

# Teaching of Faraday's and Lenz's theory of electromagnetic induction using java based Faraday's lab simulations



**Sanjay Prakashchand Hargunani**

*Department of Physics, G.S. Science, Arts and Commerce College, Khamgaon- 443201 (Maharashtra), India.*

**E-mail:** sanjayhargunani@rediffmail.com

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## Abstract

The effect of Faraday's lab simulation software on perception of the students about Faraday's and Lenz's theory of electromagnetic induction (EMI) was studied. Students' perception about the topic before and after simulation was noted. Teaching with Faraday's lab simulation creates the interest and curiosity about EMI phenomenon among students. It makes the study easy and reduces the real laboratory work. This simulation helps the students to learn the EMI phenomenon by their own.

**Keywords:** Physics education, electromagnetic induction, Faraday's lab simulation.

## Resumen

Se estudió el efecto de los programas de laboratorio de simulación Faraday en la percepción de los estudiantes acerca de la teoría de Faraday y de Lenz de la inducción electromagnética (EMI). Se señaló la percepción de los estudiantes sobre el tema antes y después de la simulación. Enseñar con simulaciones de laboratorio de Faraday crea el interés y la curiosidad sobre el fenómeno de EMI entre los estudiantes. Hace el estudio fácil y reduce el trabajo de laboratorio real. Esta simulación permite a los estudiantes aprender el fenómeno de la EMI por su cuenta propia.

**Palabras clave:** Enseñanza de la Física, la inducción electromagnética, la simulación de laboratorio de Faraday.

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## I. INTRODUCTION

School teachers teach the Faraday's and Lenz's theory of electromagnetic induction using equations, graphs, diagrams, examples and numerical. Many students face considerable difficulties in understanding the phenomenon using equations. Students use equations to calculate some variables and numbers as a solution. It is very difficult for students to see the importance of each variable and constants in given equations. However physical equations have deeper meanings. Equations represent the relation between various observations and measurements. By using simulation based experiments; students can see the importance of each variable of equation. Such simulation based teaching changes the students' view about equations. Students can imagine a lot of things just from equations. Simulation base teaching enhances the visualization power of students for physical phenomenon. Student can solve the practical problems after simulation based teaching. In this work, we investigated the effectiveness of a role of web based computer simulation teaching in electromagnetic induction using Faraday's lab simulation. [1, 2, 3].

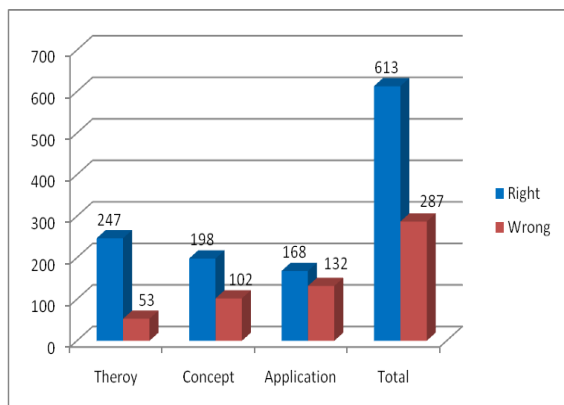
## II. METHOD

**The student sample:** Sample for this study included the 30 students of science of higher secondary level. All students were of same rank and simulation based teaching is new thing for them [4, 5, 6].

**Treatments:** Theory based lecture on the Faraday's law of electromagnetic induction and its applications was given to students for six hours (one hour daily for six days). Lecture contents are given in Appendix A. During the lecture, care was taken that no student should remain absent in any of the six lectures. On the seventh day a multiple choice question test was conducted to check their understanding of theory of EMI. Questions were selected from various section textbooks. Test included total 30 questions. It included equal number of theory, conceptual and application based questions. Time allotted to each question was of 2 minutes. After the test, question papers were collected from students. Students' response to the test is given in following table and is shown in the graph chart.

**TABLE I.** Students' response in the form of right and wrong answers before Faraday's simulation lab work:

Question type	Answers given by all 30 students	
	Right answers	Wrong answers
Theory based	247	53
Concept based	198	102
Application based	168	132
Total Answers	613	287

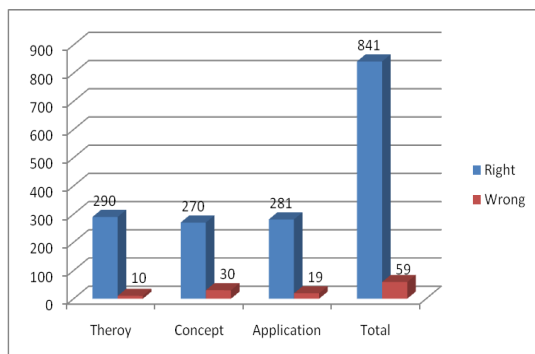


**FIGURE 1-** Student's Response before simulation lab work

On the same day Faraday's lab simulation was played on digital LCD projector in classroom. The information about each experiment of simulation was given to the students. Demonstration of every experiment was given to the students. Then the students were divided into five groups and they were allowed to do the experiment with the Faraday's lab simulation software in computer laboratory due to limited sources. Same multiple choice questions test was again taken just after Faraday's lab simulation experiments. The answers given by students were again evaluated and are given in following table.

**TABLE II** Students' response in the form of right and wrong answers after Faraday's simulation lab work:

Question type	Answers given by all 30 students	
	Right answers	Wrong answers
Theory based	290	10
Concept based	270	30
Application based	281	19
Total Answers	841	59



**FIGURE 2-** Students' Response after simulation lab work

### III. FARADAY'S EMI LAB SIMULATION

It consists of five experiments. These are:

#### A. Bar Magnet, Compass and Field Meter experiment

It describes the strength, direction of magnetic field of bar magnet at different positions near it. This part of simulation is related with the following equations:

$$B = \left[ \frac{\mu_0}{4\pi} \frac{M}{r^3} \right] \sqrt{3\cos^2\theta + 1} \text{ ----Magnetic field Induction equation}$$

$$\alpha = \tan^{-1} \left[ \frac{1}{2} \tan \theta \right] \text{ .---- Direction of B}$$

#### B. Bar Magnet Coil experiment

It describes the Lenz's Faraday's law of EMI. It describes the following equation:

$$e = - \frac{d\phi}{dt} \text{ .----- Induced emf}$$

#### C. Electromagnet experiment

It describes the Biot-Savart law and magnetic field produced by bar magnet. It is based upon the equation

$$B = \mu_0 NI \text{ .--Magnetic field Induction along axis of solenoid}$$

#### D. Transformer experiment

It is based upon principle of mutual induction and describes the following equations:

$$e_s = -M \frac{dI_p}{dt} \text{ ---- Equation of mutual induction}$$

$$\frac{e_s}{e_p} = \frac{n_s}{n_p} \text{ .----- Equation of transformation ratio}$$

#### E. AC generation experiment

In this simulation rotating bar magnet induces emf in the fixed coil. By changing the area, number of turns of coil and rotational speed of bar magnet, students can change the magnitude of induced emf. It is based upon following equations:

$$e = - \frac{d}{dt} [nAB \cos(\omega t)] \text{ .-----emf induced in rotating coil}$$

Students can study the importance of each variable in every equation of EMI using above simulations.

#### IV. INSTRUCTIONS FOR SIMULATION STUDY

For each experiment, carefully designed instructions were given to the students. (available on webpage <http://phet.colorado.edu>)

#### V. OUTCOMES OF THE STUDY

After Faraday's simulation, lab exercise students thinking and approach towards conceptual and application based question changed. Students' response to all questions improved. This happened due to experiment performed by students using simulation. It is possible to study these experiments easily using simulation without any risk. Experiments done by students removed the difficulties in understanding the EMI theory.

#### VI CONCLUSIONS

Physics lab simulations are effective tools to describe every difficult concept of physics. Faraday's lab simulation is an easy way to enhance students' understanding of Faraday's theory of electromagnetic induction.

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