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# Analysis of Speed and Acceleration of Two Mobiles in the Study of One-dimensional Movement

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**ABSTRACT**

The work discusses the analysis of the speed and acceleration of two mobiles in the study of one-dimensional movement as part of the study of kinematics, addressing in the classroom the experimental part, being projected on the board by the data show projector, where students individually, configure the system in order to observe the behavior of the blue and red furniture, comparing with the theoretical discussion also developed in the classroom. We address in an introductory way how the thinkers, philosophers, and scientists of the time of Mesopotamia and the Middle East dealt with the question of the movement of bodies and the mixture of what they believed about religion and mythology. The proposal of the operations in the simulator makes the students seek their questions and raise questions to colleagues and the teacher because, in addition to enriching the teaching-learning process, it motivates students for future proposals and consequently eases understanding of the functioning of physical theories. At the end of the simulation, we discuss the results, understanding what can change in the behavior of a mobile in front of the acceleration activation about the constant uniform movement.



## Introduction

Teaching in schools, in general, still develops works of a theoretical methodology. Few schools have laboratories with adequate instrumentation for experimental performance, but even with understanding the cost generated for implementing laboratories involving space and materials (Ruiz, 2021; Kapucu, 2017). One should certainly have the sensitivity on the part of the teacher's school to improvise their classes, using alternative methodologies as in the case of this work, with the use of a notebook being projected onto the board through a projector, the operations of the students.

The work will present the initial discussion of the concept by the thinkers of Mesopotamia, Middle East, in the section of theoretical foundation, going through with several thinkers about the movement, associating the objects observed as stars, planets, Sun, contributing with what they had at the time for the description of the phenomena (Klimovich et al., 2023; Tomin et al., 2018).

Following this thought in a contemporary way, the concepts are being elaborated in a modernized way because the scientists are improving the equipment of observation and investigation, arriving in fact and in a summary way, the theoretical discussion of the movement, speed, and acceleration in the interval of time (Çoban & Erol, 2021; Tobias & Strüder, 2020).

The work does not aim to present exhaustively the concepts of these kinematic variables, given several explorations to be made. However, it seeks to objectify the discussion precisely directed to the simulator, where students develop their activities, but that transmits good assimilation in learning, making it accessible to configure the movement of the furniture and in the survey of arguments for the discussion of

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the theme addressed (Gonzalez & Jung, 2021).

In the field of physics, studying the topic of motion is one of the fundamental aspects that explains the phenomena and symptoms of objects related to position, space, and time. One-dimensional motion is a deeply discussed perspective on the dynamics of objects along a single axis. This research describes the analysis of speed and acceleration using two objects. Scientific and technical application of motion in the field of classical mechanics, which explains the laws of motion governing macroscopic objects in fundamental or microscopic principles of motion in quantum mechanics, the study of one-dimensional movement through the movement of objects in one plane which functions as a small part of multidimensional motion complex (Monteiro et al., 2022).

Central concepts in the study of motion include speed and acceleration. Speed is defined as the rate at which an object covers a distance. Acceleration is the rate of change of speed concerning time. Speed and acceleration are vector quantities (Prastyo et al., 2022). This parameter provides a comprehensive picture of an object's travel, describing how fast it moves and how its speed changes over time. This research examines two moving objects that move along a one-dimensional path. Examining two moving objects introduces an element of comparative analysis that seeks to understand variations in mass, shape, or other factors that may influence their velocity and acceleration profiles (Atmam & Mufit, 2023; Tomin et al., 2018).

This research aims to comprehensively analyze the speed and acceleration of two moving objects in one-dimensional motion. Specific objectives include accurately measuring and comparing the velocities of two objects as they traverse a certain distance, investigating the acceleration profiles of the two objects, and examining changes in their velocities over time. Identification and analysis of differences in velocity and acceleration patterns between the two bodies exploring potential factors influencing these variations, establishing theoretical correlations between mass, shape, other characteristics, observed velocity, and acceleration profiles.

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The idea of the work is one of the ways to contribute to the development and way of thinking about Physics on the part of the student so that they can have a positive image of this science and come to develop the works consistently in general; there is a problematic implementation by the teacher for a teaching proposal of an innovative nature about the traditional model because it involves several factors, such as preparation, knowledge in the treatment of alternatives, as well as the ability to apply methods such as experimental tooling (Bonadiman & Nonenmacher, 2007).

The way the teacher approaches a particular subject in the classroom is crucial, as it will influence the student to like or dislike the subject addressed (Galiazzi & Gonçalves, 2004). Within this perspective, in an introductory way, we discuss the idea of movement in the classroom, which emerged with the first civilizations in Mesopotamia, Egypt, and the Middle East. The people were interested in understanding phenomena such as eclipses, tidal flow, and observation of the stars, where they began to transmit knowledge but involved intrinsically conceptual aspects of myth and religiosity.

Over the years, around the sixth century B.C. Greek thinkers began to use more cautious ways to treat empiricism, formulating appropriate mathematical tools more rationally. For the case of the concept of movement, thinkers argued with various points of view, and Heraclitus (535-475 BC) considered movement, where everything we could see and feel would be a consequence of this fundamental principle. Democritus (460-370 BC) mechanically described motion, where he established the concept of the atom as indivisible, the smallest particle of matter, relating the void in its absence. He believed atoms moved randomly, with collisions, attractions, and repulsions.

Alternatively, in Aristotle (384-322 BC), the discussion of motion involved the composition of matter by the four fundamental elements, earth, water, fire, and air, with defined positions in the Universe. Aristarchus of Samos (310-230 BC), after Aristotle, proposed the discussion of the movement through the celestial bodies, with the idea that the planets revolved around the Sun, being accused of disturbing the rest of the gods and for being contrary to the ideas of Aristotle that were well accepted at that time, because Aristotle believed that the planets, the Moon and Sun revolved around the Earth in circular orbits, with no movement of the Earth.

Nicolaus Copernicus (1473–1543) developed his theory on celestial motion, analogous to that of Aristarchus, where the planets revolved around the Sun in a heliocentric system. However, his ideas had little support due to Aristotle's strong influence on the doctrinal system of religion and philosophy (Ramalho Junior et al., 2009).

Within this reality, and over the years, science has been modernizing, consistently describing the concept of motion as being, in general, the trajectory of the object to be studied, which, in the case of this work, involves the study of kinematics. The description of the movement is given by kinematics, which is part of the study of Mechanics, which seeks to determine the position, speed, and acceleration of one or more bodies at each instant. In the case of kinematics, these bodies are considered mobile as material points because their dimension is negligible.

However, talking about movement will depend on the frame where the mobile is being observed, so the concept of movement and its rest is relative. The observer will observe the furniture in a place called a reference frame. For example, in Figure 1, two fighter planes can perform fueling operations in mid-flight if there is no relative movement between them in each time interval (Calçada & Sampaio, 2012).

**Figure 1**

*Operation of Refueling Fighter Aircraft in Mid-Flight. Although Airplanes are in Motion Relative to Earth, They Have No Relative Motion (Ramalho Junior Et Al., 2009)*

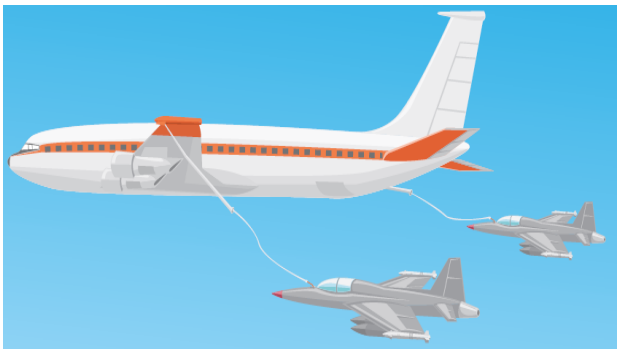


Figure 1 shows that for the observer to analyze the mobile that he intends to study, he must naturally associate the movement of the mobile with the speed quantity, which, in an introductory way, can be scalar speed or average speed. This speed is to be determined through the variation of the mobile over time, being the initial space $s_1$, in time $t_1$, and final space $s_2$, in time $t_2$. Thus, we will have the variation of space being in the $\Delta s = s_2 - s_1$ time interval $\Delta t = t_2 - t_1$, the average velocity expressed in the form according to Equation 1 (Ramalho Junior et al. 2009).

$$V_m = \frac{\Delta s}{\Delta t} = \frac{s_2 - s_1}{t_2 - t_1} \qquad (1)$$

For example, as shown below, a piece of furniture travels along a road, and between the km 10 and km 40 signs, it takes 30 minutes. Its average speed would be the ratio between space variation, in this case 30 km, and the time, half an hour, because the speed is given in km/h or m/s. Figure 2's speed would be 60 km/h (Calçada & Sampaio, 2012).

**Figure 2**

*A Mobile is Moving from km 10 to km 40 in a Time Interval of 30 Minutes (Calçada & Sampaio, 2012)*


Figure 2 for the acceleration case, the speed varies in time, and the mobile begins to perform varied movements. When a mobile present varied movement, we have, therefore, a scalar acceleration, which can be measured in each time interval, being average scalar acceleration and will be the ratio between the variation of the speed, in the time interval, in the form according to Equation 2 (Calçada & Sampaio, 2012).

$$a_m = \frac{\Delta V}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} \qquad (2)$$

We will not detail the theoretical aspects of speed and acceleration so as not to make it exhaustive for the reader. However, the idea passed to the students is that acceleration analyzes the change of speed for each instant, with a reduction in the case of the activation of the brakes.

## Methods

The study proposes the practical application of learning in the theoretical context of kinematics subjects involving speed, acceleration, and time of two pieces of furniture. Although graphically, we observe in two axes, the movement of the two pieces of furniture is given in a single axis, configuring the analysis concerning the furniture in a one-dimensional way.

The experimentation phase makes the student observe, collect data, interpret the data, raise questions, issue opinions, and draw some conclusions. This is important for the student's learning because it expresses its ideas, perceiving the meanings of the formulas treated in the classroom, obviously in a simplified way, but satisfactory. After all, all this work makes the student come to explain conceptions about the theme studied (Bonadiman & Nonenmacher, 2007).

The methodology was applied experimentally to 20 students in the 1st year of High School through the simulator that seeks to identify the movement of two pieces of furniture, one blue and the other red, analyzing the speed, acceleration, and time in the one-dimensional movement (Duffy, 2018). The students, individually, through the computer projecting the simulation image on the board, will perform the activity, analyzing the position graph with time and speed with time.

The position icon displays the student's choice from -30 to +30 meters, and the speed icon from 0 to 10 $m/s$. Both describe the movement of the red furniture. The blue furniture will have the acceleration icon, where the student will choose from 0 to 2 $m/s^2$. The simulation presents the options for play: making a move in the furniture, pausing, stepping back, stepping forward, and restarting.

**Figure 3**

*Analysis of the Position with the Time of Two Pieces of Furniture of Student F*

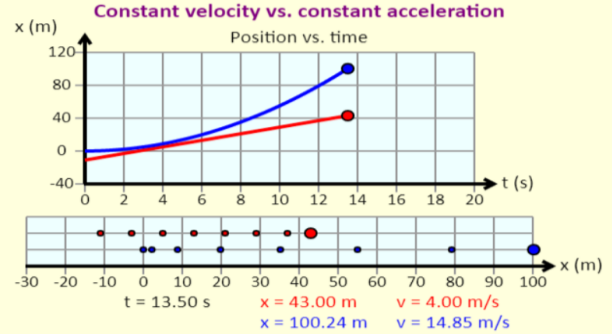
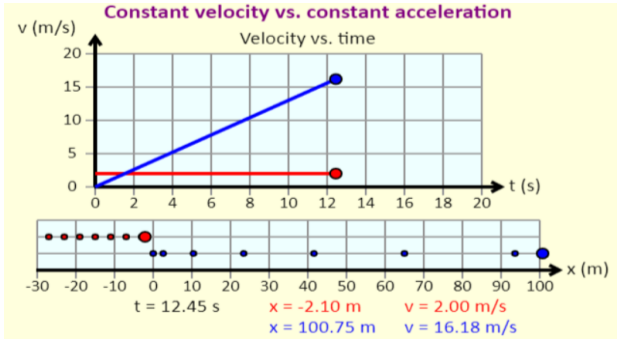



Figure 3 shows an analysis of the position with the time of two pieces of furniture of student F. The relation between constant speed and acceleration in the 0 to 20 seconds time range with variations in distance.

Figure 4 shows an analysis of the speed with the time of two pieces of furniture of student B. The relation between constant speed and constant acceleration is 0 to 20 seconds. The distance variation to the left is from 0 to 30 meters, and the distance variation to the right is from 0 to 100 meters.

**Figure 4**

*Analysis of the Speed with the Time of Two Pieces of Furniture of Student B*

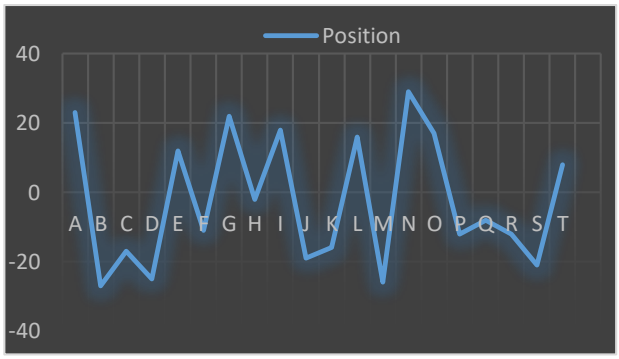



## Result and Discussions

The students generally observed that the red furniture described in its trajectory is in one-dimensional movement, with a constant spacing in its position, making markings with similar distances. For the blue furniture, in the absence of acceleration, the students observed that the mobile was stationary and followed its movement when the acceleration was triggered, increasing the spacing for each marking on the one-dimensional x-axis. Students performed the activity individually, being identified from *A* to *T*, having the freedom to configure the furniture's movement according to the simulator's conditions.

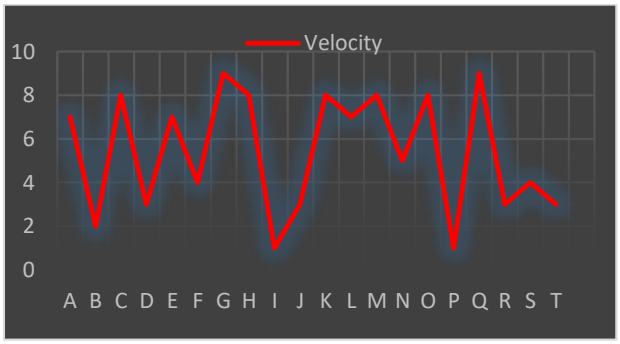
**Figure 5**

*Projection of the Configuration of the Students for the Position of the Red Furniture*



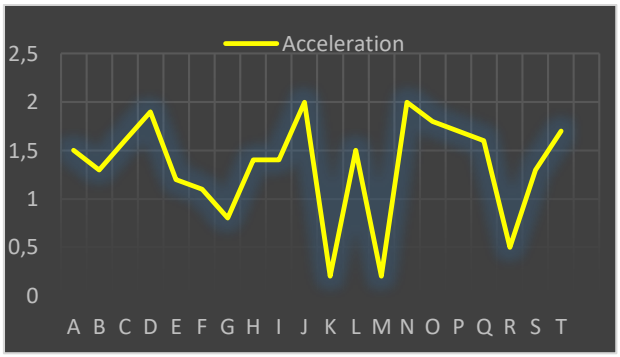

Observing Figure 5, we noticed that four students considered the choice of position at the point less than 20 meters as part of the lowest range of values, and three students chose above 20 meters for the positioning of the red furniture. The remainder for the arithmetic mean was in the range of position -2, which is reasonable, considering the tendency of students to use the settings approaching the center.

**Figure 6**
*Projection of the students' configuration for the speed of the red mobile.*




In the case of Figure 6, the speed of the red mobile, graph 4 shows that three students chose speeds less than or equal to 2 m/s, and seven students chose speeds greater than or equal to 8 $m/s$. The remainder has the arithmetic mean for 4.7 $m/s$ of velocity, which is also reasonable by the tendency of the choice by the center.

**Figure 7**
*Projection of the configuration of the students for acceleration of the blue mobile.*




In Figure 7, which deals with acceleration, ten students chose acceleration greater than or equal to 1.5 m/s 2; two chose less than or equal to 0.5 $m/s^2$. The remainder made an arithmetic mean of 1.0375 $m/s^2$, which is within the range of the trend to the center of the values.

The students realized that when activating the acceleration of the blue furniture, at some point, it would pass from the red furniture precisely because the speed of the red mobile is uniform and constant, going according to the formulas and discussions presented in the classroom (Couland et al., 2018; Eutsler, 2021).

In positioning red furniture, projection refers to the planned arrangement of elements in a space. Student configuration projections for the position of red furniture describe how certain elements are arranged in an environment. Space Utilization Projecting the position of red furniture requires considering the room's layout. Factors such as the size and shape of the furniture, the number of students, and the room's overall design need to be considered. This projection involves optimizing the arrangement for efficient use of space, contributing to its visual appeal. This provides ease of movement and interaction. Ergonomic projection considers the optimal placement of red furniture according to needs and activities (Lalti et al., 2022; Monteiro et al., 2022).

The projection of the configuration of the speed of the red object involves kinematic principles related to the object's motion, which explains that the speed of the red object depends on its position, changing over time (Ruiz, 2021). The speed and acceleration of the red phone estimate the influencing parameters that can change with the phone's movement (Susilawati et al., 2019). This estimate can be based on initial conditions, such as initial velocity and other factors influencing acceleration. Other factors, such as initial position, speed, and any external forces acting on the phone, contribute to this projection.

## Conclusions

The analysis of the graphs by the configuration of the students to perform the activity sought once again to emphasize the idea of the centrality of the data in a general way, not that it is a rule, because in few cases, we have the possibility of escaping from this pattern of estimation. This observation comes from the teacher-researcher, from the motivational behavior of the students to the tendency of choice for the system's configuration in the individual operation. In a broader view, the work aimed to show the students the experimental consistency, even in a simulation, regarding the velocity and acceleration analysis concerning the time of two mobiles in the one-dimensional movement. The students raised questions, making comparisons in their observations and understanding the consistency of the theory, in particular kinematics, where it describes the equations of motion with the variables of speed, space, acceleration, and time. The closure of the activities was due to the consolidation of the student's data and discussion in the classroom, emphasizing the liberality of operating in simulation systems but understanding the objective of assimilating the content, using the simulation as a complement to the theoretical approaches.

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