

FIRST YEAR UNIVERSITY STUDENTS' GRAPH UNDERSTANDING

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Abstract: The aim of this research is to investigate first year university physics students' graph understanding and students' response on use of ICT tools for online testing. It focuses on kinematics graphs, as they are essential for understanding further fields of physics and engineering. Standardized Test of Understanding Graphs – Kinematics (TUG-K) is applied in order to measure the knowledge. The test was uploaded to the Moodle platform. The sample consists of students from four consecutive academic years. Answers reveal some misconceptions related mainly to understanding area below the curve in the graph. There are slight misconceptions related to understanding slope of the curve. Further analysis is recommended to reveal the content dependence of the incorrect answers.

Non-structured interview reveals positive students' response to online testing.

Key words: Kinematics, online testing, graph understanding, misconceptions, university students

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1. INTRODUCTION

Physics is both experimental and theoretical scientific discipline. Graphic presentation of results, relations and dependences are very important in both of these approaches, particularly in experimental approach. This is the reason for giving special attention to graphs in education as well as in physics education research. Kinematics is very important part of physics since it gives foundations for further understanding motion and interactions. Three main kinematics graphs are position vs. time, velocity vs. time and acceleration vs. time [1, 2]. Unfortunately, many researches show that students in all stages of education face problems related to understanding and applying graphs [3]. Kinematics graphs are supported by two pillars: physics and mathematics. Thus, all the problems and misconceptions meet each other in the area of kinematics graphs and give additional quality and raise the level of the misconceptions.

However, graphs are important as they give wide range of opportunities for presenting and obtaining data. In order to see trends and spot subtle differences in shape of the curve presented in graph, scientists and engineers use their powerful visual pattern recognition facilities. Although graphs contain large amount of data, like information on the experiment and used apparatus, results, errors etc., they still allow resolving details, as no other statistical tool [4].

2. METHODS AND SAMPLE

In order to investigate and measure the misconceptions standardized Test of Understanding Graphs-Kinematics (TUG-K) was applied. This test is developed by Robert Beichner from The Physics Department at the North Carolina State University [5]. It consists of 26 questions, each with different objective and testing different knowledge and skill.

The objectives of the test are given in Table 1.

Table 1 – Objectives of the TUG-K

	given	The students will
1.	Position-time graph	Determine velocity
2.	Velocity-time graph	Determine acceleration
3.	Velocity-time graph	Determine displacement
4.	Acceleration-time graph	Determine change in velocity
5.	A kinematics graph	Select another corresponding graph
6.	A kinematics graph	Select textual description
7.	Textual motion description	Select corresponding graph

In order to enable easier access to the test, as well as easier processing of the data, the test was uploaded to a

Moodle platform. Students did not have any previous experience with online testing. The test was administered during november at the begining of the first semester. It means that the knowledge and skills the students have shown are mainly the ones they have gained in high school. The lectures and exercises at the faculty during those month to month and a hlaf had very small impact on their knowledge.

The sample that was tested consists of 88 first year physics students at the Faculty of Natural Sciences and Mathematics in Skopje, Macedonia. The number of physics students is relatively small. In order to create a sample with acceptable big number, students from four consecutive academic years were tested, beginning with academic 2013/14 year ending with academic 2016/17 year. The sample is not analyzed from gender, social or any other students' background point of view, since it was not of interest for this research.

3. RESULTS AND DICSUSSION

Relative numbers of the students' answer for each of the 26 question are given in fig. 1. Answers can be divided into three groups:

- answers with satisfactory big number of students who gave correct answers,
- answers with number of correct answers close to the number of incorrect answers and
- answers with number of incorrect answers significantly bigger than the one of the correct answers.

One can easily see that big number of the students have answered correctly to questions: 1, 2, 3, 4, 8, 11, 12, 13, 14, 15, 17, 18, 20, 21, 22, 23, 24, 25 and 26, which makes about two thirds of the questions. Answers of the questions 6 and 9 belong to the second group where the number of the correct answer is close to the number of at least one incorrect answer. The third group of answers, clearly revealing existence of misconception is made of questions: 5, 7, 10, 16 and 19.

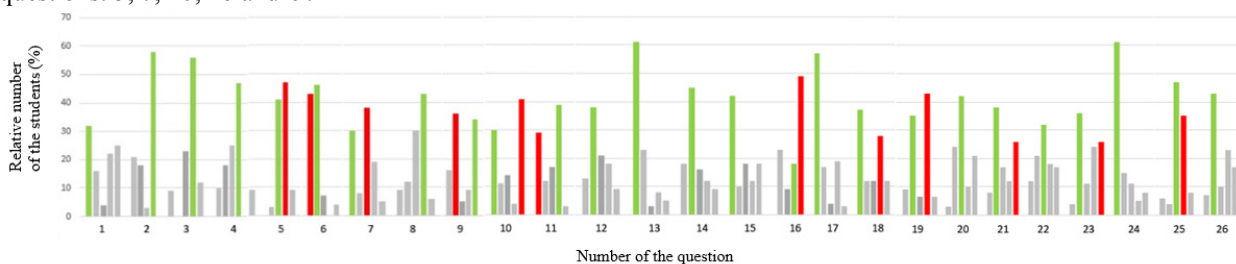


Figure 1. Relative number of the students in percents for each question. Green columns present the correct answer, red columns present the incorrect answers where misconception appears.

The third group of answers shows existence of misconceptions. Three of them (10, 16 and 19) are related to understanding area below the curve in the graph, while number 5 and 7 reveal problem with understanding slope of the curve.

3.1 Item 5

Students' task is to determine velocity using position-time graph. They take the simplest formula to calculate the velocity. Students read the value for the position and time in one point and use formula $v=x/t$, forgetting that velocity is ratio between change of the position and change of the time. Very often students forget that x is position and not traveled distance. They forget that it is about the change. It is probably consequence of the problems solved in classes. In order to simplify the cases, problems and examples analyzed at the classes are mostly taken with initial position set to zero and in that case the change in position is equal with the position and with traveled distance. This is enough to inititate misconceptions related to understanding slope of the curve.

3.2 Item 7

This item involves velocity-time graph and the task is to determine acceleration. Response to item 7 reveals misconception related to understanding slope of the curve. 30 % of the students give correct answer. But, 38 % of them calculate acceleration by simple use of the values for velocity and time taken in the moment of interest i.e. taking the values from one point and obtaining incorrect value of 0.46 m/s^2 . This shows that students have problems with understanding slope of the curve. The problem is even bigger with the students who have chosen answers d) and e), which makes them 25 % of the whole group. They read the acceleration directly from the v -axes, confusing velocity with the acceleration.

3.3 Item 10

This item task is to use the acceleration-time graph in order to determine change in velocity. 30 % of the students chose correct answer a), but 41 % of them chose the incorrect answer e). This response reveals problem with understanding area under the curve. The incorrect answer is in accordance with the incorrect answers of item 7.

Whenever student have to calculate something from the graph, no matter if it is slope or area under the curve, they always take the readings from one point and apply them into the most simple formula to get the result. This question gives the students opportunity to explicitly explain that they apply this procedure.

3.4 Item 16

The task is completely the same as in item 10, using acceleration-time graph in order to determine change in velocity. Unlike in the item 10, only 18 % of the students give the correct answer d) and even 49 % of them chose the incorrect answer e). Taking in account the similarity of items 10 and 16, this response is unexpected. Like in other items, they take the values from one point in the graph and apply them in the simplest formula. This motion is not common for the Macedonian students. They do not solve motions with variable acceleration. However, if they understand motion with constant acceleration and velocity-time graph, they should easily solve this situation.

3.5 Item 19

Students have to use velocity-time graph in order to determine the displacement i.e. change in position. Like in the previous two items, response to this item reveals misconception related to understanding area under the curve. Most of the answers are concentrated on the correct answer, b) and incorrect one, d), 38 % and 43 % respectively. The other distractors are very weak. In other words, this item reveals one misconception, which is repeated. This question gives the students opportunity to explain their misconception explicitly. Instead of average velocity, they take the velocity value from one point of the graph and apply it in the formula $s = v \cdot t$. Thus, instead of calculating area and obtaining a result for object that moves uniformly accelerated, they obtain result for an object that moves with constant velocity.

4. GENERAL REMARKS

In general, there is no correlation between number of misconceptions and types of graphs or tasks the students have to fulfil. This can lead to a conclusion that the answers are content dependent. It means that the same problem set in different situation and question initiate various responses.

If one takes in consideration item 6, where the difference in percentages of the correct and incorrect answers is only 3 % in favor of correct answers, then one can conclude that the number of the misconceptions related to understanding slope and number of the misconceptions related to understanding area are equal.

Deeper analysis reveals also existence of the GAP phenomenon. Students see graph as a visual presentation of the motion itself, which means graph is a sketch of the objects motion. Therefore, very often the curve in the graph is seen as object's motion path [3, 6, 7].

Researches show that students have problems with using mathematical apparatus in physics and they do not know how to apply it to describe physics phenomena [8]. Moreover, inappropriate transfer from mathematics to physics can adversely affect the development of physics concepts [9].

Many students have answered correct to most of the questions. This percentage is biggest for two thirds of the questions, where we cannot talk about existence of misconception. But, it does not mean that we have to be satisfied. For example, the worst situation is with the first item, where 32 % of the students have answered correctly, meaning that 68 % of the students gave incorrect answer. On the other side, the best situation is at the thirteenth item and twenty fourth item, where only 39 % of the students answered incorrectly. All other answers are somewhere in between. Considering that these students study physics and applied physics, we cannot be satisfied, since their development of physics, technical and technological concepts can be influenced by their abilities to use, apply and construct graphs.

Non-structured group interview revealed positive students' response to online testing. Although online activities and applications are their everyday routine, they say it was unusual to answer online an educational test. However, they proposed use of ICT online tools and applications for teaching and learning, which could help them to overcome the problems with graphs understanding.

5. CONCLUSION

We can be satisfied with the knowledge that physics students have as their background. But deeper and detailed analysis reveals certain number of students with misconceptions, which can not be neglected, considering that they study physics and that those misconceptions can initiate additional problems in understanding further physics phenomena and their application in engineering. Furthermore, most of the students study applied physics, which means they have to further develop and apply their physics knowledge into technology. This indicates need for improvement of this part of high school education by introducing additional classes or activities in high school physics and mathematics curricula.

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