Thai first-year engineering student ideas about magnetic forces

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BACKGROUND
In 2010 and 2011, an interactive teaching method was trailed in an introductory physics course. Only the concepts concerned with the direction and magnitude of a magnetic force on a charged particle moving through a magnetic field were the focus. The first-year engineering students of University of Phayao, who enrolled in this course, were taught in those concepts by an interactive teaching method rather than a traditional teaching method. Student's understandings were investigated by applying the two diagnostic tests, developed from the previous research, for the mid-term examination. Student responses were categorized into groups by considering the correct conceptions. In this article, we focus on identifying the different conceptions a group of first year engineering students had of a concept in magnetism. In particular, the conceptions of a charged particle moving in a magnetic field. This is very important data that can be used to provide guidance about the design of the introductory physics course modifications of University of Phayao in the future.

PURPOSE
To identify different conceptions held by of a group of 608 first year engineering students, University of Phayao, Thailand, about a charged particle moving in a magnetic field.

DESIGN/METHOD
The sample of this study are 608 first year engineering students, University of Phayao, Thailand, they are 214 students and 394 students who registered in the introductory physics course in 2010 and 2011, respectively. They were asked to indicate the directions and magnitudes of the crossed products on charged particles moving in a magnetic field, for midterm examination. All student answers were classified into groups by determining correct conceptions. Student's misconceptions were identified from the group of student had incorrect answers.

RESULTS
All student' answers were classified into 3 main groups by determining the correct conceptions, all correct (AC), partial correct (PC) and unclassified (UC), respectively. In 2010, there are 50.0%, 40.4% and 9.60% of (AC), (PC) and (UC), respectively. As the same scenarios, there are 49.2%, 31.7% and 19.1% of (AC), (PC) and (UC), respectively. The 6 different groups of misconceptions were identified from PC.

CONCLUSIONS
Most students confused how to indicate magnitudes and directions of the crossed products on charged particles moving in a magnetic field. The right-hand rule and the basic ideas related to a magnetic filed should be taught carefully.

KEYWORDS
Misconceptions, magnitudes and directions of crossed products, a magnetic field and a charged particle

Background

In the introductory physics course at the University of Phayao, first-year engineering students of are usually taught by a traditional method rather than an interactive learning method. The lecturers often use a PowerPoint to describe physics content in the class. In the traditional teaching class, the lecturers usually give them the examples and show how to solve the problems and then encourage student to do exercises. Since 2010 and 2011, an interactive teaching method had been applied in the class; but only the concepts involved a charged particle moving in a magnetic field. Students were given a chance to predict the direction and magnitude of the magnetic force on a charged particle moving in a magnetic field in different directions according to their conceptions. The correct answers were then revealed step-by-step based on the right-hand rule with experiment kits. To measure students' understandings, conceptual questions about those concepts were developed from the questions presented in the previous research. For instance, the conceptual test "The Conceptual Survey of Electricity and Magnetism (CSEM)", developed by Maloney, O'Kuma, Hieggelke and Heuvelen in 2000, is a set of multiple-choice questions that can be used to assess students' conceptions about electricity and magnetism. Another used was the conceptual test "The Brief Electricity and Magnetism Assessment" (BEMA) developed by Ding, Chabay, Sherwood, and Beichner in 2006.

In this case study, only two conceptual questions were applied in the mid-term examination. From the results, we found that most students could not identify the magnitude and direction of the magnetic force acting on a charged particle moving through a magnetic field. Also, most of them could not apply the right hand rule to indicate a direction and a magnitude of a crossed product. Even though they were taught by an active learning method. For a preliminary work, student's answers are categorized into groups by determining correct conceptions. The misconceptions are identified from students got uncorrected answers.

Purpose

To identify different conceptions held by of a group of 608 first year engineering students, University of Phayao, Thailand, about a charged particle moving in a magnetic field.

Method

The samples of this article were 608 first-year engineering students at the University of Phayao, Thailand, who studied the introductory physics course in 2010 and 2011. In 2010 and 2011, they were 214 students and 394 students who registered in this course respectively. In each year, the same lecturers taught students in the same topics and content. Most topics were taught by a traditional teaching method, describing the content with PowerPoint and solving problems. Only the concept about the magnitude and direction of the magnetic force on charged particles moving in a magnetic field was taught by an interactive teaching method. The lectures needed to investigate students understanding about those concepts, which were taught by an interactive teaching method. So, the conceptual questions, developed based on the previous research, were applied in the midterm examination in each year. The conceptual questions mentioned above were composed of two questions. The first question was designed to investigate student's conceptions used to determine the direction of a magnetic force and velocities of a charged particle moving in a magnetic field. As we know, when considering a crossed product and using the right hand rule between velocities of a charged particle and a magnetic filed, we are able to identify a direction of a magnetic force on a charge particle. The direction of a crossed product is perpendicular to the plane of other two operated vectors.

Followings are the first conceptual questions of 2010 and 2011 respectively. The direction of the magnetic force acting on the charged particles and the velocity of charged particles are required identifying.

The first question of 2010 & 2011

2010 (Figure 1): For A - C, draw the direction and magnitude of the magnetic force acting on the charged particles. For D-F, draw the direction and magnitude of the velocity of charged particles. Let the magnetic field propagates into the paper page.

2011 (Figure 2): For A - C, draw the direction and magnitude of the magnetic force acting on the charged particles. For D-F, draw the direction and magnitude of the velocity of charged particles. Let the magnetic field propagates into the paper page.

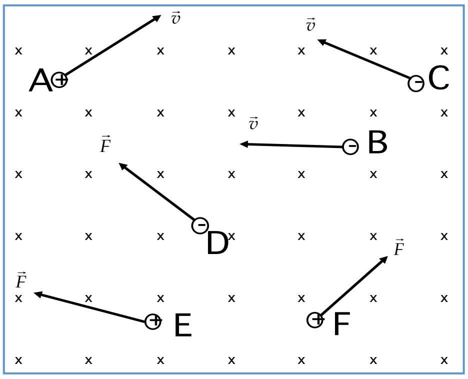


Figure 1: First question of 2010

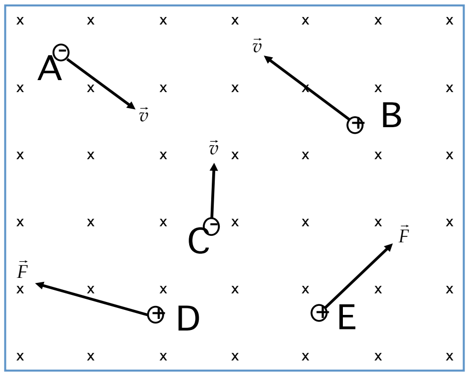


Figure 2: First question of 2011

Noticeably, the 2011 question is more complicated than the 2010 question, as the magnitude and a type of the charged particle are varies. A direction and a magnitude of the magnetic force acting on the charged particles are required identifying. The important concept for solving this question is the magnitude of the magnetic force converts to the magnitude of the charged particles. Followings are the second conceptual questions of 2010 and 2011, respectively.

The second question of 2010 & 2011

2010 (Figure 3): Draw suitable directions and indicate the magnitude of the magnetic force acting on any charged particles moving through a magnetic field.

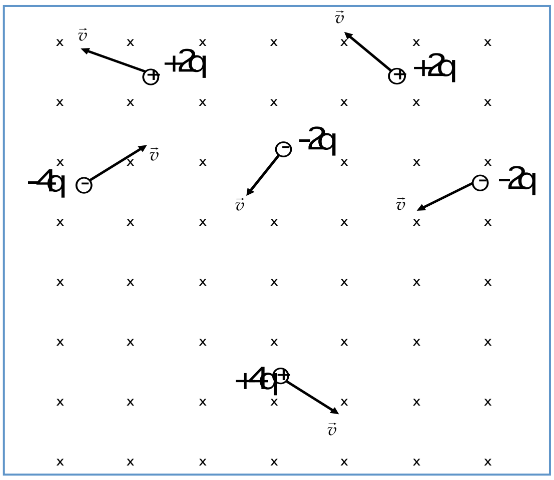


Figure 3: Second question of 2010

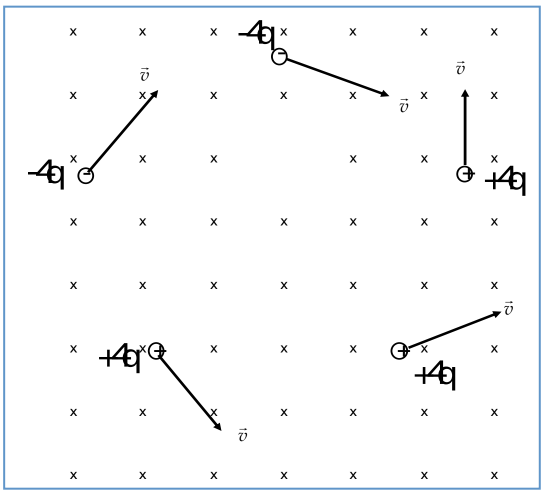


Figure 3: Second question of 2011

2011 (Figure 4): Draw suitable directions and indicate the magnitude of the magnetic force acting on any charged particles moving through a magnetic field.

The correct answers of each question are presented in Figure 5 to Figure 8. All students' responses were classified into 3 main groups by considering the answers from both two questions. Students who answered all correct were grouped into the all-correct group (AC). Most students in this group had good total scores for the mid-term examination. Students who had no results or answered questions in random patterns were classified into the unclassified group (UC).

The final group was the partial correct group (PC). The students' responses in this group were amazing. Their drawing patterns investigated from both two questions was the same. The ideas they had appeared in both questions obviously. The students in this group was very interesting because about a half of all students were classified into this group, if they had a suitable encouragement to have better understanding in those concepts, the percentages of students in (AC) would be increasing. The misconceptions of the students in (PC) were classified in to groups. For students' responses in (UC) could not be interpreted all their ideas in this moment because their drawing patterns in both two questions were not coherent. Some overlapping ideas among the misconception groups of (PC) are discussed.

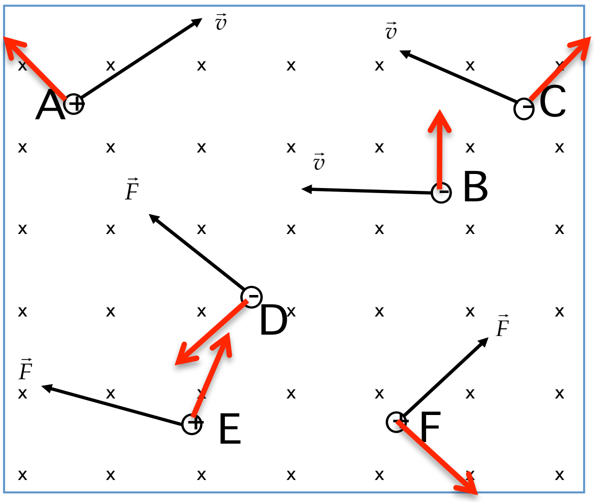


Figure 5: Solution to first question of 2010

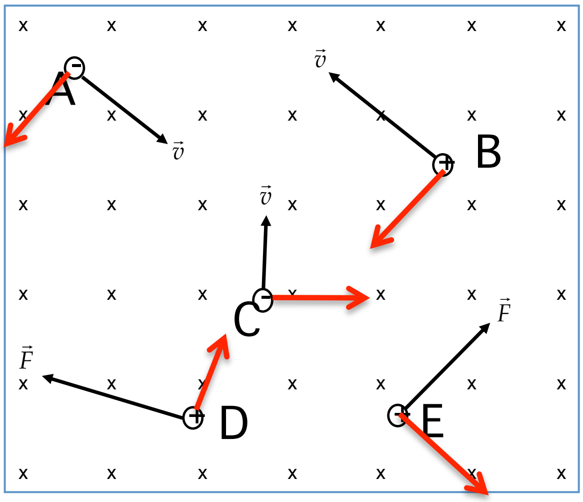


Figure 6: Solution to first question of 2011

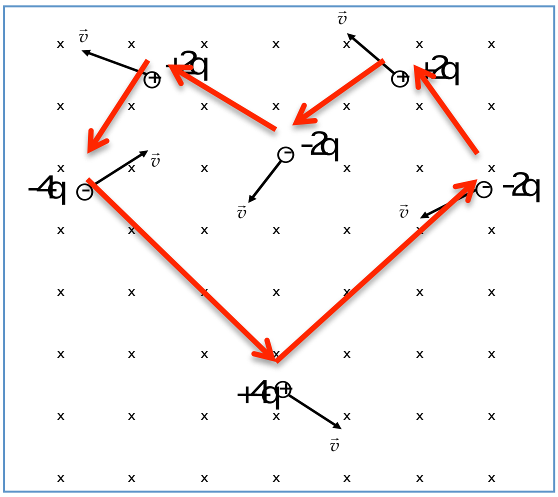


Figure 7: Solution to second question of 2010

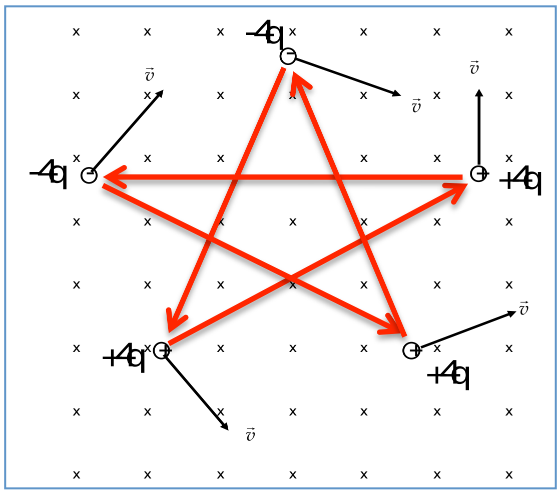


Figure 8: Solution to second question of 2011

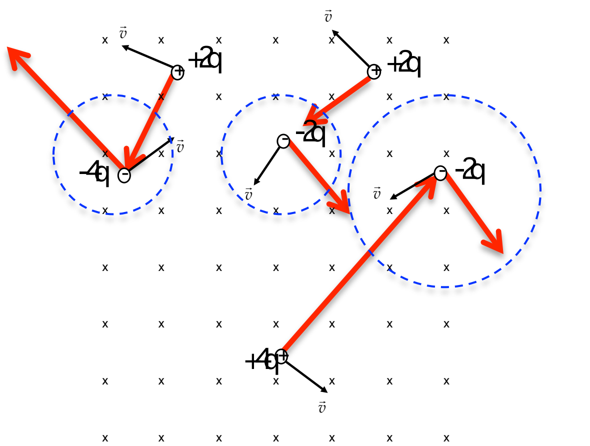
Results & Discussion

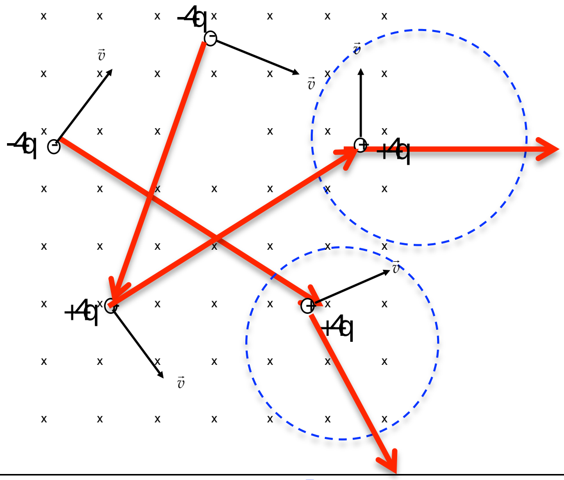
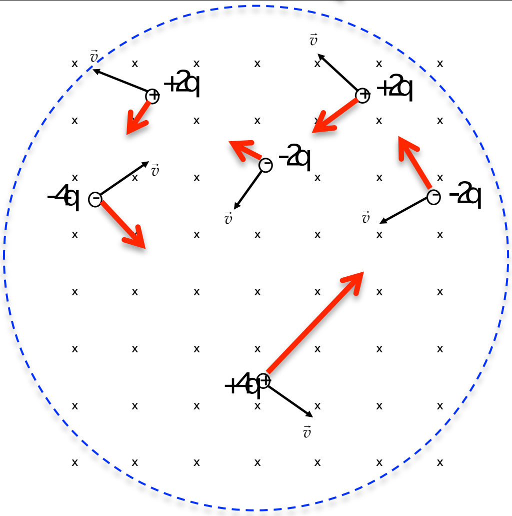
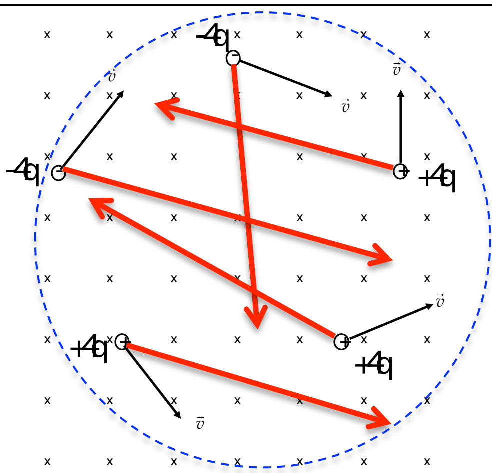
All student' responses were classified into 3 main groups by referencing against the correct conception (answer). As shown in Table 1, there were 50% and 49.2% of all students in 2010 and 2011, respectively, were able to indicate suitable directions of magnetic forces on particles and velocities of charged moving in a magnetic field. They were classified into (AC). A few students, 9.6% and 19.1% of all students in 2010 and 2011, respectively, had no answers or answer the questions in random patterns; they were classified into (UC). Interestingly, there were many students, who had partial understanding, in (PC) for each year, 40.4% and 31.7% of all students in 2010 and 2011, respectively. From the results, misconceptions of students became apparent when the answers of students in (PC) and (UC) were determined. However, this research still has limitations for approaching exactly ideas of students classified in (UC). Because, most students classified in this group did not give any responses, other few students used incoherent ideas for solving problems. To find the exactly misconceptions of students in (UC), the interview should be applied for getting more information. The students' responses in (PC) were able to classify in to sub-groups by determining misconceptions and drawing patterns. They were 6 sub-groups of (PC) as shown in Table 2.

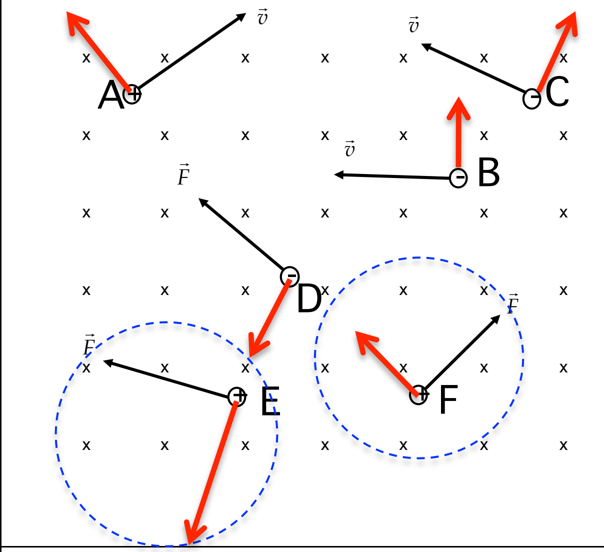
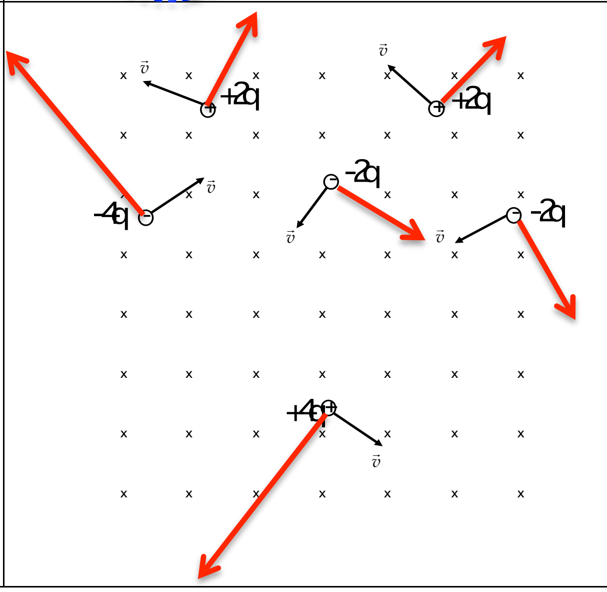
Table 1: The percentage of students answer in each year

Group	Percentage of students in each year	
	2010 (214 students)	2011(394 students)
All correct (AC)	50.0%	49.2%
Partial correct (PC)	40.4%	31.7%
Unclassified (UC)	9.6%	19.1%

Table 2: The percentage of students in six sub-groups of (PC) group

Sub group	Misconceptions	The example of students answers	Percentage of students	
			2010 (87 students)	2011 (125 students)
1	Charge disregarded, all treated as positive charges		23.57%	28.12%

2	Charge disregarded, treated some as negative and positive charges alternately		12.86%	8.88%
3	Didn't account for charge magnitude		31.79%	34.33%
Sub group	**Misconceptions**	**The example of students answers**	**Percentage of students** **2010 (87 students)**	 **2011 (125 students)**
4	Angle not ninety degrees		16.07%	15.23%

5	Didn't distinguish between velocity or force		11.81%	9.64%
6	Left hand used instead of right hand		3.90%	3.80%

Sub-Group 1, they were 23.57% and 28.12% students of (PC) in 2010 and 2011, respectively, classified in this sub-group. They confused about a type of charged particles when a magnitude and a direction of a magnetic force and a charged particle' velocity required indicating. As the example of students answer shown in Table 2; we found that students could identify a direction and a magnitude of the magnetic forces on positive charges moving in a magnetic field. But they could not for the negative charges. They could indicate a direction and a magnitude of the positive charge velocities when a magnetic field and a magnetic force were represented. It was possible that students did not know how to use the left hand for indicating the direction of the crossed products resulting from a negative charge moving in a magnetic field.

Sub-Group 2, they were 12.86% and 8.88% students of (PC) in 2010 and 2011, respectively, classified into this sub-group represented a magnitude of a magnetic force on charged particles which converted to the magnitude of each charged particle correctly. The ratios of a magnitude of magnetic forces appear on each particle in the first question and the second question was compared. We found that student realized in a magnitude of a magnetic force on each charged particle but the directions, considering from both positive and negative charges, were wrong, as shown in dash-line circle (only in the case of positive charges), see Table 2. The students' responses in this group were different from Sub-group 1, which appeared only on the negative charged.

Sub-Group 3, they were 31.79% and 34.33% students of (PC) in 2010 and 2011, respectively, classified into this sub-group, they could not draw a suitable magnitude of the crossed products which depended on the magnitude of charged particles. As shown in Table 2, the directions of the magnetic forces were indicated correctly but the magnitudes were wrong. It can be implied that they understood how to use the right and the left hand for indicating the direction of the crossed products but they did not concern the magnitude of charged particle affected to the magnitude of the magnetic force.

Sub-Group 4, they were 16.07% and 15.23% students of (PC) in 2010 and 2011, respectively, classified into this sub-group, they all presented a magnetic force in the correct magnitude. But the directions of all magnetic forces on each charged particle they presented were incorrect. It were different from Sub-group 2 because the direction of magnetic forces classified in this group were not perpendicular to a plane of charged particles velocity and a magnetic field, in sharp angle, as the example of students answers shown in Table 2. While the wrong directions of a magnetic force on each particle in Sub-group 2 were presented in an opposite way.

Sub-Group 5, they were 11.81% and 9.64% students of (PC) in 2010 and 2011, respectively, classified into this sub-group presented a direction and a magnitude of a magnetic force on each charged particle correctly. But they could not apply the right hand rule to indicate the direction of charged particles velocities when the direction and the magnitude of the magnetic force and a magnetic field were indicated as shown in Table 2.

Sub-Group 6 they were 3.90% and 3.80% students of (PC) in 2010 and 2011, respectively, classified into this sub-group. They drew all crossed product in opposite way compared with the correct direction. The results presented in this group were different from Sub-group 2; they drew all crossed product in opposite way, all wrong, while some answers of Sub-group 2 were correct. Students still had some confuses about the type of charged particles as shown in Table 2.

Conclusions

Most students lack understanding in how to identify a magnetic force on charged particles moving through a magnetic field, especially by applying the right–hand rule. Many students' misconceptions are present, such as the confusion about the type of charged particles. Shaffer and McDermott (2005) said that the development of instructional materials that help improve student learning at the introductory level is necessary. For example, Marr, Thomas, Benne, Thomas and Hume (1999) developed instructional systems for teaching an electricity and magnetism course for engineers. To help students have better understanding in physics, students understanding in mathematics should be approached, especially in the topics that concerned with application in physics as presented in the recent research of Flores, Kanim and Kautz (2004). For this case study, valuable data about student's conceptions are revealed. Even though this case study is small in scope, it is a good first step for helping our students. This research is a project that encourages physics lecturers, especially in the University of Phayao, to realise how to investigate student's misconceptions and design curricula which is suitable to address these misconceptions. The results from this study will be the base for developing the physics curricula of the University of Phyao for the next year.

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