UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF ELECTRICAL ENGINEERING LEARNING KIT FOR STEM APPLICATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

by

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DECLARATION

I hereby, declared this report entitled DEVELOPMENT OF ELECTRICAL ENGINEERING LEARNING KIT FOR STEM APPLICATION is the results of my own research except as cited in references.

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Date: 17 JANUARI 2021

APPROVAL

This report is submitted to the Faculty of Electrical and Electronic Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honors. The member of the supervisory committee is as follow:

Signature : .....

Supervisor : IR. DR. MOHD FARRIZ BIN HJ MD BASAR

ABSTRACT

Throughout the year, the implementation of the traditional approach (lecture-based) in the teaching and learning process seems to be less effective in increasing the interest among students towards the STEM subjects. Conversely, the use of practical learning method emphasizes on the psychomotor domain so that readers gain a clearer and more effective understanding. Thus, the aim of this project is to develop ten mini projects that related to basic science and electrical engineering, to conduct experiments on ten mini electrical projects and to investigate the performance of each project based on the output results. These projects are developed using low-cost apparatus, a short period of time and easy-to-construct experiment. After that, all projects are discussed in detail form the short description, apparatus used, simple-to-follow procedures with real coloured images, the technical behind, the further investigation which improves the validity in the experiment and the summary of the project. From the findings result, the most influential parameters for each project are predicted to obtain a good performance of the projects. In conclusion, the impact of the implementation from this unique approach, students will increase their understanding towards the fundamental of science and electrical engineering using this learning kit.

ABSTRAK

Sepanjang tahun, pendekatan tradisional (berasaskan ceramah) terhadap proses pengajaran dan pembelajaran dilihat semakin kurang berkesan dalam meningkatkan minat pelajar terhadap mata pelajaran STEM. Sebaliknya, penggunaan kaedah pembelajaran praktikal menekankan pada domain psikomotor yang memberi pembaca pemahaman yang lebih jelas dan berkesan. Oleh itu, tujuan projek ini adalah untuk menbina sepuluh projek mini yang berkaitan dengan sains asas dan kejuruteraan elektrik, untuk menjalankan eksperimen pada sepuluh projek mini elektrik dan untuk menyiasat prestasi setiap projek berdasarkan output eksperimen. Projek-projek dibangunkan dengan menggunakan alat yang berkos rendah, dibuat dalam jangka masa yang pendek, dan eksperimen yang mudah dibina. Selepas itu, semua projek dibincangkan secara terperinci dalam bentuk penerangan ringkas, alat yang digunakan, prosedur yang mudah diikuti dengan gambar kehidupan sebenar, teknik di belakangnya, penyelidikan lebih lanjut yang meningkatkan kesahan eksperimen dan ringkasan projek. Melalui hasil kajian, parameter yang paling berpengaruh untuk setiap projek dapat diramalkan untuk mencapai prestasi projek yang baik. Kesimpulannya, hasil daripada menerapkan pendekatan unik ini, pelajar dapat meningkatkan pemahaman mereka mengenai asas sains dan kejuruteraan elektrik menggunakan kit pembelajaran ini.

DEDICATION

This thesis is dedicated to my beloved parents, my family members, my supervisor, and my fellow friends who always support me through thick and thin throughout the process completing this report.

ACKNOWLEDGEMENT

In the name Allah, the Most Merciful and the Most Gracious. Alhamdulillah and thanks to Allah for giving me this opportunity to complete this project report. I would like to thanks to all my family members for always gives the continuous support and encouragement. On top of that, I would love to express my appreciation to my dedicated project supervisor, Ir Dr Farriz bin Hj Md Basar for his patience and guidance throughout my Bachelor Degree Project (BDP) journey. May Allah bless him and repay his kindness.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presented the background of the project to get an overview of the project title. Then, the objective, scope of work, problem statement and the significant of the project also included in this chapter.

1.2 Background of Project

Learning kit is very crucial in the process of teaching and learning. It can assist the process of sharing knowledge among the students with respect to the subject taught. The use of learning kit increases the student's interest in learning the STEM subjects and assist them to learn electrical engineering through a misleading experience at the same time. The main purpose of learning kit development is to help student understand the subjects more easily and systemically (Che Ghani C. K., 2019).

The process of teaching and learning in Electrical Engineering topics consists of two parts which are theoretical and practical. In order to master the subject, students are encouraged to have strong basic knowledge about the related subjects. By doing that, students will be able to face more high-level studies in the electrical engineering field. However, the level of difficulties in the subjects sometimes makes them study only to pass the exam without truly understand the content in the studies.

In addition, knowledgeable students somehow rely on the effectiveness of how teachers use the appropriate learning kits towards their teaching process. Apart from that, the way of how the subject is delivered also affects the students. The failure of delivering the subject causes the students to assume the subject to be difficult to understand.

The project includes five topics covering the electricity, electrical applications, magnet, electrical motor and energy. The purposes of the topics are explained in Table 1.1.

Table 1.1: Purposes of the topics in Electrical Engineering Learning Kit.

Topic	*Purposes*
 **Topic 1:** Electricity	Provide the basic concept of electricity involving electron and charge, voltage and current, electrical conductor, electrical circuit, switching and battery.
 **Topic 2:** Electricity Application	Apply the applied physics concepts such as Newton's First Law of motion and Newton's Third Law of motion.
 **Topic 3:** Magnet	Investigate the effects of magnet's polarity and apply the electromagnet and magnetic field concept.
 **Topic 4:** Electric Motor	Explain the basic motor construction and the principle of motor and generator which is important in applying the concept of Fleming's Left-Hand rule.
 **Topic 5:** Energy	Focuses on generating the electricity via renewable energy system with further understanding of the system through the study of the energy conversion that occurs in the system.

Normally teachers used the teaching aids for easier teaching and learning in the classroom. Following this matter, the electrical engineering learning kit is developed as it is capable to affect the process of teaching and learning (Alias 2013). Alias (2013) also stated that the students are most likely to play and not pay attention when the teaching process is delivered by a teacher that is not from the electrical field.

Up to this day, it is quite difficult to find a teaching and learning apparatus for electrical engineering subjects and suitable for students in school. In this project, there are ten compilations of mini experiments complete with the theoretical explanations with the aid of diagrams for each experiment that is suitable for beginners in electrical engineering.

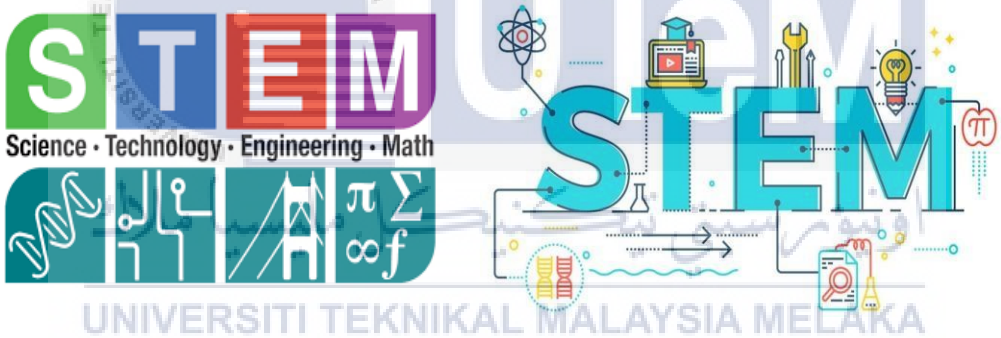


Figure 1.1: STEM's logo by Bebarrel (Ref.: https://cutt.ly/kuVtulq)

The implement of STEM subjects in this project is one of the main parts of the development of this project. STEM is a curriculum based on the idea of educating students in four specifics disciplines – science, technology, engineering, and mathematics – in an interdisciplinary and applied approach. The STEM integrates the four disciplines into a cohesive learning paradigm based on real-world applications rather than teaching them as separate and discrete subjects. This learning kits is able to provide the STEM understanding especially students in primary school. Figure 1.1 below shows the STEM's logo.

The aim of this study is to develop the electrical engineering learning kit that is suitable for students from primary to secondary school. In fact, students and lectures in higher education can implement the learning kit through the learning and teaching process whether for formal or informal learning. Apart from that, the parametric analysis is included in order to determine and evaluate the performance of different parameters towards the project's outcomes.

1.3 Problem Statement

STEM originally called Science, Mathematics, Engineering, and Technology (SMET) (David W. White, 2014) introduced by the National Science Foundation (NSF). This mainly created to provide all the students with high critical thinking skills which helps them to become creative problem solvers and gain good opportunities in the workforce. Figure 1.2 shows the shift of enrollment among students in school in 2015 to 2016.

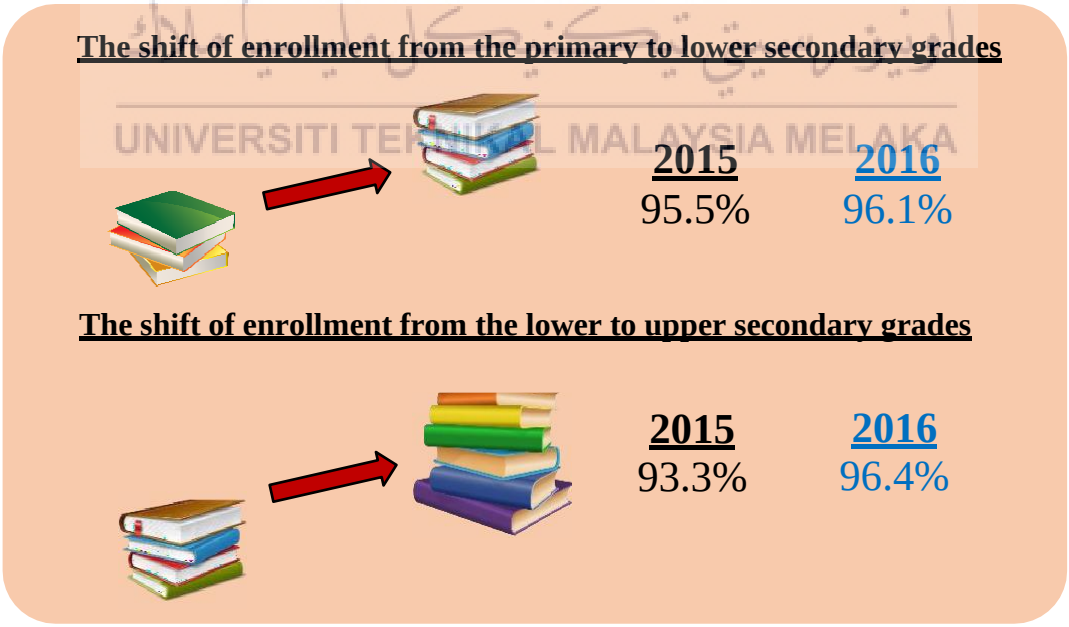


Figure 1.2: Shift of Enrollment in 2015 and 2016 (Ministry of Education, 2016)

A recent report from the Ministry of Education shows that students nowadays are less interested in STEM subjects. The ineffective teaching methods are one of the factors that leads to this situation. As a result, students most likely being misunderstood the content of the subject and drawing them away from choosing STEM as for their choice of study.

Referring to Figure 1.2 (Ministry of Education, 2016), the percentage of students pursuing their studies from primary to secondary school is increasing from year to year. Therefore, the big number of students that are not interested in STEM gives gigantic anxiety and causes a detrimental effect on the formation of youth capable of competing and leading science and technology Malaysia. In addition, there is a lack of learning medium that can assist students to learn the basics of science and engineering effectively.

According to N. Asyikin (2018), Malaysia has been predicted to be short of 236,000 engineers and technical personnel through the estimating steady declining rate of engineering students. Despite various efforts that have been done, it is still unconfirmed whether it helps to increase the interest in engineering.

To date, the scenario of engineering education in Malaysia is still not fully aware the implementation impact of the practical learning in teaching and learning process. In fact, some of the teachers still apply the traditional approach even in critical topics that are more appropriate by conducting an experiment in order to understand the theoretical concepts. Therefore, most of the students will not have a solid understanding regarding the subjects. As for this matter, an urgent solution is needed because the technology development demanding the new engineering model that include the fundamental of science and engineering, technical skill, professional practice, and soft skills to face challenges in the future (N. M. Nor, 2010).

According to above statement, it has influenced the main objective of this research; to develop ten mini experiments based on the basic science and electrical engineering. All these ten mini experiments are mostly used low cost and easy to find apparatus. Through this learning kit, readers will be more excited to practice the projects with the aid of the diagram and the attached video that can be accessed any time through QR code.

1.4 Objective

This study embarks on the following objectives:

- To develop ten mini projects related to basic science and electrical engineering.
- To conduct experiments on ten mini electrical projects.
- To investigate the performance of ten mini electrical projects based on the experimental results.

1.5 Scope of Project

The scope of this project is limited to the following items so that the project could be focused to achieve the stated objective. The scope of this project is listed below;

- The project focusing on five group of projects including electricity, electrical applications, magnet, electrical motor, and energy.
- The project development limited to ten mini electrical experiments with low cost and a short period of time.
- Conduct parametric analysis results based on the experimental result output of each experiment.

1.6 Project Significance

The development of this electrical engineering learning kit will potentially benefit to the society considering that it able to enhances the positive attitudes among the students in the teaching and learning process especially in STEM education. Besides that, this learning kit can be used as a reference for individuals who want to strengthen their understanding through the basic concepts in electrical engineering field.

Apart from that, the actual target of this learning kit is students from primary and secondary grades. However, it can be useful for lecturers and technicians who involved in the electrical engineering field as well as students in the higher education institutions as it includes the basic concepts in electrical engineering which are compulsory subjects in Year 1 and 2. Figure 1.3 shows the total number of students in government schools by the education level.

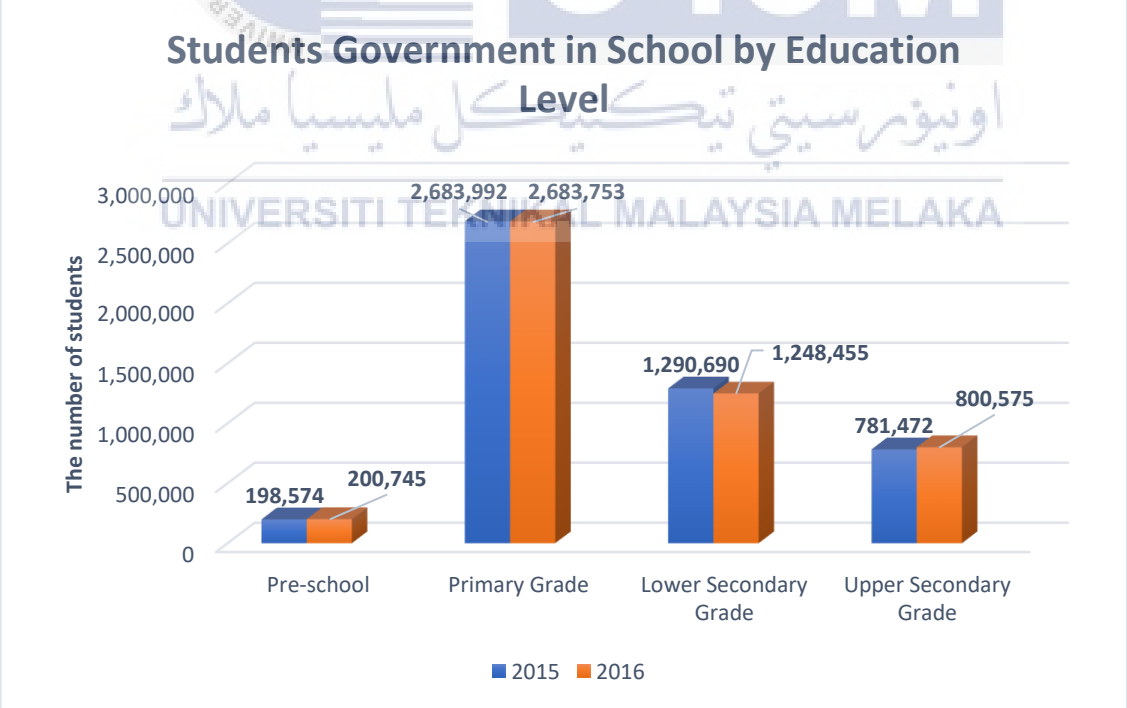


Figure 1.3: Students in Government Schools by Education Level

(Ministry Education of Malaysia, 2016)

According to Figure 1.3 statistics from the Ministry of Education in Malaysia as shown in Figure 1.3 (Ministry of Education, 2016), there were 2,683,753 primary school students and 2,049,030 secondary school students in 2016. This statistic reflects the fact that this product has a very extensive buyer and market target.

From the business perspective, the key target market for this learning kits is for secondary and primary school students not only in Malaysia, but all over the world as it represents a larger population of students in general.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The Electrical Engineering Learning Kit for STEM Application consists of ten noncomplex electrical projects that able to convey the fundamental of sciences and electrical engineering. The purpose of study is to develop the suitable and effective approach towards the process of teaching and learning for both teachers and students.

In this chapter, the summary of studies related to this project is discussed. The studies included the topics in sciences and electrical engineering that is compulsory for students in schools and universities. Apart from that, the implication of practical learning in the teaching and learning process will be compared to the traditional (lecture-based) to observe the effectiveness towards the education system. Next, the STEM application also will be discussed along with the subject related and the critical topics in Electrical Engineering that affects the interests among the students towards the subject. Then, the influence of the coloured image in the textbook, the QR code features and the use of video learning in teaching process will be elaborated to enhance the quality of the learning and teaching process.

In conclusions, this chapter elaborated the effects that influenced the process of development this learning kit and provided the ideas to build a quality learning kit for students who involved in STEM in general and electrical engineering student in particular.

2.2 STEM Application

David W. White (2014) mentioned that STEM was primarily used in engineering firms in order to generate revolutionary technologies such as light bulbs, machines and automobiles. Nowadays, many countries heading towards innovation as they make a lot of improvements in their school system by emphasizing the teaching of Science, Technology, Engineering and Mathematics more vital (S. Makhmasi, 2012).

E. Sujarwanto et. al (2019) mentioned that the purpose of STEM is to prepare students with the development of science and technology, be ready for the career life and able to solve problems. E. Sujarwanto et. al. (2019) also added that in the application of STEM should integrate at least two disciplines. For example; i. The application of Science-Technology, ii. The application of Science-Engineering, and iii. The application of Science-Mathematics. The examples of STEM applications performed are given in Table 2.1;

Table 2.1: STEM Application

Mathematics: Learning Field	**Science: Subject Field**	**Electrical Engineering**	**Technology**	**Skills**
Conversion Geometry	Wind Energy	Electrical Motor, Energy	Wind Power Generator	Cooperation Communication Creativity Critical Thinking
Problem	Chemical Reactions	Electrical power	Rocket, Rocket Launcher	
Algebra, Geometry, Calculus	Electricity, Physics	Control System, Electrical Motor	Robot	
Algebra, Geometry, Calculus,	Physics	Control Systems	Medical Machine	

2.3 Student's Perspective in Electrical Engineering

The lack of understanding of the fundamental has made the students less interested in Electrical Engineering subjects. Aharon G. (2016) stated that most students assume that the basic electrical circuits course does not reflect a deep understanding of the discipline of electrical engineering. Dianne Q. Nguyen (2007) recognized the lack of appeal of subject contents, the method of delivery, passion, and basic knowledge of teachers as one of the factors that contribute to the downward trend in the number of engineering students. Figure 2.1 shows the skill required and the characteristics of ideal engineer based on Nguyen (2003).

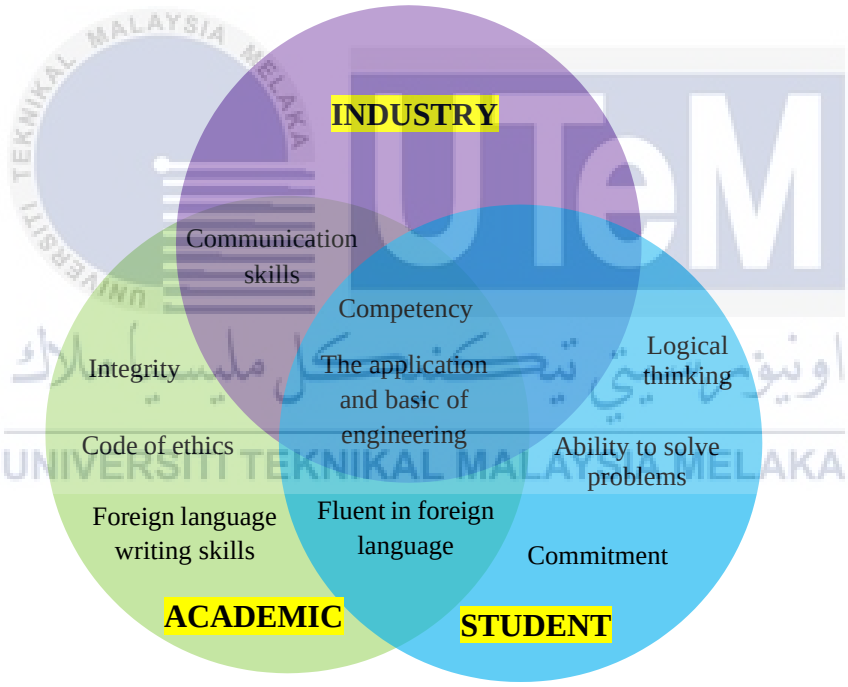


Figure 2.1: Skills Required and the Characteristics of Ideal Engineer (Nguyen, 2003)

In addition, Tatiana V. Goris (2009) had been surveyed the common misunderstandings of basic electricity revealed that student from the first year until last year often misunderstood about the difference between the voltage and current, the definition of electricity and the concept of 'dead' battery.

The high-quality graduates in the engineering field is very indispensable due to the growth of technology. Siti Hajar H. (2012) found in her research that the requirement of the general and specific skills for an ideal engineer as shown in Figure 2.1.

2.4 Critical Topics in Electrical Engineering

Electrical Engineering is a broad field that deals with the technology of electricity and often includes electronic engineering. According to Prof. Tom C. (2016), the majority of electrical engineering students spend approximately the first two years in developing a strong foundation in subjects such as math, physics basic circuit theories for both analog and digital domains. Prof. Tom C. (2016) also mentioned that there are three pillars of core competencies which are; i. Signal and system, ii. Electronics and iii. Electromagnetic. Figure below are the general concepts in Electrical Engineering based on James H. Bently (1984), K. Sahay (2006). Figure 2.2 below shows the general concept in electrical engineering.

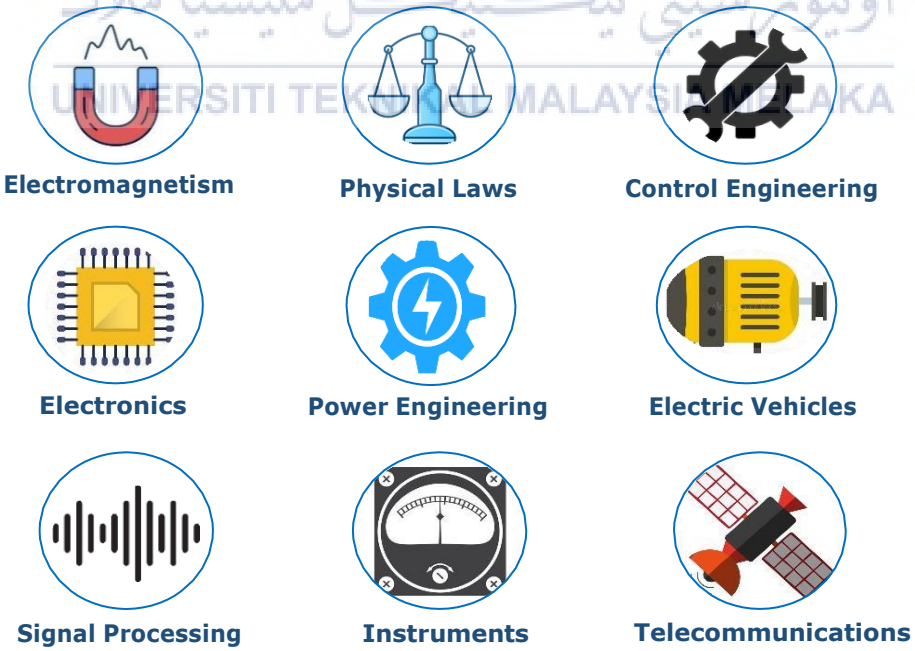


Figure 2.2: General Concepts in Electrical Engineering

2.4.1 Electrical Curriculum in Primary and Secondary Grades

The science curriculum is designed by the Ministry of Education in order to develop the opportunity to gain scientific knowledge, increase the ability in critical thinking skills, and able to apply the knowledge in daily life based on the Educational Development Plan for Malaysia from year 2001 to 2010. According to the Trends in International Mathematics and Science Study (TIMSS) 2015, the curriculum is categorized into three domains;

- **Scientific Knowledge:** Include the concepts, facts, rules, and principles.
- **Skills:** Involvement of scientific and critical thinking skills.
- **Scientific Attitudes and Values:** Development through experiential learning.

The Table 2.2 below shows the syllabus of science curriculum for primary and secondary grades based on Ministry of Education;

Table 2.2: Syllabus of the Electrical Curriculum for Primary and Secondary Grades adapted from Ministry of Education

Main topics	Grade	Year	Subject
Electricity	Primary	Standard 5	Chapter 7
	Lower Secondary	Form 2	Chapter 7
	Lower Secondary	Form 3	Chapter 6
	Upper Secondary	Form 5	Physics (Chapter 2)
Energy	Primary	Standard 5	Chapter 5
	Lower Secondary	Form 2	Chapter 7
Magnet	Primary	Standard 3	Chapter 5
	Lower Secondary	Form 2	Chapter 7
	Lower Secondary	Form 2	Chapter 6
	Upper Secondary	Form 5	Physics (Chapter 2)

2.4.2 Topics related to Electrical Engineering for Institutes of Higher Education (Diploma and Degree Level)

The purposes of Electrical Engineering programme is to equip students with a full understanding of the fundamental theories along with the concepts in electrical engineering. J. M. Jornet (2008) also highlighted the foundation of physical science, mathematics, computing, and technology to be added in understanding the subjects.

Following the aims of Malaysian Technical University Network (MTUN) which to educate and train the highly skilled manpower, Universiti Teknikal Malatsia Melaka (UTeM) has been provided the suitable subjects for Electrical Engineering programme. The Table 2.3 below shows the syllabus on engineering topics covered for diploma and degree level in UTeM;

Table 2.3: Syllabus on Engineering Topics for Diploma and Degree Levels in Universiti Teknikal Malaysia Melaka (UTeM)

Main topics	Level	Year	Subject
Electricity	Diploma	1	Electrical Circuit
	Degree in Engineering	1	Electrical Circuit
	Degree in Engineering	2	Electrical Technology
Energy	Degree in Engineering	2	Electrical Technology
	Degree in Engineering	2	Generation & Distribution
Magnet	Degree in Engineering	2	Theory of Magnet
	Degree in Engineering	2	Electrical Technology
Electrical Motor	Degree in Engineering	2	Generation & Distribution
	Degree in Engineering	2	Electrical Technology
	Degree in Engineering	3	Motor & Generator

2.5 Practical Learning

Practical learning is a combination of education and work known as cooperate education (Shengli C., 2017). Robin M. (2014) in his book defined practical learning or wok as any teaching and learning activity that involves the students to observe and manipulate the real object and materials. Upon the practical activity, the students will have a discussion of the observations whether their activity succeeds or fail. Robin M. (2004) also added that practical tasks should act as communication for the students' scientific knowledge development instead of acts as opportunities for inquiry. The illustration in Figure 2.3 shows how learning style affects the students understanding.

Figure 2.3: Theoretical Learning vs Practical Learning

(Ref.: https://cutt.ly/7uD5HPc)

As shown in Figure 2.3, the learning styles influences students' understanding of the subject they have learned. Mei Chi Lee (2017) reviewed her findings where the laboratory investigation (practical learning) enhances the students' behaviors such as positive attitudes, encouragement, and interest towards learning in related subjects. Conversely, the theoretical learning approach affects the interest of students. Thus, they become not excited and finally not understand the subjects (Fauziah S., 2017).

Degang Shi, (2014) analyzed that students that applied practical learning had dramatically improved the students' result in the exam. Traditional education is still considered a good system that can be implemented in the education system. However, the rapid growth of technology had demanded the people especially graduates to have strong capability skills resulting in traditional education to become unsuited to the requirements of modern society. In Figure 2.4 below shows the Sustainable Development Goals that have been developed by Division for Sustainable Goals (DSDG).

Figure 2.4: Sustainable Development Goals (SDG), based on the Division for Sustainable Goals (DSDG) (Ref.: https://sustainabledevelopment.un.org/sdg4)

The United Nations Department of Economic and Social Affairs (UNDSEA) stated that the efforts in providing the effective teaching methods is related to the sustainable development goals UNESCO specifically in Leading SDG 4: Quality Education. In addition, the Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs) had stated that by the

year of 2030, the number of youth and adults that have relevant skills such as technical skill increases for employment, eligible jobs and entrepreneurship as one of global target indicators of the Leading SDG 4: Quality Education.

On top of that, different students have their own learning styles. By knowing their own learning styles, the process of learning will become easier and successful. Hawkar A.A. (2014) in his paper listed the classification of learning styles which are;

- Visual versus verbal
- Auditory learners
- Kinesthetic or tactile learners
- Intuitive versus sensing
- Global versus analytic
- Individual versus group preferences

The practical learning is being applied among the kinesthetic or tactile learners and analytic learners. As for the kinesthetic learners, they prefer to work with touchable objects and move around during work while the analytic learners focus on logical analysis and thinking as ways to tackle the problems (Hawkar A.A., 2014).

2.6 Influences of Coloured Picture in the Textbook

According to Dunlosky et al., (2013), most students often endorse the use of rereading and highlighting for study. These two ineffective methods are found to have low utility besides not able to retain knowledge for a longer period. Nevertheless, some of the students that applied the practice testing methods appear to gain benefit from its use. Those students show better performance on a final exam. Following this matter, it is believed students that are being left

behind by an educational system are in crisis which then makes them not fully understand what they have learned. It is even worse when the country will not be able to produce quality engineers in the future.

Dunlosky et al. (2013) also stated that there are five techniques that are considered as a low utility assessment; i. The summarization, ii. The highlighting, iii. The keyword mnemonic, iv. The imagery uses for text learning and v. The rereading. These techniques may find useful in a certain time but still not provide full benefits and ineffective. Therefore, improving the teaching and learning methods are very crucial for both teachers and students. Figure 2.5 shows six types of colors with their impact to memory;

Figure 2.5: Colors Impact on Memory.

(Ref.: https://www.ryman.co.uk/blog/revise-with-colour)

Nowadays, textbooks are still considered as an important resource in the education system. The way how the information is delivered is very crucial to grab students' attention. One of the best ways is by adding images with attractive color in into the textbooks. Certain colors have their own impact on memory that can be applied in learning process.

Referring to Figure 2.5, it can be concluded that by using different colors to different topics will improve the availability to recall the topic at any time. However, the evaluator more focuses on the content rather than the study of the impact of pictures in the textbooks (Sara K., 2015). It is good to note that, pictures capable in encourage students to study the related text and increases their attention to detailed processing of textual data that is included in illustrations. Moreover, they can explain the content that hard to understand and thus increase recovery potential for the picture text content (Sara K., 2015). The Figure 2.6 below shows the three elements that influences the quality of the textbook.

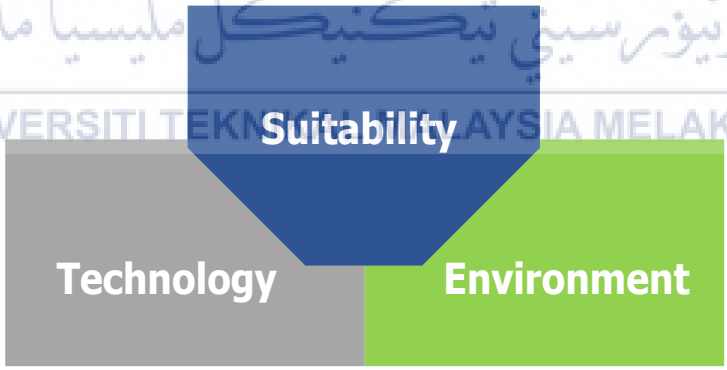


Figure 2.6: Elements of Quality Textbook (Sara K., 2015)

As shown in Figure 2.6, Sara K. (2015) suggested that there are three elements that make up the quality of the textbook which included; i. Persuade the use of technology, ii. Suitability and iii. Environment. These elements are the things that the author should be aware

of to motivate students in their studies. Therefore, it is to avoid students become boring even the book is incredibly inspiring and informative.

2.7 QR Code Feature

Quick Response (QR) code is a 2D barcodes consists of black modules that are arranged in a square pattern on a white background. It is developed in 1994 by Denso – Wave which is a Japanese automatic data capture equipment company for the Toyota motor corporation (Dr. Gurhan D., 2016). It is created as an alternative to the barcodes system (Woof D., 2015) and initially used to track the vehicles at the time manufacturing (Deepashree M., 2017). According to Deepashree M. (2017), people become more interested to use the QR code system because it is easy to generate, fast reading, and able to load a lot of information in many forms. For instance, information such as the website URL link, contact information, video streaming and plain text (So, 2010). Figure 2.7 shows the structure and components in QR code.

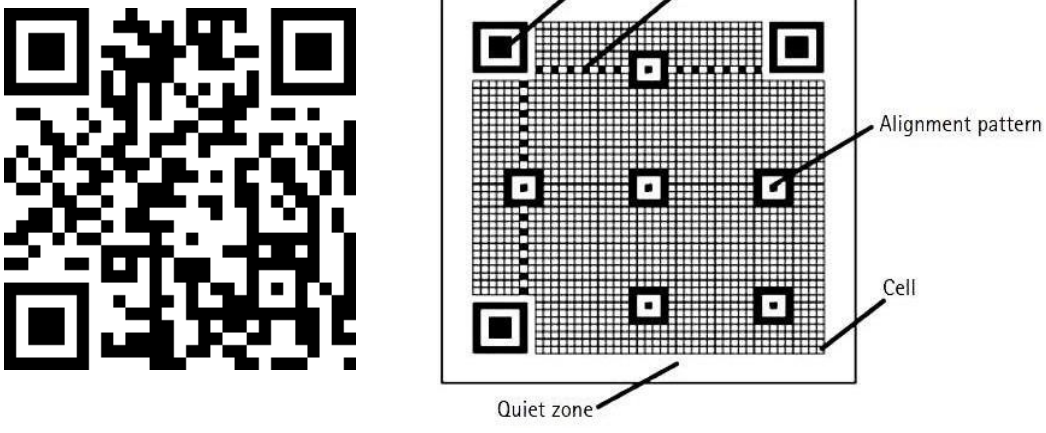


Figure 2.7: Structure and Components of QR code (Wara Aliyu A., 2014)

As shown in Figure 2.7, there are three patterns on the QR code which are finder patterns, timing patterns and alignment patterns. The finder patterns are used to detect position, size and inclination of the QR code. As for timing patterns, it acts as an identifier for the central co-ordinate of data cell whenever the QR code is distorted. Next, the alignment used as a correction pattern that corrects the distorted data while the quiet zone is a margin space that is crucial for reading the QR code.

It is known that the features in QR code mostly reflect the positive feedback towards the users. Therefore, Deepashree M. (2017) mentioned in her paper that the QR code exhibits the potential to apply in education system. The use of QR code in the education can be categorized in the context of mobile learning (Rikala J., 2012). Thus, it is considered as one of the effective medium of learning since the most used device in the world is the mobile smartphone (Ivan J., 2013). Figure 2.8 shows the process on how does the QR code work on smartphone.

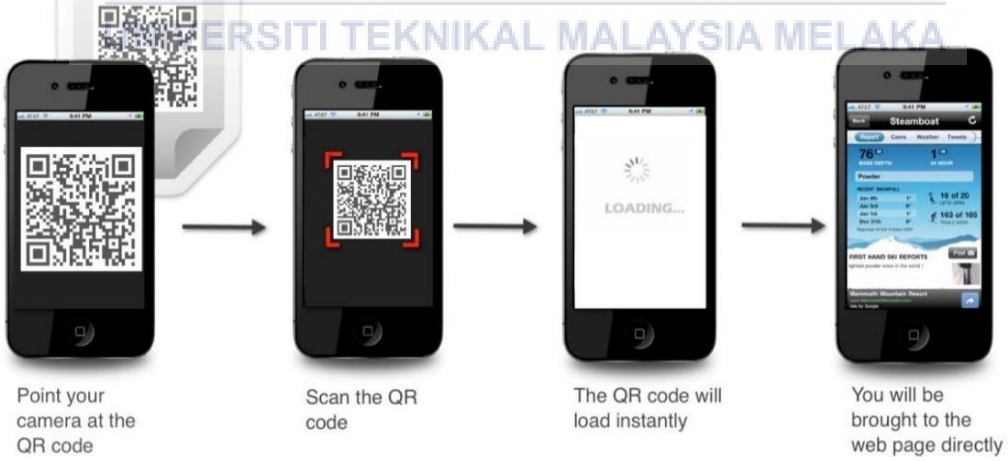


Figure 2.8: QR Code Recognition Process

(Ref.: http://blog.escanav.com/2015/04/beware-of-surprises-from-qr-codes/)

Based on Figure 2.8, the QR code recognition process starts when the smartphone scans the code. After that, the code will be decoded by the software on the smartphone and converted into a string of characters. The commands on the characters determine the type of information that appear, for example, web page, location verification as well as access to video link or any other information at rapid rate. Following this matter, it can be said that the use of QR code in mobile learning is very effective and easy to apply. Apart from that, teachers will become more creative in performing the learning session with the student to blend with the development of the technology.

For example, by applying the QR code, it capable in draw the attention of the students allowing them to learn effectively. Next, Rikala J. (2012) from her research stated the use of QR code able to expand the learning experience and provide the genuine tasks that take place in real-world settings. Furthermore, the QR code can be accessed all over the areas as long as the users are in the internet coverage area and equipped the mobile phones with a QR code scanner.

2.8 The Implication of Video Learning Among Students

Following today's educational trend, teaching material based on video clips is seen to have at least as equally efficient as standard teaching lectures. Panagiota N. (2010) explained in his paper that by using video as a learning medium, it shows more effective effects rather than text. Consequently, it enhances the student's satisfaction and motivation during the learning process. Apart from that, video learning is flexible because it can pause or skip throughout the video and able to access in particular areas.

Emily C. (2007) mentioned that the ability to communicate with viewers' emotions is one of the greatest strengths of video. Due to this ability, the video may have a strong positive effect to develop the motivation and effective learning. Marshall (2002) clarified that people will generally remember according to the; 10% of what they read, 20% of what they hear, 30% of what they see and 50% of what they hear and see. Figure 2.9 shows how video – based learning is conduct.

Figure 2.9: Video – Based Learning (Ref.: https://elearningindustry.com/how-video-based-learning-impacts-corporate-training-future)

Guo et al. (2014) analyzed that the duration time of the streaming video affects student engagement. As the streaming videos lengthened, student engagement is dropped off and decreased. The maximum median engagement time is lasts within six minutes of video length. Otherwise, it will be likely wasted effort for making videos longer than six to nine minutes. Therefore, it is recommended to create two or more videos depending on the content for the topics that require long explanation.

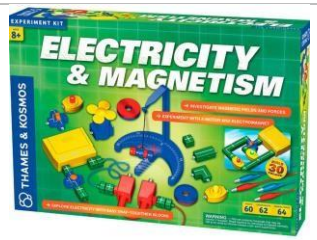
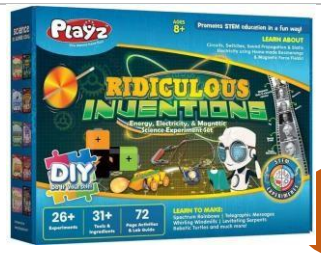
As for that, Cynthia J. Brame (2016) suggested four characteristics to attract students which can be applied in video learning are; i. Conversational style, ii. Speak relatively fast with passion, iii. Ensure that the materials are for students in this class and iv. Match modality.

Throughout students' participation in video learning, they can improve their understanding of the subject. Apart from that, the video learning also supports the active learning that enhances the students' performance. N. Sasikumar (2014) listed that, the involvement of students more than passive listening, engagement in activities and increase motivation to study are the major characteristics that related to active learning strategies.

2.9 Comparison of Electrical Engineering Learning Kit products in Market

There are many electrical Engineering Learning Kit that available in the market. Thus, find the best learning kit, a comparison should be made in detail. Table 2.4 presents the comparisons between three products of learning kits related to electrical engineering. Most of the feedback are based on the people's reviews at online shopping websites such as Amazon, Ebay and Lazada.

Table 2.4: Comparison of Learning Kit's Products available in Market

	 1	 2	 3
Product	**Electromagnetism: Electricity & Magnetism Kit**	**Electricity & Magnetism**	**Ridiculous Inventions**
Price	RM 214.00	RM 230.00	RM 300.00
Age Range	8+	8 – 15	8+
Topics	Electricity, Magnetism	Electricity, Magnetism	Science, Technology, Art, Engineering
Total Projects	18	62	26+
Kids friendly	★★★	★★★	★★★
Learn-at-home ready	★★	★★	★★
Theoretical Explanation	★	★	★★
Guide-to-do	★★★	★★	★★
Availability of material	★	★★	★
Source	https://cutt.ly/quDmx7d	https://cutt.ly/iuDmTHc	https://cutt.ly/cuDmSoM

**The star symbol represents the rate of customer reviews.*

Legend:

★ Good ★★ Very Good ★★★ Excellent

Referring to Table 2.4, the star symbol starts from the Kids friendly element until availability material reflects the rate of customers' reviews. The higher number of stars means the user is very satisfied with the product while the least number of stars shows the weakness of the products that draw the users' dissatisfaction.

The product 1 which is Electromagnetism: Electricity & Kit has a price of RM214.00. It is considered expensive since it only contains 18 projects. Some of the review mentioned that they have received the some of the defective components' parts and asked for the replacement. Unfortunately, the manufacturer does not sell the parts separately and they must buy the new kit. For an expensive kit, it covers only two topics which are electricity and magnetism but poor in explanation. Apart from that, one of the reviews claimed that they has trouble in understanding the theoretical explanation and need to search for other resources for further explanation regarding the projects. However, there are parents that mentioned that their kids enjoyed the experiment because the experiments are very interesting and easy to follow.

Moving to product 2, the Electricity & Magnetism, this product cost RM 230.00 which considered expensive. Although there are 62 projects in total, the price is considered unreasonable because most of these projects involve the very basic and simple circuits. Therefore, some of the users said that the recommended age should not reach until fifteen years old. At certain time, the resemble project fail to work even though they follow the given instructions. This reflects the poor instructions which needs to be updated for the projects to be effective. Still, there are some reviews mentioned they need to find other sources to understand the concept in the experiments. The advantage for this product is kids friendly where all the components is made form plastics and easy to resemble.

For product 3, the Ridiculous Invention costs RM 300.00 which is the most expensive form the other products. The components included in the kit are not complete which required them search the additional parts that are difficult to find (Reviews adapted from Apart from that, this kit covers general topic on science, technology, art, and engineering. Thus, it may be found that the kit is not suitable for people in the electrical engineering field because it does not focus on electrical engineering topics in particular.

2.10 Points of Departure

Points of departure based on the *Dictionary.com* is the starting point to begin in something (project, discussion, etc). First, the comparisons had been made for the improvement of the electrical engineering learning to become the best choice for students in their learning process. Apart from that, this learning kit also suitable for people in the electrical engineering field including lectures and technicians as a reference in the basic science and electrical engineering. The Table 2.5 shows the descriptions and reviews on the electrical engineering learning kit.

Table 2.5: Details and Reviews of the Electrical Engineering Learning Kit

Product	**Electrical Engineering Learning Kit**
Price	RM 100.00
Age Range	7+
Topics	Electricity, Electrical Application, Magnet, Electric Motor, Energy
Total Projects	10
Kids friendly	★★
Learn-at-home ready	★★
Theoretical Explanation	★★★
Guide-to-do	★★★
Availability of material	★★★

**The star symbol represents the rate of 50 respondents' reviews. (Refer legend in Table 2.4.)*

Table 2.5 presents the descriptions and the reviews from the respondents that already use the electrical engineering learning kit. The Electrical Engineering Learning Kit costs only RM100.00 which the cheapest among the three kits. Compare with the three products in Table 2.4, the total topics covered in electrical engineering learning kit are five topics which are electricity, electrical application, magnet, electric motor and energy. The most valuable in this learning kit is in the theoretical parts complete with the systematic and structured explanation for further understanding about the concept of each projects. Apart from that, this learning kit consist of the detailed project making procedure assisted with an eye-catching color image that able to attract the interest from the user. However, most of the respondents claimed that there are few projects that uses sharp apparatus such as cutter and driller and solder which then made this learning kit lack in the Kids Friendly element compared to the other three products in topic 2.9. Thus, guidance from an adult is needed while conducting the experiments.

There are three domains of learning which is the psychomotor domain (knowledge), cognitive domain (skills), and affective domain (attitudes). These domains are crucial in teaching and learning and become the main reference point for this project. Figure 2.10 shows three domains of learning.

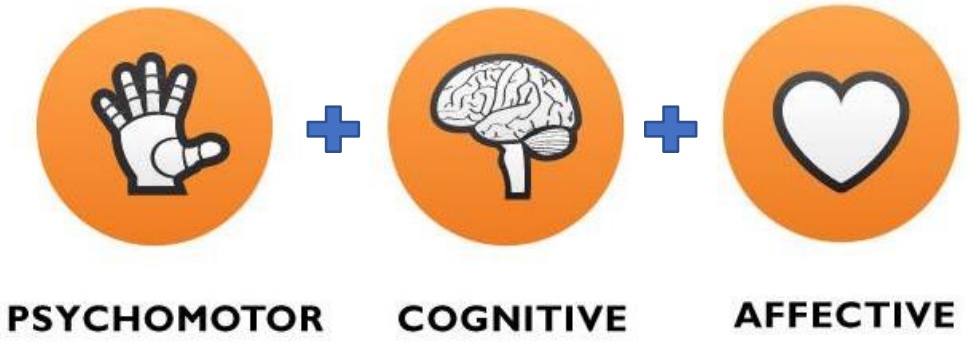


Figure 2.10: Three Domains of Learning
(Ref.: https://cutt.ly/nuFRWSx)

The relationship between the domains in the learning and this project is presented at Figure 2.11.

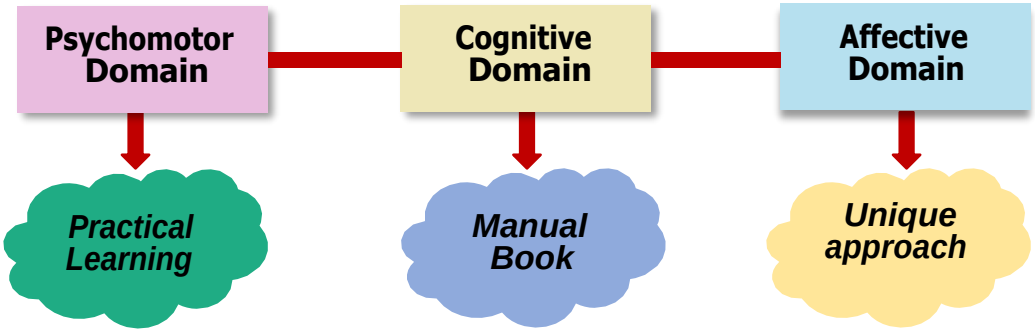


Figure 2.11: Implementation of Three Domains of Learning in Electrical Engineering Learning Kit

Referring to Figure 2.11, all three domains have been fulfilled to develop the best electrical engineering learning kit for teachers and students who involve in STEM in general and in the electrical engineering field. Leslie O. W. (2016) stated that all three domains should be applied in constructing learning tasks for students. By applying more diversity in the teaching process, students will become more creative and help them to revise their lessons.

The Psychomotor domain (Simpson, 1972) is the domain related to skills, practical and practical movements. As for this project, the implementation of this domain can be seen through experimentation and practical learning. Based on the topic 2.5, the practical learning method is able to improve the students' understanding especially in science and electrical engineering. Apart from that, this method will attract students' interest in pursuing a career related to STEM.

The second domain is the cognitive domain which is the learning skills related to thinking processes. The manual book for this learning kit is an example of the implementation of cognitive learning. the manual provides the concept and theoretical explanation for each

experiment complete with the aid of diagrams and coloured images to ease the reader to understand the content in the manual book. Topic 2.6 mentioned how certain colors stimulate the memory to helps the reader recall the subjects that have been learned. Apart from that, this manual book also has QR codes feature that allow them to access the video project.

The video project intends to guide the students as well as shows the result upon completing the projects. Because of that, this learning kit is different from the three products that have been compared in Table 2.4 in Topic 2.9 with an additional feature which is video learning. The topics included in this learning kit also equivalent to the syllabus topic in electrical curriculum and electrical engineering listed in Table 2.2 and Table 2.3.

Lastly, the affective domain is the involvement of elements such as emotion, feelings and attitudes included in the learning process. It refers to the way we deal with things emotionally, for example, appreciation, motivations, and enthusiasm. Using the unique approach to deliver the contents such as in the practical method, video learning and coloured images can increase student awareness to adapt with the subject and draw their intentions. Then, this unique approach also able to gain satisfaction on topics that they have learned because it is hands-on activities that require them to move around and conduct experiments.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, all the method involved in developing the electrical engineering learning kit will be discussed. The project workflow and the seven major stages will be elaborated in detail.

3.2 Project Workflow

The project starts from investigate the ten mini projects to be included in the electrical engineering learning kit project. The projects are selected accordance with the syllabus on the electrical curriculum in primary and secondary schools and subjects in electrical engineering courses in diploma and degree level. besides that, lot of research had been done to choose the suitable projects. After listed out the projects, the apparatus needed for each project is identified. There are three parts for the apparatus to be used; i. Electricity, ii. Magnet and iii. General. The electricity parts included electrical components such as DC motor, buzzer, switch, solar cell, LED and vibration motor. For magnet parts, the magnet that will be used is the neodymium magnet in code N42 and N35. Lastly, for the general apparatus, items such as wires, recyclable material, and metal keys are used. The total price for all apparatus and magnets is calculated and proceed to purchase the things.

The next process is continued with the development of the ten mini projects. All fifteen must be done to move to the next step which is identify the experiment parameter for example the current generated. Otherwise, the process will start over from the investigation of the ten mini projects. After getting the experimental parameter, the table for data collection is prepared to be able recorded the outcome result.

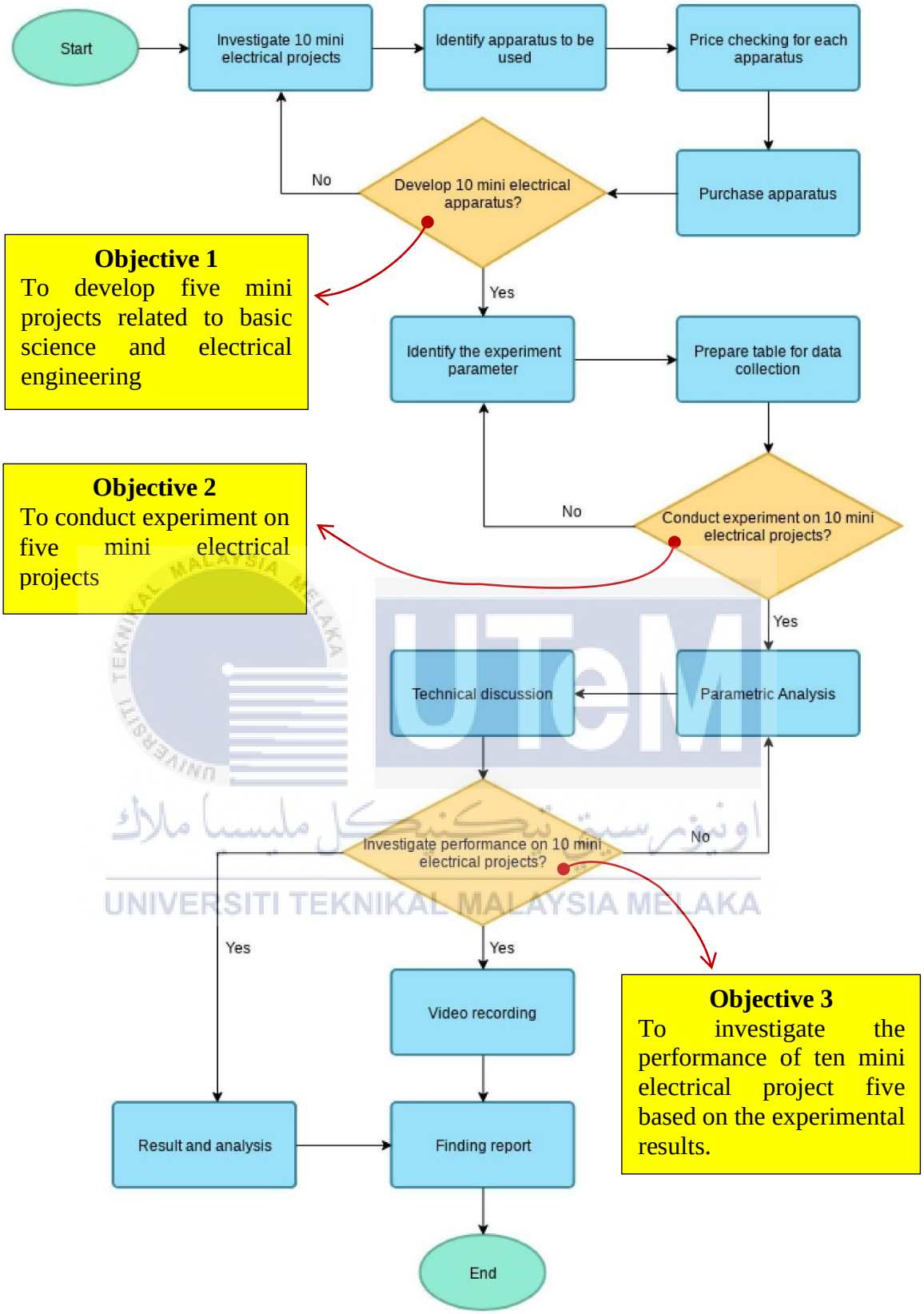


Figure 3.1: Flow Chart of Project

Next, the process is conducting the experiment for the ten mini electrical projects. The result from the experiment is collected and recorded in the data collection table to conduct the parameter analysis. However, the process will be repeated from the experiment parameter identification. Then, the technical discussion is discussed based on the parameter analysis of the experiment.

Upon completing the technical discussion, the process continues to investigate the performance on ten mini electrical projects. Then, proceed to the video recording of each project complete from the introduction of the title, procedures, and the result. However, the process will be repeated from the parameter analysis if the investigation of ten mini electrical projects is not succeed. Next, the process will end after all the data regarding the project have been recorded and the result have been analyzed in the finding report.

3.3 Stages Research of the Project

Table 3.1 below shows the seven major stages of research activities that involved in the electrical engineering learning kit project. These seven major stages are crucial to make sure the project is complete and successful.

Table 3.1: Seven Major Stages of Research Activities

Stages	Research Activities	Milestone
Stage 1	Literature review.	1
Stage 2	Development of ten mini electrical projects.	2
Stage 3	Conduct experiment on ten mini electrical projects.	3
Stage 4	Identify the parametric analysis for ten mini electrical projects	4
Stage 5	Investigate the performance on ten mini electrical experiments based on the experiment results.	5
Stage 6	Video recording of the projects.	5
Stage 7	Finding report	7

3.3.1 Stage 1: Literature Review

The first stage of this project is reviewing lot of research studies and literature review to identify the problems encountered among the people in electrical engineering field from the students in primary grades level to the educators in institute of higher education. In this stages, the best and effective method in teaching and learning processes also have been studied. Apart from that, the students' perspective, and their performance in studies in the STEM education are analyzed to investigate the students' interest in this subject. After going through the process of research, five mini electrical projects are listed compatible with the syllabus of electrical in schools and universities.

3.3.2 Stage 2: Development of Ten Mini Electrical Projects

This stage starts upon the apparatus that is to be used is identified. After that, all ten projects are grouped as in Table 3.2 below.

Table 3.2: Five Mini Electrical Projects

Project	Subproject	Name
Project A Electricity	A1	Magic LED
Project B Electrical Application	B1	Propeller Car
Project C Magnet	C1	On – Off Magnet
Project D Electric Motor	D1	Spinning Coil
Project E Energy	E1	Pico Hydro

All projects in the topics required basic apparatus and magnets that inexpensive and easy-to-found items in order to develop the projects. Then, the related electrical parameter is identified for each project. The projects are developed until it successfully obtains the result. Otherwise, the project will be troubleshot or replace with the new project.

3.3.3 Stage 3: Conduct Experiment on Five Mini Electrical Project

The data from the output result will be recorded in the table for the data collection. From the data collection, the parametric analysis is constructed to observe the output data for each project. The purpose of the parametric analysis is to compare the experimental result and the theoretical of the project.

3.3.4 Stage 4: Identify the Parametric Analysis for Five Mini Electrical Projects

Parametric analysis is the research activities that study the factors that influences the experimental result. Generally, there are two types of parametric in every experiment which are fixed Parameter and variable parameter. Fixed parameter will be held fixed along and remains the same along the experiment, meanwhile variable parameter will be changed through each experiment.

3.3.5 Stage 5: Investigate the Performance of Five Mini Electrical Experiments based on the Experiment Results

The performance of the five mini electrical experiments is investigated based on the experimental result after conducting the experiment. In this part, the most influence of electrical parameter towards the project will be obtained.

3.3.6 Stage 6: Video Recording of the Projects

After completing the hardware part, each process of developing the video will be recorded including the result from the experiment. The video will start from the introduction of the title then going through the step by step in developing the project along with the apparatus used, and lastly show the output result. Then, the video project will be stored in the QR code.

3.3.7 Stage 7: Findings Report

All the data regarding the development of the electrical engineering learning kit will be recorded and finalized in the findings report.

3.4 Summary

In conclusion, this chapter summarizes all the process and method to be used in developing the electrical engineering learning kit. The project starts from the research articles and journals regarding the electrical engineering field. All information that has been collected is analyzed to list out the five mini electrical projects that are compatible with the STEM and electrical engineering education. After that, the hardware of the project is developed using the list of apparatus that have been identified. Upon developing the hardware, the results from the experiments are studied and the parametric analysis is constructed.

This is to identify the most influential electrical parameter towards the output of the project. Then, the process of the project will be recorded and stored in QR code form. All the data information about the project will be recorded and discussed in the finding report.

CHAPTER 4

EXPERIMENTAL SETUP

4.1 Introduction

In this part, the process of how the development of the Electrical Engineering Learning Kit is discussed. The implementation of this project is categorized into three parts which are; i. Hardware Development, ii. Interactive Media and iii. Finding Report as shown in Figure 4.1 below; On top of that, all concepts and theory regarding the projects will be discussed in the finding report.

Figure 4.1: Implementation of Electrical Engineering Learning Kit Project

4.2 Relevant Topics

After going through a lot of research and literature review, the ten mini projects are finalized according to the topics covered in the syllabus for science curriculum in primary and secondary school as well as topics for diploma and degree level in electrical engineering. All projects are suitable for beginners in electrical engineering as it focuses on the basics of science and engineering.

The subject matter of the learning kit is divided into five group of projecs; i. electricity, electrical application, magnet, electrical motor and energy. Figure 4.2 shows the topic covered in Electrical Engineering Learning Kit including the electrical laws, the fundamental of electrical, physics and sciences.

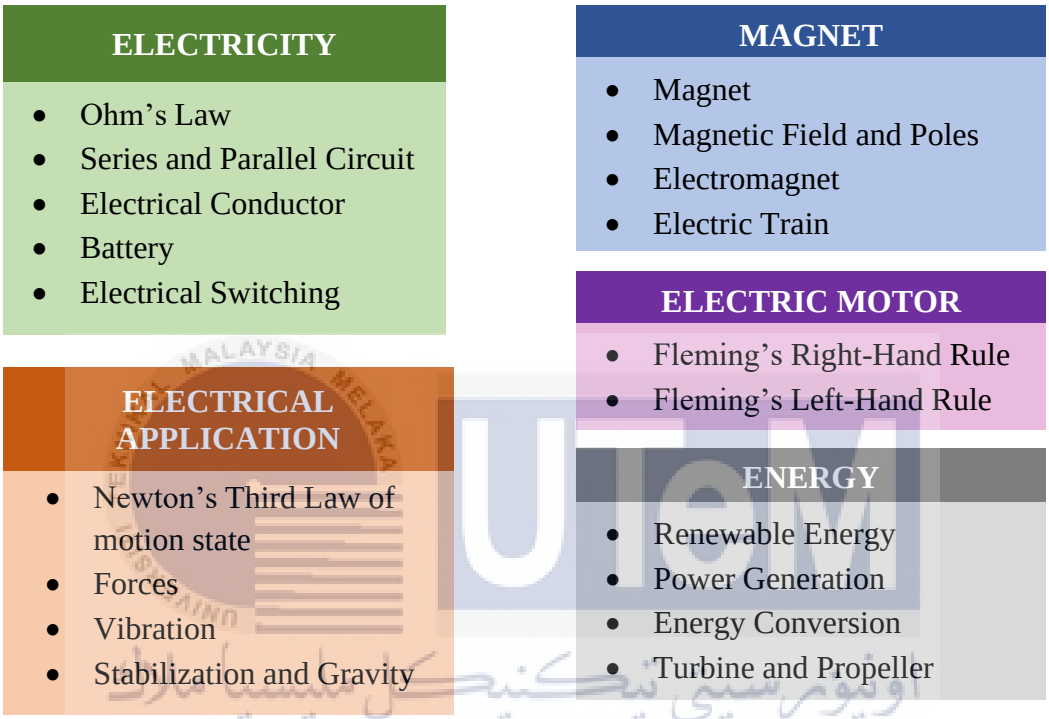


Figure 4.2: Topics covered in Electrical Engineering Learning Kit

4.3 Hardware Development.

The hardware development consists of three parts which are; investigate the topics, identify the apparatus, interactive media and final report. The apparatus used for each project is identified and divided into two parts; electricity and magnet. Figure 4.3 show types of magnet used in the projects;

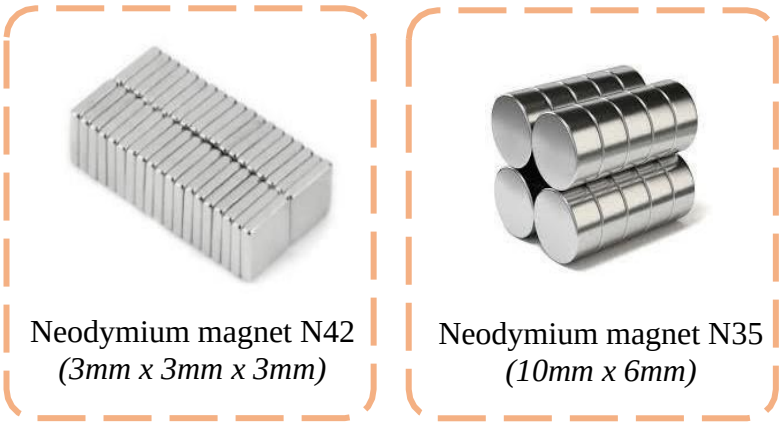


Figure 4.3: Type of Magnets to be Used

There are two types of magnet that have been for projects in Project C: Magnet and Project D: Electrical Motor. The first magnet is Neodymium magnet N42 which is used in project C2 Electromagnetic Car. Then, the second magnet is Neodymium magnet N35 used in project D1 Spinning Coil. For the electrical parts of apparatus used, there are eight main components that have been used. Figure 4.4 shows the list for electrical parts of apparatus used;

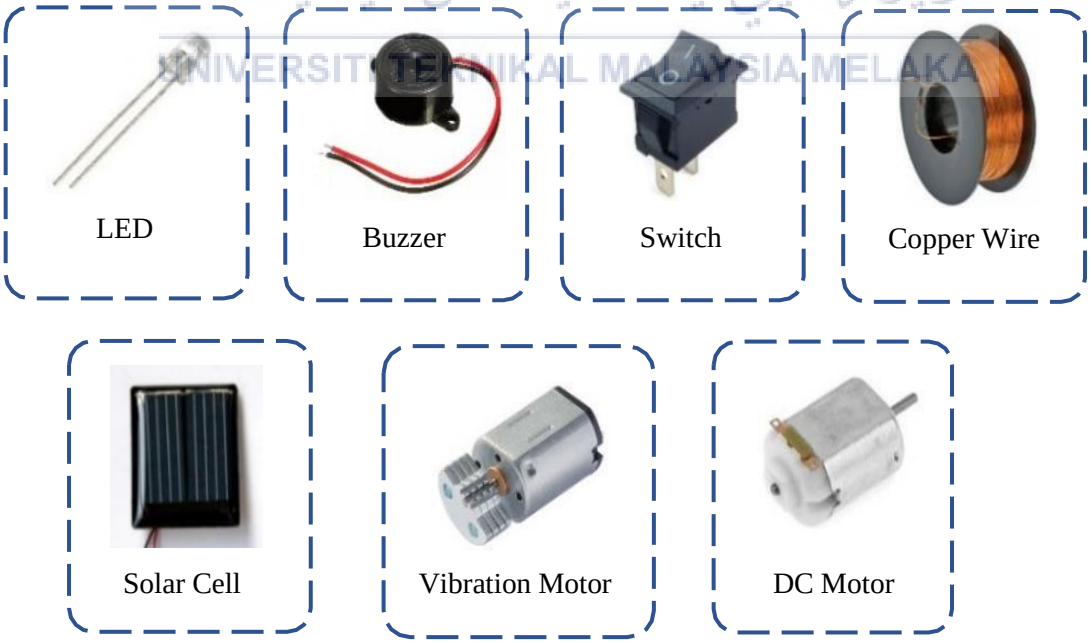


Figure 4.4: Apparatus Used for Electrical Parts

In Table 4.1, the apparatus and magnet used is listed along with the total quantity, prices per unit for each item and the total price.

Table 4.1: Total Cost of Magnet and Apparatus

ITEMS	QUANTITY	PRICE PER UNIT	TOTAL PRICE
Magnet			
1. Neodymium magnet N42 (3mm x 3mm x 3mm)	6	RM 1.00	RM 6.00
2. Neodymium magnet N35 (10mm x 6mm)	4	RM 2.00	RM 8.00
Apparatus			
1. LED	6	RM 0.30	RM 1.80
2. Buzzer	1	RM 1.00	RM 1.00
3. Switch	3	RM 2.50	RM 7.50
4. Copper Wire	1.5m	RM 3.00 / 1m	RM 4.50
5. Solar Cell	1	RM 9.80	RM 9.80
6. Vibration Motor	1	RM 5.00	RM 5.00
7. DC Motor	4	RM 1.50	RM 5.50

Apparatus listed in Figure 4.4 used for most of the projects on all topics. Apart from that, there are general items such as batteries, wire, recyclable material, aluminum foil, mini fan, paper clip, disc and screw that were also used to develop the projects. Then, the process of development of the project upon identifying the apparatus to be used in the project.

4.4 Interactive Media - QR code

In this part, interactive media presents the video of the project once the reader scan the QR code available in the manual book. Each video of the project will be included in the QR code. There are a lot of online QR code generator that can be used to generate the QR code. Figure 4.5 below shows one of the online QR code generator named QR code-monkey.

Figure 4.5: QR Code Generator using QR Code – Monkey

(Ref.: https://www.qrcode-monkey.com/)

Referring to Figure 4.5, the link URL will be inserted to the box *"Enter the Content"* (Step 1). The link can be all types of information for example video, pictures, text or animations. After that, click the *"Create QR Code"* button to generate the new QR code (Step 2). Finally, click the *"Download PNG"* to get the QR code generated (Step 3). Each duration of video project is set to a maximum two minutes only. All information such as tittle project, apparatus used, procedures and result are comprised in the video. Figure 4.6 describes the content available in the video for the Magic LED project.

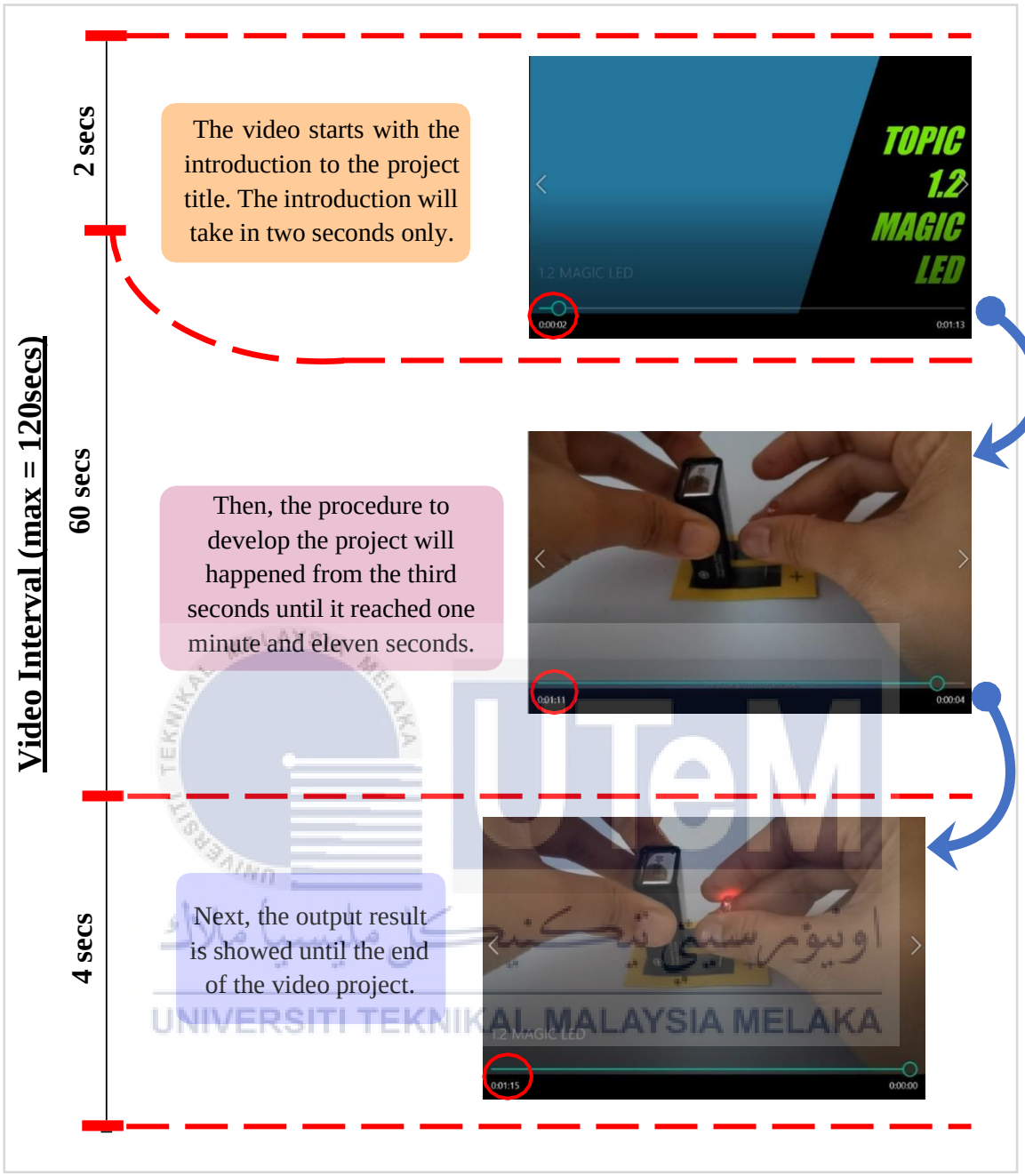


Figure 4.6: Video Interval of Project

4.5 Testing Procedures

In the experiments, there are steps by steps project – making procedures that need to follow in order to achieve accurate results. In addition, all experiments will highlight the parameters that are fixed and variable to observe the performance of each experimental result. Basically, the fixed - parameter is held constant throughout the experiment session, while the variable changes through each experiment. Both types of parameters influence the output or behavior of components that are being measured.

4.5.1 Project A: Electricity

Four simple apparatus is required to develop experiment A1 Magic LED which are a pencil, a piece of paper, a nine–volt battery and LED. The objective for this experiment is to measure the effect of size graphite line towards the brightness of LED. Thus, two parameters such as length and width of graphite line are being varied to successfully achieve the objective.

Firstly, draw two lines on a piece of paper using pencil indicating the positive and negative terminals. To obtain an equal concentration of pencils on each line, try to shade ten times when draw the line. Label positive and negative terminals beside the lines. Thereby, an error such as wrong terminal connection can be avoided. The length and width of graphite line are changed throughout the experiment. Then, place the positive terminal and negative terminal of nine–volt battery onto the graphite line.

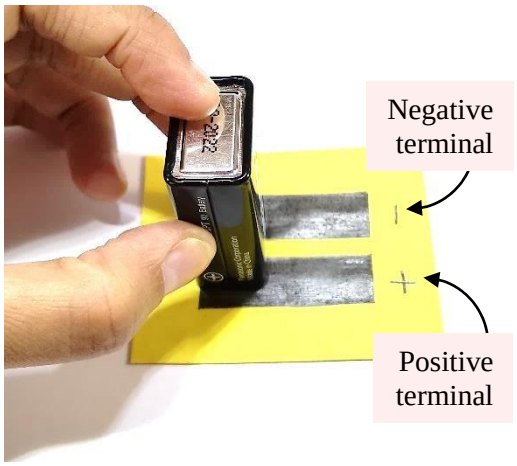


Figure 4.7: Position of Positive Terminal and Negative Terminal of Nine-Volt Battery

After that, place the LED's positive terminal on the positive label and vice versa. At this point, observe the brightness of the LED and record the observation. Remember not to add more shade on graphite line as this can affect the experimental results. Figure 4.8 shows the complete setup for Magic LED.

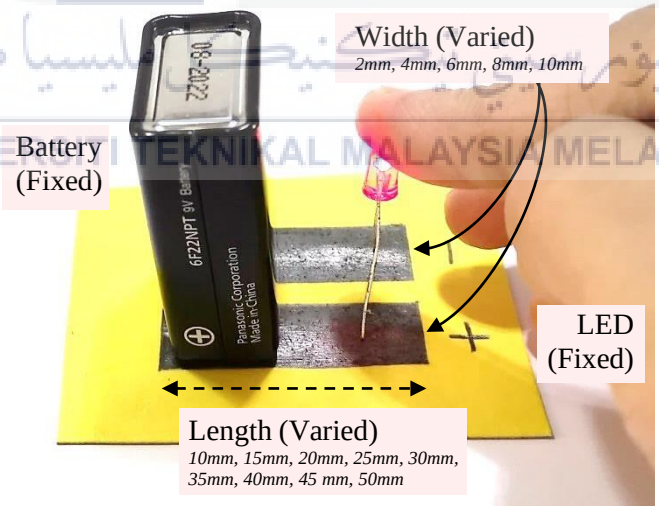


Figure 4.8: Complete Experimental Setup for Magic LED

Based on Figure 4.8, the length and width of graphite line is varied for 2cm and 5mm respectively. Each measurement determines the different value of voltage and current flows to LEDs through graphite line.

Hence, the LEDs will shine according to the voltage and current received from battery supply after flow through the graphite line. Measure and record the data for each different width of graphite line in Table 4.2 below.

Table 4.2: Experimental Result for Magic LED

Width: 2mm/ 4mm/ 6mm/ 8mm/ 10mm

Length (mm)	*Voltage (V)*	*Current (A)*
10		
15		
20		
25		
30		
35		
40		
45		
50		

4.5.2 Project B: Electrical Application

Experiment B1 Propeller Car uses electric motor, rocker switch, nine–volt battery, propeller, and recycled parts such as drinking straw, wooden chopstick, and bottle caps. The objective is to study the relationship between the total of resistance and the speed of propeller using two different types of DC motor.

To begin, make a hole at the center of each part of bottle caps. The diameter of the hole should be slightly bigger than the diameter of the chopstick so that it able fit into the hole. Then, cut two pieces of chopsticks into 5cm length and glue each chopstick into the hole at two bottle caps as shown in Figure 4.9.

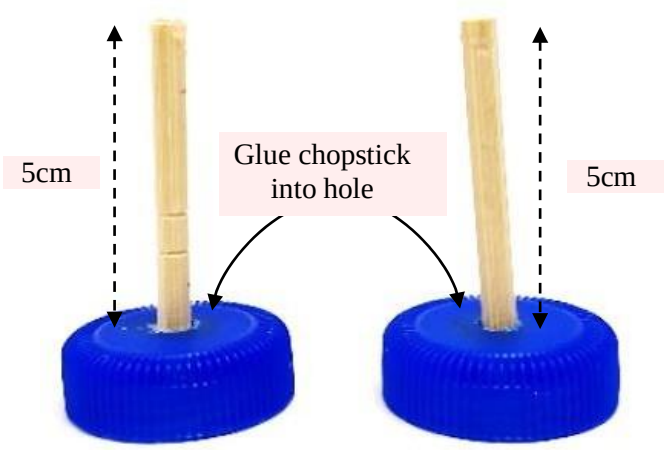


Figure 4.9: Glue Chopstick into Bottle Cap

Figure 4.9 shows on how to build two pairs of car's wheels using recycled materials. The next step is to make a roller to moves the wheels. To do that, cut two pieces of drinking straw with 4cm length. Ensure that the length of straw is shorter than the length of chopsticks. Then place a straw over the chopstick and glue the end of chopstick into the hole of the other bottle caps. Repeat this step to the other pair of wheels. Check if the wheels are able to move in back-and-forth motion.

After that, glue a nine–volt battery on top of the wheels followed by the 1k variable resistor, switch and DC motor on top of the battery. Glue the motor with the shaft of the motor behind the car. Then, solder all the components to build an electrical connection. Lastly, attach a propeller to the motor shaft and turn on the switch to moves the car. The complete setup as shown in Figure 4.10.

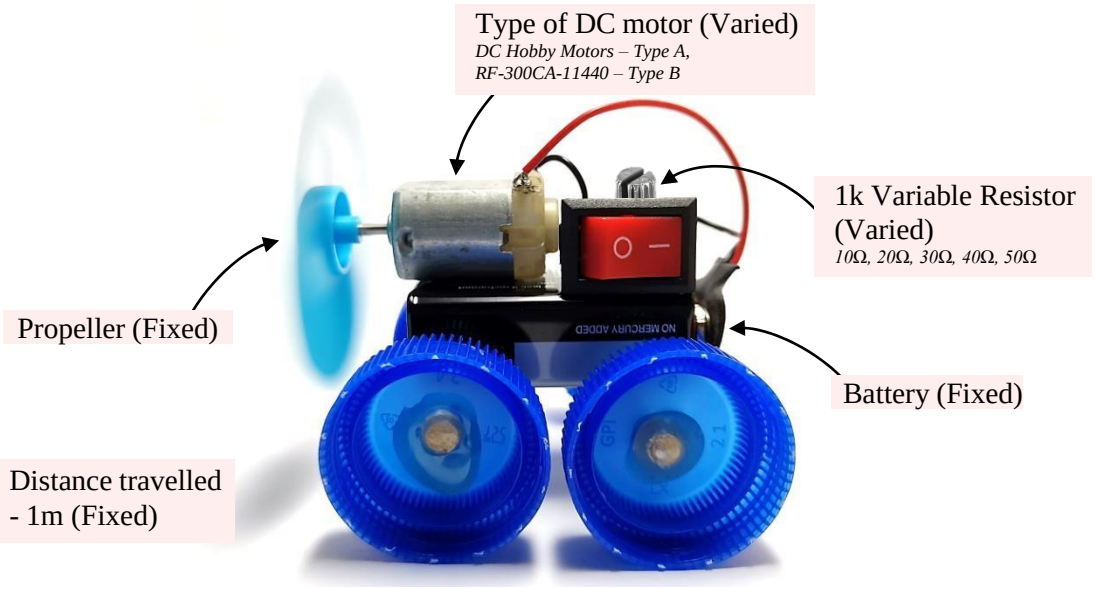


Figure 4.10: Complete Experimental Setup for Propeller Car

Based on the Figure 4.10, there are two parameters that are varied which are DC motors and resistance. Each of a motor resulting in a different rotational speed of the propeller. To calculate the speed of propeller, the time taken of each car with different types of motor to reach 1m destination is measured. Then, calculate the speed of propeller using the speed formula which is, speed (m/s) = distance travelled (m) / time (s). Apart from that, the resistance in the circuit also varies through each experiment in order to achieve the objective of the experiment. Then, the measurement data for each type of motor used is recorded in Table 4.3.

Table 4.3: Performance of Car with Variable Resistance using Motor Type A/B

Resistance (Ω)	Time Taken (s)	Speed (m/s)	Current (mA)	Voltage (mV)
0				
10				
20				
30				
40				
50				

4.5.3 Project C Magnet

The experiment included in Project C Magnet are C1 On – Off. For On – Off Switch, three basic apparatus is needed such as AA battery, a long nail and enameled copper wire. The objective of this experiment is to investigate the performance of electromagnetic strength when the turns of the coil are modified for each different diameter of copper wire. Therefore, two parameters that need to vary are the number of turns and the diameter of copper wire used. Firstly, wind wire around the nail with both ends of wire are long enough to touch with positive and negative terminals of battery. Remove the wire coat by using sandpaper at the ends of wire as shown in Figure 4.11.

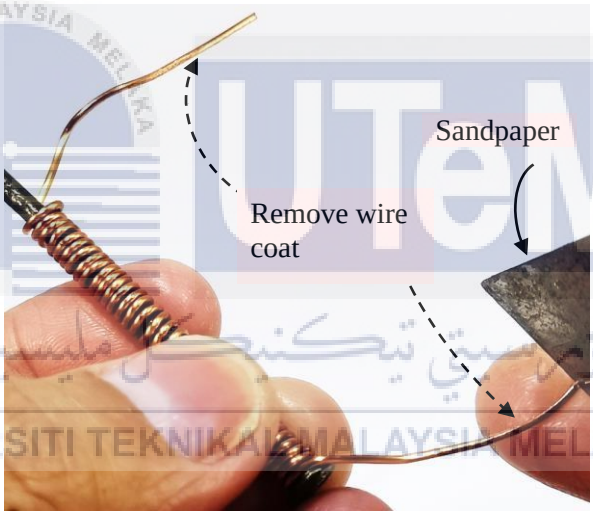


Figure 4.11: Removing Coating Wire using Sandpaper

Literally, there are several ways to remove the wire coat such as scrape off using a sharp knife, burn the wire and many more. This is the crucial part because uncoated wire allows electric current running through it while coated wire prevents the electric current to pass through it. Then, touches the end of the wire to the positive and negative terminals of a battery to build a temporary magnet. At this time, the battery will start getting hotter because the current form battery is running through the coil. The battery might be worn out if it in contact with the coil for a longer

time. Finally, try to attract any metal object to observe the magnetic strength existed in coil and nail. Figure 4.12 shows the complete experimental setup for On – Off Switch.

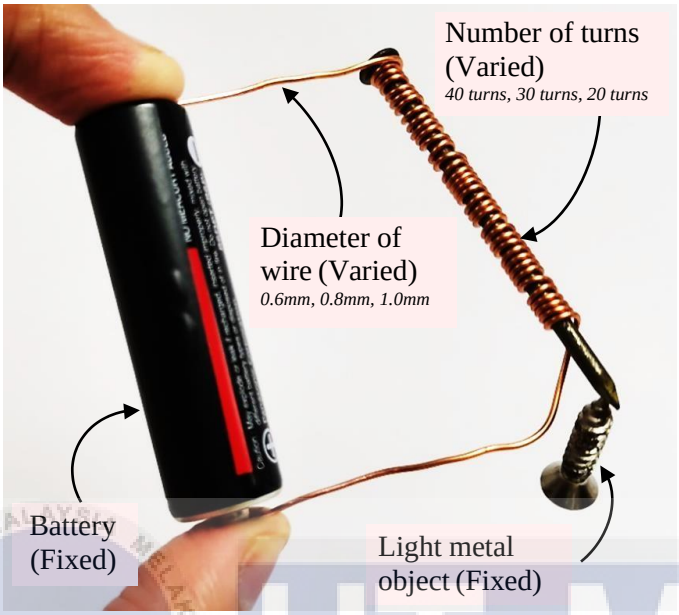


Figure 4.12: Complete Experimental Setup for On – Off Switch

Based on Figure 4.12, the nail that is wrapped with coil becomes a temporary magnet that is capable to attract small and light metal object as long as the battery is connected to the coil. Two parameters are varied to investigate the most effective magnet that can attract high number of metal object chosen for this experiment. The measurement data for each experiment is recorded in Table 4.4 and presented in experimental graph.

Table 4.4: Performance of On – Off Magnet using Different Diameter of Wire

Diameter of Wire: 0.6mm/ 0.8mm/ 1mm

Number of Wire Turns	Current (A)	Number of Paper Clip can it Hold
10		
20		
30		
40		

4.5.4 Project D: Electric Motor

Project D introduces the basic concept of the electric motor through experiment D1 Spinning Coil. For experiment D1 Spinning Coil, there are three simple apparatus that is needed to develop the project which are neodymium magnet, AA battery and insulated copper wire. This project is conducted to observe the effect of varying the number of turns and the number of magnets towards the strength of electromagnetic in the spinning coil. The strength of electromagnetic will be observed through the rotational speed of the coil.

To begin, make a tight coil by wrapping the wire around the battery for about ten turns. The number of turns will be decreasing at each experiment which are eight turns, six turns, four turns and two turns. Apart from that, the battery is used to fix the diameter of the coil. Then, remove the coil from the battery and tie both ends of the wire by winding the excess around the coil a couple of times. Figure 4.13 below shows the coil after removed the insulation at both ends of the excess wire.

Figure 4.13: Coil from Insulation Copper Wire

The insulation at the end of the excess wire is removed to allow the current to flow through the coil. Next, in order to build the connection from the coil to the battery, cut two pieces of wires for about 15cm and remove the insulations at the ends of the wires. The connection wire is used as a medium transmission of voltage source from the battery to the coil.

Then, tape the wires on top of the base or any flat surface for conducting the experiment. The distance between both wires should not be too far and suitable for the length of the battery used as shown in Figure 4.14 below.

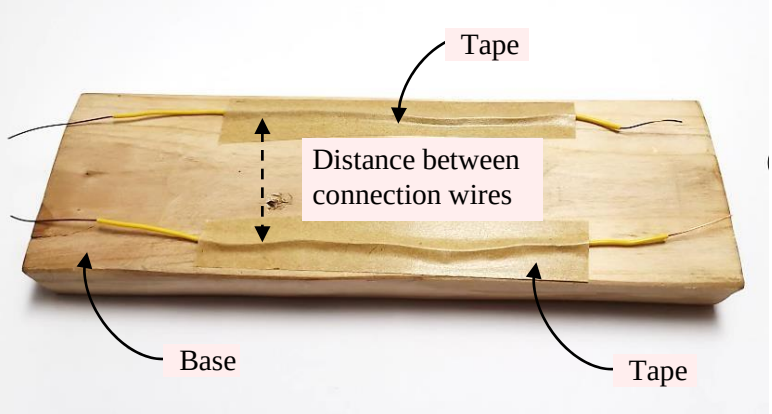


Figure 4.14: Connection Wires on Base

Bend about 90 degrees the one side of connection wire and bend the non-insulated wires into hooks shaped as shown in Figure 4.15 below.

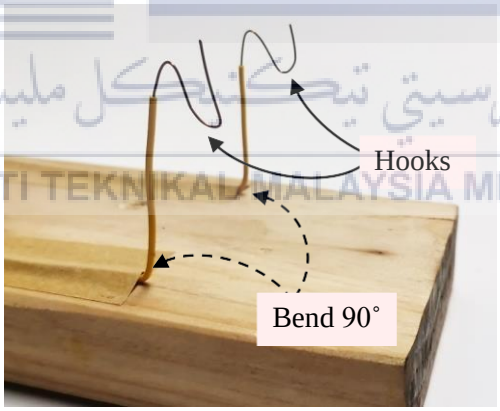


Figure 4.15: Hooks at Non-Insulated Connection Wires

After that, place the coil onto the hooks and the magnets under the coil. The coil and magnets should close but not touch each other. This is because the coil will not be able to rotate if it touches the magnets. Therefore, adjust the height of the hooks for it compatible with the height between magnet and coil.

Finally, connect the other ends of the connection wire to the battery to build the connection in the system. Figure 4.16 shows the complete experimental setup for Spinning Coil.

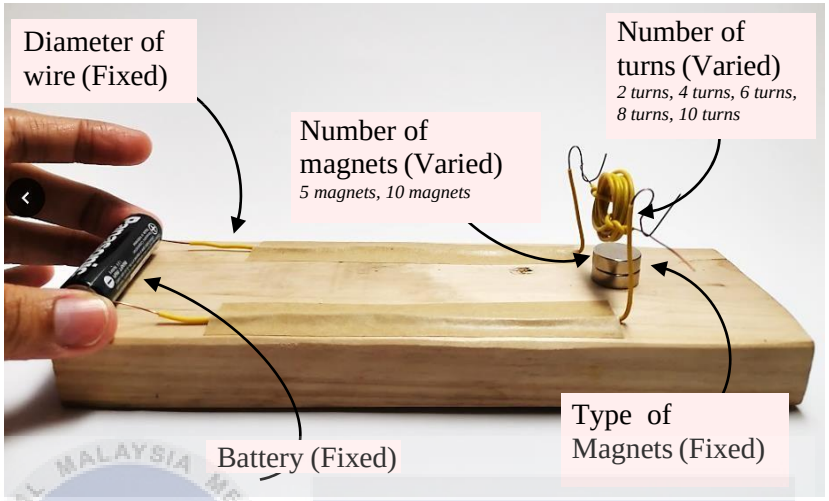


Figure 4.16: Complete Experimental Setup for Spinning Coil

The electric current from the battery creates an electromagnet when it flows through the coil. Meanwhile, the interaction between the motor's magnetic field (permanent magnet) and electromagnet helps to rotate the coil. The speed in rpm of rotational coil per min is measured for each number of turns and the number of magnets. The data is tabulated as in Table 4.5 and presented in the experimental graph.

Table 4.5: Speed Profile with Various Number of Wire Turns

Number of wire turns	Speed (rpm)	
	5 magnets	10 magnets
2		
4		
6		
8		
10		

4.5.5 Project E: Energy

Project E consists of green energy projects which are Pico hydro. The project focuses on generating electricity via renewable energy systems such as water and solar. Experiment E1 Pico Hydro is an experiment that uses the flow of water to light up an LED. The apparatus that is required included a cylindrical plastic container, low voltage DC motor, LED and plastic bottle. The objective of conducting this experiment is to study the relationship between the current generated and the water flow rate. Therefore, two parameters have been varied which are the type of motor used and the flow rate of water.

To construct the water turbine, take the plastic bottle and cut it from the lid until the 'shoulder' part of the bottle. Then, cut the bottle into eight parts and fold each part outward. To build the turbine, fold each part to 45 degrees as shown n Figure 4.17 below.

Figure 4.17: Construction of Bottle Turbine for Pico Hydro

The purpose of folding the bottle turbine is to allow the rotational of turbines when water flows from any domestic pipeline. After that, drill a small hole at the center of the botte cap. The size of the hole should be matched with the size of the motor shaft. For the body part, drill the same size of the hole on the side of the plastic container and insert the shaft motor into the hole along with the gear so that it will hold the motor to the plastic container.

Then, attach the bottle turbine to the shaft motor through the small hole at the center of the bottle lid. Secure the bottle turbine by applying adhesive to the bottle lid. Figure 4.18 shows the construction of bottle turbines attached to motor shaft.

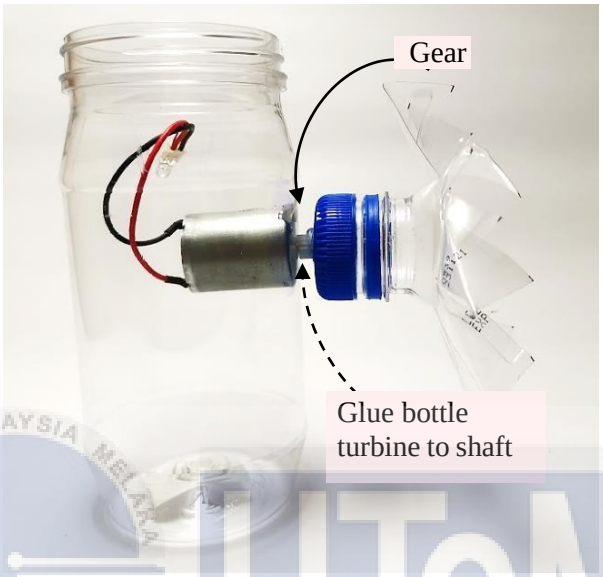


Figure 4.18: Attachment of Bottle Turbine to Motor Shaft

Next, use solder to connect the LED to the DC motor. Drill a second hole at the other sides of plastic container as shown in Figure 4.19.

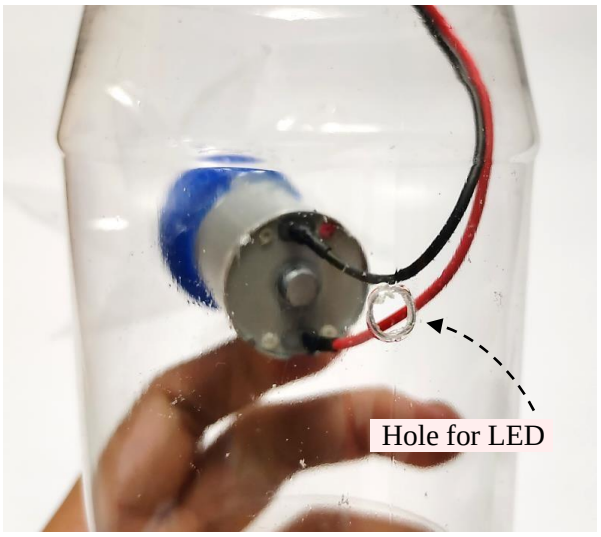


Figure 4.19: Second Hole for LED

Ensure that the size of the hole is compatible with the size of LED. Use adhesive to attach the LED to the hole and close the lid. Lastly, run water onto the bottle turbine. The LED starts to lighting up once the turbine starts to rotate. Figure 4.20 shows the complete setup for Pico hydro.

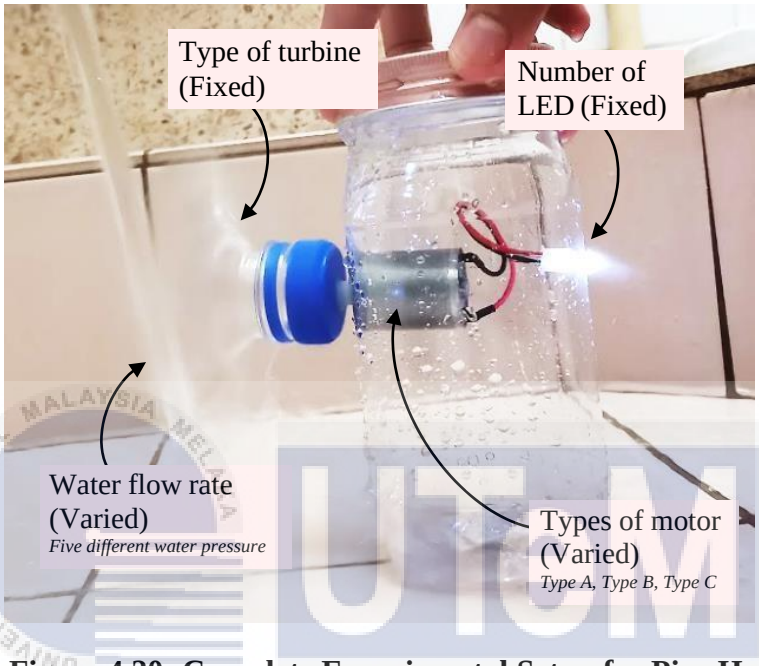


Figure 4.20: Complete Experimental Setup for Pico Hydro

The LED starts to light up according to the different water flow rate and the type of motor used. This shows the dissimilar of each performance of motor used with different pressure of water flows onto the turbine. Measure and record the data according to the Table 4.6 below. After that, repeat the experiment with five different water flow rates for Motor A, Motor B and Motor C.

Table 4.6: Experiment Data for Pico Hydro

Parameter	***Motor A***	***Motor B***	***Motor c***
Flow rate (ℓ/s)			
Current (A)			
Voltage (V)			
Power (W)			

4.6 Summary

In conclusion, the electrical engineering learning kit consists of five mini electrical projects covering five groups of projects which are electricity, electrical application, magnet, electric motor and energy. All topics are listed based on the research and the syllabus from the electrical curriculum in school and electrical subjects for diploma and degree level. After listed out the topics selected, the apparatus to be used is identified to develop the hardware project. This is to make sure the process of developing the hardware project went smoothly and successfully.

Each of the experiments comes with the objective to be achieved in order to understand the basic concepts of the topics related. Apart from that, all the experiments emphasize more on psychomotor domains in developing electrical engineering projects practically so that students gain clearer and more practical understanding.

Upon developing the project, the process of recording the procedures and the results of the project is recorded in the finding report and by video. The video project will be inserted into the QR code generate to generate the new QR code for each project. Therefore, step by step will be followed accurately to obtain the experimental result.

CHAPTER 5

RESULT AND ANALYSIS

5.1 Introduction

This chapter discusses the project results and gives deeper explanation regarding the performance of the ten mini electrical projects based on the experimental results. In addition, the analysis of each projects also provided for further understanding.

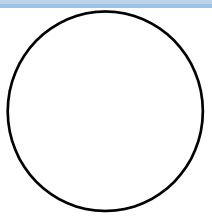
Generally, there are two types of parameters that need to emphasize when conducting an experiment which are; fixed parameter and variable parameter. The fixed parameters are held during the experiment and remain constant until the end of the experiment. On the other hand, variable parameters are changed through each experiment. Both parameters influence the output or results upon completing the experiments.

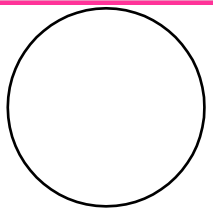
All data from the experiment will be measured and recorded in the table to observe the performance of each parameter. Then, the recorded data will be presented in an experimental graph for clear understanding. The technical aspect or analysis of each experiment will be discussed based on the theory and experimental result.

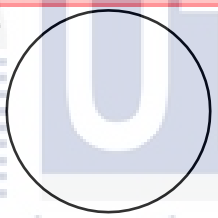
5.2 Final Development

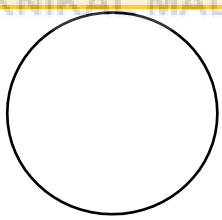
As mentioned, there are five mini electrical projects in total. All the projects involved in hardware development with technical discussion. Hence, in this section, the analysis results for each project will be elaborated according to the topics related to the projects. Each topic consists of two mini electrical projects. Table 5.1 shows the list of projects and Table 5.2 consists of QR code for video project. Each project emphasizes more on psychomotor domains so that new beginners in the field of electrical engineering, gain clear and more practical understanding.

Table 5.1: List of Projects

PROJECT A: ELECTRICITY

A1 Magic LED

PROJECT B: ELECTRICAL APPLICATION

B1 Propeller Car

PROJECT C: MAGNET

C1 On-Off Switch

PROJECT D: ELECTRICAL MOTOR

D1 Spinning Coil

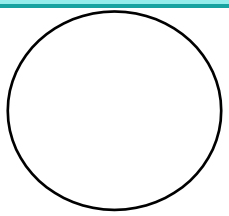
PROJECT E: ENERGY

E1 Pico Hydro

Table 5.2: QR Code for Video Project

PROJECT A: ELECTRICITY
A1 Magic LED

PROJECT B: ELECTRICITY APPLICATION
B1 Propeller Car

PROJECT C: MAGNET
C1 On-Off Switch

PROJECT D: ELECTRICAL MOTOR
D1 Spinning Coil

PROJECT E: ENERGY
E1 Pico Hydro

5.3 Project A: Electricity

The electrical project included in this topic is; Magic LED. A short description is given to provide an overview of each projects along with the finding results.

Experiment A1 Magic LED is a project that showed a basic electrical connection without using a wire as a transmission medium. The graphite pencil act was used as a conductor that enable the electric current from battery to flow through to the LED to light it up.

5.3.1 Magic LED

A copper wire is normally used as a conductor to connect the components in an electrical circuit. Copper wire is a type of metal that has low level of resistivity to electrical currents which made it an excellent conductor. Basically, a conductor with lower level of resistivity does not need high power source to push the current through. Figure 5.1 shows electrical wires inside an electrical cord and pencil lead.

Figure 5.1: Similarities of Electrical Wires inside an Electrical Cord and Pencil Lead.

Magic LED is a simple project that shows a different way to light up the LED by using a pencil, specifically pencil lead. Pencil lead is made of graphite which is a form of carbon and in a group of electrical conductors. As a conductor, it allows the electricity to pass through it. However, it has a larger resistance than a normal metal wire. Meanwhile, materials that does not allow the electricity to pass through it is referred to as insulator.

In this experiment, there are two parameters that have been varied which are length and width of graphite line. Whereas the fixed parameters are graphite grading of pencil – 2B grade pencil, battery (voltage supply) and type of LED used. The objectives of this experiment are to measure the output voltage and current and observe the effect of size of graphite line towards the brightness of LED. Figure 5.2 until 5.6 shows the results of each experiment which are according to different width of graphite line.

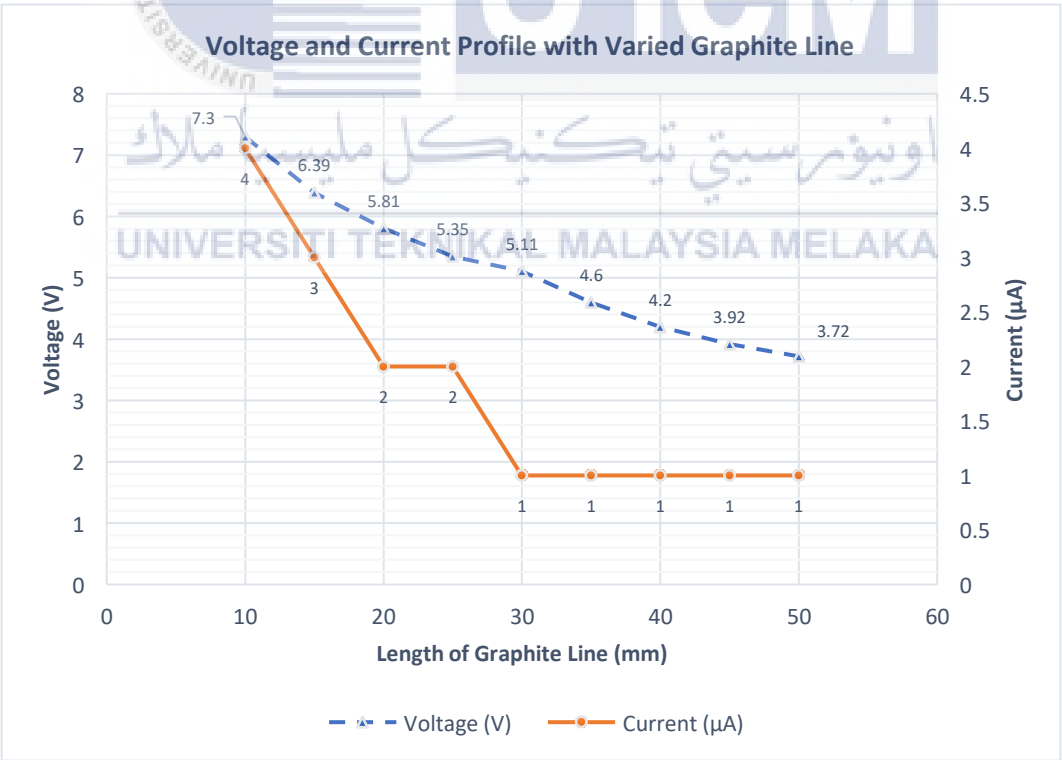


Figure 5.2: Magic LED's Performance during Graphite Line 2mm

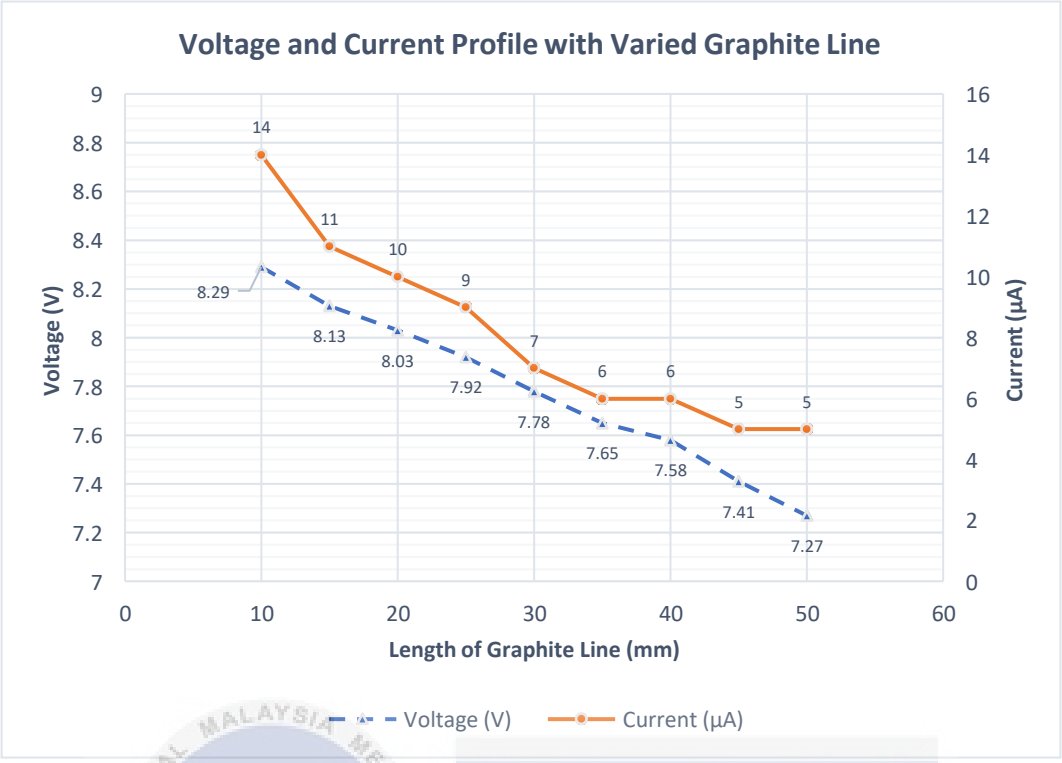


Figure 5.3: Magic LED's Performance during Graphite Line 4mm

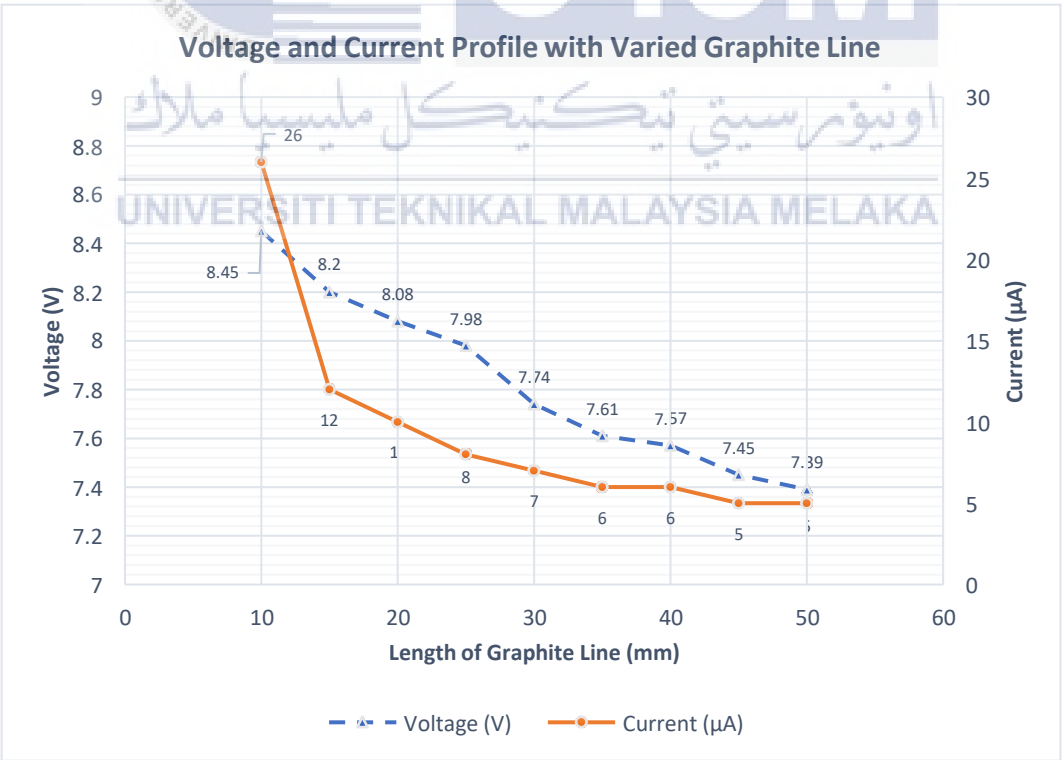


Figure 5.4: Magic LED's Performance during Graphite Line 6mm

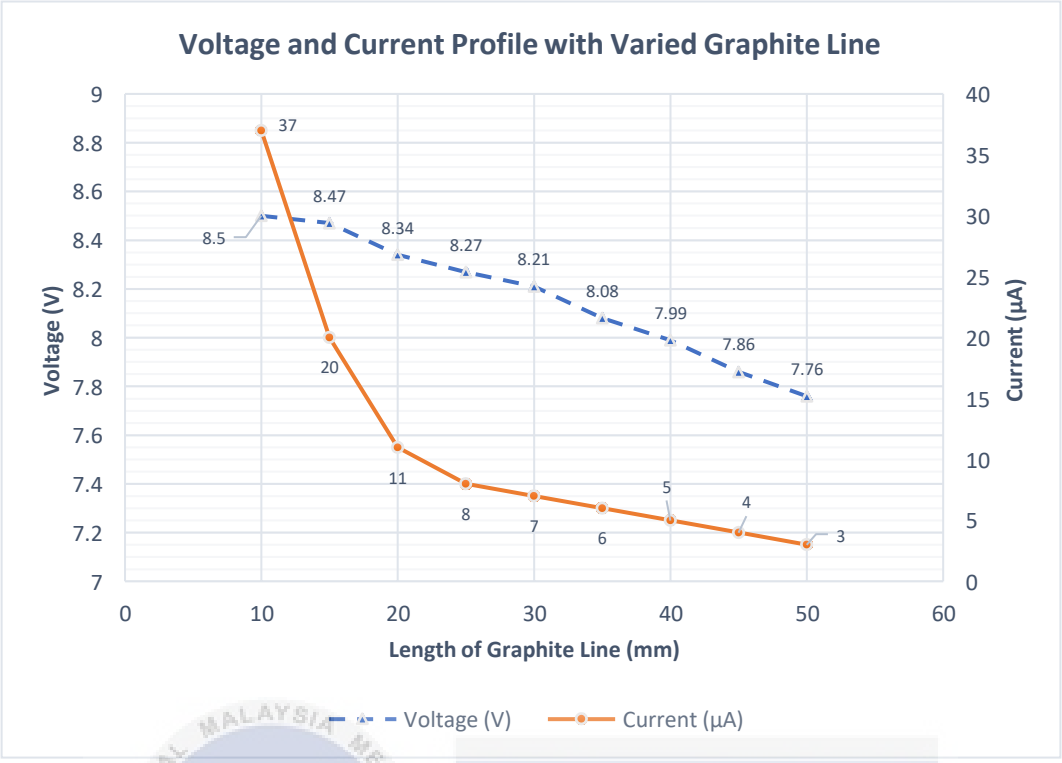


Figure 5.5: Magic LED's Performance during Graphite Line 8mm

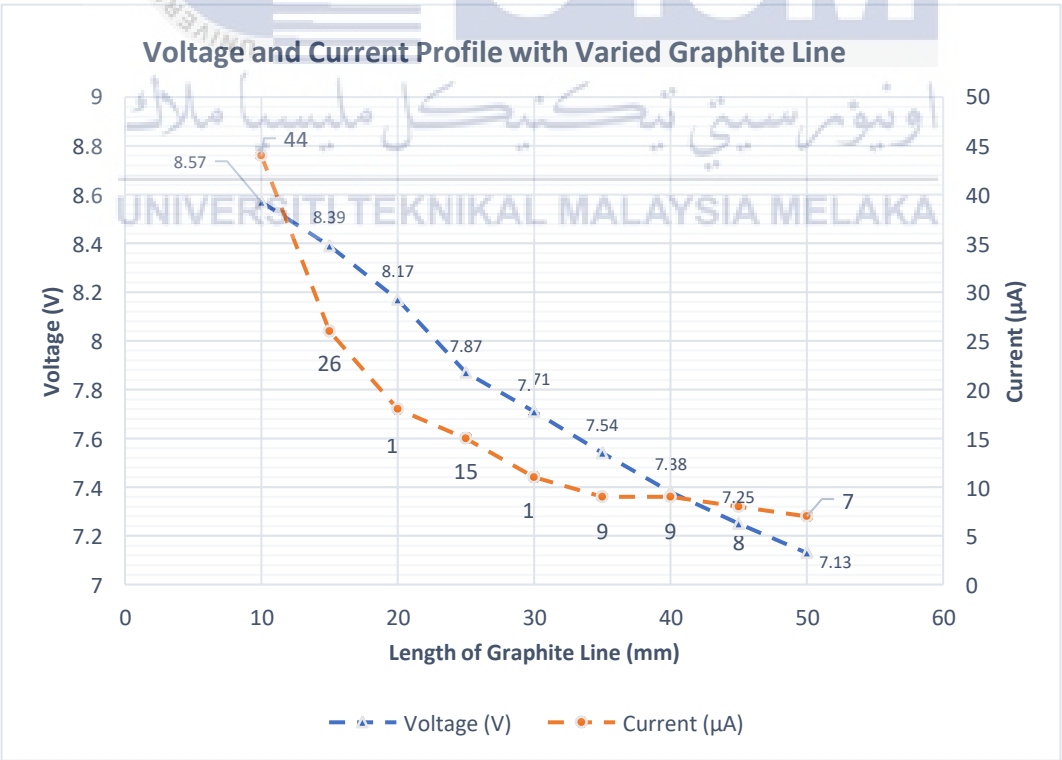


Figure 5.6: Magic LED's Performance during Graphite Line 10mm

From the results, we can see that the LED reached the highest voltage and current at the thickest and the shortest graphite line. The voltage is decreasing as the graphite line becomes thinner. Meanwhile, the current decreases when the length of the graphite line increased. Hence, we can conclude from the experimental result that, the LED is brightest when the size of graphite line is 1.0 x 0.2 m. In conclusion, the thicker the size of the drawn line, the better the conductance of electricity, the brighter the LED will be. While the thinner the size of the drawn line, the higher the electrical resistance, the dimmer the LED will be.

Basically, an electric current flow when the electrons move through a conductor. The moving electrons may collide with the ions in the conductor, in this case; graphite line, which causes the existence of resistance to the flow of an electrical current. This affects the brightness of LED as well as the voltage and current drop across the LED.

The resistance of a thin graphite line is greater than the resistance of a thick graphite line as thin wire has less electrons to carry the current. Thicker graphite line has more electrons since the size of the line is bigger and vice versa. Therefore, the relationship between resistance and area of the cross section of graphite line is inversely proportional. Figure 5.7 illustrates the cross sections of graphite line for further understanding.

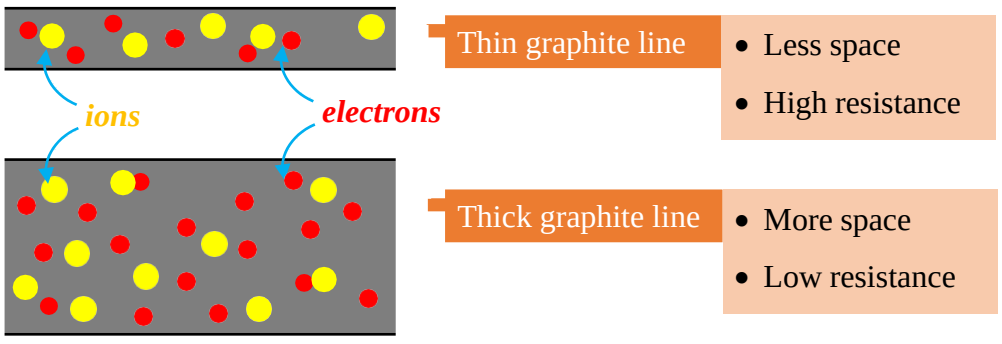


Figure 5.7: Cross Sections of Graphite Line

As for the length of graphite line, the resistance become greater in a long wire because electrons collide with more ions when they pass through and vice versa. To sum up, the relationship between resistance and length of graphite line is proportional with each other.

5.4 Project B: Electricity Application

The electrical project included is; Propeller Car. A short description is given to provide an overview of each projects along with the finding results.

Experiment B1 Propeller Car is a D.I.Y. toy car project that uses components such as DC motor, switch, battery, and propeller. Once the switch is turned on, the current from the battery is supplied to the DC motor and rotates the propeller. The propeller, attached to the motor shaft, helps to moves the car as it pushes the air backward.

5.4.1 Propeller Car

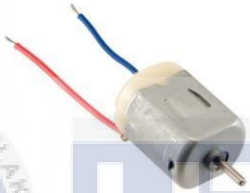
The propeller car uses components such as 1k variable resistor, electric motor, switch and battery, recycled materials, and propeller. The propeller is mounted at the back of the car and rotates along with the motor shaft when the switch is turned on. The propeller pushes the air and pushing the car forward. As for this project, there are two types of DC motors that is used.

The battery that is connected with DC motor stores chemical energy and converts it to electrical energy. The chemical reactions in the battery provide the electric current for the DC motor. Then, motor uses the electrical energy and converts to mechanical energy which rotates the motor's shaft and propeller. Once propeller rotate, it will create an artificial wind and simultaneously moves the car.

It is important to note that, the direction of the wind and the car is not the same. This is related to Newton's third law of motion; every action has an equal and opposite reaction. The magnitude of the force for the first object is equal to the magnitude of the second object but in different direction.

As for this project, there are two types of DC motors that is used. The following DC motors and its specifications as shown in Table 5.3.

Table 5.3: Type of DC Motor Used and its Specifications

	Type A	*Type B*
Photo		
Manufacturer	DC Hobby Motors	RF-300CA-11440
Voltage range	3 – 6V	0.7 – 5V
Loaded Current	250 mA max	55 mA max
Loaded Speed	4500 ± 1500 rpm	1600 rpm

This experiment is conducted to measure the time taken for each car to reach the destination at 1m distance from initial point. At the same time, the voltage and current drop in the circuit also have been measured. Then, the speed of propeller rotates have been calculated using formula for speed; speed (s) = distance traveled (d) / time taken (t). The units will be in metres per second (m/s). Then, the experimental result when there is no resistance is recorded in Table 5.4.

Table 5.4: Performance of Car when No Resistance

	Hobby - Type A	*Rf1234646 - Type B*
Time taken (s)	2.28	2.73
Speed (m/s)	0.439	0.366
Current (mA)	583	187
Voltage (mV)	7.9	0.1

Data collection from Table 5.4 shows that propeller car with motor A is faster than motor B. The distance traveled by both cars is the same, but the time taken to reach the destination is different. Car with motor A has higher current and voltage drawn from nine-volt battery which gives more speed and for the car to reach the destination.

Next, a 1k variable resistor is added to the car to observe the performance of the speed of car using two types of motor. The resistance is varied from 10Ω until 50Ω and the measured data is collected and presented in Table 5.5 and Table 5.6 below. Figure 5.8 and Figure 5.9 shows the relationship between the time taken for the car to reach 1m destination and speed using two different motor.

Table 5.5: Performance of Car with Variable Resistance using Hobby – Type A

Resistance (Ω)	Time Taken (m/s)	Speed (m/s)	Current (mA)	Voltage (mV)
0	2.28	0.439	583	7.9
10	2.43	0.412	569	7.15
20	3.03	0.33	481	6.43
30	3.54	0.282	425	6.09
40	4.1	0.244	339	5.4
50	4.47	0.224	261	4.15

Table 5.6: Performance of Car with Variable Resistance using RF1234646 – Type B

Resistance (Ω)	Time Taken (m/s)	Speed (m/s)	Current (mA)	Voltage (mV)
0	2.73	0.366	187	0.1
10	2.92	0.342	165	0.08
20	3.34	0.299	152	0.053
30	3.87	0.258	121	0.032
40	4.9	0.204	98	0.039
50	5.67	0.176	76	0.016

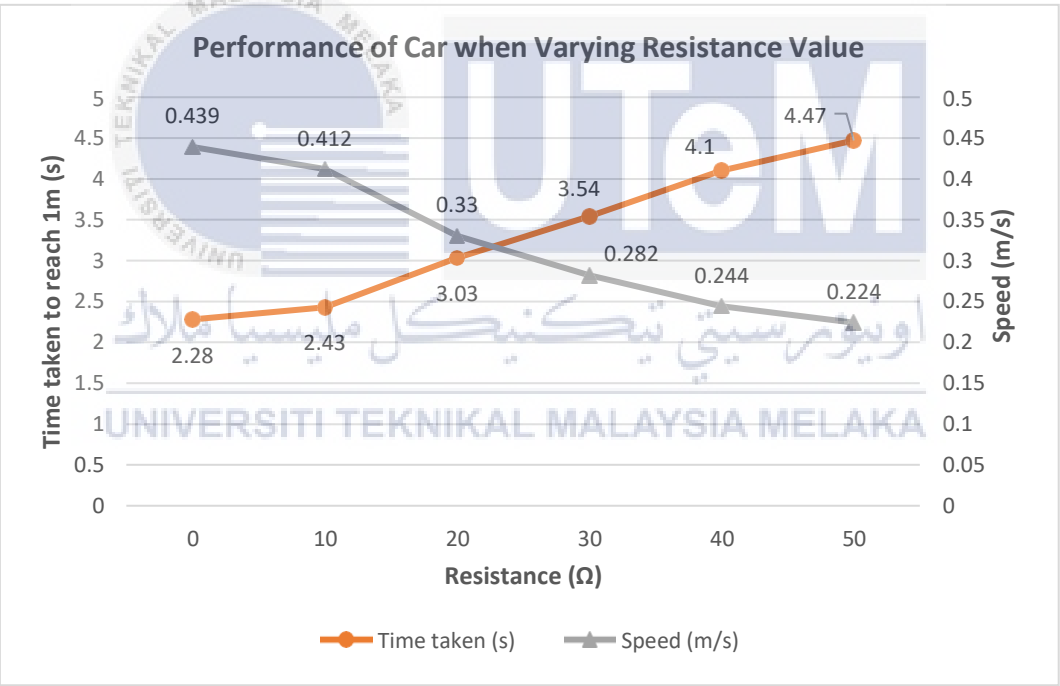


Figure 5.8: Performance of Car using DC Motor Hobby – Type A

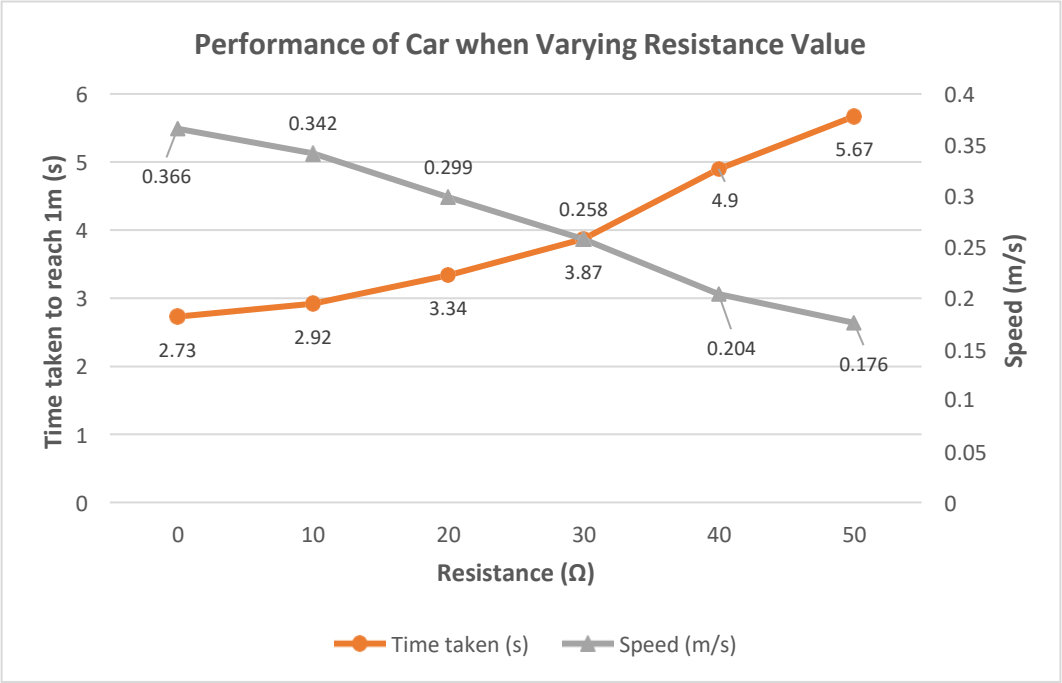


Figure 5.9: Performance of Car using DC Motor RF1234646 – Type B

Both motor A and B are permanent magnet DC motor which uses a permanent magnet to create field flux. Therefore, it has a wide range of speed and better speed regulation. However, what is the reason that makes the motors appears different performance even they had received same voltage supply?

Basically, there are few characteristics that need to emphasize when selecting a DC motor and the most crucial are voltage, current and speed (rpm). Voltage helps net current flows in one direction and to overcome back current. Motor with high voltage will increase the torque which is the turning force that runs the motor. As for current, the operating and stall current are important which prevents the damage in motor if there are too much current drawn. Loaded current is the maximum value of current that is draws from source. Lastly, speed (rpm) will influence the power generated by motor. Normally, motor with highest speed is the most efficient. Loaded speed will determine how fast the shaft will turn when load is added to the motor.

5.5 Project C: Magnet

The electrical project included in this topic is; On-Off Switch. A short description is given to provide an overview of each projects along with the finding results.

The experiment C1 On – Off Magnet is a D.I.Y. temporary magnet powered by electricity. This project introduces the concept of electromagnetic, where magnets can be made using a coil and allowing a flow of current through it. As long as there is current flowing, the coils become a magnet.

5.5.1 On – Off Magnet

The On – Off Magnet applies the concept of electromagnetic to develop a device that works just like an ordinary magnet. The electromagnet is a temporary magnet that can be turned on and off using a switch. The magnetic field is produced by an electric current that is passed through a coil of wire wrapped around a metal core. The metal becomes a magnet when electricity runs through it. Figure 5.10 shows the illustrations of how current flows through coil.

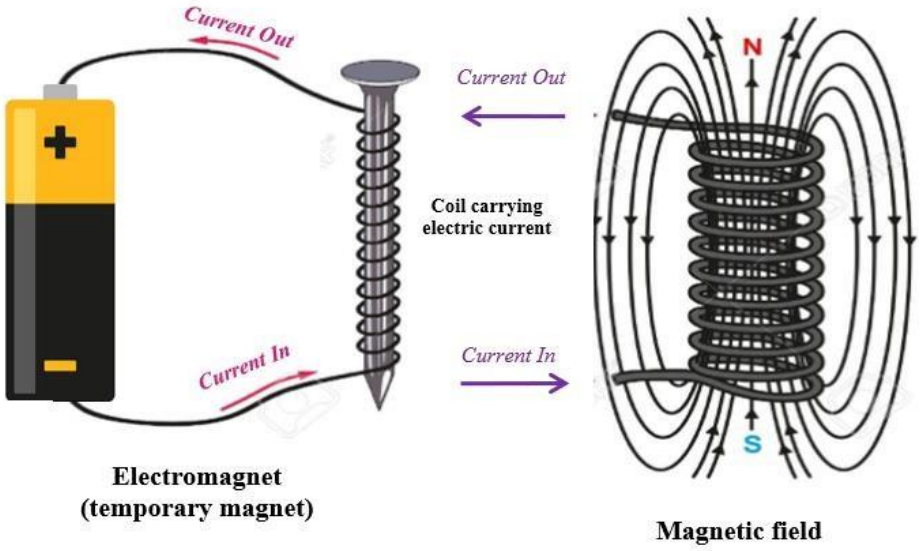
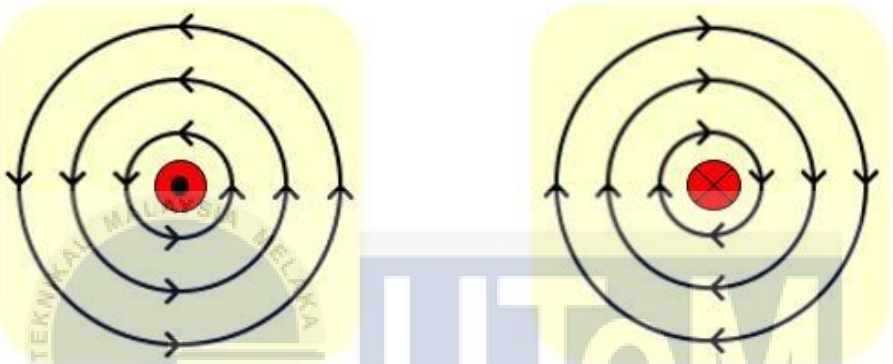


Figure 5.10: Flow of Current through Coil

A wire that has the electrical current running through it creates a magnetic field around the wire. The simplest electromagnet is a single wire that is coiled up and an electric current running through it. The magnetic field will disappear when the current is discontinued. The magnetic field generated by the coil of wire is like a bar magnet. If we put an iron rod (nail) through the center of the coil, the nail also becomes the magnet. Figure 5.11 below shows the direction of electric current flow through the wire.



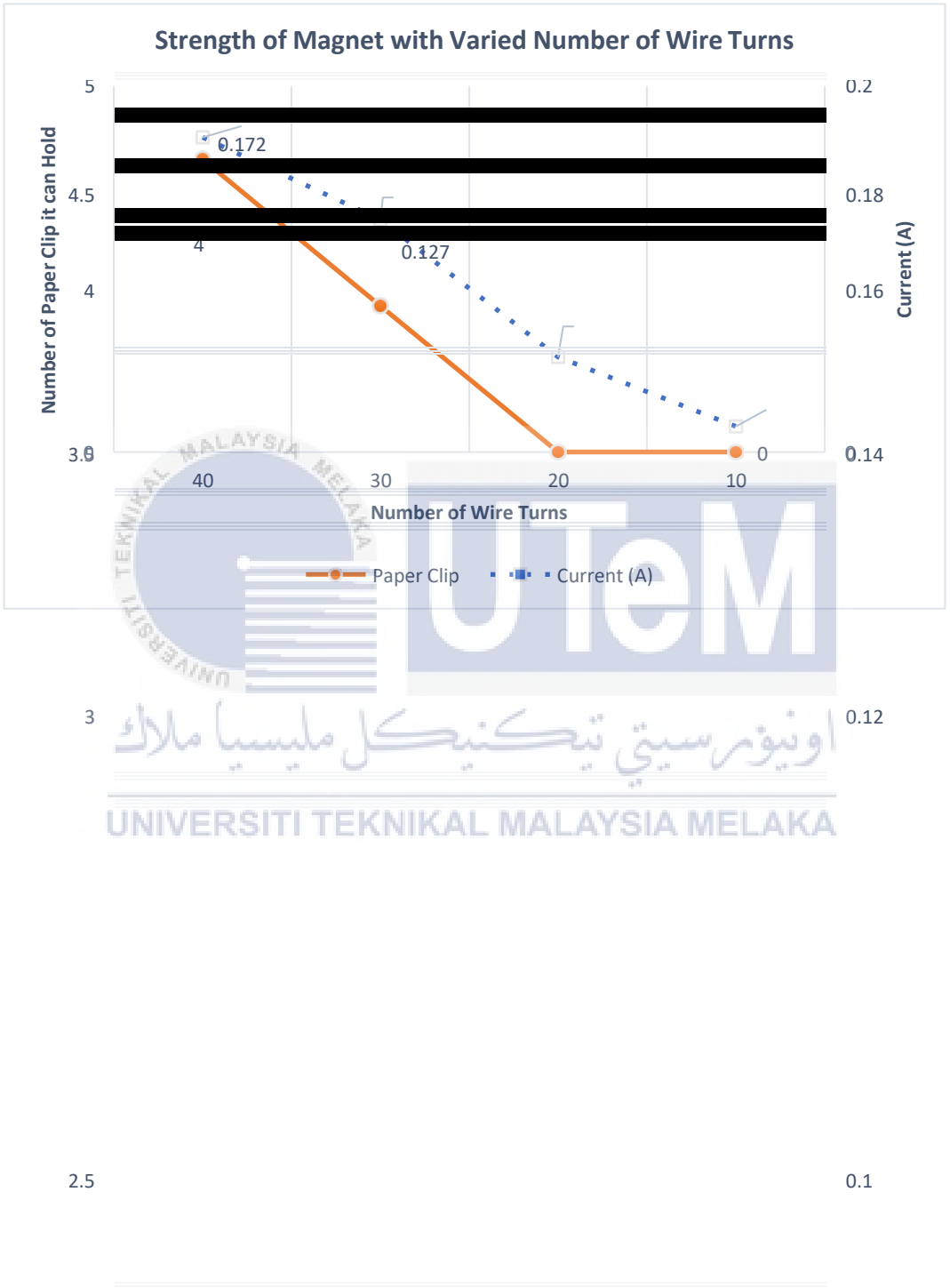
Type - A *Type - B*

Figure 5.11: Direction of Electric Current

Figure 5.11 illustrates the direction of electric current. For Type – A, it shows that when an electric current flow directly towards you, the magnetic field created by it circles around the wire in a counter-clockwise direction. Meanwhile, when the direction of the electric current is entering the node (recircle), the magnetic field circles around the wire in a clockwise direction.

As for this experiment, the number of wire turns is varied for a different diameter of copper wire such as 0.6mm, 0.8mm and 1.0mm. These two parameters influence the strength of magnetic field which measured by the quantity of paper clip attracted to the magnet (nail) when battery is connected to coil or how many paper clip that can be hold by the magnet.

Figure 5.12, 5.13 and 5.14 presents the experimental results for three differences diameter of copper wire.



2	2	0.08

0.052

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

0.5 0.02

Figure 5.12: Magnet Performance when Diameter of Copper Wire is 0.6mm

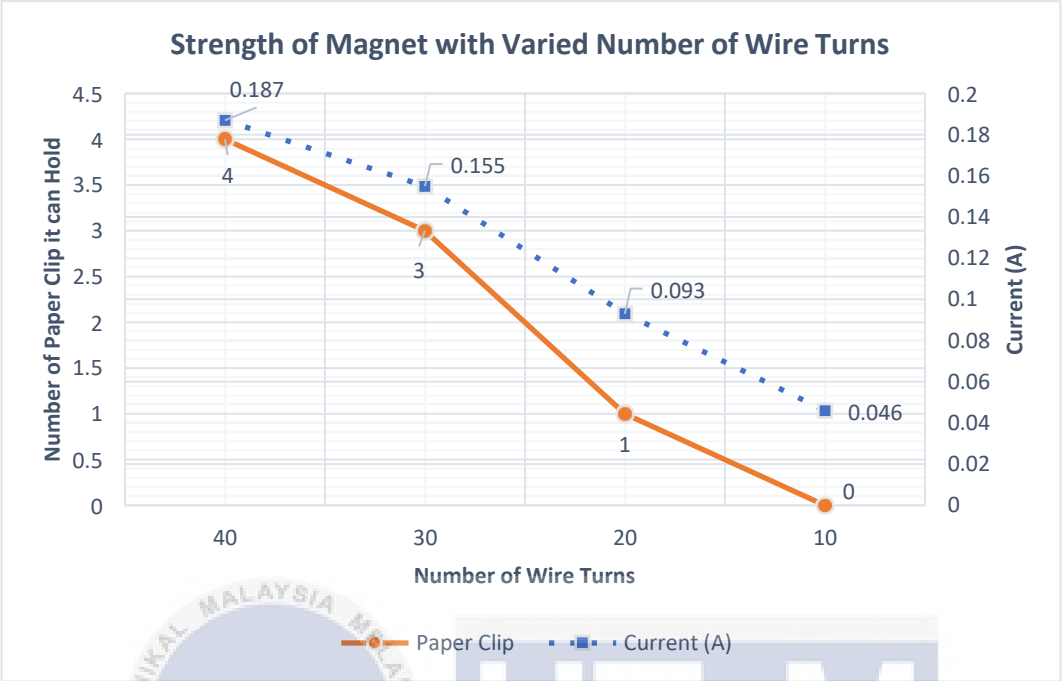


Figure 5.13: Magnet Performance when Diameter of Copper Wire is 0.8mm

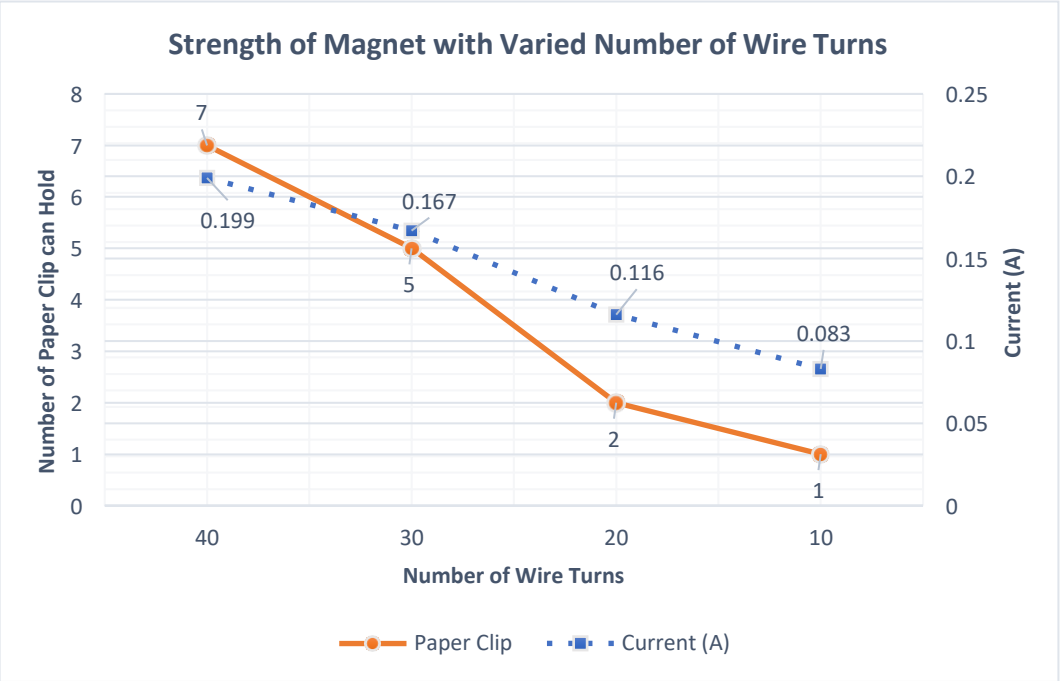


Figure 5.14: Magnet Performance when Diameter of Copper Wire is 1.0mm

Based on the graph, it can be seen that the copper wire with diameter 1.0mm have the better performance among the copper wire with diameter 0.8mm and 0.6mm. The device is capable to hold until seven paper clips at the maximum current 0.199A. Then, the number of paper clips it can hold starts to decrease as the number of wire turns decrease until ten turns. Besides that, the copper wire with diameter 0.6mm is the lower strength of magnet among the other wires because the device not able to hold any paper clip when the current at 0.052A and below. Same with that, the copper wire with 0.8mm also uncapable to hold any paper clip when the current at 0.046A and below.

To conclude, the magnetic field can be made stronger by increasing the number of wire turns in the coil of the electromagnet or use the thicker copper wire. The other way that can be use is increases the amount of electric current going through the wire.

5.6 Project D: Electric Motor

The electrical project included in this topic is; Spinning Coil. A short description is given to provide an overview of each projects along with the finding results.

Experiment D1 Spinning Coil is a simple electric motor. It operates through the interaction between the motor's magnetic field (permanent magnet) and electric current in a coil (electromagnet). The interaction an alternation of push and pull action. As a result, the coil rotates and eventually spins due to entire pushing and pulling activity.

5.6.1 Spinning Coil

The Spinning Coil is an electric motor that consists of two types of magnets that are permanent and temporary magnets. The temporary magnet also known as an electromagnet is produced by when current flows through a coil. The interaction between the magnetic field of the permanent magnet and the electromagnet, will cause the coil to spin.

In this experiment, the types of magnets and wire used in this experiment are fixed whereas the number of wire turns and magnet is varied. This experiment is conducted to observe how the changes at the number of wire turns and magnet affect the speed of rotational coil. Moreover, this project shows the basic construction of an electric motor. The motor converts electrical energy into mechanical energy, and it works on the principle of Fleming’s Left-Hand Rule.

Most electric motors operate through the interaction between the motor's magnetic field (permanent magnet) and electric current in a coil (electromagnet) to generate force in the form of rotation of a shaft. As they interact, they will alternate between "liking" each other (pulling together), and "disliking" each other (pushing away from one another).

All that pushing and pulling will create some serious spinning and that is precisely what a motor is, a spinning axle. The illustrations of Spinning Coil as shown in Figure 5.15.

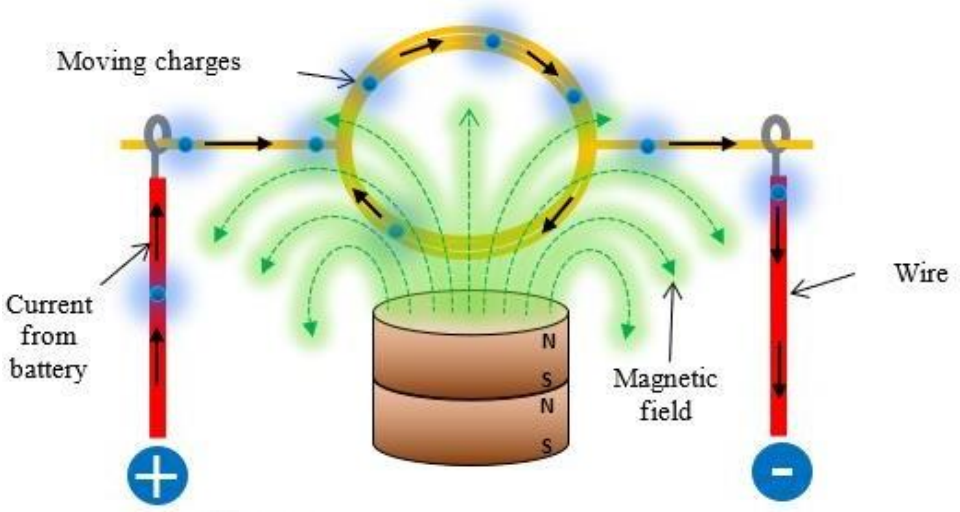


Figure 5.15: Illustration of Spinning Coil

Referring to Figure 5.15, the current from the battery flows through the coil turning into an electromagnet. Since the loop is in a magnetic field of permanent magnets, the moving charges in the coil wire will be affected by the force of the magnetic field. The charges at the top of the coil that is moving to the right will feel a force pushing forward. While the charges at the bottom of the coil that is moving to the left will feel a force pushing the other way. These forces make the coil turn, and the process continues as long as the interaction exists. The pushing and pulling activity between the magnets generate force and results in the rotation of a coil.

The measurement data is presented in Table 5.7. Then, the measurement data is presented in experimental graph to investigate the performance of the spinning coil as shown in Figure 5.16.

Table 5.7: Speed of Rotational Coil for each Number of Turns

Number of turns	*Speed (rpm)*	
	5 magnets	*10 magnets*
2	10	13
4	11	15
6	16	20
8	9	12
10	1	4

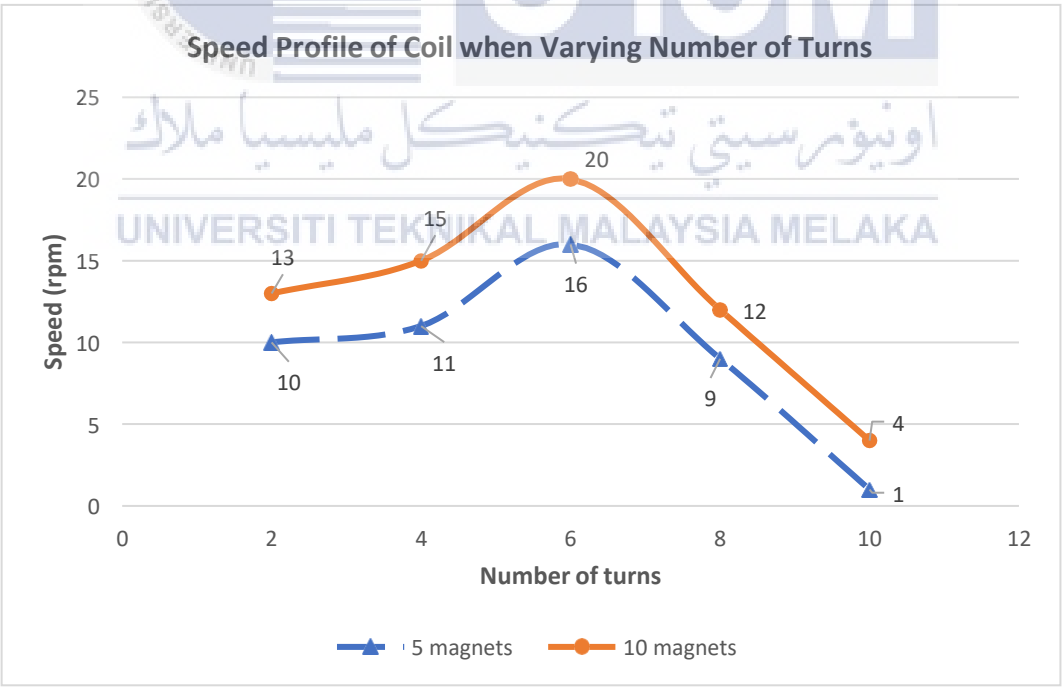


Figure 5.16: Speed Profile of Different Number of Magnets with Varied Number of Turns

Based on Table 5.7 ang Figure 5.16, the coil with eight turns shows the highest speed for both five and ten magnets. Meanwhile, the coil with ten turns rotates slowest among the other turns. Theoretically, the higher number of turns will increase the rotational speed of the spinning coil. However, the additional number of turns will increase the weight of the coil. Thus, a higher force is required to lift the coil otherwise more force is needed to lift the coil. This is because the lower number of turns has the highest speed. Therefore, the coil with six turns is the effective number of turns since it has the highest total rotation per minute showing that the coil is in the fastest rotational speed.

5.7 Project E: Energy

The electrical project included in this topic is; Pico Hydro. A short description is given to provide an overview of each projects along with the finding results.

Experiment E1 Pico Hydro is a renewable energy project that generates electricity using water flow. This system converts potential energy from the flowing water to rotate the water turbine and finally producing electricity by the generator. The electricity then is used to light up the LED.

5.7.1 Pico Hydro

Pico hydro is a term used for hydro system that capable of generating electrical power less than 5kW. It is useful in small, remote communities that require only a small amount of electricity. A typical Pico hydro system is setup with a run-of-the-river approach. Meaning that dams are not required, only water pipes to divert water flow to hit the water turbine before returning it to the water stream.

Pico Hydro uses the flow of water to light up an LED. This project converts potential energy from the flowing water to mechanical energy. The mechanical energy drives the water turbine and rotates the shaft generator.

The rotation of the shaft generates electrical energy thus lighting up the LED. Figure 5.17 describes the energy conversion in Pico hydro system.

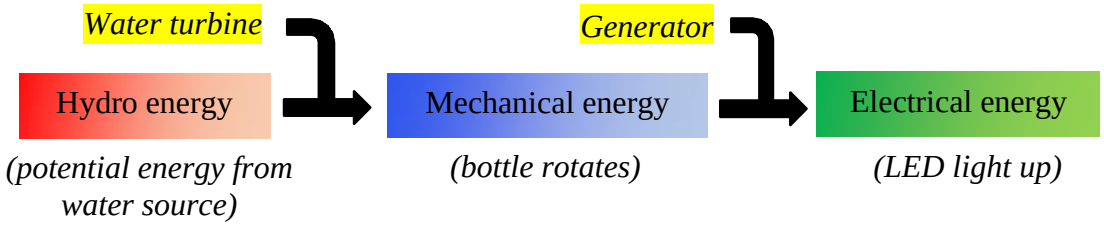


Figure 5.17: Energy Conversion in Pico Hydro System

In this experiment, there are three different types of motor that have been varied. The idea is to investigate the performance of all motors towards the electricity generated with different level of water pressure that rotates the turbine attach to motor shaft. Table 5.8 below shows the type of DC motor used in this experiment.

Table 5.8: Type of Motor Used

	DC Motor – Type A	***DC Motor – Type B***	***DC Motor – Type C***
Photo			
Manufacturer	RF-300CA-11440	Electronic Spices	DC Hobby Motors
Voltage range	0.7 – 5V	3 – 5V	3 – 6V
Loaded Current	55 mA max	200 mA	250 mA max
Loaded Speed	1600 rpm	2000 rpm	4500 ± 1500 rpm

To begin, the arrangement of Pico hydro system has the same concept and basic setup of a hydropower system. The Pico hydro power is harnessed by a water turbine made of a plastic bottle. And this water turbine is connected to the motor's shaft. The water source from the domestic pipeline has potential energy that causes the turbine to rotate and at the same time turn the shaft of the motor. The rotation of the of motor's shaft produces electricity. In summary, the water turbine converts the kinetic energy of the water source into mechanical energy and finally generate electrical energy. And the electricity is capable to light up an LED.

The electricity generated is proportional to the volume of water flow and the pressure of water. Higher volume and pressure of water flow hitting the water turbine, the faster the turbine rotates. The faster the turbine rotates; the faster the motor's shaft rotates and the higher the electricity is generated. Therefore, in this experiment, the objective is to investigate the effect of the volume of water flow and the pressure of water to amount of electricity generated using two different types of motor. The measurement of data is recorded and presented in graph as shown in Figure 5.18, 5.19 and 5.20.

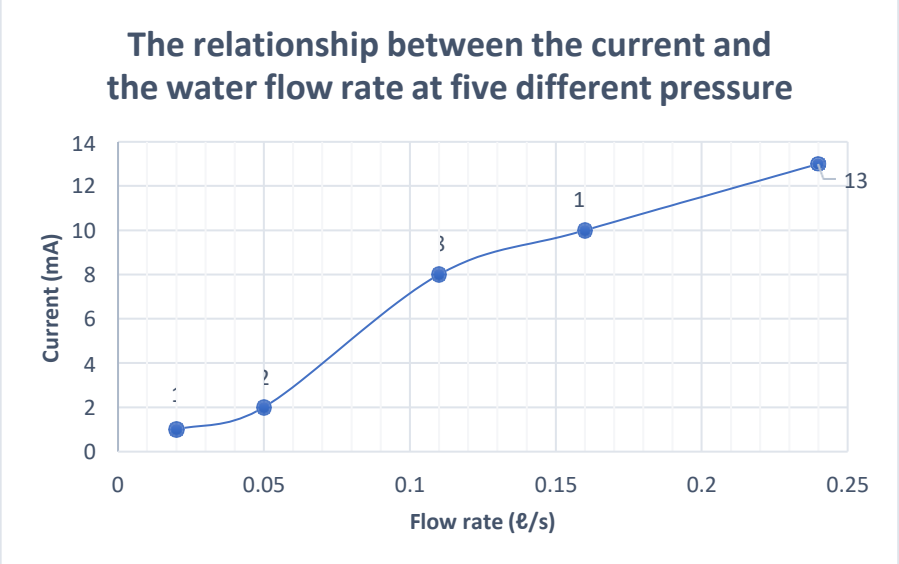


Figure 5.18: Current Generated at Five Different Pressure using Motor A

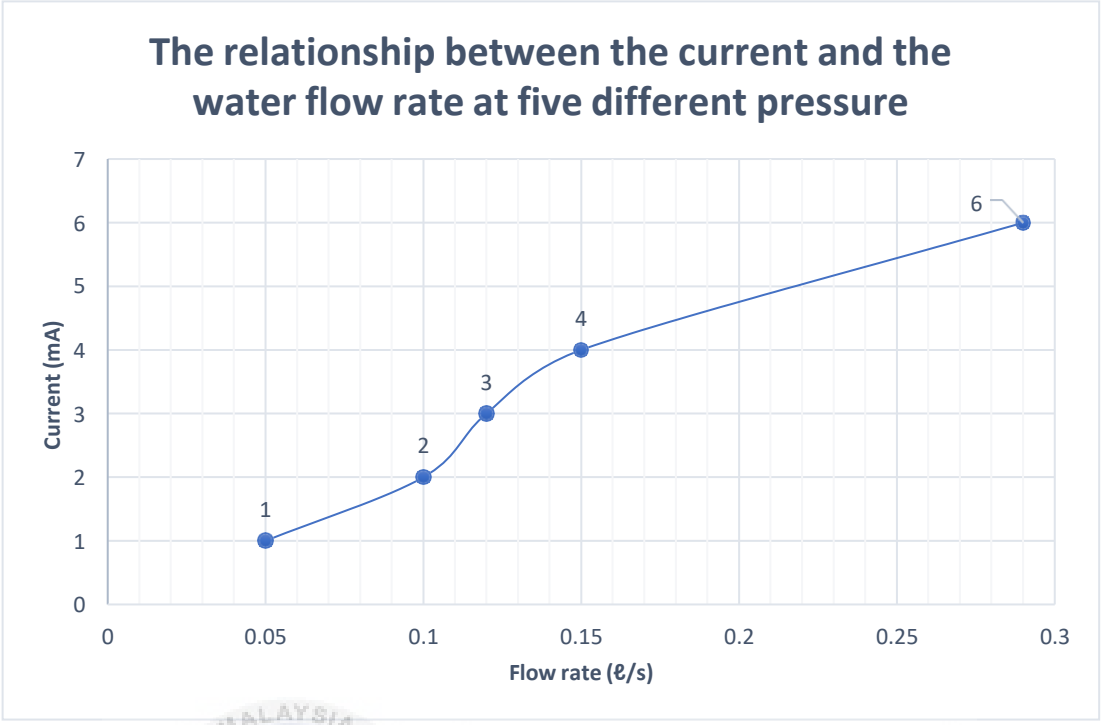


Figure 5.19: Current Generated at Five Different Pressure using Motor B

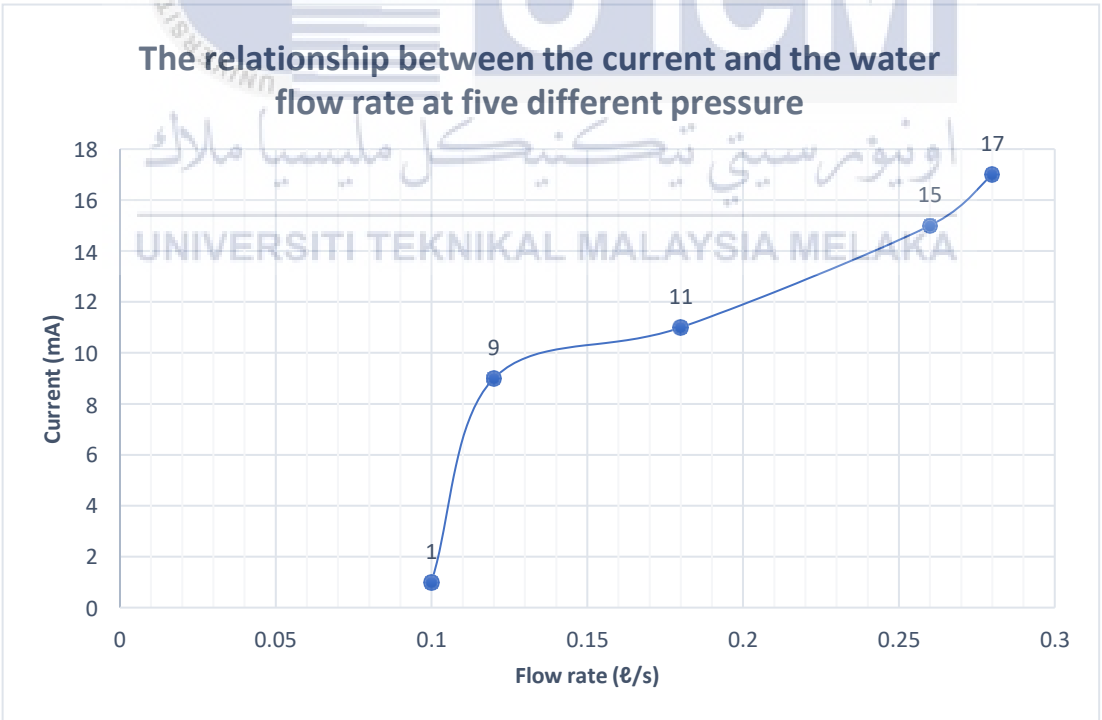


Figure 5.20: Current Generated at Five Different Pressure using Motor C

From the graph above, the increase in flow rate resulting in the amount of current generated that used to light up the LED. Motor B generated the highest amount of current which makes the LED appears brighter when it reaches flow rate 0.29ℓ/s. However, the LED appear dimmer at the lowest flow rate shows that the low pressure of water. In short, the LED starts to blinking but still dimmer when the current lower than 1mA. Figure 5.21 shows the comparison of power generated using three different types of motor.

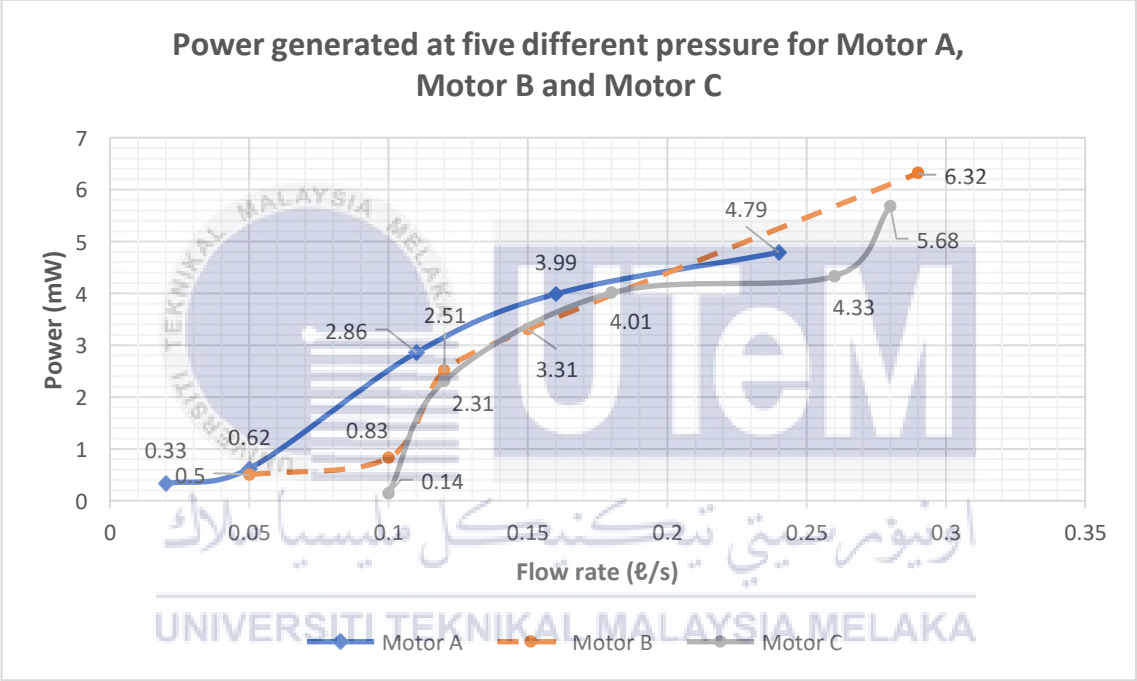


Figure 5.21: Power Generated at Five Different Water Flow Rate for Motor A, Motor B and Motor C

5.8 Summary

In summary, this chapter elaborated the explanation of five topics which are electricity, electrical applications, magnet, electrical motor and energy regarding the five topics included in this electrical engineering learning kit. The result of each experiment is recorded and presented in table and experimental graph. All the data will be observed and analyzed to obtain clear understanding on what components or physical parameters that influences the performance of the experiment. The analysis is made based on the fixed and variable parameter that have been set up. Apart from that, the technical description to clarify the basic electrical concepts applied to the experiment are explained.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This report has discussed the development of the electrical engineering learning kit for STEM application. In Chapter 1, the details of the project are introduced including the background of the project, problems statement, objectives, scopes of project, and project significance. The main goals of this projects are to develop ten mini electrical projects, conduct the experiment on the projects and lastly, investigate the performance of the projects based on the experiment results. The development of the project is based on the problem statement that have been highlighted which are lack of understanding in the STEM subjects such as sciences and engineering among the students in school and universities.

For Chapter 2, this chapter highlighted the research studies and literature studies that have been categorized into nine parts including the points of departure of the project. The nine parts of the literature review includes; STEM application, students' perspective in electrical engineering, critical topics in electrical engineering, practical learning, influence of coloured picture towards the textbook, QR code feature, implication of video learning among students, comparison of electrical engineering kit available in market and points of departure. All these points influence on how this project is develop, the suitable topics to be choose and the effective approaches towards the learning and teaching process.

Next, in Chapter 3, the process and the method applied for the project is discussed. The flowchart of project in Figure 3.1 pictures the flow of the process that have been done to produce the electrical engineering learning kit. Seven major stages involved in the projects is explained in this chapter. The process starts from the investigation of the ten mini electrical projects to be included in learning kit based on the research studies and literature review

from lot of journal. Then, all the information about the result and analysis will be discussed and recorded in the finding report.

Then, for Chapter 4, the details about the experimental setup are discussed. These includes the research activities that have been done in order to observe the electrical projects that is suitable for the learning kit. The listed of projects according to the topics also is presented along with the apparatus to be used. Basically, the apparatus used are mostly low – cost and easy to find in local hardware store as well as the magnets used for the projects in Project C and Project D. Apart from that, this projects also explained on how to store the video project in the QR code. The QR code is used to ease the readers to access the video project at anytime to make sure they follow the procedure correctly. The testing procedures for each project are explained including the objective and the parametric that have been specified.

In Chapter 5, the results of the projects are discussed. Each of the experimental output will be recorded in the data collection table and presented into the experimental graph to perform the parametric analysis for each project. The parametric analysis provided the information of most influence parameter that can affect the output result.

Lastly, the electrical engineering learning kit is developed after going through the research studies from lot of articles, case studies and journals. This project is expected to help students and lectures in the learning and teaching process for basics science and electrical engineering and able to attract their interest to pursue studies in electrical engineering field.

6.2 Recommendations

This project has been achieved the objectives which have been set. However, there are several things that need to be improved in the future in order to accomplish better results. Firstly, the development of the test rig that will be used for evaluating the performance of each experiment that needs to be done. This is because an experiment may lead to inconsistent output result when conducting repeatedly without using a proper test rig.

After that, use the proper equipment such as a function generator for the replacement of battery and oscilloscope to replace multimeter. For the reason that a component such as a battery will slowly drain when it is used for long and many times. Hence, some output results may not be valid fail to achieve the objective of the experiment. Similar to that, mini test equipment such as multimeter sometimes have unstable value when measured a component in an experiment. Therefore, appropriate test equipment should be used when measuring output value to obtain accurate data.

Last but not least, perform a simulation test before construct the hardware part. The advantages are the output simulation results can be used as a reference and avoiding any small error before conducting the hardware experiment. For example, imagine that we connect a large current supply to a high-risk component that is supposedly not to ause high current. Apart from that, an outcome from the simulation is generally accurate compared to the analytical model. Therefore, a simulation before conducting the experiment is highly recommended.

REFERENCES

[1] David W. White. "What is STEM Education and why is it important?", *Florida Association of Teacher Educators Journal.* Volume 1, Number 14, pp. 1-9, 2014

[2] N. Asyikin M. Radzi, Suhaila S. "Measuring Students' Interest Towards Engineering in Technical School: A Case Study", Journal of Technology and Science Education. *JOTSE, 2018 – 8(4): 231 – 237.* February 2018.

[3] N. M. Nor, N. Rajab and K. M. Ismail. "Educating the Engineer of 2020: Malaysian Scenario", College of Science and Technology, Kuala Lumpur.

[4] J. Dunlosky, Katherine A. Rawson, Elizabeth J. Marsh, Mitchell J. Nathan and D. T. Willingham. "Improving Students' Learning with Effective Learning Techniques: Promising Directions from Cognitive and Educational Psychology", *Association for Psychological Science*. 2013.

[5] Dunlosky et al. "Strengthening the Student Toolbox: Study Strategies to Boost Learning", American Educator. 2013.

[6] J. Sweller, Jeroen J. G. van Merrienboer and Fred Paas. "Cognitive Architecture and Instructional Design: 20 Years Later", *Educational Psychology Review (2019) 31:261-292*. January 2019.

[7] Emily C. "Using Educational Video in The Classroom: Theory, Research and Practice", 2007.

[8] Zac W. "The Effective Use of Video in Higher Education", *Lectorate Teaching, Learning and Technology.* October 2015.

[9] Deepashree M., Reshma M., Sonali N., and Sunaya S. "To study the use of QR Code in the Classroom to Enhance Motivation, Communication, Collaboration and Critical Thinking", *International Journal of Innovative Research in Computer and Communication Engineering.* Vol. 5, Issue 4. April 2017.

[10] Rikala J., Marja K. "The Use of Quick Response Codes in the Classroom", *University of Jyvaskyla Agora Center*. 2012.

[11] Khiu, Alexander L., Hazalizah H. "Exploratory Analysis of Pilot Data: Trends of Gadget Use and Psychosocial Adjustment in Preschoolers", *International Journal of Early Childhood Education Care*, Vol. 7. 2018.

[12] Degang Shi. "Improving the Practical Ability of Civil Engineering Students", *World Transactions on Engineering and Technology Education.* Vol. 12, No. 1. 2014.

[13] Shengli C. "Higher Educaation Development Path Based on Practical Education Pattern", *EURASIA Journal of Mathematics, Science and Technology Education.* ISSN: 1305-8223, 2017 13(12):7921-7927. November 2017.

[14] E. Sujarwanto et. al., Madlazim and M. Ibrahim. "Attitude, Knowledge and Application of STEM Owned by Science Teachers", *Journal of Physics: Conference Series 1417 (2019) 012096*. 2019.

[15] Hanover Research (HR). "Encouraging Students to Embrace STEM Programs", *Academy Administration Practice*. October 2014.

[16] N. Sasikumar. "Impact of Active Learning Strategies to Enhance Student Performance", *Innovare Journal of Education.* ISSN 2347-5528 Vol. 2, Issue 1. March 2014.

[17] Jia Zhou and Pei-Luan P. R. "Age-Related Difference in the Use of Mobile Phones", *Universal Access in the Information Society*. November 2013.

[18] Robin M. "The Role of Practical Work in the Teaching and Learning of Science". October 2014.

[19] Sara K., Masoumeh P., and Mohtaram R. "Effects on Pictures in Textbooks on Students Creativity", *Multi Disciplinary Edu Global Quest (Quarterly).* Vol. 4, Issue2#14. April 2015.

[20] Dr Gurhan D., E. Emre Ozkeskin, and Dr Murat A. "QR Codes in Education and Communication", *Turkish Online Journal of Distance Education-TOJDE.* ISSN 1302-6488 Vol. 17, No. 2, Article 4. April 2016.

[21] Abdulhakeem A. W., Sunday D. "Enhancing User Experience using Mobile QR Code Application", *International Journal of Computer and Information Technology.* ISSN:2279-0764 Vol. 03, Issue 6. November 2014.

[22] Thomas F., Micheal N. "Planned Chaos in Electrical Engineering Education", *6th International Conference on Higher Education Advances.* 2020.

[23] M. Riyad and Cipta P. "Theoretical Education vs Practical Education". ISSN: 0193-4120. January -February 2020.

[24] Che Ghani C. K., A. Shah., Noor Aida A. N. and Halimation S. "Effects od Learning Aid Kit on Student Performance for Electric Circuits Topics", *International Journal of Academic Research in Business Social Sciences.* ISSN: 2222-6990. Jan 30, 2019.

[25] Che Ghani C. K., A. Shah, Noor Aida A. N. and Halimaton S. "The Effect of Learning Kit Material among Students", *International Journal of Recent Technology and Engineering (IJRTE).* ISSN: 2277-3878, Vol. 7, Issue 6S2. April 2019.

[26] Dianne Q. Nguyen and Zenon J. "Issues and Challenges in Engineering Education and the Future Outlook of the Engineering Profession in Australia", *Global J. of Engineering Education.* Vol. 11, No. 12. 2007.

[27] Koti R., B SreeBindu. "Recent Challenges in Electrical Engineering and the Solution with IT", *International Journal of Recent Technology and Engineering (IJRTE).* ISSN: 2277-3878, Vol. 8, Issue 2S11. April 2019.

[28] Tatiana V. Goris. "Common Misunderstanding of Electricity: Analysis of Interview – Responses of Electrical Engineering Technology Students". 2009.

[29] Bakir Y. and Sabri S. "STEM Applications in Mathematics Education: The Effect on

Different Dependent Variables", *Journal of Baltic Science Education.* ISSN 2538-7138. Vol. 17, No. 2. 2018.

[30] S. Makhmasi, Rachard Z, H. Barada, Y. Al-Hamadi. "Student's Interest in STEM Education", *A survey from the UAE.* April 2012.

[31] Aharon G., Yinnon S. and Netanel Y. "Increasing Motivation of Engineering Students: Combining 'Real World' Examples in a Basic Electric Course", *International of Engineering Educationn.* Vol. 32, No. 6, pp. 2460 – 2469. 2016.

[32] Prof. Tom C., and Prof. Anthony A. Maciejewski. "Mastering the Core competencies of Electrical Engineering through Knowledge Integration", *New Orleans Jazed Engineering Education.* June 26-29, 2016.

[33] Mei Chi Lee and Fauziah S. "The Effectiveness of Practical Work on Students' Motivation and Understanding towards Learning Phsics", *International Journal of Humanities and Social Science Invention (IJHSSI).* Vol. 7, Issue 08, Ver. III. August 2018.

[34] Hawker A. A. "Learning Styles and Their Relation to Teaching Styles", *International Journal of Language and Linguistics.* June 20.

[35] J. M. Jornet, E. Alarcon and E. Sayrol. "Electrical Engineering Curriculum: International Overview", *International Affairs Office and Dean's Office – Telecom BCN: UPC.* July 2008.

[36] Panagiota N. and Christos N. "Evaluating the impact of Video-Based versus Tradisional Lectures on Student Learning", *Educational Research.* (ISSN: 2141 – 5161). Vol. 1(18). Pp. 304-311. September 2010.

[37] James M. Marshall. "Learning with Technology: Evidence that Technology can, and does support Learning", *A White Paper Prepare for Cable in the Classroom.* May 2002.

[38] Guo et. al., Kim J. and Robin R. L. "How Video Production Affects Student Engagement: An Empirical Study of MOOC Videos", pp. 41-50. March 2014.

[39] So Simon and Law Ching-yin. "QR codes in Education", *Journal of Educational Technology Development and Exchange (JETDE).* Vol. 3. Issue 1. 2010.

[40] Wooff D. and Mclain M. "Educational use of QR Codes", *In: 2015 SOLLSTICE eLearning Conference Learning and Teaching in Higher Education: Effective Practices.* June 2015.

[41] Cynthia J. Brame and Kathryn E. Paraz. "Effective Educational Videos: Principles and Guidelines for Maximizing Student Learning from Video Content", *CBE Life Science Education.* 2016

[42] Ivan J., Francisco I. Hirata, Mabel V. B. "Using RFIV/NFC and QR Code in Mobile Phones to Link the Physical and the Digital World". March 2012

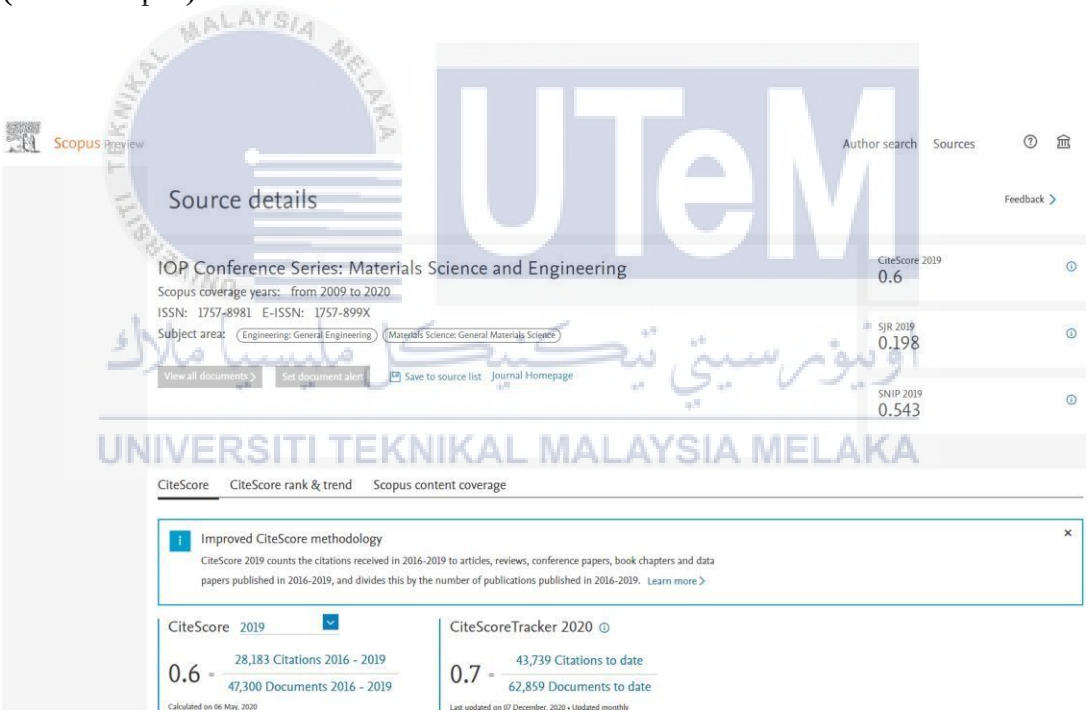
[43] Leslie O. W. "The Three Domains of Learning: Cognitive, Affective and psychomotor/Kinesthetics". 2016

APPENDIX A

LIST OF PUBLICATIONS

a. Journal

M. F. Basar, I. A. Zulkarnain, N. H. A. Razik, Z. Zakaria and W. A. Mustafa. 2020. *"Exploratory of Electrical Learning Kit for STEM Application"*, International Conference on Technology, Engineering and Sciences (ICTES) 2020. IOP Conf. Series: Materials Science and Engineering 917 (2020) 012070. doi:10.1088/1757. (Index Scopus)



Exploratory of Electrical Learning Kit for STEM Application

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Abstract. Throughout the year, the implementation of the traditional approach (lecture-based) in the teaching and learning process seems to be less effective in increasing the interest among students towards the STEM subjects. Conversely, the use of practical learning method emphasizes on the psychomotor domain so that readers gain a clearer and more effective understanding. Thus, the aim of this paper is to investigate and exploratory the unique approach in implementation the learning kit where the students will increase their understanding towards the fundamental of electrical engineering. The effects that influenced the development process of learning kit is discussed and provided the ideas to build a quality learning kit for students who involved in STEM.

1. Introduction

Learning kit is very crucial in the process of teaching and learning. It can assist the process of sharing knowledge among the students with respect to the subject taught. The use of learning kit increases the student's interest in learning the STEM subjects and assist them to learn electrical engineering through a misleading experience at the same time. The main purpose of learning it development is to help student understand the subjects more easily and systemically [1].

The process of teaching and learning in Electrical Engineering topics consists of two parts which are theoretical and practical. In order to master the subject, students are encouraged to have strong basic knowledge about the related subjects. By doing that, students will be able to face more high-level studies in the electrical engineering field. However, the level of difficulties in the subjects sometimes makes them study only to pass the exam without truly understand the content in the studies.

In addition, knowledgeable students somehow rely on the effectiveness of how teachers use the appropriate learning kits towards their teaching process. Apart from that, the way of how the subject is delivered also affects the students. The failure of delivering the subject causes the students to assume the subject to be difficult to understand.

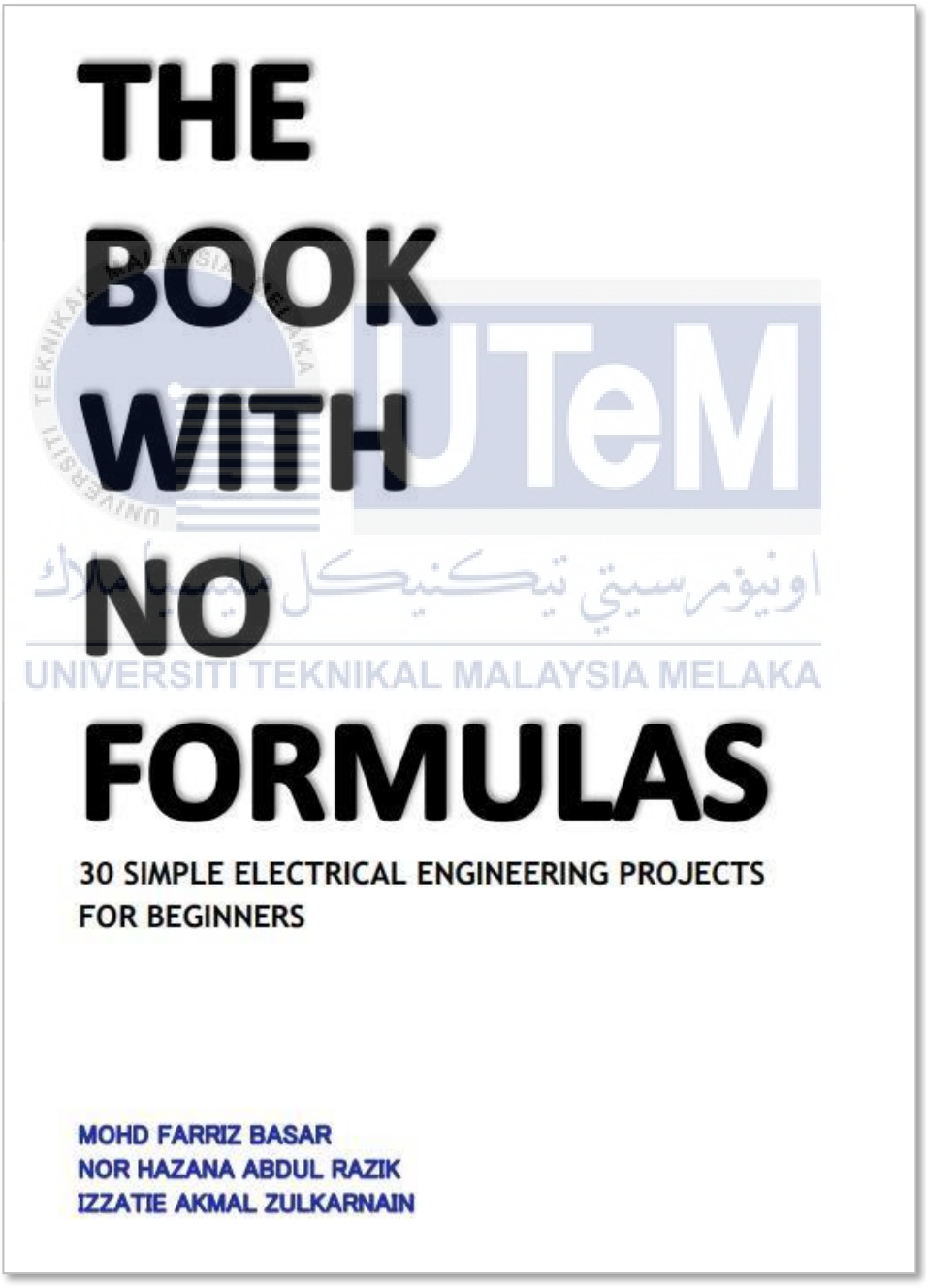
In this chapter, the summary of studies related to this project is discussed. The studies included the

b. Manual Book

Tittle: The Book With No Formulas – *30 Simplei Electrical Engineering Projects for Beginners*

Type: Teaching and Learning Series (219 pages)

Publisher: Universiti Teknikal Malaysia Melaka (UTEM) Publishing



APPENDIX B

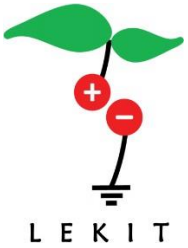
AWARDS

	Award	*Event*	*Info*	
1	Champion	Mainstreaming Grassroots Innovations (MaGRis) 2020	Organizer: Venue: Date:	Yayasan Inovasi Malaysia (YIM) Online Platform 10 June 2020
2	Silver	International Research and Innovative Symposium and Exposition 2019 (RISE 2019)	Organizer: Venue: Date:	Universiti Tun Hussein Onn, Johor Online Platform 24 September 2019
3	Silver	Karnival Inovasi UTeMEX 2019	Organizer: Venue: Date:	Universiti Teknikal Malaysia Melaka (UTeM) Dewan Canselor UTeM 10 October 2020
4	Bronze	Research & Innovative Competition 2019 (RITEC 2019)	Organizer: Venue: Date:	Universiti Tun Hussein Onn, Johor FTK, Universiti Tun Hussein Onn Malaysia 24 September 2019

APPENDIX C

INTELLECTUAL PROPERTY

a. Trademark myIPO

	Title of IP	*No.*	*Other*
1	LEKIT	TM2020011875	

b. Copyright myIPO

	Title of IP	*No.*
1	Electricity Learning Kit for STEM Application	LY2020004893
2	Electrical Motor Learning Kit for STEM Application	LY2020006031
3	Magnet Learning Kit for STEM Application	LY2020006026
4	Energy Learning Kit for STEM Application	LY2020004892

APPENDIX D

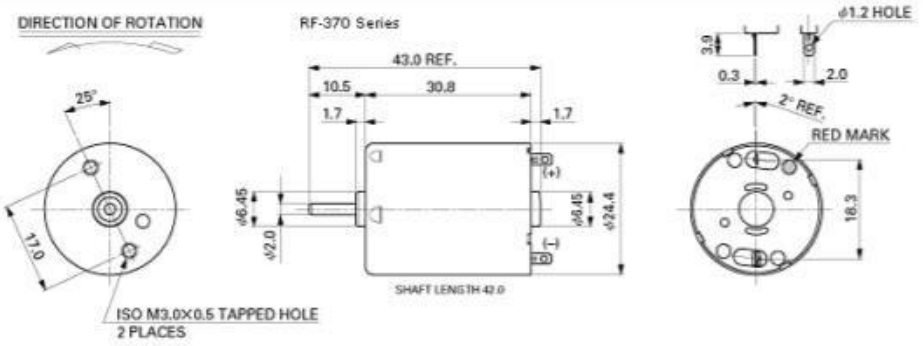
COMPONENT SPECIFICATIONS

a. DC Motor: RF-300CA-11440 and RF-500TB-12560 - 6V

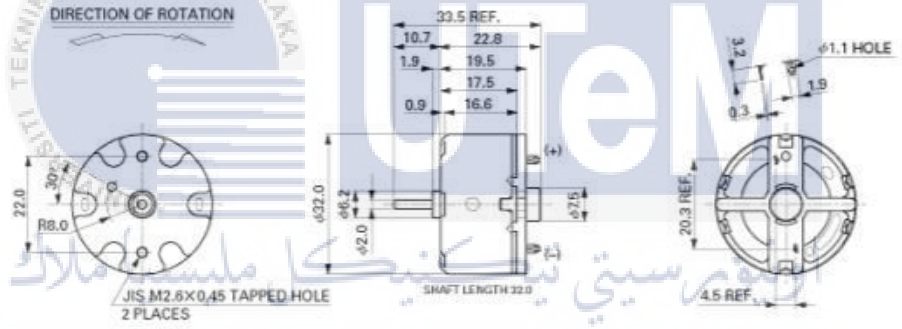
Audio & Visual Equipment

KYSAN	Manufacturer	Voltage		No Load		At Maximum Efficiency					Pricing in US$		
SKU	Cross Reference	Operating	Nom	Speed	Current	Speed	Current	Torque		Output			
Number	Number	Range	VDC	RPM	A	RPM	A	mN-m	g-cm	W	1+	10+	100+
1112089	RF-300CA-11440	0.7-5.0	2V	2200	0.018	1600	0.055	0.27	2.8	0.06	3.17	2.85	2.57
1112014	RF-300CA-11400	1.0-6.1	3V	3000	0.018	2400	0.065	0.42	4.3	0.11	3.17	2.85	2.57
1112013	RF-300CH-11400	1.0-6.3	3V	3000	0.018	2400	0.65	0.42	4.3	0.11	3.17	2.85	2.57
1111107	RF-300CH-11440	0.7-5.0	2V	2200	0.015	1600	0.055	2.8	2.8	0.06	3.17	2.85	2.57
1111136	RF-300PA-11440	0.7-5.0	2	2200	0.018	1660	0.055	0.28	2.9	0.049	3.17	2.85	2.57
1112319	RF-300PA-11400	1.2-6.0	3	3700	0.018	2970	0.073	0.37	3.8	0.12	3.17	2.85	2.57
1111142	RF-300PA-12350	1.5-6.0	3	3500	0.022	2830	0.093	0.48	4.9	0.14	3.17	2.85	2.57
1111140	RF-300EA-1D390	2.8 - 7.0	3.9	4400	0.021	3520	0.084	0.47	4.8	0.17	3.17	2.85	2.57
1111141	RF-300FA-11420	0.7 - 5.0	3	2900	0.017	2320	0.068	0.42	4.3	0.1	3.17	2.85	2.57
1111142	RF-300FA-12350	1.5 - 6.0	3	3500	0.022	2830	0.093	0.48	4.9	0.14	3.17	2.85	2.57
1112001	RF-310TA-11400	1.0-6	2.5	2800	0.17	2190	0.061	0.32	3.3	0.73	1.80	1.62	1.46
	RF-310TA-11400-A	1.2-6	6	7680	0.04	5800	0.14	0.79	8.1	0.48	2.00	1.80	1.62
	RF-500TB- 14415A	1.0-9.0	3	1800	0.022	1400	0.085	0.78	8	0.11	2.00	1.80	1.62
16071	RF-500TB- 14415B	1.5-9.0	5	3100	0.026	2540	0.12	1.23	12.6	0.33	2.00	1.80	1.62
	RF-500TB- 14415C	1.0 - 9.0	6	3700	0.028	3000	0.13	1.37	14	0.43	2.00	1.80	1.62
1112003	RF-500TB-12560-6V	6.0-12	6	2700	0.02	2180	0.084	1.13	11.6	0.26	2.00	1.80	1.62
1111146	RF-500TB-12560-12V	6.0-12	12	5600	0.03	4653	0.11	1.76	18	0.88	2.00	1.80	1.62
	RF-500TB-12560-19V	12.0-24	19	5150	0.0157	4300	0.082	2.06	25		2.00	1.80	1.62
	RF-500TB-18290	1.5-4.0	3	2660	0.03	2175	0.16	1.18	12	0.27	2.00	1.80	1.62
1112092	RF-500TB-18280	3.0-6.0	6	5150	0.05	4300	0.26	2.06	21	0.27	2.00	1.80	1.62
1112076	FF-N20PA-10190	2.0-5.0	3	12100	0.045	9390	0.16	0.21	2.1	0.2	1.15	1.04	0.93
	FF-N20PN-8260	1.5 - 6.0	5	14600	0.043	11150	0.14	0.26	2.6	0.3	1.15	1.04	0.93
1111126	RF-400CA-10350	1.0-6.0	2	3300	0.022	2460	0.065	0.21	2.1	0.054	1.63	1.47	1.32
1111122	RF-400CA-12265	1.0-6.0	2	4000	0.03	3070	0.099	0.25	2.6	0.08	1.63	1.47	1.32
15963	RF-356CA-10250	1.0-6.0	2	3200	0.02	2460	0.066	0.25	2.6	0.064	2.20	1.98	1.78
1112012	RF-370CA-15370	3-12.0	12	5600	0.026	4840	0.17	2.48	25.3	1.25	2.20	1.98	1.78
1111503	RF-370CA-12560	4-12.0	8	2400	0.015	1970	0.069	1.57	16	0.32	2.20	1.98	1.78
1111054	RF-370CA-15390	3-12.0	12	5500	0.026	4840	0.17	2.48	25.3	1.25	2.20	1.98	1.78
1111064	RF-370CA-10620	3-12.0	12	3000	0.026	3529	0.17	2.48	25.3	1.25	2.20	1.98	1.78

RF-300FA	RF-300CH	RF-500	RF-310	FF-N20PA
				
24.4 Diameter x 12.3 Length x 6.0 Shaft (mm)	24.4 Diameter x 12.3 Length x 7.05 Shaft (mm)	32.0 Diameter x 22.8 Length x 10.7 Shaft (mm)	24.4 Diameter x 20.1 Length x 18.9 Shaft (mm)	12.0 Diameter x 15.0 Length x 7.1 Shaft (mm)
CD Player	CD/DVD-ROM Drive	CD/DVD-ROM Drive	CD Player	CD Player



RF-400	RF-356	FF-N20	RF-370	FF-180
24.4 Diameter x 9.0 Length x 7.5 Shaft (mm)	24.4 Diameter x 7.8 Length x 6.0 Shaft (mm)	12.0 Diameter x 15.0 Length x 7.1 Shaft (mm)	24.4 Diameter x 30.8 Length x 10.5 Shaft (mm)	20.4 Diameter x 32.1 Length x 8.55 Shaft (mm)
CD Player	Digital Camera	Drill Screwdriver Tools	Styling Brush	Electric Shaver



RF-500 Mechanical drawing

b. DC Toy/ Hobby Motor – 130 Size

adafruit

DC Toy / Hobby Motor - 130 Size

PRODUCT ID: 711

DESCRIPTION

These are standard '130 size' DC hobby motors. They come with a wider operating range than most toy motors: from 4.5 to 9VDC instead of 1.5-4.5V. This range makes them perfect for controlling with an Adafruit Motor Shield, or with an Arduino where you are more likely to have 5 or 9V available than a high current 3V setting. They'll fit in most electronics that already have 130-size motors installed and there's two breadboard-friendly wires soldered on already for fast prototyping

TECHNICAL DETAILS

- Operating Temperature: -10°C ~ +60°C
- Rated Voltage: 6.0VDC
- Rated Load: 10 g*cm
- No-load Current: 70 mA max
- No-load Speed: 9100 ±1800 rpm
- Loaded Current: 250 mA max
- Loaded Speed: 4500 ±1500 rpm
- Starting Torque: 20 g*cm
- Starting Voltage: 2.0
- Stall Current: 500mA max
- Body Size: 27.5mm x 20mm x 15mm
- Shaft Size: 8mm x 2mm diameter
- Weight: 17.5 grams

c. DC Vibration Motor

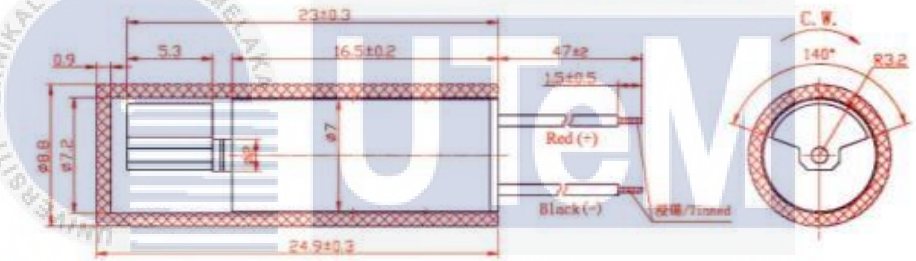
Vibration Motor, Vibrator Motor, Micro Motor, Coin & Pancake Motors , Pager Motors

KOTL JinLong Machinery

Home | Product Info | About us | Factory tour | ISO Certifications | RoHS Info | Sample Request | Contact us | Email us

Part No. Z7AL2B1692082

Technic requirement
1. Rated voltage:3.0V
2. Rated current:250mA Max
3. Rated speed:12000 ± 2500rpm
4. Stall current:680mA Max
5. Terminal resistance:5.5Ω(±20%)
6. Starting voltage:1.7V Max
7. Shaft end play:0.1~0.3mm
8. Lead spec: AWG30 UL1571
9. Overall length is measured after counterweight being pressed against body in direction A. (Shaft end play is not included.)
10. Unmarked tolerance: ± 0.1mm



1. General scope

1-1 This specification applies to cylindrical permanent magnetic DC vibration motor model **Z7AL2B1692082**.

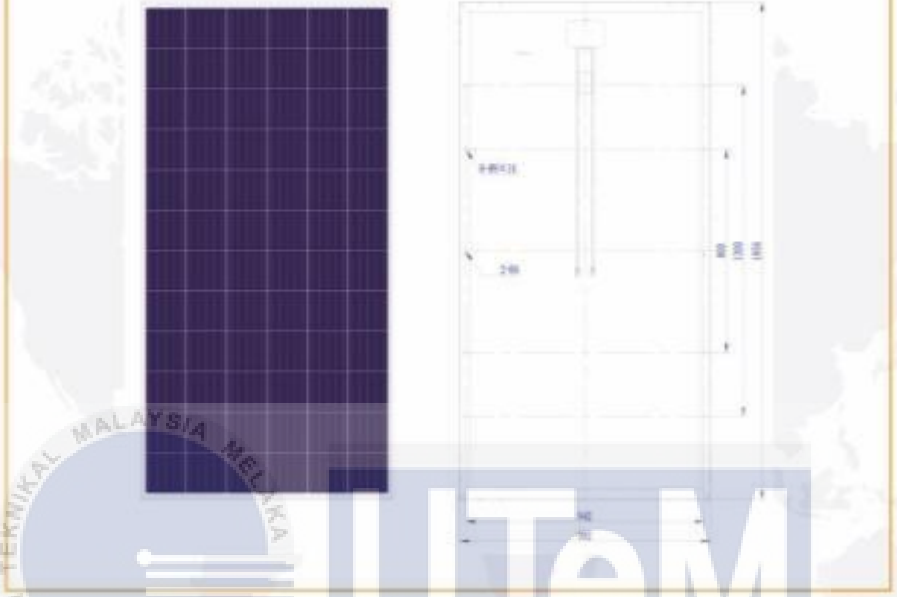
2. Operating conditions

Items		Specifications	Condition & Remarks
2-1	Rated voltage	3.0V DC	
2-2	Rated load	Counter weight	As specified in 10. Outline drawing.
2-3	Rotation	C.W/C.C.W (clockwise or counter clockwise)	

d. Solar Modules – 6V

SOLAR MODULES RZ-315P/320P/325P/330P

● Blueprint of the module



● Performance parameter

Type designation 规格型号	RZ-315P	RZ-320P	RZ-325P	RZ-330P
Maximum power 峰值功率(Pm)	315W	320W	325W	330W
Open circuit voltage 开路电压(Voc)	45.5V	45.5V	45.7V	45.9V
Short circuit current 短路电流(Isc)	9.17A	9.32A	9.39A	9.47A
Maximum power voltage 峰值电压(Vm)	36.7V	36.7V	36.9V	37.1V
Maximum power current 峰值电流(Im)	8.58A	8.72A	8.81A	8.89A
Cell 电池片规格	Poly-crystalline 156×156mm			
Number of cells 电池片数量(Pcs)	72 (6*12)			
Size of module 外形尺寸	1956×992×40mm			
Weight 重量	22.5kg			
Maximum system voltage 最大系统电压	1000V			
Temperature Range 温度范围	-40℃~+85℃			
Standard Test Conditions 标准测试条件	Irradiance:1000 W/m² temperature:25℃ AM:1.5			