

# INTRODUCTORY COURSE OF ELECTRONIC CONTROL ENGINEERING WITH EXPERIMENTAL LEARNING

**Tsutomu Matsumoto  
Hirofumi Ohtsuka  
Yoshiich Yamamoto  
Masanobu Nagata  
Kosei Nojiri**

Department of Electronic Control Engineering, Kumamoto National College of Technology

## ABSTRACT

In this report, the development of the introductory course of engineering for a first grade student of electronic control engineering department in Kumamoto National College of Technology is discussed. The objective of this course is a cultivation of creativity and the abilities of both cooperation and communication. In special, the development, practice and effect of “falling egg” program is described.

## KEYWORDS

Experimental learning, introductory course, creativity development, competition

## INTRODUCTION

In Japan, the higher educational organizations of Engineering consist of a university, a junior college, and a college of technology. While the former two types of organization accept a student who graduates a high school over the 18 years old to enter, a graduator of junior high school aged 15 years can enter the college of technology. So such younger students do not have enough basic knowledge for general educations, such as the mathematics, the physics and etc. Therefore, till the first term of third grade, students should learn such basic subjects selectively. As a result, the remaining two and half years, namely after the second term of third grade to the end of the 5<sup>th</sup> grade, are jam packed with the basic and applied engineering subjects and practices. However, the industrial circles of Japan evaluate the abilities of the graduators of colleges of technology as considerably high. The reasons of that are considered that the college of technology has both the small capacity and the well-furnished environments for experiments and practices [1].

On the other hand, there existed the problem on the learning along the courses during this short period that students can't hold the enough understandings of the relations between the different subjects. As a faculty development activity, we have modified the basic subjects concerning to engineering for first and second grade students in 2003 [2]. The “Basics of Engineering” is a one of them for first grade student, which is an introductory course of engineering. While the about 160 students are divided by 4 classes without a relativity of their original department, the classes for the lecture and practices of Basics of Engineering are organized depending on their original department in order to press the students for recognition of the significance of the creativity, the ability of cooperation, and one of the communication based upon the each policy and the suitable method of the department. In

this report, the development of the lecture and practices of “Basics of Engineering” of Electronic Control Department are described.

Basics of Engineering is consists of the lectures of the techniques of drawing up of technical document, the introduction of manufacturing and an outline of electronic control system. To develop the creativity, this subject involves several practices such as the “falling egg”, “robot scavenger”, “Line tracer” and etc. The “falling egg” is a name of the experimental learning activity with making a shock-resistance tool for egg, made by using only one sheet of a thick paper (almost A2 size), so as to protect a egg from the shock caused by the fall from the 5<sup>th</sup> floor of the school building. It can regarded as one of the practice based on PBL method [3]. Students can recognize the significance of the invention for realization of own idea. The objective of the practice of “robot scavenger” is almost same as one of the “falling egg” but brought close to the electronic control system. Furthermore, in this course, the practice of line-trace robot controlled by simple logic circuit is also involved in order to introduce the concept of feedback control system.

Effectiveness of this course was evaluated through the questionnaire survey for student. Then, we consider that such course is much effective for development the first step of engineer’s attitude.

## **INTRODUCTORY COURSE OF “BASIC ENGINEERING”**

Basics of Engineering is consists of the lectures of the techniques of drawing up of technical document, the introduction of manufacturing and an outline of electronic control system. To develop the creativity, this subject involves several practices such as the “falling egg”, “robot scavenger”, “Line tracer” and etc. The syllabus of this course is shown in Table 1. The “falling egg” is a name of the practice to make a shock-resistance tool for egg, made by using only one sheet of a thick paper (almost B3 size), so as to protect a egg from the shock caused by the fall from the 5<sup>th</sup> floor of the school building. Students can recognize the significance of the invention for realization of own idea. The objective of the practice of “robot scavenger” is almost same as one of the “falling egg” but brought close to the electronic control system. Furthermore, in this course, the practice of line-trace robot controlled by simple logic circuit is also involved in order to introduce the concept of feedback control system.

### **Lectures**

Lectures use the 40 % of the total hours for this course. First, we explain about the outlines and the relationships between the each subject, and the summary of control system using some examples such as the robot, the elevator, the air conditioner and etc. In special, the difference between the feedback control and sequential control and the relationships between mechanical engineering, electronics, computer engineering are considered as the important points to teach. These contents need 6 hours including a guidance of this course.

Next, we lecture how to make the technical reports. Namely, it involves a structure of the technical documents, a usage of the technical terms and phrases, a description of references, and etc Drawing is significantly lectured. The drawing method of solid body, namely a projection, is lectured in detail for 10 hours including the practices. Achievement is evaluated by examination and its results normally become 75% in average.

In advance of electronic circuit work, the basic theory and techniques of a soldering. And the introduction of logic circuit is lectured before making the simple line-tracer. These lectures require 2 hours for each.

### **Experimental Study**

The “falling egg” is a one of the practice to develop the creativity. Students try to make a shock-resistance tool for egg, made by using only one sheet of a thick paper (almost A2 size),

Table 1  
Syllabus of “Basics of Engineering”

Name of Subject	Code	Name of Lecturer	Code	Class	Term	Credit	Type
Basics of Engineering	L111	Hirofumi Ohtsuka Kosei Nojiri	C02 C15	C1	Whole year	2	Compulsory
Text	Printed original synopsis						
Study aid book	“handy book of mechatronics”, Hirofumi Miura, OHM-sya						
Abstract	In this course, students can understand the outline of control system, the basics of the drawing techniques for making a technical report, and the significance of the creativity required for engineer, and etc. In the practice of “Training for creativity”, students will try to solve the simple craft problem with many solutions under the several limitations. And, through the “Line tracer”, students can learn about the significances of both the hardware and the software.						
Objective	Students can 1. Understand the basic structure of control systems and explain it. 2. Make the technical report with the figure based on drawing techniques and the simple electric circuit. 3. Learn an enterprising spirit for solving a problem under some limitations.						
Contents		Hour	Objective of achievement			Evaluation	
Guidance		2				Based on the result of the examination, the report, and the work of manufacturing.	
Basics of Control System		6	Understanding of the construction of control system and the roles and relationships of its components.				
Basics of Drawing		10	Getting an ability of drawing. (Understanding the projection methods.)				
How to make a technical report		6	Getting an ability of Making the technical report of simple manufacturing problem, using the figures.				
Training for creativity 1		10	Getting an enterprising spirit for solving a problem under some limitations through the simple paper craft practice.				
Training for creativity 2		14	Getting an enterprising spirit for solving a problem under some limitations through the practice of simple robot.				
Line Trace robot		14	Through the making of Line Trace robot, understanding the outline of the feedback control system and the significance of the collaboration between the hardware and the software to the successfully works.				
Total evaluation	Evaluated from the results of the examinations (50%), the report evaluation (40%), and the work of the manufacturing (10%).						
Course Style	Lecture : 40 %, Experimental Practice : 50 %, others : 10 %						

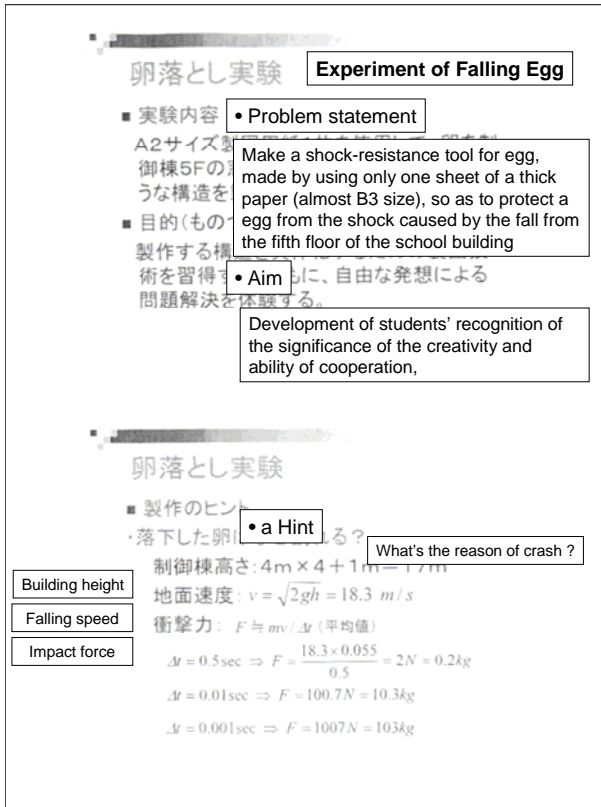


Figure 3. Instruction document

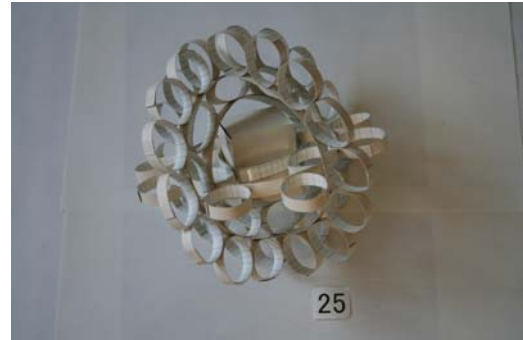


Figure 1. Work example for “falling egg”

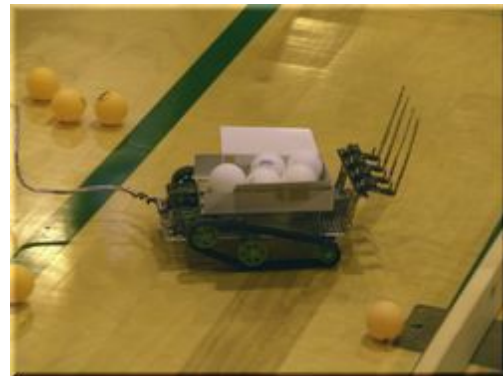


Figure 2 Work example of “robot scavenger”

so as to protect a egg from the shock caused by the fall from the fifth floor of the school building (see figure .1). Details will be described in the next section.

The other practice aiming at the development of creativity is the “robot scavenger”(see figure 3). We have also obtained the effective educational result.

The practice of a simple “line-tracer” using a gate circuit is located as the final practice of this course. From the result of questionnaire for fifth grade student, we have confirmed that this practice is very helpful for student to understand the relationship between the subjects and its contents and improve their motivation.

## EXPERIMENTAL STUDY “FALLING EGG”

As Mentioned above section, “Falling Egg” is a title of “Training for creativity 1” shown in the table 1. Its objective of achievement is settled that students get an enterprising spirit for solving a problem under some limitations through the simple paper craft practice. Similar efforts have been done as shown in reference [4]. But the program was finished in a lecture for only 150 min and the problem setting was not so impressive. This program requires 10 hours involving the experiment.

### Guidance

At first, we distribute the simple document in which the problem statement and a few hints were given as shown in Figure 3, and white A4 paper in order to make notes of original ideas. And we give the following significant advice in advance:

- (1) Never make an imitation.
- (2) Never be bound by preconceptions.
- (3) Failure is a stepping-stone to success.



Figure 4. Now thinking

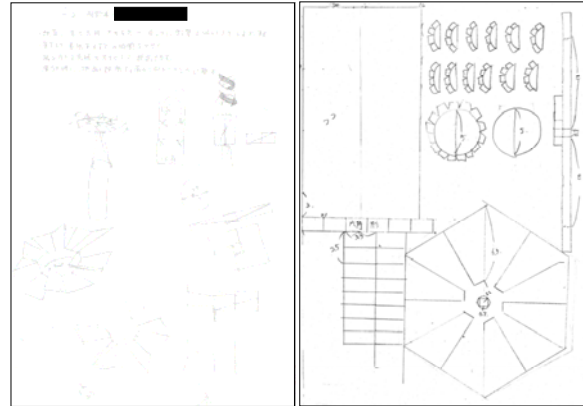


Figure 5. Conceptive illustrations



Figure 6. Making a paper craft

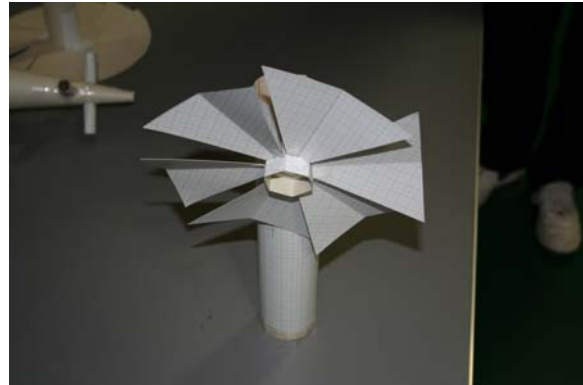


Figure 7 Finished good

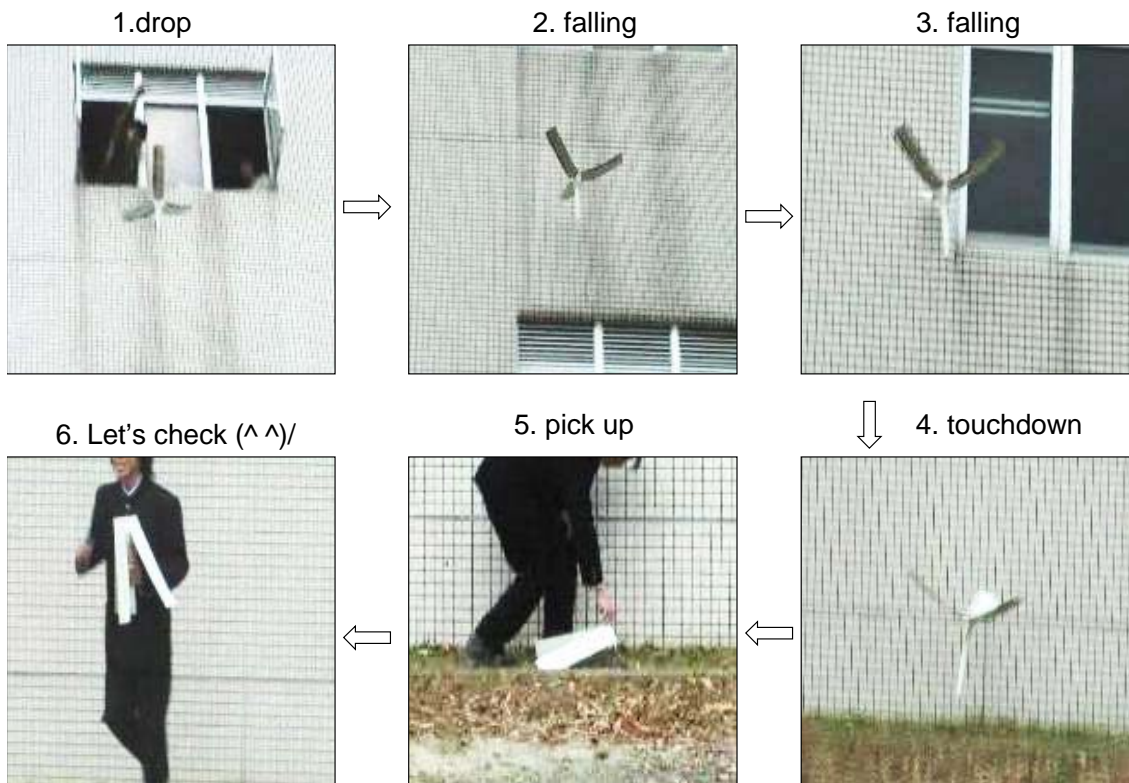


Figure 8 A Sample View of Experiment

## Activities

Students make a shock-resistance tool for egg individually. They start activity by prediction of the shock force caused by the collision to the ground, and try to enumerate several concepts. So, in the initial hour, they devoted themselves solely to thinking on a solution to the problem. Then, they gradually start an argument about candidates for solution (See Figure 4), We do not disturb rather than encourage them to discuss about each other's ideas, because they can smoothly find a weak point of own idea and sort a better/best idea from several candidates. Figure 5 shows an example of conceptive illustrations and its cutting plan. After the lecture's check about the cutting plan, they can start making a paper craft (See Figure 6). There exists some restriction for production, such that student never uses a spare paper, and never use anything else of the specified materials: string (1m), glue, and adhesive tape. Furthermore, usage of the glue and adhesive tape must be accord with original aim. And, student must take into account the way of loading the tool with egg at the final stage of production. It was required about 3 hours for production on the average. Figure 7 shows an example of finished good.

## Experiment

Experiment has been executed on January 9<sup>th</sup> in 2009. Weather condition was almost fine and there was almost gentle north wind but sometimes changed. Figure 8 is a sample view of experiment. Lecturer drops the shock resistant tools from the fifth floor of school building (height is almost 17m). Student must fix his eyes on falling tool (in order to give consideration to a result in later). The experimental results are shown in Table 2.

Table 2  
Experimental Results

Success	Cracked	Broken	Total
22	2	20	44
50%	5%	45%	

## Making a Report

Lecturer asked each student to submit a report of the "Falling Egg" till 2 week after the experiment. As shown in Table 1, the report evaluation point was accounted for 40% of the total evaluation point. The instruction for making a report is given as follows:

- (1) Report must be composed of the following items: Problem Statement, Concept, Structure of the tool, Experiment (method and result), Considerations, Impression
- (2) Use Table and Figure adaptively to make the description easy to understand. Figures should be drawn based on the projection methods.
- (3) Considerations about experimental results have to include not only own result but also colleagues' results. It is necessary required that reasons of such results are considered.
- (4) Report should be more than 5 pages.

Figure 9 shows an example of student's report. Reports were evaluated based on the grading method according to five ranks by two lecturers. Average evaluation points resulted in 4.18 and 4.14, respectively.

According to the part of "impression" in the student's report and the direct hearing, we can see that experimental study program "Falling Egg" was supported by an overwhelming majority. Some typical comments are the follows.

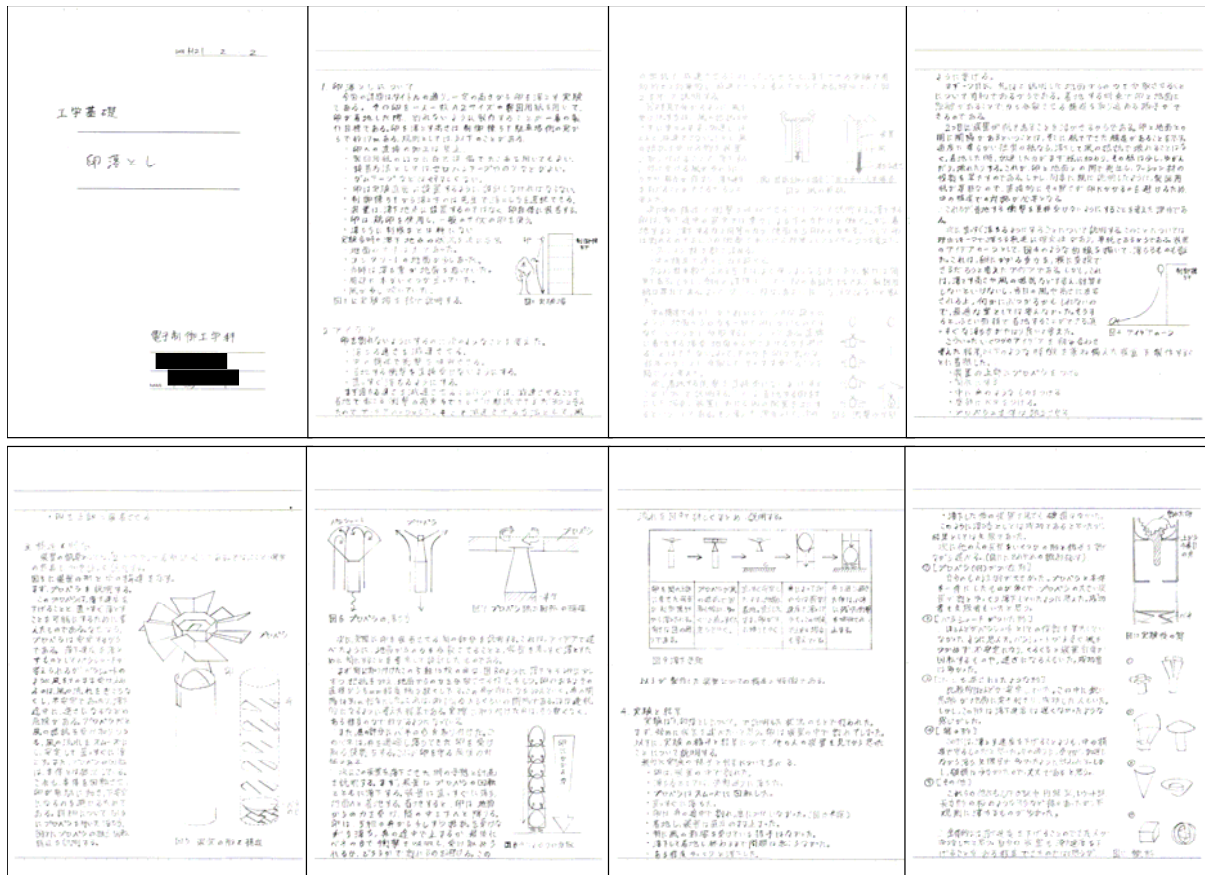


Figure 9 Example of Student's Report (an extract)

- “My tool failed to protect. The experimental result was different from my prediction. But, I have a sense of fulfilment because I really felt and studied the significance of analysis of the cause and effect through this project.”
- “However I got unexpected results, I have recognized that repetition of Trial and Error is very important.”
- “As the production of tool progressed, I came to enjoy this project.”
- “I was very surprised at the unexpected experimental result. I recognized that a production is very difficult under such a hard situation to estimate. But, in such difficulty, there exists a pleasure. I didn't feel a pain. I thought an enjoyment of difficulty is required to get a success.”
- “I was very enjoyed because there are several types of tools and there exists different form tools even if their ideas are essentially same.
- “I want to try again with another idea.”
- “I tackled such a unique project with fun.”

## CONCLUSIONS

In this report, the development and the practices of “Basics of Engineering” of Electronic Control Department are introduced. This course involves many practices aiming at the development of student's creativity and the lectures of the basics of control system and of the drawing and writing techniques for technical document. Its evaluation has been done based on the activity and the report describing the own idea and developed tool (with figures), analysis of the experimental result and consideration (finding the point to be improved). Students have eagerly tackled this difficult problem and over the 90 % of them have evaluated every year that it can successfully develop their motivations and assist to

understand the aim of this subject. In special, the features of the program “Falling Egg” are considered as follows. The problem setting gives impact for students such that it is an impossible problem because of many restrictions. But it gives an impulse for student to challenge. Finally, students become to recognize “That is only a surface impression”. As shown in Table 2, namely almost 50% success rate, we can note that its difficulty is attractively adjusted as exquisite level. Furthermore, because there exists many solution candidates and students are allowed plenty of scope for their imagination, they can examine many solution candidates through other students’ experimental results. Students’ impressions prove that both the success and the fail motivate them to study engineering. At the end of this program, students can share the recognition about an important responsibility of engineers by imaging the egg as human. We consider that this course is a effective for development the first step of engineer’s attitude.

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### **Biographical Information**

Tsutomu Matsumoto is a Professor in the Department of Electronic Control Engineering (ECE) at the Kumamoto National College of Technology (KNCT), Koshi, Kumamoto, JAPAN. His current scholarly interests are in system integration technology.

Hirofumi Ohtsuka is a Professor in Department of ECE at KNCT. His current research focuses on human-machine system and automatic control. He is the professor who teaches the subject “Basics of Engineering”

Yoshiichi Yamamoto is a Professor in Department of ECE at KNCT. His current research interests are in an autonomous robot and mechatronics system.

Masanobu Nagata is a Professor and Dean of Department of ECE at KNCT. His current scholarly interests are focused in intelligent medical sensor system.

Kosei Nojiri is a Assistant Professor in Department of ECE at KNCT. His current research area is biomechanics.

### **Corresponding author**

Dr. Hirofumi Ohtsuka  
Department of Electronic Control Engineering  
Kumamoto National College of Technology  
2659-2 Suya, Koshi, Kumamoto, JAPAN 861-1102  
81-96-242-6091  
ohtsuka@knct.ac.jp