

## **The Effect of Smartphone Usage Intensity on High School Students' Higher Order Thinking Skills in Physics Learning**

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### **ABSTRACT**

Smartphones are no longer just a communication tool, but also a means of information exchange by students. Smartphone may also positively contribute to students' higher order thinking skills (HOTS). This research aimed to determine smartphone usage intensity, students' HOTS level, and the effect of smartphone usage intensity on students' HOTS in physics learning. This quantitative research was conducted with a pre-experimental method with a single-group post-test design. The sample involved 312 students who were selected using the convenience sampling technique. The data of smartphone usage intensity was obtained using a closed-ended questionnaire and students' HOTS were obtained through the physics HOTS test. The closed-ended questionnaire and physics HOTS test were tested for reliability and validity by six expert validators. The results of the validator's assessment were analyzed using Aiken's V equation to determine the validity and were analyzed through the Quest program to determine reliability. The ideal standard deviation equation was used to analyze smartphone usage intensity and students' HOTS. Multiple regression analysis was used to analyze the effect of smartphone usage intensity on students' HOTS. The results indicated that smartphone usage intensity and students' HOTS level in physics learning are in high and low categories with percentages respectively of 48.72% and 51.28%. The students' HOTS is affected by smartphone usage intensity in physics learning by 21.10%. These results indicated that the smartphone usage intensity of most students is very high, but not yet can contribute optimally to the students' HOTS. Therefore, there necessary to have the right policies in utilizing smartphones in physics learning so that students can optimize HOTS.

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## Introduction

In the current era, it can be said that almost all aspects of human life have faced or interacted with digital systems. This is in line with the demands of the 21<sup>st</sup> century and in the context of facing the 4.0 industrial revolution where all aspects of human life need to be carried out in a beneficial, effective, and efficient manner, one of which is done using smartphone assistance (Suprpto et al., 2017). This is also true in the world of education. The usage of smartphones is very important in terms of delivering information and making it easier for students to learn (Awedh et al., 2014). In addition, through the help of a smartphone, it is also easier for teachers to conduct variations in the implementation of learning (Wirjawan et al., 2020). Therefore, the usage of smartphones is very important to advance the education and knowledge of students and teachers if smartphones are used wisely.

It cannot be denied that smartphones are sometimes unwisely used by students such that misuses and deviations occur. The misuse of smartphones by students is mostly done during learning when the teachers deliver the learning material (Hochberg et al., 2018). Abuses of smartphones are committed by students such as playing video games, chatting, photos, or viewing social media and videos (Martinez & Garaizar, 2014). Therefore, with the cases of smartphone misuse in learning, some high schools have issued regulations that prohibit the usage of smartphones while learning (Parmin & Sajidan 2014). There are many reasons behind the ban, e.g., the lack of students' concentration, the teacher's explanation may not be heard, and students are not focused on learning causing poor learning outcomes (Shatri, 2020).

However, this smartphone ban has also caused many pros and cons for students and teachers. Teachers reasoned that with the development of the world today learning needs to be integrated with the demands of the 21<sup>st</sup> century and 4.0 industrial revolution (Liu et al., 2017). One of them is through the usage of smartphones that are specifically intended to help teachers in explaining the material and help students optimize their abilities and learning outcomes (Klein et al., 2014). Therefore, the usage of smartphones in learning should still be allowed if students are given the responsibility to use smartphones to help understand the material and optimize their abilities. The fact is that almost all students bring and use smartphones in high school (Astuti et al., 2018; Sukardiyono et al., 2019). This has made it easier for schools and teachers to realize digitalization by the demands of the 21<sup>st</sup> century and the 4.0 industrial revolution. All that remains is the participation of teachers and schools in utilizing this momentum so that the usage of smartphones by students does not violate the rules. One effort that can be done is that teachers develop learning media or physics learning assisted by smartphone (Kuhn & Vogt, 2013; van Deursen et al., 2015). This certainly makes smartphones more useful in physics learning with the hope that the ability of students can improve.

In general, something that is currently trending in smartphones gives students pleasure, so they do not get bored (Klein et al., 2015; Mulyeni et al., 2019). This is certainly an important point that may be used to optimize the higher order thinking skills (HOTS) of students in physics learning. One way to optimize the HOTS ability of students who enjoy using smartphones is to integrate physics learning, physics demonstrations, group discussions, or physics experiments with smartphones (Karaca & Şimşek, 2019; Svensson, 2017). The HOTS ability of students can be improved because they enjoy physics learning through a smartphone. Moreover, HOTS ability can be achieved optimally if students enjoy, feel happy, and comfortable in learning so they can easily understand and resolve problems (Istiyono et al., 2020; Yang et al., 2020).

HOTS are related to activities that are often carried out by students both in and out of school that require thinking abilities, such as playing games that require strategy on smartphones (Sinambela & Saragih, 2018). Mardiana and Kuswanto (2017) found that physics learning based on Android can increase the HOTS ability of students. They produced and developed a learning media based on Android called physics mobile learning (PML) which used software equipped with the Android package. The PML may be accessed anywhere, and anytime as long students have electronic gadgets, such as smartphones. This is also supported by Suprpto et al. (2020) that also developed and produced android learning media to improve students' HOTS. Meanwhile, all learning models and methods

conducted by teachers can help increase the HOTS ability of students, provided that in the implementation of learning they can give a good impression to students (Cheng et al., 2015). This is in line with previous findings that smartphone usage has a significant effect on students' learning outcomes, especially their HOTS (Khaeriyah & Mahmud, 2017). Therefore, the participation of teachers is needed in creating a learning atmosphere that can be enjoyed by students by utilizing smartphones to improve students' HOTS ability.

Students who can solve various problems using physics concepts are likely to develop more diverse ways of solving other problems using HOTS (Sariyatun et al., 2018). HOTS is a skill to solve problems using learning media that facilitates higher order thinking activities (Susilo & Yanto, 2018). Therefore, one effort to improve HOTS is to practice solving physics problems assisted by media that facilitate such thinking activities, which is in this case using a smartphone. HOTS is a thinking skill proposed by Bloom in addition to lower-order thinking skills (LOTS) that students must have (Hugerat & Kortam, 2014; Saido et al., 2015). However, the results of TIMSS show that the average achievement of HOTS of Indonesian students is low (Wartono et al., 2018). Therefore, the achievement of HOTS of high school students in Indonesia is low (Yanti et al., 2019) and thus it is ranked low in the Southeast Asian region (Gülen & Yaman, 2019). The low achievement of HOTS can be caused by the lack of learning media usage (Arslan et al., 2020). In addition, this can also be caused by the school's demands related to HOTS are too high, so students do not enjoy the learning process (Bozdoğan & Uzoğlu, 2015). Hence, this causes a major blow to Indonesia's education. Therefore, a solution is needed to overcome the above problem. This research offered integration of HOTS with smartphones enjoyed by students. It is hoped that the HOTS ability of students may be improved and thus improving the HOTS ranking of Indonesia's students. Based on the above explanations, this research aimed to find out the effect of smartphone usage intensity on students' HOTS in physics learning. Moreover, it is necessary to develop a learning media that is used to obtain the data concerning the smartphone usage intensity and high school students' HOTS discussed in the method section.

## Research Questions

Physics learning in Indonesia should be integrated with technology, i.e. the use of smartphones. Physics learning that integrates the use of smartphones has been considered effective in developing high school students' HOTS. Therefore, to further optimize the HOTS of students, teachers need to integrate the use of smartphones in physics learning appropriately, wisely, and be able to provide the comfort of students in physics learning. Therefore, the research questions were as follows:

- a. How intense is smartphone usage of high school students in physics learning?
- b. What is the level of high school students' HOTS in physics learning?
- c. What is the effect of smartphone usage intensity on high school students' HOTS in physics learning?

## Research Focus

This research focuses on analyzing high school students' HOTS level based on the smartphone usage intensity in physics learning physics. The regression between the smartphone usage intensity and high school students' HOTS in physics learning is also explored. The results of this research can be used as a reference for teachers, researchers, or lecturers in optimizing the usage of smartphones in physics learning as an effort to face the challenges of the 21<sup>st</sup> century and the 4.0 industrial revolution. In addition, it can also be used as a guide in improving the ability of students, especially HOTS.

## Methods

### Research Design

The research type used was the quantitative research method as the basis to discuss the research results. The quantitative research method is a research type used to examine a specific population or sample, data collection using research instruments, quantitative or statistical data analysis, to test established hypotheses (Johnson & Christensen, 2019). Furthermore, this research was conducted using a pre-experimental method with a single-group post-test design. This research was conducted by measuring the smartphone usage intensity in physics learning. The smartphone usage intensity in physics learning is measured using a questionnaire given to high school students. In addition, students are also given a physics test instrument to measure their HOTS after they learn physics using a smartphone. The next step was regression analysis. This analysis aims to understand the effect between two or more research variables (Creswell, 2008; Rawlings et al., 2001). In this research, students' HOTS is the dependent variable, while the smartphone usage intensity is the independent variable. This research was conducted at the end of the semester when students had finished attending physics learning for the final discussion of the material.

### Research Sample

The sample used in this study were 312 students of class XI science from four high schools in Yogyakarta, Indonesia, namely SMA N A Yogyakarta, SMA N B Yogyakarta, SMA N C Yogyakarta, and SMA N D Yogyakarta. in the 2018/2019 school year. SMA itself is an abbreviation of state senior high school and MIPA is mathematics and natural science which is under the responsibility of the ministry of education and culture of the Republic of Indonesia. The technique used to determine the sample in this research was the convenience sampling technique. This sampling technique is one of the non-probability sampling methods, in which the research population is ready and feasible to be used by researchers (Fraenkel et al., 2012). In this research, there were no students who refused to participate in the research. Therefore, all samples used in this research provided valid information. The samples involved in this study were students who were in high school aged between 15 and 16 years.

### Instrument and Procedures

The technique of collecting data was done using the questionnaire of HOTS for students via reasoned multiple-choice physics test or two-tier physics tests. Ethical procedures were followed by the researchers in the data collecting process. The first step taken in this research was to develop instruments to measure the smartphone usage intensity of students in the form of questionnaires and students' HOTS in the form of reasoned multiple-choice physics tests that are valid and reliable. The researchers developed new instruments to ensure that the two measuring instruments developed are relevant to the. The researchers developed new instruments to ensure that the two measuring instruments developed are relevant to measuring students' abilities as stated in the objectives of this study.

The literature review of HOTS was carried out before designing the research instrument, which produced three indicators that reflect students' HOTS, i.e. analyzing, evaluating, and creating (Anderson & Krathwohl, 2014; Yee et al., 2015). The instrument used to measure the smartphone usage intensity by students is a questionnaire consisting of 8 questions (Appendix A). Meanwhile, the instrument used to measure students' HOTS is in the form of a reasoned multiple-choice physics test or physics two-tier test consisting of 25 reasoned multiple-choice questions that can be shown in Appendix B. The two instruments used to measure these variables were validated by 6 expert validators before being distributed to the students. In general, the procedure carried out in this research can be illustrated in Figure 1.

Based on Appendix A, the physics test looks more like typical and general physics problem-solving ability. However, the problems were not just choosing the correct answer, but also have the ability to choose the correct reason as well. This additional thinking demand indicated that the problems were elevated to HOTS. The indicators of the problems were indeed based on the 3 indicators of HOTS, i.e. analyze, evaluate, and create, e.g. problems No. 1 to 3 (see in Appendix B) were related to the analysis indicator. An example of a physics problem concerning the evaluation indication was given as follows:

Dani fell from a tree and landed on an empty sled that was sliding on ice without friction. Hence, the correct prediction that corresponds to the event is ... and the reason is...

**Option:**

- A. The speed of the sled is faster.
- B. The speed of the sled is slower.
- C. The speed of the sled is equal to zero.
- D. The speed of the sled is great both before and after Dani's ride.
- E. The speed of the sled is maximum.

**Reason:**

- A. The system mass decreases.
- B. The skateboard mass is larger than the Dani mass.
- C. The mass of the system increases.
- D. The mass of Dani is greater than the sled.
- E. The system mass is zero.

Finally, an example of the physics problem that corresponds to the created indicator was given as follows:

A man drives his car at high speed such that an accident occurs. If the airbag of the car expands and minimizes the driver from a collision, then the explanation of the impulse material by the event is ... and the reason is ...

**Option:**

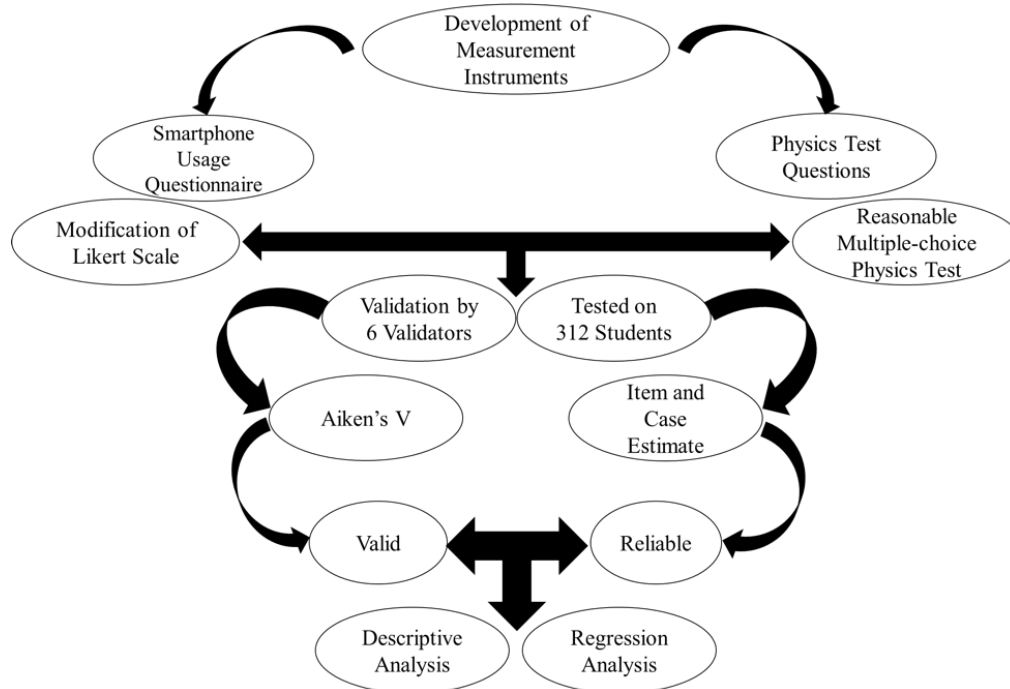
- A. If the driver's head and upper body are pushed forward, the airbag does not expand.
- B. If the driver's head and upper body are pushed forward, the expanded airbag will not hold it.
- C. If the driver's head and upper body are pushed forward, the expanded airbag will hold it.
- D. If the driver's head and upper body are pushed back, the inflated airbag will hold it.
- E. If the driver's head and upper body are pushed back, the airbag will not expand.

**Reason:**

- A. The airbag functions to increase the collision time interval so that the reaction force exerted by the dashboard is smaller, so the risk of collision is reduced.
- B. Airbags reduce the collision time interval so that the reaction force exerted by the dashboard is smaller, so the risk of collisions increases.
- C. The airbag functions to increase the collision time interval so that the reaction force exerted by the dashboard is greater, so the risk of collision is reduced.
- D. Airbags reduce the collision time interval so that the reaction force exerted by the dashboard is greater, so the risk of collisions increases.
- E. Airbags reduce the collision time interval so that the reaction force exerted by the dashboard is smaller, so the risk of collision is reduced.

**Figure 1**

*Process in Research Activities*



### Validity and Reliability of Measurement Instruments

The questionnaire and HOTS test in the form of reasoned multiple-choice are firstly tested for validity and reliability conducted by 6 expert validators. The questionnaire and HOTS test were then analyzed using Aiken's V formula to obtain the results of the content validity of the two measurement instruments.. The Aiken's V coefficient was then compared with the Aiken's table that can be shown in Appendix B. An item in the test or questionnaire was said to be valid if the Aiken's coefficient value is greater or equal to the minimum value listed in the Aiken's table (Aiken & Stephen, 1985). Meanwhile, the reliability of the questionnaire and reasoned multiple-choice test were tested using the item separation index (item estimate) and person separation index (case estimate) through the Quest program (Subali & Suyata, 2011). The greater the index value of the test item separation, the greater the overall accuracy of the questionnaire items and tests with the model used, namely PCM. In addition, the higher the value of the person separation index, the higher the consistency of each item in measuring the ability of people (Subali & Suyata, 2011). The item and case estimates criteria are shown in Table 1 (Sumintono & Widhiarso, 2015).

**Table 1**

*Item and Case Estimate Value Criteria*

Value of Item and Case Estimate Reliability	Criteria
> 0.94	Excellent
0.91 - 0.94	Very good
0.81 - 0.90	Good
0.67 - 0.80	Moderate
< 0.67	Poor

The completion of the questionnaire was carried out by the students by implementing a Likert scale assessment, which was modified to a scale of 4, i.e. score 1, 2, 3, and 4 meaning strongly disagree,

disagree, agree, and strongly agree, respectively. Meanwhile, the measurement of students' HOTS was done by not only choosing the correct answer choice of an item but students are also required to choose the correct reason as well. In conducting this research, the research design used was a post-test-only design. Students were given treatment in the form of smartphone usage in physics learning. This was used to find out whether the usage of smartphones in physics learning affects students' HOTS.

## Data Analysis

The analysis used to determine the smartphone usage intensity and students' HOTS in physics learning was done using equations of ideal standardized deviation with the help of MS Excel software. The technique used was to enter the results of the students' HOTS questions into very low, low, moderate, high, or very high categories through the ideal average equation ( $M_i$ ) and standard deviation ( $SD_i$ ). This analysis technique was carried out using each score obtained from the questionnaire and HOTS physics test (Azwar, 2012). The interval scores for the smartphone usage intensity and students' HOTS can be shown in Table 2.

There were 8 items in the questionnaire. A student checked or chosen one value, i.e.: 1 to 4 corresponding to strongly disagree to strongly agree for each item. Then, the score entered by the student was summed from item 1 to 8 and divided by the total score, i.e.: 32. This ratio was then put into a scale system given in Table 2, hence each student should fall into one given category of very high to very low smartphone usage intensity. The number of students that fall within each category was summed and divided by the total number of students to obtain the percentage in Table 5. Moreover, the students' HOTS was also determined similarly to the smartphone use intensity level above. However, a scoring system was needed for the physics test. The scoring system was given as follows:

- i) if the answer and the reason were both correct, the score given is 4,
- ii) if the answer was incorrect, but the reason was correct, the score given is 3,
- iii) if the answer was correct, but the reason was incorrect, the score given is 2,
- iv) if the answer and the reason were both incorrect, the score given is 1.

**Table 2**

*Scores Interval of Smartphone Usage Intensity and HOTS*

No.	Score Interval	Category
1	$M_i + 1.5 SD_i < \theta$	Very High
2	$M_i + 0.5 SD_i < \theta \leq M_i + 1.5 SD_i$	High
3	$M_i - 0.5 SD_i < \theta \leq M_i + 0.5 SD_i$	Moderate
4	$M_i - 1.5 SD_i < \theta \leq M_i - 0.5 SD_i$	Low
5	$\theta < M_i - 1.5 SD_i$	Very Low

Based on Table 2 it can be stated that  $\theta$  is the level of smartphone usage intensity and HOTS of students. Furthermore, the effect of smartphone usage intensity on students' HOTS in physics learning was determined using regression analysis with the help of the SPSS software. The significant level used in this research was .05 with  $H_a$  was the hypothesis that the smartphone usage intensity significantly affects the HOTS of students in physics learning, while  $H_o$  was the hypothesis that the smartphone usage intensity does not significantly affect HOTS of students in physics learning.

## Results of Validity and Reliability of Measurement Instruments

This research first presents the feasibility results of the measurement instruments that have been developed. The feasibility data of this measurement instrument includes the validity and reliability of the questionnaires and reasoned multiple-choice physics test. The first results are the validity of the

questionnaires and reasoned multiple-choice tests that are analysed using the Aiken's V formula, which is shown in Table 3.

**Table 3***The Validity of Measurement Instruments*

Measurement Instruments	Number of Items	Aiken's Validity Value	Category
The Questionnaire	8	0.921	Valid
Physics HOTS test	25	0.918	Valid
Validity Value of Measurement Instruments		0.92	Valid

The number of validators who validated the questionnaire and physics test was 6 experts. Therefore, the error rate in Aiken's V table used was 1% ( $p < .01$ ) (Aiken & Stephen, 1985). Based on Table 3, the questionnaire and physics test were both valid because Aiken's validity values were greater than 0.89 ( $V \geq 0.89$ ), which was equal to 0.92. It can be stated that the questionnaire and physics test were feasible to measure the smartphone usage intensity and HOTS ability of students in physics learning.

**Table 4***Reliability of Measurement Instruments*

Reliability	Reliability Coefficient		Category	
	Questionnaire	Physics HOTS Test	Questionnaire	Physics HOTS Test
Item Estimate	0.87	0.79	Reliable	Reliable
Case Estimate	0.89	0.80	Reliable	Reliable

The reliability is also used to determine the feasibility of the questionnaire and physics test that have been developed by researchers. The reliability results can be presented in Table 4. It can be observed that the reliability coefficients of the questionnaire for the item and case estimates are larger than 0.7, which are included in the reliable category. Meanwhile, the measurement instrument of the physics test for the item and case estimates are also larger than 0.7, which are also included in the reliable category. Meanwhile, the values of item and case estimates indicate that the questionnaire and the physics test developed are included in good and sufficient criteria, respectively. Furthermore, this questionnaire and physics test show the correct consistency of the choice of students. In other words, each item of the questionnaire and physics test show the same score if assessed by different students. So, it can be stated that the measurement instruments are suitable for usage in measuring the smartphone usage and HOTS of students in physics learning.

## Findings

### Students' Smartphone Usage Intensity in Physics Learning

This research also found the smartphone usage intensity by high school students in physics learning. The smartphone usage intensity by high school students in physics learning obtained through a questionnaire is given in Table 5. It can be observed that 48.7% and 44.55% of students used the smartphone with high and moderate intensities, respectively. These results indicate that the smartphone usage intensity by high school students in Indonesia in physics learning is high. Hence, there is a need for smartphone utilization that provides positive benefits in physics learning.



**Table 5**  
*Smartphone Usage Intensity in Physics Learning*

Number of Students	Percentage (%)	Smartphone Usage Intensity
9	2.88	Very High
152	48.72	High
139	44.55	Moderate
12	3.85	Low
0	0.00	Very Low

### Students' HOTS Levels in Physics Learning

Furthermore, this research presented the results of students' HOTS in physics learning. The students' HOTS level in physics learning obtained through the physics test in the form of reasoned multiple-choice tests is observed in Table 6. It can be stated that the HOTS for students in physics learning is at a low level with a percentage of 51.28% or equivalent to 160 students. These results indicated that the HOTS level of high school students in physics learning is still relatively low because no students obtained very high HOTS levels. The maximum HOTS level of students is at a high level with a percentage of 0.96% or equal to 3 students. These results indicated the need for appropriate treatment in physics learning by teachers, both in the explanation of physics material or the use of smartphones in physics learning.

**Table 6**  
*Students' HOTS Levels in Physics Learning*

Number of Students	Percentage (%)	Students' HOTS Level
0	0.00	Very High
3	0.96	High
6	1.92	Moderate
160	51.28	Low
143	45.83	Very Low

### The Effect of Smartphone Usage Intensity on Students' HOTS

Next, this research showed the results of the effect of the smartphone usage intensity on high school students' HOTS in physics learning. The results of the effect of these two variables are stated in Table 7 below.

**Table 7**  
*The Effect of Smartphone Usage Intensity on Students' HOTS in Physics Learning*

R	R Square	Adjusted R Square	Std. Error of the Estimate	Statistics		
				R Square Dif.	F Dif.	Sig. F Dif.
.459	.211	.201	6.764	.211	2.291	.006

Based on Table 7, the effect of the smartphone usage intensity on students' HOTS in physics learning based on the results of the regression test has been confirmed with  $R = .459$  and  $R^2 = .211$ . According to Drape and Smith (1996), the results of the regression coefficients found in this study indicated a positive effect. In other words, the results of the regression coefficient indicated that the

smartphone usage intensity affects the HOTS of students in physics learning by 21.10% and the remaining 78.90% is influenced by other factors. These results caused the  $H_a$  to be accepted because the significance level is smaller than .05, which was .06. So, the smartphone usage intensity significantly influenced the HOTS of students in physics learning.

## Discussion

The purpose of this research was to determine the level of smartphone usage intensity by students, the students' HOTS level, and the effect of the smartphone usage intensity on students' HOTS in physics learning. The results of the two measurement instruments (questionnaire and physics test) are feasible to measure the smartphone usage intensity and the students' HOTS level. Meanwhile, the results of the questionnaire showed that the smartphone usage intensity in physics learning was high with a percentage of 48.72% as shown in Table 5. The high smartphone usage in physics learning occurs because teachers have realized the importance of using a smartphone to help understand the physics material delivered to their students. However, the high smartphone usage intensity was also abused by students to play video games or chatting with others, thus disrupting the course of physics learning and causing students to lose concentration on the material learned (Karanfiller et al., 2017; Mertala, 2016). Therefore, it is necessary to have policies and wisdom from physics teachers related to smartphone usage in physics learning, so that it can help facilitate students in physics learning and achieving the desired abilities.

Previous studies also obtained similar results, e.g., Alzubi and Singh (2018) showed that many students from elementary schools to senior high schools had used smartphones in learning especially physics in their schools, both permit and prohibited for use by the school. However, although it was prohibited students unconsciously become more curious to bring and use a smartphone in learning (Shi et al., 2016). Therefore, students were not only given verbal instructions related to smartphone usage in physics learning but the need for smartphones usage that directly involve students as well as facilitating the smartphone usage (smartphone technology development) in the curriculum or special subjects. Thus, it is expected that the high smartphone usage intensity by students in physics learning also has a positive impact on students' knowledge and skills that can be implemented in daily life.

Meanwhile, the results of students' HOTS level in physics learning are at a low level, but certain treatments needed to be given in the learning process so that their HOTS can increase. In addition, it is necessary to allocate a considerable amount of time to train HOTS of students in physics learning (Utomo & Narulita, 2018). HOTS training for students can be done by utilizing the use of a smartphone to help students in solving various physics problems that required HOTS. This is in line with the result by Al-Mashaqbeh (2016) who explored strategies in improving students' HOTS, for example, analyzing a physics problem with various approaches, evaluating the solution to solve various physics problems, and trying to create of solution the easiest and most recent. The research findings reveal that students in high school in physics learning have a low level of HOTS with a percentage of students as much as 51.28%. In addition, only 0.96% of the students had a very high HOTS level. This of course depends on each student's ability to identify physics concepts that arise in the problem and find the best solution to solve the physics problems (Prayogi et al., 2019).

The test pattern also influences the HOTS results, for example, there are several groups of students who tend to find it more difficult in carrying out physics tests in the form of a reasoned multiple-choice or description test (Hadi et al., 2018). In line with these findings, the results found in this study indicate that there are errors that occur in physics learning, both in terms of the explanation of physics material by teachers or students who do not understand the physics material delivered by the teacher. This certainly needs to be immediately introspected and addressed if students' HOTS is wanted to be improved. These findings in detail can be displayed in Table 6. In line with these findings,

Rokhmat et al. (2019) claim that the low level of high school students' HOTS in physics learning is due to the habits of students, which are only demanded by teachers in solving physics problems contained in physics textbooks. This of course only provides a slight benefit to students' thinking skills at a low level (Istiyono, 2017). The treatment given by such teachers is not able to develop HOTS because the skills developed are only limited to understanding and repeating. There is no exploring students' thinking to solve real physics problems that occur in everyday environments.

It has been confirmed earlier in this research that the smartphone usage intensity by students in physics learning is high. However, the high smartphone usage intensity in physics learning still causes students' HOTS to be low. Based on these findings, there should be an influence of the high smartphone usage intensity on HOTS of students in physics learning. This is in line with the findings of Khaeriyah and Mahmud (2017) that the smartphone usage intensity had a positive effect on learning motivation and student learning outcomes in high school. Here, the effect of the smartphone usage intensity on students' HOTS in physics learning is 21.10% as shown in Table 7. In general, the smartphone usage intensity by students has a relatively small effect on their HOTS in physics learning, because the percentage is not close to 50%. The effect of the smartphone usage intensity on the students' HOTS in physics learning is caused by several factors. Students tend not to use smartphones for good use in physics learning. They use smartphones only for entertainment purposes and to carry out tasks assigned by teachers carelessly or ask diligent friends in their groups to complete the assignments given by the teacher (Kwon et al., 2014). This certainly does not able to optimize the HOTS of students.

Based on these findings it can be stated that the HOTS of students in physics learning is influenced by other factors besides the smartphone usage intensity by 78.90%. This indicates that the smartphone usage intensity is less influential on HOTS achieved by students in physics learning. The students' HOTS in physics learning is far more optimally achieved if the supervision of teachers and parents is also involved in learning activities in addition to the smartphone usage intensity. This is in line with the findings of Sahin-Topalcengiz and Yildirim (2020) who found that the supervision of teachers and parents in physics learning that utilizes smartphone usage is far more optimal in the achievement of students' skills because the supervision given to students can reduce the negative impact arising from the smartphone usage itself. In addition, Vieyra et al. (2015) also stated their findings in line with previous findings that smartphone usage in learning has a positive and negative effect on the skills of students. These influences can arise depending on the discretion of students who utilizes a smartphone.

The results found in this research also showed that students with higher HOTS scores tend to use the smartphone appropriately in physics learning. These results are also consistent with the findings of Rabacal (2016) who found that students' thinking skills have a positive relationship with smartphones and help in optimizing their thinking skills. This is also supported by the opinion of Pogrow (2005) that students' thinking skills are more optimal if obtained through things they like and meaningful experiences. The findings of this research imply that physics learning needs to take serious attention to the role of the learning environment on the thinking skills achieved by students. Physics teachers should also not only transfer physics concepts but the need for a student center method by utilizing technological advancements such as smartphones. In addition, physics learning conducted by teachers in high schools has not yet applied an effective learning method by linking physics concepts with real physics problems that occur in daily life that lead to optimizing the HOTS of students (Tanudjaya & Doorman, 2020). Thus, in general, our results provide evidence that the HOTS of students is significantly influenced by the smartphone usage intensity but also influenced by the physics learning itself.

## Conclusion and Implications

The smartphone usage intensity by high school students is dominantly high in intensity with a percentage of 48.72%. However, the level of students' HOTS in physics learning is still low with a percentage of 51.28%. However, the smartphone usage intensity by high school students influenced their HOTS by 21.10%. These findings proved that the smartphone usage intensity by high school students does not have much positive effect on HOTS for high school students in physics learning. Thus, special attention needs to be given by the teachers and parents of students in supervising smartphone usage in physics learning. It is also necessary for the participation of teachers to facilitate learning that leads to the achievement of students' HOTS in physics learning so that it is expected that the HOTS of students in physics learning can increase and be in a better category. In other words, teachers need to implement an effective physics learning strategy by utilizing smartphone usage wisely by students which leads to optimizing students' HOTS. Teachers and further researchers also need to develop physics learning media that is suitable for the daily experiences of students, so that they can be interested and easily understand physics. Researchers are encouraged to expand this research by adding dependent variables, independent variables, and adding more students from different high schools and other scientific backgrounds. Finally, a practical implication of this research may be realized for the government or policymakers, especially those who are concerned in Education to produce policies that guide students in using smartphones for learning, especially in physics. Hence, reducing the negative impacts of smartphone usage by students.

## Limitations

This research has limitations that can be overcome in future studies. As this research is limited to public senior high school students in Yogyakarta, research in other provinces should be conducted. This research is also a pre-experimental study with a one-group posttest design, so there is no control class and no pretest. This results in no control over treatment which includes the smartphone usage intensity. This research only focuses on the effect of the smartphone usage intensity on student HOTS, so that the existing abilities of other students need to be explored. Finally, this quantitative research needs to be followed up through quasi or true experiment research.

## References

- Aiken, L. S., & Stephen, G. (1985). *Multiple regression: Testing and interpreting interactions*.
- Al-Mashaqbeh, I. F. (2016). iPad in elementary school math learning setting. *International Journal of Emerging Technologies in Learning (ijET)*, 11(2), 32-46. <https://doi.org/10.3991/ijet.v11i02.5053>
- Alzubi, A., & Singh, M. (2018). The impact of social strategies through smartphones on the Saudi students' socio-cultural autonomy in EFL reading context. *International Electronic Journal of Elementary Education*, 11(1), 31-40. <https://doi.org/10.26822/iejee.2018143958>
- Anderson, L. (2014). W., & Krathwohl, DR (2001). *A taxonomy for learning, teaching, and assessing*. Pearson Education Limited.
- Arslan, R., Kofoğlu, M., & Dargut, C. (2020). Development of augmented reality application for biology education. *Journal of Turkish Science Education*, 17(1), 62-72. <https://doi.org/10.36681/tused.2020.13>
- Astuti, I. A. D., Dasmu, & Nurullaeli. (2018). The use of pocket mobile learning to improve critical thinking skills in physics learning. *International Journal of Recent Contributions from Engineering, Science & IT*, 6(4), 80-86. <https://doi.org/10.3991/ijes.v6i4.8877>
- Awedh, M., Mueen, A., Zafar, B., & Manzoor, U. (2014). Using socrative and smartphones for the support of collaborative learning. *International Journal on Integrating Technology in Education (IJITE)*, 3(4), 17-24. <https://doi.org/10.5121/ijite.2014.3402>
- Azwar, S. (2012). *Reliability and validity 4th edition*. Pustaka Pelajar.

- Bozdoğan, A. E., & Uzoğlu, M. (2015). Science and technology teachers' opinions about problems faced while teaching 8th grade science unit "force and motion" and suggestions for solutions. *Journal of Turkish Science Education*, 12(1), 57-70. <https://doi.org/10.12973/tused.10133a>
- Cheng, P. H., Yang, Y. T. C., Chang, S. H. G., & Kuo, F. R. R. (2015). 5E mobile inquiry learning approach for enhancing learning motivation and scientific inquiry ability of university students. *IEEE Transactions on Education*, 59(2), 147-153. <https://doi.org/10.1109/TE.2015.2467352>
- Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Pearson Education.
- Drape, N. R., & Smith, H. (1996). *Applied regression analysis*. John Wiley and Sons Inc.
- Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education (8th edition)*. McGraw-Hill.
- Gülen, S., & Yaman, S. (2019). The effect of integration of STEM disciplines into Toulmin's argumentation model on students' academic achievement, reflective thinking, and psychomotor skills. *Journal of Turkish Science Education*, 16(2), 216-230. <https://doi.org/10.12973/tused.10276a>
- Hadi, S., Retnawati, H., Munadi, S., Apino, E., & Wulandari, N. F. (2018). The difficulties of high school students in solving higher order thinking skills problems. *Problems of Education in the 21st Century*, 4(76), 520-532. <http://oaji.net/articles/2017/457-1533495738.pdf>
- Hochberg, K., Kuhn, J., & Müller, A. (2018). Using smartphones as experimental tools-effects on interest, curiosity, and learning in physics education. *Journal of Science Education and Technology*, 6(2), 1-19. <https://doi.org/10.1007/s10956-018-9731-7>
- Hugerat, M., & Kortam, N. (2014). Improving higher order thinking skills among freshmen by teaching science through inquiry. *Eurasia Journal of Mathematics, Science & Technology Education*, 10(5), 447-454. <https://doi.org/10.12973/eurasia.2014.1107a>
- Istiyono, E. (2017). The analysis of senior high school students' physics HOTS in Bantul district measured using PhysReMChoTHOTS. *AIP Conference Proceedings*, 1(1868), 070008. <https://doi.org/10.1063/1.4995184>
- Istiyono, E., Dwandaru, W. S. B., Setiawan, R., & Megawati, I. (2020). Developing of computerized adaptive testing to measure physics higher order thinking skills of senior high school students and its feasibility of use. *European Journal of Educational Research*, 9(1), 91-101. <https://doi.org/10.12973/eu-jer.9.1.91>
- Johnson, R. B., & Christensen, L. (2019). *Educational research: Quantitative, qualitative, and mixed approaches*. Sage.
- Karaca, S., & Şimşek, Ö. (2019). The Turkish physics teachers' views of the 'radiation' subject in the current textbooks. *Journal of Turkish Science Education*, 16(3), 290-298. <https://doi.org/10.12973/tused.10282a>
- Karanfiller, T., Göksu, H., & Yarkan, K. (2017). Basic concept teaching mobile application design for students with special education needs. *Eğitim ve Bilim*, 42(192), 76-87. <https://doi.org/10.15390/EB.2017.7146>
- Khaeriyah, K., & Mahmud, A. (2017). The effect of smartphone usage intensity use and internet utilization of learning motivation and economic learning outcomes. *Economic Education Analysis Journal*, 6(1), 140-149. <https://journal.unnes.ac.id/sju/index.php/eeaj/article/view/13480/7364>
- Klein, P., Hirth, M., Gröber, S., Kuhn, J., & Müller, A. (2014). Classical experiments revisited: Smartphones and tablet PCs as experimental tools in acoustics and optics. *Physics Education*, 49(4), 412-419. <https://doi.org/10.1088/0031-9120/49/4/412>
- Klein, P., Kuhn, J., Müller, A., & Gröber, S. (2015). Video analysis exercises in regular introductory physics courses: Effects of conventional methods and possibilities of mobile devices. *Multidisciplinary Research on Teaching and Learning*, 7(1), 270-271. [https://doi.org/10.1057/9781137467744\\_15](https://doi.org/10.1057/9781137467744_15)

- Kuhn, J., & Vogt, P. (2013). Smartphones as experimental tools: Different methods to determine the gravitational acceleration in classroom physics by using everyday devices. *European Journal of Physics Education*, 4(1), 16-27. <https://files.eric.ed.gov/fulltext/EJ1052301.pdf>
- Kwon, Y., Kang, K., & Bae, C. (2014). Unsupervised learning for human activity recognition using smartphone sensors. *Expert Systems with Applications*, 41(14), 6067-6074. <https://doi.org/10.1016/j.eswa.2014.04.037>
- Liu, C. Y., Wu, C. J., Wong, W. K., Lien, Y. W., & Chao, T. K. (2017). Scientific modeling with mobile devices in high school physics labs. *Computers & Education*, 105, 44-56. <https://doi.org/10.1016/j.compedu.2016.11.004>
- Mardiana, N., & Kuswanto, H. (2017). Android-assisted physics mobile learning to improve senior high school students' divergent thinking skills and physics HOTS. *AIP Conference Proceedings* 1868, 070005. <https://doi.org/10.1063/1.4995181>
- Martinez, L., & Garaizar, P. (2014). Physics learning down a slide: A set of experiments to measure reality through smartphone sensors. *Proceedings of the IEEE Global Engineering Education Conference (EDUCON), Turkey*, 75, 1153-1156. <https://doi.org/10.3991/ijim.v8i3.3873>
- Mertala, P. (2016). Fun and games-finnish children's ideas for the use of digital media in preschool. *Nordic Journal of Digital Literacy*, 4(11), 207-226. <https://doi.org/10.18261/issn.1891-943x2016-04-01>
- Mulyeni, T., Jamaris, M., & Supriyati, Y. (2019). Improving basic science process skills through inquiry-based approach in learning science for early elementary students. *Journal of Turkish Science Education*, 16(2), 187-201. <https://doi.org/10.12973/tused.10274a>
- Parmin & Sajidan. (2014). The application of STEM education in science learning at schools in industrial areas. *Journal of Turkish Science Education*, 11(1), 3-23. <https://doi.org/10.12973/tused.10281a>
- Pogrow, S. (2005). HOTS revisited: A thinking development approach to reducing the learning gap after grade 3. *Phi Delta Kappa*, 87(1), 64-75. <https://doi.org/10.1177/003172170508700111>
- Prayogi, S., Muhali, M., Yuliyanti, S., Asy'ari, M., Azmi, I., & Verawati, N. N. S. P. (2019). The effect of presenting anomalous data on improving student's critical thinking ability. *International Journal of Emerging Technologies in Learning*, 14(6), 68-79. <https://doi.org/10.3991/ijet.v14i06.9717>
- Rabacal, J. S. (2016). Test of science process skills of biology students towards developing of learning exercises. *Asia Pacific Journal of Multidisciplinary Research*, 4(4), 9-16. <http://www.apjmr.com/wp-content/uploads/2016/08/APJMR-2016.4.4.02.pdf>
- Rawlings, J. O., Pantula, S. G., & Dickey, D. A. (2001). *Applied regression analysis: a research tool*. Springer Science & Business Media.
- Rokhmat, J., Marzuki, Wahyudi, & Putrie, S. D. (2019). A strategy of scaffolding development to increase students' problem-solving abilities: The case of physics learning with causalitic-thinking approach. *Journal of Turkish Science Education*, 16(4), 569-579. <https://doi.org/10.36681/tused.2020.8>
- Sahin-Topalcengiz, E., & Yildirim, B. (2020). Teachers' opinions about distance web 2.0 tools training and teachers' in-class web 2.0 practices. *Journal of Turkish Science Education*, 17(4), 561-577. <https://doi.org/10.36681/tused.2020.45>
- Saido, G. A. M., Siraj, S., Nordin, A. B., & Al-Amedy, O. S. (2015). Teaching strategies for promoting higher order thinking skills: A case of secondary science teachers. *Malaysian Online Journal of Educational Management*, 3(4), 16-30. <https://mojem.um.edu.my/article/view/6077/3788>
- Sariyatun, Joebagio, H., & Akhyar, M. (2018). Teachers' perception on digital teaching material development in social science education. *Journal of Turkish Science Education*, 15(1), 13-21. <https://doi.org/10.12973/tused.10252a>
- Shatri, Z. G. (2020). Advantages and disadvantages of using information technology in learning process of students. *Journal of Turkish Science Education*, 17(3), 420-428. <https://doi.org/10.36681/tused.2020.36>

- Shi, W. Z., Sun, J., Huan, C. X., & Huan, W. (2016). Assessing the use of smartphone in the university general physics laboratory. *EURASIA Journal of Mathematics, Science and Technology Education*, 12(1), 125–132. <https://doi.org/10.12973/eurasia.2016.1424a>
- Sinambela, S. E., & Saragih, A. (2018). Promoting HOTS and better literacy for EFL students through the cognitively challenging reading material. *Proceedings of the The 1st Annual International Conference on Language and Literature, KnE Social Sciences*, 806–815. <https://doi.org/10.18502/kss.v3i4.1987>
- Subali, B., & Suyata, P. (2011). *Guide to analyzing educational measurement data to obtain empirical evidence of validity using the Quest program*. Institute for Research and Community Service at Yogyakarta State University.
- Sukardiyono, Rosana, D. & Dwandaru, W. S. B. (2019). Measuring junior high school students' science learning and science process skills through and integrated science instructional assessment. *Journal of Turkish Science Education*, 16(4), 467–477. <https://doi.org/10.36681/tused.2020.1>
- Sumintono, B., & Widhiarso, W. (2015). *Rasch modeling application in educational assessments*. Trim Komunikata.
- Suprpto, E., Saryanto, Sumiharsono, R., & Ramadhan, S (2020). The analysis of instrument quality to measure the students' higher order thinking skill in physics learning. *Journal of Turkish Science Education*, 17(4), 520-527. <https://doi.org/10.36681/tused.2020.4>
- Suprpto, N., Chang, T. S., & Ku, C. H. (2017). Conception of physics learning and self-efficacy among Indonesian university students. *Journal of Baltic Science Education*, 16(1), 80-92. [http://www.scientiasocialis.lt/jbse/files/pdf/vol16/7-19.Suprpto\\_JBSE\\_Vol.16\\_No.1.pdf](http://www.scientiasocialis.lt/jbse/files/pdf/vol16/7-19.Suprpto_JBSE_Vol.16_No.1.pdf).
- Susilo, S. V., & Yanto, A. (2018, September). *Multiliteration pedagogic model based on higher order thinking skill (HOTS) as efforts to face the 21st century education in education from Ki Hadjar Dewantara*. Paper presented at the 3<sup>rd</sup> National Seminar on Educational Innovation. <https://doi.org/10.20961/shes.v1i2>
- Svensson, T. (2017). *Smartphone physics-a smart approach to practical work in science education?* Stockholm Universitet.
- Tanudjaya, C. P., & Doorman, M. (2020). Examining higher order thinking in Indonesian Lower secondary mathematics classrooms. *Journal on Mathematics Education*, 11(2), 277-300. <https://doi.org/10.22342/jme.11.2.11000.277-300>
- Utomo, A. P., & Narulita, E. (2018). Diversification of reasoning science test items of TIMSS grade 8 based on higher order thinking skills: A case study of Indonesian students. *Journal of Baltic Science Education*, 17(1), 152-161. [http://www.scientiasocialis.lt/jbse/files/pdf/vol17/152-161.Utomo\\_JBSE\\_Vol.17\\_No.1.pdf](http://www.scientiasocialis.lt/jbse/files/pdf/vol17/152-161.Utomo_JBSE_Vol.17_No.1.pdf)
- van Deursen, A. J. A. M., Bolle, C. L., Hegner, S. M., & Kommers, P. A. M. (2015). Modeling habitual and addictive smartphone behaviour: The role of smartphone usage types, emotional intelligence, social stress, self-regulation, age, and gender. *Computers in Human Behavior*, 45, 411-420. <https://doi.org/10.1016/j.chb.2014.12.039>
- Vieyra, R., Vieyra, C., Jeanjacquot, P., Marti, A., & Monteiro, M. (2015). Turn your smartphone into a science laboratory. *The Science Teacher*, 82(9), 32. [https://doi.org/10.2505/4/tst15\\_082\\_09\\_32](https://doi.org/10.2505/4/tst15_082_09_32)
- Wartono, W., Hudha, M. R., & Batlolona, J. R. (2018). How are the physics critical thinking skills of the students taught by using inquiry-discovery through empirical and theoretical overview? *EURASIA Journal of Mathematics, Science and Technology Education*, 14(2), 691-697. <https://doi.org/10.12973/ejmste/80632>
- Wirjawan, J. V., Pratama, D., Pratidhina, E., Wijaya, A., & Untung, B. (2020). Development of smartphone app as media to learn impulse-momentum topics for high school students. *International Journal of Instruction*, 13(3), 17-30. <https://doi.org/10.29333/iji.2020.1332a>
- Yang, Y., van Aalst, J., & Chan, C. K. (2020). Dynamics of reflective assessment and knowledge building for academically low-achieving students. *American Educational Research Journal*, 57(3), 1241-1289. <https://doi.org/10.3102/0002831219872444>

Yanti, F. A., Kuswanto, H., Mundilarto, Habibi, & Rosa, F. O. (2019). Pre-service physics teachers' research activities by research-based learning. *Journal of Turkish Science Education*, 16(1), 77-84. <https://doi.org/10.12973/tused.10267a>

Yee, M. H., Yunos, J. M., Othman, W., Hassan, R., Tee, T. K., & Mohamad, M. M. (2015). Disparity of learning styles and higher order thinking skills among technical students. *Procedia-Social and Behavioral Sciences*, 204, 143-152. <https://doi.org/10.1016/j.sbspro.2015.08.127>

### Appendix

#### Appendix A

#### The Questionnaire about the Intensity of Smartphone Use by Students in Physics Learning Activities

**Instruction:**

1. Read each statement carefully and thoroughly!
2. Answer each statement as honestly as you think!
3. Not cheating or imitating answers from friends!
4. Put a check mark (✓) in the column that matches your opinion in the space provided with the score description as follows.

**1** : Strongly Disagree (SD)                      **3** : Agree (A)  
**2** : Disagree (D)                                      **4** : Strongly Agree (SA)

No.	Statement	1	2	3	4
1.	I always use physics learning media in the form of simulations or android applications through smartphone.				
2.	I chose to use learning media in the form of books, videos, or power points rather than the android simulation media on smartphone.				
3.	I learned a little bit of physics material through teacher explanations rather than through learning media on smartphone.				
4.	The teacher needs to vary the physics learning media by using an android simulation on a smartphone.				
5.	I use a smartphone only to play games and social media.				
6.	I rarely play smartphone when the teacher is explaining physics material.				
7.	Physics learning that I obtained rarely uses android simulation media on smartphone.				

Student's signature,  
 .....



**Appendix B**

**HOTS Assessment Instrument for Students in Physics Subjects**

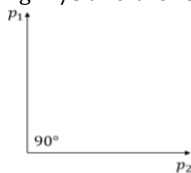
Subjects : Physics Name :  
 Class/Program : X/IPA Presence Number/Class :  
 Time : 45 Minutes Date :

**Instruction:**

1. Write down the name, presence number /class number, and date of the test on the answer sheet provided!
2. Pray before working on test questions!
3. Read the test questions first!
4. Do the problems that you think are easier first!
5. Choose by giving a sign (x) in the answer and the reason that you think is most appropriate!

**Re-examine your work before it is submitted to the supervisor!**

1. Two bullets each have a mass of 5 grams and 10 grams. The two tulip bullets were fired from the same position simultaneously and the trajectory of the two tulip bullets formed at an angle of 90° as shown below. If the speed of the first and second *tulup* (bamboo gun) bullets are 40 m/s and 5 m/s, then the result of the analysis of the total momentum of the two tulup bullets is right ... kg.m/s and the reason is ...



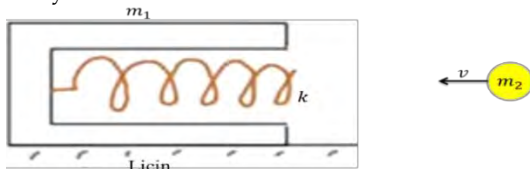
**Answer:**

- A. 0.01 C. 0.43  
 B. 0.21 D. 0.50  
 E. 0.39

**Reason:**

- A.  $p_{total} = \sqrt{p_1 + p_2}$   
 B.  $p_{total} = \sqrt{p_1 - p_2}$   
 C.  $p_{total} = \sqrt{p_1^2 + p_2^2}$   
 D.  $p_{total} = \sqrt{2p_1p_2 \cos 90^\circ}$   
 E.  $p_{total} = \sqrt{\frac{p_1}{p_2}}$

2. A bullet with mass  $m_2$  is fired with velocity  $v$  at an object with mass  $m_1$  as shown below. If the object being shot has a hole which contains a spring (spring constant =  $k$ ) and at first be quiet, then the right spring deviation analysis result is ... and the reason is ...



When a bullet with a 0.01 kg mass is fired at a ballistic swing made of foam with a mass of 0.25 kg, so the bullet attaches to the ballistic swing. When the swing reaches its maximum height, the swing rises 0.2 m from its original position. If  $g = 10 \text{ m/s}^2$ , then the results of the analysis of the velocity of the bullet fired on the ballistic swing is ... m/s and the reason is ...

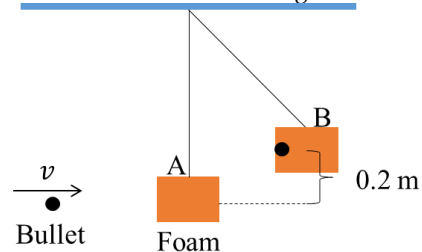
**Answer:**

- A.  $x = \frac{m_1 m_2 v^2}{k(m_1 + m_2)}$  D.  $x = \sqrt{\frac{m_1 m_2 v^2}{(m_1 + m_2)}}$   
 B.  $x = \sqrt{\frac{m_1 m_2}{k(m_1 + m_2)}}$  E.  $x = \sqrt{\frac{m_1 m_2 v^2}{k(m_1 + m_2)}}$   
 C.  $x = \frac{m_1 m_2 v^2}{(m_1 + m_2)}$

**Reason:**

- A.  $v' = \sqrt{\frac{m_2 v}{m_1 + m_2}}$  and  $m_2 v^2 = (m_1 + m_2)(v')^2 + kx^2$   
 B.  $v' = \sqrt{\frac{m_2 m_1}{m_1 + m_2}}$  and  $m_2 v^2 = (m_1 + m_2)(v')^2 + kx^2$   
 C.  $v' = \sqrt{\frac{m_2 v}{m_1 + m_2}}$  and  $m_2 v^2 = (m_1 + m_2)(v')^2 + x^2$   
 D.  $v' = \sqrt{\frac{m_1 v}{m_1 + m_2}}$  and  $m_2 v^2 = (m_1 + m_2)(v')^2 + kx^2$   
 E.  $v' = \sqrt{\frac{m_1 v}{m_1 + m_2}}$  and  $m_2 v^2 = (m_1 + m_2)(v')^2 + x^2$

3. Observe the motion picture of the bullet fired on the ballistic swing below!



Answer:

- A. 14
- B. 36
- C. 52
- D. 77
- E. 91

Reason:

- A.  $v = \frac{(m_p+m_b)\sqrt{gh}}{m_p}$
- B.  $v = \frac{(m_p+m_b)\sqrt{2gh}}{m_p}$
- C.  $v = \frac{(m_p+m_b)\sqrt{2h}}{m_p}$
- D.  $v = (m_p + m_b)\sqrt{2gh}$
- E.  $v = (m_p + m_b)\sqrt{gh}$

Figure 2

Aiken's Table

No. of Items (m) or Raters (n)	Number of Rating Categories (c)											
	2		3		4		5		6		7	
	V	p	V	p	V	p	V	p	V	p	V	p
2							1.00	.040	1.00	.028	1.00	.020
3							1.00	.008	1.00	.005	1.00	.003
3			1.00	.037	1.00	.016	.92	.032	.87	.046	.89	.029
4					1.00	.004	.94	.008	.95	.004	.92	.006
4			1.00	.012	.92	.020	.88	.024	.85	.027	.83	.029
5			1.00	.004	.93	.006	.90	.007	.88	.007	.87	.007
5	1.00	.031	.90	.025	.87	.021	.80	.040	.80	.032	.77	.047
6			.92	.010	.89	.007	.88	.005	.83	.010	.83	.008
6	1.00	.016	.83	.038	.78	.050	.79	.029	.77	.036	.75	.041
7			.93	.004	.86	.007	.82	.010	.83	.006	.81	.008
7	1.00	.008	.86	.016	.76	.045	.75	.041	.74	.038	.74	.036
8	1.00	.004	.88	.007	.83	.007	.81	.008	.80	.007	.79	.007
8	.88	.035	.81	.024	.75	.040	.75	.030	.72	.039	.71	.047
9	1.00	.002	.89	.003	.81	.007	.81	.006	.78	.009	.78	.007
9	.89	.020	.78	.032	.74	.036	.72	.038	.71	.039	.70	.040
10	1.00	.001	.85	.005	.80	.007	.78	.008	.76	.009	.75	.010
10	.90	.001	.75	.040	.73	.032	.70	.047	.70	.039	.68	.048
11	.91	.006	.82	.007	.79	.007	.77	.006	.75	.010	.74	.009
11	.82	.033	.73	.048	.73	.029	.70	.035	.69	.038	.68	.041
12	.92	.003	.79	.010	.78	.006	.75	.009	.73	.010	.74	.008
12	.83	.019	.75	.025	.69	.046	.69	.041	.68	.038	.67	.049
13	.92	.002	.81	.005	.77	.006	.75	.006	.74	.007	.72	.010
13	.77	.046	.73	.030	.69	.041	.67	.048	.68	.037	.67	.041
14	.86	.006	.79	.006	.76	.005	.73	.008	.73	.007	.71	.009
14	.79	.029	.71	.035	.69	.036	.68	.036	.66	.050	.66	.047
15	.87	.004	.77	.008	.73	.010	.73	.006	.72	.007	.71	.008
15	.80	.018	.70	.040	.69	.032	.67	.041	.65	.048	.66	.041
16	.88	.002	.75	.010	.73	.009	.72	.008	.71	.007	.70	.010
16	.75	.038	.69	.046	.67	.047	.66	.046	.65	.046	.65	.046
17	.82	.006	.76	.005	.73	.008	.71	.010	.71	.007	.70	.009
17	.76	.025	.71	.026	.67	.041	.66	.036	.65	.044	.65	.039
18	.83	.004	.75	.006	.72	.007	.71	.007	.70	.007	.69	.010
18	.72	.048	.69	.030	.67	.036	.65	.040	.64	.042	.64	.044
19	.79	.010	.74	.008	.72	.006	.70	.009	.70	.007	.68	.009
19	.74	.032	.68	.033	.65	.050	.64	.044	.64	.040	.63	.048
20	.80	.006	.72	.009	.70	.010	.69	.010	.68	.010	.68	.008
20	.75	.021	.68	.037	.65	.044	.64	.048	.64	.038	.63	.041
21	.81	.004	.74	.005	.70	.010	.69	.008	.68	.010	.68	.009
21	.71	.039	.67	.041	.65	.039	.64	.038	.63	.048	.63	.045
22	.77	.008	.73	.006	.70	.008	.68	.009	.67	.010	.67	.008
22	.73	.026	.66	.044	.65	.035	.64	.041	.63	.046	.62	.049
23	.78	.005	.72	.007	.70	.007	.68	.007	.67	.010	.67	.009
23	.70	.047	.65	.048	.64	.046	.63	.045	.63	.044	.62	.043
24	.79	.003	.71	.008	.69	.006	.68	.008	.67	.010	.66	.010
24	.71	.032	.67	.030	.64	.041	.64	.035	.62	.041	.62	.046
25	.76	.007	.70	.009	.68	.010	.67	.009	.66	.009	.66	.009
25	.72	.022	.66	.033	.64	.037	.63	.038	.62	.039	.61	.049