MECHATRONIC SYSTEM EDUCATIONAL KIT FOR UNDERGRADUATE STUDENT: MAGNETIC LEVITATION SYSTEM

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Mechatronic Engineering

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"I hereby declare that I have read through this report entitle "Mechatronic System Educational Kit for Undergraduate Student: Magnetic Levitation System" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronic Engineering"

Signature : ……

Supervisor's Name : Encik Nik Syahrim bin Nik Anwar

Date : 2 July 2012

I declare that this report entitle “Mechatronic System Educational Kit for Undergraduate Student: Magnetic Levitation System” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……..

Name : Khairul Ridza bin Ramli

Date : 2 July 2012

Specially dedicated to my beloved parents: Encik Ramli bin Samat and Puan Rohana binti Dahlan, and wonderful brother and sisters.

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ABSTRACT

Most of mechatronic students find it hard to cope and understand with the subject control system engineering and how to apply the knowledge in real life. To solve this problem, an educational kit is to be designed. The main idea is to build a kit that will integrate the knowledge of control system engineering with electric and electronic circuit design subjects. Magnetic levitation system is chosen to be the educational kit as the system applies all three subjects that are mentioned above and it is suitable for laboratory experiment and classroom demonstration. The system is a magnetic ball suspension system which is used to levitate a ball in the air by electromagnetic force produced by the electromagnetic field with the help of actuator and sensor. From this educational kit, the students will learn in details about the three important elements in mechatronic engineering, how to control a system, how to choose the right circuit design to make sure the design functions well and how to integrate the circuit and the control system elements.

ABSTRAK

Berdasarkan pengalaman sepanjang pembelajaran di universiti, didapati bahawa kebanyakan pelajar-pelajar terutamanya pelajar-pelajar kejuruteraan mekatronik tidak dapat memahami dengan sepenuhnya matapelajaran teknikal yang diajar di dalam kuliah terutamanya matapelajaran kejuruteraan sistem kawalan. Sekiranya mereka tidak memahami isi kandungan matapelajaran tersebut, maka mereka tidak akan dapat mengaplikasikan pengetahuan mereka itu di dalam kehidupan sebenar kerana pengetahuan mereka yang terbatas di samping mereka tidak memahami apa yang mereka belajar. Sistem pembelajaran konvensional di mana pelajar-pelajar hanya mendapat input dan ilmu di dalam kuliah secara mendengar dan melihat apa yang disampaikan oleh pensyarah-pensyarah menjadi salah satu sebab mengapa penyampaian ilmu dan pengetahuan ini tidak dapat dilakukan dengan efektif. Sebagai penyelesaian kepada masalah tersebut, projek ini telah mencadangkan untuk merekabentuk dan membina satu kit pembelajaran untuk pelajar-pelajar kejuruteraan mekatronik khususnya dan pelejar-pelajar kejuruteraan elektrik umumnya. Kit ini sesuai digunakan sebagai alat bantu mengajar di kelas dan juga sebagai alat untuk melakukan eksperimen di dalam makmal. Sistem pengapungan magnet telah dipilih untuk menjadi kit pembelajaran ini, di mana ia akan menggabungkan pengetahuan di dalam matapelajaran kejuruteraan sistem kawalan dan rekabentuk elektrik dan elektronik. Mekanisme sistem ini adalah di mana sebiji bola akan diapungkan di udara oleh daya elektromagnet yang dihasilkan oleh medan elektromagnet dengan dibantu oleh sensor dan aktuator. Dengan bantuan kit pembelajaran ini, pelajar-pelajar akan mengaplikasikan pengetahuan mereka dalam matapelajaran kejuruteraan sistem kawalan dan rekabentuk eletrik dan elektronik bagi menyelesaikan masalah untuk mengapungkan bola tersebut di udara tanpa sebarang masalah.

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LIST OF ACRONYMS

W/D	-	Wish/Demand
DIY	-	Do it yourself
R&D	-	Research and development
PWM	-	Pulse Width Modulation

LIST OF PUBLICATION

1. Nik Syahrim Nik Anwar, Khairul Ridza Ramli, Mohd Najib Ali Mokhtar, "Development of Magnetic Levitation System," *presented at 3rd International Conference on Engineering and ICT*, Melaka, Malaysia, 2012. (see Appendix I)

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

From self experience, the subject control system engineering is hard to be understood and coped by the students and they seemingly have no idea how to apply the knowledge in real life. Based on the 'Cone of Learning' by Edgar Dale, an American educationist, passive learning such as reading, listening to the lecture or looking at the slides generally leads to a restricted retention by the students. The students tend to forget what they read, see or hear during class and definitely do not understand the knowledge they get. So he has suggested introducing an active learning in education. Active learning means to engage the students in doing something besides taking notes and listening to a lecture to help them learn and apply course material by observing and give the response to others, or writing, reading and reflecting individually. Active learning includes doing the experiment, simulation, presentation and survey.

This project proposed a set of educational kit which could help the undergraduate students to understand the purpose of learning control system engineering, and also electrical and electronic design and use the knowledge in real life. Magnetic levitation system has been chosen to be applied in this education kit as the system combines the control system and circuit design and it is an appealing area of control system engineering that can attract the students to be more interested with the subject. From this kit, the students will get the idea of how to control the magnetic levitation system, what kind of controller can be used in the system, how the system works, what are the electronic devices they need to make the system functions, the sensors and actuators to be used and how to design a circuit.

1.2 Project Objectives

The objectives of the proposed project are:

1. to built an educational kit for mechatronic students as a learning tool.
2. to help mechatronics students to elevate their understanding in control system engineering and also in electrical and electronics design.

Table 1.1: Requirements and Specifications of the Educational Kit

W/D	Requirements/Target	Specification
W	Cost	< RM 500
W	Assembly time	< 2 days
D	Kit's dimension	20cm x 15cm x 15cm
D	Levitating a ball at a height x	0.010m < x < 0.012m

1.3 Project Scopes

This project is focused on helping mechatronic students to have a better understanding in the control system engineering and electric and electronics design. So, an educational kit will be developed to achieve the goal. This project is only a hardware-based kit and no computer programming will be involved. As the kit focuses on control system engineering and electric and electronics design, PID controller will be used on the system. The price of the kit is important as it is developed for the students. It is estimated that the cost of the kit will not exceed RM500, so the students and anyone interested can buy the kit without any financial burden.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Since the beginning of the creation of the earth, the creatures called human learn. They learn everyday about how to live, how to survive, how to improve their life and how to make themselves better. What is learning actually? Learning is the act, process or experience of gaining knowledge or skill. The knowledge and skill can be gained through observing, schooling or studying. It is a psychologically behavioural modification especially through experience or conditioning.

As the engineering students, we also learn everyday. We learn about the fundamental knowledge of engineering and technologies, the mathematical and physical knowledge, the engineering process in the context of ethical views and many more. We learn all that in school and university.

Traditionally, we learn all the engineering knowledge through the conventional method which is by listening to the lectures, looking and understanding the slides and reading the text books or articles. These methods of learning can be categorized as passive learning. According to Wilbert J. McKeachie [1], research shows that such passive engagement in class generally leads to a limited holding of knowledge by the students, as indicated in the 'cone of learning' as shown in *Figure 2.1*.

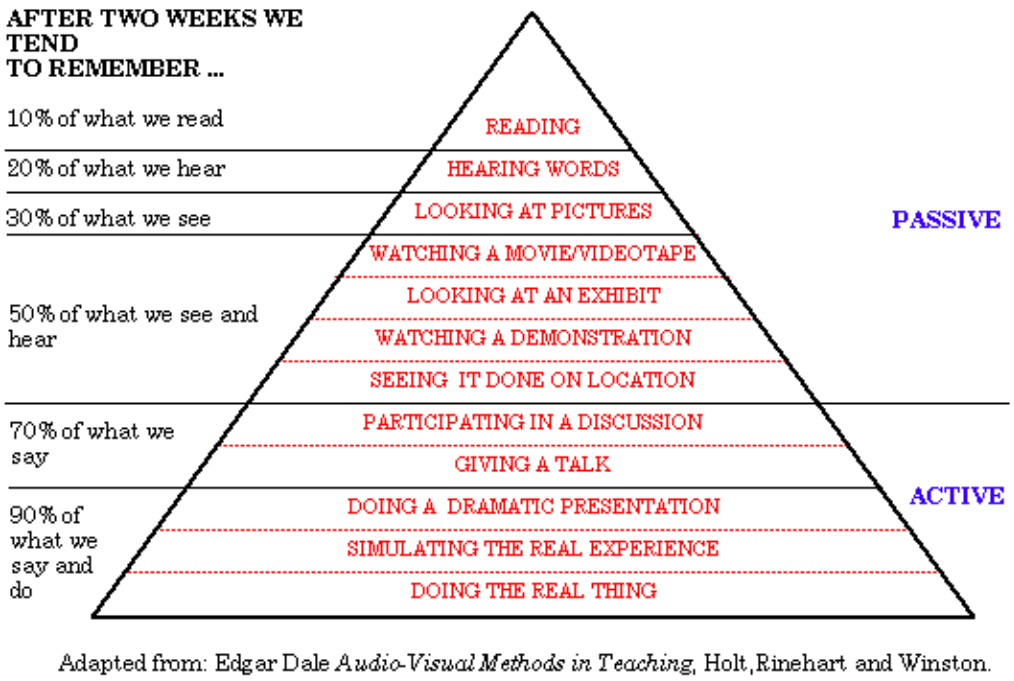

Figure 2.1: The Cone of Learning

It is true, that lecturing is an important aspect of school or university instruction but it is not necessarily the only and best way to deliver and information and knowledge. Passive learning is ineffective if the students just read, hear or listen, look, watch or see. The students could only give 100% concentration to the lectures in the first ten or fifteen minutes. After that, they seem to get bored, sleepy and not interested in listening to the lectures.

Ronald A. Berk has mentioned [2] that the only way to get 100% holding of information is by hearing, seeing, doing, smelling, feeling, tasting, inhaling, injecting and purchasing. According to the cone of learning, the effective way to learn is by participating in a discussion, giving a talk, doing presentation, simulating the experience or doing the real thing. These methods of learning can be categorized as active learning. But what exactly is active learning?

2.2 Active Learning

As mentioned in Chapter 1, active learning means to engage the students in doing something besides taking notes and listening to a lecture to help them learn and apply course material by observing and give the response to others, or writing, reading and reflecting individually. It involves giving opportunities for students to talk and listen, write, read, and reflect on the content, ideas, issues and concerns of an academic subject. It means that when they are given a matter or a problem to be solved, the students will be given the chance to interpret the problem their way, to present their way of solving the problem and to give their opinion about the problem.

There are many examples of active learning strategies such as brainstorming, simulating, experimenting, presenting, discussing and concluding. Those strategies can be utilized and adapted in solving the mechatronic engineering problems. Implementing active learning in engineering has many benefits [3] such as:

1. reinforces subject content
2. develops team building skills
3. promoted participating learning
4. allows for creative problem solving
5. promotes the concept of discovery learning
6. strengthen the knowledge and understanding of the subject
7. allows for practical application of subject content
8. offers an enjoyable and exciting learning environment
9. helps improve student retention and motivation

As the active learning brings so many benefits to the students especially the mechatronic engineering students, the project to build and design an educational kit for mechatronic students is proposed.

2.3 Educational Kit

Education kit is one of the learning tools for engineering students especially for mechatronic engineering students that will enhance the process of learning easily and practically. When the students are given a task or a problem and use the kit to complete the task or solve the problem, it will trigger them to do the research, brainstorming and discussing with the other students on how to solve the given problem, test their solutions by doing the simulation or experiment, apply the best solution they have chosen using the kit and presenting the result by doing the demonstration to the class. By applying all the active learning elements and the knowledge they have learnt in the class, with the help of the educational kit, it will definitely help the students to understand more about the subjects or courses they apply, when they do the task or solve the problem.

There are many educational kits for mechatronic student offered in the market nowadays. Most of them are robot based kits that apply the microcontroller and computer programming knowledge. For this project, magnetic levitation system has been chosen to be applied in this educational kit as the system combines the control system and circuit design. They are not many educational kits for the control system engineering and circuit design in the market. The comparison of several educational kits in the market with the magnetic levitation system kit is shown in *Table 2.1*.

Table 2.1: The Comparison between Magnetic Levitation System Kit with Other Educational Kits

	Magnetic Levitation System Kit	**Multifunction Mobile Robot Kit**	**Temperature Control System using LM35**	**Robotic Arm Trainer**	**Walking Robot**
Subjects Applied	Control System Engineering, Circuit design	Microcontroller, Computer Programming	Microcontroller, Computer Programming	Robotic, Mechanical Design	Robotic, Mechanical Design
Kit Type	DIY	DIY	DIY	Assembled	DIY
Type of Project	Hardware	Hardware & Software	Hardware & Software	Hardware & Software	Hardware
Sensor	Light Sensor	IR Sensor	Temperature Sensor	-	-
Price	< RM500	RM 330	RM 130	RM 800	RM 4200

Figure 2.2: Multifunctional Mobile Robot Kit and Walking Robot

2.4 Magnetic Levitation System

As mentioned before, magnetic levitation system has been chosen to be applied for designing the educational kit. Magnetic levitation system is a system, which can levitate or suspend a body in the air by the electromagnetic force. Many engineers are now turning their attention to this system due to their practical significance in many engineering systems [4]. The system has been well applied for many applications, such as frictionless bearing, high-speed maglev passenger train, levitation of wind tunnel models, levitation of metal slabs during manufacturing, vibration isolation of sensitive machinery and many more [5]-[7]. Magnetic levitation system is now becoming popular because it has many advantages such as no friction, no abrasion, no lubrication needed, long endurance, controllable support force and many more [5]. It can be said that this system can overcome many engineering problems.

Figure 2.3: Maglev Transrapid – High Speed Maglev Passenger Train

For magnetic levitation system educational kit, it will levitate a ball with a permanent magnet attached inside it. The ball is suspended in the air by the electromagnetic force produced by the electromagnetic field. The electromagnetic field is produced by an electromagnet, which are the coils that wrap the soft iron core. When the current passes through the coil, it produces the electromagnetic force, so that this force counteracts the gravity of the ball because this electromagnetic force attracts the magnetic force of the permanent magnet inside the ball and makes the ball suspended in a stable state at a given location. The light sensor is used to determine the position of the ball, when it is levitated in the air as explained in papers [4, 5, 7, 8]. The details and the modelling of the system are explained in Chapter 3.

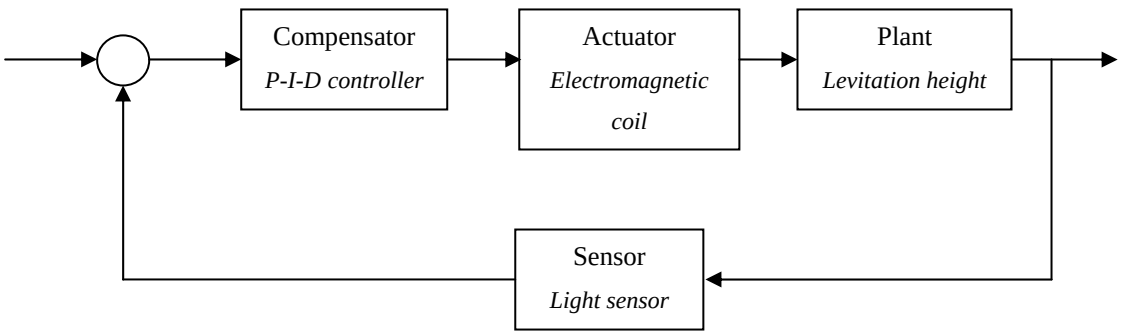

Figure 2.4: Block Diagram of a Magnetic Levitation System