Identification students’ misconception using four-tier diagnostic test on Newton Law subject

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Abstract. Misconception is something that causes students fail to understand physics concept intensively. The research aims to identify the students’ misconception on Newton Law concept using four-tier diagnostic test. Method used in the research was descriptive method. Data of students’ misconception was collected using test and interview. The subjects of the research were students of X MIPA 5 in State Senior High 10 Malang in 2019/2020 academic year and they were 32 students. The result of the research shows that the level of students’ misconception of X MIPA 5 in State Senior High 10 Malang is 54% which belongs to medium category. The research found that the misconception which happened to most students was on Newton II Law which is 63%. It also revealed that misconception in students occur because of experiences or events experiences by students in everyday life, students’ initial concepts and teacher teaching methods.

1. Introduction
Misconception is something that causes students fail to understand physics concept intensively [1]. Many students experience misconceptions in physics [2]. It often happens not because the students’ understanding is not correct, but because the pre-conception appears to be error during the learning process that it influences into the class. Misconception may appear in students’ daily activity when they make contact with their surroundings. The error physics-concept will then become their base because the understanding formed before is wrong and it will be hard to get it right [3].

Misconception which happens in physics learning process may obstruct the students, so that it causes error and difficulty in learning physics because it is hard for them to understand and to relate to the lesson gained before [4]. Misconception which happens in physics learning must be identified soon because it may obstruct the students in understanding knowledge [5]. Students’ daily activity which relates to their surroundings can be the trigger that causes misconception. Every student must have experienced physics phenomenon; such as falling objects, electric current, collision, and so on before they receive the lesson of physics concept [3].

Misconception may be influenced by students who direct their thought on something which appears in certain situation or incident [6]. They only pay attention to certain parts in many problems [7]. This error physics-concept will become a base because the understanding which has been formed before is wrong and it will be hard to get it right [3]. Therefore, it is necessary to identify misconceptions in physics concepts using diagnostic test so that the misconceptions that students have do not last long in students. Four-Tier diagnostic test is a method which can be used to identify the students’
misconception. It is applied both in the beginning and at the end of the lesson to identify the students’ misconception on learned-subject [8].

There have been many analyzes of students’ misconceptions using several tools, including third-level diagnostic tests on thermodynamic law material [9] and rotational dynamics [10], test questions on equilibrium material [11], fourth-level diagnostic tests on Newton's law material about gravity [12] and using the FCI and CRI tests [13]. However, the identification of students' misconceptions using four-tier diagnostic tests on Newton's law I, II, and III has never been done, so it needs to be done.

2. Methods
Method used in the research was descriptive method. The research flow of 3 stages namely (1) the preparation stage is the stage of making a physics question instrument on Newton material in the form of a four-tier diagnostic test, (2) the implementation stage, namely the stage of giving a four-tier diagnostic test on Newton's Law material to students of class X MIPA 5 with a total of 32 students, and (3) the data analysis stage which analyzed and analyzed students' answers using the student misconceptions rubric in table 1.

The research sample was selected by using cluster random sampling technique. Data collected by giving four-tier diagnostic test on Newton Law to 32 students of X MIPA 5 class in the form of computer-based isomorphic test which was used to diagnose the misconception [1]. Data of diagnostic test which has been identified was then analyzed based on high, medium, and low criteria. Four-tier diagnostic test [10] is presented on Table 1.

Table 1. Students’ concept category based on the answer of four-tier diagnostic test.

| No. | Category            | Combination of Answer | Conviction level for answer | Student’s reason | Conviction level for student’s reason |
|-----|---------------------|-----------------------|-----------------------------|------------------|---------------------------------------|
| 1   | Misconception (M)   | Wrong                 | Sure                        | Wrong            | Sure                                  |
| 2   | Correct             | Sure                  | Wrong                       | Sure             |
| 3   | Correct             | Not sure              | Wrong                       | Sure             |
| 4   | Wrong               | Not sure              | Wrong                       | Sure             |
| 5   | Concept Understanding (P) | Correct               | Sure                        | Correct          | Sure                                  |
| 6   | Not Understanding (TPK) | Correct               | Sure                        | Correct          | Not sure                              |
| 7   | Correct             | Sure                  | Correct                     | Not sure         |
| 8   | Correct             | Not sure              | Correct                     | Not sure         |
| 9   | Correct             | Not sure              | Correct                     | Not sure         |
| 10  | Correct             | Not sure              | Wrong                       | Not sure         |
| 11  | Wrong               | Sure                  | Correct                     | Not sure         |
| 12  | Wrong               | Sure                  | Wrong                       | Not sure         |
| 13  | Wrong               | Not sure              | Correct                     | Not sure         |
| 14  | Wrong               | Not sure              | Correct                     | Not sure         |
| 15  | Error (E)           | Wrong                 | Sure                        | Correct          | Sure                                  |
| 16  | Wrong               | Not sure              | Correct                     | Sure             |

Besides the test, data was collected by giving interview. Interviewing the students is used to deeply understand the students’ misconception.

3. Results and discussion
The result data of identifying students’ misconception is presented on Figure 1.
Figure 1. Entire students misconception of X MIPA class.

Figure 1 shows the entire result of the students’ answers after given four-tier diagnostic test to identify the misconception and it shows 54% for misconception, 21% understanding concept, 16% for not understanding the concept, and 9% for error. The result shows that students who have misconception are more than half of the class. It means the misconception belongs to medium category. It is the same result with the previous research in which students had misconception in Newton Law [12].

Misconception happens because the students have not mastered the concept taught yet; it is because the students’ initial concept is not good enough [13] and the teachers use monotone teaching method, which is giving speech so that the teachers do not urge their students to gain knowledge like a scientist [14].

Supported by the interview result to 9 students who have the highest misconception, the researcher found that the students’ misconception happens because of the students’ previous skill, not good enough competence or concept understanding, and the teachers’ teaching method which does not involve the students’ being active or is giving speech only. The students’ condition, the situation, and the learning method are the main cause which leads to students’ misconception [13].

The percentage data of misconception on each problem is presented on Figure 2. The percentage data of students’ misconception will show the representation of misconception scale on each problem indicator on Newton Law.

Figure 2 shows that the students have high, medium, and low misconception levels. High misconception level has range between $100\% < N < 60\%$, medium misconception level has range between $30\% < N < 60\%$, and low misconception level has range between $0\% < N < 30\%$. High misconception level is on problems number 2, 4, 6, 7, 10, 12, 19, and 20. The highest percentage is on problem number 2 with $78\%$. Medium misconception level is on problems number 1, 3, 5, 8, 11, 13, 14, 16, 17, and 18. Low misconception level is on problems number 9 and 15. High misconception happens on problems related
with Newton III Law Subject. It is the same result with the previous research which found that the highest misconception appeared on problems related to Newton III Law [12]. The example for problem and student’s answer which has high misconception level is presented on Figure 3.

![Figure 3](https://example.com/figure3.png)

**Figure 3.** Problem number 2 and student’s answer.

Based on the student’s answer on Figure 3, it can be seen that he/she chose the wrong answer and reason, but he/she was sure with his/her answer. If it is identified according to Table 1, then this student belongs to misconception category.

In this case, mostly students answered that to preserve a force of an object, then it needs another force. It obviously shows the student’s mistake. In fact, if an object moves in constant velocity, it does not need any additional force to preserve its motion. Or in other words, it does not need any force to preserve the motion of an object. Thus, according to the problem, the tennis ball keeps moving in constant velocity because it does not need external force to preserve its motion. This concept is based on Newton I Law which states that

\[
\sum F = 0
\]

The physics formula above means if there is no external force, then a still object will keep being still; while a moving object will keep moving in constant velocity [15,16]. So, the correct answer for when the tennis ball moves from B to C is it will keep moving in constant velocity because it does not need any force to preserve its motion. The correct reason for problem number 2 is It does not need external force to preserve an object which moves in constant motion.

Problem number 2 belongs to subchapter on Newton I Law, the influence of the force to a constant-velocity object; there were 22 students having misconception in solving the problem. After identifying all the answers for problem number 2, the researcher found that there are two criteria for students’ misconception; they are 1) wrong answer, sure about the answer, wrong reason, sure about the reason; and 2) correct answer, sure about the answer, wrong reason, sure about the reason. Based on the interview result, the students’ misconception on problem number 2 is caused by the students’ daily activity.
4. Conclusion

Based on the result of the research, it can be concluded that the students have misconception on Newton Law subject with the percentage of 54% which belongs to medium misconception level. From the entire 20 problems, there are 8 problems with high misconception level, 10 problems with medium misconception level, and 2 problems with low misconception level. Students’ misconception happens because of their daily activity or experience, their previous skill, and the teachers’ teaching method.

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