ്ചരിച്ച ദൂരമെത്ര?

a) $3 \times \frac{22}{7} \times 28$ m

b) $2 \times \frac{22}{7} \times 28$ m

c) $2 \times \frac{22}{7} \times 176$ m

d) $2 \times \frac{22}{7} \times (176 + 28)$ m

ii. 6min കൊണ്ടു ആ വസ്തുവിനുണ്ടായ സ്ഥാനാന്തരമെത്ര?

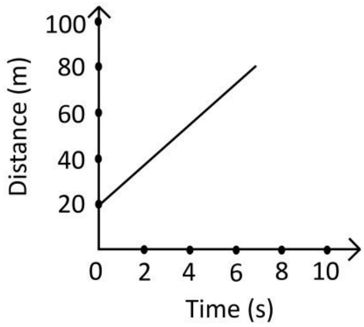
a) (176 + 28) m

b) (2 × 28) m

c) $3 \times \frac{22}{7} \times 28$ m

d) $2 \times 2 \times \frac{22}{7} \times 28$ m

42. The distance-time graph of a car is shown below. Its speed is



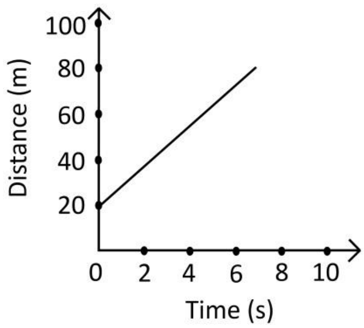
a) $\frac{80+20}{10}$ m/s

b) $\frac{20+60}{8}$ m/s

c) $\frac{80-20}{8}$ m/s

d) $\frac{80}{8}$ m/s

ഒരു കാറിന്റെ ദൂര-സമയ ഗ്രാഫാണ് താഴെ കാണിച്ചിരിക്കുന്നത്. കാറിന്റെ വേഗത എത്ര?



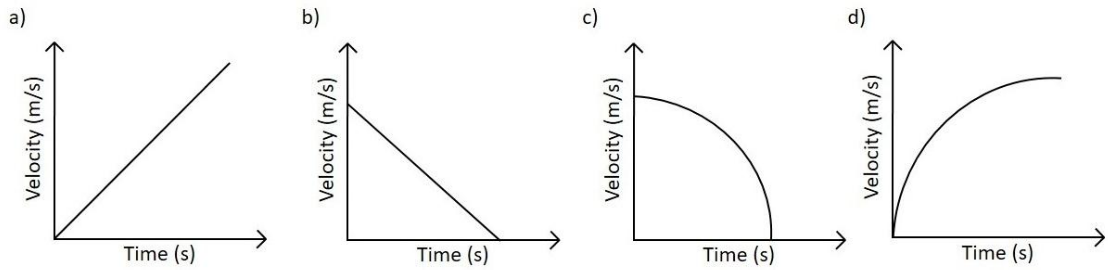
a) $\frac{80+20}{10}$ m/s

b) $\frac{20+60}{8}$ m/s

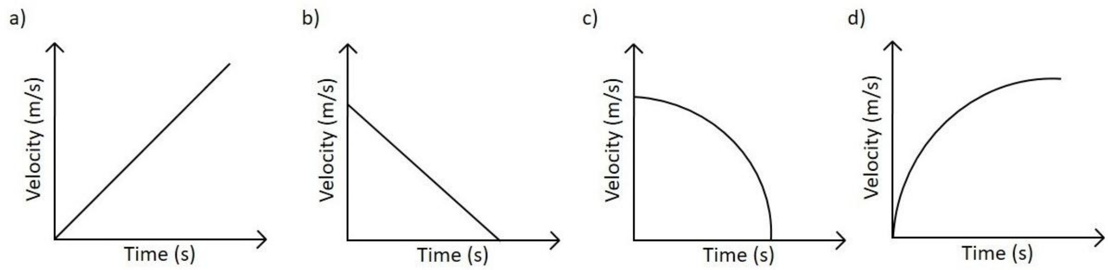
c) $\frac{80-20}{8}$ m/s

d) $\frac{80}{8}$ m/s

43. The graph showing uniform retardation when a body is thrown vertically upwards is



ലംബമായി മുകളിലേക്ക് എറിയപ്പെട്ട ഒരു വസ്തുവിന്റെ സമമന്ദീകരണം ശരിയായി കാണിച്ചിരിക്കുന്ന ഗ്രാഫ് ഏത്?



44. A body in motion has velocities of 20m/s in 4s and 40m/s in 8s. What will be the distance covered by the body between 4s and 8 s?

a) $[\frac{1}{2}\left(\frac{40-20}{4}\right) 4 \times 4]$ m

b) $[20 \times 4 + \frac{1}{2}\left(\frac{40-20}{4}\right) 4 \times 4]$ m

c) $\frac{40-20}{4}$ m

d) $[\frac{20}{4} + \frac{40}{8}]$ m

ചലിക്കുന്ന ഒരു വസ്തുവിന് 4sec ൽ 20m/s പ്രവേഗവും, 8sec ൽ 40m/s പ്രവേഗവുമാണ്. അങ്ങനെയെങ്കിൽ 4sec നും 8sec നുമിടയിൽ വസ്തു സഞ്ചരിച്ച ദൂരം കണക്കാക്കുക.

a) $[\frac{1}{2}\left(\frac{40-20}{4}\right)4 \times 4]$ m

b) $[20 \times 4 + \frac{1}{2}\left(\frac{40-20}{4}\right)4 \times 4]$ m

c) $\frac{40-20}{4}$ m

d) $[\frac{20}{4} + \frac{40}{8}]$ m

45. Find the acceleration produced by a force of 12N exerted on an object of mass 3kg.

a) $4\text{m}/s^2$

b) $9\text{m}/s^2$

c) $15\text{m}/s^2$

d) $36\text{m}/s^2$

3kg മാസുള്ള ഒരു വസ്തുവിൽ 12N ബലം പ്രയോഗിക്കപ്പെടുമ്പോഴുണ്ടാകുന്ന ത്വരണമെത്ര?

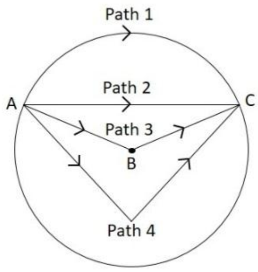
a) $4\text{m}/s^2$

b) $9\text{m}/s^2$

c) $15\text{m}/s^2$

d) $36\text{m}/s^2$

46. A car moves from A to B and from B to C. The displacement of the car is represented by



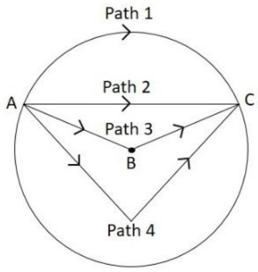
a) Path 1

b) Path 2

c) Path 3

d) Path 4

ഒരു കാർ A ൽ നിന്നു B യിലോട്ടും, പിന്നീട് C എന്ന ബിന്ദുവിലേക്കും സഞ്ചരിക്കുന്നു. അങ്ങനെയെങ്കിൽ കാറിന്റെ സ്ഥാനാന്തരം പ്രതിനിധാനം ചെയ്യുന്ന പാതയേത്?



a) പാത 1

b) പാത 2

c) പാത 3

d) പാത 4

47. A truck is moving along a straight line AB. It moves from A to B covering 360m in 15s and returns from B to C (C lies in between A and B), covering 120m in 5s. The average velocity of the truck in its whole journey is

a) $\frac{360-120}{15+5}$ m/s

b) $\frac{360+120}{15+5}$ m/s

c) $\frac{360-120}{15-5}$ m/s

d) $\frac{360+240}{15-5}$ m/s

ഒരു ട്രക്ക് AB എന്ന നേർരേഖയിലൂടെ ചലിക്കുന്നു. അത് Aൽ നിന്നു Bയിലേക്ക് 15s ൽ 360m സഞ്ചരിച്ചതിനു ശേഷം, പിന്നീട് Bൽ നിന്നു തിരികെ Cയിലേക്ക് (C എന്ന ബിന്ദു Aയിനും Bയിനും ഇടയിലാണ്) 5s ൽ 120m സഞ്ചരിച്ചു. അങ്ങനെയെങ്കിൽ മൊത്തം യാത്രയിൽ ട്രക്കിന്റെ ശരാശരി പ്രവേഗം കണക്കാക്കുക.

a) $\frac{360-120}{15+5}$ m/s

b) $\frac{360+120}{15+5}$ m/s

c) $\frac{360-120}{15-5}$ m/s

d) $\frac{360+240}{15-5}$ m/s

48. A cyclist travelling at a speed of 5 m/s lowers his speed to 2 m/s in 30 seconds by applying brakes. The acceleration of the cyclist will be ……………

a) $[\frac{2-5}{30}]$ m/s^2
c) $[\frac{5+2}{30}]$ m/s^2
b) $[\frac{2\times5+2}{30}]$ m/s^2
d) $[\frac{5\times 2}{30}]$ m/s^2

ഒരു സൈക്കിൾ യാത്രികൻ ബ്രേക്ക് പ്രയോഗിച്ചുകൊണ്ട് 30sec നുള്ളിൽ വേഗത 5m/s ൽ നിന്നും 2m/s ആയി കുറക്കുന്നു. അങ്ങനെയെങ്കിൽ യാത്രികന്റെ ത്വരണം എത്ര?

a) $[\frac{2-5}{30}]$ m/s^2
c) $[\frac{5+2}{30}]$ m/s^2
b) $[\frac{2\times5+2}{30}]$ m/s^2
d) $[\frac{5\times 2}{30}]$ m/s^2

49. A train starting from rest moves over a distance of 1800m for 1min. Find the acceleration of the train.

a) 1m/s^2
c) 1800 m/s^2
b) 30 m/s^2
d) 108000 m/s^2

ഒരു തീവണ്ടി നിശ്ചലാവസ്ഥയിൽ നിന്നും 1min കൊണ്ട് 1800m സഞ്ചരിക്കുന്നു. അങ്ങനെയെങ്കിൽ അതിന്റെ ത്വരണമെത്ര?

a) 1m/s^2
c) 1800 m/s^2
b) 30 m/s^2
d) 108000 m/s^2

50. A man pushes a box of mass 50kg with a force of 80N. What will be the acceleration of the box due to this force?

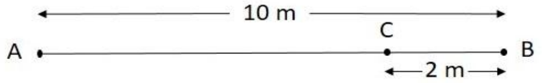
a) 0.625m/s^2
c) 130m/s^2
b) 1.6m/s^2
d) 4000m/s^2

50 kg മാസുള്ള ഒരു പെട്ടി ഒരാൾ 80N ബലം പ്രയോഗിച്ചു തള്ളുന്നു. ഈ ബലം കാരണം വസ്തുവിലുണ്ടാകുന്ന ത്വരണമെത്ര?

a) $0.625 \text{m}/s^2$ c) $130 \text{m}/s^2$

b) $1.6 \text{m}/s^2$ d) $4000 \text{m}/s^2$

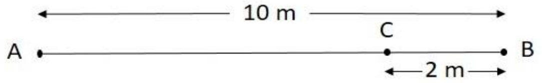
51. A ball is rolling along a straight line. Its displacement when it rolls from A to B, then to C and finally to A will be



a) 10m, 12m, 20m c) 12m, 2m, 10m

b) 12m, 2m, 0m d) 10m, 8m, 0m

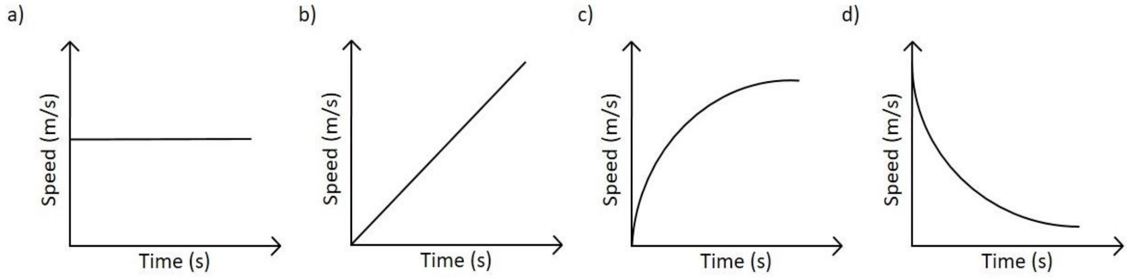
ഒരു പന്ത് നേർരേഖയിലൂടെ ഉരുളുന്നു. അങ്ങനെയെങ്കിൽ A ൽ നിന്നു B യിലേക്കും, അവിടെ നിന്നു C യിലേക്കും പിന്നീടു തിരിച്ചു Aയിലേക്കും ഉണ്ടാകുന്ന സ്ഥാനാന്തരം എത്ര?



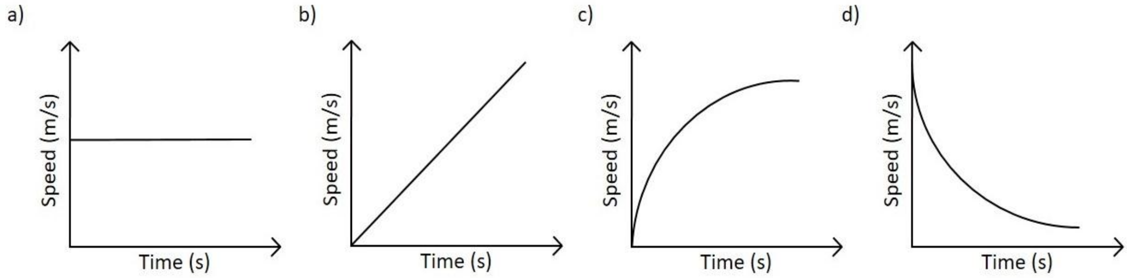
a) 10m, 12m, 20m c) 12m, 2m, 10m

b) 12m, 2m, 0m d) 10m, 8m, 0m

52. The graph representing uniform speed is



താഴെകൊടുത്തവയിൽ സ്ഥിരവേഗത വിശേഷിപ്പിക്കുന്ന ഗ്രാഫ് ഏത്?



53. A body in motion have velocities of 10m/s in 2s and 20m/s in 9s. What will be the acceleration of the body?

a) $[\frac{20+10}{9+2}]\ m/s^2$

b) $[\frac{20+10}{9-2}]\ m/s^2$

c) $[\frac{20-10}{9-2}]\ m/s^2$

d) $[\frac{20-10}{9+2}]\ m/s^2$

ചലിക്കുന്ന ഒരു വസ്തുവിന്റെ പ്രവേഗം 2s ൽ 10m/s ഉം 9s ൽ 20m/s ആണെങ്കിൽ വസ്തുവിന്റെ ത്വരണം കണ്ടെത്തുക.

a) $[\frac{20+10}{9+2}]\ m/s^2$

b) $[\frac{20+10}{9-2}]\ m/s^2$

c) $[\frac{20-10}{9-2}]\ m/s^2$

d) $[\frac{20-10}{9+2}]\ m/s^2$

54. With initial velocity of 2m/s, an object is thrown vertically upward. How far will the object travel from the ground?

a) 0.2m	c) 20m

b) 0.4m	d) 40m

2m/s ആദ്യപ്രവേഗത്തിൽ ഒരു വസ്തുവിനെ ഭൂപ്രതലത്തിനു ലംബമായി മുകളിലേക്ക് എറിയപ്പെട്ടു. അങ്ങനെയെങ്കിൽ ആ വസ്തുവിന് എത്താൻ പറ്റുന്ന ഉയരം എത്ര?

a) 0.2m	c) 20m

b) 0.4m	d) 40m

55. Ramu threw a stone against a mango on the tree which was 3m above the ground. The mango fell down along with the stone after collision. The total distance covered by the mango is ……………………..

a) Zero, since the ground is taken as reference point.
b) 3m
c) 6m
d) The given data is insufficient sine the time of delay of collision is not provided in the question.

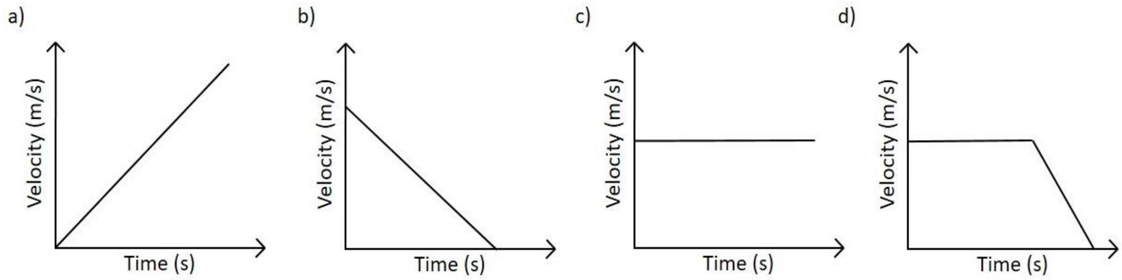
തറനിരപ്പിൽ നിന്നു 3m ഉയരത്തിലുള്ള ഒരു മാങ്ങക്ക് രാമു കല്ലെറിഞ്ഞു. കല്ല് മാങ്ങയിൽ തട്ടി രണ്ടും ഒരുമിച്ചു താഴേക്ക് വീണു. അങ്ങനെയെങ്കിൽ മാങ്ങ സഞ്ചരിച്ച ദൂരം എത്ര?

a) 0m , കാരണം ഭൂമിയാണ് അവലംബക വസ്തു.
b) 3m

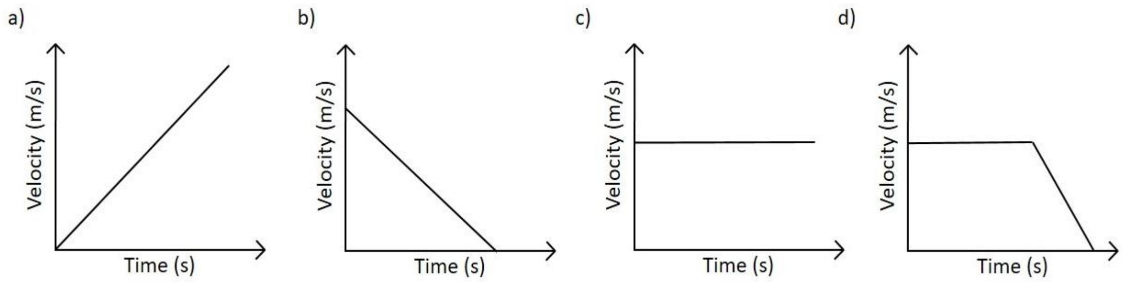
c) 6m

d) തന്നിരിക്കുന്ന വിവരണങ്ങൾ അപര്യാപ്തമാണ്. മാങ്ങയും കല്ലും കൂട്ടിമുട്ടുമ്പോഴുണ്ടാകുന്ന കാലതാമസത്തെക്കുറിച്ച് സൂചിപ്പിച്ചിട്ടില്ല.

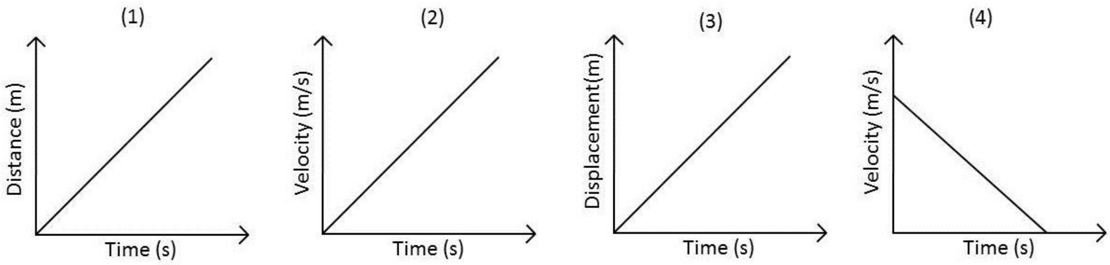
56. Which of the following graphs show the change in velocity of a freely falling body?



ഭൂമിയുടെ ആകർഷണബലം കൊണ്ടു നിർബാധം പതിക്കുന്ന ഒരു വസ്തുവിന്റെ പ്രവേഗമാറ്റത്തെ ശരിയായി വിശേഷിപ്പിക്കുന്ന ഗ്രാഫ് താഴെ കൊടുത്തവയിൽ ഏത്?



57. Which of the following graphs show uniform acceleration?



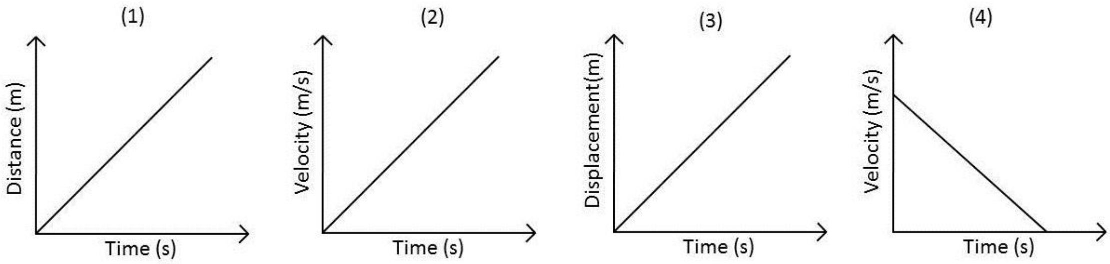
a) Only (1)

b) Only (2)

c) Both (2) and (3)

d) Both (1) and (4)

താഴെ കൊടുത്തിരിക്കുന്ന ഗ്രാഫുകളിൽ സമത്വരണത്തെ ശരിയായി കാണിക്കുന്നത് ഏത്?



a) (1) മാത്രം

b) (2) മാത്രം

c) (2)ഉം (3)ഉം

d) (1)ഉം (4)ഉം

58. A train starts from rest and moves with uniform acceleration 0.1m/s^2 for 2min. Calculate the distance travelled by the train.

a) 0.05m

b) 20m

c) 360m

d) 720m

ഒരു തീവണ്ടി നിശ്ചലാവസ്ഥയിൽ നിന്നും 2min നേരത്തേക്ക് 0.1m/s^2 സമത്വരണത്തിൽ സഞ്ചരിക്കുന്നു. അങ്ങനെയെങ്കിൽ സഞ്ചരിച്ച ദൂരമെത്ര?

a) 0.05m
b) 20m
c) 360m
d) 720m

59. A motor car of mass 1200kg is moving along a straight line with uniform velocity of 25m/s. Its velocity is slowed down to 5m/s in 4s by an unbalanced external force. Calculate the change in momentum.

a) 1200×(25-5)kgm/s
b) 1200×(5-25)kgm/s
c) $\frac{25-5}{1200}$ kgm/s
d) $\frac{1200}{25-5}$ kgm/s

1200 kg മാസുള്ള ഒരു മോട്ടോർ കാർ 25m/s സമപ്രവേഗത്തിൽ ഒരു നേർരേഖയിലൂടെ സഞ്ചരിക്കുന്നു. അസന്തുലിത ബാഹ്യബലത്താൽ അതിന്റെ പ്രവേഗം 4s നുള്ളിൽ 5m/s ആയി കുറയുന്നു. അങ്ങനെയെങ്കിൽ ആക്കവ്യത്യാസം കണക്കാക്കുക.

a) 1200×(25-5)kgm/s
b) 1200×(5-25)kgm/s
c) $\frac{25-5}{1200}$ kgm/s
d) $\frac{1200}{25-5}$ kgm/s

60. Consider a man walking around a house in a rectangular pattern. He walks 70 feet across the front, 30 feet along the side, 70 feet along the back and 30 feet along the other side to bring him back to where he began. What is the distance covered by the man walking around the house?

a) 0 feet
b) 100 feet
c) 140 feet
d) 200 feet

ഒരാൾ വീടിനു ചുറ്റും ദീർഘചതുരാകൃതിയിൽ നടക്കുകയാണ്. മുൻവശത്തു കൂടെ 70 അടിയും, അരിക് വശത്തുകൂടെ 30 അടിയും, പിൻവശത്തു കൂടെ വീണ്ടും 70 അടിയും, മറുവശത്തു കൂടെ 30 അടിയും സഞ്ചരിക്കുമ്പോൾ അയാൾ വീണ്ടും തുടങ്ങിയ സ്ഥാനത്തു തന്നെ എത്തുന്നു. അങ്ങനെയെങ്കിൽ അയാൾ സഞ്ചരിച്ച ദൂരം എത്ര?

a) 0 അടി
b) 100 അടി
c) 140 അടി
d) 200 അടി

61. Study the table:

TIME	**DISTANCE FROM ORIGIN (km)**
10:30 am	0
11:00 am	15
11:30 am	28
12:00 pm	40
12:30 pm	60

i. Which duration represents the maximum velocity?

a) Between 10:30 am to 11:00 am
b) Between 11:00 am to 11:30 am
c) Between 11:30 am to 12:00 pm
d) Between 12:00 pm to 12:30 pm

ii. The average speed of the whole journey is ………….

a) 35 km/hr
b) 30 km/hr
c) 26 km/hr
d) 20 km/hr

പട്ടിക വിശകലനം ചെയ്യുക:

സമയം	ആധാര ബിന്ദുവിൽ നിന്നുള്ള ദൂരം (km)
10:30 am	0
11:00 am	15
11:30 am	28
12:00 pm	40
12:30 pm	60

i. ഏറ്റവും കൂടുതൽ പ്രവേഗമുള്ള സമയപരിധി ഏത്?

a) 10:30 am ഇനും 11:00 am ഇനും ഇടയ്ക്ക്

b) 11:00 am ഇനും 11:30 am ഇനും ഇടയ്ക്ക്

c) 11:30 am ഇനും 12:00 pm ഇനും ഇടയ്ക്ക്

d) 12:00 pm ഇനും 12:30 pm ഇനും ഇടയ്ക്ക്

ii. മുഴുവൻ യാത്രയുടെ ശരാശരി വേഗമെത്ര?

a) 35 km/hr

b) 30 km/hr

c) 26 km/hr

d) 20 km/hr

62. A scooter is moving with a velocity and it takes 5s to stop after the brakes are applied. If the mass of the scooter along with the rider is 180kg and change in momentum is 4500kgm/s, find its initial velocity.

a) $\frac{4500}{18}$ m/s

b) $\frac{4500}{180+5}$ m/s

c) $\frac{-180 \times 5}{4500}$ m/s

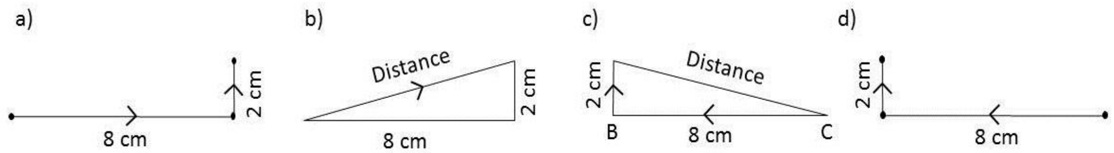
d) $\frac{-4500}{180}$ m/s

ബ്രേക്ക് പ്രയോഗിക്കപ്പെട്ടതിനാൽ ഒരു നിശ്ചിത പ്രവേഗത്തിൽ സഞ്ചരിച്ചിരുന്ന സ്കൂട്ടർ 5s കൊണ്ട് നിശ്ചലമാകുന്നു. സ്കൂട്ടറിന്റെയും യാത്രികന്റെയും ആകെ മാസ് 180kg ഉം ആക്കവ്യത്യാസം 4500kgm/s മാണെങ്കിൽ, ആദ്യപ്രവേഗമെത്ര?

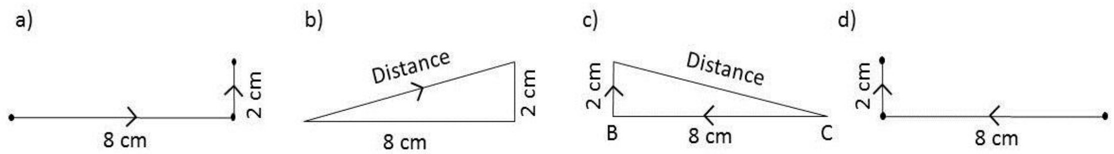
a) $\frac{4500}{18}$ m/s c) $\frac{-180 \times 5}{4500}$ m/s

b) $\frac{4500}{180+5}$ m/s d) $\frac{-4500}{180}$ m/s

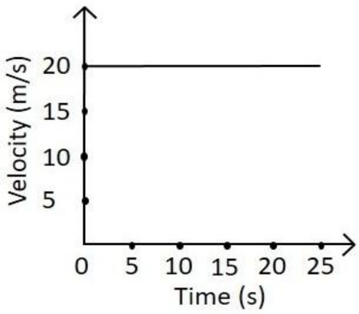
63. A toy car after moving 8cm along +x-direction from origin, turns in the +y-direction and moves 2cm. Which of the following diagram shows the distance travelled by the toy car?



ഒരു കളിവണ്ടി ആധാരബിന്ദുവിൽ നിന്നു +x ദിശയിൽ 8cm സഞ്ചരിച്ചതിനു ശേഷം +y ദിശയിലേക്ക് തിരിഞ്ഞു 2cm സഞ്ചരിക്കുന്നു. താഴെ കൊടുത്തിരിക്കുന്ന ചിത്രങ്ങളിൽ ഏതാണ് കളിവണ്ടി സഞ്ചരിച്ച ദൂരം ശരിയായി കാണിച്ചിരിക്കുന്നത്?

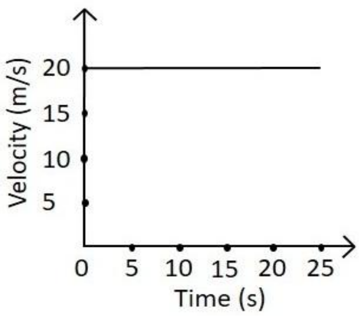


64. The velocity-time graph represents the motion of a cyclist. The distance covered in 15s is



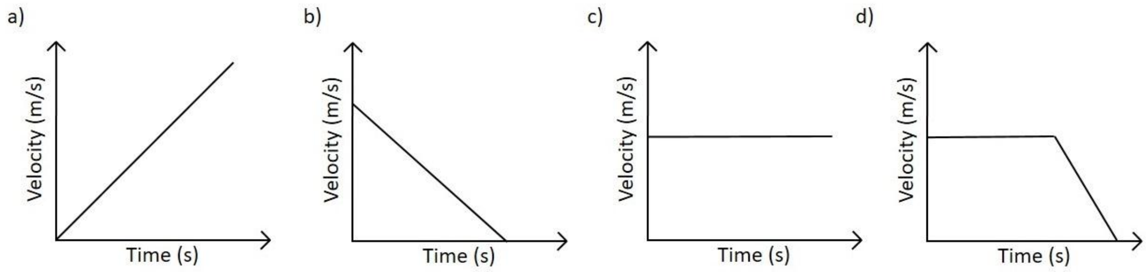
a) 0m
c) 300m
b) 200m
d) 500m

ഒരു സൈക്കിൾ യാത്രികന്റെ ചലനമാണ് താഴെ കൊടുത്തിരിക്കുന്ന പ്രവേഗ-സമയ ഗ്രാഫിൽ കാണിച്ചിരിക്കുന്നത്. 15s നുള്ളിൽ അയാൾ സഞ്ചരിച്ച ദൂരം എത്ര?

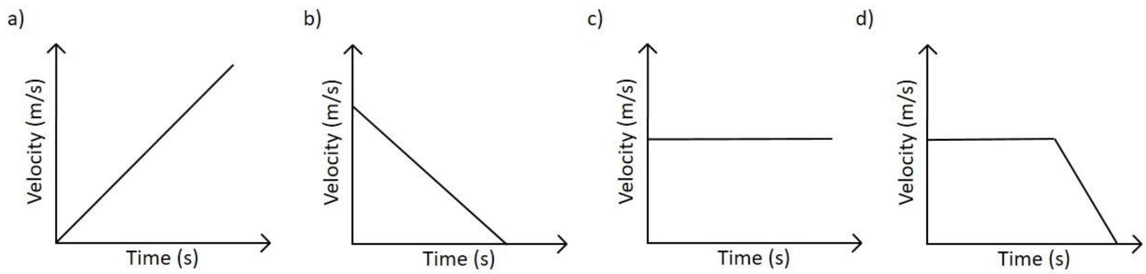


a) 0m
c) 300m
b) 200m
d) 500m

65. Which of the following graphs show the change in velocity of a body thrown vertically upwards and reaches the maximum height?



ലംബമായി മുകളിലേക്ക് എറിയപ്പെട്ട ഒരു വസ്തു പരമാവധി ഉയരത്തിൽ എത്തിയപ്പോഴുണ്ടായ പ്രവേഗമാറ്റത്തെ ശരിയായി കാണിക്കുന്ന ഗ്രാഫ് താഴെ കൊടുത്തവയിൽ ഏത്?



66. A girl of mass 50kg jumps out of a moving boat of mass 300kg on to the bank with a horizontal velocity of 3m/s. With what velocity does the boat begin to move backwards?

a) 0.5m/s
b) 5m/s
c) 18m/s
d) 117m/s

50kg മാസുള്ള ഒരു പെൺകുട്ടി 300kg മാസുള്ള ചലിക്കുന്ന വഞ്ചിയിൽ നിന്നും 3m/s സമാന്തരപ്രവേഗത്തിൽ കരയിലേക്ക്ചാടുന്നു. അങ്ങനെയെങ്കിൽ എത്ര പ്രവേഗത്തിലാണ് വഞ്ചി പിറകോട്ട് ചലിക്കുക?

a) 0.5m/s | c) 18m/s
b) 5m/s | d) 117m/s

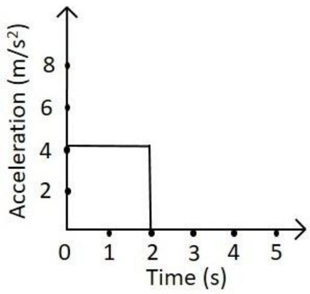
67. Ramu was in his school at 4:00 pm, which was 400m away from his home. Later at 4:15 pm, he reached his friend's house which was 600m away from his school. What was Ramu's velocity during his journey from school to his friend's house?

a) 66.66m/s c) 1.11m/s
b) 13.33m/s d) 0.66m/s

വൈകുന്നേരം 4 മണിക്ക് രാമു അവന്റെ വീട്ടിൽ നിന്നു 400m അകലത്തിലുള്ള വിദ്യാലയത്തിലായിരുന്നു. തുടർന്ന് അവന്റെ വീട്ടിൽ നിന്നു 600m അകലത്തിലുള്ള സുഹൃത്തിന്റെ വീട്ടിൽ 4:15 ന് എത്തി. അങ്ങനെയെങ്കിൽ വിദ്യാലയത്തിൽ നിന്നു സുഹൃത്തിന്റെ വീട്ടിലേക്കുള്ള യാത്രയിൽ രാമുവിന്റെ പ്രവേഗം എത്ര?

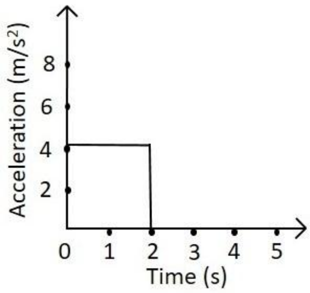
a) 66.66m/s c) 1.11m/s
b) 13.33m/s d) 0.66m/s

68. The change in speed of the body from the following graph will be



a) 8m/s c) 1m/s
b) 2m/s d) 0m/s

താഴെ കൊടുത്ത ഗ്രാഫിൽ നിന്നും വസ്തുവിന്റെ വേഗതയിലുണ്ടായ മാറ്റം കണ്ടെത്തുക.



c) 8m/s	c) 1m/s

d) 2m/s	d) 0m/s

69. A body travelling along a straight line covered half of the total distance with a velocity v_1 and the remaining distance with a velocity v_2. The average velocity of the body is

a) $\frac{2\,v_1\,v_2}{v_1+v_2}$	c) $\frac{v_1\,v_2}{2\,(v_1+v_2\ )}$

b) $\frac{v_1}{2}+\frac{v_2}{2}$	d) $\frac{2(\,v_1+v_2)}{v_1 v_2}$

നേർരേഖയിലൂടെ സഞ്ചരിക്കുന്ന ഒരു വസ്തു പാതയുടെ പകുതി ദൂരം v_1 പ്രവേഗത്തിലും, ബാക്കി ദൂരം v_2 പ്രവേഗത്തിലും ചലിക്കുന്നു. വസ്തുവിന്റെ ശരാശരി പ്രവേഗം എത്ര?

a) $\frac{2\,v_1\,v_2}{v_1+v_2}$	c) $\frac{v_1\,v_2}{2\,(v_1+v_2\ )}$

b) $\frac{v_1}{2}+\frac{v_2}{2}$	d) $\frac{2(\,v_1+v_2)}{v_1 v_2}$

70. A train travels at a speed of 50km/h for 0.5hr, at 30km/h for the next 0.3hr and then at 70km/h for the next 0.7hr. What is the average speed of the train?

a) 0.1km/hr
b) 50km/hr
c) 100km/hr
d) 200km/hr

ഒരു തീവണ്ടി ആദ്യ 0.5hr ൽ 50km/hr വേഗതയിലും, അടുത്ത 0.3hr ൽ 30km/hr വേഗതയിലും, പിന്നീടുള്ള 0.7hr ൽ 70km/hr വേഗതയിലും സഞ്ചരിക്കുന്നുവെങ്കിൽ, തീവണ്ടിയുടെ ശരാശരി വേഗത കണക്കാകുക.

a) 0.1km/hr
b) 50km/hr
c) 100km/hr
d) 200km/hr

APPENDIX - II

RESPONSE SHEET

Name of the Student :

Gender : MALE / FEMALE

Name of the School :

Type of Management : GOVERNMENT / AIDED / UNAIDED

Locality of the School : URBAN / RURAL

Marks scored in Physics in First-term examination of XI standard :

1. ⓐ ⓑ ⓒ ⓓ
2. ⓐ ⓑ ⓒ ⓓ
3. ⓐ ⓑ ⓒ ⓓ
4. ⓐ ⓑ ⓒ ⓓ
5. ⓐ ⓑ ⓒ ⓓ
6. ⓐ ⓑ ⓒ ⓓ
7. ⓐ ⓑ ⓒ ⓓ
8. ⓐ ⓑ ⓒ ⓓ
9. ⓐ ⓑ ⓒ ⓓ
10. ⓐ ⓑ ⓒ ⓓ
11. ⓐ ⓑ ⓒ ⓓ
12. ⓐ ⓑ ⓒ ⓓ
13. ⓐ ⓑ ⓒ ⓓ
14. ⓐ ⓑ ⓒ ⓓ
15. ⓐ ⓑ ⓒ ⓓ
16. ⓐ ⓑ ⓒ ⓓ
17. ⓐ ⓑ ⓒ ⓓ
18. ⓐ ⓑ ⓒ ⓓ
19. i) ⓐ ⓑ ⓒ ⓓ
    ii) ⓐ ⓑ ⓒ ⓓ
    iii) ⓐ ⓑ ⓒ ⓓ
20. ⓐ ⓑ ⓒ ⓓ
21. ⓐ ⓑ ⓒ ⓓ
22. ⓐ ⓑ ⓒ ⓓ
23. ⓐ ⓑ ⓒ ⓓ
24. ⓐ ⓑ ⓒ ⓓ
25. i) ⓐ ⓑ ⓒ ⓓ
    ii) ⓐ ⓑ ⓒ ⓓ
    iii) ⓐ ⓑ ⓒ ⓓ
    iv) ⓐ ⓑ ⓒ ⓓ
26. ⓐ ⓑ ⓒ ⓓ
27. ⓐ ⓑ ⓒ ⓓ
28. ⓐ ⓑ ⓒ ⓓ
29. ⓐ ⓑ ⓒ ⓓ
30. i) ⓐ ⓑ ⓒ ⓓ
    ii) ⓐ ⓑ ⓒ ⓓ
31. ⓐ ⓑ ⓒ ⓓ
32. ⓐ ⓑ ⓒ ⓓ
33. ⓐ ⓑ ⓒ ⓓ
34. ⓐ ⓑ ⓒ ⓓ
35. ⓐ ⓑ ⓒ ⓓ
36. ⓐ ⓑ ⓒ ⓓ
37. ⓐ ⓑ ⓒ ⓓ
38. ⓐ ⓑ ⓒ ⓓ
39. ⓐ ⓑ ⓒ ⓓ
40. ⓐ ⓑ ⓒ ⓓ
41. i) ⓐ ⓑ ⓒ ⓓ
    ii) ⓐ ⓑ ⓒ ⓓ
42. ⓐ ⓑ ⓒ ⓓ
43. ⓐ ⓑ ⓒ ⓓ
44. ⓐ ⓑ ⓒ ⓓ
45. ⓐ ⓑ ⓒ ⓓ
46. ⓐ ⓑ ⓒ ⓓ
47. ⓐ ⓑ ⓒ ⓓ
48. ⓐ ⓑ ⓒ ⓓ
49. ⓐ ⓑ ⓒ ⓓ
50. ⓐ ⓑ ⓒ ⓓ
51. ⓐ ⓑ ⓒ ⓓ
52. ⓐ ⓑ ⓒ ⓓ
53. ⓐ ⓑ ⓒ ⓓ
54. ⓐ ⓑ ⓒ ⓓ
55. ⓐ ⓑ ⓒ ⓓ
56. ⓐ ⓑ ⓒ ⓓ
57. ⓐ ⓑ ⓒ ⓓ
58. ⓐ ⓑ ⓒ ⓓ
59. ⓐ ⓑ ⓒ ⓓ
60. ⓐ ⓑ ⓒ ⓓ
61. i) ⓐ ⓑ ⓒ ⓓ
    ii) ⓐ ⓑ ⓒ ⓓ
62. ⓐ ⓑ ⓒ ⓓ
63. ⓐ ⓑ ⓒ ⓓ
64. ⓐ ⓑ ⓒ ⓓ
65. ⓐ ⓑ ⓒ ⓓ
66. ⓐ ⓑ ⓒ ⓓ
67. ⓐ ⓑ ⓒ ⓓ
68. ⓐ ⓑ ⓒ ⓓ
69. ⓐ ⓑ ⓒ ⓓ
70. ⓐ ⓑ ⓒ ⓓ

APPENDIX - III

SCORING KEY

1. a	**14.** d	**25. i)** c	**34.** a	**46.** b	**59.** b
2. d	**15.** c	**ii)** b	**35.** b	**47.** a	**60.** d
3. b	**16.** d	**iii)** a	**36.** c	**48.** a	**61. i)** d
4. c	**17.** c	**iv)** c	**37.** c	**49.** a	**ii)** b
5. c	**18.** c	**26.** b	**38.** a	**50.** b	**62.** d
6. d	**19. i)** c	**27.** c	**39.** a	**51.** d	**63.** a
7. b	**ii)** c	**28.** d	**40.** c	**52.** a	**64.** c
8. c	**iii)** a	**29.** d	**41. i)** a	**53.** c	**65.** b
9. d	**20.** b	**30. i)** a	**ii)** b	**54.** a	**66.** a
10. c	**21.** b	**ii)** b	**42.** c	**55.** b	**67.** d
11. d	**22.** c	**31.** d	**43.** b	**56.** a	**68.** a
12. d	**23.** a	**32.** d	**44.** b	**57.** b	**69.** a
13. b	**24.** c	**33.** d	**45.** a	**58.** d	**70.** d

APPENDIX – IV

LIST OF SCHOOLS

Sl. No.	Name of the school	Locality	Type of management	Number of pupils		
				Boys	Girls	Total
1.	Government Higher Secondary School, Edappal	Rural	Government	23	33	56
2.	Darul Hidaya Orphanage Higher Secondary School, Pookarathara	Rural	Aided	21	19	40
3.	Technical Higher Secondary School, Nellissery	Rural	Un-aided	59	19	78
4.	Achutha Varrier Higher Secondary School, Ponnani	Urban	Aided	19	23	42
5.	Maunathul Islam Boys Higher Secondary School, Ponnani	Urban	Aided	20	31	51
6.	Government Higher Secondary School, Thrikkav	Urban	Government	17	39	56
7.	Government Higher Secondary School, Chalissery	Rural	Government	18	33	51
8.	Government Higher Secondary School, Kadavallur	Rural	Government	19	20	39
9.	Government Higher Secondary School, Kadikkad	Rural	Government	20	19	39

10.	Islamic Cultural Association English Higher Secondary School, Thozhiyoor	Rural	Un-aided	14	19	33
11.	Government Higher Secondary School, Marancherry	Rural	Government	18	-	18
12.	Government Model Boys' Higher Secondary School, Kunnamkulam	Urban	Government	11	47	58
13.	Government Model Girls' Higher Secondary School, Kunnamkulam	Urban	Government	14	36	50
14.	T. M. Vocational Higher Secondary School, Perumpilavu	Urban	Aided	9	17	26
15.	Dr. K. B. Menon Memorial Higher Secondary School, Thrithala	Rural	Aided	22	17	39
16.	Gokhale Government Higher Secondary School, Kalladathur	Rural	Government	23	22	45
17.	Modern Higher Secondary School, Pottur	Rural	Un-aided	9	17	26
18.	St. George Higher Secondary School, Thozhiyoor	Rural	Aided	23	12	35
19.	Rahmath English Medium School, Guruvayur	Rural	Un-aided	28	-	28
20.	Government Model Residential Higher Secondary School, Parakkulam	Rural	Government	-	30	30
21.	Government Higher Secondary School, Kadanchery	Rural	Government	33	7	40
	TOTAL			420	460	880