Simple and Beautiful Experiments III by LADY CATS and Science Teachers' group

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Abstract. LADY CATS (LADY Creators of Activities for Teaching Science) is an organization of science teachers. Our group includes a lot of female teachers, which is rather unusual in the field of physics. We would like to propose and exhibit beautiful and simple science experiments that can demonstrate the principles of physics to fascinate students' interest. These experiments are easily made and low-cost. It is also aimed to catch female and humanities students' eyes on physics from the view point of female teachers. Furthermore, we believe that these ideas help resolve gender problems and support non-specialist teachers in primary school.

Keywords: Simple Experiments, Low-cost Experiments, Attracting Girls to Physics, Teacher Training.
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INTRODUCTION

LADY CATS is a science teachers' organization mainly consisting of women ranging from primary school teachers to university researchers. Our activities aim at encouraging students and teachers who are not interested in physics[1-3]. Recently many primary teachers feel uncomfortable with science because they have studied only general science and they feel it is not enough to teach science, especially physics. There are many women teachers at primary schools. Moreover not many girls major physics, too. It causes there are fewer women physics teachers in higher education.

We formed LADY CATS in 2005 to change these tendencies through our activities. We are dedicated to exhibiting simple yet beautiful science experiments that demonstrate the principles of physics. These experiments should be easy to prepare at low costs. We presented some experiments in international conferences such as ICPE with male teachers.

The name of LADY CATS is taken over from the group called "STRAY CATS''[4]. They have introduced interesting experiments by demonstrations at numerous international conferences for over twenty years, and now most of them are near retirees.

We believe that our activities fascinate many people through our passion in physics.

EDUCATIONAL CONTENTS

Teaching Materials Based on Science History

It is expected that carrying out the experiment along with the discovery of electromagnetic induction, which is famous on the science history, can bring us educational effect. It can encourage us to comprehend electricity and magnetic phenomenon easily, to find the scientists' point of view and to know how much science benefits our daily life.

We would like to show 3 simple devices we created based on Faraday's experiment[5].

1. Arago's Experiments on Rotatory Magnetism

Arago discovered the phenomena of rotary magnetism. The discovery was completed and explained by Faraday. A rotating plate of copper tends to transmit its motion to a magnetic needle suspended over it. If the magnet revolves, the copper plate follows its motion.

FIGURE 1. The Arago's disk.

2. Aluminum Coin Sliding on a Magnetic Field

This device does not need any cells or wire conductors, despite it is an experiment on electromagnetism. The simple mechanism of the device helps beginner's understand the phenomenon of rotary magnetism, which is explained by Faraday's law of electromagnetic induction.

An aluminum coin cannot be attracted by any magnets. However, if the aluminum coin gets across high magnetic field, then the aluminum coin reduces its speed, and it looks as if the coin had been attracted by the magnet. (But the behavior of the coin is clearly different from that of steel one.)

The movement of the coin is caused by Lorentz force which the generated eddy current within the coin experiences.

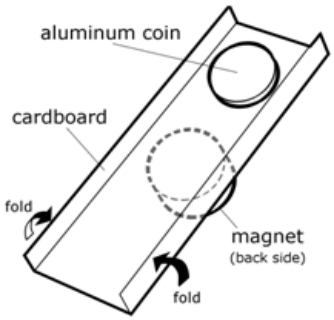

FIGURE 2. An aluminum coin sliding in a magnetic field.

3. Unipolar Motor

The first motor was built and demonstrated by Michael Faraday in 1821 at the Royal Institution in London. It was Michael Faraday's early motor which he called electromagnetic rotation. The latter device is known as a unipolar motor.

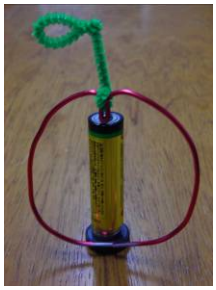

Figure 3. Unipolar motor

Reflection Cup

Reflection Cup is a fun activity with light. It is interesting to make pictures disappear. It is a good experiment to think about how light travels. It is an example of total internal reflection, or TIR.

Draw a picture on a card and put in a plastic bag like zip log. Put the picture card in Reflection Cup. When you fill water in the cup, the picture disappears. When you pull the card up from the water, the picture appears again.

We can discuss how light travels with this experiment. When light crosses a boundary between two different media such as glass and water and air, it bends away from a line. As the angle of light hitting the boundary becomes sharper, the light bends farther and farther from the normal line. Finally it reaches an angle where it no longer exits into the other material. At the critical angle, the light is reflected back inside. The light is completely reflected inside the substance and not refracted.

Figure 4. Reflection Cup

Construction of the Animal LED and Semiconductor Circuit

The following experiment helps students to get a better understanding of the properties of a semiconductor and of the overall circuit

Many high school students have heard of an LED and a transistor, but very few students have had a chance to use these both in class and in daily life.

Why?: The purpose of this experiment;

- To give students a better understanding of the semiconductor properties, by making the Animal tester circuit in class.
- To use simple only materials to make the circuit.
- Keep the class excited and active in class.

Results: After 40 high school students tried to make the Animal circuit in an hour class.

- All students who made the circuit gained a better understanding of the characteristics of both an LED and a transistor.
- Every student drew their own personal circuit before making it. This activity helped the students understand the circuit more clearly.
- The experiment was very successful in keeping both the boys and girls very interested.

Improvements:

- It takes one hour to design and make the circuit. (30minutes are spent designing the circuit on paper first. After this time the students are very motivated to complete their own individual circuits by the end of class).
- It is very important to give the students a sample circuit they can see working, to give them an example circuit. It is very difficult for students if there is no sample circuit available.
- Thirty percent of students could not get their circuits working due to faulty connections between the aluminum tape, the LED and/or the transistor of the circuit.

Dancing Snake

Sound is an attractive topic to study, because sounds are everywhere in our daily lives. You may use a human voice or music instruments when you teach a sound wave. A "Dancing Snake" is one of hand-made teaching materials in this topic [6-7]. A snake, which is made by a piece of wire, is on the cup as shown in Fig.1. This snake swings slowly or quickly on the cup according to the voice pitch when we vocalize through the tube. With this material, we can learn the relationship between voice pitch and the frequency. A sound wave's frequency determines how high the pitch is. When we blow with a low voice, the snake swings slowly (low frequency), on the other hand, we blow with a high voice, and the snake swings quickly (high frequency).

Figure 5. Dancing Snake

Utilize the Heat of the Palm

Convection is a global weather phenomenon. Origami paper makes this phenomenon visualized[8]. Make a windmill with a thin Origami paper and put it onto a toothpick as shown in Fig.6. Put the toothpick into an eraser for convenience. Close your palm into windmill, then, the windmill rotates because of the heat of the palm.

Figure 6. Paper Windmill

Angel Hair

"Angel Hair" is a well-known experiment in Japan on the static electricity[9-10]. This experiment is usually called as "flying electric jellyfish". It is meaningful to carry out this experiment successfully in high humidity and spread it to the world including Southeast Asia.

Angel Hair and pencil balloon becomes negatively charged if we rub them respectively. They keep leaving each other because of the repulsive force. It is also able to make angel hair charged positively, if we rub it on the pencil balloon with tissue papers. In this case, they attract each other.

How to make and play: (1) Tie the center of a polyethylene rope and tear it. This is "angel hair." (2) Brow up a balloon. (3) Rub the "angel hair" and balloon by sheets of tissue paper on the acryl board. (4) Hold a balloon on your hand and throw the angel hair in the air. Move a balloon to keep "angel hair" flying in the air.

Points: Do not touch the "angel hair" and pencil balloon as possible, because dirt disturbs for them to become charged. If they become dirty, you should clean them up with ethyl alcohol.

Plastic Bottle Microscope

Van Leeuwenhoek [1632-1723] discovered many micro-organisms using his handcraft microscope. His microscopes were made of one small grass ball and its frame. Mr.Yoshikawa made a portable Leeuwenhoek's Microscope using metal or plastic bottle as its frame[11].

A glass sphere is a kind of lens. Students realize the theory of lens and microscope through this experiment. This microscope expands the place of studying because of its portability. Students can use it in any time and any place that they want to look invisible small things by their own eyes.

How to make EYEPIECE: (1) Make a small hole in the center of plastic bottle's cap. (2) Insert a glass ball into the hole from inside.

How to make SPECIMEN: (1) Cut the plastic bottle and make a mount (Fig.7) and slide glass (Fig.8). (2) Put the sample in the center of the slide glass. (3) Cover the slide glass with sell tape (Fig.9).

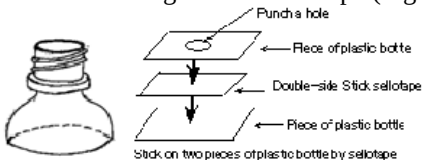

Fig.7 Fig.8 Fig.9

How to use: (1) Fit the eyepiece on the mount. (2) Adjust the focus: turn on the eyepiece.

Paper Boomerang

The educational aim is as follows: (1) Learn how to make a boomerang from paper. (2) Learn the property of the boomerang depending on the shape of the wings. (3) Learn the reason why a boomerang returns, why a boomerang flies stably (undergraduate student level).

How to make: (1) Prepare the 3 pieces of paper wings and staple each piece (Fig.10). (2) Bend each wing in

mountain shape in 1mm (Fig.11). (3) Twist each wing counter-clockwise in 1mm (Fig.12). (4) Bend the center of wings in 1mm (Fig.13). If you are left-hand, twist each wing clockwise.

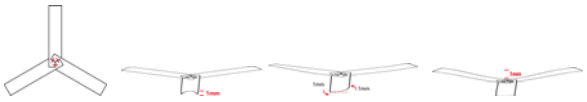

Fig.10 Fig.11 Fig.12 Fig.13

How to play: (1) Make sure nobody is around you. It is danger if a boomerang hits one's eye. (2) Hold the boomerang between the thumb and the forefinger. (3) Stand the boomerang vertically. (4) Throw the boomerang with a snap of the wrist. At that time, don't move the arm so much. (5) Catch the returning boomerang between palms of the hands[12-13].

A Paper Airplane

The Paper Airplane is a good teaching material, because of these three reasons. (1) "A Flying Body" is mysterious for children. (2) The paper airplane can be easily made. (3) The paper airplane can study the principle of "Hydrodynamics" while playing it.

How to adjust:
(1) Folds the edge of wing about 20 degrees. (2) Install a paper clip in the front of the body. (3) Pick up with top of the body and throw.

Low Cost THEREMIN

What is Theremin?

Theremin is a mysterious musical instrument to manipulate the interval and the volume by moving the hand toward the antenna that expands from the main body without touching it directly. It is an oldest electronic instrument invented by Professor Léon Theremin (Lev Sergeyevich Termen, 1896-1993). It is well known as Jimmy Page (Led Zeppelin) used it. In this time, we introduce to make Theremin with fewer parts. it is easy to make it with low cost.

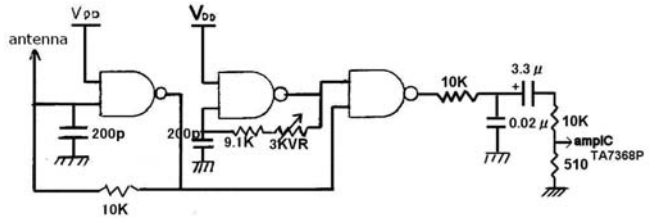

Figure 14. Circuit

Origami diamonds

It is easy to make diamond with "unit Origami." We make carbons and its joints with folding papers, respectively. After making carbon and joint respectively, we assemble these parts.

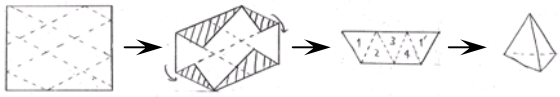

Figure 15. How to make "Carbon"

Figure 16. How to make joint

Talking cup

Can you believe that paper cups really talk, "A", "E", "I", "O", "U"? This is originally invented by European scientists and improved by Japanese teachers (Kenji Doi, Haruka Onishi, etc.) for simple and beautiful educational experiments.

How to make and play:
(1) Make a round hole on the bottom of the cup. (2) Attach a plastic straw to the cup bottom with adhesive tape. (3) Rub the straw by your wet hand.

Points: Watch carefully your mouth shape and its movement by the mirror pronouncing "A", "E", "I", "O", "U".

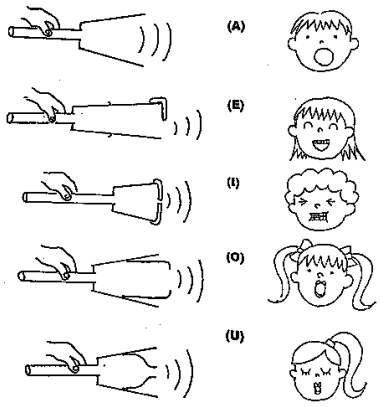

Figure 17. Paper Cup and Pronunciation

CONCLUDING REMARKS

We introduced these teaching materials at the hands -on workshop in the ICPE 2009. We have been developing low-cost teaching materials since we formed LADY CATS managing to arrange the time and opportunities to communicate with each other on the phone, the e-mail, the free video phone and so on. We cannot meet regularly because we live and work all over Japan, also teach in different schools and universities in which we are devoting to research in physics education.

Our practical activities' policies are following.

1. To exchange information on teaching materials. These materials are not necessarily invented by us. Some of them are invented by our members, but others are already popular ones in Japan.
2. To share and improve the research topic which has some difficulties in teaching materials on hands-on books. One reason why makes elementary school teachers feel hard to deal with physics might be that the experiment following the teaching guide book is often unsuccessful to get good results. It is important to encourage teachers who feel physics difficult. To discuss this theme and to show a specific advice will be one of solutions of the problem.
3. To organize workshops and to demonstrate our policies in various opportunities, such as teacher training, a local selection camp for Physics Olympiad, international conference and so on. These activities aim at promoting physics (science) education activities.

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