THE EFFECT OF CONCEPTUAL APPROACH ON STUDENTS' ACHIEVEMENT AND ATTITUDES TOWARD PHYSICS

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ABSTRACT

THE EFFECT OF CONCEPTUAL APPROACH ON STUDENTS' ACHIEVEMENT AND ATTITUDES TOWARD PHYSICS

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This study aimed to explore the effectiveness of Conceptual Approach on students' achievement and attitudes toward physics. In this study two types of teaching were used. These are; (1) Conceptual Approach, and (2) Traditional Method. For this study, Physics Attitude Scale and Teaching/Leaning Materials for teacher and student were developed. Physics Attitude Scale and Physics Achievement Test were used as measuring tools.

The pilot study was conducted with 9 classes, total of 160 9^{th} grade high school students. According to the results of the pilot study, some questions of Physics Attitude Test were revised and some were totally discarded.

This study was conducted with 2 teachers, 4 classes, and total of 73 9^{th} grade students in the academic year of 2001-2002. For each teacher, 2 classes were used in study. The teachers were trained for how to implement Conceptual Approach in the classroom. Students from 2 classes participated in Traditional Instruction group and referred as control group, whereas the other 2 classes instructed by Conceptual Approach referred as experimental group. Physics Attitude Scale and Physics Achievement Test were applied twice as pre-test and after a three-week treatment period as post-test to both groups to asses and compare the effectiveness of two different types of teaching utilized in physics course.

The data obtained from the administration of post-tests were analyzed by statistical techniques of Multivariate Analyses of Covariance (MANCOVA). The statistical results indicated that Conceptual Approach was more effective than Conventional Lecturing. Hence, it is strongly advised that teachers should use the Conceptual Approach while studying physics; first they should implement the concepts, after that, they should use mathematics and computations.

Keywords: Conceptual Approach, Conceptual Learning, Conceptual Teaching, Misconceptions, Preconceptions

ÖZ

KAVRAMSAL YAKLAŞIMIN ÖĞRENCİNİN FİZİK BAŞARISINA VE FİZİĞE KARŞI OLAN TUTUMUNA ETKİSİ

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Bu çalışmanın amacı; Kavramsal Yaklaşımın öğrencinin fizik başarısına ve fiziğe karşı olan tutumuna etkisini araştırmaktır. Çalışmada iki farklı öğretim kullanılmıştır. Bunlar; (1) Kavramsal Yaklaşım, ve (2) Geleneksel Öğretim Metodu. Bu çalışma için, Fizik Tutum Ölçeği, Öğretmen ve Öğrenciler için Öğretim/Öğrenim Materyalleri geliştirildi. Ölçüm araçları olarak, Fizik Tutum Ölçeği ve Fizik Başarı Testi kullanıldı.

Pilot çalışma, 9 sınıf ve toplam 160 9.sınıf öğrencisinin katılımı ile gerçekleştirildi. Pilot çalışmanın sonuçlarına göre, Fizik Tutum Ölçeğindeki bazı sorular kısmen değiştirildi ve bazıları da tamamen çıkartıldı.

Çalışma, 2001-2002 akademik yılında, 2 öğretmen, 4 sınıf, toplam 73 9.sınıf öğrencisi ile yapıldı. Her öğretmenin 2 sınıfı kullanıldı. Öğretmenler Kavramsal Yaklaşım hakkında bilgilendirilip, sınıflarda bu yaklaşımın nasıl uygulanacağı hakkında eğitildiler. Geleneksel Öğretim Metodu ile öğretim yapılan 2 sınıf kontrol grubu ve Kavramsal Yaklaşım ile öğretim yapılan diğer 2 sınıf da deneysel grup olarak belirlendi. Fizik Tutum Ölçeği ve Fizik Başarı Testi her iki gruba, iki farklı öğretimin etkisini karşılaştırmak için, ön test ve üç haftalık bir öğretim sonunda da son test olarak uygulandı.

Problemler çerçevesinde kurulan hipotezlerin test edilmesi için, son test skorları MANCOVA istatistiksel tekniği kullanılarak analiz edildi. İstatistiksel sonuçlar, Kavramsal Yaklaşımın Geleneksel Öğretim Metoduna göre daha fazla etkili olduğunu gösterdi. Bu yüzden öğretmenlere, fizik dersini anlatırken Kavramsal Yaklaşımı kullanmalarını; öncelikle kavramları geliştirip daha sonra matematiksel işlemleri ve hesaplamaları yaptırmaları tavsiye edilir.

Anahtar Kelimeler: Kavramsal Yaklaşım, Kavramsal Öğrenme, Kavramsal Öğretim, Kavram Yanılgıları, Ön Kavramlar.

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PREACH:	Students' Physics Achievement Pre-Test Scores
PREATT:	Students' Physics Attitude Pre-Test Scores
PSTACH:	Students' Physics Achievement Post-Test Scores
PSTATT:	Students' Physics Attitude Post-Test Scores
PCGPA:	Students' Previous Cumulative Grade Point Average
PPCG:	Students' Previous Physics Course Grades
PACT:	Physics Achievement Test
PATS:	Physics Attitude Scale
MOT:	Methods Of Teaching
CA:	Conceptual Approach
TM:	Traditional Method
df:	Degrees of Freedom
N:	Sample Size
α:	Significance Level

CHAPTER 1

INTRODUCTION

We live in era in which there are rapid changes as a result of scientific and technological advances. These rapid changes will continue with enormous speed. Özinönü (1970) studied the pattern of scientific development in Turkey between the years 1933 and 1966. At the end of this study, he stated that although the growth is rapid, it has not reached an exponential yet. According to the Faure (1972), the research and innovation are institutionalized and the gap between scientific discovery and its large-scale applications diminished. So this event affects the nature, quantity, and the status of science and its influence on economy, political considerations and our lives become very different from that of "preatomic and premissile centuries" (Hurd, 1965).

The power of the science and technology has greater importance in the lives of human-life. Within this rapid change of science and technology, physics takes important role. Because physics is the basic science, it is the foundation of chemistry, biology and the discipline of science.

As a basic science, physics should be learned very well. This is a requirement to follow technological development and to understand the nature. In this aim, schools and teachers take important responsibilities. As Hewitt states in his Conceptual Physic book, "Physics should be the part of the educational mainstream for both science and nonscience students" (Hewitt, 1998, pp. XVI). Hewitt (1972) reports that while brightest students regard the study of physics course as scientific bent, the average non-science students regard it as an incompressible discipline. In addition, Hewitt (1990) reports that for the past several decades, physics has been the least popular science course in U.S. high schools. Biology has been more popular than physics. It has been common belief that physics courses frustrate average ability students and drive them to despair. It has been a weddest course, a course to "get through" rather than a course to "get into".

According to Hewitt (1990), there has been a common belief between students that, physics course allow only a few academically elite students be successful and defeats others. What is the reason that physics has been the least popular science course? What is the reason that students prefer to take biology course than to take basic physics? Biology is more complicated than physics. Moreover physics is simple, it can be easily expressed in mathematical form. But for most people mathematics is a problem. It is like a foreign language for them. The answer to the question of why is biology popular than physics is; because biology is taught qualitatively while physics is taught quantitatively. It is easy to teach physics by using mathematical equations. But it is a big mistake. Hewitt (1990) indicates that physics course usually emphasize the final stage of the learning cycle. It means that before exploration and concept development, the application and skipping is tried to be achieved. Than students are forced to make practice of manipulating terms in equations without understanding conceptually.

Physics is different from other academic disciplines with its mathematical structure. The language of physics is mathematics. Mathematics helps physics to explain and describe the physical phenomena. Because of this, it has been taught as a course in applied mathematics. To gain the knowledge of physical world with traditional course, students must be able to translate academic language of mathematics into everyday language. But for a typical nonscience student mathematics is a foreign language. Most students chose to avoid this difficult task and regard physics course as an incompressible discipline. They choose to memorize formula, manipulate the terms in equations. Their aims become just to solve the quantitative problems and find the correct answers of these problems. At the end of the course, they pass it without learning the physics conceptually.

According to the physicists, the mathematical structure of physics is beautiful and elegant. But Hewitt (1990) indicates that when mathematical structure is used to solve the physics problem before developing the concept, the beauty of mathematical structure is lost and students see the physics course as a course to "get through" rather than to "get into".

What is the recipe that students can see the physics course as a compressible discipline? What kinds of revolutions do we achieve that science and nonscience students study it with an enthusiasm?

Hewitt (1998) states:

> "You know you can't enjoy a game unless you know its rules; whether it's a ball game, a computer game, or simply a party game. Likewise, you can't fully appreciate your surroundings until you understand the rules of nature. Physics is about the rules of nature -- so beautiful elegant that it can be neatly described mathematically. That's why many physics courses are treated as applied mathematics. But introductory physics that emphasizes the computation misses something essential –***comprehension***- " (Hewitt, 1998, p. XV).

First of all, we have to be conscious that, by urging the mathematical backgrounds of the students we cannot teach physics very well and cannot have it liked by students. Redish, Saul and Steinberg (1997) state that if inappropriate expectations play role in the difficulties our students commonly have with introductory calculus-based physics, we need to find a way to track and document them. In this aim as a teacher we take huge and important responsibilities. If students are not able to translate the mathematical language into the everyday language, we should help them to translate and to understand the environment. Hewitt (1972) suggests that we should depart from the beauty and elegance of mathematical language, it is time to speak to students in their own language. We know that the relations in physics are mathematical. But, if ideas are developed non-mathematically at the beginning of the subjects, and exercises or problems are developed by qualitatively, students will start to see physics course as compressible discipline. If concepts are developed before computations, they will understand the meaning of physics and life. At the end, physics will be fascinating body of knowledge and exiting process. “Let’s address this problem by starting in our classrooms. Let’s begin by making physics accessible. Let’s teach our discipline qualitatively. Let’s legalize physics. I do this by teaching conceptual physics” (Hewitt, 1983, p. 305).

What does conceptual physics mean? Hewitt (1983) describes conceptual physics as the study of the concepts of physics qualitatively by emphasizing on mental imagery. That means, studying physics by relating the concepts to the things, events that are familiar in the everyday environment. The concepts should be developed by giving examples from daily life. The environment is full of events related to physics. Hewitt (1990) states that physics first brought from the everyday environment to the laboratory. By relating the ideas and concepts in physics with examples familiar to the students' everyday surrounding, common curiosity can be reinforced.

Hewitt (1972) reports:

> "Just as a botanist taking a 10–minute stroll through a wooded park can be more alive to his surroundings than a layman walking through the same area, a person with a conceptual knowledge of physics can become more aware of his surroundings than the "educated" person who has managed to avoid any understanding of physics" (Hewitt, 1972, p.522).

How can we get this aim successfully? Hewitt (1990) suggests that the first course in physics should be conceptual physics. Teachers should stress on concepts, critical thinking rather than algebraic manipulations and derivations. We accept that the language of physics is mathematics. But, at the beginning, we should use the mathematical structure of physics in order to show the relationships between ideas, and concepts. This type of approach, without algebraic manipulations and computations encourage students to learn physics. Students will see equations as a meaningful guides to thinking rather than as a rules for multiplying, dividing adding and subtracting numbers. And also Hewitt (1983) reports that the primary aim of this first conceptual course must be to teach a comprehension and understanding of the principles of the physics. And, after that the mathematical calculations should be applied to all students. "A physics student who lacks a conceptual understanding of physics and who is working with physics problems is a kin to a deaf person writing music or blind person painting" (Hewitt, 1983, p.309). When the mathematical structure of physics is used before concept, students feel very uncomfortable. They view it as a negative stimulus. For nonscience students, a mathematical treatment is the biggest obstacle to a positive attitude toward physics.

Teaching physics is a difficult task. As Hewitt (1972) states we should have three main objectives while teaching this course. The first and main objective is to teach hardcore physics with emphasis on the everyday environment. The everyday world is rich with physics. The second is to shape the critical thinking of students and the third is to relate the role of physics and technology toward the positive future.

As a teacher, we should help students to learn concepts. After that as Brouwer (1984) suggests teachers should encourage students to express their conceptual understandings of physics by means of questions, classroom discussions and assignments.

As Brouwer (1984) reports the effect of Conceptual Approach on students' achievement and attitudes toward physics is positive. Conceptually oriented teaching will encourage students to learn physics. Physics course will be more popular course.

Hewitt (1990) reports that physics course has been the least popular course in U.S., it is also unpopular course in Turkey. Students have difficulties when learning physics in Turkey also. The results of the study conducted by ÖSYM supports our idea. Moreover, in 2001 ÖSS, 19 physics questions were asked. The results of study achieved by ÖSYM (2001), students would have solved at average of 2.89 physics questions in 2001 Ö.S.S (ÖSYM Yayınları, No: 2001-6, Ankara). The results of this study enforce teachers to change their instructional methods and then as they teach physics with enthusiasm, students will learn with desire also.

This study was undertaken to investigate the effect of Conceptual Approach on student's achievement and attitudes toward physics. It will be compared the relative effectiveness of Conceptual Approach and Traditional Method on students' achievement and attitudes toward physics.

1.1 The Main Problem

The main problem of this study is stated as follows;

What are the effects of Conceptual Approach on students' achievement and attitudes toward physics?

1.2 Hypotheses

The problem stated above was tested with the following hypotheses, which are stated in null form.

Null Hypothesis 1

$H_{0[1,2]}$: $\mu_{CA} - \mu_{TM} = 0$

1: scores on physics achievement post-test, 2: scores on physics attitude post-test

There will be no significant effect of methods of teaching (Conceptual Approach versus Traditional Method) on the population means of collective dependent variables (DV) of physics achievement post-test scores and physics attitude post-test scores when student' age, physics achievement pre-test scores, physics attitude pre-test scores, previous cumulative grade point average, previous physics course grades, gender and teacher are controlled.

Null Hypothesis 2

$H_{0[1, 2]}$: $\mu_{CA} - \mu_{TM} = 0$

There will be no significant effect of methods of teaching (Conceptual Approach versus Traditional Method) on the population means of the physics achievement post-test scores when student' age, physics achievement pre-test scores, physics attitude pre-test scores, previous cumulative grade point average, previous physics course grades, gender and teacher effects are controlled.

Null Hypothesis 3

$H_{0[1, 2]}$: $\mu_{CA} - \mu_{TM} = 0$

There will be no significant effect of methods of teaching (Conceptual Approach versus Traditional Method) on the population means of the physics attitude post-test scores when student' age, physics achievement pre-test scores, physics attitude pre-test scores, previous cumulative grade point average, previous physics course grades, gender and teacher effects are controlled'

1.3 Definition of Important Terms

This study will measure the effectiveness of Conceptual Approach on physics course. In the dictionary of COLLINS COBUILD, the meaning of "Conceptual" is given as; means related to ideas and concepts formed in the mind. The word of "approach" is approaching a task, problem or situation in a particular way, dealing with it or thinking about it in that way. I will use in this meaning. The word of “attitude” will be used in the meaning of, the way you think and feel about it, especially when this shows in the way you behave.

Students’ age, physics achievement pre-test scores (PREACH), physics attitude pre-test scores (PREATT), students’ previous cumulative grade point averages (PCGPA) just before the study began in spring semester, students’ previous physics course grades (PPCG) just before the study began in spring semester, students’ gender and teacher are the variables of this study. These variables are considered as covariates. Methods of teaching (MOT; Conceptual Approach versus Traditional Method) are considered as group membership. Physics achievement post-test scores (PSTACH) and physics attitude post-test scores (PSTATT) are dependent variables. Following terms are necessary in understanding my study.

Students’ age: The ages of students in years participated in the study were taken at the time of post-testing.

PREATT: 45 items which were designed to be rated on 5 point likert type response format were used to measure this variable. Higher scores indicate positive attitudes toward simple electricity and lower scores indicate negative attitudes toward simple electricity.

PSTATT: 24 items which were designed to be rated on 5 point likert type response format were used to measure this variable. Higher scores indicate positive attitudes toward simple electricity and lower scores indicate negative attitudes toward simple electricity.

PREACH: 25 items was used to measure this variable. It measures the students' physics achievement pre-test scores on the concept of simple electricity. It includes qualitative questions and quantitative questions.

PSTACH: 25 items was used to measure this variable. It measures the students' physics achievement post-test scores on the concept of simple electricity. It includes qualitative questions and quantitative questions

Method of Teaching (Conceptual Approach versus Traditional Method): Hewitt (1983) describes Conceptual Approach as the study of the concepts qualitatively by emphasizing on mental imagery. That means, studying concepts by relating to the things, events that are familiar in the everyday environment. Conceptual Approach requires 3 main objectives. It requires, teaching hardcore physics, enforcing students' critical thinking and relating role of physics and technology. Traditional Method is the conventional lecturing method.

1.4 Significance of the Study

The main purpose of this study is to investigate the effect of Conceptual Approach on students' achievement and attitudes toward physics. It will be compared the relative effectiveness of Traditional Teaching Method and Conceptual Approach on students' achievement and attitudes toward physics in the topic of Simple Electricity Circuit.

As mentioned before, physics is important discipline to follow the technology. It should be educational mainstream for all students. However, it has been least popular science in abroad and Turkey for a long time. Studying physics frustrate average ability students and encourage them to despair. For physics course to be educational mainstream for science and non-science students, teacher should teach conceptual physics. This method will result in more science oriented students and more positive attitudes toward physics lessons.

Researches conducted abroad provide us with the knowledge of the effect of Conceptual Approach on students' achievement and attitudes toward physics. As Hewitt (1990) reports there are lots of success stories of conceptual physics abroad. For example, Nancy Watson began pioneering the Conceptual Approach with eighth graders at Burris Laboratory School in Muncie, Indiana five years ago. She switched half her students from physical science to conceptual physics and found the results so impressive that she went entirely conceptual the following years. However, no study investigating the effect of Conceptual Approach on students' achievement and attitudes toward physics, in the topic of simple electricity circuit, have been found in Turkey so far. The results of this study will provide insights into the effect of Conceptual Approach on students' achievement and attitudes toward physics in Turkey. Moreover, results of this study will give some important cues to secondary science teachers in Turkish educational system about the criteria of conceptual physics, then how to improve and use Conceptual Approach in physics. It is also hoped that this study will be a guide to future studies about Conceptual Approach in other science (mathematics, chemistry, biology). It is also expected that physics courses will be more popular science than does it now in Turkey.

CHAPTER 2

REVIEW OF THE LITERATURE

In order to be familiar with all of the relevant research that preceed the present research; to integrate them with the current research; and to identify the foundations of ideas and results on which the current research was built, the literature relevant and necessary to understand the present study is given below.

2.1 Importance of Physics

It seems logical to begin with the importance of physics and to consider the weakness of physics education and to find solutions to these problems. Physics is an important discipline. As Hewitt (1998) states in his Conceptual Physics, It is the basic and important science, it is the foundations of chemistry, biology and all disciplines of science. This important subject should be learned well by all students. As Bilgiç (1985) states we live in an era in which there are lots of rapid changes due to scientific and technological developments. Within this rapid change of science and technology physics takes important roles. It is a need to understand and evaluate events that occur around nature and us.

Hewitt (1998) states:

> "You know you can not enjoy a game unless you know its rules whether it's a ball game, a computer game, or simply a party game. Likewise, you cannot fully appreciate your surroundings until you understand the rules of nature. Physics is about the rules of nature" (Hewitt, 1998, pp. XV).

It is a guide to understand the nature. So physics should be part of the educational mainstream for both science and non-science students (Hewitt, 1998).

2.1.1 Reasons Why Physics Course Has Been Unpopular

Unfortunately, we are not very successful while teaching physics to both science and non-science students. Hewitt (1972) reports that while science students regard the study of physics course as a scientific bent, the average non-science students regard it as an incompressible and difficult discipline. Hewitt (1990) reports that for a long time physics has been the least popular science in U.S high schools. The same situation is also valid in Turkey. According to the data reported in ORTAÖĞRETİM KURUMLARINA GÖRE 1999, 2000, 2001 ÖĞRENCİ SEÇME SINAVI SONUÇLARI, 2000-2, 2000-9, 2001-6, number of schools, number of students, average number of physics questions succeeded, standard deviation with respect to years given in Table 2.1. From this table, we can see that average number of physics questions succeeded is really low. It can be inferred that physics course frustrate the students.

Table 2.1 Some Important Information Related to 1999, 2000, 2001 Ö.S.S Exams.

Ö.S.S	Number of schools		Number of students		Average number of physics questions succeded		Standard deviation	
	General	Private	General	Private	General	Private	General	Private
1999	3023	154	301148	11023	2,33	4,3	4,57	5,66
2000	3239	185	295112	11488	2,18	3,88	4,23	5,01
2001	3484	200	298654	9510	2,89	5,23	5,2	6,34

It has been a common thought that studying physics frustrate average ability students and encourage them to despair. It has been an unpopular course; moreover, it has been a course to "get through" rather than to "get into". A common belief between students is that; physics course allow only a few academically elite and successful students and it despair other average non-science students. Biology has been more popular than physics. Although it is more complicated than physics, students prefer studying biology to studying physics.

What is the reason that physics course has been the least popular course? Where is the mistake? Who is responsible from this? Physics is simple. Moreover, it can be easily expressed mathematically. As Hewitt (1972) states the language of physics is mathematics. By using mathematical equations, the physics and physical phenomena can be expressed easily. If students can translate effectively the academic language of mathematics into everyday language, he can understand physics and he can gain knowledge of physical world via the traditional physics course. But for a typical non-science student mathematics is a foreign language. "Unfortunately, mathematical prerequisites often deter average non-science students from an encounter with physics" (Hewitt, 1998, pp. XV). And also, as Hewitt (1990) states physics courses generally emphasize the final stage of learning cycle, without achieving exploration and concept development. When the physics courses are introduced with this final stage, students are forced to solve mathematical problems. Because of that "Physics has been a course taught as a course in applied mathematic of the least popular kind-algebraic word problems" (Hewitt, 1990, p. 55). This kind of instruction forces students to manipulate terms in equations. Most of them just try to solve mathematical problems without learning, understanding subjects conceptually. Students do not like this kind of approach, especially non-science students, dislike and choose to avoid physic courses. Non-science students are right, because with this approach, students are trying to recite the poems without missing a single word.

We stated that biology is more popular than physics. What are the reasons that make biology course more popular than physics course in U.S. Biology is much more complicated than physics. In fact physics is simple.

According to Hewitt (1983) the reason for people to select biology is that; biology is taught qualitatively but physics is taught quantitatively. The source of problem is here. The physics course taught in schools is not the real physics; it is the course in applied mathematics. The teachers are teaching students to use the mathematical equations and to manipulate the terms within equations. The student's aim become just to solve the quantitative mathematical problems and to find the correct answers to these problems. At the end of the semester, they pass the course without learning it conceptually. But, in fact "A person with a conceptual understanding of physics is alive to his or her surroundings, just as a botanist taking a stroll through a wooded park is more alive than most of us to the trees, plants, and fauna" (Hewitt, 1983, pp. 306). Just solving mathematical problems without understanding it conceptually is like trying to memorize the poem without missing a word. This is not good. It does not supply the students' expectations. So physics course become an incompressible discipline, and an unpopular course.

2.1.2 Solution to the Problem

What should be the recipe that physics course become compressible, understandable and popular? As stated, physics is easy to teach mathematically, but we make a huge mistake by assuming that it is easy to learn mathematically. Redish, Saul and Steinberg (1997) indicate that if inappropriate expectations play role in the difficulties our students commonly have with introductory calculus-based physics, we need to find a way to track and document them. Hewitt (1972) suggests to depart from the beauty and elegance of mathematical language. We know that the relations in physics are mathematical whether or not they are developed and expressed in symbolic form. But, if the ideas are presented non-mathematically and exercises and problems are concerned with qualitatively, then student will see the physics as compressible and interesting discipline. When the mathematical analysis is given much more emphasis than conceptual reasoning, students see the physics as the course in applied mathematics (Hewitt, 1983). Our students haven't learned enough physics to distinguish between two. Most probably, biology course would be seen as the applied math if it was simple enough to be as easily expressed mathematically. At this point, teachers have important responsibilities.

As Hewitt (1983) suggests we should start to solve this problem in our classrooms. Lets make physics accessible, understandable and compressible. Lets achieve this aim by teaching qualitatively. Paul G. Hewitt is a physics teacher in U.S.

He has been teaching at city college of San Francisco since 1964 and trying to solve this important problem with the conceptual physics course. According to Hewitt the first course in physics should be conceptual physics. Because he regards that "A physics student who lack a conceptual understanding of physics and who is working physics problems is a kin to a deaf person writing music or a blind person painting" (Hewitt, 1983, pp. 309). It doesn't matter the students are science or non-science students. We should first teach our students to conceptualize, and then to computation (Hewitt, 1983). The starting point is teaching conceptual physics.

2.2 Conceptual Physics

What is conceptual physics? Hewitt (1983) describes the conceptual physics as the qualitative study of the central concepts of physics with emphasis on mental imagery that relates the things events that are familiar in the everyday environment. In his another article (1990) he describes it as, teaching physics by stressing on the concepts rather than derivations, and on critical thinking rather than computation. Hewitt claims that using mathematical structure of physics to show the relationships between ideas and concepts, without the algebraic manipulations and computations do not frustrate students. Hewitt (1983) also argue that we have to be very clear about a possible misconception. We don't mean to diminish the importance of mathematical analysis and problem solving in physics instruction. It is absolutely essential to mastering good physics. We know how essential mathematics is. But it is argued that there is also another essential point to be considered. That essential point is conceptual understanding of physics.

2.2.1 Criteria of Conceptual Physics

Hewitt (1972; 1983) reports that he has 3 main course objectives while studying conceptual physics. These are; to teach hardcore physics on the everyday environment, to shape the critical thinking of students, and to relate the role of physics and technology toward future.

2.2.1.1 To Teach Hardcore Physics

What does Hewitt mean by teaching hardcore physics with emphasis on the everyday environment. Our environment and everyday world is full of physics. As Hewitt (1983) states physics is everywhere and our task should be to bring it alive in the minds of students. The richness in life is not observed only seeing the world with open eyes, but also knowing what to look for. For example lets look at the notion of force, as in the example of Hewitt; teacher know that the forces occur only in pairs, but least number of students know this fact. We can bring them to see that every force is actually an interaction between at least between two things. If one of the pair of forces is obvious, the other pair perhaps escaped its notice. In order to make it clear, teacher should produce interesting stories. For example, teacher should tell students that "Suppose one day you get angry and hit the wall with your fist. Your hand damaged. You bandage your hand and a friend of you asked what happened. What you say? "Most probably student tells, "I hit the wall". If students understand the conceptual physics he or she can say, "The wall hit my hand". Another story, "You hold up a sheet of paper and state that the heavy weight champion of the world couldn't strike the paper with 50 pounds of force" (Hewitt, 1983, pp. 306) why? These kinds of questions are helpful while implementing the hardcore physics.

Hewitt (1983; 1972) suggests being very careful while limiting our selection of topics. We should always remember Alan Holden's principle of least knowledge "We learn what we need to learn in order to survive and we forget the rest". There is no need to learn needless information. The important think is to get the main ideas and improve it with good real life examples. In his lectures Hewitt studies only one or two ideas and support these with examples during one period of lesson.

Another point of studying lesson is that, Hewitt makes much use of drawings on the chalkboard. He suggests all teachers to learn basic, simple things such as cube, or ellipse. Improving the simple drawing skills affects the lecture positively (Hewitt, 1983).

Classroom discussions are the important part of his lectures. Hewitt believes that as the ideas are discussed, they are most probably remembered. Because of that he promotes lots of classroom discussions in his lectures no matter the size of classroom (Hewitt, 1983). He suggests teachers to prepare the discussion within the students. After asking the discussion questions, he asks students to make a written response in their notes and then to look at their neighbors' papers and briefly discuss their answers. After a while, he let the students to explain why they choose their answer and why they did not choose the other answers. According to Hewitt, in-class discussion is important and only one part of the conceptual teaching story.

2.2.1.2 To Shape Critical Thinking

The second important objective of the Hewitt (1983) is to shape the critical thinking. According to Hewitt the questions of "how do we know that such-and-such is valid? What evidence do we have for believing so? If we're wrong, how would we know?" Are these important to improve and shape critical thinking? He stresses on the Feyman's idea of, naming the thing doesn't mean understanding the thing. According to Hewitt (1972) many people think that by finding a name, a phrase, or a label for certain phenomenon, they understand the whole things. The important thing is to understand the underlying idea of principles or rules rather than finding a name, a phrase, or a label for that certain phenomenon. Education mean to distinguish which names we understand and which don't understand rather than acquiring new names and labels (Hewitt, 1983). He (1972) reports an example that; some students would say that a body projected in free space continues in its state of motion due to inertia. This answer may be taken after the Newton's laws of motion studied. This is not true. A body continues its motion because there are no retarding forces. The name of inertia is given to this property of matter to persist, not the reason for it.

We stated that physics is easily expressed with mathematical equations. Hewitt (1990) suggests using equations to improve the critical thinking. Equations should be used as guides to thinking in conceptual physics. Hewitt (1983) indicates an example related to using formulas as guides to thinking. In his example he used the formula of gravitational force; $F \propto m.M/d^2$. As we know, gravitational force is responsible from our weight. The formula gives the relationship of mass m and that of the world is M. It is easy to say that as the mass of object increases, the gravitational force (so the weight of object) increases. And also it is easy to express that as the distance between the center of object and that of world is increased, the gravitational force decreases. While studying this subject, he suggests asking questions like; what happens to your weight if you climb a tall ladder? Or how does the gravitational force acting on the earth satellite would change if the satellite temperature increased? These kinds of questions enforce students to think critically. According to Hewitt if students learn to use the formula as a guide, they can give the certain answer. For example, for the second question, students would learn to give the answer such as; in the formula, there is no symbol for temperature, so the gravitational force is independent of temperature.

Hewitt indicates another important point that most people are not good at thinking of more than one idea at a time. But formulas help us to think of more than one idea at a time. In order to support his idea, Hewitt (1990) gives the following example;

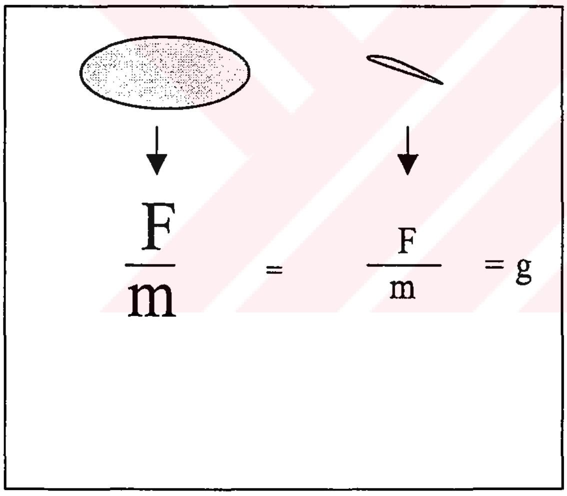

Figure 2.1 An example of Hewitt to enforce students think more than one idea at a time.

The Newton's second law is expressed with the formula of F = m*a. It is the base formula for computation. We can reorganize the formula as, a = F/m to explain why a feather and a boulder fall equally in the absence of air resistance. The gravitational force acting on the boulder is larger, but the boulder has a correspondingly greater mass. So the ratio of force/mass, which is defined as the acceleration, is same for both feather and boulder. The gravitational force acting on feather is small but its mass also small, then the ratio of force to mass is same to that of boulder. For these situations the relative size of symbols are effective in establishing the importance of the different magnitudes. When the students learn critical thinking in classroom, they will carry it to the out of classrooms.

2.2.1.3 To Relate the Role of Physics and Technology

The third objective of Hewitt is to relate the role of physics and technology and to impart positive attitude toward science and its role in the future. As Hewitt (1972) reports most of the people are afraid of future. They view the technological and scientific advances as stepping-stones to an inevitable totalitarian society. Growing role of science is seen as an ally of worst fears for future. People are warned with the dangers of growing technology. They think that the improvements in technology will result in worst world. For example nuclear power plants are effective for the production of energy. On the other hand, they are harmful to the environment. The nuclear useless products and radiations lead to cancer and other illnesses. There has been a negative attitude toward nuclear power plants. Nearly, 70% of electrical power in the United States comes from fossil fuels, with 21% from nuclear power. People have grown to depend on fossil fuels because they have been plentiful and inexpensive. But things have changed. Fossil fuels are being consumed at a rate that threatens to deplete the entire world supply. Locally and globally, fossils fuel consumption is measurably polluting the air we breath an the water we drink. We have to find out new energy sources by using technology. The worst think for the people is to give up hope for better world.

According to Hewitt (1983) as a physics teacher we have great chance and huge responsibility to point out the positive things, which happened technologically. We should balance the negative vision of the future that is mostly resulted from misleading data, with more accurate forecasts based on the correct and suitable information.

2.2.2 Benefits of Conceptual Physics

There are lots of benefits of Conceptual Approach on physics. As Hewitt (1972) stated an important benefit of teaching physics with a nonmathematical approach is the saving of time. Because with Conceptual Approach, the equations are used as meaningful guides to thinking. When mathematical equations are used as relations or proportions rather than equations involving constant and when they are used by focusing on the conceptual ideas rather than numerical computation, the systems or lots of units of measurements will be omitted. We need a larger time and a greater number of topics to teach students to distinguish between units and the conversion between the systems of units.

Another important result of teaching physics conceptually is the greater teacher satisfaction. Hewitt (1990) states that students enjoy learning physics when they are taught conceptually, and they enjoy working hard. Because Conceptual Approach do not urge the mathematical background of students. There are no difficult computations. It is appropriate for both science and non-science students. And the important thing is to enforce critical thinking, general interest and confidence in science for all students. The goal is not to filter the students for future careers. The purpose of filtering of future researchers should be a function of some other advanced courses.

The other benefit is the student satisfaction. Hewitt (1990) states that the students studied the course of conceptual physics course feel good about themselves and science in general. Because conceptual physics feeds other science courses also. The result is the greater number of students taking physics course and a greater proportion of science-oriented students. With this approach we can make it a course to "get into" rather than to "get through". Brouwer (1984) states that conceptual understanding is generalized to new situations. Ideally, students try to learn themselves, because they are active in developing their knowledge. This approach enables students to test out their own preconceptions about reality.

2.2.3 Successes of the Conceptual Physics

Hewitt (1990) mentions about the success of Conceptual Approach on his article. This kind of approach attracts the 9^{th} and 10^{th} grade students who would have taken biology if they wanted a course that was taught qualitatively. Elaine Robinson is biology teacher at Juanita High School in Kirkland, Washington. She was teaching physics to students and struggled to keep up with students. She used to apply the mathematics to chapter-end problems. After urging her principle, she changed her Traditional Method to Conceptual Approach and converted struggle to delightful experience. The course was so affective and successful that the number of students enrolled in physics course tripled in the next year. Another success story is achieved by Nancy Watson. She began to apply the Conceptual Approach with eight graders at Burris Laboratory School (a K-12 school) in Muncie, Indiana. She started to teach half of her students conceptually and the other half traditionally. The result of teaching conceptually so impressive that she entirely taught conceptually following years. The student enrollment and the student enthusiasm increased. She reports that the primary reason to the increase of enrollment of student and student enthusiasm is the Conceptual Approach. In the late 1960s, Ed North, at Taft School in Watertown, developed three tenth grade entry-level physics course. All of them have varying degrees of emphasis on the Conceptual Approach. These courses are designed to both science and non-science students alike. The result is impressive and successful. Approximately 90 percent of the whole students at Taft have taken physics course. In Taft, physics really has been a educational mainstream. Similarly, more than 90 percent of the students at Gun High School in Palo Alto, California take physics course. Hewitt states that this success is the direct result of the development of a three-tier physics system. This system was developed by Art Farmer who is the recipient in California of the Presidential Award for Excellence in Science Teaching in 1983. The first tier is completely conceptual for non-science students and the second tier is conceptual with some algebra, and the third is for the students who want to be engineers or scientists. Farmer studied the course pure conceptually until the midway through the semester. He does not solve problems. When he is convinced that his students can understand the concepts on verbal level and distinguish between closely related ideas than he decided to apply to mathematical problems. Poul Robinson who is the California's 1987 recipient of the Presidential Award for Excellence Science Teaching, emphasize the laboratory activities and the experiments that use computer in his conceptual physics course. Poul Robinson and his friends at Computech High School like teaching conceptual physics.

Approximately 100 percent of the students take physics course. Most of the high school teachers report that the number of students enrolled in physics courses doubled since Conceptual Approach has been adopted.

Hewitt (1990) states that some teachers are afraid of the fact that a course teaching conceptual physics will put students at a disadvantage when they are required to take exams need mathematical application for college entrance. The study of Paul Hickman's at Cold Spring Harbor High allayed their fears. He applied the New York Regent Exam to his ninth and tenth grades conceptual physics class and that of his twelfth graders as final exam. The result is impressive; the ninth and tenth graders got higher scores than the twelfth graders on the exam.

Madsen, A.L. and Lanier, P.E (1992) Investigated the effect of conceptually oriented instruction on students' computational competencies. Their study presents the results of a computational test taken by two groups of students in ninth-grade general mathematics classes. One group of students practiced computational procedures without an emphasis on the mathematical concepts. The other group of students are taught the mathematical concepts by underlying the procedures and spent little time on practicing computational procedures. The results of the computational test showed that the conceptually oriented class increased average grade-level equivalence for computational competence. This class has the average grade level of 6.5 at the beginning of the school and increased it to 9.1 grades at the end of the year. At the beginning, the computationally oriented class had the average grade level of 7.1 at the beginning of the school and increased it to 7.5 grades at the end of the year. And also other findings showed that students in the conceptually oriented classes tried more items on the post-test than the other students in the computationally oriented classes. At the end of the year, students in the conceptually oriented classes stated that they had learned more mathematics than they had any of their previous mathematics classes. The result of this study indicates that conceptual understanding increase students' computational competence and promote more positive attitudes toward mathematics.

Rosenquist and McDermott (1986) made a research with the name of "A Conceptual Approach to teaching kinematics". In this study, they tried to develop Conceptual Approach to teaching kinematics by means of results of the research on students understanding of velocity and acceleration. Their study describes how instruction based on the observation of actual motions can help students. They intended to help by; (1) developing a qualitative understanding of velocity as a continuously varying quantity, of instantaneous velocity as a limit, and of uniform acceleration as the ratio of the change in instantaneous velocity to the elapsed time; (2) distinguishing the concept of position, velocity, and change of velocity, and acceleration from one another; and (3) make connections among the various kinematical concepts, their graphical representations, and the motions of real objects. The Physics Education Group at the University of Washington firstly, identified a number of specific conceptual difficulties encountered by students in their study of kinematics. Then they use the results of study to guide design of an instructional module in kinematics. In laboratory, by using specific examples, they help students recognize key features of definitions, distinguish closely related concepts, and make explicit connections among concepts, graphical representations and real world. They stated that stressing on these goals results in a deeper conceptual understanding than traditionally and mathematically oriented instruction. While studying concepts of velocity and acceleration some of the students are included in the special preparatory physics course. Like other group, these students participated in interviews before and after instruction. In these instructions students are asked to perform specific task based on the demonstration of an actual motion. In post course interview, 90 % of the students in preparatory physics course were able to make a correct comparison, whereas before instruction only 60 % were successful. By contrast students enrolled in the algebra-based physics course haven't showed any improvement from their initial 60 % of success. They state that successful performance on the interview indicates the development of an important kind of qualitative understanding. Students' ability of applying kinematical concepts to real motion increased. This ability of students taking, calculus-based physics, often do not develop spontaneously during the introductory course.

2.3 Concept of Misconception

Driver and Easley (1978) report that most of the students begin the study of science with pre-existing conceptions about scientific phenomena that interfere with students' learning of scientific principles or concepts. These pre-existing conceptions are called as pre-instructional conceptions. Most of the research results showed that these pre-instructional conceptions deeply influence learning. Misconception is the sub category of pre-instructional conception. Champagne, Gunstone and Klopper (1982) State that these misconceptions are widespread and have harmful effect on course performance and conceptual understanding of the materials. According to Sjoberg, S., & Lie, S. (1981) these misconceptions appear to be resistant to change via traditional instructional approaches.

2.3.1 Misconceptions Concerning Simple Electricity

Chambers and Andre (1996) report that in the last 15 years, the role of prior alternative conceptions or misconceptions has been explored extensively in learning natural science. Meanwhile this period, research studies have been conducted related to students' conceptions concerning various fields of physics. One active area of research on physics misconceptions is the topic of simple electric circuits. Researchers have identified misconceptions in the area of electrical circuits.

Arons (1982) points out that according to the results of the many research, related to electricity topic, students are incapable of analyzing simple circuits qualitatively. The reason of this unsuccessful situation can be students' development of their own mental model and using this model to make prediction about the outcome of different circuits. Besides this, concept of electricity has lots of invisible nature. Al of them encourages students to construct misconceptions related to electricity.

Shipstone et al. (1988) investigated the understanding of basic electrical concepts shown by 15-17 year-old students in five European countries including England, France, The Netherlands, Sweden and West Germany by administering the same objective test to sample of students in each of these countries. Result of the study showed that although the students are educated with very different systems of education they have similar incorrect ideas.

Osborne (1983) and Shipstone (1984) identified the development of students' preconceptions in the area of simple electrical circuits: They have defined five model; (a) The sink model. (b) The clashing-currents model. (c) The unidirectional without conservation or weakening model (d) the unidirectional with sharing or shared current model. (e) The correct model. According to the correct model, a constant current travels in one direction throughout the circuit. Another additional misconception that does not fall in the above developmental sequence is the short circuit preconception on parallel circuit preconception

In literature there are lots of studies concerning the misconceptions about simple electric circuits. The common ones are explained below:

The Sink Model: Developmentally earliest misconception has been labeled as sink model. Students holding this misconception believe that electricity sinks along a single wire connection from a power source to a electrical device like water flowing downhill along a single path (Chambers & Andre, 1997; Chang, Liu & Chen, 1998; Osborne, 1981)

Clashing Current Model: Developmentally, this model is followed by sink model. According to this model there are two different kinds of current, plus and minus current (Chambers & Andre, 1997; Heller & Finley, 1992; Osborne, 1983; Tiberghien & Delacote, 1976).

The Unidirectional Without Conservation or Weakening Current Model: The Unidirectional Without Conservation or Weakening Current Model is the next in the developmental sequence. According to this model students believe that in circuit, current flows in one direction and as it flows it becomes weakened.

The Unidirectional or Shared Current Model:. In this model, students believe that current flows around the circuit unidirectionally and is shared equally by the circuit devices, but is partially or completely used up in the circuit components (Chambers & Andre, 1997; Chang, Liu & Chen, 1998; Heller & Finley, 1992; Osborne & Gilbert, 1980).

Emprical Rule: According to this misconception model, students believe that current is used by circuit wire also. If wire use up circuit current then the bulb, which is from the battery, will be less bright than the closer bulb.

Power Supply as a Constant Current Source: Tiberghien and Delaote (1976) report that students regard the simple battery as the constant current source rather than a potential source.

Local and Sequential Reasoning: Local reasoning can be defined with the fact that students focus their attention upon one point in the circuit and ignore what is happening elsewhere (Closset, 1983; Cohen et al., 1983; Gil-Perez & Carrascosa, 1990; Dermott & Shaffer, 1992; Licht, 1991; Shipstone, 1984; Tiberghien & Delacote, 1976).

Short Circuit Preconception: Chamber and Andre (1996) present that students having this misconception appear to believe that a wire connection without an electrical device (e.g., bulb, buzzer) can be ignored while analyzing the circuit.

Parallel Circuit Misconception: Chambers and Andre (1996) present this misconception as the confusion between serial and parallel circuits; According to the students holding this misconception, the bulbs in parallel would shine less than a single identical bulb and adding a resistance in parallel path increases the equivalent resistance of the circuit.

2.4 Studies Related to Conceptual Change Approach

The conceptual change approaches dealing with the students' misconceptions has developed during 15 years and is based on the Piaget's (1964) construct of disequilibrium. One clear conceptual change approach was provided by Postner, Strike, Hewson, and Gertzog (1982) and revised. According to this approach, there must be four condition before conceptual change occur: (a) Students must dissatisfied with their existing conception. (b) The new conception must be intelligible; it must enable students to understand how experience can be structured by the new concept. (c) The new conceptions must be plausible; any new concept adopted must be able to solve problems generated by its predecessors. (d) The new concept must be fruitful; it should have capacity to open new areas of inquiry (Chamber & Andre, 1996).

Many specific instructional strategies were developed. The instructional model of Roth (1985) is one of them. In Roth's model teacher or instructional designer identifies the common misconception. Then, misconceptions are activated by presenting students with situations. After that students' misconceptions are challenged by evidence. Finally, the correct and scientific explanation is given. According to Roth students who were instructed with this approach learned better and developed more mature conception of role as a student than those who were instructed with traditional approach (Chamber & Andre, 1996).

Brown (1990) reports that concept learning is a potential solution for the task of remediating misconception. Chambers and Andre (1996) conducted a research to investigate relationship between gender, interest and experience in electricity, and conceptual change text manipulations on learning fundamental direct current concepts. They used conceptual change text to lead the better conceptual understanding of electrical concepts rather than traditional text. The primary purpose of their study is to investigate how learning from traditional and conceptual change-designed text related to individuals' prior interest, experience, and knowledge in electricity. Totally, 206 male and female students enrolled in this study. The experiment was 2 x 2 x 2 factorial. They produce the text by adapting from Wang and Andre (1991). The conceptual change text was designed by inserting conceptual change sections into the traditional text. They first investigated the differences between males and females in their interest in and experience with electricity. The result of the multivariate analysis of variance, using Interest and Experience scores as the dependent variable and Gender as the independent variable, was significant, Wilks' lambda = 0.596; $p < 0.0001$. Then they performed one-way analyses of variance (ANOVA) by considering interest and Experience scores as the dependent variables and Gender as the independent variables. The results showed that, the males had significantly more experience with electricity than females, $F(1,203) = 76.58$; $p < 0.0001$. Similarly, the mean score of the male for the interest in electricity (mean = 44.6) is higher than that of females (mean=22.7), $F(1,203) = 127.81$; $p < 0.0001$.

To find out if gender differences in performance could be attributed to pre-existing differences in experience, interest and knowledge, they performed Gender x Type of text x Question type ANOVA on the post-test performance score without including the any of the covariates. Results indicates significant main effects of Gender, $F\ (1,197) = 16.80$, $p < 0.0001$; and of text type, $F\ (1,197) = 16.12$, $p < 0.0001$. The mean of the males is higher than that of females on the posttest. And also, conceptual change text (mean =18.1) leads to better performance than did traditional text (mean =13.8).

The result of their study showed that using conceptual change text led better conceptual understanding of electrical circuit would students using the traditional text. This result consistent with the research findings of Wang and Andre (1991) which reports that a text-based conceptual change approach facilitate learning of direct current concept.

Suchner (1988) reports that the level of interest affects science achievement. Like Suchner, other previous studies mentioned about the level of interest and science achievement.

But the results of Chambers and Andre (1996), the level of prior interest and prior experience did not correlate significantly with post-test performance. But, effects of level of interest and level of experience influence learning indirectly by influencing prior knowledge. Prior interest and prior experience correlated with pretest performance. The results suggest that conceptual change features added to text or to classroom teaching are useful for students to achieve conceptual understanding.

2.5 Summary of the Literature Review

1. For a long time, physics has been least popular science in U.S. and Turkey (Hewitt, 1990).
2. "Physics has been a course taught as a course in applied mathematic of the least popular kind-algebraic word problems" (Hewitt, 1990, pp. 55).
3. "The first course in physics should be conceptual physics. A physics student who lack a conceptual understanding of physics and who is working physics problems is a kin to a deaf person writing music or a blind person painting" (Hewitt, 1983, pp. 309).
4. Conceptual physics as the qualitative study of the central concepts of physics with emphasis on mental imagery that relates the things events that are familiar in the everyday environment. Teaching physics by stressing on the concepts rather than derivations, and on critical thinking rather than computation (Hewitt, 1983; Hewitt, 1990).
5. Studying conceptual physics require three main criteria. These are; to teach hardcore physics on the everyday environment, to shape the critical thinking of students, and to relate the role of physics and technology toward future (Hewitt, 1972; Hewitt, 1983; Hewitt, 1990).
6. The important benefits of conceptual physics; time saving, teacher satisfaction, student satisfaction (Hewitt, 1972; Hewitt, 1990).
7. Conceptual Approach is also effective on the students' computational competencies (Madsen et al, 1992).
8. Conceptual Approach increases the students' ability of applying concepts to real situations (Rosenquist & McDermott, 1986).

9. Most of the high school teachers reported that the number of students enrolled in physics courses doubled since Conceptual Approach adopted (Hewitt, 1990).

The summary obtained from all of these studies is that, physics should be educational mainstream for all students. Hence, Conceptual Approach is important while teaching physics. So, the first course in physics should be conceptual physics. With the help of conceptual physics, we can prepare more science-oriented students and make the physics course as a popular course.

These summary results propose that, there is a need for research to accomplish some goals. These are: 1) to develop and validate measurement tools to asses the students' achievement and attitudes toward simple electricity. 2) To develop teaching/learning materials regarding criteria of Conceptual Approach (teaching hardcore physics, enforcing critical thinking and relating role of physics and technology), 3) to test the effects of Conceptual Approach on students' achievement and attitudes toward simple electricity in physics while controlling threats to internal validity. This study mainly achieves these goals.

CHAPTER 3

METHOD

In the previous chapters, problems and hypotheses of the study were presented, the related literature was reviewed accordingly and the essence of the study was justified. In this chapter, population and sampling, description of variables, development of measuring tools, procedure, methods used to analyze data and assumptions and limitations will be explained briefly.

3.1 Population and Sample

The target population of the study consists of all ninth grade private high school students in Balgat. There are five private high schools in this region. Since it is not feasible to select a representative sample from this population, it will be appropriate to define an accessible population. The accessible population is determined as all 9th grade private high school students in Balgat. It consists of 9 classes. This is the population for which the results of this study will be generalized.

The study sample chosen from the accessible population is a sample of convenience. Two physics teachers, their 4 classes, and 73 private high school students were involved in this quasi-experimental study. Each teacher had an experimental group class and a control group class. As shown in Table 3.1, number of students in each class varied between 20 and 22. Two classes were randomly assigned to the experimental group and instructed by Conceptual Approach. The other two classes were assigned as control group and instructed by Traditional Method. There are 42 students in experimental groups and 40 students in control groups.

Table 3.1 Numbers of Students in Each Class

	Experimental Group	Control Group	Total
Teacher	Class size	Class size	students
1	20	20	40
2	22	20	42
All	42	40	82

The ages of students range from 14 to 18. The reason to the variation in age is that some students failed in 9th grade from last year. Characteristics of the students who took the pre-tests and post-tests are presented in Table 3.2. Most of the students enrolled in this study are 15 years old. As seen in Table 3.2. numbers of female students are greater than that of male students.

Table 3.2 Characteristics of the Sample

	Gender		
Age	Female	Male	Total
14	5	2	7
15	27	19	46
16	11	13	24
17	0	4	4
18	0	1	1
All	43	39	82

3.2 Variables

There are ten variables involved in this study, which were categorized as dependent and independent variables. There are 2 dependent variables and 8 independent variables. Independent variables are divided in two groups as covariates and group membership. Table 3.3 indicates all the variables.

3.2.1 Dependent variables

The dependent variables (DV) of this particular design are Students' Physics Achievement Post-Test Scores (PSTACH) and Students' Physics Attitude Post-Test Scores (PSTATT). PSTACH and PSTATT are students' post-test scores on the Physics Achievement Test and Physics Attitude Scale, respectively. They are both continuous and interval variables.

3.2.2 Independent variables

The independent variables (IV) of the present study are collected in two groups; set A and set B. Students' age, Physics Achievement Pre-Test Scores (PREACH), Physics Attitude Pre-Test Scores (PREATT), Previous Physics Course Grades (PPCG), Previous Cumulative Grade Point Averages (PCGPA), Gender and Teacher are considered within set A as covariates. Methods of Teaching (MOT) (Conceptual Teaching and Conventional Lecturing) are included in set B as group membership. In set A, students' age, PREACH, PREATT, PCGPA, PPCG were considered as continues and interval variables. Teacher and Gender were determined as discrete and nominal. In set B, the variable of MOT was considered as discrete and nominal variables.

Table 3.3 Identification of Variables

TYPE	NAME	NATURE	DATA
DV	PSTACH	Continuous	Interval
DV	PSTATT	Continuous	Interval
IV	Age	Continuous	Interval
IV	PREACH	Continuous	Interval
IV	PREATT	Continuous	Interval
IV	PCGPA	Continuous	Interval
IV	PPCG	Continuous	Interval
IV	MOT	Discrete	Nominal
IV	Gender	Discrete	Nominal
IV	Teacher	Discrete	Nominal

3.3 Measuring Tools

For this study, two measuring tools were used. These are Physics Achievement Test (PACT) and Physics Attitude Scale (PATS) about Simple Electricity.

3.3.1 Physics Achievement Test (PACT)

Physics Achievement Test, used in this study, was developed by Hardal (2002). Researcher chose this test since it consists of questions about simple electricity and it was prepared just before the study began. Test covers the physics content taught in the ninth grade curriculum in simple electricity. It consists of 25 multiple-choice questions. 3 of them are qualitative and 22 of them are quantitative questions. Hardal used 12 questions from the study of Sencar (2001), and in addition to these 12 questions, she also added 13 more questions from various test banks. Reason for preferring multiple-choice items is that it is easy and quick to administer and it enables the researcher to evaluate objectively.

3.3.2 Physics Attitude Scale (PATS)

Adopted from the test used by Abak (2002), as a first step, 45 items Physics Attitude Scale was designed. Its aim is to collect data about students' attitudes toward simple electricity, so it is content based. The content of simple electricity covers; flow of charge, electric current, electric resistance, electric potential, voltage source, ohm's law, simple electric circuits, short circuit, series circuits, parallel circuits and compound circuits. The questions designed to be rated on a 5-point likert type response format (absolutely disagree, disagree, neutral, agree, absolutely agree)

The test initially covered seven sub-categories. These categories were; Importance of Physics, Interest in Physics, Motivation, Extra Activities, Achievement-Motivation, Physics Self-Concept and Self-Efficacy. Then a pilot study was designed and it was administered to160 ninth grade private high school students. During pilot study, 25 minutes were given to the students to complete the scale. The time was adequate. 45 item Physics Attitude Scale requested only the information of students' name and surname. After data collected, using SPSS, Varimax Rotated factor analysis was done. According to the result of pilot study, some questions were revised, some were completely discarded and finally a 24-item Physics Attitude Scale was prepared. In addition to students' name and surname, questions of students' gender and age were also added to the scale and the seven sub-categories decreased to five sub-categories. It has been a test to measure students' attitudes toward simple electricity in five sub-categories. These new categories are; Enjoyment, Self-Efficacy, Importance of Physics. Achievement Motivation, Interest Related Behavior. Enjoyment is students' personal interest toward simple electricity. It is measured by five items. These are:1, 2, 3, 4, 5. Self-Efficacy is the belief in one's capabilities to organize and execute the sources of action required to manage prospective situation. Five items which are; 20, 21, 22, 23, 24 measure self-efficacy. Importance of Physics deals with the importance of simple electricity. It measures to what degree simple electricity is important for students. It is measured by five items. They are; 6, 7, 8, 9, 10. Achievement Motivation is a combination of psychological forces, which initiate, direct, and sustain behavior toward successful attainment of some goal, which provides a sense of significance. It is measured by four items, these items are; 16, 17, 18 and 19. Interest Related Behaviors respond to the question to what degree that students' like to do out of the class activities related to simple electricity. It is measured also by five items. They are; 11, 12, 13, 14 and 15.

3.3.3 Validity and Reliability of Measuring Tools

To establish the face and content validity, Physics Attitude Scale and Physics Achievement Test about simple electricity concept were checked by one instructor and two research assistance from the department of Science and Mathematics Education at METU and one research assistance from the department of Science and Mathematics Education at Hacettepe, two private high school physics teacher according to the content and format of the instrument. All these people were explained about the main purpose of test and then they evaluate measuring tool according to given criteria of appropriateness of items to the grade level and understandable so on.

During the pilot study, Physics Attitude Scale and Physics Achievement Test were administered to 160 ninth grade students from the same private high school. The data were collected. Reliability analysis was performed by using SPSS. The internal reliability coefficient of Physics Attitude Scale was obtained as 0.932 by using cronbach alpha coefficient. Based on the result of pilot study, 21 items were completely discarded and some items were rearranged. At the end of the pilot study, with the guidance of an instructor in physics education, Physics Attitude Scale has taken the final form. The reliability analysis was performed again according to the post-test scores, and the value of alpha (α) was calculated as 0.944 (See Appendix A).

Similarly, reliability analyses were also performed for the physics achievement pre-test scores and physics achievement post-test scores. The values of α were 0.40 for pre-test scores and 0.72 for the post-test scores. Since Physics

Achievement Test was directly taken from the previous study, no change was performed on the questions of the test.

3.4 Teaching/Learning Materials

Various materials were used in this study; objective list, table of specification, objective-conceptual physics teaching criteria table, lesson plan (for teacher and for student), acetates, demonstrations, experiments and methodology.

3.4.1 Objective List and Table of Specification

In order to implement the simple electricity, an objective list was prepared. The objectives are collected in 5 main categories. These are; ability to recognize electric current, ability to recognize electric circuits, ability to identify series connected electric circuits, ability to understand the parallel connected electric circuits, ability to solve compound circuit problems. Total number of objectives was 58 (See Appendix B). After that, table of specification was prepared. In this table, the objectives were categorized according to the cognitive domain of taxonomy (See Appendix C).

3.4.2 Objective-Conceptual Physics Teaching Criteria Table

For the implementation of conceptual physic, some criteria must be taken into consideration. These criteria are mainly; teaching hardcore physics, shaping critical thinking, relating role of physics to the technology. They were concluded from the studies of Hewitt (1972; 1983; 1990; 1995). It guides instructor that which objective can be taught by which conceptual physics teaching criteria (See Appendix D).

3.4.3 Lesson Plans

For the implementation of simple electricity conceptually, two different lesson plans were prepared. These are lesson plan for teacher and lesson plan for students.

3.4.3.1 Lesson Plan for Teacher

The lesson plan used in this study was developed to teach simple electricity conceptually. It was developed by making use of wide range of sources (Hewitt, 1998; 1999; Tolman, 1995…). It was designed by regarding the conceptual teaching criteria (teaching hardcore physics, shaping critical thinking, relating role of physics to the technology). It includes lectures, conceptual analogies, activities, questions, home works, think and explain parts, link to technology parts, home projects parts, examples from real life and real life applications about simple electricity. It contains the titles of; flow of charge, electric current, voltage source electric resistance, ohm's law, ohm's law and electric shock, electric circuit, a battery and a bulb circuit, short circuit, schematic diagrams, series and parallel circuits, series circuit, parallel circuit and compound circuit.

Teacher copy contains solutions of home works and answers of examples, think and explain parts and home projects parts. There are important notes to be stated while implementing the concept. These parts are included in parenthesis (See Appendix E).

3.4.3.2 Lesson Plan for Student

This lesson plan was prepared for students to learn simple electricity conceptually. It is similar to the teacher copy. Sequence of the titles and format are same with that of teacher copy. But some important points, to be implemented in lessons, and answers of questions, problems, home works, think and explain parts and home projects part were not included within this text.

3.4.4 Misconception - Activity Table

Arons (1982) points out that according to the results of the many research, related to electricity topic, students are incapable of analyzing simple circuits qualitatively. Misconception- activity table indicate which misconception is eliminated by which activity (See Appendix F).

3.4.5 Acetates

For the implementation of simple electricity, seven pages of acetates were prepared. All of them contain figures included within the lesson plan These figures are; Figure 1-a, b, Figure 2, Figure 3, Figure 4, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10, Figure 12, Figure 15 and the acetate page related to parallel circuit. Reason of preparing acetates is that, they are effective while making analogies and effective for time saving (See Appendix G).

3.4.6 Demonstrations

Demonstrations are important part of conceptual teaching. Since they might be risky for students, teachers achieved demonstrations by themselves. The demonstrations to be performed by teacher were written on the methodology text. Some of them were in activity parts and some of them were included within lecture parts.

3.4.7 Experiments

Experiments also play important role while achieving conceptual teaching. It enables students to eliminate the misconceptions. They are included within activities part of lesson plan.

3.4.8 Methodology

Researcher prepared a methodology text. The main purpose is to get the consistency between teachers while implementing the simple electricity subject conceptually. It guides how to achieve objectives by using conceptual physics teaching criteria (See Appendix H).

3.5 Procedure

The study started with a detailed review of the literature. After determining the keyword list, the databases of Educational Resources Information Center

(ERIC), International Dissertation Abstracts, Social Science Citation Index (SSCI), Ebscohost, science direct and Internet (Goggle) were searched systematically. Previous studies made in Turkey were also searched from the YOK, Hacettepe Eğitim Dergisi, Eğitim ve Bilim and Çağdaş Eğitim Dergisi. Photocopies of obtainable documents were taken from METU library, library of Bilkent University and TUBİTAK Ulakbim. All of the papers were read; results of the studies were compared with each other. To implement the conceptual physics we searched for conceptual physics books using Internet sites. Then we requested two physics books; "Hewitt, Conceptual Physics and Laboratory Manual, 1999" and "Cunningham, J & Herr, N., Hands-On Physics Activities With Real-Life Applications, 1994" from abroad over the Internet site of "www.amazon.com". These books were investigated carefully. In case of new recent articles on this topic the researcher continuously checked and followed the literature.

After that, researcher developed the measuring instrument (PATS) and teaching/learning materials as mentioned in section 3.3 and 3.4. These materials (Objective list, table of specification, objective-conceptual physics teaching criteria table, lesson plans, acetates, methodology, Physics Achievement Test, Physics Attitude Scale) were checked by an instructor from the department of secondary school science and mathematics education at METU, two research assistants from the department of secondary school science and mathematics education at METU and two physics teacher from private high school. Necessary changes and update in all teaching learning materials, tests and treatment were done before the final study. Then a pilot study was achieved in a private high school in the middle of April in

2002. PACT and PATS were applied to 160 private high school ninth grade students. All feedback and criticism about pilot study were analyzed by the researcher and an instructor from department of secondary school science and mathematics education at METU. As a result of pilot study, some arrangements were done on the Physics Attitude Scale. Some questions were rearranged and some totally discarded completely.

A quasi-experimental study design was used in final study because it was not possible to randomly assign subjects to both experimental and control groups. Three week before the beginning of the study, all teaching/learning materials were given to the teachers who participated in this study. Just before the study began teachers were trained by the researcher. They were informed about the conceptual physics and how to implement the simple electricity conceptually. They were warned not to mention about the activities, performed in experimental classes, in control group classes. Teachers promised to standardize the administration procedures and application of treatments, and allowed researcher to observe their classes. One class hour and twenty-five minutes were given to the students to complete the physics achievement pre-test and physics attitude pre-test. The time was adequate for students. In order to have students relaxed and comforted the researcher and the teachers read directions and made necessary explanations to them. The students in experimental groups lectured via using Conceptual Approach and that of control groups were instructed by Traditional Method. In classes of one teacher the treatment ended within two and half week because of school activities and general examinations.

One of the teachers administered instruments to his classes during the last two week of the spring 2001-2002 semester in his lessons. The other teacher couldn't apply post-tests in his classes. Because in the last week of the semester some school activities were performed. So researcher took permissions from other teachers' lesson and tested other two classes by himself. Directions were read and necessary explanations were made by the researcher to make students more conscious about the research. Moreover, students were told that the grades of this test would not affect their physics grade. They were also warned not to forget to complete the information part related to their age and gender at the beginning of the Physics Attitude Scale. One class hour was given to students to complete the Physics Achievement Test and Physics Attitude Scale. Time was adequate to complete the instruments. No problems were encountered during the administration of the post-tests.

3.6 Analyses of Data

Data list, consisting of students' sex, age, previous physics course grades, previous cumulative grade point average, physics attitude pre-test scores, physics attitude post-test scores, physics achievement pre-test scores, physics achievement post-test scores, types of methods of teaching, class and teacher, were prepared by using Excel in which columns show variables and rows show students participating in the study. The statistical analyses were done by using both Excel and SPSS.

3.6.1 Descriptive Statistics

The mean, standard deviation, skewness, kurtosis, range, minimum, maximum values and the histograms were presented for each control group and experimental group.

3.6.2 Inferential Statistics

In order to test the null hypotheses, all statistical computations were done by using statistical package program (SPSS). Statistical technique named MANCOVA was used since it can both equate groups on one or more independent variables. During analyses, the probability of rejecting true null hypothesis (probability of making Type 1-error) was set to .05 as a priori to our hypothesis testing and significance level was set to .05, because it is mostly used value in educational studies. To find the effect size, the mean difference of two groups was divided by the standard deviation of the comparison group. Then effect size was set to large (0.8 for mean difference and 0.33 for variance). This study conducted with 73 ninth grade private high school students and the number of variables was 17. Table 3.4 shows all variables and the variable set entry order that were used in the statistical analyses.

Table 3.4 MANCOVA Variable Set Composition and Statistical Model Entry Order

Variable set	Entry order	Variable name
A (Covariates)	1 st	X1 = Age X2 = PREACH X3 = PREATT X4 = PPCG X5 = PCGPA X6 = Gender X7= Teacher
B (Group Membership)	2 nd	X8 = Methods of Teaching
A*B (Covariates * Group Interactions)	3 rd	X9 = X1*X8 X10 = X2*X8 X11 = X3*X8 X12 = X4*X8 X13 = X5*X8 X14 = X6*X8 X15 = X7*X8

The power of this study was calculated as 0.98; therefore, the probability of failing to reject a false null hypothesis (probability of making Type 2-error) was found 0.02 (i.e., 1-0.98).

3.7 Assumptions and Limitations

The assumptions and the limitations of this study considered by the researcher are given below.

1. The subjects of the study answered the items of the tests sincerely.

2. The teachers followed our instructions, and were not biased during the treatment
3. The administration of the Physics Achievement Test and Physics Attitude Scale were under standard conditions.
4. Students from experimental group and control group did not interact and shared questions of Physics Achievement Test and Physics Attitude Scale before or during the administration of the tests.

CHAPTER 4

RESULTS

The result of this study is explained in three different sections. First section deals with missing data analysis. The second section presents descriptive statistics and inferential statistics. In this section descriptive comparison of Traditional Method and Conceptual Approach for students' pre-test and post-test scores will be presented. Finally, the last section presents the summary of results.

4.1 Missing Data Analysis

The first step is related with missing data analysis. It was achieved before descriptive statistics and inferential statistics due to the fact that all analysis will be performed on the analyzed data. Initially, 82 students were intended to be applied post-tests. But, 9 students were absent on the date of post-tests. So the data of these 9 students were excluded from the statistical analysis of the study completely. Besides this, four students did not complete some questions of pre-achievement test and nine students did not complete some questions of pre-attitude scale.

Missing data in physics achievement pre-test constitute 12.3 % of the whole data and that of physics attitude pre-test constitute 5.5 % of the whole data. Since the missing data in these two independent variables constitute a range greater than 3 % of the whole data, they were tested for significance by Dummy Coded Method.

According to the result of the analysis, there was no significant difference between the mean scores of post-achievement, post-attitude tests of students having missing data and those of having no missing data, respectively. So, the assigned Dummy coded missing data variables were ignored and missing values were replaced with the series mean of the entire subjects (SMEAN) as shown in Table 4.1

Table 4.1 Missing Data versus Variables

Resultant Variable	Missing Values Replaced	Valid Cases	Missing Percentage	Creating Functions
Pre-achievement (PREACH)	4	73	5.5	SMEAN (PREACH)
Pre-attitude (PREATT)	9	73	12.3	SMEAN (PREATT)

4.2 Descriptive And Inferential Statistics

4.2.1 Descriptive Statistics

Descriptive statistics related to scores on Physics Achievement Post-Test (PSTACH) and Physics Attitude Post-Test (PSTATT) for both experimental group and control group were presented in Table 4.2. Students' achievement scores can range from 0 to 25 in which higher scores mean greater physics achievement in simple electricity. As Table 4.2 indicates, experimental group showed a mean increase of 5.39. Moreover, the mean of the pre-test scores was 9.45 and it increased to 14.84 for experimental group. On the other hand the mean of control group has increased slightly, it increased from the mean value of 10.07 to 11.22. The change of mean for control group is 1.15 points. It can be seen that experimental group students had gained greater physics achievement than control group students. Table 4.2 also presents some other basic descriptive statistics of participants like mean, standard deviation, skewness , kurtosis, range, minimum and maximum values. For experimental group students, the value for skewness was 0.577, and changed to 0.244. Both values could be accepted as approximately normal. In a similar manner, the value of skewness for the control group students' was -0.560 and changed to 0.631which could also be accepted as normal.

Similarly, descriptive statistics related to scores on Physics Attitude Scale were also categorized according to the experimental group and control group as in Table 4.2. Students' attitude scores can range from 24 to 120 in which higher scores mean more positive attitude toward simple electricity circuit, lower scores mean negative attitudes toward simple electricity circuit. As Table 4.2 indicates, mean for the post-attitude scores of students instructed by Conceptual Approach is higher than that of students instructed by Traditional Method. It means that students, thought by Conceptual Approach, had much more positive attitudes toward simple electricity circuit than the students thought by Traditional Method. Moreover, experimental group showed a mean increase of 6.68 points from pre-test to post-test of Physics Attitude Scale. Opposite to the experimental group, the mean of control group has decreased about 5.17 points.

Table 4.2 Basic Descriptive Statistics Related to the Data of the Physics Achievement Scores and Physics Attitude Scores

	Experimental Group		Control group	
	Pre-test	Post-test	Pre-test	Post-test
Scores on Achievement Test				
N	37	37	36	36
Mean	9.45	14.84	10.07	11.22
Standard Deviation	3.13	4.34	2.48	2.99
Skewness	0.577	0.244	-0.560	0.631
Kurtosis	1.491	-0.651	0.717	-0.631
Range	16	16	11	12
Minimum	3	7	3	6
Maximum	19	23	14	18
Scores on Attitude Scale				
Mean	76.94	83.62	73.42	68.25
Standard Deviation	16.32	17.04	15.54	14.97
Skewness	0.233	0.106	-0.332	-0.308
Kurtosis	-0.730	-1.215	-0.06	-0.399
Range	66	58	66	55
Minimum	43	54	39	37
Maximum	109	112	105	92

For experimental group students, the value for skewness was 0.233 and changed to 0.106. Both values could be accepted as approximately normal. In a similar manner, the value for the control group students' was -0.332 and changed to 0.308, which could also be accepted as normal.

Figure 4.1 and Figure 4.2 show the histograms with normal curves related to PSTACH and PSTATT for control group and experimental group. These are also an evidence for the normal distribution of these four variables

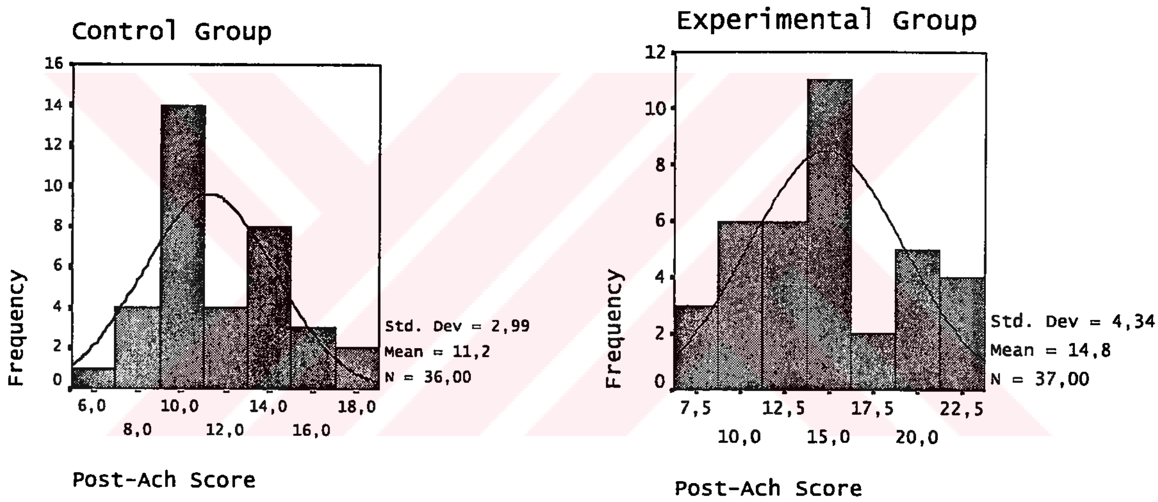

Figure 4.1 Histograms with normal curves related to PSTACH for control group and experimental group on simple electricity.

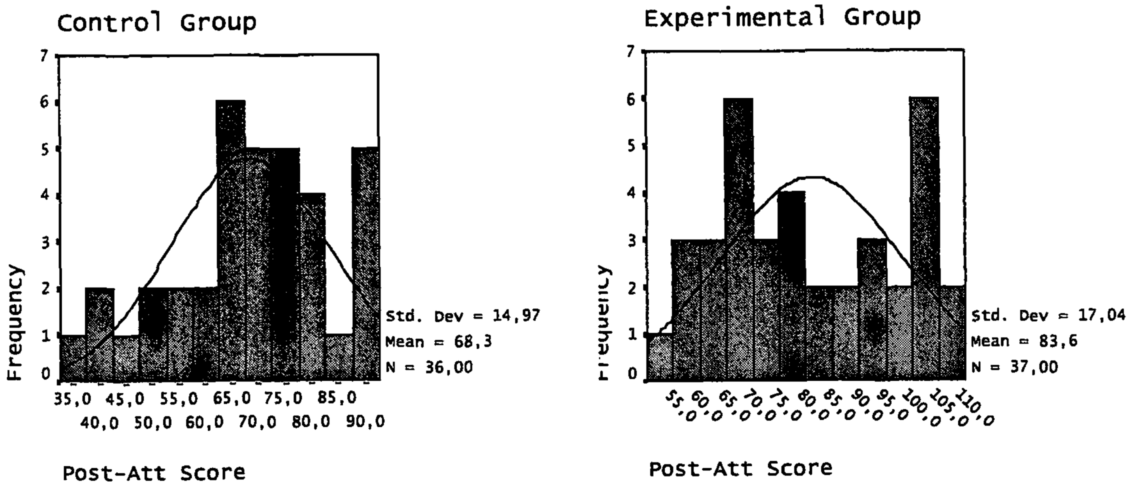

Figure 4.2 Histograms with normal curves related to PSTATT for control group and experimental group on simple electricity.

4.2.2 Inferential Statistics

This section has 3 different sub sections. The first sub section deals with the determination of the covariates. Second sub section deals with the verification of MANCOVA assumptions. Finally, statistical model of MANCOVA and the analyses of the hypotheses are given.

4.2.2.1 Determination of Covariates

Seven independent variables; age, gender, physics achievement pre-test scores (PREACH), physics attitude pre-test scores (PREATT), previous cumulative grade point average (PCGPA), previous physics course grades (PPCG) and teacher were pre-determined as potential confounding factors of the study. To statistically equalize the differences among experimental group and control group, these variables were included in set A as covariates. All pre-determined independent variables in set A have been correlated with dependent variables of physics achievement post-test scores (PSTACH) and physics attitude post-test score (PSTATT). Table 4.3 presents the results of these correlations and their level of significance. Five of the independent variables in set A, PCGPA, PPCG, PREACH, PREATT and teacher have significant correlations with at least one of the dependent variables of PSTACH and PSTATT. But gender and age did not have correlation with dependent variables. Hence, PPCG, PCGPA, PREACH, PREATT and teacher were determined as covariates for the following inferential analyses.

Table 4.3 Significance Test of Correlations between Dependent Variables and Covariates.

Variables	Correlation Coefficients	
	PSTACH	PSTATT
PPCG	.401*	.298*
PCGPA	.542*	.226
Teacher	-.294*	-.056
PREACH	.282*	.166
PREATT	.271*	.596*
Age	-.227	-.118
Gender	.059	-.142

*Correlation is significant at least 0.05 level (2-tailed)

Table 4.4 indicates the correlation between covariates. There is significant correlation between PPCG and PCGPA, PPCG and PREACH. However, none of the correlation value is greater than 0.80. So no multicollinearity can be assumed among covariates.

Table 4.4 Significance Test of Correlations between covariates.

Variables	PPCG	PCGPA	Teacher	PREACH	PREATT
PPCG		.739*	.054	.298*	.204
PCGPA			-.240	.201	.054
Teacher				-.094	.010
PREACH					.357*
PREATT					.357*

*Correlation is significant at least 0.05 level (2-tailed)

4.2.2.2 Assumptions of MANCOVA

Multiple analysis of covariance (MANCOVA) has five assumptions: Normality, homogeneity of regression, equality of variances, multicollinearity and independency of observations. All the variables were tested for all the assumptions.

For normality assumption, skewness and kurtosis values were used. The skewness and kurtosis of scores on PSTACH and PSTATT were in acceptable range for normal distribution as stated in descriptive statistics.

Homogeneity of regression assumption means that the slope of the regression of a dependent variable on covariates must be constant over different values of group membership. Table 4.5 indicates the results of Multivariate Regression Correlation (MRC) analysis of homogeneity of regression. For this analysis, 5 new interaction terms were produced. These interaction terms were prepared by multiplying the group membership with the covariate independent variables of, PPCG, PCGPA, PREACH, PREATT and gender separately. After that, three different blocks were produced. Covariate variables were set to Block 1, group membership was set to Block 2 and interaction terms were set to Block 3. Then the MRC was performed to test the significance of R^2 change using Enter method.

Table 4.5 Results of Multivariate Regression Correlation (MRC) Analysis of Homogeneity of Regression.

Model	Change Statistics				
	R^2 change	F Change	df1	df2	Sig. F Change
Block 1	.409	9.264	5	67	0.000
Block 2	.151	22.589	1	66	0.000
Block 3	.024	0.698	5	61	0.627

As seen from Table 4.5, there is no significant interaction between

Block1 and Block 2 (Block 3) and R^2 change ($F(5, 61) = 0.698$, $p = 0.627$). So the interaction term (Block 3) is dropped. As a result of this study homogeneity of regression assumption was also validated.

Table 4.6 indicates the Box's Test of Equality of Covariance Matrices. As seen from the table, the observed covariance matrices of the dependent variables are equal across groups.

Table 4.6 Box's Test of Equality of Covariance Matrices

Box's M	5.105
F	1.650
df1	3
df2	930523
Sig.	0.176

Levene's Test of Equality was used to determine the equality variance assumption. As Table 4.7 indicates, the error variances of the selected dependent variables across groups were equal.

Table 4.7 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
PSTACH	0.705	1	71	0.404
PSTATT	0.315	1	71	0.577

As table 4.4 indicates, there is correlation between covariates. But the correlations between these covariates are smaller than 0.80. So the assumption of multicollinearity was also supplied.

Independency of observation was also examined. Although the smallest unit during the administration of test was a class not individual; independency assumption was met with the observations of researcher. It is observed that all participants did their test by themselves.

4.2.2.3 MANCOVA MODEL

Dependent variables of the study are PSTACH and PSTATT. The variables of PPCG, PCGPA, PREACH, PREATT and Teacher are covariates of the study. Table 4.8 presents the results of multivariate analysis of covariance (MANCOVA). As seen from table, methods of teaching (MOT) explain 37.0 % variance of model for the collective dependent variables of PSTACH and PSTATT.

Table 4.8 Multivariate Analysis of Covariance (MANCOVA) Test Results

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig	Eta Squared	Observed Power
Intercept	.91	3.2	2.0	65.0	.045	.09	.59
Teacher	.90	3.6	2.0	65.0	.034	.01	.64
PREACH	.93	2.3	2.0	65.0	.106	.07	.45
PREATT	.67	15.7	2.0	65.0	.000	.33	.10
PPCG	.92	2.7	2.0	65.0	.078	.08	.51
PCGPA	.92	2.9	2.0	65.0	.063	.08	.55
MOT	.63	18.9	2.0	65.0	.000	.37	1.00

In Table 4.8, it can be seen that, the variables of PREACH, PPCG and PCGPA have no significant effect on the dependent variables of PSTACH and PSTATT. Based on the literature review, these variables had significant effects on high school students' physics achievement and attitudes toward physics. Although we know that these variables would decrease the power of our study, we used them in our analyses.

4.2.2.4 Null Hypothesis 1

The first null hypothesis was; 'There will be no significant effect of methods of teaching (Conceptual Approach versus Traditional Method) on the population means of collective dependent variables of physics achievement post-test scores and physics attitude post-test scores when student' age, physics achievement pre-test scores, physics attitude pre-test scores, cumulative grade point average, previous physics course grades, gender and teacher are controlled'.

Multivariate analysis of covariance (MANCOVA) was conducted to determine the effect of MOT on the collective dependent variables (DV) of PSTACH and PSTATT.

As seen from Table 4.8, the first null hypothesis was rejected ($\lambda = 0.63$, p =. 000). Significant differences were found among Conceptual Approach and Traditional Method on the collective dependent of variables of PSTACH and PSTATT.

In order to test the effect of independent variable of methods of teaching on each dependent variable, an analysis of covariance (ANCOVA) was conducted as follow-up tests to the MANCOVA. Table 4.9 indicates the result of the statistical analysis of ANCOVA.

Table 4.9 Test of Between-Subjects Effect

Source	DV	Type III Sum of Squares	Df	Mean Square	F	Sig	Eta Squared	Observed Power
Corrected model	PSTATT	12643.6	6	2107.3	14.0	.000	.56	1.0
	PSTACH	702.1	6	117.0	14.7	.000	.57	1.0
Intercept	PSTATT	965.7	1	965.7	6.4	.014	.09	.70
	PSTACH	11.8	1	11.8	1.5	.228	.02	.22
Teacher	PSTATT	259.5	1	259.5	1.7	.194	.03	.25
	PSTACH	56.0	1	56.0	7.0	.010	.01	.74
PREACH	PSTATT	66.8	1	66.8	.4	.508	.01	.10
	PSTACH	24.4	1	24.4	3.1	.085	.04	.41
PREATT	PSTATT	4779.0	1	4779.0	31.7	.000	.32	1.0
	PSTACH	13.9	1	13.1	1.6	.204	.02	.24
PPCG	PSTATT	760.5	1	760.5	5.0	.028	.07	.6
	PSTACH	13.0	1	13.0	1.6	.207	.02	.24
PCGPA	PSTATT	49.2	1	49.2	.3	.570	.01	.09
	PSTACH	33.5	1	33.5	4.2	.044	.06	.52
MOT	PSTATT	3407.0	1	3407.0	22.6	.000	.26	1.0
	PSTACH	223.1	1	223.1	28.0	.000	.30	1.0
Error	PSTATT	9954.2	66	150.8				
	PSTACH	525.7	66	8.0				
Total	PSTATT	444854.	73					
	PSTACH	13669.0	73					
Corrected Total	PSTATT	22597.8	72					
	PSTACH	1227.8	72					

4.2.2.5 Null Hypothesis 2

The second null hypothesis was; 'There will be no significant effect of methods of teaching (Conceptual Approach versus Traditional Method) on the population means of physics achievement post-test scores when student' age, physics achievement pre-test scores, physics attitude pre-test scores, previous cumulative grade point average, previous physics course grades, gender and teacher effects are controlled'.

As seen from Table 4.9 the second null hypothesis was rejected (F (1, 66) = 28, p= .000). That is; Conceptual Approach was effective in PSTACH. Students instructed by Conceptual Approach had higher physics achievement scores than the students thought by Traditional Method.

4.2.2.6 Null Hypothesis 3

The third null hypothesis was; 'There will be no significant effect of methods of teaching (Conceptual Approach versus Traditional Method) on the population means of physics attitude post-test scores when student' age, physics achievement pre-test scores, physics attitude pre-test scores, previous cumulative grade point average, previous physics grades, gender and teacher effects are controlled'.

As seen in Table 4.9, the third null hypothesis was also rejected (F (1, 66)= 22.6, p=. 000). That is, Conceptual Approach was effective in improving positive attitudes toward physics than Traditional Method did. The gain scores of student on physics attitude post-test scores instructed by Conceptual Approach were higher than those students instructed by Traditional Method. Moreover, as seen in Table 4.2 experimental group showed a mean increase of 6.68 points from pre-test to post-test of Physics Attitude Scale. Opposite to the experimental group, the mean of control group has decreased of 5.17 points. From this we conclude that Traditional Method changed students' attitudes toward physics in a negative manner.

Table 4.10 shows adjusted means of experimental and control group for both dependent variables of PSTACH, PSTATT and independent variable of MOT. All inferential analyses were performed on these adjusted means.

Table 4.10 Estimated Means for Variables Related to Null Hypothesis 1

DV	Methods of Teaching	Prior Mean	Adjusted Mean
PSTACH	Conceptual Approach	9.5	14.9
	Traditional Method	10.1	11.2
PSTATT	Conceptual Approach	76.9	83.2
	Traditional Method	73.4	68.7

4.3 Summary of Results

The average scores on the Physics Achievement Test were appear to be low, because of the nature of test. Mainly it consists of questions related with misconceptions in simple electricity. In fact, we were not surprised with pre-test results. The researcher made a short conversation with students just after pre-test.

Most of students stated that they had forgotten the simple electricity, because of that they could not the find the correct answer for most of the questions.

The statistical analyses showed that there were significant correlations between some variables of independent variables and dependent variables. Moreover, independent variables of PPCG, PCGPA, PREACH, PREATT and teacher, have significant correlations with at least one of the dependent variables of PSTACH and PSTATT. But gender and age did not have significant correlation with dependent variables of PSTACH and PSTATT.

The statistical analyses of ANCOVA indicated that there is a positive correlation between students' physics achievement and Conceptual Approach. Students instructed by Conceptual Approach gained more physics achievement than students instructed by Traditional Method. Statistical results also enable us to conclude that there is positive correlation between Conceptual Approach and student's attitude toward physics. Experimental group students gained more achievement and more positive attitudes toward simple electricity in physics. But, although control group students had gained little achievement scores their attitudes toward physics changed in a negative manner.

In the light of the findings, obtained by statistical analyses, the following results could be summarized as follows:

1. There were positive significant correlations between PPCG, PCGPA and PSTACH about simple electricity in physics. Similarly, positive significant correlation was found between PPCG and PSTATT toward simple electricity.

2. Contrary to the expectations, there was not significant correlation between PCGPA and PSTATT. On the other hand, negative significant correlation was found between teacher and PSTATT separately.
3. As expected, statistical results showed that there was a significant positive correlation between PREACH and PSTACH. But no significant correlation was found between pre-achievement scores and post-attitude scores. Similarly, it has been found positive significant correlation between PREATT and PSTACH. The correlation between PREATT and PSTATT was also significant and positive.
4. The mean of Physics Achievement Test scores for experimental group for pre-test to post-test changed drastically, but that of control group changed very little.
5. The mean of Physics Attitude Scale scores instructed by Conceptual Approach from pre-test to post-test had changed positively but that of Traditional Method changed negatively.
6. The Conceptual Approach was effective for improving positive attitudes toward physics. On the contrary, the Traditional Method affected students' attitudes toward physics in a negative manner.
7. The Conceptual Approach was effective for improving students' physics achievement. Moreover the Conceptual Approach increased students' achievement more than Traditional Method did.

CHAPTER 5

CONCLUSIONS, DISCUSSIONS AND IMPLICATIONS

This chapter is divided into six sections. Conclusions are given in the first section. The second section presents the discussion of the results. The third section presents implications and the importance of the study. The fourth section gives information about Internal validity and possible threads to the study. In the fifth section, it was mentioned about external validity. Finally, the last section presents recommendations for further studies.

5.1 Conclusions

As previously stated before, the sample of study chosen from accessible population. It was a sample of convenience. So, there was a limitation on the generalizability of this research. But the conclusions stated here can be applied to an extended population of similar private high school students. Here are the conclusions:

1. Conceptual Approach was an effective means of increasing both physics achievement and physics attitudes about simple electricity in physics. Moreover Conceptual Approach was an effective means of increasing the physics achievement about simple electricity. Students, instructed by Conceptual Approach, gained more physics achievement than that of

instructed by Traditional Method. Similarly, Conceptual Approach was also an effective means of increasing the positive attitudes toward simple electricity. Students, instructed by Conceptual Approach, gained more positive attitudes toward simple electricity concept. On the contrary, attitudes of students instructed by Traditional Method changed in a negative sense.

2. Conceptual Approach requires 3 main objectives. These are teaching hardcore physics, shaping critical thing and relating role of physics to technology. For the attainment of these objectives some methods are effective. For instance, while teaching hardcore physics; conceptual analogies, demonstrations, drawings, student oriented experiments, discussions, games, exemplifications from daily life, their applications and home projects were effective. Similarly, stressing on the meaning of terms and using formulas as guides rather than equations for solving problems were effective for improvements of students' critical thinking. In addition to these relating role of physics to technology was effective for increasing students' interest into physics. To sum up, all of the approaches, stated, are important for students to gain more physics achievement and more positive attitudes toward physics.

5.2 Discussions of Results

When the findings of this research compared with those of previous ones, this research supports most of the findings of previous studies conducted abroad.

For instance, as can be understood from the basic descriptive statistics of achievement result, Conceptual Approach increased the means scores of the experimental group from pre-test to post-test. But in general their mean scores are still low. From here we can conclude that physics is still incompressible discipline for some students.

When histograms with normal curves related to PSTACH for experimental group and control group, in Figure 4.1, are investigated, it can be easily seen that, some students gained more achievement from Conceptual Approach. The histograms present that standard deviation of physics achievement post-test scores for the experimental group is greater than that of control group. It is 4.34 for experimental group and 2.99 for control group. On the other hand, it could be concluded that mastery learning could not have been achieved completely for experimental group. Because, for mastery learning to be achieved, most of the students must have higher scores than mean of the post-achievement scores. But in our study, the percentage of the students below the mean is almost equal to that of above the mean. Similar conclusions could be stated from the histograms of PSTATT for the experimental group and control group on simple electricity in Figure 4.2. Moreover, standard deviation of physics attitude post-test scores for experimental group is greater than that of control group. It is 83.6 for the experimental group and 68.3 for the control group. It could be concluded that, Conceptual Approach changed some of the students' attitudes in a positive manner drastically.

In most of the previous studies, there were a significant gender difference on high school students' achievement and attitudes toward physics. In the study, gender difference was not manifested. The interaction of students' gender and the treatment was not investigated because students' gender as a variable is not a focus of this study.

From the articles reviewed the most appropriate to our study is the study of (Chambers & Andre, 1997). Chambers and Andre (1997) aimed to investigate the relationship between gender, interest and experience in electricity and conceptual text manipulations on learning fundamental direct current concept. In our study we aimed to investigate the effect of Conceptual Approach on students' physics achievement and attitudes toward physics. One of the difference of my study than that of Chambers and Andre is that they prepared conceptual change text consisted of conceptual change session inserted into the traditional text. In our study we prepared a lesson plan about the topic of simple electricity and the lessons were studied by Conceptual Approach. While improving it, all of the conceptual physics criteria (teaching hardcore physics, shaping critical thinking and relating role of physics to technology) were regarded and a lesson plan was prepared according to them. Besides this, teachers were informed about the conceptual physics. Teachers were effective while studying their lessons. They tried to implement simple electricity conceptually (the qualitative study of the central concepts of physics with emphasis on mental imagery that relates the things events that are familiar in the everyday environment or teaching physics by stressing on the concepts rather than derivations, and on critical thinking rather than computation). Chambers and

Andre performed their experimental study by using 206 volunteer college students. They had two independent variables gender and forms of conceptual change text. We conducted our study by using 73 students included in four classes. The classes were randomly assigned as experimental group and control group for sample of convenience. They used MANCOVA and follow up analysis of ANCOVA. We have used statistical analysis of MANCOVA and follow up ANCOVA. According to the statistical results they have reported that students using conceptual change text gained better conceptual understanding of simple electricity. Similarly, Wang and Andre (1991) supported this result in their study. These conclusions are consistent with our results. Our results indicate that the Conceptual Approach was effective for students included in experimental group. Their physics achievement post-test scores were greater than that of students instructed by Traditional Method. This result indicates that the Conceptual Approach did lead better understanding of simple electricity.

The results of the research conducted by Madsen at al supports our findings also. They investigated the effect of conceptually oriented instruction on students' competencies. They used two groups of students in their study. As a measuring tool a computational test was used. It was applied two times as pre and post-tests to both groups. One of the group students practiced a computational procedure without emphasis on the mathematical concepts. The second group of students learned the mathematical concepts underlying the procedures and spent little if any, time on practicing computational procedures. The findings of the computational test showed that in one conceptually oriented class the average-grade level equivalence for computational competence was increased from a 6.5 grade level at the start of the school year to a 9.1 grade level at the end of the year. On the other hand, computationally oriented class had an average level of 7.1 at the start of the school year and at the end of the school year the grade-level equivalence was 7.5. One of the difference of our study from that of Madsen at al is that, our study was conducted for three weeks. But the results are consistent. Moreover Hewitt (1990) reports that some of the teachers are afraid of conceptual physics; they think that conceptual physics would put students at a disadvantage if they were required to take mathematically rigorous tests for college entrance. Poul Hickman's study at Col Spring Harbor High School allayed their fears and supported our findings. He compared the performance of his ninth and tenth grade conceptual physics class with that of his twelfth graders by giving each class a New York Regent exam as a final exam. Although there were no statistical results, Hickman's explanation was that there was no substitute for a strong conceptual foundation.

Suchner (1998) reports that level of interest affects science achievement. On the other hand, Chamber and Andre (1997) report that the level of interest and prior-experience did not correlate significantly with post-test scores. Different from Chamber and Andre, we have found significant correlation between students' pre-attitude scores and post-achievement scores.

Wang and Andre (1991) reported that the effectiveness of conceptual change text varied with gender. But, Chambers and Andre (1997) reported that they did not find any interaction between effectiveness of conceptual change text and gender. Similarly, we did not find any significant interaction between Conceptual

Approach and gender. Both males and females benefited from Conceptual Approach equally. Chambers and Andre (1997) did not investigate the effectiveness of conceptual change text and students' age. We investigated the Conceptual Approach and students' age, but no significant interaction was found.

The results of our study also showed that, the Conceptual Approach affected students' attitudes toward physics in a positive manner. The study of Madsen at al (1992) support our results; they report that the students in the conceptually oriented classes attempted more items in post-tests. Furthermore at the end of the year, students included in their study stated that they had learned more mathematics in conceptually oriented class than they experienced in any of their previous mathematics classes. The results of their study indicate that conceptual understanding increase students' computational competence and promote more positive attitudes toward mathematics. Brouwer (1984) supports our finding in his article. He states that the effects of Conceptual Approach on students' achievement and attitudes toward physics are positive. Christiansen (1990), Chambers and Andre (1997) observed also positive effects of conceptual change approach. Researcher did not come across any finding of statistical information about the effect of Conceptual Approach on students' attitude toward physics. But in our study, the mean score of physics attitude pre-test was 76.94 for experimental group. After a three-week treatment period their means for physics attitude post-test was 76.94. This indicates that Conceptual Approach changed experimental group students' attitudes in a positive manner. On the other hand, for the control group students, the means for pre-attitude test was 73.42. At the end of study their means for the physics attitude post-test scores decreased to 68.25. This result also indicates that Traditional Method changed control group students' attitude in a negative manner. The reason for this result should be that the study conducted at the last three weeks of the semester. Classical teaching without experiments, demonstrations, and analogies may discourage students from giving their attention to the lesson. They could have been bored and their attitudes toward physics changed in a negative manner.

Hewitt (1990) mentioned about the positive effect of conceptual physics on students' achievement and attitudes toward physics without any statistical values. Elaine Robinson, Nancy Watson, Ed North all them are science teacher abroad. They report that after using conceptual physics in their lessons, the students' achievements and attitudes changed in a positive manner.

In our study, effect size was preset to 0.33 in a large scale by researcher. The statistical result of the SPSS calculated it as 0.30 for PSTACH and 0.26 for PSTATT. These values are approximately equal to large effect size. So, our results have also practical significance.

5.3 Implications

According to the findings of this study and previous studies conducted in abroad on the same topic, following suggestions are offered.

1. Each student has different personal interest and capabilities. Some of them are science oriented and some of them are not science oriented. For a long time, average non-science students regard studying physics as an

incompressible discipline On the other hand, as Hewitt (1998, p. XVI) reports, physics should be educational main stream for both science and non-science students. So the first course in physics should be conceptual physics. Every physics teacher should be aware of this fact.

2. Essential studies are needed to improve the Conceptual Approach in simple electricity or in other concepts of physics. The results of this study showed the effectiveness of Conceptual Approach on Turkish High School students.
3. Conceptual Approach should be improved and used for in any other branches of science (mathematics, chemistry and biology).
4. Students instructed by Conceptual Approach were mere aware of their surroundings. The real life examples, relationship of physics and technology changed students' attitudes in a positive manner. Hence, physics teachers should emphasize the role of physics on technology in their lessons by giving daily life examples.
5. Students instructed by Conceptual Approach gained more physics achievements. This might increase students' self esteem and self-efficacy.
6. Conceptual physics resulted in greater students' satisfaction, and enabled students to learn physics by doing. Hence, physics lessons should be supplied with experiments and activities that student can perform and learn concepts by doing themselves.

5.4 Internal Validity of the Study

There are various possible threads that most of the studies suffer. The internal validity of the study refers to the degree to which extraneous variables may influence the results of research.

In this study, the groups were randomly assigned. The individuals included in each group have different characteristics. Hence, many subject characteristics (students' previous electricity knowledge, previous cumulative grade point average (PCGPA), age, gender, physics achievement pre-test scores (PREACH), physics attitude pre-test scores (PREATT) and teacher) might affect Students' physics achievement post-test scores (PSTACH) and physics attitude post-test scores (PSTATT). They could be regarded as potential extraneous variables to the study. As shown in Table 3.3, most of the variables were included in the covariate set to statistically match subjects on these factors. The statistical analyses indicated that PPCG, PCGPA, PREACH, PREATT and teacher were covariates. And also, other factors were assumed to be effective on internal validity such as students' cognitive development and mathematical skills. The mathematical background and previous science studies were assumed to be equal for all students.

A Hawthorne effect and data collector characteristics should not be thread for the study. All classes included in study were made aware of this point and trained by the researcher to ensure standard procedures under which the data were collected. Being expose to a pre-test might affect students' performance on the lessons and post-test. However, it is assumed that pre-test would affect both control group and experimental group equally. All situations for both groups were tried to be made similar. Post-tests were tried to be administered to all groups approximately at the same time in order to alleviate location threat.

Mortality is the most important thread to internal validity to control. Missing data analysis was done as mentioned in previous chapter. The variables that have missing subjects were analyzed for significance using SPSS. According to the results, the missing data were changed with the series means.

Finally, confidentially was not a problem for this study since names of the students were not used anywhere. Their names were just taken for the sake of statistical analysis.

5.5 External Validity

Subjects of the study were not randomly selected from the accessible population. They were the students of two teachers from same private high school. Sample of the study consisted of 73 individuals. Generalization according to the results of this study is limited due to use of nonrandom sample convenience. But, generalizations to similar populations of private high school students might be accepted.

Treatments and all testing procedure took place in ordinary classrooms. There were possibly no remarkable differences among environmental conditions. Hence, all issues related to ecological validity were adequately controlled by the settings used in this study.

5.6 Recommendations for Further Research

This study has suggested a variety of useful topics for further studies. These are briefly as follows:

1. Future research could perform a replication of this study using different physics topics.
2. Future research could examine the effectiveness of Conceptual Approach for eliminating the students' misconception about simple electricity.
3. This study was about a private high schools students in Ankara. Future study could examine the effect of Conceptual Approach on students' physics achievement and attitudes toward physics in public high schools.
4. Sample size of a further research could be increased to obtain more accurate results.
5. Future study could examine the effect of Conceptual Approach on students' physics achievement and attitudes toward physics for longer time that is integrated in the flow of normal physics course.

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APPENDIX A

PHYSICS ATTITUDE SCALE

Basit Elektrik Devreleri Konularına Karşı Tutum Ölçeği

Sevgili Öğrenciler,

Bu anket sizin basit elektrik devreleri konularına karşı tutumlarınızı öğrenmek için geliştirilmiştir. Cevaplarınız önümüzdeki yıllarda fizik derslerinin sizin görüşleriniz ve beklentileriniz doğrultusunda şekillenmesine katkıda bulunabileceğinden önem taşımaktadır. Lütfen bütün soruları yanıtlayınız. Bu araştırmada toplanılan tüm bilgiler kesinlikle gizli tutulacaktır.

Her bir cümleyi dikkatle okuduktan sonra, cümleye ne derecede katıldığınızı veya katılmadığınızı belirtmek için yanındaki seçeneklerden birini işaretleyiniz.

Adı Soyadı: **Cinsiyeti:** **Yaş:**

Basit elektrik devreleri konusu; • elektrik yüklerinin akması, elektrik akımı, elektrik direnci • potansiyel, potansiyel kaynağı, ohm kanunu, • basit elektrik devresi, kısa devre, • seri bağlı devreler, paralel bağlı devreler, karışık bağlı devreler bölümlerini kapsamaktadır.	**Kesinlikle Katılıyorum**	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**	**Kesinlikle Katılmıyorum**
1. Basit elektrik devreleri konularını severim.					
2. Basit elektrik devreleri konularına karşı olumlu hislerim vardır.					
3. Benim için basit elektrik devreleri konuları eğlencelidir.					
4. Okulda basit elektrik devreleri konularını çalışmaktan hoşlanırım.					
5. Diğer konulara göre basit elektrik devreleri konuları daha ilgi çekicidir.					
6. Basit elektrik devreleri konularının, ilerideki meslek hayatımda önemli bir yeri olacağını düşünüyorum.					
7. Basit elektrik devreleri konularında öğrendiklerimin, gündelik hayatta işime yarayacağını düşünüyorum.					
8. Basit elektrik devreleri konularında öğrendiklerimin, hayatımı kolaylaştıracağını düşünüyorum.					
9. Elektrik konularının, gelecekte öneminin gittikçe artacağına inanıyorum.					
10. Basit elektrik devreleri konularının, ilerideki çalışmalarımda bana yararlı olacağını düşünüyorum.					
11. Elektrik konuları veya teknolojideki uygulamaları ile ilgili kitaplar okumaktan hoşlanırım.					
12. Bana hediye olarak basit elektrik devreleri ile ilgili bir kitap veya basit elektrik devreleri ile ilgili aletler verilmesinden hoşlanırım.					
13. Fizik topluluğuna üye olmak isterim.					
14. Arkadaşlarla elektrik konuları veya teknolojideki uygulamaları ile ilgili meseleleri konuşmaktan hoşlanırım.					
15. Günlük hayatta arkadaşlarla basit elektrik devreleri konularını hakkında konuşmak zevklidir.					
16. Basit elektrik devreleri konularında başarılı olmak için elimden geleni yaparım.					

Basit elektrik devreleri konusu; • elektrik yüklerinin akması, elektrik akımı, elektrik direnci • potansiyel, potansiyel kaynağı, ohm kanunu, • basit elektrik devresi, kısa devre, • seri bağlı devreler, paralel bağlı devreler, karışık bağlı devreler bölümlerini kapsamaktadır.	Kesinlikle Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle Katılmıyorum
17. Basit elektrik devreleri konularında elimden gelenin en iyisini yapmaya çalışırım.					
18. Basit elektrik devreleri konularında başarısız olduğumda daha çok çabalarım.					
19. Basit elektrik devreleri konularında yapılacak iş ne kadar zor olursa olsun, elimden geleni yaparım.					
20. Basit elektrik devreleri konularını öğrenebileceğimden eminim.					
21. Daha zor elektrik devreleri ile ilgili problemler ile başa çıkabileceğimden eminim.					
22. Basit elektrik devreleri konularında başarılı olabileceğimden eminim.					
23. Basit elektrik devreleri konularında zor işleri yapabileceğimden eminim.					
24. Yeterince vaktim olursa en zor basit elektrik devreleri ile ilgili problemleri bile çözebileceğimden eminim.					

APPENDIX B

OBJECTIVE LIST

A. Ability to recognize Electric Current

1. To recall that for heat to flow over a conductor, there must be a temperature difference between the ends of conductor.
2. To state that for charges to flow over a conductor, there must be potential difference or difference in potential (voltage) across the ends of a conductor.
3. To explain the similarities between the flow of charge within a wire and flow of water in a pipe.
4. To define electric current.
5. To give the unit of electric current.
6. To explain the electric current in terms of ampere.
7. To define voltage source.
8. To understand that for a continuous flow of charge an electric pressure is needed. This is supplied by batteries, dry cells...
9. To outline that battery supply energy to the charges to flow the circuit.
10. To define voltage.
11. To extend the voltage by giving examples.

12. To distinguish charge flowing through a circuit and voltage being impressed across a circuit.
13. To define electric resistance.
14. To state that resistance depends on the conductivity of the material, the cross sectional area and the length of wire.
15. To discover that electric resistance of a conductor depends on; length, cross sectional area and the conductivity of material.
16. To give some examples related to resistance of real life apparatus.
17. To define resistor.
18. To define ohm's law.
19. To explain ohm's law.
20. To solve problems related to ohm's law.
21. To understand that voltage (electric potential) is not dangerous. The electric current is dangerous.
22. To state that human body has a resistance, and it depends on the condition.
23. To list the effect of electric current when it flows through the human body.
24. To solve problems.
25. To discover that for current to flow, there must be closed path and the electric current is harmful for human body.

B. Ability to recognize Electric Circuits.

26. To define electric circuit.
27. To state that there must be complete circuit for the flow of electrons, electric current.
28. To discover that, there must be a complete circuit for the flow of electrons or electric current.
29. To extend the electric circuit with the help of water analogy.
30. To extend the flow of electrons over the filament and bulb.
31. To state the limitations of water analogy.
32. To define short circuit.
33. To demonstrate short circuit.
34. To give the schematic diagrams of the circuit elements.

C. Ability to identify Series Connected Electric Circuits.

35. To describe series connection of circuit.
36. To discover that there is only one path for current to complete the circuit.
37. To state that the brightness of the lamp is directly proportional with the current flowing on each lamp.
38. To discover that same amount of current pass over each circuit device when they are connected in series form.
39. To explain that voltage drop or potential difference across each individual device depends directly on its resistance.

40. To show that as the number of series connected lamp increase the brightness of the lamp decrease.
41. To explain the equivalent resistance.
42. To explain that as the number of series connected lamp (device) increase the equivalent resistance of circuit increase and the current flowing through the circuit decrease. This leads to the dimming of lamps.
43. To explain that the potential drop on each circuit device is directly proportional with the resistance of the circuit device.
44. To extend that the potential difference of the power supply (battery) is divided by each circuit device directly proportional with the resistance of each device.
45. To solve problems related to series connected circuit.

D. Ability to understand the Parallel Connected Electric Circuits.

46. To describe the parallel connection of the circuit.
47. To discover that there are different paths for current to complete the circuit.
48. To explain that the total circuit current is divided on each parallel branches.
49. To discover that the brightness of each identical lamp is same when they are connected parallel.
50. To state that potential drop on each parallel braches is same.

51. To show that as the number of parallel-connected lamp (device) change, the brightness of each lamp do not change.
52. To state that as the number of parallel-connected lamp (device) change the equivalent resistance of the circuit change.
53. To explain that as the number of parallel connected lamps (device) change the equivalent resistance of circuit change and so the amount of current taken from battery. But the amount of current passing through each individual branch does not change.
54. To solve problems related to parallel connected circuit.

E. Ability to solve Compound Circuit Problems.

55. To define the compound circuit.
56. To explain the compound circuit.
57. To breaks down the compound circuit.
58. To solve compound circuit problems.

APPENDIX C

TABLE OF SPECIFICATION

TABLE OF SPECIFICATION

		Know.	Comp.	Appl.	Analy	Synth.	Eva.	Total	Percent
A	Electric Current	1, 2, 4, 5, 7, 9, 10, 13, 14, 16, 17, 18, 22, 23	3, 6, 8, 11, 12, 19,21	15, 20, 24	25			25	43.10
B	Electric Circuits	26, 27, 31, 32, 34	29, 30	28 ,33				9	15.50
C	Series Circuit	35	39,41, 42, 43, 44	36, 37, 38,40, 45				11	18.96
D	Parallel Circuit	46, 50	48, 52, 53	47, 49, 51, 54				9	15.51
E	Compound Circuit	55	56	57	58			4	6.89
	Total	23	18	15	2			58	100
	Percent. (%)	39.65	31.03	25.86	3.44			100	100

APPENDIX D

OBJECTIVE-CONCEPTUAL PHYSICS TEACHING CRITERIA TABLE

OBJECTIVE - CONCEPTUAL PHYSICS TEACHING CRITERIA TABLE													
		Teaching hardcore physics									Shaping Critical Thinking		Relating role of physics and technology
		Lecture	Activity	Demo	Anology	Drawing	Discussion	Game	Examplifications from daily life	Homework-projects	meaning of terms	Using formula	Physics and Technology
A - Electric Current	1	/											
	2	/											
	3	*			/	/(Fig 1)							
	4	*											/(Electrolysis)
	5	/											
	6	*				/(Fig 2)			/		/		
	7	*		/					/		/		
	8	*			/		/						
	9	/											
	10	*							/		/		
	11	*		/(Fig3)					/		/		
	12	*			/	/(Fig1,2)					/		
	13	/											
	14	*			/	/(Fig 4)			/		/		
	15	*	/(1)		/		/	/	/		/	/	
	16	*							/				
	17	*									/		/(Electronics)
	18	*											
	19	*				/(Fig 6)			/		/	/	
	20	*							/		/	/	/(real life prob)
	21	*					/		/				
	22	*							/		/		
	23	*					/		/				
	24	*							/		/	/	
	25	*					/		/	/	/		/(real life)

Note.
1. " / " mean that the objective will be achieved with lecture only
2. " * " mean that the objective is achieved with the help of activity and lecture
3. " prob " mean problems
4." Ex " mean example

		Teaching hardcore physics									Shaping Critical Thinking		Relating role of physics and technology
		Lecture	Activity	Demo	Anology	Drawing	Discussion	Game	Examplifications from daily life	Homeworks projects	meaning of terms	Using formula	Physics and Technology
B - Electric Circuits	26	•		/(Fig3)					/				/(real life)
	27	/											
	28	•	/(2)	/(Fig7)			/						
	29	•			/	/(Fig 8)			/				
	30	•		/		/(Fig 9)							/(bulb)
	31	•			/	/(Fig 8)							
	32	/				/(Fig10)							
	33	•	/(3)	/		/(Fig10)	/		/	/	/	/	
	34	•				/(Fig 11)							

		Teaching hardcore physics									Shaping Critical Thinking		Relating role of physics and technology
		Lecture	Activity	Demo	Anology	Drawing	Discussion	Game	Examplifications from daily life	Homeworks projects	meaning of terms	Using formula	Physics and Technology
C - Series Circuits	35	•	/(4)	/		/(Fig 12)			/		/		
	36	•	/(4)	/			/		/	/	/		/(fuse)
	37	•	/(4)	/			/					/	
	38	•	/(4)				/		/		/		
	39	•									/	/	
	40	•	/(4)	/			/						
	41	•				/Fig (13 14)					/	/	
	42	•									/	/	
	43	•									/	/	
	44	•									/	/	
	45	•				/(prob)	/				/	/	

Note.
1. " / " mean that the objective will be achieved with lecture only
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		Teaching hardcore physics									Shaping Critical Thinking		Relating role of physics and technology
		Lecture	Activity	Demo	Anology	Drawing	Discussion	Game	Examplifications from daily life	Homeworks projects	meaning of terms	Using formula	Physics and Technology
D - Parallel circuits	46	•	/		/	/(Fig15)					/		
	47	•	/(5)				/		/	/	/		/
	48	•	/(5)				/		/	/	/		
	49	•	/(5)	/			/						
	50	/											
	51	•	/(5)	/									
	52	•				/Fig (16,17)					/	/	
	53	•			/					/	/	/	/(fuse)
	54	•				/(prob)				/	/	/	
E - Compound Circuits	55	•				/(Fig18)							/(real life)
	56	•		•		/					/		/(real life)
	57	•				/Fig (18,19,20)	/				/		
	58	•				/(Ex)	/					/	

Note.
1. " / " mean that the objective will be achieved with lecture only
2. " • " mean that the objective is achieved with the help of activity and lecture
3. " prob " mean problems
4." Ex " mean example

APPENDIX E

LESSON PLAN FOR TEACHER

ELECTRIC CURRENT

(**Note:** This text is prepared for teacher. In some parts, some of the sentences are included in parenthesis. These sentences or information are not included in student's notes. So, the sentences included within parenthesis will be explained by teacher)

Flow of Charge

Recall that heat flows through a conductor when a difference in temperature exist across its ends. Heat flows from the end of higher temperature to the end of lower temperature. When both ends reach the same temperature, the flow of heat stops.

Similarly, when the ends of an electric conductor are at different electric potentials, charge flows from one end to another end. Charge flows when there is a *potential difference* or *difference in potential (voltage)*, across the ends of a conductor. The flow of charge will continue until both ends reach a common potential. When there is no potential difference, there is no longer flow of charge through the conductor. This situation is analogous to the flow of water from higher reservoir to a lower reservoir as in figure 1 a. Water will flow in pipe that connects the reservoirs only as long as a difference in water level exist. The flow of water in the pipe will stop when the pressure at each ends are equal.

To attain a sustained flow of charge in a conductor, some arrangements must be provided to maintain a difference in potential while charge flows one end of a conductor to the other end. In order that the flow be continuous, there must be a suitable pump to maintain a difference in water level as in figure 1 b. Then there will be a continual difference in water pressure and a continual flow of water. The same is true for electric current.

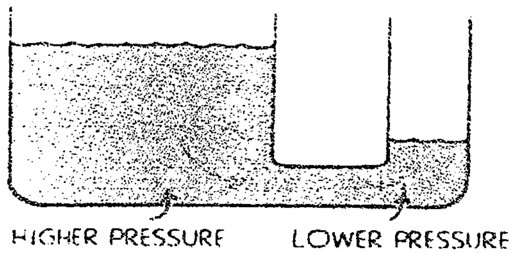


Figure 1 a. Water will flow from the higher – pressure end of the pipe to the lower pressure end. The flow will cease when the pressure ceases.

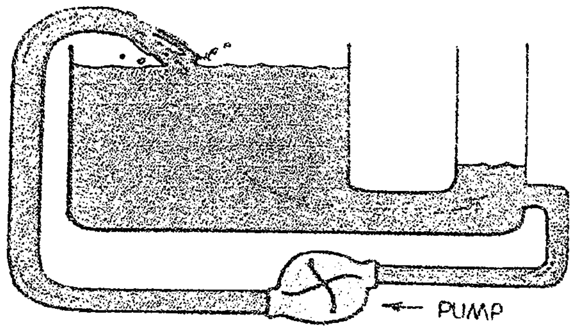


Figure 1 b. Water continues to flow because a difference in reservoir level is maintained with the pump

Electric current

Electric current is defined as the flow of electric charge. In solid conductors, the electrons carry the charge through the circuit because they are free to move throughout the atomic network. These electrons are called *conduction electrons*. Protons, on the other hand, are bound inside atomic nuclei. In fluids, such as the electrolyte in a car battery, positive and negative ions as well as electrons may compose the flow of charge.

If there is a charge flow through a conductor then there is a current. Electric current is measured in amperes (A). An ampere is the flow of one coulomb of charge per second. (Recall that one coulomb, the standard unit of charge, is the electric charge of 6.25 billion billion electrons.) In a wire that carries a current of five amperes, for example, five coulombs of charge pass any cross section in the wire each second. So that is a lot of electrons! In a wire that carries 10 amperes, twice as many electrons pass any cross section each second.

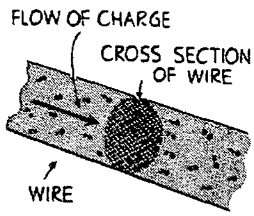
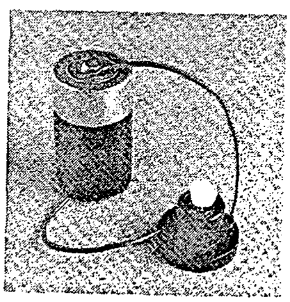


Figure 2. When the rate of flow of charge pass any cross section is 1 coulomb (6.25 billion billion) per second, the current is 1 ampere.

Voltage Source

A continuous charge flow require a suitable "electric pump" to provide a sustained potential difference. Something that provides a potential difference is known as *voltage source*. If you charge a metal sphere positively, and another negatively, you can develop a large voltage between them. This voltage source is not a good electric pump because when the spheres are connected by a conductor the potential equalize in a single brief surge of moving charges. Batteries, dry cells, wet cells, and generators, are capable of maintaining a steady charge flow. In other words, batteries, dry cells, wet cells, and generators supply energy that allows charge to move. The potential energy per coulomb of charge available to electrons moving between terminals of battery is the voltage. The voltage provides the "electric pressure" to move the electrons between the terminals in the circuit.



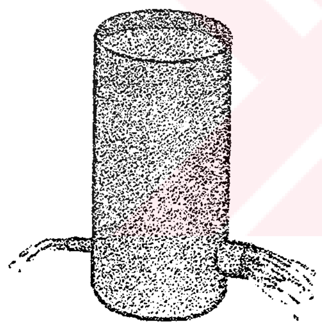
For example, when a bulb is connected to the terminals of 1.5volt battery, as in figure 3, Electric pressure of 1.5 volts is placed across the bulb. This means that 1.5 joules of energy is supplied to each coulomb of charge to flow the circuit.

Figure 3. Each coulomb of charge that is made to flow in a circuit that connects the ends of this 1.5-volt battery is energized with 1.5 joules of energy

There is often some confusion between charge flowing *through* a circuit and voltage being impressed across a circuit. To distinguish between these ideas, consider a long pipe filled with water. Water will flow *through* the pipe if there is a difference in pressure *across* or between its ends. Water flows from high-pressure to the low-pressure end. Only the water *flows*, not the pressure. Similarly, you say that charges flow through a circuit because of an applied voltage across the circuit. You do not say that voltage flows through a circuit. Voltage doesn't go anywhere, for it is the charges that move. We can say that voltage is the cause of charge flowing, or voltage is the causes of current.

Electric Resistance

The amount of current that flows in a circuit depends on the voltage provided by the voltage source. The current flows also depend on the resistance that the conductor offers to the flow of charge. The resistance of conductor to the flow of charge or to the current is called as the electric resistance. Electrical resistance of the material is measured in units called **ohms (Ω)**.



This is similar to the rate of water flow in a pipe, which depends not only on the pressure difference between the ends of the pipe but on the resistance offered by the pipe itself, as in figure 4. The resistance of a wire depends on the *conductivity* of the material used in the wire (that is, how well it conducts) and also on the thickness and length of the wire.

Figure 4. For a given pressure , more water passes through a large pipe than a small one. Similarly for a given a voltage, more electric current passes through a large-diameter wire than a small-diameter one.

Activity 1

Purpose: To discover the electric resistance of wire.

Required equipments: Group of students labeled as "battery", "electron", "wire", "notebook", "duster" chair, ...

Discussion: The resistance of the wire depends on the *conductivity* of the material used in the wire, and also the thickness and the length of the wire.

Procedure: Assign 10 students to be wire, with five students holding hands in outer circle and another five students holding hands in inner circle as in figure 5. State that these students formed a wire. Assign one student to be electron (student A) and one student to be battery (student B). Place the battery (student B) near the wire, which will send the electron (student A) to the circuit. State that student A, will be sent into the wire, is the charge flowing through wire.

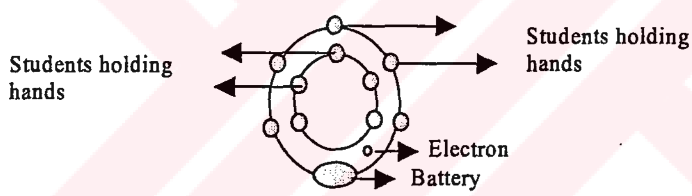


Figure 5. The schematic diagram of the position of students

Step 1.

a- Tell the battery (student B) send electron (student A) to the circuit formed by students.

Ask electron that if he/she walked comfortable.

....

b- Decrease the distance between two row students (narrow the cross sectional area of wire), and tell battery (student B) send electron (student A) again to the circuit. Ask electron that if he/she walked comfortable

....

(It is always difficult to walk in a hall when it is narrow. Similarly, it is difficult for electrons to move within a wire when the wire is narrow. It means that, it is difficult for electrons to move within a wire when the cross sectional area of wire is small. *We can conclude that, as the cross sectional area of wire decreases the resistance of wire increases.*)

Step 2.

Call another four students and increase the length of the wire with the help of this four student. Then tell the battery (student B) send the electron (student A) to the circuit again.

Ask electron which journey takes the longer time and boring?

....

(It is always difficult and boring to walk within a very long hall compared to short hall. Similarly, it is difficult for electrons to move within a long wire compared to short length wire. *We can conclude that; as the length of the wire increases, the resistance of the wire increases too.*)

Step 3.

Place a chair, and students assigned as “notebook”, “duster” between the wires formed by students.

Tell the battery (student B) send the electron (student A) to the circuit.

Ask electron that if he/she walked comfortable compared when there is nothing such as chair, notebook, within the wire.

....

....

(Similarly, each wire has different characteristic properties. Due these different characteristic properties, electrons move in different difficulties. *The resistance of the wire depends on the conductivity of the material used in the wire (that is, how well it conducts*).

The resistance of the typical bulb cord is much less than 1 ohm. The resistance of the typical light bulb has a resistance of about 100 ohms. An iron or electric toaster has a resistance of 15 to 20 ohms. The low resistance permits a large current, which produces considerable heat. Inside electric devices such as radio and television receivers, the current is regulated by circuit elements called resistor whose resistance may range from a few ohms to millions of ohms.

Ohm's Law

George Simon Ohm, a German physicist, discovered that the current flowing through a circuit is directly proportional to the voltage applied across the circuit, and is inversely proportional to the resistance of the circuit. In short,

Voltage = Current * Resistance

This relationship between voltage, current, and resistance is called **ohm's law**.
The relationship between the units of measurement for these three quantities is

1 volt = 1 Ampere * 1 ohm

For a given circuit of constant resistance, current and voltage are proportional. This means that you will get twice the current if you increase the voltage twice. The greater the voltage, the greater the current. But the ratio of voltage to current is always constant and this constant value is always equal to the value of the resistance. For a constant applied voltage, if the resistance is doubled, the current will be half. The greater the resistance, the less the current.

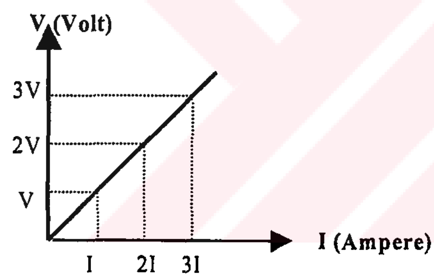


Figure 6. The graph of voltage – current relationship.

If you apply a potential difference of 1 volt across a circuit having resistance of 1ohm, then a current of 1 ampere will flow through this circuit. If 12 volts of potential difference is applied across same circuit, the current will be 12 ampere.

Question 1. What is the resistance of an electric frying pan that draws 12 amperes of current when connected to a 220-volt circuit?

....

....

....

Question 2. How much current is drawn by a bulb that has a resistance of 100 ohms when a voltage of 220 volts is impressed across it?

....

....

....

Ohm's law and Electric Shock

What causes electric shock in the human body - current or voltage? The damaging effects of shock are the result of current passing through the body. From ohm's law, we can see that this current depends on the voltage applied, and also on the electric resistance of the human body.

The resistance of your body depends on its condition and ranges from about 100 ohms (if you are soaked with salt water) to about 500000 ohms (if your skin is very dry).

If you touch the two electrodes of a battery with dry fingers, the resistance of your body which normally offers to the flow of charge is about 100000 ohms. You usually would not feel 12 volts, and 24 volts would just barely tingle. But if your skin were moist, on the other hand, 24 volts could be harmful. The table 1 describes the effects of different amounts of current on the human body.

Table 1. Effects of Various Electric Currents on the Body

Currents in amperes	**Effect**
0.001	Can be felt
0.005	Painful
0.010	Involuntary muscle contractions (spasms)
0.015	Loss of muscle control
0.070	If through the hearth, serious disruption; probably fatal if current lasts for more than 1 second.

Homework 1

Question 1. If the resistance of your body were 13000 ohms, what would be the current in you body when you reached the terminals of 220-volt battery? What kind of effect do you feel?

....

....

....

Question 2. If your skin were very moist so that your resistance was only 180 ohms, and you touched the terminals of a 9-volt remote control TV battery, how much current would you draw? What kind of effect do you feel?

....

....

....

Think and Explain 1

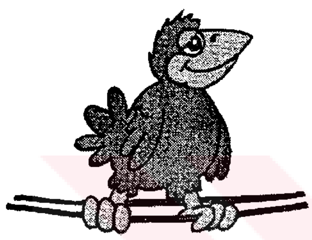
1. Electricians usually work "with one hand in their pocked"; that is to say, they use only one hand when there is any danger of a "hot wire" Why?

……………………………………………………………………………………………

……………………………………………………………………………………………

(If they use two hands and there is a hot wire, the current may go from one hand to another across the chest and paralyze the heart.)

2.



The bird can stand harmlessly on one wire of high potential, but it had better not reach over and grab a neighboring wire!
Why not?

……………………………………………………………………………………………

……………………………………………………………………………………………

(You have seen birds perched on high-voltage wires. Every part of their bodies at the same high potential as the wire, and they feel no ill effects. For the bird to receive a shock, there must be a difference in electric potential between one part of its body and another part. Most of the current will then pass along the path of least electric resistance connecting these two points)

Link to Technology 1: Electrolysis

Electrochemistry is about electric energy and chemical change. Molecules in a liquid can be broken apart and separated by the action of electric current. This is electrolysis. A common example is passing an electric current through water, separating water into its hydrogen and oxygen components. This common process is also at work when a car battery is recharged. Electrolysis also used to produce metal ores. Aluminum is a familiar metal produced by electrolysis. Aluminum is common today, but before the advent of its production by electrolysis in 1886, aluminum was much more expensive than silver and gold.

ELECTRIC CIRCUITS

Mechanical thinks seem to be easier to figure out for most people than electrical things. Maybe this is because most people have had experience playing with blocks and mechanical toys when they were children.

Any path along which charges can flow is defined as circuit. A simple circuit consists of a voltage source, connecting wires and an electric device. For a continuous flow of charge, there must be a complete circuit with no gaps.

Activity – 2 (Eliminating the sink model)

Purpose: To understand simple circuit, a battery and a bulb.

Required equipments:

-Dry cell (battery)

-Bare copper wires

-Flashlight bulbs

-Bulb holders

Discussions: A dry cell (commonly called a battery) is a source of electric energy. Many arrangements are possible to get this energy from dry cells to flashlight bulbs. In this activity, you will test these arrangements to see whether they light bulb or not. Figure 7. shows the arrangements of a battery and a bulb circuit.

Procedure:

Step 1.

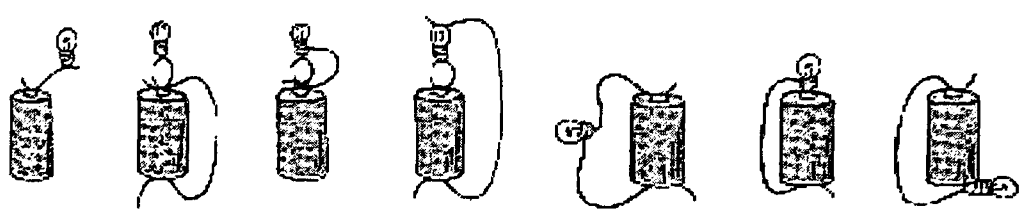


Figure 7. Connections of the bulb and battery

Arrange one bulb (without a holder), one battery, and wire as in many ways as you can make the bulb emit light as shown in figure 7. Define each of your arrangements as successful and unsuccessful. Label the sketches of the successes.

....

....

....

Question 1. Describe the similarities among your successful trials.

....

....

....

Step 2. Use a bulb holder (instead of a bare bulb), one battery and wire. Arrange these in many ways as you can to make the bulb light.

Question 2.

What two parts of the bulb holder make contact with?

....

....

....

The flow of charge in a circuit is very much like the flow of water in a closed system of pipes. For the set up shown in figure 8, the battery is analogous to a pump, the wires are analogous to pipe, and the bulb is analogous to any device that operates when the water is flowing. When a valve in the line is opened and the pump is operating, water already in the pipes starts to flow.

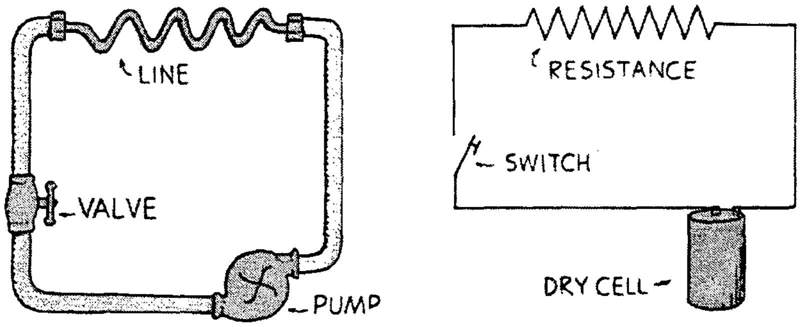


Figure 8. Analogy between a simple hydraulic circuit and electric circuit

Similarly when a switch is turned on to complete an electric circuit, the mobile conduction electrons already in the wires and the filament begin to drift through the circuit. The water flows *through* the pump and electrons flow *through* the battery. Neither the water nor the electrons "squash up" and concentrate in certain places; they flow continuously around circuit.

The important think is to note that there must be a complete path, or circuit, from positive terminal at the top of the battery to the negative terminal, which is the bottom of the battery. Electrons flow from the negative terminal of the battery through the wire to the side of the bulb, through the filament inside the bulb, and out the bottom and through the other piece of wire to the positive part of the battery. Figure 9 shows the part of bulb.

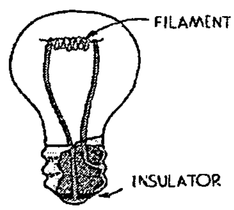


Figure 9. Electrons do not pile up inside a bulb, but instead flow through its filament

The water analogy is quite useful for gaining a conceptual understanding of electric circuits, but it does have some limitations. An important one is that a break in a water pipe results in water spilling from the circuit, whereas a break in an electric circuit results in a complete stop in the flow of electricity. Another difference has to do with turning current off and on. When you close an electric switch that connects the circuit, you allow the current to flow in much the same way as you allow water to flow by opening a faucet. Opening a switch stops the flow of electricity. Opening a water faucet, on the other hand, starts the flow of water.

Activity - 3 (Short Circuit)

Purpose: To understand the short circuit.

Required equipments:

-Dry cell (battery)

-Copper wires

-Flashlight bulb

-Bulb holder

Discussion: When the additional wire is placed across the bulb, the light goes out. A general rule in electrical circuits is that electricity will follow the path of least resistance. It means electrons will follow the shortest, easiest path back to its battery. This is called short circuit.

Procedure:

Step 1. Connect the circuit as shown in figure 10.

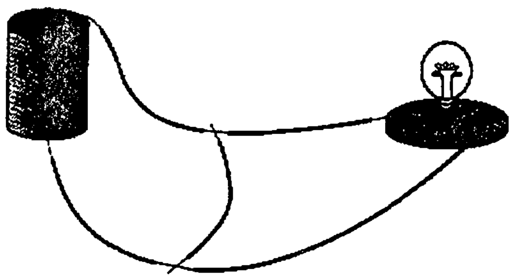


Figure 10. Battery and bulb, short-circuited.

Step 2. Strip the insulation from 1 cm in the center of each wire.

Question 1. Does the light still on?

....

....

Step 3. Put the bare ends of the extra piece of wire across the bare sections of your wires.

Question 2. Does the light on? What do you think, what happened? Why?

....

....

(In this activity you have made the path shorter and avoided the bulb. If you permit current to flow through the short circuit for more than a few seconds, the wire will begin to heat up. This is caused by providing an easy path for electricity to flow. The amount of electricity going through the wire increases beyond its normal capacity)

Think and explain 2

In your daily life, if you connect the negative terminal of battery to the positive terminal by a wire, you feel that the wire gets hotter in a very small time interval. Why? (Hint: Remember the ohm's law)

....

....

(When you connect the ends of the battery by a wire you form a short circuit. The resistance of the wire is very small compared to the other devices. According to ohm's law, when the resistance is very small, the current will be great. So the wire becomes hotter.)

Home project 1

When you turn the ignition key in automobile, you complete a circuit from the negative battery terminal through the electric starter and back to the positive terminal. This is a circuit and electrons migrate trough the circuit in a direction from the negative battery terminal to the positive terminal. About how long must the key be in the ON position for electrons starting from the negative terminal to reach the positive terminal?

a) A time shorter than that of the human reflex turning a switch on or off

b) Some seconds

c) Some minutes

d) Some hours

(In a typical circuit of, in the electric system of an automobile for example, the electrons have net average speed of 0.01 cm/s. At this rate, it would take about three hours for an electron to travel one meter of wire. In circuit the energy is transmitted through the conductors at nearly the speed of light. It is not the speed of electron that moves at this speed. Because electrons make collisions with other electrons.)

Schematic Diagrams

Electric circuits are frequently described by simple diagrams, called schematic diagrams. Some of the symbols used to represent certain circuit elements are shown in figure 11.

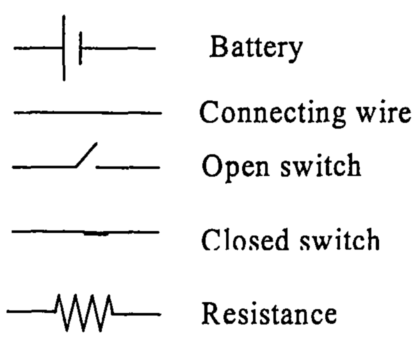


Figure 11. Symbols of some common circuit devices.

A zigzag line shows resistance, and ideal resistanceless wires are shown with solid straight lines. A battery is represented by with a set of short and long vertical parallel lines. The convention is to represent the positive terminal of the battery with a long line and the negative terminal with a short line.

Series and Parallel Circuits

Most circuits have more than one device that receives electrical energy. These devices are commonly connected in a circuit in one of two ways, *series* or *parallel.* Both series and parallel connections have their own distinctive characteristics.

Activity 4 (Series Circuit)

In Christmas day, Christmas tree lights are used as a fun. Some cheap Christmas tree lights are connected in series. When one of the bulbs is burned out, all the bulbs light off. It is fun to find out which one burned out and replace it with a new bulb.

When the electrical devices are in series, they form a single pathway for charge between the terminals of the battery, generator or wall socket (which is simply an extension of these terminals).

Purpose: To identify the series circuit.

Required equipments:

-Dry cell (battery)

-Bare copper wires

-Identical Flashlight bulbs

-Bulb holders.

Discussion: Figure 12 shows three bulbs connected in series with battery. This is an example of a *series circuit.* When the switch is closed, a current exists almost immediately in all three bulbs.

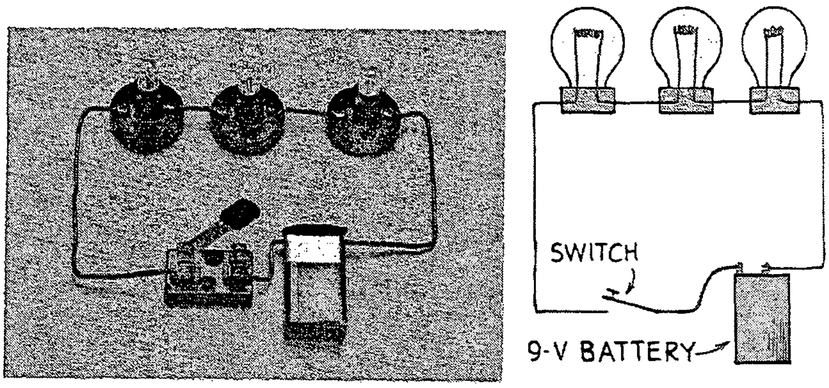


Figure 12. A series circuit.

Procedure.

Step 1. Connect the circuit as shown in figure 12.

If you connect the bulbs using bulb holders as shown in the figure, then the bulbs are connected series to each other.

Step 2. Close the switch.

Question 1. Do the bulbs light on <u>at the same time</u>? Repeat the step 2. Discuss it with your friends.

....

....

When the switch is closed, a current exists almost immediately in all three bulbs. The current does not "pile up" in any bulb but flows *through* each bulb. Electrons in all part of the circuit begin to move at once. Some electrons move away from the negative terminal of the battery, some move toward the positive terminal of the battery and some move through the filament of each bulb. Eventually the electrons move all the way around the circuit

Step 3. Unscrew one of the bulbs from the bulb holder. (Be careful that the bulb would be hot it light on for along time)

Question 2. What happened to the other bulbs?

…………………………………………………………………………………………

A break anywhere in the path results in an open circuit, and the flow of electrons ceases.

Question 3. What would happen to other bulbs if one bulb in this circuit burns out?

…………………………………………………………………………………………

…………………………………………………………………………………………

(If one of the bulb filaments burns out, the path connecting the terminals of the battery will break and current cease. All bulbs will light off)

Step 4. Screw the bulb again.

Question 4. What happened? Compare the brightness of each bulb in this circuit.

…………………………………………………………………………………………

…………………………………………………………………………………………

If the bulbs are identical, the brightness of the bulbs is directly proportional with the amount of current passing over the bulb.

Question 5. If the brightness of each bulb is same, what is the reason to the same brightness? Discuss it.

…………………………………………………………………………………………

…………………………………………………………………………………………

(In series circuits, same amount of current pass over each circuit elements)

(Ohm's law also applies separately across each device. If the bulbs are identical their resistance will be equal. If same amount of current pass over each bulb the voltage drop or potential difference across each bulb is same. Voltage drop or potential difference across each individual device depends directly on its resistance. This follows from the fact that more energy is used to move each unit of charge through a large resistance than through a small resistance)

Step 5. Add one or two more bulbs with bulb holder to the circuit.

Question 6. What happened to the brightness of each bulb after the number of bulb increased?

....

....

(The brightness of each bulb decreased. It means that the current flowing over each bulb decreased. Any change in the circuit affect the overall circuit)

(In a circuit with several resistors, equivalent resistance is the value of the single resistor that would comprise the same load to the battery. The addition of more bulbs in series circuit results in a greater circuit resistance. The equivalent resistance of the series circuit is found by simple adding the resistance of each device. Because the current is resisted by the resistance of the first device, the resistance of the second, and the third also, so that the total resistance to current in the circuit is the sum of the individual resistances along the circuit path. In figure 13, the resistors R_1 and R_2 are connected in series. Figure 14 shows the equivalent circuit of figure 13.

The equivalent resistance of this two resistor is found by;

$$R_{equivalent} = R_1 + R_2$$

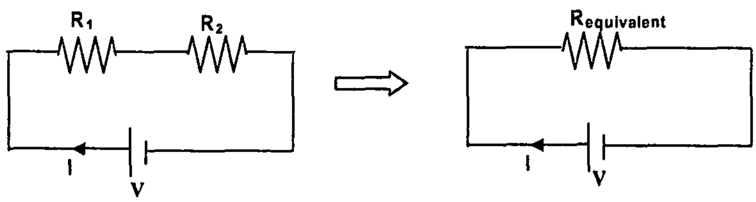


Figure 13. Two resistor connected in series **Figure 14.** The equivalent circuit of figure 13

For more than two resistor connected in series form the equivalent resistance of the circuit is calculated by;

$$R_{equivalent} = R_1 + R_2 + R_3 + R_4 \ldots\ldots$$

Pay attention that the equivalent resistance is greater than the resistance of individual resistance of each resistor.

The current in the circuit is numerically equal to the voltage supplied by the source divided by the total resistance of the circuit.

$$I=\frac{V}{R_{equivalent}}$$

According to ohm's law as the resistance increases, the current in the circuit decreases and therefore less current flow over each bulb. This will result the dimming of the bulbs.

Same amount of current flows over each circuit element in series circuit. According to the ohm's law the potential difference across each element is equal the multiplication of current and the resistance of each device.

$$V_1= I*R_1 \quad \text{and } V_2= I*R_2$$

The total voltage impressed across a series circuit divides among the individual electrical devices so that the sum of the voltage drops across each device is equal to the total voltage supplied by the source.

$$V= V_1+ V_2.$$

This follows from the fact that the amount of energy used to move each unit of charge through the entire circuit equals the sum of the energies used to move that unit of charge through each of the electrical devices in the circuit.)

Questions.

1. If three bulbs are connected in series to a 6-volt battery, how many volts are impressed across each bulb? (2 volts)

   ………………………………………………………………………………

   ………………………………………………………………………………

2. If one of the three bulbs blows out when connected in series, what happens to the current in other two bulbs? (Current stops In other words, the current flowing through the circuit is zero)

....

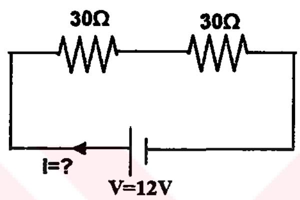
....

3. What happens to the total circuit resistance when more devices are added to series circuit? (Increases. The magnitude of the equivalent resistance of a series circuit is greater than the magnitude of individual resistance)

....

....

4.



Calculate the current in a 12 volt battery that powers a pair of 30Ω resistors connected in series.

....

....

<u>Think and explain-3</u>

Why are household appliances almost never connected in series?

....

....

(Current would vary as new appliances connected, and if one of the appliances burns out, the other never works. Because of this reason household appliances are connected in parallel to each other)

Activity - 5 (Parallel Circuits)

Parallel circuit is like a road with alternate routes. If there is a roadblock or cave in, the traffic along alternate routes keeps moving. The greater the number of routes, the less resistance to traffic going from one place to another that is by these routes

When the electrical devices are connected in parallel, they form branches, each of which is a separate path for the flow of charges.

Purpose: To identify the parallel circuit.

Required equipments:

Dry cell (battery)

-Bare copper wires

-Flashlight bulbs

-Bulb holders.

Discussion: Figure 15 shows three bulbs connected to the same two points A and B. This is an example of a *parallel circuit.*

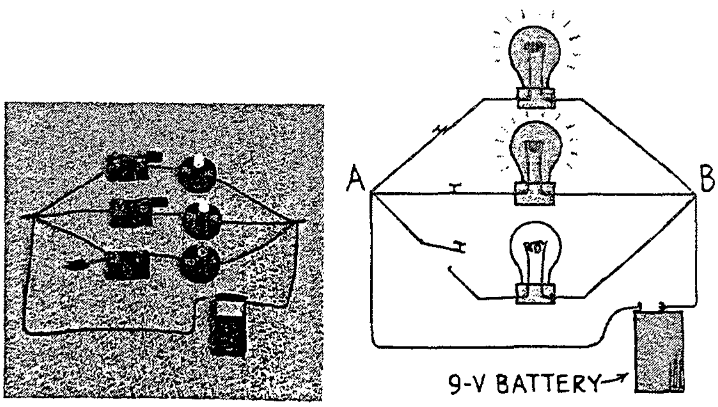


Figure 15. A parallel circuit.

Electrical devices connected in parallel are connected to the same two points of an electric circuit.

Procedure:

Step 1.

Connect the circuit as shown in figure 15.

If you connect the bulbs as shown in figure 15, then the bulbs are connected parallel to each other.

Step 2. Close all the switches.

Question 1. Do the bulbs light on <u>at the same time</u>? Discuss it with your friends.

…………………………………………………………………………………………

…………………………………………………………………………………………

(The entire bulb light on.) Because there are three separate pathways for current, one through each bulb. The current taken from battery divides on each parallel branches at point A and then they collected at point B as in figure 15.

Step 3. Open one of the switches on the parallel branch of the circuit.

Question 2. What happens to the other bulbs?

…………………………………………………………………………………………

…………………………………………………………………………………………

(They still light on. Because each bulb has its own path from one terminal of the battery to the other. In contrast to a series circuit, the current in one bulb does not pass through the other bulbs.)

Question 3. What happens to the brightness of other two bulbs?

…………………………………………………………………………………………

…………………………………………………………………………………………

(no change.)

step 4. Open another switch of the parallel-connected bulb.

Question 4. What happens to the brightness of other bulb?

…………………………………………………………………………………………

…………………………………………………………………………………………

(No change.)

Step 5. Close all the switches connected to bulbs again.

Question 5. What happens to the brightness of the bulbs?

………………………………………………………………………………………………

………………………………………………………………………………………………

(No change.)

Question 6. If the brightness of each identical bulb is the same, when there is only one bulb and when there are two or three bulbs, what is the reason to the same brightness. Discuss it.

………………………………………………………………………………………………

………………………………………………………………………………………………

(If one bulb is removed or added to the circuit in parallel, the other bulbs are unaffected. Each device connects the same two points A and B of the circuit. The voltage is therefore the same across each bulb.

$$V_1 = V_2 = V$$

According to ohm's law, the current in each parallel branch is equal to (voltage/resistance), and since neither voltage nor resistance is affected in the individual branches, the current in those branches is unaffected. If one bulb burns out, the total current in the overall circuit (the current through the battery), however, is decreased by an amount equal to the current drawn by the bulb before it burned out. But the current in any other single branch is unchanged.)

(The brightness for each bulb is unchanged as the other bulbs are added or removed. Only the total resistance, and the total current in the total circuit changes, which is to say, the main current flowing through the circuit changes. As bulbs are added in parallel, the total circuit resistance decreases. In figure 16 resistors R_1 and R_2 are connected parallel to each other. The equivalent resistance of the R1 and R_2 are calculated by;

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Figure 17 show the equivalent circuit of figure 16.

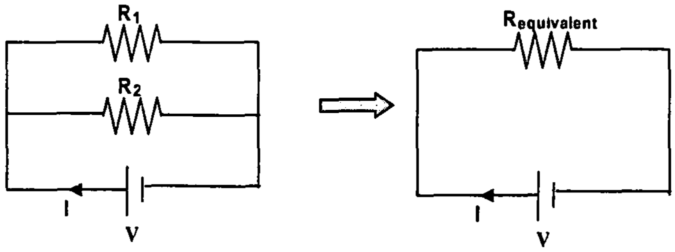


Figure 16. Two resistors connected in parallel **Figure 17.** Equivalent circuit of figure 16.

For more than two parallel connected resistors, the equivalent resistance of the parallel circuit is calculated by ;

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots..$$

(Pay attention that as the number of parallel branches increased the equivalent resistance of the circuit is decreased. Equivalent resistance is lowered with each added path between any two points of the circuit. This means that the equivalent resistance of the circuit is less than the resistance of any one of the branches. This decreased resistance is accompanied by an increased current, the same increase that feeds energy to the bulbs as they are introduced. Although changes of resistance and current occur for the circuit as a whole, no changes occur on individual branch in the circuit.)

Questions.

1. If three bulbs are connected in parallel to a 6-volt battery, how many volts are impressed across each bulb? (6 volt)

....

....

2. If one of the bulbs burns out when connected in parallel, what happens to the current in the other bulbs?

....

....

(The current flowing over other bulbs does not change. So, the brightness of the bulbs do not change)

3. What happens to the equivalent resistance when more than one devices are added to parallel circuit?

....

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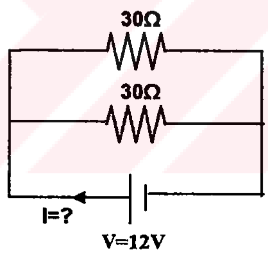
(The total resistance, which is equivalent resistance, decreases. Because there will be more pathways for current. The equivalent resistance of the circuit is always smaller than the smallest resistance of the resistor.)

4.



Calculate the current in a 12-volt battery that powers a pair of 30 Ω resistors connected in parallel.

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Compound Circuit

Sometimes it is useful to know the equivalent resistance of a circuit that has several resistors in its network. Circuit having several resistors parallel and series to each other is called as compound circuit. Figure 18 shows a combination of three 8-ohm resistors. The two resistors in parallel are equivalent to a single 4-ohm resistor, which is in series with an 8-ohm resistor. The new shape of the circuit is like figure 19. Two resistors $R_{eq1}=$ 4-ohm and 8-ohm adds to produce an equivalent resistance of 12 ohm as in figure 20. If a 12-volt battery were connected to these resistors, can you see from ohm's law that the current through the battery would be 1 ampere. (In practice it would be less, because there is resistance inside the battery. This resistance of battery is called battery' internal resistance)

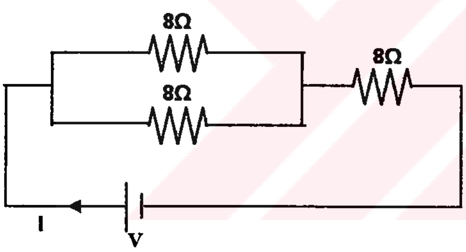


Figure 18. Three resistors form a compound circuit.

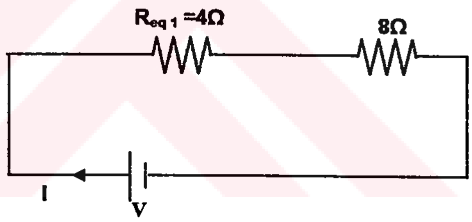


Figure 19. The equivalent resistance of two 8 Ω resistor is 4Ω and in series to 8 Ω resistor

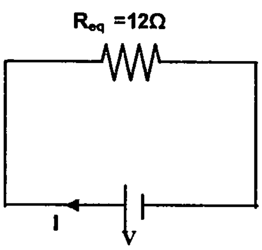
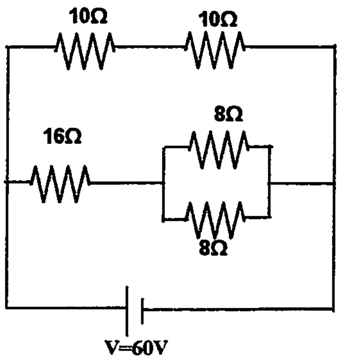


Figure 20. The equivalent resistance of the figure 18.

Example



a. What is the magnitude of the main current flowing through the circuit?

b- What is the magnitude of the current flowing through the pair of 10 Ω resistor?

c- What is the magnitude of the current flowing through each of the 8 Ω resistor?

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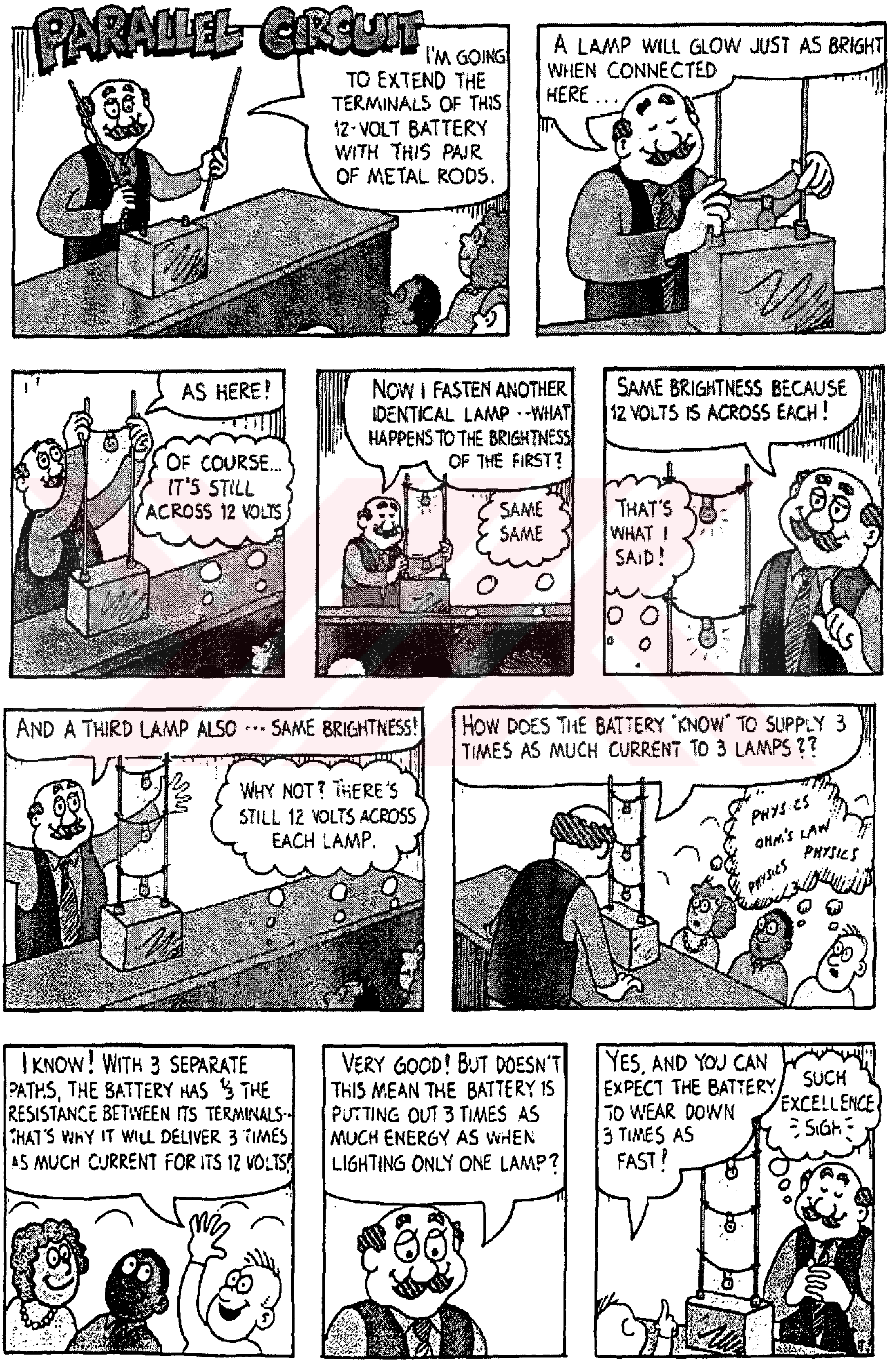
PARALLEL CIRCUIT
I'M GOING TO EXTEND THE TERMINALS OF THIS 12-VOLT BATTERY WITH THIS PAIR OF METAL RODS.
A LAMP WILL GLOW JUST AS BRIGHT WHEN CONNECTED HERE . . .
AS HERE!
OF COURSE... IT'S STILL ACROSS 12 VOLTS
NOW I FASTEN ANOTHER IDENTICAL LAMP --WHAT HAPPENS TO THE BRIGHTNESS OF THE FIRST?
SAME SAME
SAME BRIGHTNESS BECAUSE 12 VOLTS IS ACROSS EACH!
THAT'S WHAT I SAID!
AND A THIRD LAMP ALSO --- SAME BRIGHTNESS!
WHY NOT? THERE'S STILL 12 VOLTS ACROSS EACH LAMP.
HOW DOES THE BATTERY "KNOW" TO SUPPLY 3 TIMES AS MUCH CURRENT TO 3 LAMPS??
PHYSICS
OHM'S LAW
PHYSICS
PHYSICS
I KNOW! WITH 3 SEPARATE PATHS, THE BATTERY HAS 1/3 THE RESISTANCE BETWEEN ITS TERMINALS-- THAT'S WHY IT WILL DELIVER 3 TIMES AS MUCH CURRENT FOR ITS 12 VOLTS!
VERY GOOD! BUT DOESN'T THIS MEAN THE BATTERY IS PUTTING OUT 3 TIMES AS MUCH ENERGY AS WHEN LIGHTING ONLY ONE LAMP?
YES, AND YOU CAN EXPECT THE BATTERY TO WEAR DOWN 3 TIMES AS FAST!
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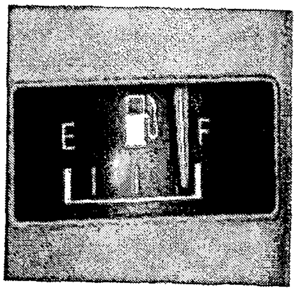
Link to Technology 2: Measuring with current



A fuel gauge in an automobile uses variable resistance to measure the level in gasoline tank. A float in the tank adjusts the resistance of variable electric resistor. Maximum resistance occurs when the float bottoms out in the tank. Maximum resistance produces the minimum current, which barely deflects the pointer on the fuel gauge.

When the tank is full, the variable resistor has its lowest resistance and the maximum current flows through the fuel gauge. For this current, the gauge is calibrated to read a full tank. Between empty and full, corresponding values of current produce appropriate deflections of the fuel gauge pointer.

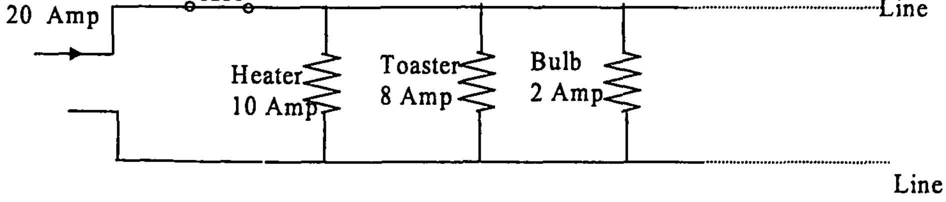
Link to Technology 3: Fuse

What is the function of fuse? Explain it briefly.

Electricity is usually fed into a home by way of two lead wires called lines. These lines are very low in resistance and connected to wall outlets in each room. About 220 volts impressed on these lines by generators. This voltage is applied to appliances and other devices that are connected in parallel by plugs to the lines.

As more devices are connected to the lines, the circuit resistance decreases. Therefore, a greater amount of current occurs in the lines. Lines that carry more than a safe amount of current are said to be overloaded. The resulting heat may be sufficient to melt the insulation and start a fire.

We can see the overloading in the following circuit.



The supply line is connected to an electric heater that draws 10 amperes, to an electric toaster that draws 8 amperes, and to an electric bulb that draws 2 amperes. When only the toaster operating and drawing 8 amperes, the total line current is 8 amperes. When also the heater and bulbs are operating, the total line current increases the 20 amperes. If you operate any more devices, then the total line current will increase.

To prevent overloading in the circuit, fuses are connected in series along the supply line as shown above. In this way the entire line current will must pass through the fuse. If the fuse is rated at 20 amperes, it will pass 20 amperes but no more. A current above 20 amperes will melt the fuse and breaks the circuit. In houses, the automatic fuses rate up to 42 amperes.

APPENDIX F

MISCONCEPTION ACTIVITY TABLE

Misconception-Activity Table

	Activity-1	Activity-2	Activity-3	Activity-4	Activity-5
1. The Sink Model		/		/	
2. Clashing Current Model		/		/	
3. Weakeaning Current Model		/		/	
4. Shared Current Model		/		/	
5. Emprical Rule				/	
6.Power Supply as a Constant Current Source				/	/
7.Local and Sequential Reasoning				/	
8. Short Circuit Misconception			*		
9. Parallel Circuit misconception					/

APPENDIX G

ACETATES

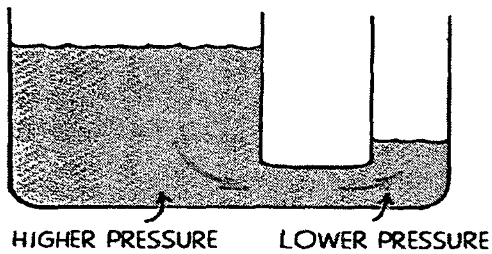


Figure 1 a. Water will flow from the higher – pressure end of the pipe to the lower pressure end. The flow will cease when the pressure ceases.

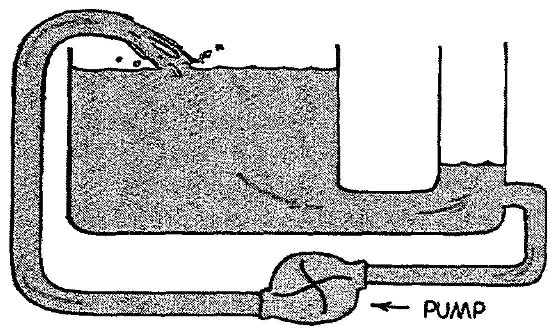


Figure 1 b. Water continues to flow because a difference in reservoir level is maintained with the pump

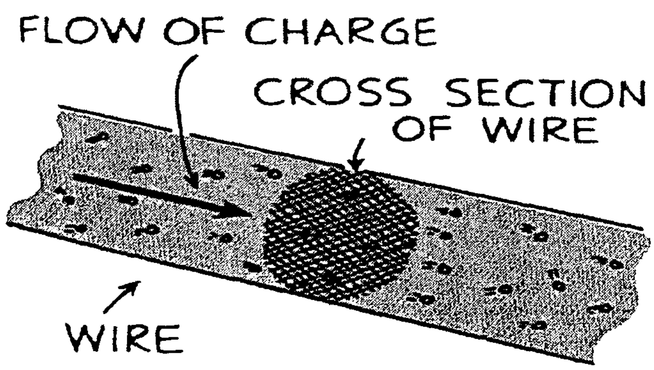


Figure 2. When the rate of flow of charge pass any cross section is 1 coulomb (6.25 billion billion) per second, the current is 1 ampere.

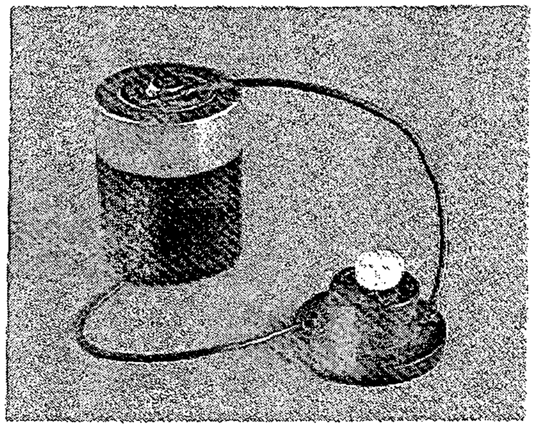


Figure 3. Each coulomb of charge that is made to flow in a circuit that connects the ends of this 1.5-volt battery is energized with 1.5 joules of energy.

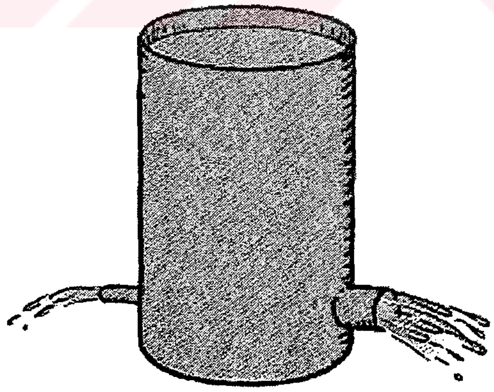


Figure 4. For a given pressure, more water passes through a large pipe than a small one. Similarly for a given a voltage, more electric current passes through a large-diameter wire than a small-diameter one.

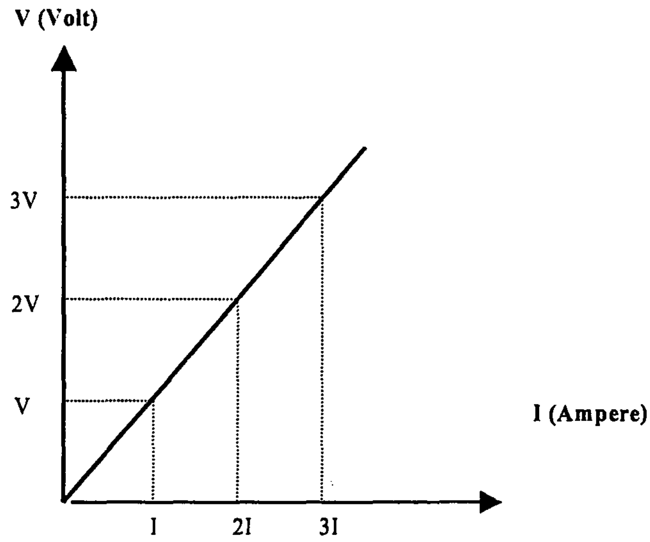


Figure 6. The graph of voltage – current relationship.

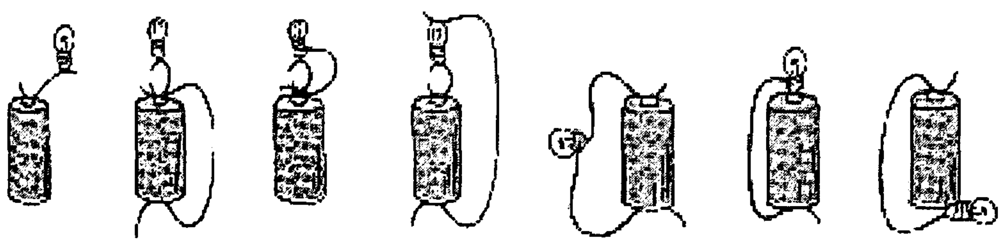


Figure 7. Connections of the bulb and batter

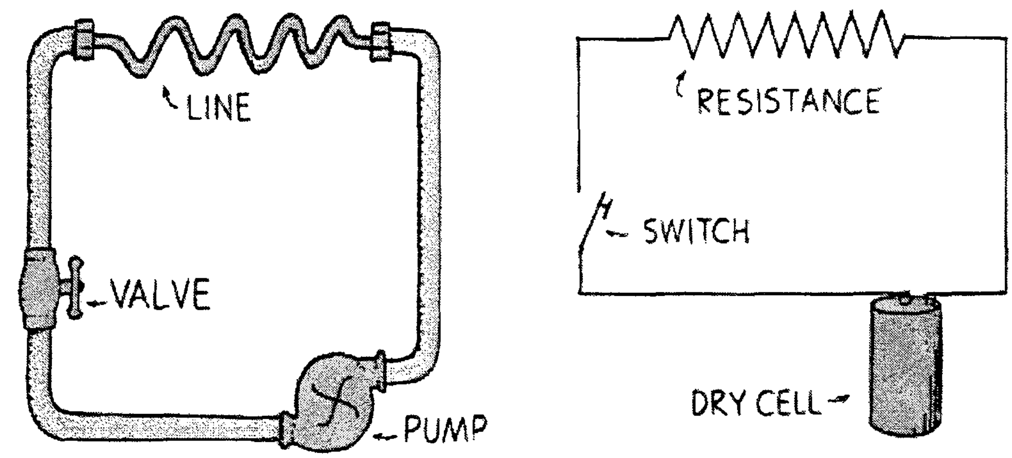


Figure 8. Analogy between simple hydraulic circuit and electric circuit.

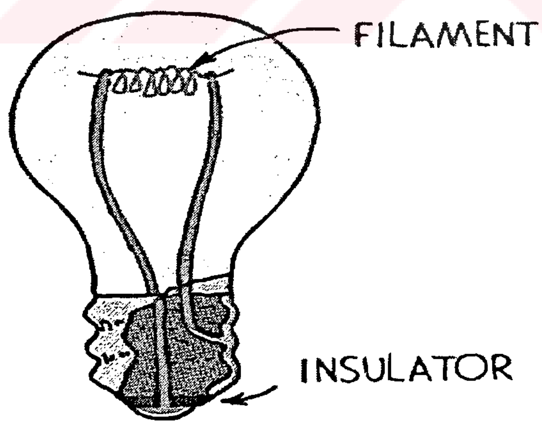


Figure 9. Electrons do not pile up inside a bulb, but instead flow through its filament

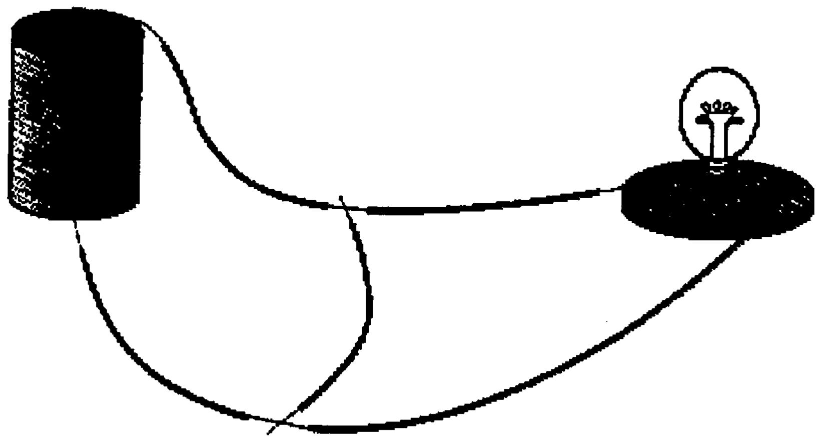


Figure 10. Battery and bulb, short-circuited.

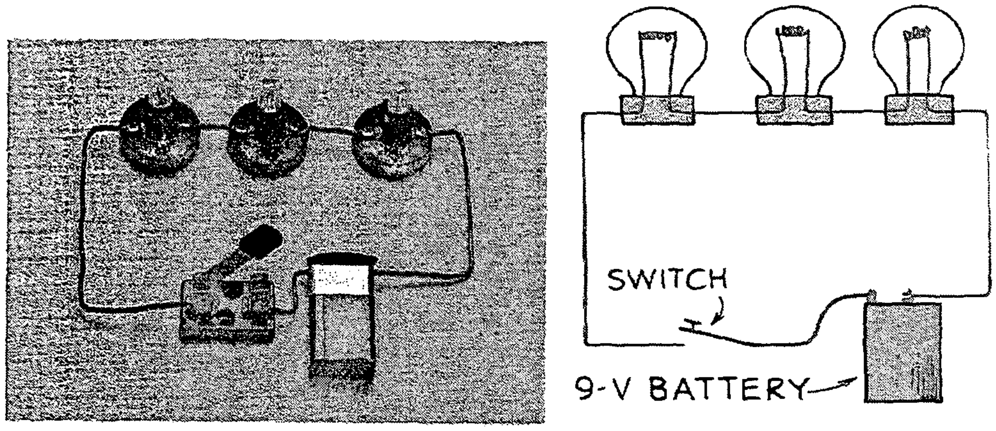


Figure 12. A series circuit.

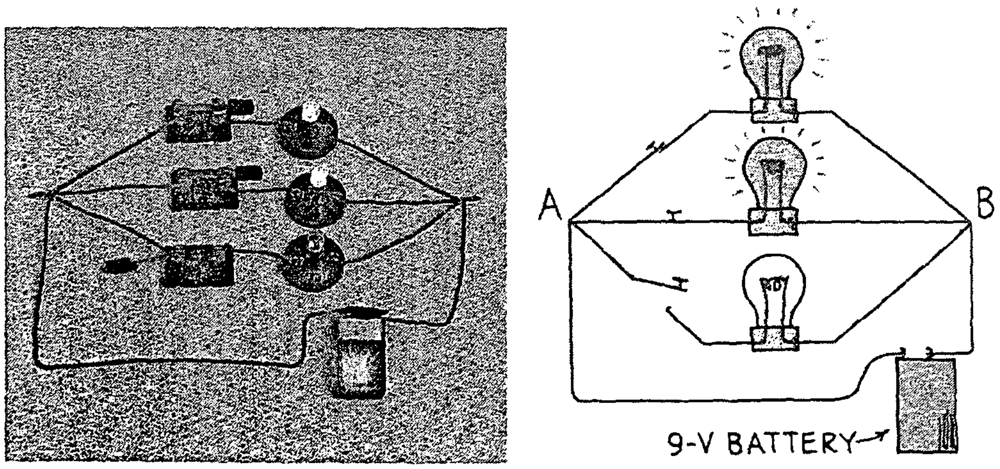
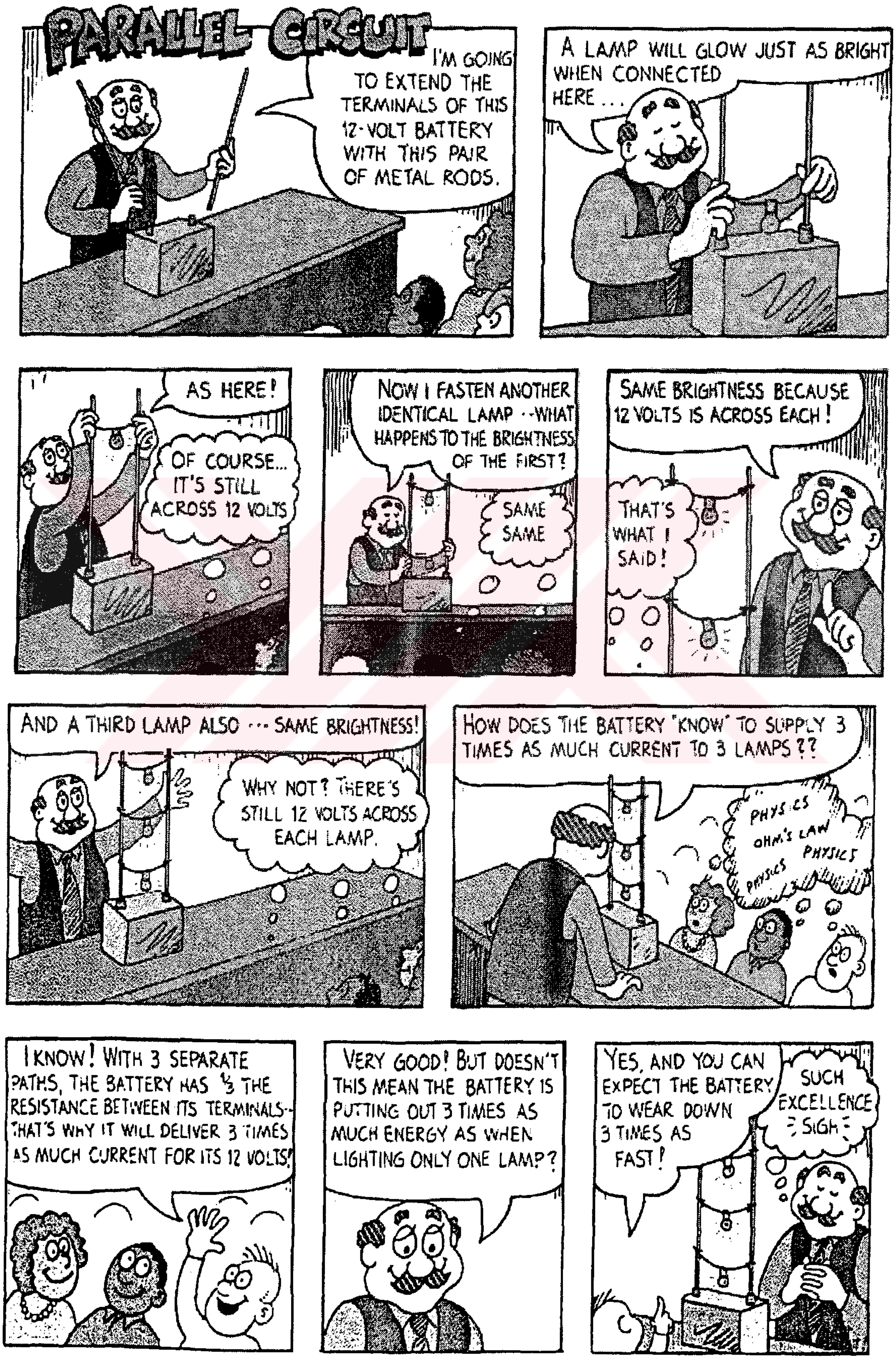


Figure 15. A parallel circuit


PARALLEL CIRCUIT
I'M GOING TO EXTEND THE TERMINALS OF THIS 12-VOLT BATTERY WITH THIS PAIR OF METAL RODS.
A LAMP WILL GLOW JUST AS BRIGHT WHEN CONNECTED HERE ...
AS HERE!
OF COURSE... IT'S STILL ACROSS 12 VOLTS
NOW I FASTEN ANOTHER IDENTICAL LAMP --WHAT HAPPENS TO THE BRIGHTNESS OF THE FIRST?
SAME SAME
SAME BRIGHTNESS BECAUSE 12 VOLTS IS ACROSS EACH!
THAT'S WHAT I SAID!
AND A THIRD LAMP ALSO --- SAME BRIGHTNESS!
WHY NOT? THERE'S STILL 12 VOLTS ACROSS EACH LAMP.
HOW DOES THE BATTERY "KNOW" TO SUPPLY 3 TIMES AS MUCH CURRENT TO 3 LAMPS??
PHYSICS
OHM'S LAW
PHYSICS
PHYSICS
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YES, AND YOU CAN EXPECT THE BATTERY TO WEAR DOWN 3 TIMES AS FAST!
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APPENDIX H

METHODOLOGY

ELECTRIC CURRENT

(Note: This material is prepared for teacher to achieve the objectives of the lesson)

A- Electric Current.

For objective 1 and 2;

- Mention about the flow of heat over a conductor; state that heat flows through a conductor when a difference in temperature exist across its ends. Heat flows from the end of higher temperature to the end of lower temperature. When both ends reach the same temperature, the flow of heat stops.
- Tell that there ere similarities between the flow of heat and the flow of charge over conductor. Similarly, when the ends of an electric conductor are at different electric potentials, charge flows from one end to another end. Charge flows when there is a *potential difference* or *difference in potential (voltage)*, across the ends of a conductor. The flow of charge will continue until both ends reach a common potential.

For objective 3, use figure-1. State that;

- Higher reservoir is like higher potential and lower reservoir is like smaller potential.
- Flow of water is like flow of charge.
- Water pump is like electric pump (or battery).

For objective 4-5;

- Write definition of current and unit of ampere.

- State that electric current has important role in human life and technology. For instance electrolysis is achieved with the help of electric current.

For objective 6, use fig-2;

- Stress the meaning of 1 coulomb of charge.
- Stress the meaning of 1 ampere.

For objective 7;

- Write definition of voltage source.
- Show a simple dry-cell battery.
- Mention about the usage of dry cells in our daily life and kinds of batteries.

For objective 8;

- State that, For a continues flow of charge an electric pressure is needed. This requirement is supplied by batteries or dry cells.
- State that, a voltage source can be produced by using two charged conducting metal sphere.
- Discuss whether charged conducting metal spheres are good voltage sources or not?

For objective 9;

- Write that batteries pump electric charges to the circuit.

For objective 10-11;

- Write definition of voltage.
- Show the figure 3.
- Extend the meaning of voltage by giving examples from daily-life.
- Extend the meaning of 1.5 volt batter.

For objective 12, use figure 1-a, b. State that;

- Water flows from higher reservoir to lower reservoir, because of pressure difference; only the water *flows*, not the pressure. Similarly, in a circuit, charges flow through it because of voltage difference. The flowing thing is the charge not the voltage.

For objective 13;

- Write definition of electric resistance and give the unit.

For objective 14, use figure 4 and present that;

- Flow of water inside the pipe is like flow of charge inside wire. The same water level above on two pipes is like same potential difference between the ends of two wires. But the rate of flow of water is like the rate of flow of charge and they are different for both pipes
- There are some factors influencing the resistance of the wire. These factors are; length, cross sectional area, conductivity of material.

For objective 15;

  - Follow the instruction given in activity-1 carefully.
  - Tell the students, outside the game, to observe their friends carefully.
- Write the formula concerning resistance of conducting wire and interpret on it.

For objective 16-17;

- Give some examples of the resistance of some real life apparatus such as bulb, electric toaster... These values are present in the lesson plans of students.

- Define resistor. State that resistor are important for the electronics devices such as in televisions radios,.. For instance in manual radios the volume control is achieved by resistors. As the button rotated, the magnitude of resistance changes. This leads to the change of volume.

For objective 18-19-20;

- Define ohm's law.
- Explain ohm's law by using figure 6.
- Solve the question 1and 2. State that these are real life examples.

For objective 21;

- Discuss whether electric potential or the electric current is dangerous for human life.
- After discussion, conclude that the electric current flowing through the body is dangerous. But state that without electric potential difference no electric current occurs.

For objective 22;

- State that human body has a variable resistance and the resistance of it depends on the condition of body.

For objective 23;

- Discuss how much current is dangerous for the human life.
- After discussion tell students to follow the table-1.

For objective 24-25;

- Give homework 1 of Question 1 and 2, Think and Explain 1 parts as home projects and discuss the results at the beginning of next lesson for a few minutes. State that physics has important relation ship technology and their usage.

B- Electric Circuits.

For the objective 26;

- Write the definition of circuit.
- Show the figure 3 as an example of circuit.
- State that there are lots of electric circuits that we use them, in houses, in computers...

For the objective 27;

- State that there must be a complete path for electrons for the flow of electrons in any circuit.

For the objective 28, use figure 7;

- Tell students to follow step 1 and 2 of the activity, by trying themselves.
- After all students finished their study, let them to explain their answers. Than discuss why some of the bulbs did not emit light in some situations.
- Sum up that there must be a complete path for electrons to flow through a circuit.

For the objective 29;

- Use fig-8 and have students remember flow of water and flow of charge. State the similarities between water circuit and electric circuit. Moreover, battery is like a pump, wires are like pipes, flow of charge is like flow of water, bulb is like any device operating when the water is flowing and valve is like switch.

- State "When a valve in the line is opened and the pipe is operating, water already in the pipes start to flow. Similarly, when a switch is turned on, (closed path is formed) the mobile conduction electrons already in the wires and the filaments begin to drift through the circuit. The water flows through the pump and electrons flow through the battery. Neither the water nor the electrons "squash up" and concentrate in certain places; they flow continuously around a circuit".

This paragraph is very important. Because, they will help students to eliminate the misconceptions of;

-Weakening current model
-Clashing current model
-Shared current model.

For the objective 30, use figure 9 and;

- Present that "Electrons flow from the negative terminal of the battery through the wire to the side of the bulb, through the filament inside the bulb, and out the bottom and through the other piece of wire to the positive part of the battery".
- Mention about the relationship of physics and technology. For instance bulb is very useful technological device. It eases our life in a very important degree.

For objective 31, use figure8;

- State the limitations of analogy as written it the lesson plan.

For objective 32, use figure 10;

- Define and explain the meaning of short circuit.

For objective 33; (**Caution!** This activity should be performed by teacher only)

- Construct the figure shown in figure 10.
- Discuss students why the bulb light off.
- Give the "Think and explain 2" part as homework to the students and discuss the results at the beginning of the lesson for few minutes. After taking the answers of students, sum up as; "When you connect the ends of the battery by a wire you form a short circuit. The resistance of the wire is very small compared to the other devices. According to ohm's law, when the resistance is very small, the current will be great. So the wire becomes hotter".

- Assign the Home project 1 as homework; tell them to find out the answer for the next lecture. At the beginning of the next lecture discuss the results. Then sum up as; " In a typical dc circuit of, in the electric system of an automobile for example, the electrons have net average speed of 0.01 cm/s. At this rate, it would take about three hours for an electron to travel one meter of wire. In circuit the energy is transmitted through the conductors at nearly the speed of light. It is not the speed of electron that moves at this speed. Because electrons move in any direction and make collisions with other electrons".

For objective 34;

- Draw the figure 11 to state the schematic diagrams of the circuit elements.

C – Series circuits.

For objective 35;

- Speak about the Christmas tree lights.
- Write the definition of series connection.
- Draw figure 12 and state that "These bulbs are connected in series to each other".
- Tell students to follow the step 1 of activity 4. After all of them completed step 1, present that "you have connected bulbs in series form successfully".

For objective 36;

- Tell students to follow the step 2 and answer the question 1.
- Take the answer of the question-1 discuss the results with students.
- Sum up as; "When the switch is closed, a current exists almost immediately in all three lamps. The current does not "pile up" in any lamp but flows *through* each lamp. Electrons in all part of the circuit begin to move at once. Some electrons move away from the negative terminal of the battery, some move toward the positive terminal of the battery and some move through the filament of each lamp. Eventually the electrons move all the way around the circuit".
- Tell students to follow step 3 and answer the question 2 and 3.
- After taking their answers, present that " A break anywhere in the path results in open circuit and the flow of electrons ceases, if one of the bulb filaments burns out, the path connecting the terminals of the battery will break and current cease. All bulbs will light off".
- Ask students why a Christmas tree light off when one of the bulb is burn out.
- State that there is relationship between physics and technology. Assign homework to the students about the fuse, mainly connection

of it to the other appliances in our houses. At the next lesson discuss it briefly for a few minutes.

For objective 37;

- Write "If the bulbs are identical, the light intensity of the bulbs is directly proportional with the amount of current passing over the bulb".
- Perform a simple demonstration related to ohms law, as the voltage over a bulb increased the amount of current flowing through circuit increase so the brightness of bulb increases.

For objective 38;

- Tell students to follow the step 4 and answer the question 4 and 5.
- After discussing the answers of students, sum up that " in series circuits same amount of currents pass over each circuit elements".

For objective 39;

- State "Ohm's law also applies separately across each device. If the bulbs are identical their resistance will be equal. If same amount of current pass over each bulb the voltage drop or potential difference across each bulb is same. Voltage drop or potential difference across each individual device depends directly on its resistance. This follows from the fact that more energy is used to move each unit of charge through a large resistance than through a small resistance".

For objective 40;

- Tell students to follow the step 5 and answer the question 6.
- Take the answers of students and their discussions.

- After all, conclude that; "The light intensity of each bulb decreased. It means that the current flowing over each bulb decreased by same amount. Any change in the circuit affect the overall circuit".

For objective 41;

- Write the definition of equivalent resistance as "equivalent resistance is the value of the single resistor that would comprise the same load to the battery" and explain the meaning of equivalent resistance.
- Draw figure 13, 14 to explain the equivalent resistance by using these figures.
- Write the formula of equivalence formula for series connected two resistors.

For objective 42;

- State "The addition of more lamps in series circuit results in a greater circuit resistance. The equivalent resistance of the series circuit is found by simple adding the resistance of each device. Because the current is resisted by the resistance of the first device, the resistance of the second, and the third also, so that the total resistance to current in the circuit is the sum of the individual resistances along the circuit path".
- Write formula of;

$$R_{equivalent} = R_1 + R_2 + R_3 + R_4 \ldots\ldots$$

- State "The current in the circuit is numerically equal to the voltage supplied by the source divided by the total resistance of the circuit.

$$I = \frac{V}{R_{equivalent}}$$

According to ohm's law as the resistance increase, the circuit current decreases and therefore less current flow over each lamp. This will result the dimming of the lamps".

For the objective 43;

- State that "The same amount of current flows over each circuit element in series circuit. According to ohm's law the potential difference across each element is equal the multiplication of current and the resistance of each device. V=I*R, the circuit element with greater resistance has greater voltage drop".

For the objective 44;

- State that "The total voltage impressed across a series circuit divides among the individual electrical devices so that the sum of the voltage drops across each device is equal to the total voltage supplied by the source. If there is more than one device in the circuit, the potential of the battery is divides among each device.

  $V=V_1+V_2+V_3+\ldots$

  This follows from the fact that the amount of energy used to move each unit of charge through the entire circuit equals the sum of the energies used to move that unit of charge through each of the electrical devices in the circuit.

For objective 45;

- Solve the questions part of 1, 2, 3 and 4.

!!! For the objective 2 and general of the series circuit part, give the "Think and Explain 3". At the beginning of the next lesson discuss the answers of the students for a few minutes.

D- Parallel Circuits.

For objective 46;

- State that "Parallel circuit is like a road with alternate routes. If there is a roadblock or cave in, the traffic along alternate routes keeps moving. The greater the number of routes, the less resistance to traffic going from one place to another that is by these routes"
- Use figure 15 and state that "Figure 15. shows three lamps connected to the same two points A and B. This is an example of a simple parallel *circuit* ".
- Tell students to follow step 1. After they completed it, state that you have connected three bulbs in parallel form to each other.

For objective 47-48;

- Tell students to follow step 2 and answer the question 1. After taking their answers state that "All the bulb light on. Because there are three separate pathways for current, one through each lamp".
- Tell students to follow the step 3 and discuss the results with their friends than answer the question 2.
- Use figure 15 and state "Current taken from battery divides on each parallel branches at point A and then they collected at point B as in figure 15".
- Tell students that, in many electronics devices, electronics parts such as resistors, capacitors or any other parts are connected parallel to each other. Assign students home project as " What is the type of connection of your home appliances in your houses? Why? "

For the objective 49:

- Tell students to answer the question 3. Then follow step 4, 5 and answer the question 4, 5 respectively. Wait until students complete their study and take their answers. Discuss them to compare their results.

For the objective 50:

- Tell students to answer the question 6 and discuss them their results.
- After taking the answers of students than start to explain the answer of question 6.
- State, "If one lamp is removed or added to the parallel circuit, the other lamps are unaffected. Each device connects the same two points A and B of the circuit. The voltage is therefore the same across each bulb".

For the objective 51;

- Teacher should follow step 4 and step 5 quickly, in front of students again.

For the objective 52;

- Any change in the circuit affects the overall circuit.
- State that "The current in each parallel branch, according to ohm's law, is equal to (voltage/resistance), and since neither voltage nor resistance is affected in the individual branches, the current in those branches is unaffected. If one bulb burns out, the total current in the overall circuit (the current through the battery), however, is decreased by an amount equal to the current drawn by the lamp before it burned out, but the current in any other single branch is unchanged".
- State that "The light intensity for each lamp is unchanged as the other lamps are added or removed. Only the total resistance, and the total current in the total circuit changes, which is to say, the current in the battery changes".

- State, "As lamps are added in parallel, the total circuit resistance decrease. Equivalent resistance of the parallel connected circuit is calculated by;

$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots..$$

- Use figure 16 and 17 while explaining the equivalent resistance of parallel connected two resistors.
- Take the students' attention to the formula and state that as the number of parallel-connected resistor increase the equivalent resistance decreases. Moreover the equivalent resistance is smaller than the smallest resistance.

For objective 53;

- State that "As the number of parallel branches increased, the equivalent resistance of the circuit is decreased. Equivalent resistance is lowered with each added path between any two points of the circuit. This means that the equivalent resistance of the circuit is less than the resistance of any one of the branches. This decreased resistance is accompanied by an increased current, the same increase that feeds energy to the lamps as they are added. Although changes of resistance and current occur for the circuit as a whole, no changes occur on individual branch in the circuit".
- For this objective give home project "Why do we use fuse in our houses?
- Then tell students to read the Link to technology 3.

For objective 54;

- Solve the questions 1,2, 3 and 4.

E- Compound Circuits

For objective 55;

- Define the compound circuit as "Circuit having several resistors parallel and series to each other is called as compound circuit".

For objective 56;

- Draw figure 18 and state that "Figure 18 shows a combination of three 8-ohm resistors. Two 8-ohm resistors are in parallel combination. These parallel-connected resistors are in series to the other 8-ohm resistor. As you see, there is parallel and series connection. This kind of circuits are compound circuits".

For objective 57;

- Draw figure 19 and state, "The two resistors (with a resistance of 8-ohm) in parallel are equivalent to a single 4-ohm resistor which is in series with an 8-ohm resistor".
- State "The new shape of the circuit is like figure 19".
- Draw figure 20 and state that "Two resistors $R_{eq1=}$ 4-ohm and 8-ohm adds to produce an equivalent resistance of 12 ohm as in fig 20".
- State, "If a 12-volt battery were connected to these resistors, can you see from ohm's law that the current through the battery would be 1 ampere. (In practice it would be less, because there is resistance inside the battery. This resistance of battery is called battery' internal resistance".

For objective 58;

- Solve the example.

APPENDIX I

RAW DATA

Students	Age	Gender	PPCG	PGPA	PSTATT	PSTACH	Teacher	Group	PREACH	PREATT
1	15	2	82	86	71	19	1	2	7	61
2	16	2	51	69	106	21	1	2	10	105
3	16	1	42	53	96	15	1	2	11	99
4	15	2	38	65	58	8	1	2	8	55
5	16	1	58	58	99	19	1	2	11	101
6	16	2	34	55	72	13	1	2	7	68
7	15	1	57	72	85	16	1	2	12	79
8	15	2	45	55	76	16	1	2	8	63
9	15	2	26	50	71	10	1	2	7	76
10	15	2	34	71	54	16	1	2	11	60
11	14	2	36	64	81	14	1	2	7	75
12	16	1	24	37	106	15	1	2	12	83
13	15	1	35	58	82	20	1	2	10	101
14	14	1	52	57	106	13	1	2	9	91
15	16	2	52	69	112	22	1	2	11	75
16	14	2	91	89	106	23	1	2	8	66
17	15	1	66	76	70	22	1	2	14	75
18	15	2	40	55	58	11	1	2	5	43
19	16	2	56	60	66	8	2	2	4	63
20	17	1	40	54	95	10	2	2	14	100
21	16	2	22	61	75	10	2	2	3	56
22	14	2	70	76	68	13	2	2	9	60
23	15	2	60	61	66	11	2	2	11	63
24	15	1	82	62	107	15	2	2	10	75
25	15	1	51	50	81	14	2	2	12	75
26	14	2	88	79	106	15	2	2	7	81
27	15	1	83	66	96	19	2	2	15	98
28	16	1	45	56	70	7	2	2	9	86
29	18	1	47	43	60	13	2	2	9	69
30	15	2	67	70	91	16	2	2	11	93
31	15	1	44	59	83	17	2	2	10	68
32	14	2	50	54	98	10	2	2	9	91
33	16	2	82	76	110	23	2	2	19	109
34	15	2	85	86	82	17	2	2	9	74
35	15	2	32	56	67	14	2	2	9	58
36	17	1	47	48	89	12	2	2	7	84
37	16	2	29	52	75	12	2	2	5	67
38	16	1	59	55	81	10	1	1	11	100
39	15	2	89	80	74	13	1	1	10	69
40	16	1	18	48	60	13	1	1	7	79
41	17	1	55	68	73	9	1	1	6	81
42	16	2	38	67	42	10	1	1	12	42
43	15	1	85	82	91	12	1	1	10	88
44	15	2	93	86	90	18	1	1	13	83
45	15	1	56	60	37	9	1	1	14	54
46	15	2	45	65	70	9	1	1	12	56
47	15	1	61	64	64	15	1	1	11	85
48	16	1	48	58	66	14	1	1	10	71
49	15	2	62	80	78	16	1	1	9	72

50	15	2	60	66	67	11	1	1	10	75
51	15	2	65	72	66	18	1	1	12	52
52	15	2	61	76	73	10	1	1	14	76
53	15	1	31	39	79	9	1	1	10	90
54	15	1	51	51	73	11	1	1	9	74
55	15	1	65	71	92	14	1	1	12	80
56	15	1	68	62	65	13	1	1	11	73
57	16	2	54	56	69	10	2	1	10	80
58	16	1	46	59	49	9	2	1	6	75
59	15	2	47	51	79	10	2	1	7	97
60	17	1	67	58	65	10	2	1	14	83
61	15	1	76	53	50	8	2	1	11	69
62	15	2	74	74	55	13	2	1	7	75
63	15	2	33	53	68	9	2	1	10	54
64	16	1	46	47	72	9	2	1	10	105
65	16	2	16	32	44	8	2	1	10	51
66	16	2	40	48	60	9	2	1	11	75
67	16	1	60	72	91	12	2	1	14	92
68	16	2	50	51	40	6	2	1	9	64
69	15	2	73	75	55	13	2	1	12	75
70	16	1	35	31	68	7	2	1	8	39
71	15	2	55	51	76	13	2	1	3	52
72	16	1	60	48	84	8	2	1	9	81
73	16	1	80	76	92	16	2	1	9	75