



## Diagnostic of Students' Misconceptions Motion and Force Material: An Analytical Study Based on Gender Differences

Asyrifatun Najiya<sup>1</sup>, Fatimatus Zahroh<sup>1</sup>, Inayatul Hasanah<sup>1</sup>, Nur Fajirotn Diniaty Achmad<sup>1</sup>,  
Herlina Mulyastuti<sup>1\*</sup>, Sunu Wahyudhi<sup>1</sup>, M. Amien Rais<sup>1</sup>

<sup>1</sup>Natural Sciences Education Study Program, Universitas Trunodjoyo Madura

Received: February 16, 2026. Revised: February 22, 2026. Accepted: February 25, 2026.

First Available Online: February 28, 2026. Publication Date: February 28, 2026.

DOI: 10.61142/esj.v4i1.334

\*Corresponding author: [herlina.mulyastuti@trunojoyo.ac.id](mailto:herlina.mulyastuti@trunojoyo.ac.id)

### Keywords:

Misconceptions,  
Motion and Force,  
Three-Tier Diagnostic  
Test, Gender Differences

### ABSTRACT

*This research is a descriptive qualitative study that aims to identify junior high school students' misconceptions regarding Motion and Force and to analyze gender differences. The research sample consisted of 30 students, namely 15 males and 15 females, from SMP 1 Burneh Bangkalan. The instrument used was the Three-Tier Diagnostic Test, which grouped students' understanding into the categories Know the Concept, Don't Know the Concept, and Misconception. The results showed a fairly high level of misconceptions in several topics. In the MK 3 category, female students showed a 26.2% and male students 26.7% on the topic of Average Speed. In the MK 2 category, the topic of Influence of External Forces had a high level of misconceptions, namely 16.7% in both genders. In the MK 1 category, the topic of Aerodynamics and Friction showed misconceptions of 20.0% in female students and 33.3% in male students. Overall, the gender analysis showed that both genders experienced misconceptions, but with different tendencies in each category.*

## INTRODUCTION

Understanding basic physics concepts, particularly those related to motion and force, is a key foundation in science learning because it serves as the foundation for understanding advanced physics concepts and various applications of modern technology (Basri et al., 2024). Proper mastery of these concepts enables students to develop analytical skills, critical thinking skills, and interpret natural phenomena

scientifically. However, in practical learning, students often have initial understandings that do not align with scientific concepts. These errors can persist into higher levels of education if not successfully corrected (Maliada et al., 2022). This situation makes understanding basic concepts a crucial aspect of physics education.

Misunderstanding, known as misconceptions, are a serious problem because they are strong and embedded in students' cognitive structures (Rokhim et al., 2023). Misconceptions are a major obstacle in the process of transferring and constructing new knowledge and significantly impact students' academic performance. If not identified early, misconceptions can reduce the effectiveness of learning even though students have received correct scientific explanations (Isnaini et al., 2024). The topic of motion and force, although close to everyday life, is a topic that often experiences misconceptions. Students often misunderstand the relationship between force, motion, and acceleration, as well as the concepts of friction, normal force, and Newton's law of action-reaction (Safriana & Irfan, 2021; Sila et al., 2024).

Conceptually, misconceptions in physics are influenced by students' prior understanding before formal learning. Initial concepts that do not align with scientific principles can be a barrier to understanding new materials and are often difficult to change because they stem from personal experience and everyday intuition (Maliada et al., 2022; Tenzin, 2024). Therefore, an evaluation instrument capable of comprehensively and accurately identifying misconceptions is needed. One widely used instrument is the Three-Tier Diagnostic Test, which consists of three components: multiple-choice questions, reasons for answers, and students' level of confidence (Kustiarini et al., 2019). The three-tier test instrument not only identifies correct or incorrect answers but also allows measuring the reasons behind the answers and the level of student confidence in the explanations (Khoiri & Zainuddin, 2024; Aini & Untoro, 2025). There are three levels in the three-tier test. The first level will ask for student's knowledge of the basic concepts of a phenomenon in the form of multiple choices. The second level will review student reasoning based on the results of choosing answers at the first level (Atmaja & Samsudin, 2023). Finally, the third level will ask about the answers to the first and second levels (Maulana et al., 2025). These findings highlight the urgency of more in-depth, systematic identification of misconceptions.

In addition to cognitive factors, individual factors such as gender are thought to influence students' understanding of physics concepts through differences in interests, attitudes, learning motivation, and social experiences. Recent research shows that although no significant differences were found between male and female students in understanding the physics concept of Work and Energy, students' learning interests, both cognitive and emotional aspects, were significantly correlated with their understanding of the concept, indicating the importance of motivational factors in physics learning (Safitri & Kusairi, 2025). The application of a similar diagnostic instrument in Indonesia shows that high school students still experience quite high levels of misconceptions in various physics topics (Yuberti et al., 2020). However, research on physics misconceptions in Indonesia generally focuses on identifying general levels of misconceptions without considering gender differences. However, gender-based analysis is crucial for providing a more comprehensive picture in designing inclusive learning strategies that are responsive to student characteristics. The aims of this study are to identify the level and form of students' misconceptions on the material of motion and force using the Three-Tier Diagnostic Test and to analyze the differences in the level of misconceptions between male and female students.

## **METHOD**

The quantitative descriptive method was chosen for this study. The research was conducted at a junior high school located in the Burneh District, Bangkalan Regency. In this study, the sample comprised 15 male and 15 female students from Grade VIII of SMPN 1 Burneh. In this research, a testing technique was used to collect data, with the instrument in the form of a Diagnostic Three-tier Test on the topic of Motion and Force. This test was designed to detect students' misconceptions through three stages: multiple-choice questions, selection of supporting reasons, and confidence level assessment. In the first stage, students selected answers from four options. In the second stage, they chose the appropriate

reason from four available options. The final stage involved a confidence assessment, in which students indicated their confidence in their chosen answers by selecting "confident" or "not confident" (Kustiarini et al., 2019). The instrument used in this study was developed by adapting validated measurement tools from previous research, as described by Isnainai et al. (2024). Based on the categories in the Three-tier Test categories, the data were analyzed to identify the types of understanding students possess. The detailed classification of students' understanding categories is shown in Table 1.

**Table 1.** Classification of Students' Understanding Categories

Student Response				
First Tier	Second Tier	Third Tier	Category	Code
Correct	Correct	Certain	Understanding the concept	TK
Correct	Correct	Not Sure	Don't Know The Concept (Lucky Guess)	TTK
Correct	Wrong	Not Sure	Don't Know The Concept	TTK
Wrong	Correct	Not Sure	Don't Know The Concept	TTK
Wrong	Wrong	Not Sure	Don't Know The Concept	TTK
Correct	Wrong	Certain	Misconception 1 (False Positive)	MK 1
Wrong	Correct	Certain	Misconception 2 (False Negative)	MK 2
Wrong	Wrong	Certain	Misconception 3	MK 3

The TK category indicates that students understand the concept correctly, as their answers, reasoning, and confidence are consistent with accurate conceptual understanding. TTK describes a condition in which students do not understand the concept, as evidenced by incorrect answers or reasoning accompanied by low confidence. MK 1 represents the first type of misconception, occurring when students provide correct answers but incorrect reasoning, while showing high confidence, indicating that the misunderstanding is firmly embedded. MK 2 refers to the second type of misconception, characterized by incorrect answers but seemingly correct reasoning, with high confidence, reflecting an inaccurate understanding that students believe is correct. Finally, MK 3 appears when both the answers and the reasoning are incorrect yet accompanied by high confidence, indicating the strongest form of misconception, as the entire basis of reasoning is inaccurate yet strongly believed to be correct (Isnaini et al., 2024).

## RESULTS AND DISCUSSIONS

This research results the form of a combination of students' answers to reasoned multiple-choice questions, using a three-level test. Table 2 presents the results of grouping student answers into conceptual understanding categories using the Three-Level Diagnostic Test instrument (see Table 1). This grouping includes the categories TK (Understand the Concept), TTK (Don't Understand the Concept), MK 1 (Misconception 1 – False Negative), MK 2 (Misconception 2 – False Positive), and MK 3 (Misconception 3), which describe the level of understanding and forms of misconceptions that students have for each question indicator. The presentation of data in this table aims to provide a more detailed picture of students' patterns of understanding and misconceptions in the material being tested, enabling comprehensive analysis in the results and discussion sections.

**Table 2.** Grouping of Questions and Materials

Topics	Question No.	Percentage									
		TK		TTK		MK 1		MK 2		MK 3	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Inertia	1	0	0	3.3	0	26.7	10	3.3	13.3	16.7	26.7
	3	13.3	10	13.3	0	3.3	10	0	0	20	30
	6	16.7	36.7	10	0	0	3.3	6.7	3.3	16.7	6.7
Average speed	2	0	0	15.3	3.3	0	20	7.7	0	26.7	26.7

Topics	Question No.	Percentage									
		TK		TTK		MK 1		MK 2		MK 3	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Speed and Slope graph	4	0	13.3	20	0	20	3.3	3.3	26.6	6.7	6.7
Influence of external forces	5	0	6.7	6.7	3.3	3.3	3.3	16.7	16.7	23.3	20
Lift Force and gravity	9	3.3	36.7	13.3	0	10	6.7	6.7	6.7	16.7	0
Friction and braking forces	7	10	23.3	13.3	3.3	3.3	13.3	13.3	3.3	10	6.7
Aerodynamics and friction	8	3.3	10	13.3	0	20	33.3	6.7	6.7	6.7	0
Gravity and acceleration	10	16.7	33.3	10	3.3	6.7	6.7	3.3	3.3	13.3	3.3

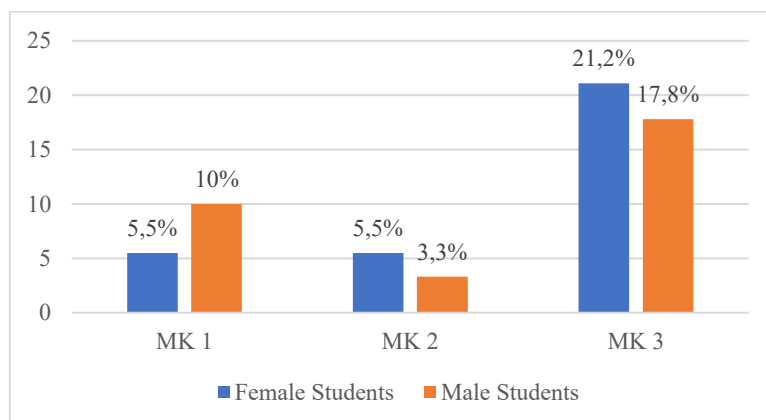
The data in Table 2 was then analyzed for misconceptions only for each topic, expressed as an average percentage of misconceptions. Details of the results of this average percentage calculation can be seen in Table 3.

**Table 3.** Grouping of average percentage of students' misconceptions

Topics	Average MK Percentage					
	MK 1		MK 2		MK 3	
	Male	Female	Male	Female	Male	Female
Inertia	10.0	5.5	3.3	5.5	17.8	21.1
Average speed	0.0	20.0	7.7	0.0	26.2	26.7
Speed and Slope graph	20.0	3.3	3.3	26.6	6.7	6.7
Influence of external forces	3.3	3.3	16.7	16.7	23.3	20.0
Lift Force and gravity	10.0	6.7	6.7	6.7	16.7	0.0
Friction and braking forces	3.3	13.3	13.3	3.3	10.0	6.7
Aerodynamics and friction	20.0	33.3	6.7	6.7	6.7	0.0
Gravity and acceleration	6.7	6.7	3.3	3.3	13.3	3.3
<b>Average</b>	<b>8.75</b>	<b>11.1</b>	<b>6.4</b>	<b>8.6</b>	<b>15.1</b>	<b>10.6</b>

Based on Table 3, which shows the grouping of average misconceptions (MK) among students, there are clear differences in the levels of misconceptions across eight physics topics and three categories of misconceptions (MK 1, MK 2, and MK 3). Overall, the Misconception 3 (MK 3) group recorded the highest total mean misconception score, namely 15.1% for males and 10.6% for females. In contrast, the Misconception 2 (MK 2) group had the lowest mean, with 6.4% for males and 8.6% for females. Interestingly, in MK 1 and MK 2, females had slightly higher mean misconceptions, but for MK 3, males showed a significantly higher mean score. Analysis by topic revealed that the Aerodynamics and friction in MK 1 for females topic had the highest misconception rate, at 33.3%. In addition, the average speed in MK 3 was high for both genders, at 26.2% for males and 26.7% for females. Meanwhile, the peak misconception value in MK 3 for females was observed in the Inertia topic, at 21.1%. On the other hand, the lowest value or zero (0.0) appeared in various categories, including the topic of Average Speed in MK 1 for males and MK 2 for females, as well as the topics of Lift and Gravity, Aerodynamics, and Friction in MK 3 for females.

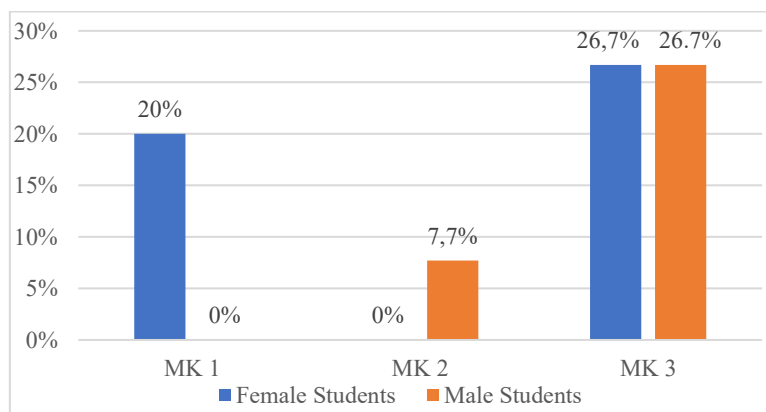
### Inertia



**Figure 1.** Comparison of The Percentage Level of Misconceptions Between Female and Male Students on The Topic of Inertia

The Figure 1 shows a comparison of misconceptions among female and male students on the topic of inertia, with MK 1 in female students at 5.5% and in male students at 10%. In comparison, the percentage of MK 2 in female students was 5.5%, and in male students was 3.3%. The percentage of MK 3 in female students reached 21.2%, and male students was 17.8%. Based on the highest percentage, the misconception was more prevalent in MK 3, with female students showing a higher percentage of misconceptions than male students. The pattern of MK 3 is the wrong answer, the wrong reason, and the level of confidence is certain. It occurs because students assume that when the truck brakes suddenly, the water in the bottle continues to move in the direction of the truck's previous speed due to inertia (Isnaini et al., 2024). Meanwhile, the correct concept according to Isnaini et al. (2024) is that objects tend to maintain their state of motion.

### Average Speed

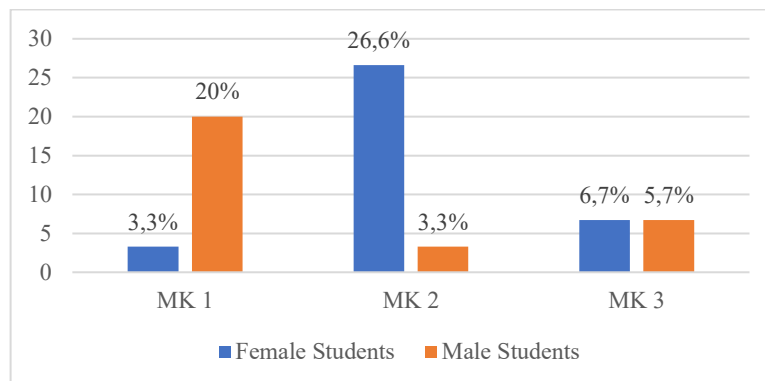


**Figure 2.** Comparison of The Percentage Level of Misconceptions Between Female and Male Students on The Topic of Average Speed

The Figure 2 shows a comparison of misconceptions among female and male students on the topic of average speed, where MK 1 in female students reached 20% and in male students 0%, while MK 2 in female students reached 0% and in male students 7.7%. The percentage of MK 3 in female students reached 26.7% and male students 26.7%. Based on the highest percentage, the misconception is more prevalent in MK 3, among both female and male students. The pattern of MK 3 is wrong answers, wrong reasons, and a certain level of confidence. In this topic, students assume that the average speed is calculated by dividing the total distance travel by the total time required. While the correct concept is that average speed is not the arithmetic mean of the speeds in the journey, but depends on

the total distance and time (Isnaini et al., 2024). The results of this study are in line with research conducted by Chrysostomou (2022), which concluded that no significant differences were found between men and women in the dominant misconception scores in mechanics.

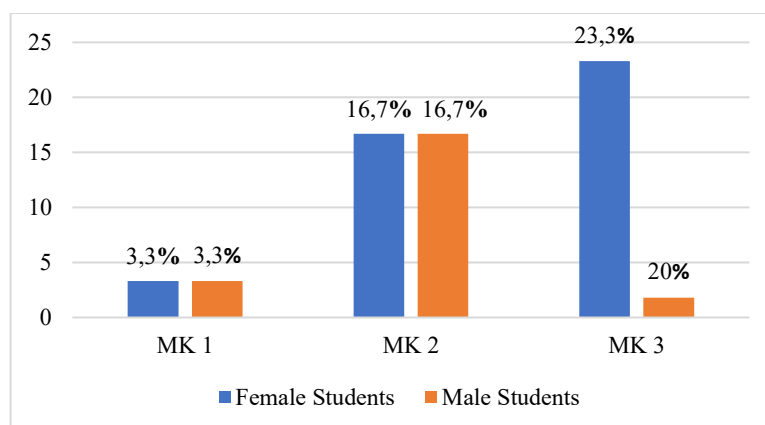
### Speed and Slope Graph



**Figure 3.** Comparison of The Percentage of Misconception Levels of Female and Male Students on The Topic Speed and Slope Graph

The Figure 3 shows a comparison of misconceptions among female and male students on the topic of average speed, where MK 1 in female students reached 3.3% and in male students 20%, while MK 2 in female students reached 26.6% and in male students 3.3%. Meanwhile, the percentage of MK 3 in female students reached 6.7% and male students 5.7%. It shows that male students have a high level of misconceptions regarding the Speed and Slope graph for the motion of objects. However, in the MK 2 category, female students had a higher percentage than male students in MK 1. The pattern in MK 2 was that the answer was wrong, the reason was correct, and the level of confidence was certain. It occurred because students assumed that the relationship between the slope of a position-time graph and an object's velocity was the same. Meanwhile, the correct concept is the relationship between the slope of the graph and velocity, where a steeper graph line indicates a higher speed and vice versa (Isnaini et al., 2024).

### Influence of External Forces

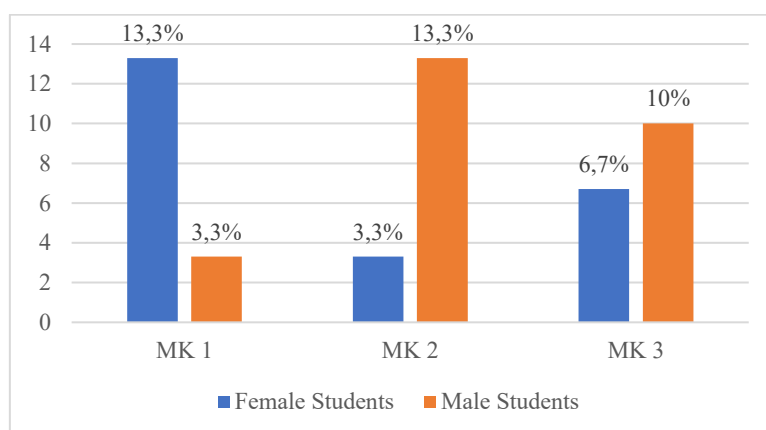


**Figure 4.** Comparison of the Percentage of Misconception Levels of Female and Male Students on The Topic Influence of External Forces

The Figure 4 shows a comparison of the levels of misconceptions among female and male students on the topic of average speed, where MK 1 in female students reached 3.3% and in male students 3.3%, while MK 2 in female students reached 16.7% and in male students 16.7%. Meanwhile, the percentage of MK 3 in female students reached 23.3% and male students 20%. It shows that male

students have a high level of misconceptions about the influence of external forces on the motion of objects. However, in the MK 3 category, female students have a higher percentage than male students in MK 2. The pattern of MK 3 is the correct answer, the reason is correct, and the level of confidence is certain. It occurs because students often assume that the ball's trajectory will not curve even if there is an influence of wind, or they misinterpret the effect of wind only on the speed of the ball without changing the trajectory (Isnaini et al., 2024).

### Lift Force and Gravity

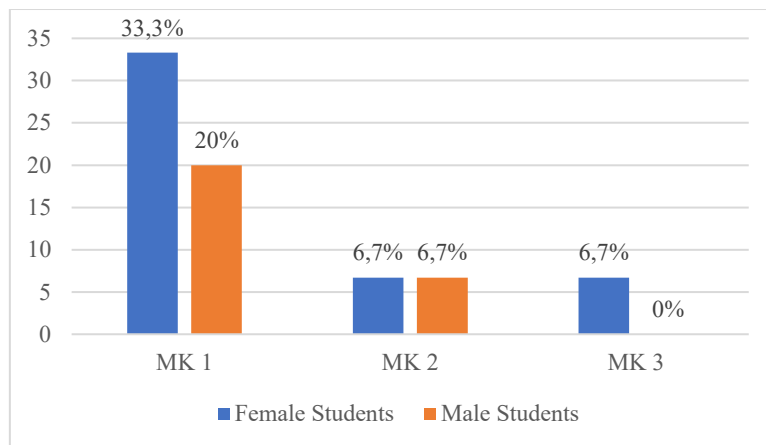


**Figure 5.** Comparison of the Percentage of Misconception Levels of Female and Male Students on The Topic Lift Force and Gravity

Based on the data on the level of misconceptions of 8th-grade students on question number 5, the Figure 5 shows the percentage in MK1 13.3% in female students and 3.3% in male students, MK2 3.3% in female students and 13.3% in male students, MK3 6.7% in female students and 10% in male students. The level of misconceptions about lift and gravity in MK1 and MK2 shows the same percentage; therefore, it can be concluded that the topic of lift and gravity is dominant in MK1 with a true, false, sure pattern and in MK2 with a false, true, sure pattern. MK1 and MK2 were chosen because they have a higher percentage of misconceptions of one gender than MK3. Many students still misunderstand the concept that an airplane can remain stable in the air (Isnaini et al., 2024). According to previous researchers, airplanes can fly stably in the air because there is a dynamic balance among the four main aerodynamic forces: lift, gravity, thrust, and drag. To achieve a state of stable flight (at a constant altitude and speed), these forces must balance each other: the lift force, which is generated mostly by the shape of the wings, according to Bernoulli's principle, must equal the force of gravity pulling the airplane down. At the same time, the thrust generated by the airplane's engines must be proportional to the drag force acting to stop forward motion (John & Anderson, 2017). This balance between opposing forces (lift, weight, thrust, and drag) ensures the airplane maintains its desired path and altitude. The design of the wings and tail also enhances stability, allowing the airplane to adjust to small disturbances and maintain its orientation automatically. This idea is the basis of the field of Aerodynamics and Aircraft Performance (John & Anderson, 2017).

### Friction and Braking Forces

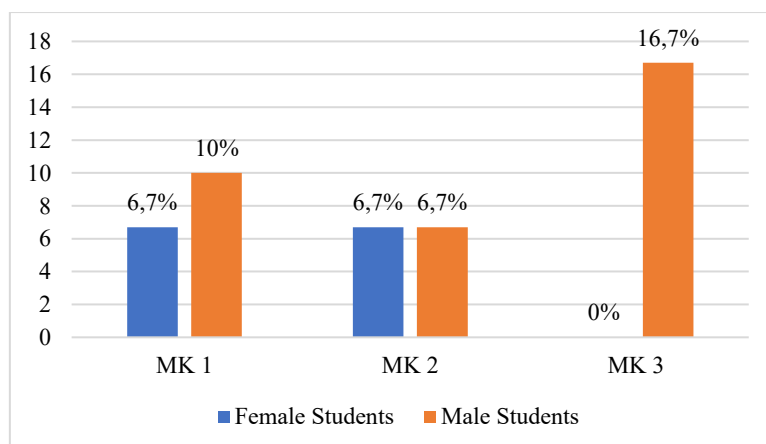
Based on the Figure 6 of the misconception level of 8th-grade students in question number 6, it shows that MK 1 in female students is 33.3% and in male students is 20%, MK 2 in female students and male students both show a percentage of 67.7%, MK 3 in female students is 6.7% and in male students is 0%. The data graph of the dominant misconception level in MK1 shows a true/false/unsure pattern, suggesting that the high percentage indicates many students have a wrong understanding of the concept or do not understand it. A greater braking force will result in faster deceleration, such as car A stopping faster than car B (Isnaini et al., 2024).



**Figure 6.** Comparison of The Percentage of Misconception Levels Between Female and Male Students on Friction and Braking Forces

The Net Force experienced by a vehicle when braking is a combination of various rearward forces, especially the Brake Force, which acts against the direction of motion. When the Brake Force is increased (assuming the vehicle's mass remains constant), the Net Force acting against the direction of motion will also increase, resulting in greater negative acceleration, or what is often referred to as more effective deceleration (Saputra & Fauji, 2022). This higher deceleration directly indicates that the time and distance required for the vehicle to reach a stationary state will decrease, which is a basic principle in braking mechanics and brake system design (Saputra & Fauji, 2022). Ngazizah (2024) emphasized that although there are differences in the percentage of misconceptions between men and women, these differences do not indicate a consistent superiority of men against misconceptions; women are actually higher in this study.

### Aerodynamics and Friction

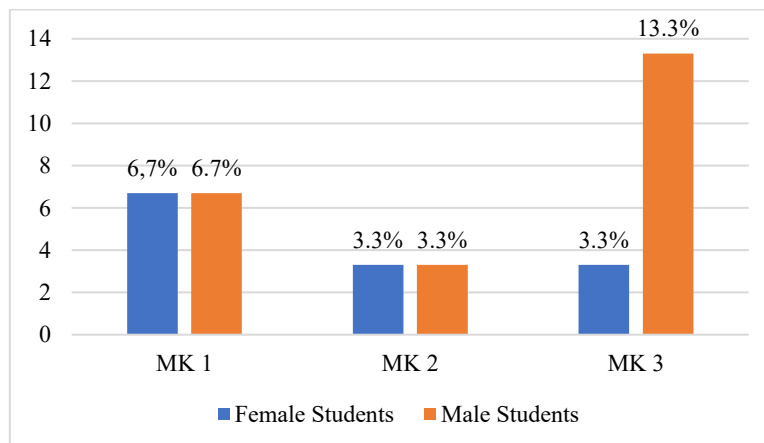


**Figure 7.** Comparison of The Percentage of Misconception Levels of Female and Male Students in Aerodynamics and Friction

Based on the Figure 7, the level of misconceptions shows a percentage of 6.7% in female students and 10% in male students in MK 1, 6.7% in female and 10% in male students in MK 2, 6.7% in female and 16.7% in male students in MK 3, and 16.7% in male students in MK 3. The bar graph shows that the highest percentage is in MK 3 in males, which is 16.7%. MK 3 indicates a pattern of wrong, wrong, sure, which means. This high percentage indicates that many male students hold this misconception, as they may not understand that the circular shape is more aerodynamic than an octagonal one, thereby reducing friction and accelerating movement on an inclined plane (Isnaini et al., 2024). It may indicate that female students have a better understanding of the concepts of Aerodynamics and Friction. In the

basic principles of aerodynamics, flow velocity and forces act on an object, affecting its performance and efficiency (Afrianto et al., 2020). Friction force is a force that is proportional to the state of lubrication on the surface of the interacting objects (Fitrianto et al., 2015).

### Gravity and Acceleration



**Figure 8.** Comparison of The Percentage of Misconception Levels Between Female and Male Students on The Topic of Gravity and Acceleration

The Figure 8 shows a comparison of misconceptions among female and male students on the topic of average speed, with MK 1 in female students at 6.7% and in male students at 6.7%. In comparison, MK 2 in female students reached 3.3%, and in male students, 3.3%; for MK 3, in female students, 3.3%, and in male students, 13.3%. It shows that male students have a high level of misconceptions about gravity and acceleration. However, in the MK 3 category, male students have a higher percentage than in MK 1, both among female and male students. The pattern of MK 3 is wrong answers, wrong reasons, and a certain level of confidence. It occurs because students often assume that acceleration depends solely on the pushing force from the rider, rather than on gravity (Isnaini et al., 2024). The correct concept is that gravity exerts an acceleration in addition to the force the rider applies. Scientifically, gravity provides a constant acceleration of approximately  $9.8 \text{ m/s}^2$  to all objects on Earth. Therefore, changes in the movement. The three-tier test instrument not only identifies correct or incorrect answers but also allows measuring the reasons behind the answers and the level of student confidence in the explanations. Movement of an object are strongly influenced by the applied force (for example, the push from the rider) plus the pull from our planet. This explanation is in line with Newton's Law of Gravity and is supported by several studies on gravitational acceleration, including research by Muryanto et al. (2024). According to our study, male students' understanding of the concept in male students is usually lower than that in female students. Male students are indeed more active in class, but unfortunately, this activeness often makes them difficult to manage. It makes them more likely to skip class and consequently lose a lot of learning time. On the other hand, according to Amir (2013), female students have better learning outcomes because they are more motivated and more active in completing schoolwork than male students.

### CONCLUSION AND SUGGESTION

This study confirms that misconceptions about motion and force are prevalent. The main findings show significant differences in how well students understand concepts by gender. Gender-based analysis revealed clear distinctions, with male students predominantly falling into the MK 3 category, averaging 15.1%, indicating high confidence even when their answers were incorrect. On the other hand, female students were mostly classified within the Know the Concept (TK) and Do Not Know the Concept (TTK) groups. However, in some cases, such as aerodynamics and friction in MK 1 and inertia, female

students were frequently identified in the MK 3 category, with a 33.3% rate. These findings highlight the importance of using three-tier diagnostic tests for accurate assessment and demonstrate that gender-based analysis is highly useful for identifying different patterns of conceptual errors. It enables more targeted and responsive instructional approaches.

Further research is expected to explore non-cognitive elements, such as risk-taking behavior, that may contribute to the high level of confidence (MK 3) observed among male students in incorrect contexts. In addition, evaluations of the effectiveness of instructional models and gender-adapted conceptual change approaches are recommended to address varying patterns of misconceptions. To improve the generalizability of the findings, future studies are advised to increase and broaden the sample size by including participants from more diverse school backgrounds.

## REFERENCES

- Afrianto, M. A., Permatasari, R., & Annas, M. S. (2020). Design, construction and testing of a subsonic type open circuit wind tunnel on a scale car replica. *Webinar Nasional Cendekiawan*, 1(6). <http://publikasi.kocenin.com/index.php/pakar/article/view/38>
- Aini, A. N., & Untoro, N. (2025). The three-tier test approach to measuring misconceptions in high school physics: Focus on work and energy. *Impulse: Journal of Research and Innovation in Physics Education*. <https://doi.org/10.14421/impulse.2025.52-03>
- Amir, Z. (2013). Gender perspective in mathematics learning. *Journal of Women's Religion and Gender*, 12(1), 15–31. <https://ejournal.uin-suska.ac.id/index.php/marwah/article/view/511/0>
- Atmaja, D. Y. S., & Samsudin, A. (2023). Are there misconceptions in my class? Misconception analysis with T3-SF (three-tier test on static fluid). *Tarbiyah: Jurnal Ilmiah Kependidikan*, 13(2). <https://doi.org/10.18592/tarbiyah.v13i2.13518>
- Basri, N. A., Salmah, U., Irawan, I. D. A., Indraloka, R. M., & Parno. (2024). Rasch analysis of the force and motion conceptual evaluation test: Validity and reliability in measuring force and motion understanding of students. *Jurnal Pembelajaran Fisika*, 13(1). <https://jurnal.fkip.unila.ac.id/index.php/JPF/article/view/30258>
- Chrysostomou, A. (2022). Gender differences in students' misconceptions in mechanics. *Education Sciences*, 12(6), Article 391. <https://doi.org/10.3390/educsci12060391>
- Fitrianto, M. B., Darmanto, & Syafa'at, I. (2015). Testing the surface friction coefficient of ST 37 steel plate on a plane. *Momentum*, 11(1), 13–18.
- Isnaini, R., Fitriani, A. D., Praba, N. N. S., Amelia, A., Pratiwi, Y. C., Rohmi, A., Nafila, A., Tuzzuhro, N., Leviawati, T. U., Hazim, M. F., Muaziyah, S. E. S., & Supriyadi. (2024). Identification of students' misconceptions about motion and force material in junior high schools in Labang District, Bangkalan Regency using the diagnostic three-tier test. *Vector: Journal of Science Education*, 5(2). <https://vektor.uinkhas.ac.id/index.php/vtr/article/view/156>
- John, D., & Anderson, J. (2017). *Fundamentals of aerodynamics*. (Tambahkan penerbit; hapus URL Google Search dan gunakan sumber resmi buku bila tersedia).
- Khoiri, M., & Zainuddin, A. (2024). Analisis profil miskonsepsi siswa pada materi fluida dinamis melalui instrumen tes berbasis three-tier diagnostic test dengan teknik certainty of response index. *Inovasi Pendidikan Fisika*, 14(2), 109–115. <https://doi.org/10.26740/ipf.v14n2.p109-115>
- Kustiarini, F. T., Susanti, V. H. E., & Saputro, A. N. C. (2019). The use of the three-tier open-ended reasoning diagnostic test to identify solution misconceptions. *Jurnal Pendidikan Kimia*, 8(2), 171. <https://doi.org/10.20961/jpkim.v8i2.25236>
- Maliada, N., Amiruddin, K., & Miftah, M. (2022). Analysis of misconception in physics subject using three-tier diagnostic test. *Jurnal Pendidikan Fisika Tadulako Online*, 10(1). <https://jurnal.fkipuntad.com/index.php/jpft/article/view/3417>
- Maulana, A. F., Fitriya, L., Layly, N. N., Putry, N. H., Faisyah, K. A., Dewi, M. R. S., Amanatillah, F., & Utami, I. S. (2025). Identification of Misconceptions about Substance Pressure in Junior High School Students using the Three-Tier Diagnostic Test. *Equator Science Journal*, 3(2), 79–88. <https://doi.org/10.61142/esj.v3i2.230>

- Muryanto, S., Efendi, M., Wuryanto, S., & Harnsoongnoen, S. (2024). Improved accuracy in determining the acceleration due to gravity in free fall experiments using smartphones and mechanical switches. *Applied Sciences*, 14(6), Article 2632. <https://doi.org/10.3390/app14062632>
- Ngazizah, N., Adilah, N., Prahadista, I. N., Rahma, F. S. A., & Syarifah, K. (2024). Miskonsepsi IPA materi magnet kelas V di SD Muhammadiyah se-Kabupaten Purworejo. *Jurnal Pendidikan Dasar*, 9(4). <https://journal.unpas.ac.id/index.php/pendas/article/view/20127>
- Rokhim, D. A., Rahayu, S., & Dasna, I. W. (2023). Analysis of chemistry misconceptions and their diagnostic instruments: Literature review. *Journal of Chemical Education Innovation*, 17(1), 17–28. <https://doi.org/10.15294/jipk.v17i1.34245>
- Saputra, R. B., & Fauji, N. (2022). Traksi drum brake: Calculation on Honda Tiger Revo 200 cc. <https://doi.org/10.26714/traksi.22.2>
- Sila, I., Djudin, T., & Firdaus, F. (2024). Analysis of students' misconceptions on Newton's laws using clinical interviews at SMPN 1 Kelam Permai. *Khatulistiwa: Journal of Education and Learning*, 13(5), 2715–2723. <https://doi.org/10.26418/jppk.v13i5.71246>
- Safitri, Y., & Kusairi, S. (2025). Learning interest and gender differences in Indonesian high schools: Their influence on understanding the concepts of work and energy. *Journal of Social Work and Science Education*, 6(2), 526–539. <https://doi.org/10.52690/jswse.v6i2.1182>
- Tenzin, K. (2024). Conceptual coherence and dominant misconceptions in the concept of force among higher education students through the administration of the force concept inventory. *ARJASS*, 22(10), 35–50. <https://journalarjass.com/index.php/ARJASS/article/view/583>
- Yuberti, Y., Suryani, Y., & Kurniawati, I. (2020). Four-tier diagnostic test with certainty of response index to identify misconception in physics. *Indonesian Journal of Science and Mathematics Education*, 3(2), 245–253. <https://doi.org/10.24042/ijsme.v3i2.6061>