DEVELOPMENT OF PROGRAMME TO ENHANCE GRAPHIC KNOWLEDGE AND SKILLS IN PHYSICS SUBJECT OF SECONDARY SCHOOL STUDENTS

Dr.CHANDRA MOHAN
Assistant Teacher
Nowrosjee Wadia College, Pune

Dr.THOMAS FELDMAN
Assistant Professor
Dr. D. Y. Patil of Education, Pimpri, Pune

ABSTRACT

The focus of the study in this research was to enhance the graphical knowledge and skills in physics subject of secondary school students studying in class nine. The study was to investigate the effectiveness of the programme, developed in physics subject for class nine students from the secondary school Kai. Sau. Shankauntalabai Anandrao Shitole Madhayamik School situated in the Old Sangvi area of Pune city, Maharashtra. The research method was an experimental method. The research design opted for study with sample size of 37 students, was single group pre-test and post-test design. The achievement test for physics subject was the measuring tool used for the research. Implementation of the learning programme after pre-test was the crucial task of the research. After comparison, the researcher found the difference of 5.81 in mean scores of pre-test and post test of class IX students from Secondary School. Also, the result showed low positive correlation (r= 0.122) between the scores of pre-test and post-test scores. The result highlights were calculated t- value as 9.0667 found to be greater than the table t value. This interprets that the programme developed to enhance the graphic knowledge and skills among class IX students of Secondary school was effective.

Keywords: *Graphic representation, scientific literacy, conceptual modeling, creativity.*

INTRODUCTION

The problem for graphic literacy of students is current. Graphs are very important types of representations in physics subject as mentioned by Aberg-Bengtsson, L., & Ottosson, T. (2006). They are used as a different kind of communication tools and a source for student learning sciences (Evitts 2000, Novak and canas, 2008). The graphical knowledge and skills are needed in the perception of information and in its presentation in physics subject. Developing graphical skills is essential for the success in school education, higher education, and also in further professional life.

The graphical skills are universal educational skills. They are a part of the key competency because they are applied in extracurricular life. Graphical knowledge brings creativity in design which is helpful to create unique and innovative solutions to problems. Graphical knowledge and skill motivates students to build divergent outlook and produce creative solutions to the problem. Traditionally, Physics concepts are taught in secondary schools and col- leges by lecture method, demonstration method and by experimental exercise in laboratory. Wherein, diagrams and graphs are key factors for scientific interpretation of data collected from experiments which develops framework of the concept. By trail and error, a student learns to frame new concepts by visualizing the graphical representation and interpretation and also corrects phenomena in physics.

But still in practice, students find difficult to analyze the data collected in Physics by minute error. (LC McDermott, ML Rosenquis, 1987.) For example they fail to understand concept of velocity and acceleration with direction, have difficulties in distinguishing force and energy, have little understanding about varying relation between the variables like voltage and current, find inadequate learning methodology of representing directive operations in physics, face difficulties to understand the hypothesis of experiments etc.

In accordance to above problem, graphic knowledge and skills were studied and observed in various way with references in articles. Students had difficulties in relating the graphs and the verbal descriptions of a given event. (Champagne, A., & Gunstone, R. (1985). Instructional consequence of students' knowledge about physical phenomena, In L. West (Ed.), *Cognitive structures & conceptual change* (pp. 61–90). Orlando: Academic.) They did not understand graphs as means of representing relationships between variables. Students also find difficulty to design abstract concept as per the verbal data, which can actually simplify the aspects of physics diagram with visual notation (symbol) and spatial arrangements. Students find difficulty in practical handling and estimating the measurements as per requirements. Proportionate and detailed diagrammatic representations are the essential elements in physics study. Whereas, student's fail to understand need of designing the diagrams with accuracy. Graphical designing or modeling, i.e., to study diagrammatic representation of facts and phenomena of physics in school develops the scientific attitude and practical handling required in physics. Grid drawing methodology modified using graph paper can be appropriate way to study diagrams in physics for higher understanding was an attempt made by the researcher in this study.

Physics is a science of measurement and accuracy. Graphical knowledge and skills are the tools to achieve these aims while learning sciences of measurement. Graphical knowledge is quick tool for any physician to elaborate the ideas and to promote the efficiency of learning and memorization of knowledge. (American Association for the Advancement of Science,1993)With respect to today's communication value, students will be able to understand recording and interpretation of physical experimental data, diagrammatic analysis of physics concept, modeling and designing as per principles of physics.

The purpose of the study serves to build the concepts of Physics subject using graphical knowledge and skills as first hand tool. The programme developed in physics subject involves attention of every student to enhance active learning. This brings the individual learning approach in students.

Background history

When data grows in size and refers to more abstract concepts, it becomes difficult to compress the data (Buagajska,2003). As a result, people are constructing graphical representations to facilitate data exploration and to ease sense-making (Ellis & Dix,2007). The increasing interest in graphical representation design in *Information Systems* and *Computer Science* is reflected in the growing research about visualization techniques (Moody,2009) and quality frameworks for graphical representations (Krogstie et al.,2006; Nelson et al.,2012). Studies frequently refer to research in *Psychology* that shows that textual representations (e.g., natural language, tabular representations) are often insufficient for efficient complex problem solving, and that graphical representation is desirable (Gaissmaier et al.,2012; Regnell et al.,1996).

The word graph first appeared in 1878 in a context related to the physical science, when the English mathematician James J Sylvester wrote a paper entitles " Chemistry and Algebra". Physical sciences , i.e., physics helps in developing and fostering the scientific outlook, scientific interest and scientific attitude among children by providing solutions for day

to day problems. Graphical knowledge and skills helps in training children for developing scientific temper and creativity. Graphical knowledge and skills enhances and controls mental abilities of an individual to visualize abstract concepts in physics.

Theoretical framework

Physics education or physics teaching refers to the education methods currently used to teach physics. Physics education research refers to an area of pedagogical research that seeks to improve those methods. (From Wikipedia, the free encyclopedia, Physical education). Graphs are fundamental building block of knowledge in Physics. In physics, graphical representation are used for interpterion of the information in order to learn the complex phenomenon and analyse it. Where in graphs are also useful to develop creative designs and model- ling in physics.

Historically, physics has been taught in the schools and colleges by lecture method together with laboratory practices aimed to verify laws and principles. These concepts are derived in lectures with help of demonstration, hand-on experiments, and questions that require students to ponder with what will happen in an experiment and why? In this type of active learning method, students need to understand the diagrammatic and graphical representation of science data or information to relate with the events for self-discovery. (Active learning strategies in physics teaching by Orhan Karamustafaoglu,2009). Experiments in physics are always accompanied with lots of numerical data which is to be synchronized and analyzed by means of simple tool like graphs and tables. (Fan, J. E. 2015).

For experiments in physics we require diagram and graph as it is the most useful and powerful method of presenting the data. Sometimes, table and graphs convey the same information but graphs are specific to read and interpret information. A graphical representation of any data can give a qualitative and quantitative relation of the variables for further analysis and perception of information. (The language in Physics,2011 pdf). Fundamentals of graphical theory at secondary school stage are beneficial to every student in learning physics. Graph designing is part of mathematics which is helpful for framing Physics concepts in sequential order.

Conceptual modeling also leads to more advance learning in physics which can be achieved by graphics (Trends in Physics teaching,2009, Rick Bagaue). Creative intelligence often requires this type of thinking in unique or unusual ways, in collaboration with other subject to find the solutions of problem. Geometric modeling is of fundamental importance to a large variety of research areas including computer graphics, computer integrated engineering and manufacturing scientific visualization.

Insight to graphic knowledge and skill

Graphic presentation gives pictorial effect of complex data which is difficult to read by common man. Classification of these scientific data and tabulation reduces the complexity and makes easy to grasp the knowledge by new learner. Baddigtton says, “The wandering of a line is more powerful in its effect on the mind than a tabulated statement; it shows what is happening and what is likely to take place just as quickly as the eye is capable of working.”

A graphical representation (or “diagram”) is the product of making abstraction of some of the real-world complexity (Nelson et al., 2012; Rockwell & Bajaj, 2005) by purposefully representing selected information objects and their relationships, in the context of a specific design goal and target audience (Cox, 1999).

Diagrammatic representations differ from textual representations on two levels: the encoding and the decoding level (Moody, 2009). To start, in contrast to one-dimensional textual (sentential) representations and to one-to- multidimensional representations, diagrams are typically encoded in a two-dimensional solution space (Larkin & Simon, 1987). Secondly, ac-

cording to dual channel theory (Paivio,1991), humans decode and process graphical and textual information in separated channels. Consequently, different design principles are required for building graphical and textual representations (Moody, 2009).

A graph is a visual form of presentation. (Gilbert, J. K. (2007). Visualization: A meta-cognitive skill. In J. J. Gilbert (Ed.), *Visualization in science education* (pp. 9–27). Dordrecht: Springer). Graphs are drawn on special type of paper known as Graph paper. Each graph paper has thick horizontal and vertical lines for each division of a centimeter and thin lines for smaller parts of the same. A graph is divided into four quadrants but normally the first quadrant is used.

Advantages of graphical presentation:

- It provides an attractive and impressive view.
- It simplifies complexity of data.
- It provides easy comparison of two or more phenomenon.
- It needs no special knowledge of mathematics to understand a graph.
- Its simplest method, less time consuming and it shows trend

analysis.

Design a Graph

We can plot both tables and graphs to represent the data, but graphs are quite easier to manipulate and interpret data than tables.

There are some terms used in graphs such as:

- The Independent variable is known as the variable that is made to change as per need.
- The dependent variable is another variable that changes as a result of the change in the dependent variable.
- Title of graph is written concisely as change in dependent variable with respect to change in independent variable.
- Proper scaling and labelling is mentioned as per dada set.
- Plotting of points in sequence as per data set and to draw best fitted line or curve is necessary element in presentation of graph.
- Slope is result of differentiation in variables or we can say steepness of a line.

Types of Graphs

- Graph study is similar to that of kinematics.
- We will be learning the three important types of graphs such as;
- Displacement -time (d-t): A displacement -time graph plots the distance of an object from a certain point. X-axis denotes time, while Y-axis denotes distance.
- Velocity-time (v-t): A velocity-time graph denoted the velocity of an object in motion from a certain point. X-axis denotes time, while Y-axis denotes velocity.
- Acceleration-time (a-t): The acceleration-time graph determines the change in velocity at regular intervals of time.
- We have learned a mathematical approach to speed, distance, velocity, and displacement. These graphs will help us to understand better about
- the motion.
- As per the physics, the observer should be able to interpret motion by visualizing the graph.

Need and significance of the research

Physics is basic science related to nature and its phenomenon. Study of physics is essential to develop creative intelligence of students in many technical fields. It provides practical knowledge for students to develop their skill, interest, understanding, aptitude and appreciation. This research formulates these ideas through graphic knowledge and skills in secondary school students.

Many investigators think, graphical knowledge and skill are basis for higher technical education which can be developed in physics. Plotting of graph from experimental data to solve various type of numerical in physics is a skill which is to be developed in students of higher secondary school. This further leads to interpretation of results in words. Graphs are usually the interpretation of physical properties of the material or phenomenon which is to be studied with large observations. It is critical-analytic method in physics needed to be understood at school level.

Students of secondary school find difficult to represent visually three dimensional diagram and working models. They find difficult to analyze diagrammatic representation with directional objectives of process and phenomenon. To develop these skills in physics we can make use of graphic knowledge.

This research is needed to satisfy the common goal of science and psychology that can develop the instincts as creativeness, self-assertion, curiosity by emphasizing on learning by doing, learning by observation and activity method. This research will serve to give students broad genuine appreciation of what development of physics mean to modern life.

Assumption

- Teaching becomes more effective using computerized programme. (Oversight on educational Technology: Joint hearing before -Page 60)
- Up to certain limit, students find graphical knowledge difficult.(Graphical thinking for science and technology through knowledge visualization - page 248)
- Students know how to draw graph on graph paper.(Information provided by school)
- Students know how to operate computers.(Information provided by school)

Objective of the study

1. To find concepts in physics subject of class IX requiring knowledge of graph.
2. To prepare a programme in Physics subject to enhance graphic knowledge and skills of class IX students.
3. To find out effectiveness of a programme in physics subject to enhance graphic knowledge and skills of class IX students.
4. To measure graphic knowledge and skills of class IX students.
5. To analyse graphic knowledge and skills in physics subject of class IX students.

Hypothesis of the research

H_0: There is no significant difference found between mean scores of pre-test and post-test in physics among students of class IX of secondary school.

METHODOLOGY

(A) Design of the study

The study was framed using experimental method which consisted single group pre-test and post-test design. The research study was based on two variables. The independent variable consists graphical knowledge and skill, and programme in physics where as the dependent variable comprises of achievements of students.

The researcher conducted pre-test, then implemented instructional and learning programme in physics subject followed by post-test for students of class nine. An achievement test was prepared by the researcher to measure graphical knowledge and physics knowledge of the students in pre-test and post-test. Further for analysis researcher has used descriptive statistics technique such as mean and standard deviation. Inferences are drawn using t-value.

(B) Population and Sample

The population for the research study was class nineth students from secondary schools studying science under Maharashtra board curriculum framework. The students from the population belong from the urban area situated at Old Sangvi, Pune city, Maharashtra. The target population was from Kai. Sau. Shankauntalabai Anandrao Shitole Madhayamik School sit- uated in the Old Sangvi area of Pune city. The sample size is 37 students (17 females and 20 males) selected randomly.

(c) Tool for the research - Achievement test

Achievement test is an important tool in school evaluation and has great significance in measuring instructional progress and progress of the students in the subject area. Ahievement test score were calculated and analyzed to find out students' knowledge in Physics subject.

Planning of test is important aspects of investigation of research. It includes designing the test and preparation of the blue print. Designing of the test which includes objectives of the test, content of the test, nature of the test, scoring schemes, number of items, length of the test, weight age to objectives, weight age to questions, allotment of time and marking scheme. In this achievement test investigator had decided to prepare teacher made test. After this, blue print was prepared keeping in view the content and objectives of learning.

(a) Objectives of the test:

This test was constructed on the basis of knowledge, understanding, skill, and application of IX class physics subject and graphics knowledge. The researcher has constructed test on basis of following objectives:

Table No 01. Weight age of objectives

Objective	Weight age	Percentage
Knowledge	6	30%
Understanding	7	35%
Application and skill	7	35%
Total	20	100%

(b) Content of the test:

The achievement test covered the content from the units of science text book of class IX published by Maharashtra state government. The researcher has selected topics related to physics subject from the Maharashtra state board class IX textbook and prepared a weight age scheme for the test.

(c) Preparation of blueprint:

Blueprint is a detail plan of action. Blueprint was prepared for the test construction in which three dimensions were included (i) Aims (ii) subject – matter (iii) Type of question. On the basis of syllabus of IX class physics subject, question of the test were framed as per the weight age fixed with the objectives.

The researcher has prepared a blue print of the test with respect to following objectives and content of physics subject from Class IX.

Table no 02. Weight age of content

Name of the topic	Knowledge	Understanding	Application and skill	Total marks
Lesson 1. Laws of motion	2	2	1	5
Lesson 2. Work and energy Les- son 11 Reflection of light	1	2	2	5
Lesson 3. Cur- rent Electricity	2	1	2	5
Lesson 13. Carbon An important element Lesson 7. Energy flow in an ecosystem	1	2	2	5
Total	6	7	7	20

Researcher in this study aimed to verify the independent variables such as graphic knowledge and skill and the programme in physics as well as record the dependent variable in the form of achievements of the students. For this purpose researcher decided to use mixed method for research study. In this study, the researcher observed the need of survey for data collection and analysis of research objectives. And then experimental method was design for interpretation of relationship between variables.

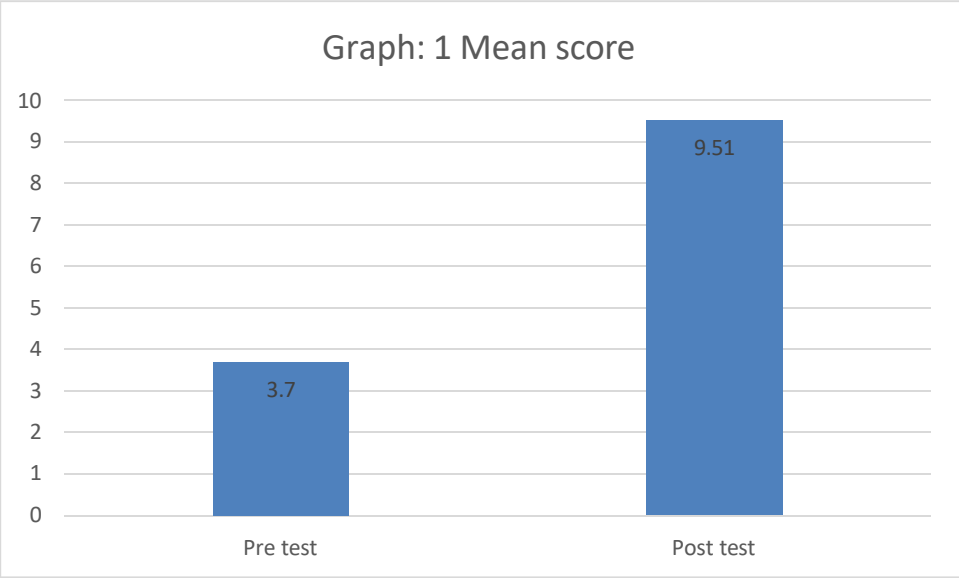
After finalizing the research method and design, researcher investigated about the research tool for data collection for this research study. Researcher taken into consideration the scheme of marking which was comprehensive enough to leave any point unexpected and thus should provide clear guidelines in respect of marks. Question type and its analysis were structured properly by the researcher.

Researcher had to motivate student while administration of test and faced challenging task to gain interest of the student. Computer based teaching techniques were implemented to carry out the research smoothly and within time.

DATA ANALYSIS AND FINDINGS

The comparison of mean pre-test and post-test scores of students is represented in graph 1. It is evident from the table no. 4 that the mean scores of pre-test and post-test were 3.70 and 9.51 respectively (Graph:1). The difference in mean scores of pre-test and post-test was 5.81. From above findings, we can say that the performance of students of class IX was found to be better in post-test in comparison with pre-test.

Graph 1: COMPARISON OF PRE-TEST AND POST-TEST SCORES



From table no. 3, we observe that the value of S.D. for pre-test and post-test are 1.42 and 3.63 respectively (table:3). From this it can be observed that the experimental group is not diverse in thinking but homogeneous in nature.

The correlation value obtained is 0.122 (table:3). This shows that there is low positive correlation between mean scores of pre- test and post-test in Physics of class IX students.

Table no. 3: Comparison of pre-test and post-test mean scores, t-value and r-value

Events	N	Mean	S.D	r- value	t value	Table t- value
Pre-test	37	3.70	1.42	0.122	9.0667	1.994
Post-test	37	9.51	3.63			

It can be concluded that the programme developed on graphic knowledge and skills in physics for class IX was effective. T-value was calculated to find out that the difference in mean score is significant or not (Sheth, Khot, 2021). The value of t-test calculated is greater than that the value in t-table. This shows that hypothesis (H_0) "There is no significant difference found between mean scores of pre-test and post-test in physics among students of class IX of secondary school" is rejected. From above finding, we see there is significant difference in mean scores of pre-test and post-test in physics of class IX. It can be concluded that the programme developed to enhance

graphic knowledge and skill in physics for class IX has given significant result.

Conclusion

The present study adopted experimental method with single group pre- test post-test design. Focus of the study is considered as only experimental group. The pre-test and post-test were administered to the same sample of class IX of Maharashtra state board. Firstly the test has been conducted prior to programme designed for teaching-learning and then after the completion of programme. The research has both dependent and independent variables. Teaching via programme here has been considered as an independent variable.

The researcher has investigated the desired result to study the graphic knowledge and skill of the students of class IX as per research design selected. Researcher has found that there is significant difference in mean scores of pre- test and post-test of physics subject in the class IX students. There is significant relation between achievement of students and the pro-gramme developed to enhance the graphic knowledge and skill of the students from class IX.

This study has shown scope to develop the Physics subject knowledge as well as sig-nificant use of graphical knowledge and skill in Physics. The study focuses on understanding the use of graphical knowledge and skill with specific significance in Physics subject. There are various techniques which can be helpful to enhance the graphical knowledge and skills of students. Computer integrated learning instructions developed in the form of programme was found to be effective to enhance the Physics subject knowledge. Details of drawing graph and interpreting it was a successful activity conducted through this programme. The task to achieve concept building in physics with help of graphical information was beneficial for the students of class IX. Diagrammatic representation of the concept in physics with directional analysis and measurement techniques was the third objective which was investigated in this test. This kind of modelling using graph paper in studies, finds substantial increase in scien-tific knowledge. Scientific literacy and graphical literacy go hand in hand as found during this research as viewed in literature survey. The perspective study as per literature review was found to be true and valid.

REFERENCE

(1) Aberg-Bengtsson, L., & Ottosson, T. (2006). What lies behind graphicacy? *Journal of Research in Science Teaching, 43*(1), 43–62.

(2) Akar, E. (2005). Effectiveness of the 5E learning cycle model on students' understanding of acid-base concepts. Dissertation Abstracts International: Section A. Humanities and Social Sciences, 41(3), 1010.

(3) American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. Oxford University Press.

(4) Champagne, A., & Gunstone, R. (1985). Instructional consequence of students' knowledge about physical phenomena. In L. West (Ed.), *Cognitive structures & conceptual change* (pp. 61–90). Academic Press.

(5) Cox, R. (1999). Representation construction, externalised cognition and individual differences. *Learning and Instruction, 9*(4), 343–363. https://doi.org/10.1016/S0959-4752(98)00051-6

(6) Deo, N. (1986). Graph theory with applications to engineering and computer science. Prentice-Hall of India Private Limited.

(7) Dhivyadeepa, E. (2015). Sampling techniques in educational research. International Journal of Advanced Education and Research, 8.

(8) Fan, J. E. (2015). Drawing to learn: How producing graphical representations enhances scientific thinking. *Translational Issues in Psychological Science, 1*(2), 170–181.
(9) Gilbert, J. K. (2007). Visualization: A meta-cognitive skill. In J. J. Gilbert (Ed.), *Visualization in science education* (pp. 9–27). Springer.
(10) IOSR Journal of Research & Method in Education (IOSR-JRME). (2016). Developing students' graphic skills in physics education at secondary school. 6(5), Ver. I.
(11) Jha, A. S. (2013). Research methodology. A P H Publishing Cooperation.
(12) Karamustafaoglu, O. (2009). *Active learning strategies in physics teaching*. Energy Education Science and Technology Part B: Social and Educational Studies. Volume (issue) 1(1): 27-50
(13) Khan, J. A. (2011). Research methodology. A P H Publishing Cooperation.
(14) Khan, M. S., & Seifert, K. (Eds.). (2011). New trends in education. A P H Publishing Cooperation.
(15) Kulshrestha, S. P. (2004). Teaching of physical sciences. Surya Publication.
(16) Larkin, J. H., & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. *Cognitive Science, 11*(1), 65–100.
(17) Maharashtra State Board of Secondary and Higher Secondary Education. (2023). Science textbook for class IX. Maharashtra Board.
(18) Moody, D. (2009). *The quality of graphical representations: A framework.*
(19) Nelson, B. D., Perlman, G., Klein, D. N., Kotov, R., & Hajcak, G. (2012). Blunted neural response to rewards as a prospective predictor of the development of depression in adolescent girls. *American Journal of Psychiatry*, *173*(12), 1223-1230.
(20) Paivio, A. (1991). *Dual coding theory and education*. Educational Psychology Review, VoL 3(3). Plenum Publishing Corporation
(21) Pandey, V. P. (2003). Major issues in science teaching. Sumit Enterprises.
(22) Rao, A. (1998). Teaching in physics. Anmol Publications Pvt Ltd.
(23) Reddy, R. J. (2011). Research methodology. A P H Publishing Cooperation.
(24) Sharma, R. C. (2013). Modern science teaching. Dhanpal Rai Publishing Company.
(25) Sheth, M. and Khot, K. (2021). The effect of stress management course on stress coping skills of M.Ed. Students. International Journal Of Multidisciplinary Educational Research, Vol. 10 (12). DOI: http://ijmer.in.doi./2021/10.12.16
(26) Singh, Y. K., & Bajpai, R. B. (2007). Research methodology: Data representation. A P H Publishing Cooperation.
(27) Stefanel, A. (n.d.). Graph in physics education: From representation to conceptual understanding. Research Unit in Physics Education, University of Udine.
(28) Sylvester, J. J. (1878). *Chemistry and algebra*.
(29) Verma, H. C. (1992). Concepts of physics. Bharti Bhawan.
(30) Wadhawa, S. (2011). Modern methods of teaching physics. A P H Publishing Cooperation.
(31) Wilson, R. J. (1996). Introduction to graph theory (4th ed.). Addison Wesley Longman Limited.